LECTURE – 9

THE CONTENTS OF THIS LECTURE ARE AS FOLLOWS:

1.0 TESTING OF METHANE OR FIREDAMP
2.0 INDIAN REGULATIONS PERTAINING TO METHANE CONCENTRATION

3.0 METHODS OF DETECTING METHANE

3.1 Flame Safety Lamp
   3.1.1 Working Principle of Flame Safety Lamp
   3.1.2 Manufacturers of Flame Safety Lamp in India
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REFERENCES
1.0 TESTING OF METHANE OR FIREDAMP

2.0 INDIAN REGULATIONS PERTAINING TO METHANE CONCENTRATION

Some of the Indian laws regarding the methane concentration are:

- Methane concentration should not exceed 0.75 % in the return of a ventilation district.
- Methane concentration should not exceed 1.25% in any part of the underground mine.
- Electric supply should be cut-off from the district if the methane concentration exceeds 1.25%. Also workers should be withdrawn from the place.
- Charging, stemming or firing of shot holes is not allowed in areas where methane is found /detected.
- In gassy mines, where electricity is used, detection/testing of methane is carried on the intake side of the first working face and on the return side of the last working face in a district as per the following rule:

<table>
<thead>
<tr>
<th>Concentration of methane</th>
<th>Testing to be carried out</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 0.6%</td>
<td>Every 30 days</td>
</tr>
<tr>
<td>0.6% - 0.8%</td>
<td>Every week</td>
</tr>
<tr>
<td>&gt;0.8%</td>
<td>Every day</td>
</tr>
</tbody>
</table>

3.0 METHODS OF DETECTING METHANE

Methane in mine air can be detected either by using chemical analysis in laboratory or by using flame safety lamp and special instruments called methanometers. Using safety lamp or methanometers, methane can be detected on the spot in underground. Let us discuss flame safety lamp and methanometers in detail.
3.1 Flame Safety Lamp

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

- Introduction of glass cylinder around the flame
- Addition of internal chimney
- Two gauzes instead of one
- Safety locks, arrangement for relighting, controlled air-feeding arrangement

Let us first discuss about the general construction of the flame safety lamp.

The flame safety lamp can be divided into three main sections – lower, middle and upper sections. There are various components in all the three sections. Table 1 lists the different components found in different section along with their functional details.

### Table 1 Components of flame safety lamp in different sections along with their functional details

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Section</th>
<th>Name of the components</th>
<th>Functions /details</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Lower</td>
<td>Fuel vessel, burner, wick assembly, a screw, locking arrangement, and re-lighting device(if available)</td>
<td>Locking arrangement is generally of magnetic type. It can be opened only in the lamp room. Thus, once it is locked, it cannot be opened in the underground.</td>
</tr>
<tr>
<td>2</td>
<td>Middle</td>
<td>Two sets of rings interconnected by five steel rods, glass (may be one or two set-inner and outer) around the flame, chimney, two asbestos washer</td>
<td>Ring and rod combination serves to protect the glass. Rings have holes to allow air in/out. Chimney is introduced to increase the illumination produced. Asbestos washer is used to make the assembly air tight.</td>
</tr>
<tr>
<td>3</td>
<td>Upper</td>
<td>A bonet, two steel wire gauzes(of 20 or 28 mesh</td>
<td>It is the wire gauze which is responsible for the working of flame</td>
</tr>
</tbody>
</table>
size), handle / hook safety lamp and not allowing the ignition of methane, even if present in the general body of air. Handle serves the purpose of holding the lamp while detecting methane.

Table 1 gives only a brief idea about the construction of the flame safety lamp. The details of different components in various sections are indicated clearly in Fig. 1.

### 3.1.1 Working principle of flame safety lamp

It is very interesting to know that wire gauze does not let methane to ignite even if there is methane in the general body of air. The ignition of methane remains limited only to the interior of the lamp. For a lay man it would be like a magic. To understand the working principle of the flame safety lamp, let us look at the Fig. 2(a) and (b).

Fig. 2(a) shows a Bunsen burner and wire gauze. The distance between the wire gauze and the mouth of the Bunsen burner is kept to be around 30 mm. The gas is turned on and then by using match box or suitable device it is ignited below the gauze. It is observed that the flame of the burning gas is restricted below the gauze only and is not able to cross the gauze wire until the gauze wire is red hot. Once the wire is red hot, the flame can be seen above as well as below the gauze wire.

Fig. 2(b) shows the same arrangement, but flame of the gas is observed above the gauze wire. This is because the gas was ignited above the gauze wire. Here also, the flame appears below as well as above the gauze wire only after the gauze wire is red hot.

It is interesting to know that, if gauze wire is lowered to the mouth of the Bunsen burner [in Fig. 2(a)] or moved upward [in Fig. 2(b)], the flame gets extinguished, even if gas supply is turned on. However, this is possible only when it is done before the gauze wire becomes red hot.
Fig. 2(a) and Fig. 2(b) show that the gauze wire does not allow flame to pass through it until it becomes red–hot. The reason behind such behavior of the gauze wire is described below.

Fig. 1 Various components of flame safety lamp (after Deshmukh, 2008)
Gauze wire is made up of metals like copper or iron. It may be made up of steel also. These metals allow the gas to pass through it. But, they are very good conductor of heat also. They conduct heat so quickly that the temperature above the gauze wire is below the ignition temperature of the gas {Fig. 2(a)}. But, once the wire becomes red hot, it is not able to conduct the heat, and the temperature
above it crosses the ignition temperature of the gas. Thus, gas gets ignited and flame appears on both the sides of the gauze wire.

