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CONTENTS


- 1.0 HISTORY OF FLAME SAFETY LAMP**
- 2.0 SAFETY FEATURES OF FLAME SAFETY LAMP**
- 3.0 FUNCTION OF VARIOUS PARTS OF FLAME SAFETY LAMP**
- 3.1 DETECTION OF GAS WITH FLAME SAFETY LAMP**
 - 3.1.1 ACCUMULATION TEST**
 - 3.1.2 PERCENTAGE TEST**
- 4. DESCRIPTION ABOUT METHANOMETER**
- 5. CO DETECTOR**
- 6. PRECAUTION AGAINST INFLAMMABLE & NOXIOUS GAS**
- 7. CLASSIFICATION OF COAL SEAM INTO IT'S DEGREEENESS**
- 8. TABLE OF MINE GASES & THEIR MEASURING INSTRUMENT**
- 9. MINE GASES & THEIR PHYSIOLOGICAL EFFECTS**
- 10. DIFFERENCE BETWEEN IGNITION & EXPLOSION**
- 11. DIFFERENCE BETWEEN INFLAMMABILITY & LAG ON IGNITION**
- 12. IGNITION, CROSSING POINT TEMPERATURE**
- 13. METHANOMETER OPERATING PRINCIPLE**
- 14. DESCRIPTION OF MINE GASES-CO,CO₂,SO₂,NO_x,H₂Ss**



Gas Testing Refresher

Session - I

- Although there is a dispute to who invented the **"first" miner's flame lamp** that was safe to use in fiery mines.
- The success of the flame safety lamp was a culmination of the principles discovered by **Dr. William R. Clanny, Sir Humphrey Davy, and George Stephenson.**
- All three worked independently on the problem at about the same time, and all had some knowledge of the other's work.



➡ The principle of isolating the flame of the lamp was evolved by Dr. Clanny in 1813.

➡ Clanny's first lamp designs involved enclosing the flame, and pressurizing the lamp via bellows that would use water reservoirs to isolate the flame.

➡ The lamp was rather clumsy, and saw no practical use in the mines.

➡ But the feature of a glass window would be later a common feature on safety lamps.

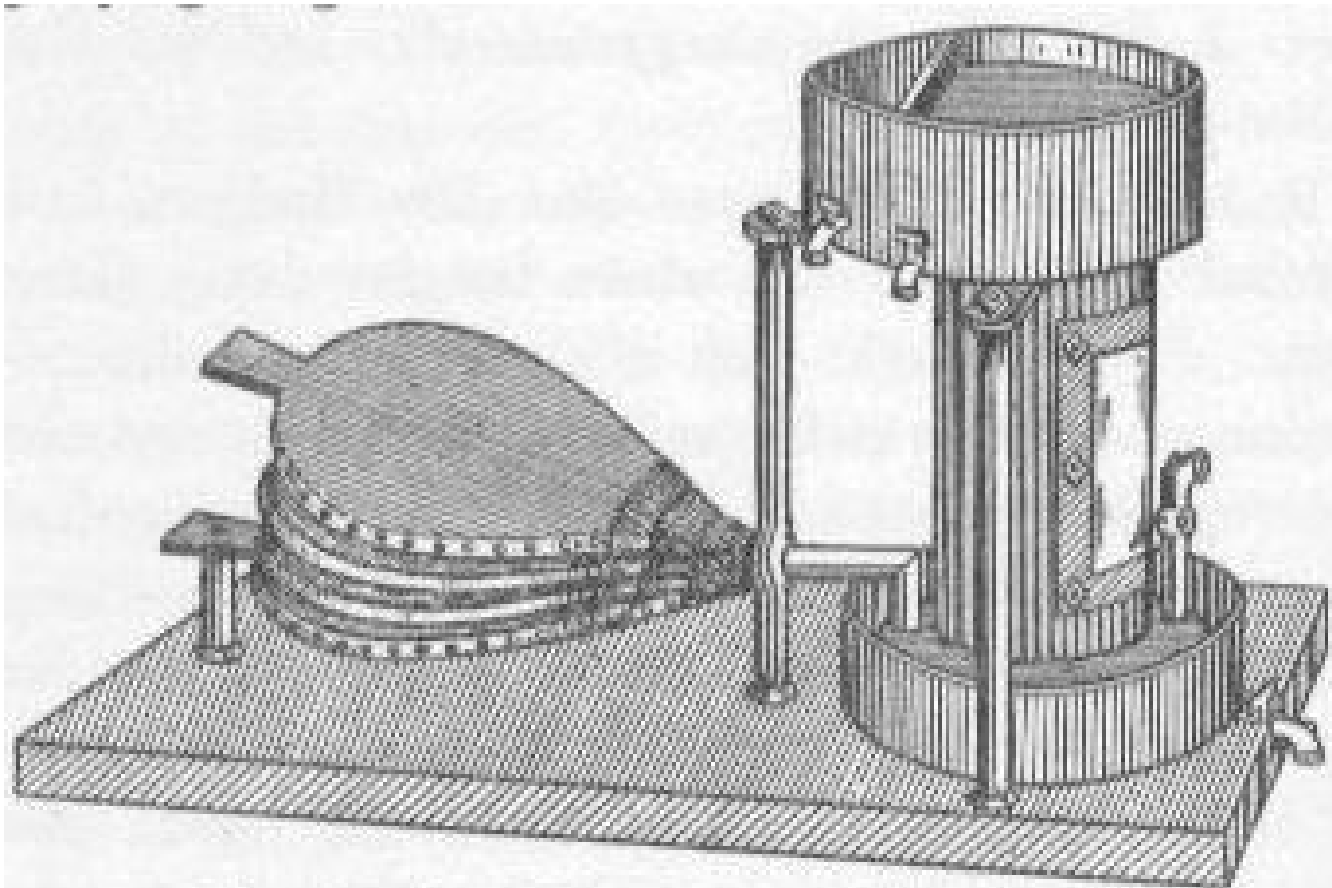


FIG. 11. THE FIRST MINER'S SAFETY LAMP.

A boy was required to keep blowing the bellows to supply the candle with air.

☞ Sir Humphrey Davy was performed **several experiments** of his own for the development of a safety lamp.

☞ **In 1815, Davy** discovered that if **two vessels were filled with explosive gas**, they might be connected together by a **narrow tube**, and the gas in one of the chambers could be exploded without transmitting the explosion to the adjoining chamber.

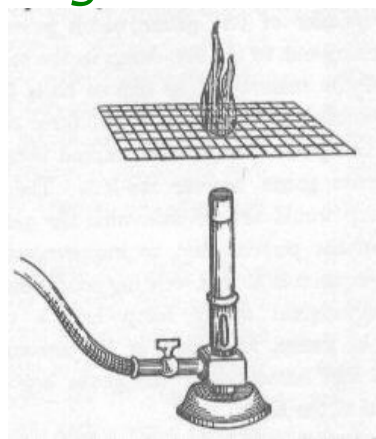
☞ This meant that a flame in a lamp, fed mine air through small orifices, would not ignite the surrounding air of the mine.

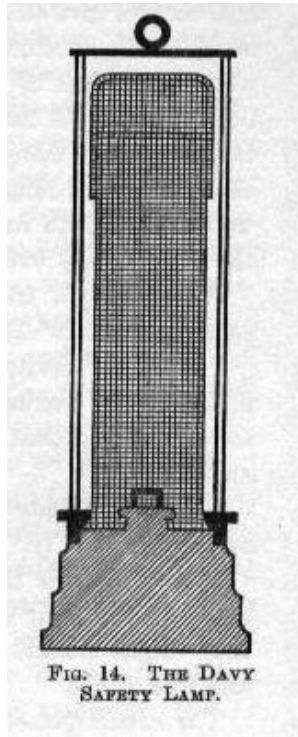
➡ Davy's further experiments found that mesh-holes of fine metallic gauze acted the same way as narrow tubes.

➡ The adjacent drawing depicts **Davy's principle** utilizing a Bunsen-burner.

