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MEASURING VERY LOW AIR VELOCITIES IN UNDERGROUND METAL/NONMETAL MINES

Objective

To accurately measure very low air velocities (0-100 ft/min) in U.S. large-opening underground metal/nonmetal mines.

Background

Hundreds of metal/nonmetal underground mines operate throughout the United States. They extract commercial products from deposits such as limestone, salt, and gypsum. Mining generates a wide variety of gases and dusts, such as silica, diesel exhaust, radon, blasting byproducts, and perhaps even methane. If these substances become airborne, they can adversely affect the health and safety of underground workers. Many metal/nonmetal mines have large cross-sectional airways that could be 60 times larger than an average underground coal mine entry. These large airways require adequate volumes of fresh air to dilute, make harmless, and exhaust the toxic and, at times, explosive byproducts. However, in some underground mine sections, air movement is barely perceptible. The technology of measuring very low air velocities will become increasingly more important for operators of large-opening stone mines in order to monitor miner exposure to diesel particulate matter.

Conventional anemometers (e.g., vane) are capable of accurately measuring air velocities only above 100 ft/min. Thus, it was necessary to investigate other anemometry technology to detect low air velocities in the range of 0-100 ft/min. Two different portable ultrasonic anemometers were tested. Actual testing was done in an underground limestone mine with openings about 51 ft wide by 29 ft high.

Ultrasonic Anemometers

Vane-type anemometers are commonly used by engineering personnel throughout the underground coal mine industry. They work well in measuring air velocities >100 ft/min. However, a separate technology, e.g., portable ultrasonics, is needed to measure air velocities much below 100 ft/min at various places within the large mine opening. Laser-doppler technology was also considered for this application, but was ruled out because of its high cost and other technical limitations. With no moving parts, the portable ultrasonic anemometers are claimed to be accurate down to about 1 or 2 ft/min.

The first type of ultrasonic anemometer that was examined underground is manufactured by Gill Instruments Ltd., Hampshire, U.K. The U.S. distributor is IN USA, Needham, MA. The Gill Instruments Solent Volometer (figure 1) is a battery-powered, single-axis anemometer meant for measuring low to medium air flows up to 1,999 ft/min. It uses the ultrasonic "time of flight" principle where pulses of high-frequency sound are transmitted along the air flow path and the time taken to reach the receiver is measured. The faster the air speed, the quicker the pulses reach the receiver.

The second ultrasonic anemometer that was examined underground is manufactured by Airflow Developments Ltd., Buckinghamshire, U.K. The U.S. distributor is Airflow Technical Products, Inc., Andover, NJ. The Anemosonic UA-6 (figure 2) is a battery-powered, handheld instrument with digital display. It measures air velocity (0 to 9,999 ft/min) or volume flow, flow turbulence intensity, and air temperature.

Neither device is considered to be intrinsically safe for use in underground gassy coal mines.

A comparison of salient specifications of both instruments is shown in table 1. The total suspended weight includes the instrument (Gill) or instrument probe (Airflow) plus about 35 ft of connecting cable attached to the pole. This combination of instrument plus cable length allows two operators to measure air velocities up to about 30 ft above the mine floor.

Figures 1 and 2 show how each unit would be attached to an extensible, graduated fiberglass rod in order to position the sensor probe at a certain spatial point (centroid of the quadrate) within the underground large opening.

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Table 1.—Comparison of two ultrasonic anemometers

Anemometer	Specification		
	Total suspended weight, lb	Digital readout location	Negative measurement
Gill Volometer	1.60 % 1.00 ' 2.60	On sensor unit (high above)	Within unit circuit.
Airflow Anemosonic UA-6	0.15 % 0.60 ' 0.75	On handheld unit (waist-high)	Not available on current unit; visual only.

Test Results

The following conclusions can be made regarding the potential use of these two portable ultrasonic anemometers in measuring very low air velocities in large-opening mines.

- The two ultrasonic anemometers were compared to a vane anemometer "standard" in the Mine Safety and Health Administration's (MSHA) anemometer calibration rig, a 6-in open jet wind tunnel, at airspeeds between 2,000 and 100 fpm. It was found that the coefficient of correlation between the two ultrasonic anemometers and the MSHA standard varied from 0.9620 to 1.0226.
- During in-mine evaluations, both instruments measured low air velocities equally well.
- Because of its remote readout, the Airflow UA-6 unit is most convenient to mount atop an extensible rod. However, for everyday underground use, the sensing unit on this instrument needs to be hardened.

Specific Mine Application

It would be advisable initially to use a nine equal-quadrate fixed-point traverse/mine-opening method to measure the average velocity within a large mine opening. At a given mine with extended use, fewer measurements could be made in conducting an air flow check.

The technique of mounting the lightweight Airflow UA-6 sensor probe to the top of an extensible/graduated rod, bringing a non-standard 35-ft-long connecting cable down the rod, and reading the air velocity at a convenient height above the mine floor was developed and tested by the NIOSH coauthors. Specific information on these procedures is available from them.

Because of the direct-readout design and the weight of the Gill Volometer, it is better suited to smaller cross-sectional entries that can be evaluated without resorting to extensible devices. In addition, this instrument is ideal for periodic measurement of air velocities within miners' working or breathing zones.

For More Information

For more information on this technology, contact William D. Mayercheck or Robert J. Timko, NIOSH Pittsburgh Research Laboratory, P.O. Box 18070, Cochrans Mill Rd, Pittsburgh, PA 15236-0070; phone (412) 386-6461 or (412) 386-6684, respectively; fax: (412) 386-6891; e-mail: **WMayercheck@cdc.gov** or **RTimko@cdc.gov**, respectively.

To receive additional information about occupational safety and health problems, call **1-800-35-NIOSH (1-800-356-4674)**, or visit the NIOSH Web site at www.cdc.gov/niosh

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Figure 1.—Gill ultrasonic anemometer taped to the top end of an extensible pole.

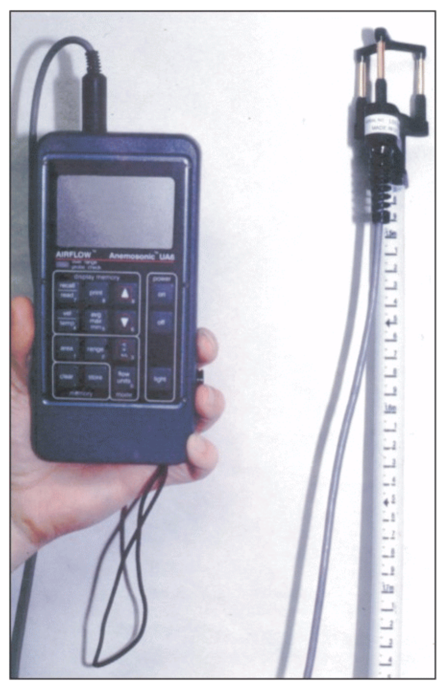

Figure 2.—Airflow UA-6 sensor probe bolted to the top end of an extensible pole.