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MINING ENGINEERING

LAB MANUAL

MINE VENTILATION LAB
(DIPLOMA)
SEMESTER V

LIST OF EXPERIMENTS

EXPERIMENT NO. 01

AIM: Demonstration of CO-detectors and measurement of carbon monoxide using CO-detector.

APPRATUS:

1. CO-detectors viz. P.S. Detector, Hopcalite Detector.
2. Carbon monoxide testing kits.
3. Substances that emit low levels of CO.

THEORY:

A carbon monoxide detector or **CO-detector** is a device that detects the presence of the carbon monoxide (CO) gas in order to prevent carbon monoxide poisoning. CO is a colorless, tasteless and odorless compound produced by incomplete combustion of carbon containing materials. It is often referred to as the "silent killer" because it is virtually undetectable without using detection technology.
CO detectors are designed to measure CO levels over time and sound an alarm before dangerous levels of CO accumulate in an environment, giving people adequate warning to safely ventilate the area or evacuate. Some system-connected detectors also alert a monitoring service that can dispatch emergency services if necessary.

CO detectors can be placed near the ceiling or near the floor because CO is very close to the same density as air. The detector consists of a pad of a colored chemical which changes color upon reaction with carbon monoxide.

PROCEDURE:

1. Each group will select one kind of CO-detector.
2. Install each of them correctly according instructions.
3. Test each CO-detector for its proper functioning.
4. Test digital Readout CO-detectors with a low level CO Source.
5. Use a CO-detector test-kit for better understanding.

A Typical CO-detector (Drager made);

EXPERIMENT NO. 02

AIM: Demonstration of MSA Methanometer and measurement of Methane using Methanometer.

APPRATUS:

1. MSA D-6 Methanometer.
2. Source that emits low amount of Methane (Aspirator Bulb).

THEORY:

A Methanometer is an instrument used to measure methane gas in the air of a mine. The Mine Safety Appliances Company Ltd. manufactured the first type - W8 Methanometer around 1950 and it was approved for use by the Ventilation Regulations. A catalytic-type Methanometer uses an array of four heated wire filament elements, two active filaments are coated with a catalyst, arranged in a Wheatstone bridge with two inactive elements that have no coating. When exposed to methane-contaminated air, the coated filaments heat up due to oxidation of the methane, and the resulting imbalance in the resistance of active and inactive elements can be displayed on a calibrated meter.

As stated earlier, this apparatus utilizes the principle of Wheatstone bridge. It is well known that the resistance of a wire will increase on heating by combustion of methane. Thus a balanced wheat stone bridge circuit becomes unbalanced and therefore it starts passing current through the galvanometer. The amount of current flow is calibrated against percentage of methane present in air.

PROCEDURE:

1. Each group will select one kind of MSA Methanometer.
2. Install each of them correctly according instructions.
3. Test each Methanometer for its proper functioning.

4. Check the voltage of the battery by pressing the voltage check button. The pointer should lie in the red zone indicating a voltage of 2.2 to 2.8 Volts.
5. Draw mine air sample by squeezing the aspirator bulb. Around 2 to 3 squeezes are enough.
6. Press the methane check button for 10–15 seconds. The pointer swings with a jerk and comes back to a steady position momentarily indicating the methane percentage.

A Typical MSA Methanometer:

EXPERIMENT: 03

AIM: Dismantling and assembling of different types of Flame Safety Lamp.

APPRATUS:

1. Flame Safety Lamp (Volex type).
2. Magnetic unlocking arrangement.

THEORY:

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 lose 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.

PROCEDURE:

1. Each group will select one kind of Flame Safety Lamp.
2. Install each of them correctly according instructions.
3. For dismantling purpose first unlock the magnetic lock by a proper unlocking arrangement. The lock bolt is pulled by the magnet and the base of the lamp can then be unscrewed.
4. Once dismantled, bring the upper section and middle section together. This assembly is then screwed onto the lower section and it gets magnetically locked.

A Typically dismantled Flame Safety Lamp:

EXPERIMENT: 04

AIM: Detection of Methane using Flame Safety Lamp.

APPRATUS:

1. Flame Safety Lamp (Volex type).
2. Source of Methane gas (Aspirator Bulb)

THEORY:

Methane in mine air can be detected either by using chemical analysis in laboratory or by using flame safety lamp and special instruments called Methanometer. Using safety lamp or Methanometer, methane can be detected on the spot in underground.