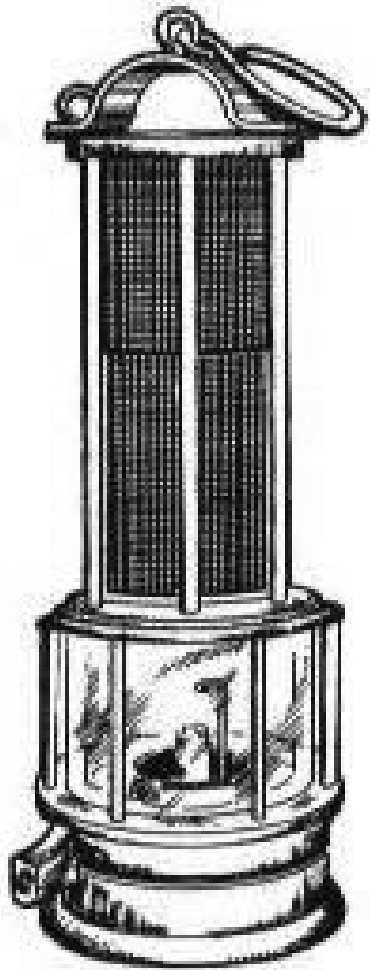
➡ ***The flame will burn on one side of the gauze without igniting the gas on the under side of the gauze.***

➡ *This is because the gauze will dissipate heat fast enough that the temperature of the gas beneath is unable to rise to the point of ignition.*

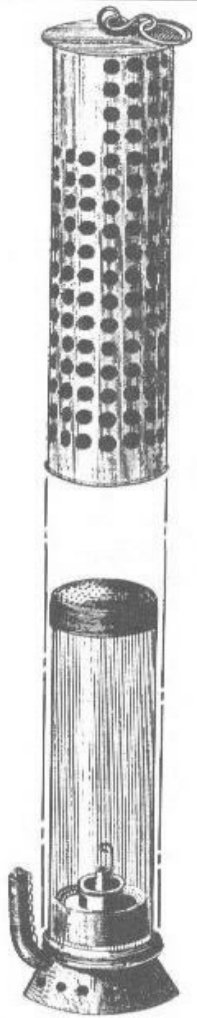




- ***Davy built a lamp that totally enclosed the flame with a cylinder of gauze.***
- ***While it did not give off much light, it was success in minimizing, although not eliminating, explosions from flame lamps.***
- ***Davy's wire gauze principle was used in almost every type of flame safety lamp that was developed for near 200 years.***



- While **Clanny and Davy** were working on their safety lamps, **George Stephenson** (who would later go on to invent the steam locomotive) was working on his safety lamp.
- In 1815 , Stephenson was an engine Wright at the Killingworth colliery near New castle.
- Stephenson started developing and testing lamps designed on two principles:
 - 1)"burnt air" (carbonic gas, CO₂) would prevent transmission of explosions.
 - 2) The velocity of burning firedamp was slow.

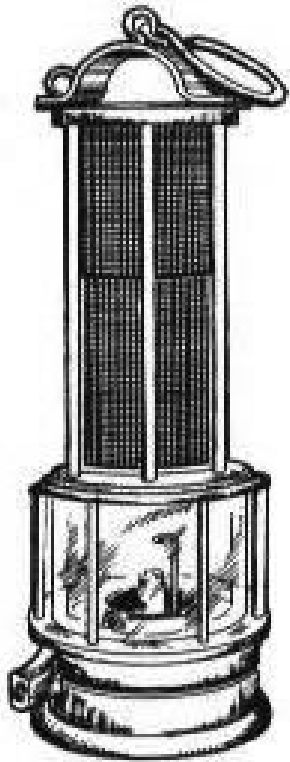


- So, if an air draft opposite to the direction of combustion of great enough velocity could be created, transmission of explosion would not occur.
- Stephenson's third lamp was a success, and with modifications was successfully used in coal mines mainly in the North of England.
- There has been a long dispute to as who really invented the first "safety lamp". Clanny, Davy, and Stephenson each contributed to the evolution of the safety lamp.
- To summarize their contributions:

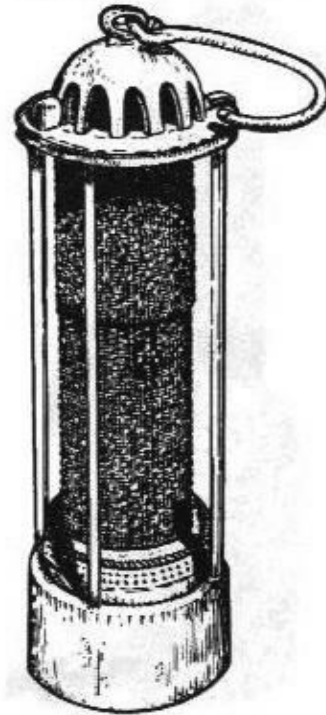
Dr. Clanny- Separated the flame from the mine's firedamp atmosphere.

Sir Humphrey Davy- Enclosed the flame in a wire gauze.

George Stephenson- Leave space above the flame for "burnt air".



Clanny eventually incorporated Davy's wire gauze.

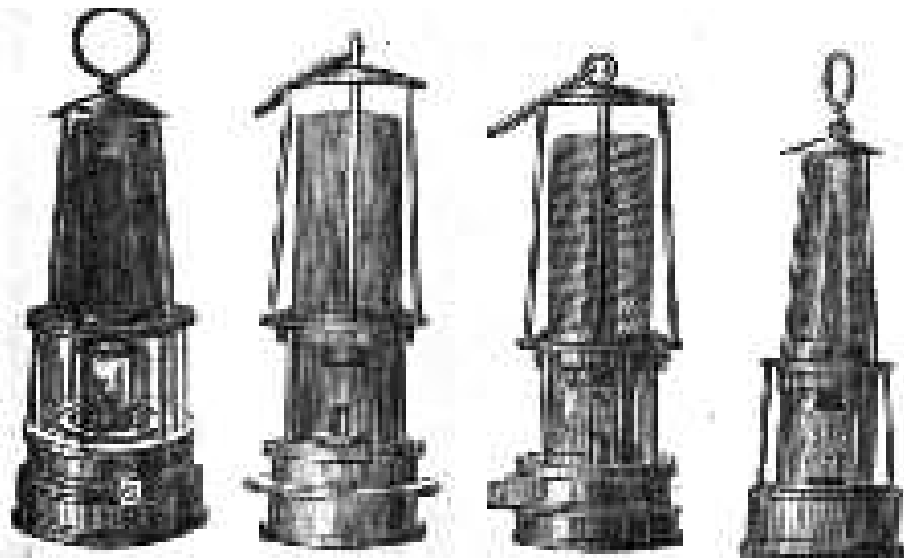


Stephenson's "GEORDIE" lamp.

Stephenson eventually incorporated Davy's wire gauze in his famous "Geordie" lamp.

This is why, even to this day, a miner's flame safety lamp has generically been called a

"Davy Lamp".



These are some of Clanny's lamps.




Three early flame safety lamps - From left to right Stephenson , Davy & Clanny Types.



**Marsaut type
Flame Safety lamp**

- A Marsaut flame safety lamp that was used at Haunch Wood Old Pit around 1886.
- By 1923, two out of every three miners used them.
- **Marsaut**, who was a French mining engineer, was responsible for inventing some of the most important safety features of the flame safety lamp.
- In 1871 he introduced a protective 'bonnet' over double and sometimes triple gauzes.
- The result was a lamp that was much safer than the un-shielded Clanny and Davy lamps that were popular at that time.
- The lamp provided for an increased level of safety in the explosive atmospheres that could develop in mines.
- The unique 'bonnet' or shield, which made it so easily identifiable, eventually became a compulsory part of all flame safety lamps.




Many variations of flame safety lamps were tried over many years, but their accuracy in determining the amount of methane gas present was questioned when it was discovered that air could be circulating around the lamp (caused by heat from the lamp) this resulted in a false percentage of methane being estimated.

The safety lamp burns oil. Inside the lamp is a wire gauze cylinder of fine mesh which forms a cage around the flame. Heat from the flame is dissipated and this prevents the flame from propagating outside of the lamp.

How heat transference in a flame safety lamp is achieved.

- 1). Convection feeds the flame and cools the lamp.
- 2). The glass allows radiation.
- 3). The brass oil vessel uses the principle of conduction and radiation.
- 4). The two gauzes conduct heat and keeps temperatures low.
- 5). The steel bonnet conducts, radiates and improves ventilation.
- 6). The outlet holes in the bonnet top allows convection from the flame and carries the heat away.

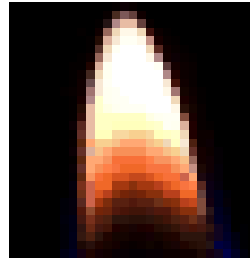


The safety lamp started to be replaced with electric mine lighting devices after 1900. By 1930 or so, almost all flame safety lamps were replaced by electric Lamps. But, safety lamps still continued to be use for detecting and measuring gas long after their use for lighting was obsolete.

☞ The quantity of methane gas present in a particular part of the mine was obtained by switching off cap lamp lights etc.

☞ So the mine was in darkness except for the light generated by the oil lamp, holding the lamp up to the roof, lowering the wick, and looking at the ***colour, size and shape of the flame.***

☞ If firedamp was present a pale blue flame appeared around the central flame, sometimes referred to as the ***"blue-cap"***.



The flame safety lamp also detects oxygen deficiency, known by miners as blackdamp, a mixture of air and carbon dioxide (CO₂) which could be found near the floor, usually where the ventilation is inadequate.



With the Garforth lamp a sample could be taken from a particular area using an aspirator bulb, the sample is then injected straight into the lamp thus giving a more accurate reading.



