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Coal dust particle size survey of US mines

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Abstract

The National Institute for Occupational Safety and Health (NIOSH) and the Mine Safety and Health Administration (MSHA) conducted a joint survey to determine the range of coal particle sizes found in dust samples collected from intake airways of US coal mines. The last comprehensive survey of this type was performed in the 1920s. The size of the coal dust is relevant to the amount of rock dust required to inert the coal dust, with more rock dust needed to inert finer sizes of coal dust.

Dust samples were collected by MSHA inspectors from several mines in each of MSHA's 10 bituminous Coal Mine Safety and Health Districts. Samples were normally collected in several intakes at each mine. The laboratory analysis procedures included acid leaching of the sample to remove the limestone rock dust, sonic sieving to determine the dust size, and low-temperature ashing of the sieved fractions to correct for any remaining incombustible matter. The results indicate that particle sizes of mine coal dust in intake airways are finer than those measured in the 1920s. This finer size coal dust in intake airways would require more incombustible matter to be effectively inerted than the 65% incombustible specified in current regulations.

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Keywords: Coal; Mine; Dust; Particle size; Explosion

1. Introduction

Despite the worldwide research on coal mine safety, coal mine explosions involving fatalities and injuries still occur. Experimental studies by the Pittsburgh Research Laboratory[1] (PRL) and similar agencies in other countries have shown that mixing a sufficient quantity of inert rock dust with coal dust will prevent coal dust explosions by acting as a heat sink. The requirements are specified in the Coal Mine Health and Safety Act of 1969 (US Congress, 1969) and in Title 30, Section 75.403 of the US Code of Federal Regulations (2006). They mandate that the nation's bituminous coal mines maintain an incombustible content of at least 65% in the non-return (intake) airways and at least 80% in the return airways where the potential for accumulation of finer float coal dust is greater. The US regulation also requires an additional 1.0% incombustible by weight for each 0.1% methane in the ventilating air in intakes and 0.4% additional incombustible for each 0.1% methane in returns.

The 65% total incombustible content (TIC) required for intake airways was based on the measured size of coal dust found in mines during the 1920s and the amount of rock dust required to inert that size of coal in full-scale experimental mine tests, as summarized by Nagy (1981). The term "mine size coal" was adopted in about 1925 and refers to coal dust, all of which passes a US Standard 20-mesh sieve (850 μm) and contains 20% minus 200 mesh (75 μm). The justification for adopting it is given in Bureau of Mines Technical Paper (TP) 464 (Rice & Greenwald, 1929). In the 1920s, representative dust samples were collected from mine passageways that were not rock dusted, and then they were sized using sieves. TP 464 states that these coal dust samples collected from the mine floors had 5–40% of the material less than 200 mesh. TP 464 further indicates that the values were weighted as far as possible, and for 80% of the mines, the final values ranged from 15% to 25% through 200 mesh. Therefore, coal dust

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[1]The Pittsburgh Research Laboratory was part of the US Bureau of Mines until 1996, when it was transferred to the National Institute for Occupational Safety and Health (NIOSH).

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having 20% through 200 mesh was considered to be typical ‘‘mine size dust’’ and was used in the experimental mine tests that determined the current 65% total incombustible requirement for intake roadways (Nagy, 1981; Rice & Greenwald, 1929). TP 464 states that dust collected from ribs, roof, and timbers was finer in size, with 40–75% finer than 200 mesh. TP 464 does not give any additional details on the total number of mines surveyed or the total number of samples analyzed for coal particle size. The 80% incombustible content required for return airways is based on the finer float coal dust that may be deposited there. Nagy (1981) defines float coal dust as dust that is finer than 200 mesh.

To comply with regulations, mine personnel periodically dust the mine intake and return airways with an inert material, such as pulverized limestone (rock) dust. The term ‘‘inert’’ in this sense means that the material does not support combustion. The rock dust is required to be at least 70% minus 200 mesh. In determining compliance with the regulation, inspectors from the Mine Safety and Health Administration (MSHA) periodically collect samples of deposited dust from various areas in a mine. When samples are collected in any given mine, they are usually collected at 500 ft intervals along an entry. Generally, a band sample is collected, which includes dust from the floor, ribs (walls), and roof at each location in the mine. The inspector then screens the sample through a 10-mesh sieve while in the mine, bags the sample, and sends it to MSHA's laboratory at Mt. Hope, West Virginia, for determination of the incombustible content. The fineness of the coal dust component is not measured and therefore not specifically considered in assessing the level of dust explosion protection afforded by the 65% inert requirement for intake airways.

