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Assessing the Methane Hazard of Gassy Coals in Storage Silos

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UNITED STATES DEPARTMENT OF THE INTERIOR

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ASSESSING THE METHANE HAZARD OF GASSY COALS IN STORAGE SILOS

by

John C. LaScola,[1] Joseph E. Matta,[2] and Fred N. Kissell[3]

ABSTRACT

The Bureau of Mines investigated coal storage silos to determine how gassy coal must be for methane accumulations in a silo to become hazardous and where such accumulations are likely to occur. Methane concentrations were measured in the open space above the stored coal pile, in the pile, and in the reclaiming area. No methane layering was found in closed-top silos. Reclaiming areas were as gassy as the top part of the silos. Coal samples were collected from the conveyors entering the silos in order to assess the gassiness of the coal. No simple correlation was found between the gassiness of the coal stored and the measured methane concentrations. However, at mines where the average 24-hour gas emission from the conveyor belt samples was 14 ft^3/ton or more, fans or open tops were used. It appears that a large fraction of the methane released during storage remains in the void space between the coal particles.

INTRODUCTION

When gassy coal is stored in a confined space, methane accumulations can become an explosion hazard. Over a century ago, explosions were known to occur on sailing ships carrying coal. More recently, coal silos have been the site of methane explosions, and as deeper and gassier coals are mined in the future, proper silo ventilation will become even more essential.

The purpose of the present study was to determine how gassy a coal must be for methane accumulations to become hazardous during silo storage and where that methane was most likely to accumulate. Current silo ventilation practices, some of which are very effective, were also noted. In all, 20 different silos were visited. Coal samples were collected from the conveyor

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entering the silo and analyzed for their methane content. Methane concentrations were measured in the silo open space above the coal, in the pile, and in the reclaiming area at the bottom. Most of the mines from which the coal was obtained would be considered very gassy, with total methane emissions exceeding 1 million cubic feet per day (1),[4] whereas none of the silos visited had gas concentrations that exceeded the 1 pct legal limit.

MEASURING THE GASSINESS OF THE COAL

In general, the gassier the coalbed is, the more gas the mine and the silo contain. If a close correlation existed, silo ventilation needs could be calculated from the coalbed gas content before any coal was mined. This is not the case, however, and unless some indication of coal gas content is available, no comparison of silos at different locations is possible. Accordingly, at each of the locations visited, several grab samples of coal weighing a few pounds each were collected from the conveyor belt entering the silo. These were sealed in an airtight can equipped with a valve and short hose. Methane bleeding from the coal was periodically vented through the hose into an inverted water-filled graduated cylinder and measured. Examples of resulting methane emission curves are shown in figure 1. Such curves may be used