TESTING PROCEDURE OF METHANE:

Test for methane is usually done in two stages. The two stages are:

1. Accumulation test
2. Percentage test

Accumulation test: It is carried out with a luminous flame of standard height. This test gives a better indication of methane. This is because luminous-flame test produces more heat inside the lamp which causes better lamp ventilation resulting in a larger quantity of methane being drawn inside the lamp. Also for carrying out accumulation test it is not necessary to create a dark surrounding. The test carried out indicates that the flame spires/jump, if the percentage of methane in the air is 3% or more. It is because of this reason that we have to raise the lamp to the roof very slowly/cautiously so that we can see the behavior of flame as well. If the flame spires/jumps, it indicates that the methane content in the air is more than 3% and percentage test is not necessary in this case.

Percentage test: This test is also called cap test. The surrounding is made dark, before carrying out this test. This test is carried out with a reduced flame. The flame can be reduced with the help of the regulating knob. The flame should be reduced to an extent such that there appears a continuous blue line just above a speck (a very small mark or shape) of white/yellow light. The lamp is raised slowly to the roof and the percentage of methane is indicated by the height of the cap produced.

PROCEDURE:

1. Each group will select one kind of Flame Safety Lamp.
2. Install each of them correctly according instructions.
3. For Accumulation test, a luminous flame of standard height is required. Therefore each group will go for a luminous flame of standard height.
4. For Percentage test, the surrounding is made dark and a reduced flame (blue line appears) is prepared. The height of cap is the sign of percentage of methane in that particular environment.

EXPERIMENT: 05

AIM: Demonstration of whirling hygrometer and determination of relative humidity using whirling hygrometer.

APPRATUS:

1. Whirling Hygrometer

THEORY:

The whirling hygrometer or sling psychrometer consists of two thermometers mounted on a frame that can be whirled in the air by hand. The bulb of one thermometer is covered with a tight-fitting muslin sack and wetted with water. This thermometer is known as the wet-bulb thermometer. The other is the dry-bulb thermometer. The psychrometer is whirled to force air past the bulbs. The dry bulb indicates the temperature of the air. The wet bulb helps determine the relative humidity.

When the sling psychrometer whirls through the air, water from the muslin evaporates. The evaporating water cools the wet bulb. The amount of cooling that occurs depends on the relative humidity. The lower the humidity, the faster the water in the muslin will evaporate, and the more the bulb will cool. High humidity will cause less evaporation, slowing the cooling process.

In air that has less than 100 per cent relative humidity, the wet bulb will record a lower temperature than the dry bulb. This difference in temperature is known as wet-bulb depression. A special chart is used to convert the wet-bulb depression to relative humidity or the relative humidity can be determined by correlating the readings with those on a simple slide rule, which is supplied with each instrument.

Relative humidity (H) is the ratio of the vapor pressure (e) of the moist air to its saturation vapor pressure (e_s) at its temperature, which is expressed in %.

$H = (e/e_s) \times 100$ %

PROCEDURE:

1. While calculating relative humidity using whirling hygrometer first of all saturated vapor pressure (e_w), as a function of (t_w) and then calculate the ratio of vapor pressure (e) to (e_w).
2. If the vapor pressure is determined to be a minus value, consider the relative humidity to be zero.
3. Using the saturation vapor pressure table e_w corresponding to t_w is taken. Similarly e is taken corresponding to t.
4. Thus the relative humidity is calculate as follows:

$$H = (e/e_w) \times 100$$

A typical whirling hygrometer:

EXPERIMENT: 06

AIM: Demonstration of kata-thermometer and determination of cooling power by kata-thermometer.

APPRATUS:

1. Kata-thermometer.
2. Muslin cloth.

THEORY:

Kata thermometer is a device consisting principally of an alcohol thermometer, used to measure air cooling power and, indirectly, small wind speeds in circulating air, by measuring the time taken for the temperature of the bulb of alcohol to make a specified drop (311K-308K).

It may be used dry or weight. For wet Kata cooling power reading the bulb is first placed in hot water so that the liquid rises and partly fills the upper section. It is then exposed to the air. The bulb is surrounded by a wet muslin cloth and time in seconds taken for the liquid to fall from 311K to 308K is observed. The wet cooling power is then found by dividing the factor marked by the no. of seconds observed.

The dry Kata reading gives only cooling due to radiation and conduction while the wet Kata reading the effect of evaporation and is thus more useful guide as the cooling power in reference to the human body.

PROCEDURE:

1. The larger bulb or reservoir is dipped in hot water until the thermometric fluid rises and fills up the smaller bulb at the top of the stem.
2. The bulb of the kata thermometer is taken out of the hot water and wiped with cotton to remove any water drops/ layer on the bulb surface.
3. Using a stopwatch, the time by kata thermometer in cooling from 311K to 308K is recorded.
4. For obtaining rate of heat loss from the surface of kata thermometer, Kata factor (written on it, provided by the manufacturers) is divided by time taken for cooling from 311K to 308K.