This paper presents the results of a recent coal dust particle size survey to determine the range of coal particle sizes found in dust samples collected from intake airways in 50 US coal mines in MSHA's 10 bituminous Coal Mine Safety and Health Districts (see Fig. 1). (MSHA District 1 covers anthracite mines in Pennsylvania, which do not require rock dusting.) This research is relevant to the amount of rock dust needed to prevent coal dust explosions under current and changing mining operations.

2. Coal particle size effects

Since the amount of rock dust required to inert a mixture varies with coal particle size (Cashdollar & Hertzberg, 1989; Nagy, 1981; Rice & Greenwald, 1929; Rice, Jones, Egy, & Greenwald, 1922; Weiss, Greninger, & Sapko, 1989), the measurement of the incombustible concentration without considering the effect of coal particle size is not, by itself, sufficient to determine the possible explosion hazard. The effect of coal particle size on the explosibility is best illustrated in Fig. 2, which shows the incombustible required to prevent explosion propagation in large-scale dust explosion experiments conducted in the NIOSH-PRL Bruceton Experimental Mine (BEM) and Lake Lynn Experimental Mine (LLEM). The graph shows the amount of incombustible required to prevent propagation for Pittsburgh high volatile bituminous coal dust with 10–80% passing through a 200-mesh sieve (75 μm). Each of the data points is an individual BEM or LLEM explosion test. The lower dashed curve shows the amount to inert based on the older BEM data (Rice & Greenwald, 1929; Rice et al., 1922). The curve is the boundary between mixtures below that can propagate an explosion and mixtures above that cannot propagate an explosion. These are the data used to support the current 65% incombustible requirement for intake airways. The dotted curve shows the amount to inert based on the more recent LLEM research (Sapko, Weiss, Cashdollar, & Zlochower, 2000; Weiss et al., 1989). The LLEM data show close agreement with the BEM data for the fine size coal at 80% minus 200 mesh. For the mine size coal at 20% minus 200 mesh, the data show that somewhat more rock dust is required to prevent explosions in the LLEM than in the BEM. The reason may be that the LLEM is more adiabatic than the BEM because of the larger cross-sectional area at the LLEM.

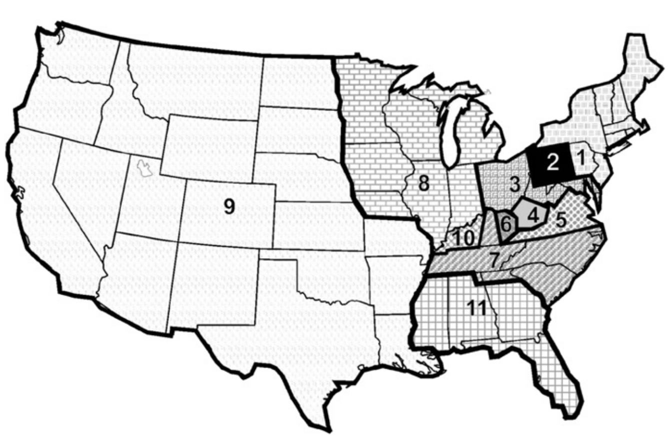

Fig. 1. MSHA Coal Mine Safety and Health Districts, identified by number.

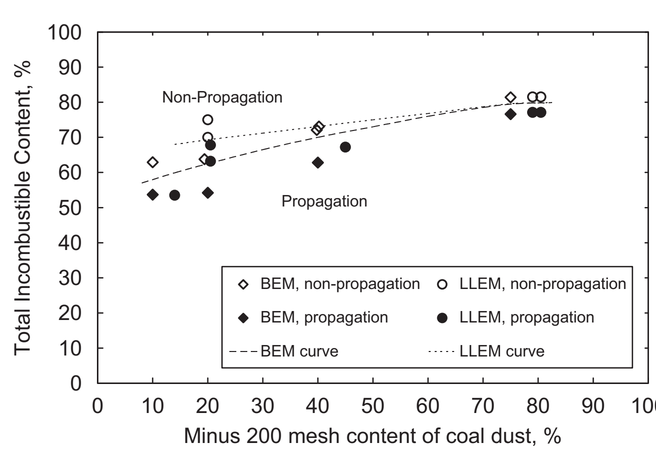

Fig. 2. Effect of particle size of coal dust on the explosibility.