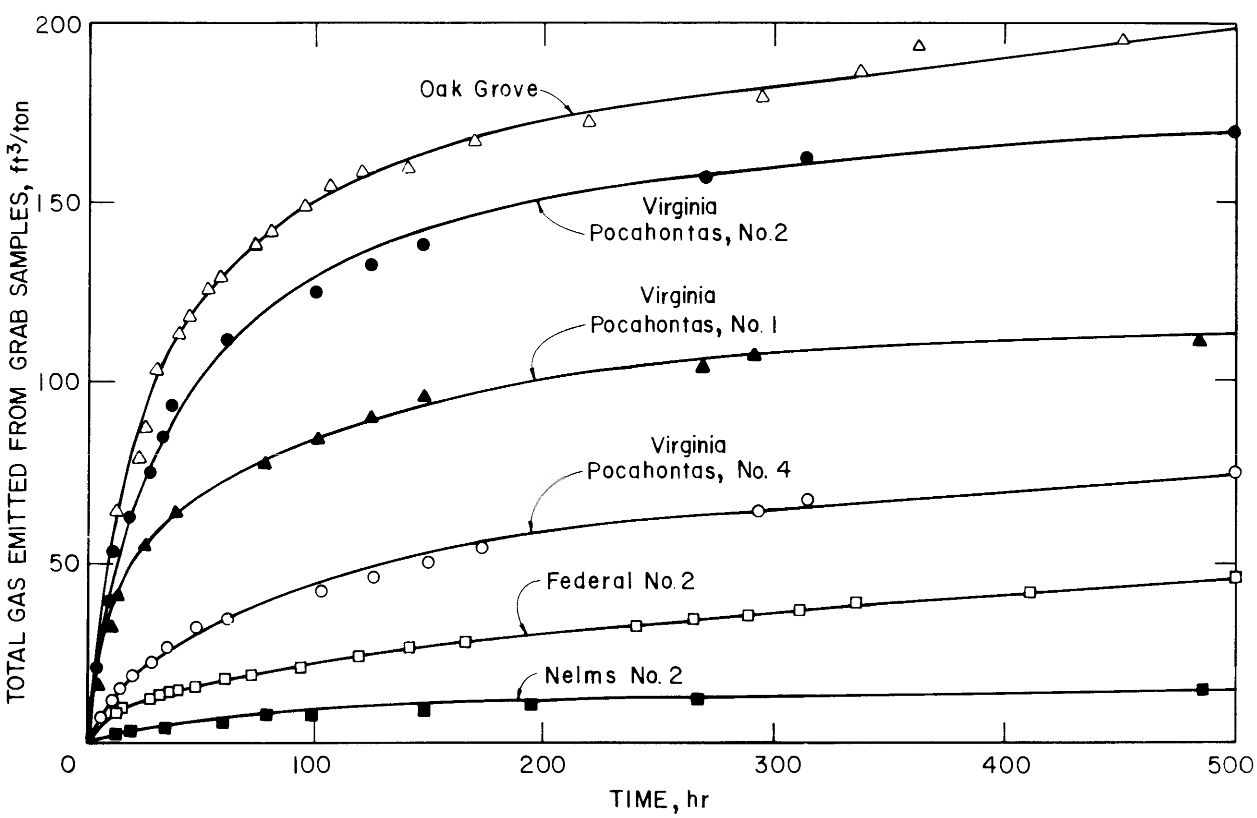

FIGURE 1. - Gas emitted from conveyor belt grab samples.

[4]Underlined numbers in parentheses refer to items in the list of references at the end of this report.

to estimate an emission rate for an entire silo (2) provided that the filling rate and quantity stored are known or estimated. Since coal is usually stored for about 24 hours, the gas emitted from the grab samples in a 24-hour period can be used as an approximate gassiness index. According to figure 1, 24-hour emissions can vary considerably, ranging from 3.3 ft^3/ton at Nelms No. 2 mine, Harrison County, Ohio, to 86 ft^3/ton at the Oak Grove mine, Jefferson County, Ala.

METHANE CONCENTRATIONS ABOVE THE STORED PILE

Silos can be divided into two groups depending upon whether their ventilation is open-top or closed-top. Open-top silos allow large air movements above the coal pile, thus reducing the hazard of a methane explosion. Closed-top silos are usually ventilated by openings at the top of the silo. These are typically rectangular holes, measuring about 1 by 2 feet and spaced along the outer edge of the silo immediately below the concrete roof. Openings on the roof such as access holes, inspection holes, and open space around the transfer point and conveyor belt enhance air circulation.

As the possibility of some methane layering in the unfilled upper part of closed-top silos has been often mentioned, this was the first area checked. For this purpose, one end of a 100-foot section of flexible plastic tubing