Model GL60



Model GL50



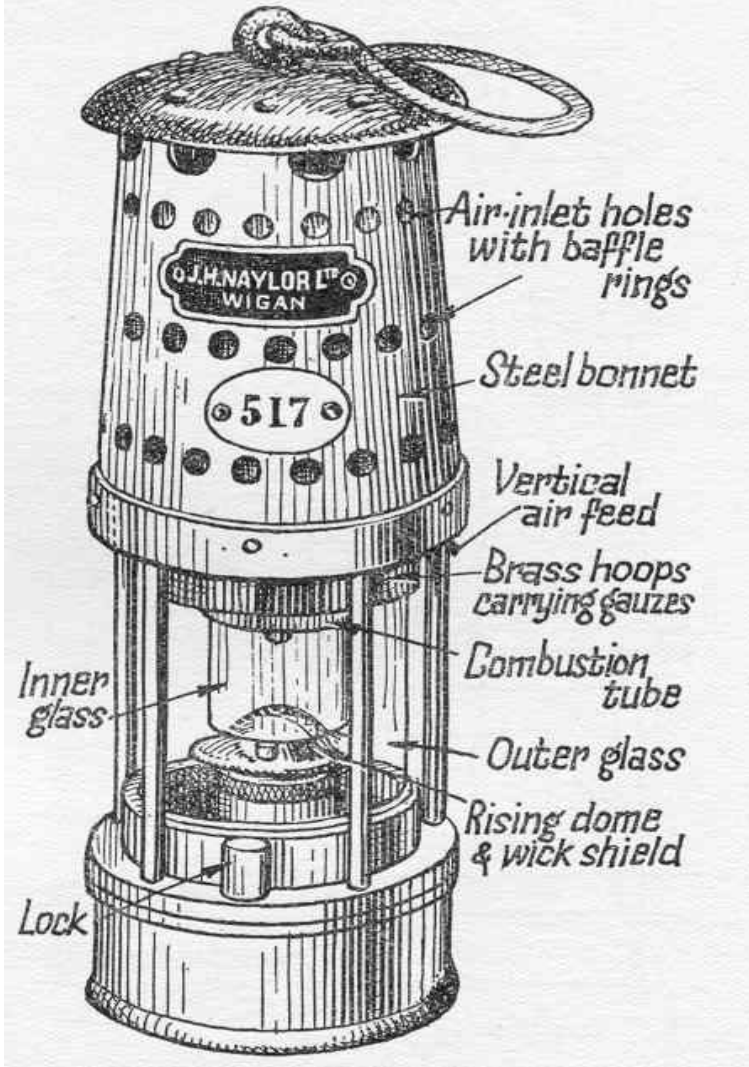
Showpiece Model



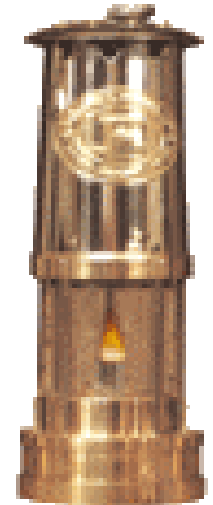
Model GL7



Model GL50
with extinguisher



Top feed Safety lamp





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GASSY MINES / SEAMS
GAS CAP WITH PETROL

GL7

GAS TESTING FLAME SAFETY LAMP

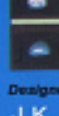
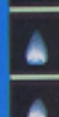


GAS CAP INDICATOR

To Read Real Percentage of Methane From 0.5% To 4%



1. Flame Test is most dependable and Safest
2. Gas Automatically reacts on Testing Flame



FLAME NEVER BETRAYS

INSTANT Relighting By

Energetic Glow Filament with two Common Dry Cells



Designers & Manufacturers
J.K. DEY & SONS
13, OLD CHINA BAZAR STREET
CALCUTTA - 700 001 (INDIA)



Approved By :
DIRECTOR GENERAL OF MINES SAFETY
DHAMBAD • INDIA
APPROVAL NO - SA-3/70, DATED-7-4-1970

- By 1800 some copper miners in Cornwall were experimenting with simple ceramic type **"Tea Pot"** lamps.
- Such lamps consisted of an oil storage reservoir (complete with lid) with a spout through which a woolen wick was pushed.
- Such lamps burnt both oil and tallow fuels and were small enough to be worn on the miners' hats in place of their traditional candles.
- By 1850 Scottish collieries working in none "gassy" mines were beginning to use similar oil wick lamps made of tin or brass.



**A Scottish
Colliers oil
wick lamp
c.1860-1900.**



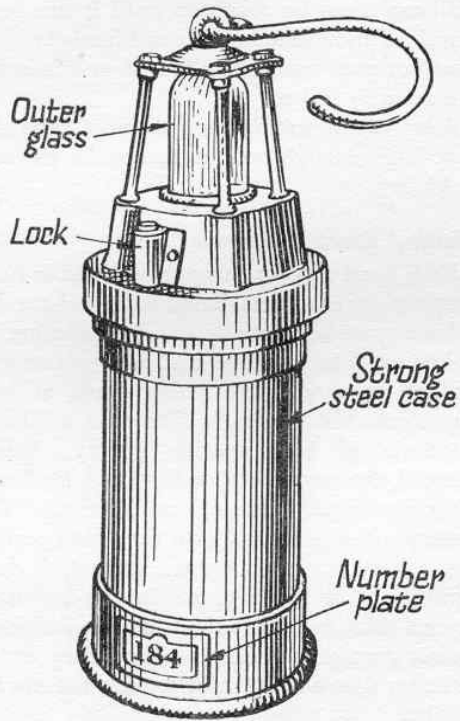
By the mid 1890s yet another form of naked flame miners light was to appear. This new device, the carbide lamp, produced *extremely good illumination* and was soon to become the standard form of miners light in most metalliferous mining regions replacing the use of candles and oil wick lamps.

Such lamps were also to become popular in none "gassy" collieries and especially the anthracite pits of South Wales. The use of carbide lamps in many collieries continued well into the post nationalization era (i.e. after 1947).





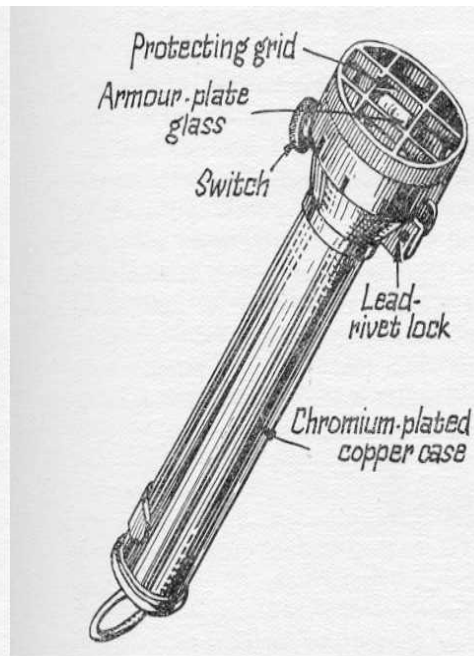
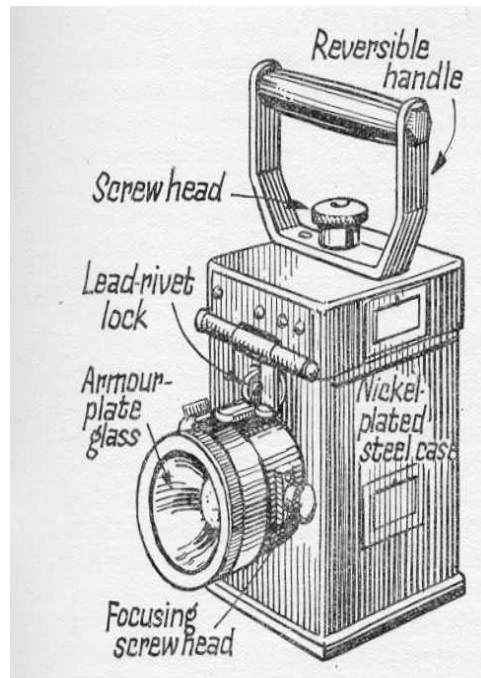
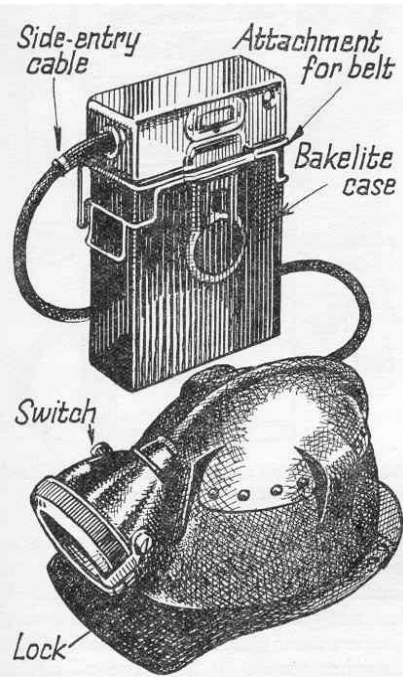
Electric Safety Lamps - By the early 1910s the role of the flame safety lamp as the only safe means of underground lighting in "gassy" mines was challenged for the first time.



