Technology News

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Apparatus for Measuring the Gas Content of Coal or Rock Core Samples

Objective

To design an apparatus that advances the state of the art in gas content testing equipment. The goal of the design is to incorporate improvements in testing sensitivity/accuracy, durability, and ease of operation over existing equipment. It is also desirable for the new design to successfully perform gas content determinations of multiple chemical species from a rock sample.

Background

When coalbeds and many other rock types containing organic matter are heated during burial, methane gas is formed as a byproduct. Methane can cause explosions in underground mines that can lead to fatalities and/or injuries to mine workers. To achieve safe underground working conditions, Federal law dictates that all U.S. underground coal mines dilute methane to 1% concentrations in air within active areas, about one-fifth of the lower explosive limit. The coal mining industry requires a test to measure the amount of methane in coal and associated rocks in order to design adequate ventilation systems to maintain a safe environment for underground workers. Accurate gas content data also play an important role in the economic evaluation of the mining potential of coal reserves. If methane dilution through mine ventilation is not sufficient to maintain a safe and compliant underground environment due to high methane emissions, methane drainage systems must be included in the mine plan, which increase development and operational costs.

Noncoal mines may also experience gas hazards due to emissions of methane, ammonia, hydrogen sulfide, and other gases. The quantity of gas contained in metal/nonmetal ore is generally less than that contained in coal. Consequently, metal/nonmetal mines require a gas content testing capability that has a lower detection limit and a higher degree of accuracy than is generally found in conventional gas content testing systems developed for coal. Noncoal mines frequently have a limited amount of quantitative gas content data. This lack of information can create unsafe conditions for underground workers when unplanned increases in gas emissions occur and create a hazardous work environment.

Approach

The Portable Modified Direct Method Testing Apparatus (figure 1) was designed, built, and developed by researchers at the National Institute for Occupational Safety and Health (NIOSH)'s Pittsburgh Research Laboratory. Previous gas content measurement apparatus designs utilize a column of water that is displaced by gas yielded by a rock sample in an airtight container. Through the use of modern electronic components powered by a rechargeable nickel-cadmium battery, the new design has eliminated all of the experimental problems associated with conventional water displacement technologies. The new design is easier to use, rugged, compact, lightweight, reliable, and relatively inexpensive, yet provides more accurate gas content data.

How It Works

The Portable Modified Direct Method Testing Apparatus uses the ideal gas law to relate differential gas pressure to gas volumes. To measure the gas content of a rock unit using the modified direct method, a sample from the rock unit (either a core sample or a grab sample) is collected and sealed in a lightweight enclosure. The gas pressure in the enclosure is periodically measured through a series of pressure transducers. With each pressure measurement the gas inside the enclosure is bled off, reducing the pressure to atmospheric, and a sample of the gas is collected. The gas sample is analyzed to determine the specific gas mixture. The gas pressure measurements and the gas species identified can be used to determine the total volume of gas contained in the rock unit and the specific volume of each gas identified.

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The Portable Modified Direct Method Testing Apparatus has a number of significant advantages over conventional water displacement technologies. The new design embodies improvements in sensitivity and accuracy due to the incorporation of modern electronic components. The benefit of this innovation is most significant in relatively low gas content rock samples, but accuracy is enhanced in any gas content test application. By eliminating the column of water used in water displacement systems, problems associated with the differing gas solubilities of specific chemical compounds are eliminated as a source of measurement error. Without this improvement, gases that are not very soluble in water, such as methane, tend to resist going into solution and can be more easily measured than more highly soluble gases such as carbon dioxide or nitrogen, which readily dissolve and may not be detected or measured. During the development of the modified direct method, it was recognized that interaction between organically rich core samples and oxygen within the sample container depleted the quantity of oxygen in the container.

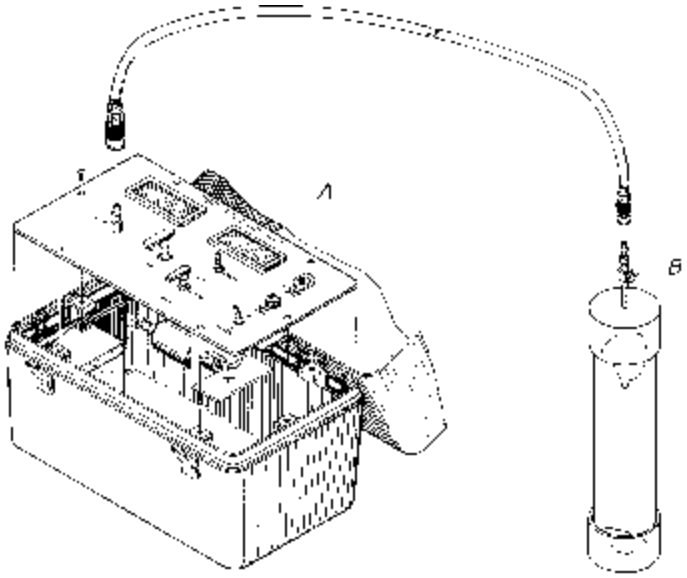

Figure 1.—*A*, NIOSH's Portable Modified Direct Method Testing Apparatus; *B*, a standard sample container with a retrieved rock core for gas content testing.

This phenomenon was found to be very common in coal core samples during methane content testing and resulted in the underestimation of methane contents, nominally on the order of at least 5% to 10% when the gas produced from the samples was not chemically analyzed. Subfreezing air temperatures are not a problem for the Portable Modified Direct Method Testing Apparatus, but can result in water line freezing with water displacement methods. The NIOSH apparatus can be used to perform gas content determinations on essentially any gas whose concentration can be analytically resolved by chromatography. The resolution improvements over conventional methods allow gas content determinations of noncoal rock cores.

Patent Status

A patent for this apparatus was granted (U.S. patent No. 5,741,959, "Portable Tester for Determining Gas Content Within a Core Sample"). NIOSH also won a prestigious R&D 100 Award for the invention; this award recognizes the 100 most technologically significant new products each year as judged by *R&D Magazine*.

For More Information

For additional information about this invention, contact Steven J. Schatzel or Fred Garcia, NIOSH Pittsburgh Research Laboratory, Cochrans Mill Rd., P.O. Box 18070, Pittsburgh, PA 15236-0070, phone: (412) 386-6521 or (412) 386-6536, fax: (412) 386-6891, e-mail: **zia6@cdc.gov** or **fbg3@cdc.gov**

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