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Advanced Ventilation Systems and Equipments Associated With UCIL, Tummalapalle Uranium Project, Andhrapradesh

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Abstract: A mine ventilation system consists of interconnected airways, work places and ventilation control devices. Mine ventilation is a critical aspect of all underground mines. Mining technological and mining environment challenges are necessitating new approaches. An overview will be given of some new developments in the atmospheric monitoring and development of new simulation approaches. In every underground mine should have good and better ventilation system. The main purpose of ventilation system is to dilute the dangerous gases. And also provide fresh air to the mine workings. In this project we have did that how ventilation is flowing from higher pressure area to the low pressure areas. The different instruments are used in mine to calculate the percentage of several gases. And also proper plan requires for effective control of ventilation.

Keywords: ventilation,underground mines,gases.

1. Introduction Of UCIL:

Uranium Corporation of India Limited was incorporated on 4th October 1967ion of India Limited is a Public Sector Enterprise under the Department of Atomic Energy. UCIL is at the forefront of the Nuclear Power cycle. Fulfilling the requirement of Uranium for the Pressurized Heavy Water Reactors, UCIL plays a very significant role in India's nuclear power generation program. UCIL is an ISO 9001:2008, 14001:2004 & IS 18001:2007 Company and has adopted the latest state of the art technology for its mines and process plant. It had an annual turnover of about Rs 304 Crores in the financial year 2007-08. The Company is having its mining operations at Bagjata, Jaduguda, Bhatin, Narwapahar, Turamudih underground mines and Banduhurang opencast mines and upcoming mining projects at Mohuldih in East Singhbhum district of Jharkhand and at Tummallapalli mining project in Andhra Pradesh and Gogi mining project at Karnataka. It has two processing plants at Jaduguda and Turamdih and an milling project at Thummalapalle in Andra Pradesh. KPM opencast mining and milling project at Meghalaya is in the pipeline.

In Andhra Pradesh the lambapur-peddagattu project in Nalgonda district has environmental clearance for open cut and three small under ground mines but faces local opposition. In august 2007 the government approved a new US$ 270 million under ground mine and mill at thummala palli near pulivendula in YSR kadapa district, for commission in 2010.

1. URANIUM RESOURCES:

In India the uranium reserves are occurred in the following states—

Table 1.3 India's uranium mines and mills – existing and announced

STATE/DISTRICT	MINE	MILL	OPERATING From
Jharkhand	Jaduguda	Jaduguda	1967 (mine) 1968 (mill)
	Bhatin	Jaduguda	1967
	Narwapahar	Jaduguda	1995
	Bagjata	Jaduguda	2008
	Turamdih	Turamdih	2003 (mine) 2008 (mill)
	Banduhurang	Turamdih	2007
	Mohuidih	Turamdih	2011
Meghalaya	Kylleng-pyndengsohiong Mawthabah	Mawthabah	2012
Andra Pradesh, Nalgonda	Lambapur-peddagattu	Seripally	2102
Andra Pradesh, YSR Kadapa	Thummala palli	Thummala palli	2010

1.1About Thummalapalli Uranium Mine:

The Tummalapalle Mine is a uranium mine in Thummala palli village located in Kadapa of the Indian state of Andhra Pradesh. Results from a research conducted by the Atomic Energy Commission of India in 2011 made the analysts conclude that this mine might have one of the largest reserves of uranium in the world.

On July 19, 2011, Secretary of Department of Atomic Energy, Dr. S. Banerjee who is also the Chairman of the Atomic Energy Commission of India confirmed on reserves of 49,000 tonnes and suggested that they could be even three times larger which would make Tummalapalli the mine with the world's largest uranium deposits.

On Aug 23, 2007 The Cabinet Committee on Economic Affairs (CCEA) of Government of India cleared the setting up of a uranium mine and processing plant by the Uranium Corporation of India with an estimated cost of 1,106 crore .After that the Uranium Corporation of India acquired 1,122 acres (454 ha) of government land at 50,000 per 1 acre (0.40 ha) and 1,118 acres (452 ha) of private land at a price of 180,000 for 1 acre (0.40 ha) of wet land and 120,000 for dry land in Tummalapalle, Rachakunta palli, KK Kottaland, and Mabbuchintala palli villages in Pulivendula constituency.

On November 20, 2007 the then Chief Minister Dr. Y. S. Rajasekhara Reddy (late) laid the foundation stone for the mine. UCIL commissions Kadapa Uranium expected Phase-1 Project with 3000 tonnes on 20 April 2012.