A new miner's light was starting to be introduced in the form of the electric safety lamp.

Not only were the new wet cell electric lamps safer but they also offered higher levels of luminosity than had been previously possible with flame safety lamps.

Initially such electric lamps were heavy hand held types which made them relatively cumbersome and unpopular in many coalfields. However by the **1940s** the **lighter weight** and more familiar electric cap lamp, with its **waist mounted battery pack**, started to appear and was fairly rapidly accepted in most mining regions.



This **lighter weight, more reliable and robust** form of miner's light was to become the standard form of safety lamp in nearly all of Britain's Coalfields.

Session - II



What are the safety features of a Flame safety lamp?

Table Group, 10 minutes



What purpose the following parts of Flame safety lamp serve?

Wire gauge, Asbestos packing, Bonnet, Deflector ring, Magnetic lock

Wire gauge: It allows the air to pass & distributes the heat and does not allow the inflammable gas to burn out side the gauge.

Asbestos packing: It protects the flame from coming out of the lamp by providing a seal in between both the ends of the glass.

Bonnet: Protects the lamp from mechanical damage and flame from blowing air.

Deflector ring: It allows the intake air to go to the cap and not allows it to move up (bottom feed)

Magnetic lock: Protects the lamp from intentional and inadvertent opening.

In spite of the availability of so many modern instruments why still Safety lamp is used in underground mines?

1. Flame never betrays, where as electrical or electronic apparatus may betray.
2. Instant reaction during Oxygen deficiency
3. No periodical calibration is required
4. Simple to operate, dismantle, and testing at all places
5. It can be used for continuous monitoring
6. All most zero maintenance cost
7. The lamp is most reliable, safest and dependable than any other gas detectors



How you will check the gas with
a Flame safety lamp?

Procedure for checking of Gas with Safety lamp.

First Step: Examine the lamp and make sure that it is properly assembled and safe in all respects.

Accumulation test:-

- ✓ The purpose of this test is to ascertain if there is any accumulation of gas in places where it is likely to accumulate.
- ✓ At first switch off the cap lamp.
- ✓ Raise the FSL cautiously with normal size flame.
- ✓ Watch its behavior carefully.
- ✓ If it elongates spires or jumps the percentage of gas can be taken as 3% or more.
- ✓ No efforts should be made to raise the FSL higher than is necessary to test for accumulation (the richer mixture may explode inside the lamp or may burn inside the lamp) which may be dangerous also the lamp may go off.

- ✓ If by chance firedamp begins to burn within the gauze, the examiner shall shelter his lamp from the air current, hold it near the floor and retreat carefully to the fresh air.
- ✓ If it is not possible, he should smother out the flame by covering the air inlet holes or submerge the lamp in water if available near by.
- ✓ It is unnecessary to conduct the percentage test if the gas is detected in the accumulation test.

Percentage test :-

If in accumulation test gas is not observed than we go for percentage test.

To conduct percentage test for methane with FSL remove all bright light in the vicinity.

- ✓ Switch off the cap lamp.
- ✓ Lower the flame of the FSL with the regulating knob till testing flame is made . This should be done at a safe place free from gas but not too far where percentage test should be conducted.
- ✓ Move slowly in a zigzag way, keeping eyes normal to the testing flame. If gas is present the gas burns with a non-luminous flame, which varies in height depending upon the percentage of the gas.

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GAS TESTING FLAME SAFETY LAMP

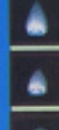


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FLAME NEVER BETRAYS

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Energetic Glow Filament with two Common Dry Cells



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MSA D-6 Methanometer: It is used for checking Methane gas_

- ✓ It is suitable for spot checking .
- ✓ Its measurement range is from 0 to 5 % by volume.
- ✓ A telescopic probe is provided for taking gas samples near the roof or other inaccessible points
- ✓ The two section telescopic probe extends from 76 cm to 1.42 m.
- ✓ Rechargeable batteries are used in the methanometer
- ✓ Two nickel cadmium batteries are connected in series and provide 2.2 to 2.6 volt for operation.
- ✓ Capacity of power pack is 1.2 AH
- ✓ A fully charged battery lasts for nearly 1000 ten-sec readings.
- ✓ Complete charging of battery takes nearly 14 hours
- ✓ Its weight is 470 g (including the battery)

Instructions for operation of methanometer

- ✓ Before taking the methanometer u/g check the voltage of the battery. It must be between 2.2 to 2.8.
- ✓ If voltage is below 2.2 do not check for methane as it will give incorrect reading.
- ✓ In u/g at the spot of methane checking , first lift the diffusion head cover so that the diffusion head is fully exposed to the atmosphere.
- ✓ Then hold the instrument in the left palm and press the methane-check button on the left side.
- ✓ Then read the percentage from the meter.(within 10 to 20 sec)
- ✓ Do not press the methane check button for longer period. This will drain the battery.
- ✓ For checking the methane percentage at inaccessible place use the telescopic probe.

Instructions for operation of methanometer

- ✓ For this purpose open the diffusion cover head, unscrew the probe cap and screw the threaded socket of the probe firmly to the diffusion head.
- ✓ With the probe end in place, squeeze the aspirator bulb, 2-3 squeezes are enough for a constant reading.

Note- Each methanometer shall be calibrated once in a quarter at CMRI or other recognized institute.

Session - III

MSA CO detector:

- ✓ It generally consists of an aspirator, a colour comparing scale and co-detecting tubes.
- ✓ 2 to 5 no of squeezes can be taken to detect the presence of co gas , comparing the change of colour of the detecting colour tubes with the scale colour provided with the instrument.
- ✓ 10 ppm to 1000ppm of gas can be detected with this instrument.
- ✓ The tube contains chemical (yellow silica gel impregnated with palladium sulphate and ammonium molybdate) and is sealed at both ends.
- ✓ The closed tube tips are broken by inserting it in the aperture provided within it the apparatus.
- ✓ Then the tube is fitted in the apparatus at both ends.

MSA CO detector:

- ✓ The aspirator bulb (60 cc) capacity is squeezed 2,3 or 5 times and the Co sucked into the instrument changes the colour of the chemical in the tube. The extent of colour change depends on the percentage of CO.
- ✓ The change in colour of the indicating gel of the detector tube is matched with the colour chart available on the rotatory knob of the detector and percentage of CO is read off corresponding to the No. of squeezes.

Note: The self life of the detector tube is generally 18 months.



Drager Miniwarn

Portable gas monitor for detection of up to 4 gases, can have pump attached for remote sampling.

Drager Micropac

Single channel renewable portable gas detector for either Oxygen, Hydrogen Sulphide or Carbon Monoxide.



Alcohol & Drug Measurement Instruments

For more than 50 years, Dräger has focused on the development of breath alcohol measurement and became one of the biggest suppliers of breath-alcohol measuring technology.



Dräger Oxy K 30 Oxygen Self Rescuer


Oxy K 30 HW/HS should be carried when toxic gases can be present or the atmosphere can be oxygen deficient.

How to read a calibrated instrument?

Actual gas %	Instrument reading %
0.5	0.6
1.2	1.4
1.8	2.0
2.4	2.6

Date of calibration 14.8.2006

Next calibration due on 14.11.2006



What Steps you will take when
gas is observed?

Precaution against Inflammable and noxious gases?

Reg.142.

(1) For the purpose of this regulation, *inflammable gas shall be deemed to have been found or detected when it is indicated by the lowered flame of a flame safety lamp or, where methane indicators are used, they indicate 1.25%, or more of inflammable gas.*

(2) When any person detects the presence of inflammable gas, he shall not brush or waft it out, but shall immediately withdraw from the place and shall inform his superior official about the same.

(3) Where in any place in a mine, inflammable or noxious gas is detected, all persons shall be withdrawn from the place, and the place shall be immediately fenced off so as to prevent persons invariably entering the same. The competent person in charge shall, without delay, take steps to remove the gas by improving the ventilation.

Reg. 142. Precautions against inflammable and noxious gases –

(4) During the removal of such gas all persons except those necessary for such removal, shall be withdrawn from the return side of the ventilating district in which the gas has been detected unless the quantity of gas is, in the opinion of the competent persons, so small that such withdrawal is not necessary: Provided that where the danger arises from the presence of inflammable gas, no naked light shall be used in the ventilating district in which the gas is detected.

(5) No person shall be re-admitted into the place where the gas was detected until a competent person has examined the place and has reported that the place is free from gas. Every such examination shall be made with an approved flame safety lamp and, in the case of noxious gas, also with a cage containing suitable birds or other means of detecting carbon monoxide gas approved by the Chief Inspector.

Reg.142. Precautions against inflammable and noxious gases –

(6) Particulars of every occurrence referred to in sub-regulation (2) and of every examination made under sub-regulation(5) together with a statement as to where and when the gas was found and when it was removed, and in case of inflammable gas, the percentage thereof, shall be recorded in a bound paged book kept for the purpose, Every such entry shall be signed and dated by the competent person making the report, and countersigned and dated by the manager.

Classification of coal seams according to their degree of gassiness (Regulation- 12A,12B,12C & 116)

Gassy seam of the first degree

means a coal seam or part thereof lying within the precincts of a mine *not being an opencast working whether or not inflammable gas is actually detected* in the general body of the air at any place in its working belowground or where the *percentage of inflammable gas if and when detected does not exceed 0.1* and the *rate of emission* of such gas does *not exceed one cu.m. per tonne of coal produced*

Classification of coal seams according to their degree of gassiness

Gassy seam of the second degree

means a coal seam or part thereof lying within the precincts of a mine not being an opencast working where the *percentage of inflammable gas* in the general body of the air at any place in the working of the seam *is more than 0.1* or the *rate of emission* of inflammable gas *exceeds one cu.m.* but *does not exceed ten cu.m.* per tonne of coal produced

Classification of coal seams according to their degree of gassiness

Gassy seam of the third degree

means a coal seam or part thereof lying within the precincts of a mine not being an opencast working in which the rate of emission of *inflammable gas exceeds ten cu.m.* per tonne of coal produced

Session - IV

Gases	Measuring Instrument	How to find out	Threshold limit value
CO₂	Flame Safety Lamp (FSL)	By observing diminishing light output (illumination)	
O₂	FSL, Oxymeter	3.5% for every % age of O₂ content	
CH₄	FSL, Methanometer, Multi Gas Detector	Reading on digital display	
H₂S	Detector tubes, Filter paper soaked in lead acetate solution, by smell like rotten Egg	With colour code, if filter paper turns brown, in smell In as low as 0.75PPM	10ppm
CO	Toximeter, Co-Detector & Munia Bird	Reading on the dial of the instrument or digital display. Behavior of bird	50ppm
NO₂	Detector Tube and exposing filter paper soaked in starch & potassium iodide.	Colour code and if filter paper turns blue	5ppm

Mine gases	% age of gas	Physiological effect
O₂	17% 15% 13% 10% 7%	Breathing becomes faster and deeper Dizziness, buzzing in the ears, rapid heart beat Leads to unconsciousness after a prolonged Exposure Unconsciousness follows within half an hour Heavy panting & palpitation. Face turns blue, unconsciousness followed
CO	0.0016% 0.01% 0.02% 0.1% 0.4%	Harmless for prolonged exposure Can cause chronic poisoning after 6 hours headache & exertion Headache, palpitation & giddiness within 2 hours Unconscious within one and half hour ,after 4 hour possible death Fatal within few minutes

Mine gases	% age of gas	Physiological effect
H2S	0.005 – 0.01 0.02 – 0.03 0.05 – 0.07 0.1 – 0.3	Within ½ to 1 hour exposure it will affect a person, symptom being irritation, inflammation of eyes, irritation of respiratory track Causes marked symptom of conjunctivitis & respiratory tract irritation Serious poisoning within ½ an hour of exposure Rapid paralysis of respiratory centre, may lead to death
SO2	< 0.015 0.015 – 0.019	Extremely irritating to the eyes & respiratory passages Fatal within ½ an hour TLV – 5 ppm
NO2	0.00025% 0.075%	Tolerable (Symptoms are cough, nausea, chronic perspiration, headache but latter develop serious bronchial troubles) Fatal Nitrous fumes are highly poisonous 7 to 10 times more toxic than CO (TLV – 5 ppm)

Difference between ignition and explosion

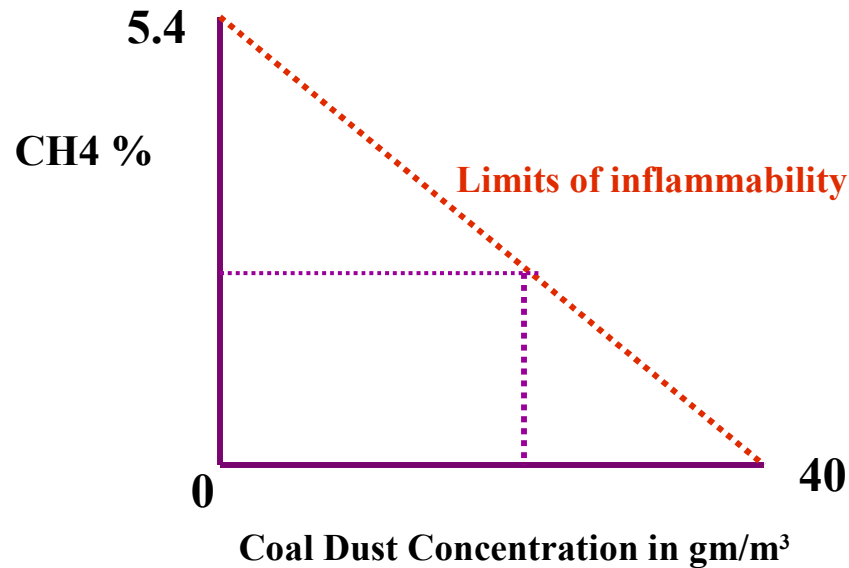
- ✓ The term *Oxidation* refers to chemical combination of substances with oxygen.
- ✓ And *combustion, explosion* and *detonation* are all forms of oxidation.
- ✓ The only difference lies in the degree of rapidity with which the chemical reaction takes place.
- ✓ The slowest form of chemical combination is Oxidation or combustion, explosion is still more rapid form of chemical combination, where as detonation is instantaneous.

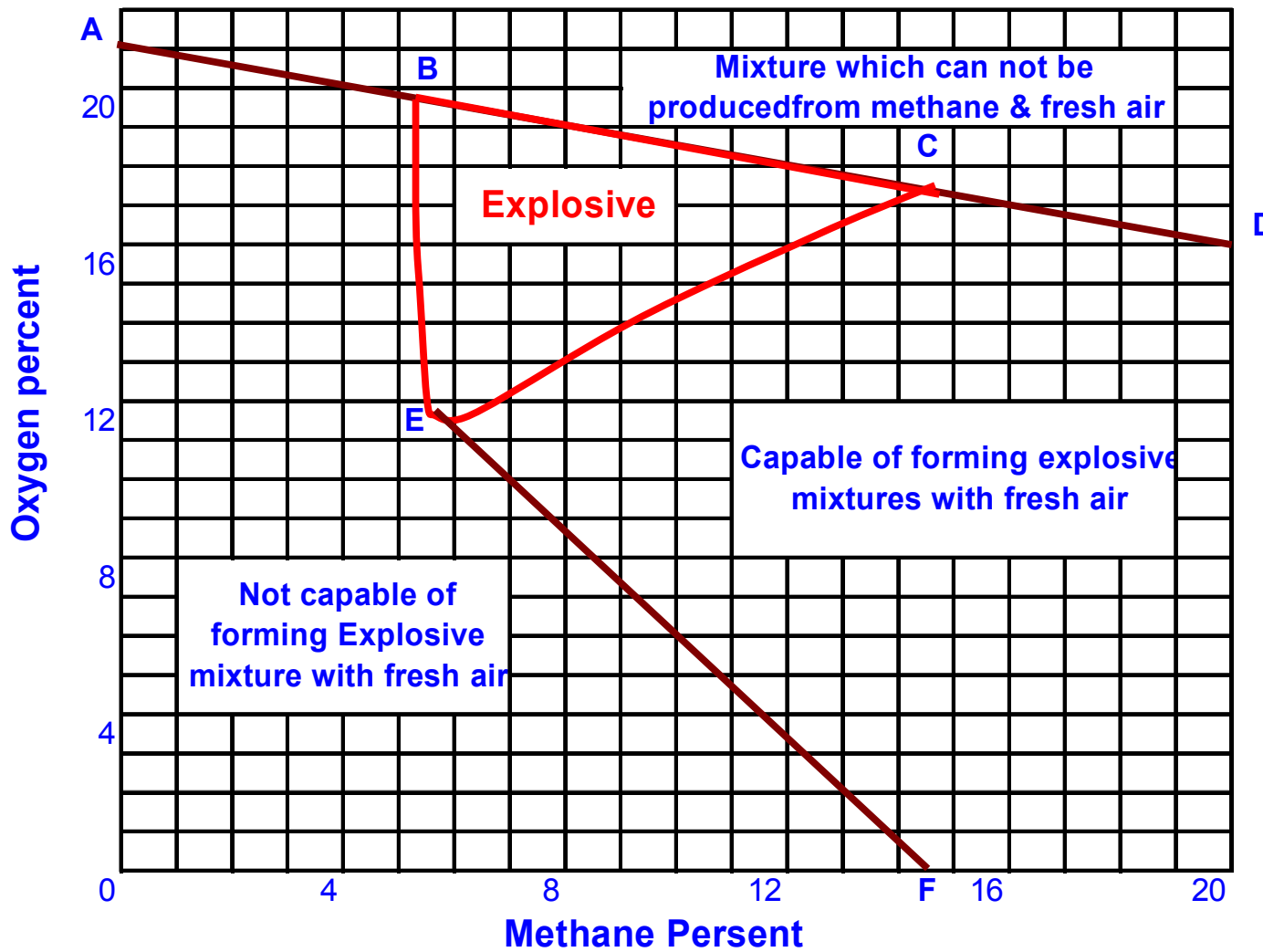
Limits of inflammability & Lag on ignition

