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Machine-mounted continuous respirable dust monitor

Objective

To continuously monitor, display, and record concentration levels of respirable coal mine dust in mines to an accuracy of ±25% with a 95% confidence level for at least 30 days without servicing.

Approach

The National Institute for Occupational Safety and Health (NIOSH) has developed a machine-mounted continuous respirable dust monitor (MMCRDM) based on the tapered-element oscillating microbalance (TEOM®) sensing technology. The sensor can be mounted on mobile mining equipment and can continuously and accurately measure respirable coal mine dust mass concentrations despite the rigors of the underground mine environment. Readings of dust levels are stored in computer memory and displayed to the machine operator. The display shows dust levels averaged over various intervals and a graph of the shift average as a function of time. The monitor also incorporates several automatic diagnostic functions to detect system failure or tampering.

Such a monitor will enable mine operators and regulatory personnel to identify specific mining practices that expose mine workers to excessive dust levels. Using information provided by the monitor, mine personnel can optimize mining procedures to reduce dust exposure to miners.

How it works

The TEOM® sensor in the MMCRDM uses a tapered vibrating tube to measure the mass of dust sampled from mine air. This tube or element (figure 2) is hollow and made of metal or an elastic, grass-like material. The wide end of the tube is firmly anchored; the narrow end supports a replaceable filter and is permitted to oscillate. By drawing air through the hollow tube, the monitor collects dust from the mine air on the filter. As the filter collects dust, its increase in mass causes the tapered element to vibrate slower. By measuring the change in frequency, an onboard computer calculates how much dust was collected on the filter.

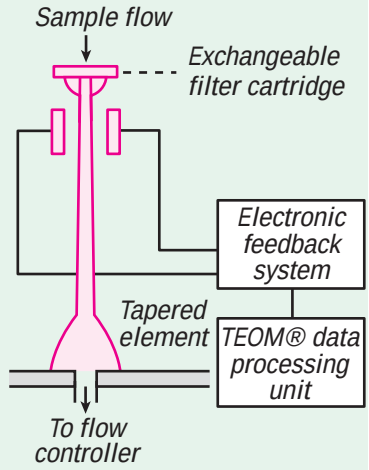

Figure 1.—Schematic of the TEOM® dust sensor

An electronic feedback system keeps the element vibrating. The details of the feedback system vary by model; typically, however, the tapered element moves across the light path between a light-emitting diode and a phototransistor. Phototransistors generate electrical signals according to how much light they receive. The light-blocking effect of the vibrating element regulates the output signal of the phototransistor, which is then amplified. Part of the amplified signal is used to provide just enough energy to keep the element vibrating. The other part of the signal from the phototransistor goes to a counter and data-processing stage. Here, the frequency of oscillation of the tapered element is calculated and stored in memory.

Unlike many aerosol measurement technologies (e.g., light scattering) that measure some aerosol parameter

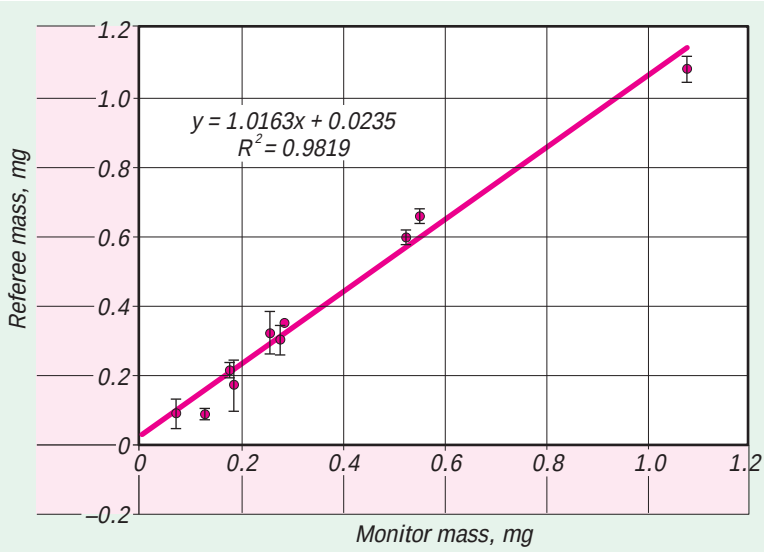

Figure 2.—Mass comparison between referee samplers and the continuous respirable dust monitor