CALCULATION:

Relation between wet kata cooling power, velocity of air current and wet bulb temperature:

$$K = (14.65 + 35.59V^{0.5})(309.65 - T_W) \quad \text{[For V<1m/s]}$$
$$K = (4.19 + 46.05V^{0.5})(309.65 - T_W) \quad \text{[For V>1m/s]}$$

Where,

K= kata cooling power (W/m^2)
V= velocity of mine air (m/s)
T_W= wet bulb temperature (K)

A typical Kata thermometer:

EXPERIMENT: 07

AIM: Demonstration of various ventilation devices.

APPRATUS:

1. Various ventilation devices.

THEORY:

Ventilation is the control of air movement, its amount, and direction. Although it contributes nothing directly to the production phase of an operation, the lack of proper ventilation often will cause lower worker efficiency and decreased productivity, increased accident rates, and absenteeism.

To ensure adequate ventilation of a mine, provision is made for suitable paths (airways or air courses) for the air to flow down the mine to the working places and suitable routes out of the mine when it has become unsuitable for further use.

Air always flows along the path of least resistance, but this may not be where it is required for use. To direct the air where it is needed, ventilation devices are necessary; the primary means of producing and controlling the airflow for the entire system are mine fans (either in the form of single fan installation or multiple fans). In addition, many other ventilation devices also are necessary for effective underground air distribution. Some of the prior ventilation devices are:

Regulators:

Flow to different areas of the mine is regulated by constructing artificial restrictions in airways in the form of a stopping or doors with an opening usually of an adjustable size (by the use of adjustable louvers, sliding doors, etc), such restrictions being known as regulators.

Air locks:

When access doors between intake and return airways are necessary and their pressure differential is high, man-doors generally are built as a set of two or more to form an air-lock. This prevents short-circuiting when one door is opened for passage of vehicles or personnel. The distance between doors should be capable of accommodating the longest train of vehicles required to pass through the air-lock.

EXPERIMENT: 08

AIM: Demonstration of vane anemometer and determination of quantity by anemometer.

APPRATUS:

1. Vane anemometer.

THEORY:

An anemometer is a device used for measuring wind speed, and is a common weather station instrument. A vane anemometer combines a propeller and a tail on the same axis to obtain accurate and precise wind speed and direction measurements from the same instrument. The speed of the fan is measured by a rev counter and converted to a wind speed by an electronic chip. Hence, volumetric flow rate may be calculated if the cross-sectional area is known. It has good accuracy when used correctly.

PROCEDURE:

1. Review the instruments to be used.
2. Select the stations.
3. Measure station cross-sections and separation distances.
4. Take velocity measurements at the ventilation stations.
5. Determine airflow through room-and-pillar area of the mine

CALCULATION:

Using the data from this lab the quantity of air movement at each station can be found.

$$\text{Quantity} = \text{Velocity} \times \text{Area}$$

$$Q = VA$$

A Typical vane anemometer:

DIGITAL TYPE:

EXPERIMENT: 09

AIM: Demonstration of Velometer and measurement of air velocity by velometer.

APPRATUS:

1. Velometer.

THEORY:

The Velometer is a direct reading instrument for measuring air velocities. It is designed to measure velocities inside heating and ventilating ducts, or in open areas such as at fume hoods, diffusers, slots on ventilated plating tanks, and so forth. It may also be used for measuring duct static pressures. The Velometer set consists of the meter, velocity and static pressure Range Selectors, measuring probes and connecting hoses.

To calculate the air volume passing through a duct, measure the average velocity inside the duct, determine the cross-sectional area of the duct, and apply the following equation:

$$Q = A \times V$$

Where:

Q = Volume flow rate.
A = Cross-section area.
V = Average duct-velocity.

The velocity of an air stream in a duct is not uniform throughout the cross-section; air near the walls moves more slowly due to friction. Transitions and obstructions also cause variations in the velocity at any one cross-section. To obtain the average velocity in ducts of 4" diameter or larger, drill a 1/2" diameter or larger hold in the duct and take a series of duct velocity readings (commonly referred to as a traverse) with the Pitot Probe at points of equal area across the duct. A formal pattern of sensing points is recommended and these points are referred to as traverse point readings. Shown are recommended velocity reading point locations for traversing round and square (or rectangular) ducts.

PROCEDURE:

1. Review the instruments to be used.
2. Place the meter where you wish to measure the air flow. If you are holding it, keep it at arm's length and stand so you do not obstruct the flow of air past the meter.
3. Hold the meter so that the arrow on the probe points in the direction of air flow; if the direction is not known, turn the meter until you observe the maximum pointer deflection.
4. Read the air velocity on the 0 to 300 FPM scale.

A Typical Velometer: