CHAPTER 18
VENTILATION

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Chapter 18
VENTILATION

I. Introduction

Adequate workplace ventilation is an important engineering method for controlling airborne contaminants. A properly designed mine ventilation system can remove contaminants from the atmosphere or dilute the contaminants in the atmosphere to safe levels. Inspectors should observe and document the general condition and operation of ventilation systems when conducting an inspection.

This Chapter provides the fundamentals of mine ventilation. For additional information see *Bureau of Mines Bulletin 589, Introduction to Mine Ventilating Principles and Practices* available at http://www.cdc.gov/niosh/mining/UserFiles/works/pdfs/bul589.pdf or contact your District Office to obtain assistance from Technical Support. Due to the complexity sometimes associated with evaluating mine ventilation, do not hesitate to request assistance when challenging conditions are encountered such as domed salt mines, large or deep underground mines, or mines with multipart local exhaust systems.

II. Definitions

Air Course - a pathway through which air travels to an area.

Anemometer (rotating vane) - a common field instrument used for measuring air velocity and flow, or wind speed (see Figure 18-10).

Brattice - a partition placed in an underground mine to control the flow of ventilation and force it into the workplaces; typically made of canvas or plywood.

Capture Velocity - the air velocity in front of the hood that is necessary to capture and convey airborne contaminants into an exhaust ventilation system.

General Ventilation – a ventilation system in a room, area, or building, designed to control contaminant levels within the structure by dilution and removal.

Local Exhaust Ventilation – a ventilation system designed to capture airborne contaminants at the source (a specific operation or process) before the contaminants can escape into the work environment.

Make-Up Air – the clean air brought into a building or area from outside to replace air that has been exhausted by the ventilation system.

Short-Circuit - the path that air may naturally travel to an exhaust outlet, bypassing worker-occupied areas and creating an unventilated area.

Smoke Tube - a thin sealed glass tube filled with reactive chemicals that, when opened and air is forced through it, generates dense smoke that can be streamed out of the tube end for visualization of air currents (see Figure 18-14).

Traverse - a method of measuring air velocity in an air passage, in which the instrument is moved across the cross-section of the air course (or a portion of it) in a steady, sweeping motion (see Figure 18-11).

Velometer - a special instrument that can be used for instantaneous air velocity measurements (see Figure 18-13).

III. Underground Ventilation

This section provides guidance to metal and nonmetal mine inspection personnel regarding enforcement of MSHA's health-related mine ventilation standards in 30 CFR Part 57 Subpart G - Ventilation. This section is not intended to provide guidance on MSHA's safety-related ventilation standards, although some of the concepts and techniques may be applicable. The safety-related ventilation standards address two issues: the spread of fire and the toxic combustion byproducts, and the control of methane gas in gassy mines. The fire standards are in 30 CFR Part 57 Subpart C - Fire Prevention and Control, and the methane gas standards are in 30 CFR Part 57 Subpart T - Safety Standards for Methane in Metal and Nonmetal Mines. See the complimentary General Inspection Procedures Handbook for additional information.

A. Examining Mine Ventilation Plans and Maps

Section (§) 57.8520 concerning ventilation plans requires a mine operator to set out a mine ventilation plan in written form. It also requires revisions of the system to be noted and updated at least annually. District Managers must request, in writing, a copy of each underground mine's ventilation system plan and must review and provide appropriate comments on the plan.

In accordance with § 57.8520, when reviewing the mine ventilation system plan, District Managers must assure that the mine operator's plan contains the following, where applicable:

1. The mine name;

2. The current mine map or schematic or series of mine maps or schematics of an appropriate scale, not greater than five hundred feet to the inch, showing:

a. Direction and quantity of principal air flows,
b. Locations of seals used to isolate abandoned workings,
c. Locations of areas withdrawn from the ventilation system,
d. Locations of all main, booster, and auxiliary fans not shown in paragraph (d) of 30 CFR § 57.8520,
e. Locations of air regulators and stoppings and ventilation doors not shown in paragraph (d) of 30 CFR § 57.8520,
f. Locations of overcasts, undercasts, and other airway crossover devices not shown in paragraph (d) of 30 CFR § 57.8520,
g. Locations of known oil or gas wells,
h. Locations of known underground mine openings adjacent to the mine,
i. Locations of permanent underground shops, diesel fuel storage depots, oil fuel storage depots, hoist rooms, compressors, battery charging stations, and explosive storage facilities. Permanent facilities are those intended to exist for one year or more, and
j. Significant changes in the ventilation system projected for one year.

3. Mine fan data for all active main and booster fans including manufacturer's name, type, size, fan speed, blade setting, approximate pressure at present operating point, and motor brake horsepower rating.

4. Diagrams, descriptions or sketches showing how ventilation is accomplished in each typical type of working place including the approximate quantity of air provided, and typical size and type of auxiliary fans used.

5. The number and type of internal combustion engine units used underground, including make and model of unit, type of engine, make and model of engine, brake horsepower rating of engine, and approval number.

District enforcement personnel must conduct a mine site visit for each ventilation plan submitted. The visit(s) can be in conjunction with quarterly inspections and must include physical verification that all of the information required by 30 CFR § 57.8520 that is shown on the plan is accurate, and must also determine whether the mine’s ventilation system meets the requirements of the standards in 30 CFR Part 57, Subpart G - Ventilation. When examining mine ventilation plans and maps check to ensure that the elements required by 30 CFR § 57.8520 are included.

Follow the **air course** from intake(s), through the working places, to the return(s). Look for discrepancies between where the map or schematic shows air flows, and where the air would actually flow based on the location of ventilation control structures such as **brattice**s, stoppings, regulators, and doors. Also check for inconsistencies in the indicated airflow rates.

Unless proper ventilation control structures are provided, you cannot assume air will travel along the pathways shown on the ventilation map or schematic. Airflow will follow the path of least resistance. In mines where the air course cross-sectional area is roughly uniform throughout the mine, air travels the shortest possible distance between two points. More air volume will travel the shorter path, and less air volume travels the longer paths.

For example, consider the section of the ventilation map in Figure 18-1. The map shows the intended direction of the air movement indicated by the arrows from 1 to 2 to 3 to 4, then turning to 8 to 12, and then turning to 11 to 10 to 9. However**, without ventilation control structures to direct the airflow**, **much of the air would follow a shorter path.** Instead, air would flow from 1 to 9**.** This path is **called a short-circuit.** It is not indicated on the map, but exists in reality and is the less resistant path that air would travel without ventilation control structures.

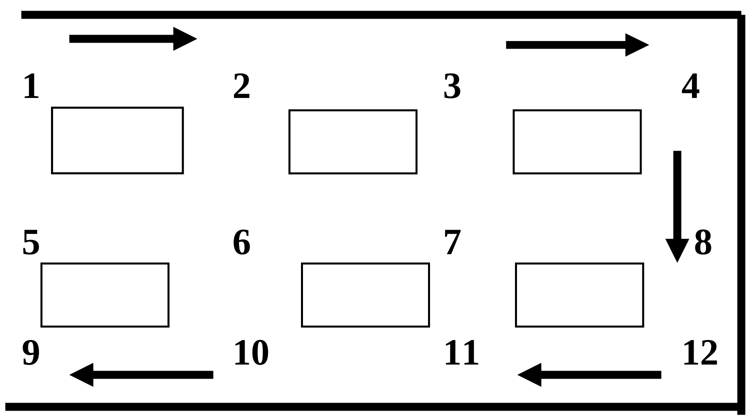

Figure 18-1. Mine section ventilation map airflow

The existence of a short-circuit is not a violation. However, a ventilation short-circuit may cause or contribute to a violation of an air quality standard. For example, if the active working face area is at 4 or 8 or 12, and diesel equipment is being operated in that area, overexposure to diesel particulate matter (DPM) might occur as a result of insufficient air reaching the working areas to dilute and carry away contaminants. Brattices or other suitable ventilation control structures between intersections 1 and 5, 2 and 6, 3 and 7, and 7 and 8 would force fresh air into the working area, and prevent the short-circuit (see Figure 18-2).

Recirculation is another problem caused by inadequate ventilation control structures. For example, consider the same mine section ventilation map. This time, as shown in Figure 18-2, with brattices installed between intersections 1 and 5, 2 and 6, 3 and 7, and 7 and 8, and a booster fan inserted between 3 to 4 to increase air volume through the working areas at 4, 8, and 12.

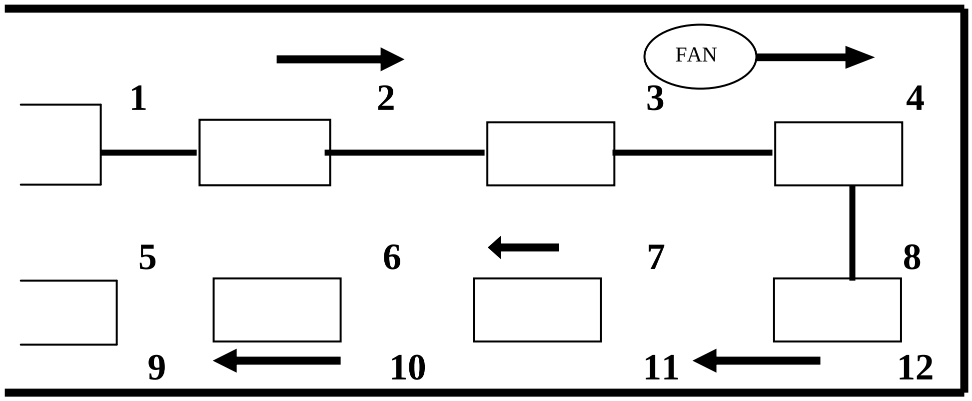

Figure 18-2. Mine section ventilation map airflow with controls and fan

Although the fan will increase the airflow through the active working areas as planned, it may have the unintended effect of creating a recirculation path through the brattices if there is leakage. This path would begin at the fan; travel through the working areas of 4, 8, and 12, and back to the fan through leaky brattices at 1-5, 2-6, 3-7, or 7-8. Some fresh air will continue to enter this system and some contaminated air will be exhausted, but a portion of the air passing through the working areas is recirculated contaminated air. A recirculation path like this can cause elevated air contaminant concentrations of dust, DPM, etc., which may result in overexposures of miners working in the areas.

When examining maps or schematics, you should also verify that the indicated volumetric flows are consistent. For example, in Figure 18-3, the flow rate in cubic feet per minute (cfm) on the left has to equal the sum of the flow rates on the right and agreement between these numbers as they appear on a map does not necessarily mean they reflect actual conditions (they could all be wrong, but consistent with each other), but disagreement definitely indicates a problem.

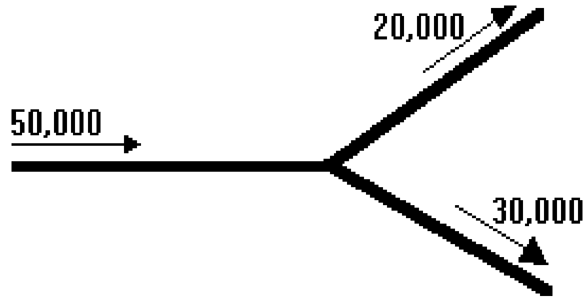

Figure 18-3. "Y" split with air quantities

The above examples are quite simple, and the ventilation system design flaws or map errors are obvious. Typically, however, airflow patterns are far more complex and the existence of short-circuits, recirculation paths, or other problems are difficult to identify. In some cases, what appear to be errors may be intentional designs. For example, a recirculation path may actually be designed into a ventilation system as a cost saving strategy. Such systems may be acceptable according to 30 CFR § 57.8529, as long as recirculation is minimal and fresh air is provided that effectively sweeps the working places. If there is an air quality compliance problem (e.g., dust or contaminant gas overexposure) that could be caused or made worse by a complex ventilation problem, contact the District Office for assistance.

B. Inspecting Ventilation Systems

The surface and underground elements of the ventilation system must be thoroughly inspected to ensure compliance with applicable provisions of 30 CFR Part 57 Subpart G – Ventilation. The elements of the system must also be consistent with the written ventilation plan or schematics, including the items mentioned in Section III. A. above. Ventilation plans need to be updated at least annually, so it is possible that recent changes in the ventilation system are not included in the plan. Inspectors should document in the General Field Notes (MSHA Form 4000-49F or H) their evaluations and observations.

C. Air Quantity Surveys

1. Airflow Direction and Quantity

Checks of airflow direction and quantity may be necessary to verify agreement between the ventilation system and the ventilation plan.

Airflow direction can usually be determined without special tools or instrumentation. An aspirator bulb-type smoke generator (**smoke tube**) can be used to enable flow visualization when necessary, such as when airflow is low, or where winzes or raises intersect a level. Trickling a small amount of very fine dust out of your hand can also provide airflow visualization to determine the direction of airflow.

To determine quantity of flow, the cross-sectional area of the air course and the air velocity must be measured. Air quantity flow is then calculated using the following formula:

$$Q = VA$$

where: Q = air quantity flow in cubic feet per minute (cfm)
V = air velocity in feet per minute (fpm)
A = cross-sectional area of air course in square feet

2. Calculating Cross-Sectional Area of the Air Course

Use the following formulas for calculating cross-sectional areas (A):

a. For a rectangle, A = H x W:

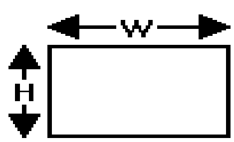

Figure 18-4. Rectangle

b. For a circle, $A = D^2 \times 0.785$:

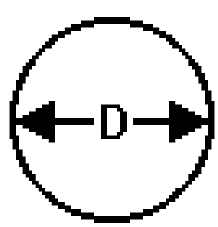

Figure 18-5. Circle

c. For a triangle, $A = (½) \times H \times L$:

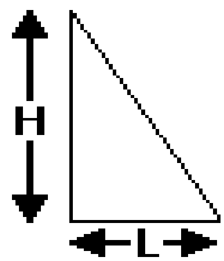

Figure 18-6. Triangle

d. For a parallelogram, $A = H \times W$:

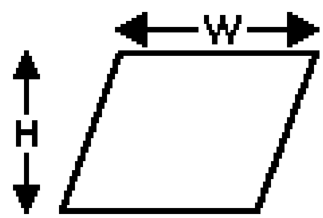

Figure 18-7. Parallelogram

For unusual shapes, divide the cross-section into shapes for which area calculations can easily be made, then add the areas. See Figure 18-8 for example:

e. For the half-circle roof top, $A_1 = (½) \times [D^2 \times 0.785]$
For the rectangle, $A_2 = H \times W$
For the triangle, $A_3 = (½) \times H \times L$
Total Area = $A_1 + A_2 + A_3$

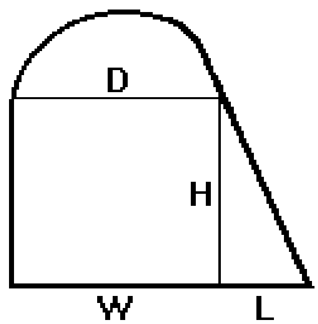

Figure 18-8. Circular Roof

f. Another common shape is a rectangle with a slanted top:
For the triangle on top, $A_1 = (½) \times W \times L$
For the rectangle on the bottom, $A_2 = H \times W$
Total Area = $A_1 + A_2$

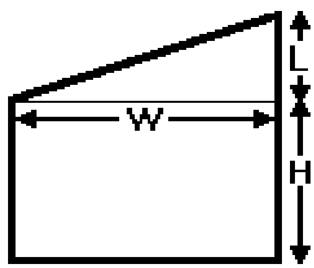

Figure 18-9. Slanted Roof Top

3. Determining Air Velocity

There are many techniques for measuring underground air velocity, but the following three are the most common: the rotating vane **anemometer**, **velometer**, and the timed smoke cloud method. Use a rotating vane anemometer when the air velocity is within its measurement range. Timed smoke clouds are used to measure velocities that are too low to measure accurately with an anemometer. District Industrial Hygienists/Health Specialists or Technical Support primarily use the velometer for special tests.

a. **Rotating Vane Anemometer** (see Figure 18-10) - The measuring range of this anemometer is indicated on the calibration data provided with the instrument. The typical range is 200 to 3,000 feet per minute (fpm), but other models are also available with ranges of 50 to 5,000 fpm, 200 to 10,000 fpm, etc. Do not use a rotating vane anemometer to measure air velocities below or above its indicated range. At air velocities below the indicated range, measurements are inaccurate and unreliable. At velocities above the indicated range, instrument damage can occur.

Figure 18-10. Rotating Vane Anemometer

The standard method for performing a velocity measurement using a rotating vane anemometer involves a "**traverse**" of the cross-section to be measured. In a traverse, the anemometer is swept across the cross-section of the air course, or portion of the air course, in a controlled, steady motion. It is important to traverse the cross-section because air travels faster in the center of the air course than along the roof, walls, or floor. A single measurement at a fixed position in the air course would not be representative of the average velocity across the entire cross-section.

In small air courses, the entire air course can be traversed. In larger air courses, it is preferable to divide the air course in half and traverse each half separately (split traverse). When performing split traverses, the velocities determined for both halves are averaged to determine the average air velocity for the air course as a whole. If the air course has a very large cross-sectional area and a high roof, divide the air course into four equal quarters with the upper edge of the lower quarters being at mid-wall height. Measure the two bottom quarters using the split traverse method. Figure 18-11 illustrates various traversing practices, depending on the dimensions of the air course cross-section to be measured.

The anemometer can be attached to an extension handle when making a traverse. This allows the instrument to be held some distance away from the body to minimize air turbulence effects on

the instrument reading. It is also helpful to use an extension handle when measurements must be made at locations with a high roof. If an extension handle is not available, the instrument should be held at arm's length away from the body when traversing. When traversing, make sure the anemometer is always perpendicular to and downstream of the air flow.

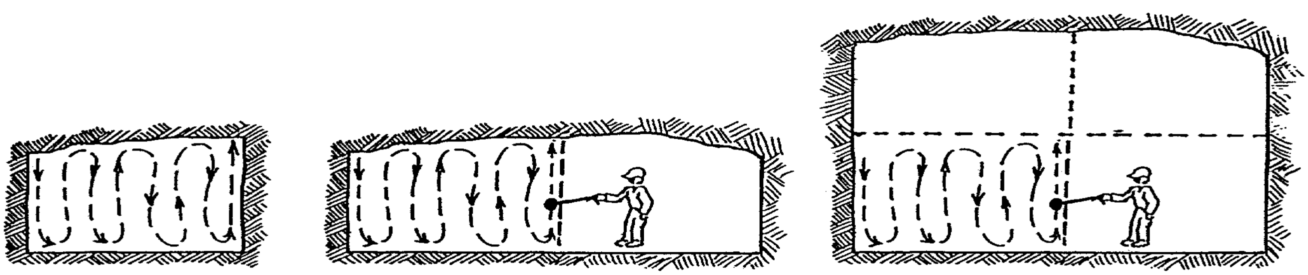

Figure 18-11. Anemometer Traverse

The traverse motion must be steady, and all parts of the area of the cross-section must be covered equally, including corners, walls, roof, and floor.