1.2 DETAILS OF THUMMALA PALLI URANIUM MINE PROJECT:

Name of the mine	:	Thummala palli uranium mine
Owner	:	Uranium Corporation of India limited

Project location	:	Thummala palli (V), Near pulivendula (M), YSR kadapa (DT). Andra Pradesh state
Nearest town	:	pulivendula
Nearest railway station	:	Muddanuru
Nearest airport	:	Bangalore
Distance from Hyderabad	:	432 KM
Distance from Bangalore	:	252 KM
Distance from Chennai	:	368 KM

2. Ventilation In UCIL

It is proposed that mine will be ventilated through **4 Nos**. mechanical ventilator fans at exhaust end. It is proposed to allow fresh air to enter through declines. The fresh air will reach to farthest part of the active mine workings and pass through active man always to exhaust through ventilation drive.

It is estimated that maximum number of persons employed in a largest shift will be around 500 and therefore the **quantity of air requirement will be 5000 m^3/min.**however keeping in view the number of diesel operated equipment working and their combined hp, the estimation of fresh air requirement for respective mine has been made (0.075 m^3/sec per KW of cumulative hp). This will enable dissipiration of not only the noxious fumes of diesel equipment but also dilute radon content of air to acceptable limit, as per the prevalent practice at existing underground mines of UCIL. Wherever required, the auxiliary ventilation is provided.

As the mining is carried out by declines, drives and Brest stoping, it is estimated that at a time **25 faces will be working**. Assuming all the headings required the forced ventilation, a total of 25 fans with suitable ducting will be required. The ventilation surveys are conducted once every month by competent person and enter the details on each and every ventilation board with sign of the competent person.

Ventilation board

V.S Name :
'X' sec. Area :
Velocity :
Quantity :
Direction :
Temperature :
Relative Humidity :
Dt. Of survey
Signature :

2.1VENTILATION STANDARDS:

2.1.1 INDIAN STANDARDS

The Indian Coal Mining Regulations (CMR-1957) [16], regulation no. 130 (2) requires that:

- In every ventilating district no less than six cubic meters per minute of air per person employed in the district on the largest shift, or no less than 2.5 cubic meters per minute of air per minute of air per daily tonne output, whichever is larger passes along the last ventilation connection in the district.
- At every place in the mine where persons are required to work or pass, the air does not contain less than 19% oxygen, and or more than 0.5% CO_2 or any noxious gas in the quantity likely to affect the health of any person.
- The percentage of inflammable gas does not exceed 0.75 in the general body of the return air of any ventilating district, and 1.25 in any place of the mine.
- The wet bulb temperature in any working place does not exceed 33.5^{0}C, and where the wet bulb temperature exceeds 30.5^{0}C, arrangements are made to ventilate the same with a current of air moving at a speed of not less than one meter per second.
- Indian mining laws sub regulation 133(4) of the CMR requires that ventilation surveys be conducted in 1st degree-I gassy mines at least once every 30 days while air quantity surveys in degree-II & degree-III gassy mines are required to be conducted at least once every 14 days.
- Sub regulation 130(2) (v) requires that concentration of noxious and inflammable gases and temperature and humidity to be determined at the working places in mines at least once in 30 days.
- Under sub regulation 145(2), the Regional Inspector of mines may require the mine management to take measurements of temperature, humidity and other environmental conditions as may be specified once at least in every 30 days.

- A ventilation pressure survey is required to be done under sub regulation 132(1) of CMR 1957 be fore installation of a booster fan in a fiery seam or gassy seam of the second or third degree gassiness.

Table(4.1.2 II) Quantity of air for degree I, II and III gassiness mines.

Gassiness degree (coal mines)	QTY per person in U/G mine	Per tonne of daily output
I	$7m^3$	$3m^3$
II & III	$8\text{-}10m^3$	$4\text{-}5m^3$

In metal mines which are not deep like up to 300m, the quantity of air should go down the intake shaft/ incline should be $4\text{-}5m^3$ per min. for every worker in the underground mine.

2.1.2 TYPES OF VENTILATION SYSTEMS

Depending on the relative position of intake and return airways, ventilation systems in mines can be broadly divided into the following:

2.1.3Boundary or Unidirectional Ventilation System

The boundary ventilation system where the air flows unidirectional from the intake to the return through the workings is by far the most efficient system necessiting the least use of ventilation control devices and thus resulting in a high volumetric efficiency of ventilation (70-80%). It is commonly adopted in metal mines working steep lodes. In the simplest form, the intake and return shafts are located at the two strike boundaries of the mine.