- ✓ Methane when in contact with a source of ignition not ignites immediately but it ignites with a delay, which depends on the temperature of the igniting sources.
- ✓ Only after absorbing 22.1 K. cal heat it will ignite.
- ✓ This delay in time is called **lag on ignition**.
- ✓ At 650° the delay is 10sec, at 1000° the delay is 1 sec, at 2000° the delay is 0.1 - 0.2 sec. At 2000° it is negligible.
- ✓ Ignition temperature of CH₄ is 650° – 750°
- ✓ A mixture is said to be inflammable when it allows the flame to be self propagated, and the percentage of methane in air, which can propagate explosion, is called lower limit of inflammability.
- ✓ Below 5.4% the heat generated is not sufficient to propagate the flame.
- ✓ When the methane is above 14.8%, the oxygen present is not sufficient to produce heat required to propagate the flame.

What is the impact of coal dust on inflammability of methane air mixture?

The lower limit decreases from 5.4% to 0% as the air borne coal dust concentration (gm/m³) increases from 0 to its lower limit of inflammability i.e.40gm/m³.





Coward Diagram

Quality standard of air required as per statute

- ✓ Not less than 6 cubic m of air per person employed in the district in the largest shift or 2.5 cubic m per daily tone of output which ever is greater.
- ✓ For solid blasting at least 284 cubic meter of air per minute shall be conducted in the last ventilation connection out by of the face for deg I & deg II (first connection) & 300 cubic meter/min in case of deg III.
1000 cubic meter per min shall be circulated in L/W face of deg III mines, if blasting is done of solid.
- ✓ Not less than 19% Oxygen
- ✓ *Gaseous impurities*
 - Not more than 0.75% inflammable gas in general body of air return air or ventilation district.
 - Not more than 1.25% anywhere in the mine

Quality standard of air required as per statute (continued)

- For diesel locomotive roadways – Gas emitted from the exhaust of the locomotive should not exceed 0.2% by vol. of CO or 0.1% by vol. of oxides of nitrogen
- Threshold limit value: TLV of a toxic gas is the minimum airborne concentration of gas, below which no adverse effect or in workplace air will occur & above which injury will result from repeated exposure day after day

Noxious gases	Threshold limit value
CO ₂	0.5%
CO	50 ppm
Oxides of nitrogen	5 ppm
SO ₂	5 ppm
H ₂ S	10 ppm

Quality standard of air required as per statute (continued)

- ✓ Solid impurities –
 - 8 hours time weighted average concentration of air borne respirable dust should not exceed 3 mg/cubic meter of air sampled by Gravimetric dust sampler where respirable free silica present is equal or less than 5%.
 - For the dust containing more than 5% free silica it will be the value arrived at by dividing “15” with the percentage of free respirable silica present.

Velocity standard of air required as per statute

Measurable points	Deg. of gassiness	VELOCITY OF AIR	
		Minimum	Maximum
Last ventilation connection	I, II & III	30 m/min	
4.5 m from the face at the intake side of brattice coursing	I & II III	30 m/min 45m/min	
7.5 m out by of the discharge end of air duct	I & II III	15m/min 25m/min	
At the max span of L/W face	I & II III	60m/min 75m/min	60m/min 75m/min
Ventilation shaft (without man winding) fan drift Man-winding shaft Ventilation shaft without man winding Other roadways Conveyor road, Loading & transfer point Working face, stopping areas & L/W face			15 m/s 8 m/s 12 m/s 6 m/s 4 m/s 4 m/s

Temperature and humidity standard required as per statute—

Wet-bulb temp. should not exceed 33.5°C in any working place. Where wet bulb temp. exceeds 30.5°C, velocity of air should be 1m/sea.

According to technical committee on fatigue of mine workers, max. wet bulb temp. should be 30° C to reduce strain. Cir -3 of 1988.

Session - V

Case study of Jeetpur Colliery Explosion on 18.3.1973

- 14 Seam, Degree III gassy mine
- Rate of emission of 13.45m³/tonne of daily output
- 18th March Sunday and 19th March was Holiday (HOLI)
- Explosion took place at 8.00PM on 18th March 1973
- Due to two consecutive non working days the job of installation of shaft cable from 16 seam inset to 14 seam was taken
- Since it was a planed job permission was given by acting Manager to stop the fan for 1 ½ hour
- for transferring the cable to the special reel, two air lock doors of the pit top had to be kept open.
- Transferring of cable to the special reel took longer time than expected & the fan was kept stopped for 3 hours.

- From 10.30 AM to 1.30PM. The fan was re started at 1.30PM.
- But shut down again at 2.10PM
- In "B" shift starting from 4PM, 87 persons were engaged in routine maintenance job and 10 persons for cable laying job.
- The fan continued to remain shut down till 8.10PM (for 6 hours)
- The explosion occurred at 8.00PM
- The MMV log book showed that fan was re-started at 8.10PM
- 48 persons were killed

Violation of Rules and Regulation:

CMR 132(2): The MMV was stopped in the second instance at 2.10PM without any authority from the manager

CMR-134

- a) In the event of stoppage of MMV all persons shall be withdrawn from the working place to the nearest intake airway & at least 270m from nearest working face.

If the MMV is not re-started within a period of 1 ½ hour from the time of stoppage, all persons shall be withdrawn from the workings below ground. However officials and competent persons like pump operator/ On-setter may be permitted by the manager to remain below ground if he is satisfied that the place where persons are to work are or to pass are adequately ventilated during this stoppage & gives an order in writing.

- b) The engineer shall arrange to cut off electric current from all apparatus below ground except for such apparatus as are located in the main intake air way at a distance more than 270m from the nearest working place.

CMR-137(1) Every Auxiliary fan:

Shall be installed, located & worked in such a manner that

- i) A sufficient quantity of air shall, at all times, reach it so as to ensure that it does not re circulate air, and there is no risk of the air which is circulates being contaminated by any substantial quantity of inflammable or noxious gases or dust.

* In this case, the first provision was violated by stoppage of MMV and second by continuing the operation of auxiliary fans re-circulating the inflammable gas emitted from the headings they ventilated.

CMR 140(4) States that: "Whenever there is any interruption of ventilation by the stoppage of any mechanical ventilator, including an auxiliary fan installed belowground, the official incharge of the mine or part shall immediately take precautionary measures including withdrawal of men, if necessary, against dangers that may arise out of non-compliance with the provisions of Regulation 130 to restore the ventilation in the mine or part."


In this case, neither were the men withdrawn nor was an attempt made to enforce the standards of ventilation as provided under regulation 130.

IER-126: Provides that electricity should be cut off

- i) during the period required for examination or adjustment of the apparatus which would necessitate the exposing of any part liable to open sparking,
- ii) or if in any part of the mine, the percentage of inflammable gas in the general body of air is at any time found to exceed 1.25 % .

The disconnection and re-connection of the supply shall be noted in a log-sheet and reported to the inspector.

This was not complied with.



IER-122 (e) (ii) : Stipulates that the cable end should be efficiently sealed so as to prevent diminution of its insulating properties.

In a few cases which were inspected, the cable terminal boxes were not found to be filled with cable compound, thus violating the provisions under the above rule.

Mines Act-Section-48(4) & (5) & Mines Rules -78 (1) & (2): Four workers of the contractor who had actually gone down 14 seam were not shown as present in Form-C register.

Findings:

- ☹ The investigations carried out by DGMS indicated that the *probable cause of ignition was a spark from an electric apparatus.*
- ☹ A drill panel was lying in an open condition in the affected workings.
- ☹ The front cover of the drill panel had been opened out and kept on the ground.
- ☹ The in coming PILSDWA cable was pulled out from the terminal box & the drill panel thrown over 1m from its original location. Dead bodies of 3 electricians & a helper with severe burn injuries were found lying near the drill panel.
- ☹ The direction of travel of the flame & violence caused by the shock wave also pointed to the drill panel being the starting point of the explosion.
- ☹ Subsequent investigation on the drill panel by CMRI had confirmed that work on the drill panel was being done without cutting off the power supply.

Where and when gas should be checked in an underground mine?

- Every shift by Mining Sirdar for checking presence of Gas. **Reg.113 & 44**
- By short-firer in each blasting of solid, **before charging & firing. Regulation 173 & 175**
- Once in every 30 days for all gases by air samples and temperature readings & humidity Results shall be recorded in a bound paged book kept for the purpose. **Reg. 130**
- For deg II & III mines where electric energy is used in any ventilating district for presence of inflammable gas in general body of air once in every 7 days by an approved apparatus or air sample. At suitable points fixed by the manager, an intake side of first working place and on the return side of the last working place in the district. **Reg. 145. By Overman.**
- If determination shows that it has exceeded 0.8% determination shall be made once in every 24 hours so long it exceeds 0.8% & for next 7 days.
- If it shows less than 0.6% for 30 days then it will be sufficient to take such measurements once in 30 days so long it does not exceed 0.6%.

Where and when gas should be checked for an underground mine?

- ☞ If any alteration is made in the ventilation system which can substantially affect the ventilation of the mine, such determination shall be made within 24 hours of such alteration. Particulars of every such determination shall be recorded in a bound paged book. **Reg. 145**
- ☞ When de-watering & re-opening check for presence of gas by overman
- ☞ First inspection after a discontinuous of mining operation for a period of 7 days & after dewatering by approved safety lamp. Result shall be recorded in a bound paged book, signed & dated. Countersigned & dated by Manager. **Reg.141**
- ☞ In each shift where diesel-loco operates for presence of CO₂ & CH₄

Where and when gas should be checked for an underground mine?

- ☞ **CMR 140(4)** States that: "Whenever there is any interruption of ventilation by the stoppage of any mechanical ventilator, including an auxiliary fan installed belowground, the official in charge of the mine or part shall immediately take precautionary measures including withdrawal of men, if necessary, against dangers that may arise out of non-compliance with the provisions of Regulation 130 to restore the ventilation in the mine or part."
- ☞ In Deg II and III all unused workings not sealed off, shall once in every seven days be inspected by a competent person for presence of inflammable & noxious gas. **Reg. 143**

Spontaneous Combustion:

The process of absorbing of oxygen with consequent increase of temperature is known as Spontaneous heating.

When coal or carbonaceous material comes in contact with air, there is a chemical reaction which evolved CO_2 , CO & some heat. Heat is evolved due to exothermic reaction. This evolved heat is disposed due to air. If ventilation is not adequate to take away the heat thus formed, more oxygen will be absorbed, and more will be the rise in temperature. This process continues till it catches fire. Reaction rate is doubled for every 10°C rise in temperature.

Factors contributing to Spontaneous combustion:

- A. Coal characteristics
- B. Air flow rate
- C. Geological factor
- D. Mining practice

INCUBATION PERIOD

This is the time interval between the first fall and first sign of heating in the goaf. These two points are correlated because after first fall in goaf there will be highly crushed coal in goaf. It may depends on :

- Type of coal
- Seam thickness
- Method of work
- Method of strata control
- Regularity & continuity of working
- Liability of coal to Sp. Heating
- Crushing of pillars
- Development of cracks in pillars
- Distortion, breakage etc.
- More surface area is exposed for heating
- Leakage possibility increases
- Leakage from surface is also possible.

The above factors are responsible for start of heating & possibility of reaching the crushing point temperature.

There is no instrument for measuring the incubation period of coal. It has to be determined for each seam at each mine from practical observations.

Jharia coal field ----- 9 to 18 months

Ranigang coal field --- 3 to 12 months

Assam coal field ----- 2 to 6 months

IGNITION TEMPERATURE:

Ignition temperature is defined as the minimum temperature where from coal bed temperature starts showing up at most verticality due to high exothermicity

CROSSING POINT TEMPERATURE

- Crossing point temperature is a measure to compare different coal seam regarding their susceptibility to their heating.
- The lowest temperature at which the exothermic reaction in coal bed is self propellant under test conditions is called critical oxidation temperature or crushing temperature.
- Lower the crossing point temperature higher the susceptibility of heating

Crossing point temperature	Moisture %	Susceptibility
Less than 120°C	> 5 %	High
120°C – 140°C	2-5 %	Moderate
140°C – 160°C	< 2 %	Poor

- * The Jharia Coal field coal indicate crossing point temperature between 140°C to 160°C
- * The low moisture rank coal of Barakar measure show value between 140°C to 150°C
- * The high moisture rank coal of Ranigang coal fields show 125°C to 135°C.

Precautions to be taken against Spontaneous heating

- a. Panel system of working of suitable size. with independent ventilation
- b. No stacking of coal, shale, carbonaceous material below ground.
- c. No extraction if fire dams are not installed
- d. Isolation after completion of depillaring
- e. Storage of sufficient material for dealing with fire in readiness, at suitable places, sufficient number of trained persons.
- f. Air samples from returns of every depillaring district & district which is not sealed off for
 - i) Testing of % of CO weekly by an approved CO detector.
 - ii) Complete analysis in every 30 days to get different ratio.Recording/signing.
- g. If the value of ratio steadily increases suitable measure shall be taken to detect heating.

Precautions (Contd.)

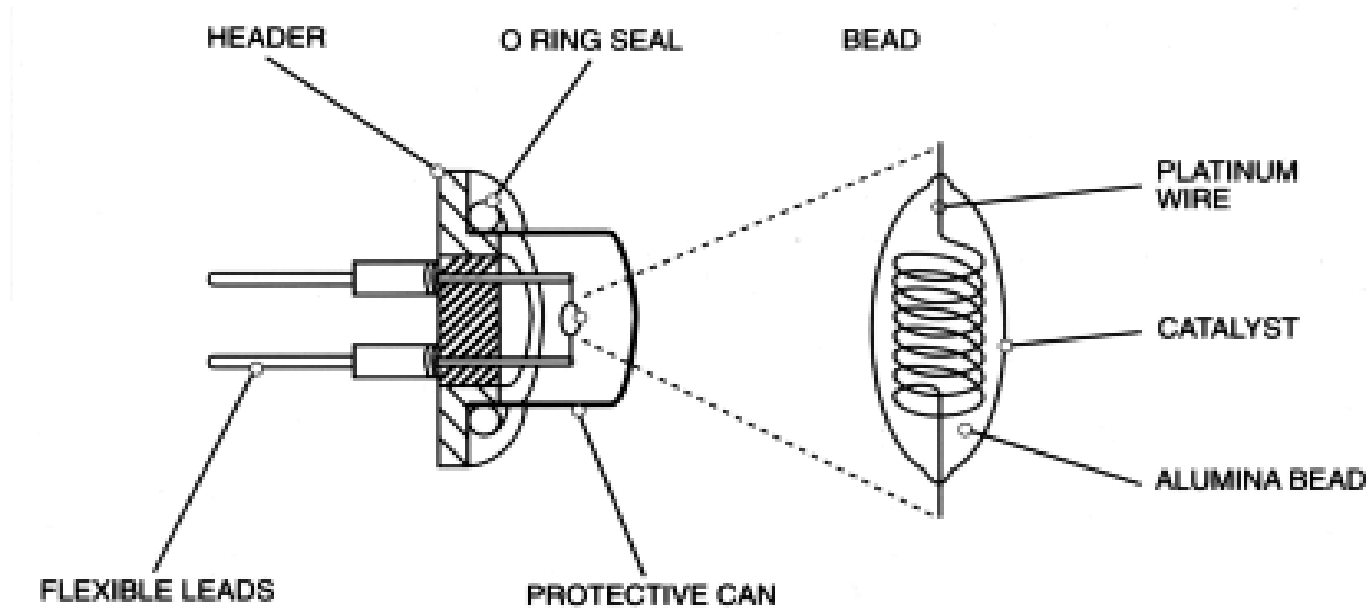
h. Idle day inspection of depillaring districts and un-used workings if not sealed of by competent person in every 7 days. Inspection of isolation stopping in the same manner.


Origin of the methanometer -

- The first electrical methanometer for use in coal mines was developed by MSA in 1949. It was known as the W8 methanometer and was powered by an Edison cap lamp battery.
- The C4 methanometer was introduced by MSA in 1966 and was later replaced by the D6 which is still the main hand held electronic methane detector used in coal mines.
- The first recording methanometer was developed by Maihak in Germany
- As a result of the work done at SMRE to develop a butane lamp methanometer, in 1961, the Sigma Recording Flame Methanometer Type 208 was introduced into underground coal mines in England to continuously chart methane levels.

Methanometer operating principles

In early methanometers sensors are used which is comprised of two filaments arranged in a Wheatstone Bridge circuit and the MSA GP Methanometer used such a sensor.