correlated with mass, the TEOM® technique measures mass directly. Used with a cyclone or other appropriate dust size preclassifier, the instrument collects and measures respirable dust mass. However, because the TEOM® instrument indiscriminately measures mass collected on the filter, it would falsely assess any collected water droplets as aerosol mass. Changes in mine air humidity and temperature could also affect the response of the instrument. To eliminate or reduce the effects of humidity and temperature variations on the sensor, the monitor controls the inlet temperature to 50° C. Under these conditions, water aerosols evaporate, leaving only solid particles on the filter. Also, because TEOM® instruments operate by measuring the change in frequency of a vibrating element, vibrations from external sources can interfere with the measurement. A special suspension system was designed for the MMCRDM to prevent vibrations from the mining machine from disrupting the operation of the sensor.

Results

In initial tests, only the TEOM® transducer/sensor with the sample inlet and sample preclassifier were mounted on a continuous miner. Measurements were taken of mining machine vibration and respirable dust levels at the position of the sensor. Except for a consistent bias introduced by the preclassifier used in that version of the MMCRDM, the respirable dust readings compared well with those measured with conventional samplers. Baseline drift for the unit was less than 1 µg, suggesting that the sensor is adequately protected from environmental factors such as vibration and humidity.

In subsequent tests, preproduction versions of the MMCRDM were tested on both continuous and longwall mining sections. Figure 3 shows a comparison of total mass measured between the monitor and referee samplers using inlets and preclassifiers identical to those of the monitor. The comparison measurements are highly correlated and are well within the accuracy specifications of the monitor, ±25% with a confidence of 95%.

The Mine Safety and Health Administration plans to test 10 production versions of the MMCRDM in mines throughout the United States to help determine how best to use them to protect the health of miners.

Patent Status

NIOSH is not applying for a patent on this development; however, Rupprecht and Patashnick Co., Inc., Albany, NY, has patented the TEOM® aerosol mass-sensing technology. Commercial units are expected to be available in late 1997.

For more information

For more information about the MMCRDM and status of the development effort, contact Kenneth L. Williams or Bruce K. Cantrell, Ph.D., NIOSH Pittsburgh Research Center, Cochrans Mill Rd., P.O. Box 18070, Pittsburgh, PA 15236-0070, phone: (412) 892-6646 or (412) 892-4019, fax: (412) 892-6764, e-mail: kfw5@cdc.gov or bec4@cdc.gov Mention of any company name or product does not constitute endorsement by the National Institute for Occupational Safety and Health.

To receive additional information about mining issues or other occupational safety and health problems, call 1-80035-NIOSH (1-800-356-4674), or visit the NIOSH Home Page on the World Wide Web at http://www.cdc.gov/niosh/homepage.html

As of October 1996 the safety and health research functions of the former U.S. Bureau of Mines have been located in the National Institute for Occupational Safety and Health (NIOSH).

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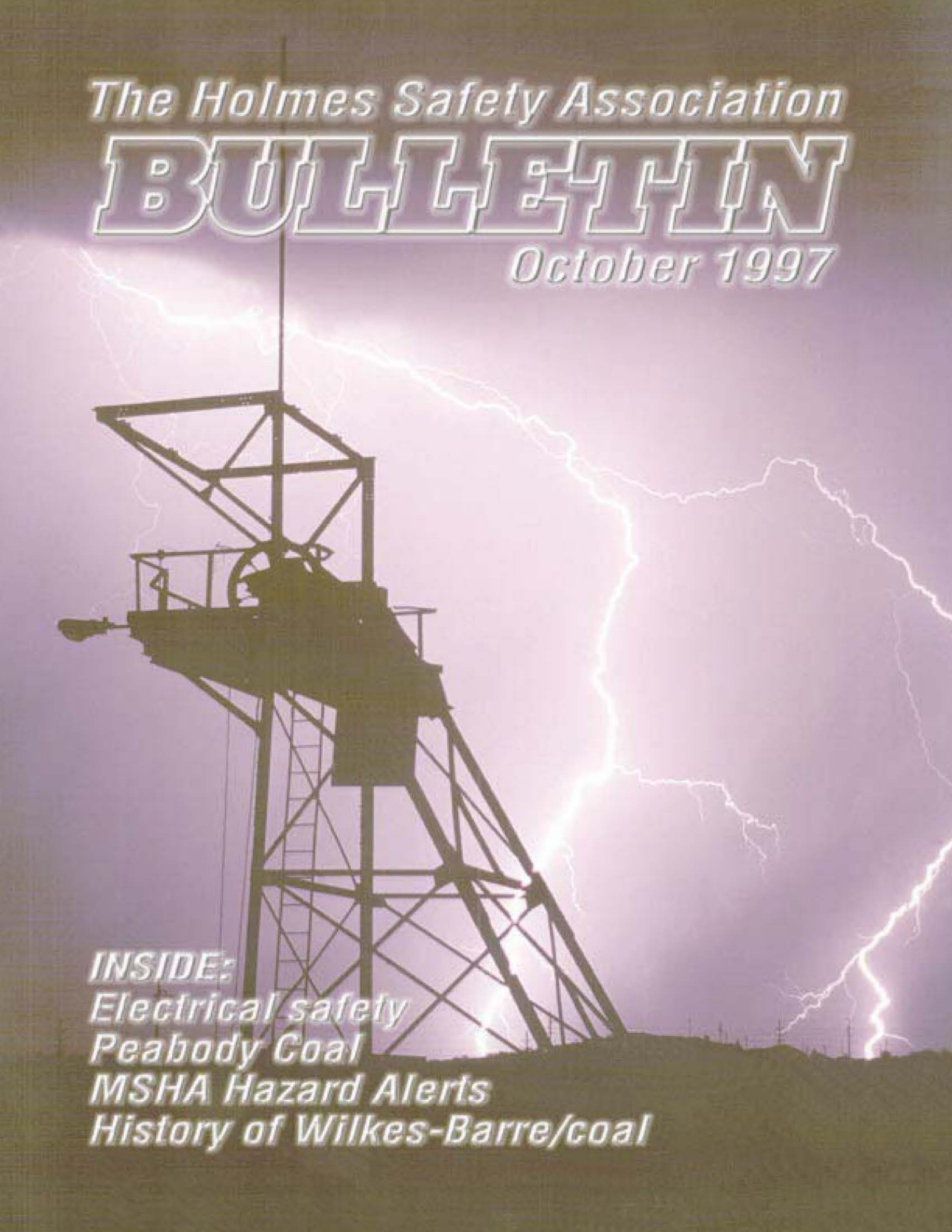
MSHA Hazard Alert

Overtraveling roadways, berms, and water hazards cost lives

Since January 1995, 15 miners have lost their lives when the equipment they were operating or riding, either traveled through an established berm, overtraveled roadways and then overturned, or carried them into a pond or other water hazard.

These types of accidents can be reduced or eliminated if mine operators do the following:

- Enforce rules governing speed, direction of travel, right of way and use of headlights.
- Design haulage roads and traffic patterns to minimize the chances for operator error.
- Establish and maintain berms along elevated roadways and around water hazards which meet or exceed MSHA requirements.
- Route traffic away from water hazards and congested areas.
- Establish a preventive maintenance program which identifies and eliminates equipment defects before operation.
- Require operators to wear seat belts.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