A dismantled flame safety lamp is assembled by bringing the upper section and the middle section together. This assembly is then screwed onto the lower section and it gets magnetically locked. Like wire gauze, even locking arrangement in a flame safety lamp is one of the important safety device. A properly assembled safety lamp will not produce any sound due to loose components, if it is shaken by hand. The locking arrangement consists of a spring loaded steel bolt housed in a tubular body which is fitted and soldered with the bottom flange of the middle section. The magnetic lock bolt passes through the collar into the notches on the oil vessel. When the middle and top sections are fitted on the oil vessel by screwing, the lock bolt prevents their unscrewing by the ratchet construction at the top end of the oil vessel. When we want to unlock, the top of magnetic locking device is placed below the pole of magnet unlocker in the lamp cabin. The lock bolt is pulled by the magnet and the base of the lamp can then be unscrewed. The magnetic locking arrangement is so designed that ordinary magnet cannot unlock the lamp. Fig. 3 (a), (b) and (c) clearly show the lock bolt, ratchet arrangement at the top end of the oil vessel and magnetic unlocking respectively.

![Fig. 3(a) Lock bolt in a Flame safety Lamp](image-url)
3.1.2 Manufacturers of flame safety lamp in India

- Mine Safety Appliances Ltd.
- J. K. Dey and Sons (trade name: Velox)
The company J. K. Dey and Sons manufactures three different types of safety lamps. The comparative details of the three different types are given in Table 2.

**Table 2 Details of various types of flame safety lamps**

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Name Parameter</th>
<th>GL-5</th>
<th>GL-50</th>
<th>GL-60</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Application</td>
<td>Accumulation test*</td>
<td>Percentage test*</td>
<td>Percentage test*</td>
</tr>
<tr>
<td>2.</td>
<td>Constructional difference</td>
<td>Two cylindrical glasses are provided</td>
<td>Single glass provided</td>
<td>- Single glass provided - Has self-contained relighting mechanism</td>
</tr>
<tr>
<td>3.</td>
<td>Feed of air</td>
<td>Mid-feed arrangement (shown in Fig. 4)</td>
<td>Top-feed arrangement (shown in Fig. 1)</td>
<td>Top feed arrangement as well as additional bottom feed arrangement</td>
</tr>
<tr>
<td>4.</td>
<td>Fuel used</td>
<td>Colorless kerosene oil</td>
<td>Solvent spirit (SBP 55/110 or ESSO solvent no. 1425) or motor spirit (petrol)</td>
<td>Solvent spirit (SBP 55/110 or ESSO solvent no. 1425) or motor spirit (petrol)</td>
</tr>
<tr>
<td>5.</td>
<td>Weight (with full fuel)</td>
<td>N. A.</td>
<td>1.6 kg</td>
<td>1.7 kg</td>
</tr>
<tr>
<td>6.</td>
<td>Permitted (as per DGMS)</td>
<td>Degree – I</td>
<td>Deg. I and Deg. II</td>
<td>All types of gassy mines</td>
</tr>
</tbody>
</table>

* Details to be discussed in Lecture – 10

**3.1.3 Approval by DGMS**

To get approved by DGMS, a flame safety lamp has to pass through several tests. Also, the safety lamp has to conform to ISI specifications No. IS 7577 or 1975. Some of the tests are:-
a. **Drop test** :- The lamp has to be dropped for 5 times from a height of 1 m (measured from the bottom of lamp to a wooden board) on to a hard wooden board. The board should be 30 mm thick and should be laid on concrete. The test is passed by lamp only if no damage to any component of the lamp is observed.

![Diagram of a flame safety lamp](image)

**Fig. 4 Mid-feed flame safety lamp (after Deshmukh, 2008)**

b. **Test for air tightness** :- After assembling the different sections of the lamp, it is lit and held before a compressed air jet of velocity not less than 6 m/s. The test is said to be passed if flame is not extinguished. Further, no undue flickering should be observed.

c. **Performance test** :- This is decided on the basis of length of the flame produced as well as the condition. By condition of flame, it is meant for intensity, colour and its sensitivity to a slight change in the concentration of the methane. Table 3 lists the length of flame and condition of flame for the
lamp to pass through this test at different concentrations of methane in the air.

**Table 3 Performance test on flame safety lamp**

<table>
<thead>
<tr>
<th>Gas %</th>
<th>Minimum length of blue flame (mm)</th>
<th>Condition of blue flame</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>-</td>
<td>Near the top of the standard flame a slight cobalt-blue lined orange-yellow flame is seen</td>
</tr>
<tr>
<td>1.0</td>
<td>7.0</td>
<td>Blue flame is not observed because the flame color is light and hence it is difficult to measure the length</td>
</tr>
<tr>
<td>1.5</td>
<td>8.0</td>
<td>Lower part of flame turns blue</td>
</tr>
<tr>
<td>2.0</td>
<td>9.0</td>
<td>Blue flame is distinctly visible except at the top</td>
</tr>
<tr>
<td>2.5</td>
<td>10.0</td>
<td>Blue color becomes more visible, but still top is invisible</td>
</tr>
<tr>
<td>3.0</td>
<td>11.5</td>
<td>Top of flame is still invisible and blue flame is seen clearer</td>
</tr>
<tr>
<td>3.5</td>
<td>14.5</td>
<td>Blue flame is clearly visible</td>
</tr>
<tr>
<td>4.0</td>
<td>20.0</td>
<td>Blue flame is extremely clear, highly sensitive to slight change in methane concentration</td>
</tr>
</tbody>
</table>

Please have a look at Fig. 5 for better understanding of Table 3

Some of the more specifications are:-

i. Rivet locking arrangement shall not be of lead type
ii. Thickness of glass cylinder shall be 4-5 mm
iii. Total heat radiation area of the gauze should not be less than 155 cm²
Fig. 5 Variation in shape and height of gas cap with methane percentage (after Karmakar, 2001)

REFERENCES