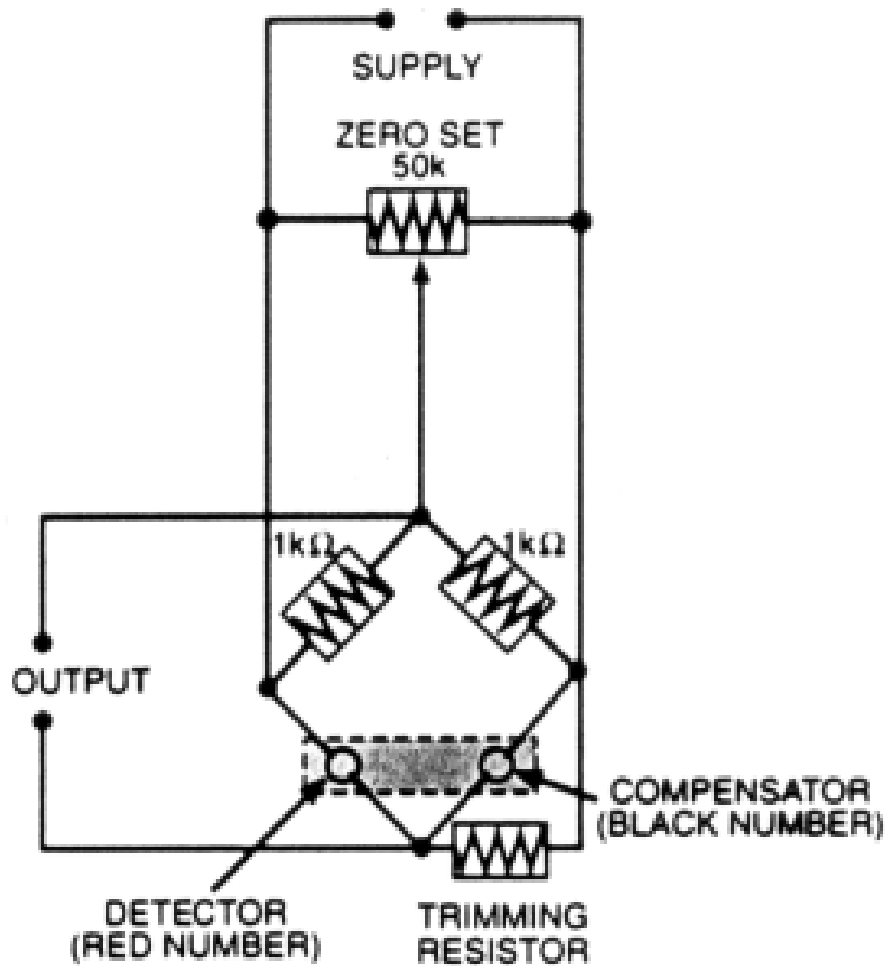




One arm of the Wheatstone Bridge consisted of an electrical filament that was heated to a high enough temperature to burn any methane in the air sample that passed over the filament (housed within a porous flame proof barrier).

The process of burning raised the temperature of the filament further which in turn increased the electrical resistance of this active filament.

This change of resistance could then be calibrated as a current change proportional to the volume of methane present



In operation, a current is passed through the coil, which heats up the bead to a high temperature. When a flammable gas molecule comes into contact with the catalyst layer, the gas "burns" in a controlled environment behind a flameproof barrier known as a sinter. Just as in a normal burning reaction, heat is released which increases the temperature of the bead. This rise in temperature causes the electrical resistance of the coil to rise & giving signal.





Methanometers manufactured since the 1980's usually have a digital display reading 0.0-4.9% methane or 0.00-4.99% methane.

Oxygen (O₂) - Oxygen is necessary for life and combustion.

- ☞ A concentration of 21% in air is ideal for man, with diminished levels having various effects depending on the degree.
- ☞ At 17%, people working will breathe a little faster and more deeply.
- ☞ A 15% level will cause dizziness, buzzing in the ears, rapid heartbeat and often headache.
- ☞ 9% causes unconsciousness and
- ☞ 6% is almost always fatal.
- ☞ A candle will be extinguished when the level falls to about 16%.
- ☞ Mine air should have an Oxygen concentration of at least 20%.

Carbon Dioxide (CO₂)

- ☞ Carbon Dioxide is an almost inert gas and is produced by the combustion or decomposition of organic matter.
- ☞ Breathing more than 5% CO₂ can cause poisoning with identical effects to Oxygen poisoning.
- ☞ Mine air should not be more than 0.5% CO₂.
- ☞ The following table shows the effects that various concentrations of CO₂ in air with a normal Oxygen level have on a person at rest (exertion worsens the effect):

% CO₂	Increase in respiration
0.5	Slight
2.0	50%
3.0	100%
5.0	300% and laborious
10.0	Unbearable

Carbon Monoxide (CO)

- ☞ It cannot be seen or smelled and is highly poisonous and explosive. Carbon Monoxide is produced when organic matter burns in a low Oxygen environment (incomplete combustion).
- ☞ It is produced in mines by diesel motors and blasting, which proper ventilation caters for, and by fires in confined areas and uncontrolled explosions, which the ventilation may not cope with.
- ☞ Carbon Monoxide is poisonous because the substance in blood that carries oxygen to the cells of the body (hemoglobin) absorbs Carbon Monoxide 300 times easier than Oxygen, with the effect that the cells of the body progressively become starved of Oxygen.

Carbon Monoxide (CO)

- The higher the concentration of Carbon Monoxide breathed, the faster the rate that Oxygen is excluded from the blood, and the fewer early symptoms of poisoning experienced.
- When hemoglobin has absorbed Oxygen or Carbon Monoxide it becomes red, but Carbon Monoxide is not absorbed by the cells and so blood vessels that normally carry dark de-oxygenated blood carry bright coloured blood, with the effect that a person suffering from Carbon Monoxide poisoning looks a very healthy colour, with pink lips, even for some time after death.

The following table shows the effects of breathing various concentrations of Carbon Monoxide (1000ppm = 0.1%):

PPM	EXPOSURE TIME	SYMPTOMS
50	long	slight
200	several hours	slight
400	2 - 3 hours	headache
1200	30 min (with exercise)	palpitations
1200	90 min	weakness in legs
1200	2 hours	confusion, headache, nausea
2000	30 min	unconsciousness

The following table shows the symptoms caused by various levels of blood saturation of Carbon Monoxide:

% SATURATION	SYMPTOMS
0 - 10	None
10 - 20	Tightness across forehead, possible headache.
20 - 30	Headache, thbbing in temples.
30 - 40	severe headache, weakness, dizziness, Dimness of vision, nausea, vomiting, Collapse
40 - 50	As for 30- 40 with increased pulse and respiration and more possibility of fainting and collapse.
50 - 60	Fainting, increased pulse and respiration, coma with intermittent convulsions.
60 - 70	Coma with intermittent convulsions, depressed heart action and respiration, possible death.
70 - 80	Weak pulse and respiration, death.

Hydrogen Sulphide (H₂S)

- ☞ Hydrogen Sulphide is one of the most poisonous gases known.
- ☞ It can be produced by blasting in sulphide ore bodies or, along with methane (CH₄), by the decay of organic matter, mainly in stagnant water.
- ☞ In low concentrations, a rotten egg smell is noticeable, but in high concentrations the sense of smell is paralysed.
- ☞ Long exposure to concentrations as low as 50 ppm (chronic poisoning) can cause inflammation of the eyes and respiratory tract and lead to bronchitis, pneumonia and oedema (swelling) of the lungs.
- ☞ Acute poisoning can occur from breathing concentrations above 600 ppm and results in serious damage to the respiratory tract and lungs within a few minutes.
- ☞ Breathing 1000 ppm will cause almost instantaneous death.

Oxides of Nitrogen (NO, NO₂, N₂O₄ = NO_x)

- ☞ Oxides of Nitrogen are produced in mines by the burning or incomplete detonation of explosives, and by diesel engines.
- ☞ They are corrosive to the respiratory tract and can result in death even the day after the casualty has apparently recovered.
- ☞ Nitrogen Dioxide (NO₂) is the most commonly encountered of the Oxides of Nitrogen, and it is also the most toxic as it combines with water in the respiratory tract to form Nitric Acid.
- ☞ Several hours after exposure, oedema of the respiratory tract occurs, which can be followed by bronchitis, pneumonia or death. Breathing 200 ppm for a few minutes can cause serious illness and breathing 700 ppm for about half an hour will be fatal.
- ☞ Nitric Oxide (NO) is rarely encountered as it readily combines with oxygen to form Nitrogen Dioxide. TLV NO₂ = 3 ppm.

Sulphur Dioxide (SO₂)

- ☞ Sulphur Dioxide is a suffocating, irritating gas that can be produced in mines by fires or blasting in sulphide ore bodies, and can be given off by explosives.
- ☞ It is very poisonous and highly irritating to the eyes and respiratory tract.
- ☞ Breathing 100 ppm will cause great discomfort and breathing 500 ppm for any length of time will be fatal. TLV 2 ppm.