2.1.4 Central or Bidirectional Ventilation System

This system is commonly adopted in in-the seam coal mines where both the intake and return shafts are located close by the centre of the property. Intake and return air from any district travel in opposite direction through parallel roadways usually separated by stoppings erected in the cross-connections between them.

2.1.5 Combined Ventilation System

Here in these type of ventilation system the ventilation of development headings is bidirectional in nature while the ventilation of the extraction panels is unidirectional through goaf connected to the return airways called bleeders.

2.1.6 Homotropal ventilation system :

In particularly dusty mines, the amount of dust in the mine atmosphere can be reduced by directing the air to flow in the same direction that the coal is being transported along the longwall face.
This system is known as homotropal ventilation.
The advantages of this system are:

- The intake air at the face is cleaner
- Reduced dust exposure for workers at the face
- The pantechnicon and the belt conveyor are in seperate gate roads which permits more room in the gate roads. This can also allow narrow the width of gate roads to be driven and reduce the amount of roof support required

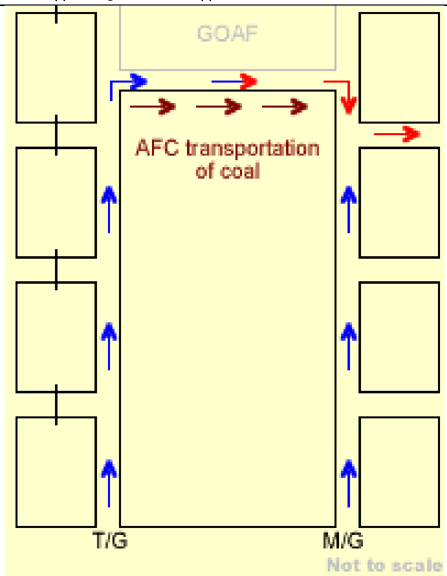

Figure 5.4 Homotropal Ventilation

2.1.7 Antitropal ventilationsystem :

The opposite of homotropal ventilation is called antitropal ventilation, in this system the coal is transported along the longwall face in the opposite direction to which the air is travelling.

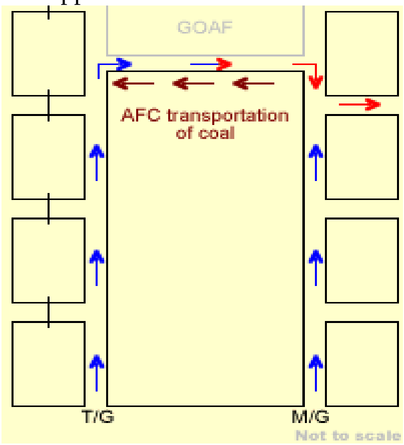

Figure 5.5 Antitropal Ventilation

2.1.8 Exhausting System

With the exhaust system, the quantity of air available at the face may be sufficient, but unless the duct or tubing is maintained close to the face the velocity may be inadequate to sweep the air across the face. Dust concentration is greatly reduced. Dust and gases are drawn into the duct and discharge into the return air course.

3. Blowing or forcing system

With a blowing system intake air at high velocity can be directed against the face through a duct. It therefore cannot pick up moisture or dust on its journey to the face and it arrives in a clean dry condition. The method is therefore particularly suitable for wet headings where the rock temperature is high.

3.1 Combined Exhaust and Blower system

Using a blower in conjunction with exhaust system provide the advantage of both systems. The system is most suitable for continuous miner faces. The principal advantage of this system is that both the fans be operating to be truly effective.

4. Mine Resistances

Roadways cause resistance to air movement. The resistance relies on upon the extent of the roadways, perimeter and roughness of the surface in touch with air and also obstruction offered by movement of men and material and supports. The resistance is numerically represented as below

$$R = \frac{(K \times p \times L)}{A^3} \qquad \text{S.I. unit (Gaul)} \ (Ns^2/m^8)$$

Where,

A- Area in square metres p- Perimeter in metres

K- Aerodynamic resistance coefficient L- Length in metres
N in Newton, s in seconds, m in metres S.I-Standard International

4.1 Laws of Mine Air Friction
The laws which govern the passage of air in the mine are as follows:
Law I : P α S where, S= rubbing surface = perimeter of airway × length
Law II: P α V^2 where, V= air velocity
Law III: P α 1/A where, A= area of cross section
Law IV: P α K where, K= co-efficient of friction
Conditions in which obstructions and disturbances are minimum should be ideally selected for measurement to get a realistic pressure and quantity summary of the mine. Hence it is wise to conduct ventilation surveys while there is no activity taking place likely during on a non-working shift. Mine resistance is often affected by the following reasons:
- Movement of tubs, vehicles etc.
- Falling water in upcast shafts.
- During opening of mine doors.
- Leakage through overcasts or air crossings.
- Movement of personnel’s and workers.
- Unexpected environmental changes.