A suitable anemometer and a timer are required to make a measurement. If a stopwatch is not available, a watch that measures in seconds is acceptable. It is easier to perform a measurement with two people - one to perform the traverse and one to operate the stopwatch and provide verbal cues - but it can be accomplished by one person. Normally, the timing period for a traverse is one minute (to make subsequent calculations easier), but any convenient time period is acceptable. Measuring air velocity with a rotating vane anemometer involves the following basics:

(1) "Zero" the anemometer dial with the appropriate levers;
(2) Position the instrument at a corner (e.g., wall/floor or wall/roof) where the velocity is slowest;
(3) Allow the anemometer's vanes to reach full speed (a few seconds), then simultaneously start the stopwatch and release the dial movement to begin measuring the traverse;
(4) Simultaneously stop the stopwatch and the dial at the end of the traverse;
(5) Record the anemometer dial reading and the elapsed time from the stopwatch;
(6) If either traverse was not fully completed, do not use that measurement. Repeat until two good traverses are completed that agree to within 10% of the lower of the two readings. Again, this method is easiest if the time period is 1 minute. The resulting two readings would then be averaged, and that value recorded;
(7) If split traverses were performed, repeat the above steps for the other half of the air course.

The dial reading on a rotating vane anemometer reads in feet. Air velocity is obtained by dividing the anemometer reading by the time measured on the stopwatch. If the traverse is completed in exactly 1 minute, the dial reading is equal to the air velocity in feet per minute (fpm).

For example, if the final anemometer value is 655 feet, and the traverse was completed in exactly 1 minute, the velocity would be:

$$\frac{655 \text{ feet}}{1 \text{ minute}} = 655 \text{ feet/min} = 655 \text{ fpm}$$

If the same traverse was completed in 1 minute, 10 seconds, the time would first need to be converted to minutes, as follows:

1 minute, 10 seconds = 70 seconds

$$\frac{70 \text{ seconds}}{60 \text{ seconds/minute}} = 1.17 \text{ minutes}$$

$$\frac{655 \text{ feet}}{1.17 \text{ minutes}} = 559.8 \text{ feet/min} = 560 \text{ fpm}$$

The next step in determining velocity is the velocity correction. Every anemometer is calibrated and provided with a velocity correction table. Measured velocities must be corrected using the correction factors provided on such tables. Listed correction factors are designated either "+" or "-." Factors that are designated "+" are added to the measured velocity. Factors that are designated "-" are subtracted from the measured velocity. For example, using the following table (Figure 18-12) of correction factors, a measured velocity reading of 200 would be corrected to 215 ft.

Serial No. 123456		**Cal. Date 01-28-2015**	
Est. Vel.	**Correction**	**Est. Vel.**	**Correction**
50	+65	500	-15
100	+42	600	-22
150	+29	750	-36
200	+15	1000	-68
250	+8	1250	-79
300	+2	1500	-90
350	-3	1750	-113
400	-8	2000	-131
When sign is : + Add - Subtract			

Figure 18-12. Correction Factors

Note: Figure 18-12 is only an example and is not to be used for correcting actual velocity measurements. Every anemometer is individually calibrated with its own applicable correction table.

If the measured velocity is not on the table, the correction factor must be "interpolated," or estimated. For example, if the measured velocity is 340 fpm, the correction would be about -2. If the measured velocity is 1655 fpm, the correction would be about -104, and similarly to interpolate for other measurements.

If a split traverse measurement were performed, the two corrected velocities would be averaged to determine the overall corrected average air velocity for the entire air course cross-section.

b. The Velometer

The velometer (see Figure 18-13) is a direct-reading instrument that provides an instantaneous measure of the air flow at the precise point that the probe is positioned. It can be used for air course velocity measurement, but since it is somewhat cumbersome to traverse a cross-section with a velometer, it is more commonly used to spot-check the velocity at a fixed point such as at the duct inlet, or with special attachments, the duct interior. District Offices maintain these instruments, and the District Industrial Hygienist/Health Specialist, with Technical Support, can be contacted for assistance.

Figure 18-13. Velometer

c. Timed Smoke Clouds

Timed smoke clouds generated by a smoke tube (see Figure 18-14) can be used to measure velocities that are too low to measure accurately with an anemometer, usually below 100 fpm. Repeat the following procedures enough times to produce reliable, repeatable results for the air velocity.

Figure 18-14. Smoke Tube

(1) **Measure the Distance** - See Figure 18-15. Determine the distance over which the smoke cloud measurements (d) are taken by observing how well a smoke cloud holds together. Pick a location that is straight, of uniform cross-section, and free of obstructions, to the extent possible. Use an aspirator bulb-type smoke generator (**Smoke Tube**) to create a smoke cloud, and watch carefully how far the cloud travels downstream before it breaks up. The smoke cloud begins to spread and dissipate as soon as it is released, but a discernible cloud should remain somewhat intact for a distance of at least 5 to 10 feet. Repeat this procedure enough times to produce reliable, repeatable results. Place upstream and downstream markers on the mine floor or wall corresponding to the smoke release point and the farthest point that the smoke cloud travels before breaking up. These markers are the reference points that are used for release of the smoke cloud and measurement of cloud travel

time. The measured distance (d) between them equals the distance the cloud holds together.

(2) **Use a Stopwatch** - See Figure 18-15. Taking Timed Smoke Cloud Readings. Use a graduated stopwatch or a watch with seconds to simplify subsequent calculations. Record the time interval from the smoke release by the upstream person until the leading edge of the smoke cloud reaches the downstream person mark. For a measurement in seconds, a velocity unit conversion from feet per second (fps) to feet per minute (fpm) is necessary. This conversion also applies to a standard watch graduated in seconds, which may be used if a stopwatch is not available. To convert from feet per second (fps) to feet per minute (fpm), multiply by 60.

For example: 2.5 fps x 60 seconds/minute = 150 fpm

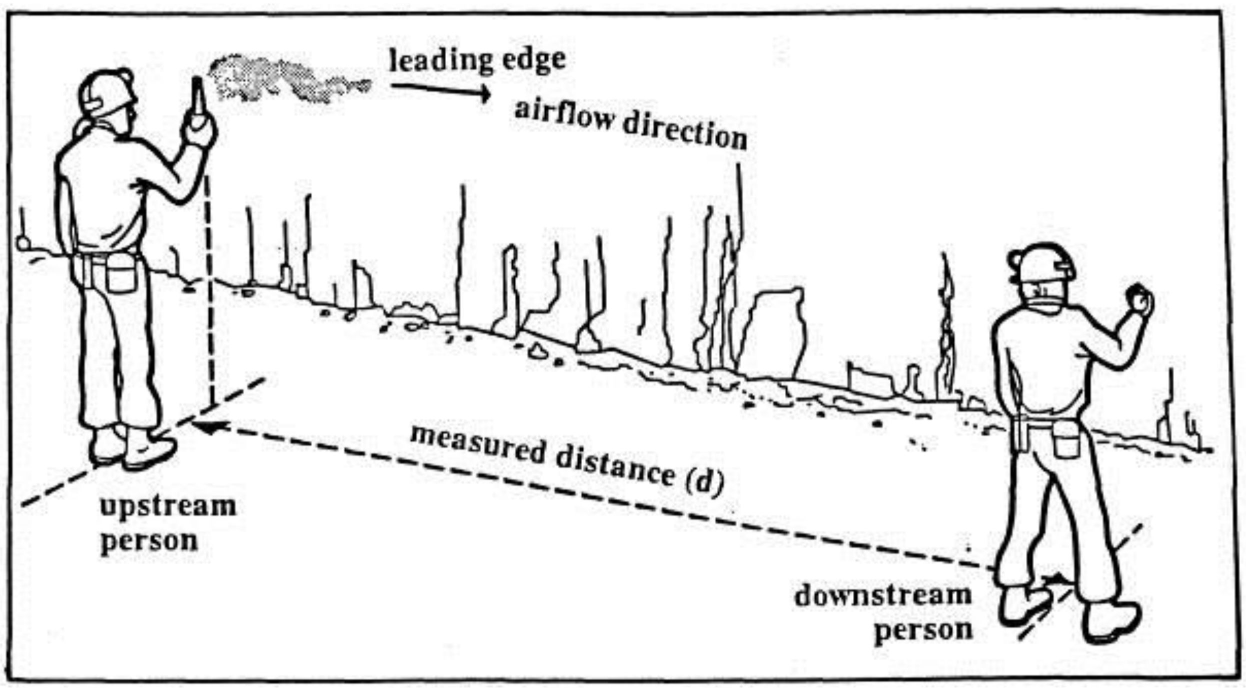

Figure 18-15. Taking Timed Smoke Cloud Readings

(3) **Compute and Adjust Air Velocity** - The air velocity in the air course is determined by dividing the distance the smoke

cloud traveled by the travel time. Remember that a velocity unit's conversion from feet per second to feet per minute is necessary if the stopwatch or watch used for time measurements is graduated in seconds. For example, using a measurement distance of 10 feet in 6 seconds:

Air velocity = 10 feet ÷ 6 seconds = 1.66 fps

1.66 fps x 60 seconds/minute = 99.6 fpm

Note: When the leading edge of the smoke cloud is used to estimate cloud travel time, resulting determinations of air velocity are about 10% too high. Thus, to improve accuracy, the velocity measurement must be adjusted by applying a method correction factor of 0.9. Using the above example, this factor would be applied as follows:

99.6 fpm x 0.9 = 89.64 feet per minute (fpm)

(4) **Determine Airflow Rate** - Airflow rate in cubic feet per minute (cfm) is determined by multiplying the air velocity by the cross-sectional area. For example, using the air velocity calculated in step (3) and a course cross-sectional area of 540 square feet:

Airflow rate = 89.64 feet per minute x 540 $feet^2$
= 48,406 $feet^3$ per minute = 48,406 cfm

IV. Surface Ventilation

Proper ventilation at surface installations helps provide a healthful atmospheric environment for mill attendants, maintenance mechanics, clean-up personnel, laborers, and others. Ventilation may be natural or mechanical. Natural ventilation is air movement by wind, temperature and/or pressure differences, or other nonmechanical factors. Mechanical ventilation is caused by a fan or other air-moving device. Building ventilation systems fall into two categories: **general ventilation** and local ventilation. General ventilation refers to systems that provide air to ventilate entire rooms, large work areas, bays, or whole buildings. Local ventilation systems provide ventilation to specific pieces of equipment or work processes. Both general and local ventilation systems incorporate supply and exhaust elements, which must be balanced for the overall system to function properly. Mills, shops, and other surface buildings of mines are often equipped with ventilation systems that combine general and local ventilation.

MSHA does not have specific standards that address ventilation system ratings in surface buildings; however the proper operation of such systems is necessary to ensure compliance with specific health standards. For example, lack of appropriate ventilation in a mill could lead to overexposures of respirable silica-bearing dust. Similarly, inadequate local exhaust ventilation in a shop could result in overexposure to welding fumes. Therefore, an understanding of basic ventilation systems can help inspectors determine the potential cause of an overexposure condition resulting in violation of health standard(s). Further, as much as is feasible, control of airborne contaminants must be by prevention of contamination, removal by exhaust ventilation, or dilution with uncontaminated air (30 CFR § 56.5005). The following sections describe the basics of ventilation systems and provide guidance to inspectors on identifying deficiencies.

A. General Ventilation

General ventilation refers to the supply and exhaust of air to an industrial area, room, or building. It is provided to dilute and carry away contaminants and may also condition air for the comfort of occupants (e.g., heating and cooling). General area ventilation systems may be large enough to accommodate an entire processing plant or small enough to service an operator's enclosed control room or booth.

A major factor that can influence the use of general ventilation systems is the outside temperature. Although these systems are usually designed for the dual purposes of controlling airborne contaminants and miner comfort, the miner's comfort component sometimes prevails. In warm weather, the tendency would be to increase the general ventilation system to draw in as much outside air as possible and to maintain a breeze across the work place floor. Operating in this mode, the system would also be most effective in diluting and removing air contaminants.

In cold winter weather, the tendency would be to decrease the system to minimize heating expense and reduce drafts of cold air on the work place floor. Because of seasonal adjustments to general ventilation systems in a large mill or shop, visible dust and haze in the air during a winter inspection might make it impossible to see from one end of the building to the other, while during summer the air might be relatively free of visible dust during an inspection, even though the work operations are the same throughout the year.

The presence of visible dust or haze does not necessarily indicate a hazardous condition. It should, however, alert the inspector to investigate further. When personal exposure sampling is performed on employees working under these conditions, the operating status of the general ventilation system should be noted in the Health Field Notes (MSHA Form 4000-31). Inspectors should note whether adequate provision is made for **make-up air**. A general ventilation system in a mill or shop may consist of ventilators and fans in the walls or roof that draw contaminated air from inside and exhaust it outside. During warm weather, make-up air usually enters the building through open doors and windows, grates or louvers in the walls, doors, etc. In the winter, however, these may be closed to prevent drafts. If no provision is made for make-up air, the general ventilation system will operate at only a fraction of its rated capacity because the exhaust fans on the roof would be starved for air.

When conducting an inspection, obvious indications of insufficient make-up air are doors that slam shut or fly open accompanied by an inrush of air into the building.

Note: The location of make-up air inlets or portals is important to air quality in a mill/mine. **The source of the make-up air should be located away from contaminated airstreams such as idling equipment exhausts or ventilation exhaust ports** to prevent re-entrainment.

If an overexposure is observed and violation found, the absence of ventilation or an obvious performance failure of an existing system in the affected area should be noted if a citation or order is issued.

B. Local Exhaust Ventilation

Local exhaust ventilation systems are designed to capture the air contaminants, such as dust, gases, mists, fumes that are produced by a specific operation or process before they can escape into the work environment. The air drawn into a local exhaust system can be transported away from the work area for removal of the contaminants (e.g., by filtration) or exhausted to the outside. Local exhaust ventilation can be employed in surface and in underground mines. A local exhaust system consists of an entry hood, a transport duct, a fan, and an exhaust. As noted above, it may or may not include a contaminant removal mechanism such as a dust collector, cyclone, filter, bag house, or electrostatic precipitator. Systems may be portable, such as a self-contained cart-mounted welding fume eliminator, or they may be fixed installations in buildings or underground shops.

Fixed systems may consist of a single hood at a work location, or scores of hoods attached to hundreds of feet of interconnected duct.

Inspectors should observe and document the general condition and operation of such systems when conducting an inspection. For example, if sampling for welding fumes, note whether a welding fume ventilator is in use and its performance. 30 CFR §§ 56/57.14213 (b) require that "all welding operations shall be well-ventilated."

A critical element in a local exhaust ventilation system is the entry hood. Therefore, when inspecting a local exhaust ventilation system, start with the entry hood. The most important feature of an entry hood is the velocity of the inflowing air at various distances and in various directions into the hood. Air velocity is critical because contaminant capture and conveyance does not occur if the velocity is too low. The minimum velocity necessary to capture and convey the contaminant into the hood is called the **capture velocity**. Capture velocity varies depending on the characteristics of the contaminant being captured and the nature of the operation producing the contaminant. The table in Figure 18-16 shows typical ranges for recommended capture velocity for various contaminants and processes. Source: American Conference of Governmental Industrial Hygienists - ACGIH Industrial Ventilation Manual®.

Condition of Dispersion of Contaminant	**Example**	**Capture Velocity, fpm**
Released with practically no velocity into quiet air	Evaporation from tanks, degreasing, etc.	50-100
Released at low velocity into moderately still air	Spray booths, intermittent container filling, low speed conveyor transfers, welding	100-200
Active generation into zone of rapid air motion	Spray painting in shallow booths, barrel filling, conveyor loading, crushers	200-500
Released at high initial velocity into zone at very rapid air motion	Grinding, abrasive blasting, tumbling	500-2000

Figure 18-16. Range of Capture Velocities

When examining an entry hood, use a rotating vane anemometer or velometer to measure the air capture velocity. If an anemometer is not available, the capture velocity can be qualitatively spot-checked with a smoke tube. Air velocity drops rapidly as the distance from the hood opening increases. This factor emphasizes the importance of proper positioning of the hood relative to the process creating the contaminants. If the hood is too far away from the process, contaminant capture by the local exhaust ventilation system will be ineffective. Observe the diagram of air velocity contours in Figure 18-17.

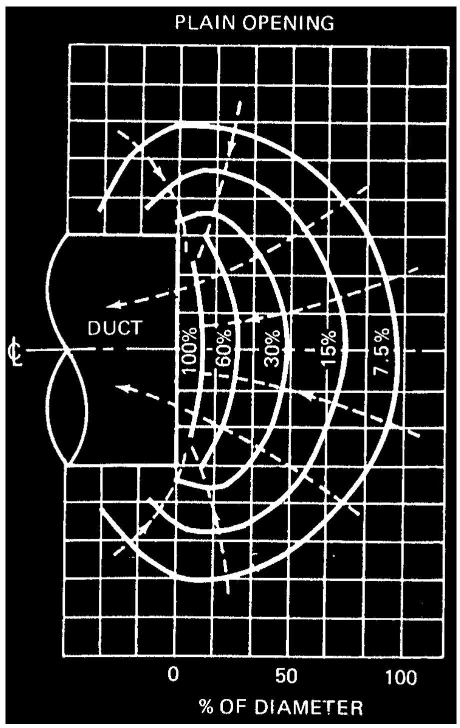

Figure 18-17. Velocity Contour Around a Hood as a Percentage of the Velocity at the Opening

One way to improve contaminant capture is to fully or partially enclose the process control point with the hood. For example, enclosure hoods are often used on conveyor transfer points, feeders, and other similar applications.

The other elements of the local exhaust ventilation system that should be checked during an inspection are the duct, fan, contaminant removal equipment, if any, and exhaust. The duct should be checked for breaks, leaks, restrictions, and plugs, any of which will reduce system efficiency or functionality. If possible, final exhaust air is best directed to the outdoors and some distance away from any intakes.

A poorly designed or ineffective local exhaust or ventilation system is not necessarily a violative condition. However, if personal sampling results indicate an overexposure to any contaminant that should have been controlled by the ventilation, the performance characteristics of that system are relevant to any resulting citation, and should be documented.