5. Ventilation System in Mine

5.1 Exhausting System
Advantages:
a) When main fan stops, underground pressure builds up to atmospheric. The increase in pressure slows gas emissions from the gob and prolongs the time required for the gas to reach active workings.
b) The haulage roads, where most travel is done, are kept free from dust, gas, and smoke. This permits the men to perform their work in fresh air.
c) In the event of a fire or explosion, exhausting ventilation enables the rescue work to pro-ceed more rapidly, because the fresh air is on the haulage road, which provides an easy route for carrying material and equipment to make mine repairs.
d) Both intake airways and track entries serve as escapeways, if stopping lines are well main-tained.
e) Greater power savings are possible if mine openings are small. This is due to the poten-tially greater recovery of velocity pressure through the use of discharge evasè (gradual ex-pansion ducts) on exhaust fans.

Disadvantages
a) It reduces temperatures in the belt slope, slope bottom, and main haulage line. During win-ter, the belt sprinkler system, damp coal on the belt rollers, and water lines along the haulageway can freeze. The temperature also is uncomfortable for the people working in these areas.
b) It is more difficult to detect a fire in belt and track entries since the air is carried directly to the return airways.
c) Dust produced at the portals and along the haulage road contaminates the intake air stream. Similarly, fire in the belt and track entries can be carried to the working areas.

d) Contaminated air goes through the fan, corrosive particles settle on the fan blades and corrode them, reduces effective air passage area, and can throw the fan out of balance.

5.2 Blowing System

Advantages

a) It applies a continuously decreasing overpressure from the air intake portal to the discharge opening. This characteristic produces airflow from intake airways to the return and pre-vents contaminated flow into working areas from idle areas and return airways. In fact, the blowing system may be the only practical method of ventilation in shallow mines having fractured ground, as well as areas of contiguous mining where there may be ground cracks into abandoned mines.
b) The haulage roads and hoisting shaft stay free from ice, making it more comfortable for the men in winter.
c) A fire in any part of the mine is soon evident, due to leakage, to anybody working in the air current coming away from the face area.
d) Only outside air, non-corrosive and with normal moisture content, goes through the fan.
e) Fan unit is cheaper because of a shorter fan duct (diffuser)

Disadvantages

a) Products of combustion from a mine fire or explosion are carried into the neutral escape-way. Thus, fire-fighting and rescue work are more difficult because access is often blocked by smoke. Ventilation reversal, in these cases, may endanger the men.
b) Dust, smoke, and other impurities are carried away from the face area and along the haulage road. Methane tends to accumulate in pockets in the roof, sometimes causing slight explosions.
c) Since neutral air flows away from working sections to the slope bottom, any accumulated air contaminants converge on workmen in the slope bottom area.
d) Shock losses are greater. It requires a distance of 30 times the duct diameter away from the pressure jet for the air velocity to lose 90% of its original velocity. For an exhausting sys-tem, only one duct diameter distance is required to lose 90% of its velocity. As result, pres-sure loss caused by shock, which is in addition to frictional loss, is considerably more in a blowing system.

AIR INLET AND ENTRENCE TO THE MINE

Photograph AIR INLET AND ENTRENCE TO THE MINE

6. Ventilation Control Devices

A well designed and properly implemented ventilation system will provide beneficial physiological and psychological side effects that enhance employee safety, comfort, health, and morale. In planning a ventilation system, the quantity of air it will be necessary to circulate to meet all health and safety standards must be decided at the outset. In addition, many other control devices also are necessary for effective underground air distribution, explained as,

6.1 Splitting: In a mine which is having multiple working districts it is always desirable to split the air flow to the sections/districts of the mine where the demand of air quantity arises and requires a separate route for flow. Like the combination of airways in parallel, which reduces their resistance, splits reduce the overall resistance of the mine and increase the air quantity .To control the flow of air to different working districts , the resistance of the split can be varied.

6.2 Stoppings: One of the commonly encountered planning errors in underground limestone operations is that main intake and return airways are located adjacent to each other, causing the exhaust air to be recirculated back into intake airway(s). This situation is exacerbated when a box cut, often used in limestone and coal mines where ore crops out, is used to enter the mine. The air can not be discharged away from the intake area.

6.3 Air Crossing: As the workings in seam extend it becomes essential to plan carefully the route to be followed by the air current, and in some places it is necessary to pass air along two roads which intersects at right angles. Whenever the return air-current has to cross the intake air-current without mixing with it air crossing is required. An air crossing may be either overcast or undercast according to one airway rises over or dips under the other airway.

6.4 Regulator: Regulators are used for the sole purpose of reducing the airflow to a desired quantity in a given airway of the mine. Regulators are usually rectangular opening left in stoppings. In practice the regulator openings are usually provided with a sliding shutter which helps in adjusting the size of the opening to suit the requirements. Regulators can be permanent when they are constructed of steel in a concrete stopping, but more often they are temporary in nature, when they are in the form of an open wooden frame in a stopping made up of brattice cloth nailed on to a wooden frame work. The air quantity can be adjusted by varying the size of the opening by nailing on strips of wood on the side of the opening.

6.5 Doors: When access through stoppings become essential then doors are used. Doors should be preferably open on one side, i.e. the high pressure side, opening in the other direction being checked by the frame. Normally, two doors used forming an air-lock so that one is always closed when the other is open. These doors are used as main separation doors near the shafts, whilst one door may suffice near the face.

6.6 Air locks: An airlock is a set of two doors so installed that one of them is always shut when the other is opened to pass men, tubs or a train. This not only minimizes leakage but becomes essential where the ventilation system is likely to be disturbed seriously by too frequent or prolonged opening of the doors. Indian coal mines regulations require that airlocks should be provided between main intakes and returns. Airlocks should also be provided where the pressure across the door is high.

6.7 Brattice Cloth: This is simply a sheet or sheets of canvas hung from props and planks to prevent the short circuit of air from intake to return, so causing the ventilation air to reach the faces. It may be used as a screen across an airway to prevent or reduce the flow of air along it, or as a partition along a roadway to divide it into two parts, intake and return or as hard screen to divert an air current upwards into a roof cavity to clear away any accumulation of gas. Brattice cloth coated with P.V.C is impermeable to airflow, and more suitable for line brattice to ventilate a heading. Brattices should be of fire resistant type.

6.8 Booster fans: Booster fans are used sometimes for augmenting ventilation in certain districts. They increase quantity by increasing the pressure causing flow. It is used when the desired increase of the airflow cannot be achieved economically. But it is essential to have a judicious choice of the size of a booster fan because too large a booster in one split can cause stoppage of air current or even reversal of the air current in the other splits.

7. Equipments Required For A Pressure-Quantity Survey

7.1 Sensitive manometers: The sensitive manometers are mostly used for the measurement of fan pressure, for determining the pressure difference across separation doors between intake and return, at the pit bottom and at several other places in the mine.

7.2 Pressure survey meters: It is a sensible type velometer calibrated to read pressure difference in mm of water-gauge. The pressure survey meters are most suitable for carrying out detail survey of a small mine or part of an extensive mine. Only trained persons can take the readings under strenuous conditions during its use .

7.3 Sensitive aneroid barometers: A barometer must be placed above ground near the entrance to the mine and must be read and recorded every day. A record of barometric pressure variations at the pit top at regular intervals of 15 minutes is needed to be maintained during ventilation measurements .

7.4 Graham's pressure survey apparatus: The graham's pressure survey apparatus is used in the same way as barometers. But as the pressure measuring element is a gas and not a metal, it voids creep and time lag associated with barometers

7.5 Rotating vane anemometer The vast majority of airspeed measurements made manually underground are gained from a rotating vane (windmill type) anemometer. When held in a moving airstream, the air passing through the instrument exerts a force on the angled vanes, causing them to rotate with an angular velocity that is closely proportional to the airspeed. A gearing mechanism and clutch arrangement couple the vanes either to a pointer which rotates against a circular dial calibrated in meters (or feet) or to a digital counter.

7.6 Inclined Tube Manometer:A variable inclination inclined tube manometer fabricated by DGMS for the purpose of the study at Nandira is used for the differential pressure survey. The inclination of the tube could be set at 1:2, 1:5, and 1:10 depending on the amount of the pressure difference to be measured. The manometer has provision for accurate levelling with the help of three levelling screws when placed on a hard and even surface

7.7 Pitot - static tube:The Pitot-static tube is an instrument which uses the principle of pressure exerted by flowing air and is suitable for measurements of high velocity. Unlike an anemometer it is not capable of measuring average velocity directly but measures the velocity at a given point in the airway/duct. The instrument consists of two concentric tubes out of which the outer tube, which contains perforations in the form of small holes drilled at right angles to its periphery, measures the staic head while the inner tube measures the total head.

7.8 Sling Hygrometer:An instrument used to determine the relative humidity of air, the extent to which it saturated with moisture, is known as hygrometer. A hygrometer is convenient to carry underground is Whirling Hygrometer. Two thermometers are placed on a frame and bulb of one is converted with wet cloth. Constant evaporation of moisture takes place from the wet bulb, thereby cooling it and bringing down its temperature. In case of air being relatively dry, it has a low relative humidity and there is large difference between readings of wet bulb and dry bulb. In case of air being nearly saturated, the two readings have hardly any difference. When the frame along with the thermometers is whirled at 200 r.p.m for about a minute which produces a relative air velocity of 3 ms^{-1}, the readings of dry bulb temperature (D.B.T) and wet bulb temperature (W.B.T) are calculated for relative humidity of air.

7.9 ANEMOMETER: This instrument is used for measuring the velocity of air in mine.The instrument consists of a small fan set at an angle of 40^0 to 45^o to the direction of air flow which will rotate the vanes at a speed proportionate to the air velocity. Range: For measuring wind speed of 1 to 15 meters per second.

7.10 Nylon Tubes:For measuring the static pressure differential between two station, nylon tubes of 8mm diameter and thickness of 4mm of length 20m was connected with Pitot tube at either end via connectors to prevent leakage.

7.11 Stop Watch

For the purpose of recording time during air quantity survey for a duration of one minute a stop watch was an essential equipment.

Table 7.11 Instruments for measuring Air velocity in Mines

Instrument	Velocity Range, fpm	Sensitivity, fpm	Accuracy	Features
Smoke Tube	20-120 (low)	5-10	70-90%	Indirect, approximate
Vane anemometer	150-2000 (intermediate to high) 2000-10,000 (very high)	10-25 50-100	80-90%	Needs calibration, needs maintenance
Velometer	30-3000 (low to high) multirange	5-10 25-50	3% of upper scale reading	Rapid, direct reading, delicate, needs maintenance
Thermoanemometer	10-500 (low to			Slow, delicate,

Thermometer	intermediate)	2-10	80-95%	requires power (6V), safe
Hot-wire	10-300 100-3000 (low to high) multirange	1-2 10-20	90-95%	Rapid, direct reading, delicate, requires power, needs maintenance
Kata thermometer	100-1500 (intermediate to high)	10-25	70-90%	Indirect, slow, delicate
Pitot tube	750-10,000 (high)	10-25	90-98%	Slow, indirect, accurate

Conversion factor: 1 fpm= 0.00508 m/s.

8. Ventilation Plan

Ventilation plans are necessary for efficient control of ventilation in mines. It is also required by law that up-to-date ventilation plans of a mine showing the distribution of air be maintained as mentioned in regulation no.139, CMR-1957. Ventilation plans are prepared based on the latest ventilation surveys and are essential for:

1) Giving a comprehensive picture of the mine air distribution system with the direction and amount of flow in various branches and circuits.
2) Indicating the position of the high resistance parts of branches and circuits
3) Indicating leakage or recirculation of air
4) Indicating the efficiency of the various ventilation control devices.
5) Indicating possible ways of reorganization of the system for better air distribution.
6) Indicating possible ventilation control measures in the event of emergency and
7) Indicating the effect of introducing new airways, installation of fans etc. in the event of reorganization of ventilation system.

Normally ventilation plans should clearly indicate:

a) The direction of air-current in various branches and circuits.
b) Quantity and pressure measuring stations.
c) Air-crossings, doors, stoppings and other devices for controlling air distribution.

d) Fire doors and stoppings with their serial number.

e) Rooms used for storing inflammable materials.

f) Position of firefighting equipment.

g) Water dams with dimensions

h) Pumping, telephone and ambulance stations and

i) Haulage and travelling roads by suitable symbols. Table below gives the standard symbols prescribed for ventilation plans by the Indian Mine Regulations.

Apart from the above, quantities at the air measuring stations should also be shown on the ventilation plan. Wherever, the scale of the plan permits, airways with unduly high resistance should be specially marked with the pressure drop suitable indicated.

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