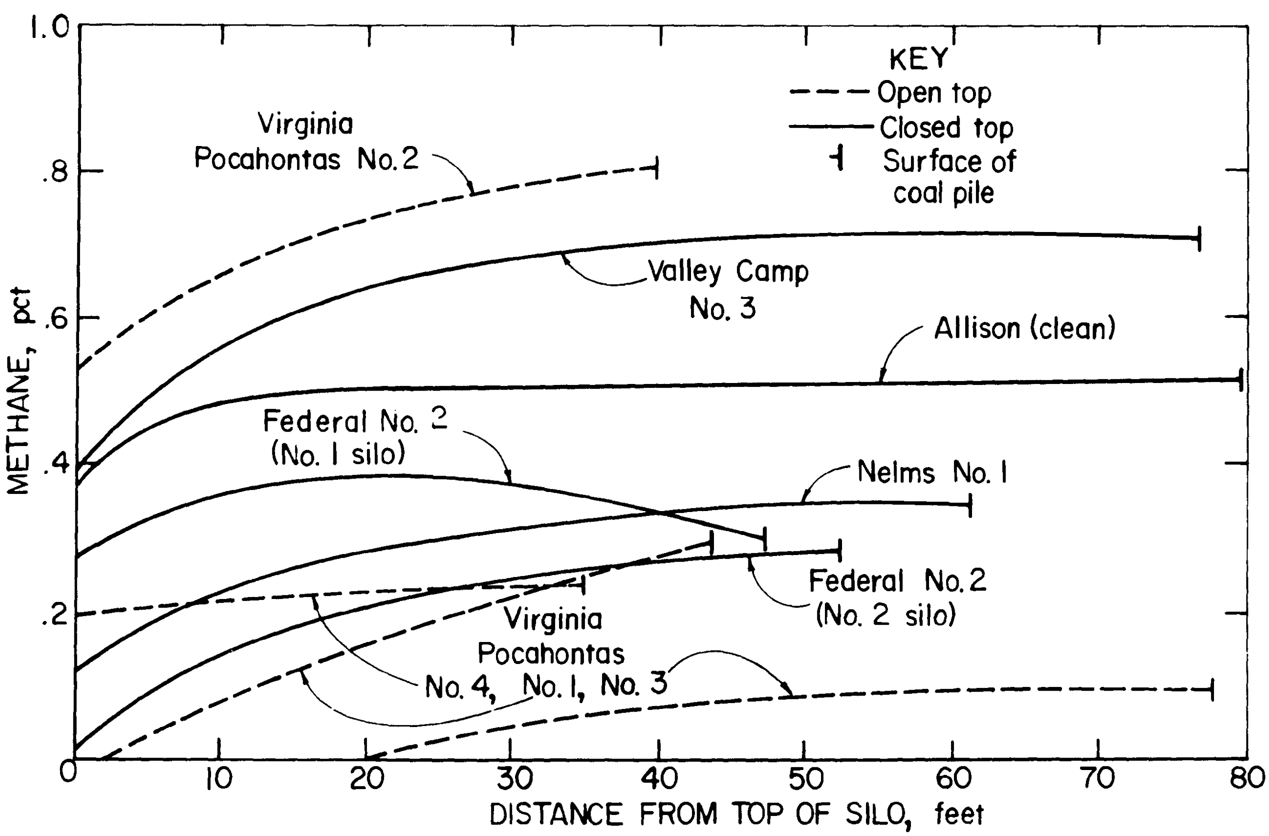

FIGURE 2. - Methane concentration gradient in coal silo.

FIGURE 3. - The Nelms No. 2 cluster of open-top silos is covered by a metal roof that allows free movement of air.

was attached to a gas detector and the other end was lowered into the silo for sampling at the centerline on 10-ft intervals. Figure 2 shows some concentration profiles obtained for open- and closed-top silos. No layering was found in closed-top silos. In fact, both types of silos showed a slight decrease in methane concentration at the top edge because of the better air circulation there.

Some unsuccessful attempts were made to correlate 24-hour gas emissions from the conveyor belt grab samples and average methane concentrations above the pile. However, it was observed that every mine, with 24-hour grab samples averaging 14 ft^3/ton or more, found it necessary either to use open-top silos or to equip closed-top silos with a fan.

An effective compromise between an open- and closed-top arrangement is used at the Nelms No. 2 mine. Here, a cluster of six open-top silos is covered by a slanted metal roof which extends high above the top edge. Large openings allow free air movement and good ventilation while providing protection against precipitation (fig. 3).

METHANE CONCENTRATIONS IN THE RECLAIMING AREA

Methane concentrations were next measured in the reclaiming area, using a methanometer and telescopic sampling probe. The highest values were generally equal to, or higher than, those on top, and these were measured in the feeders or directly above the coal on the belt while coal was being reclaimed. Figure 4 shows how the methane concentration varied as coal was loaded below a silo at the Virginia Pocahontas No. 3 mine, Buchanan County, Va. Table 1 gives some typical methane concentrations measured.

TABLE 1. - Measured methane concentrations in reclaiming area

Mine	Ventilation	Average at feeders, percent	Number of readings	Maximum value in silo, percent
Allison (Ohio).................	Natural..........	0.45	32	1.0
Beatrice (Virginia)............	5,600-cfm fan....	.21	Continuous recorders.	.3
Federal No. 2 (West Virginia)..	Natural..........	.34	38	.81
Nelms No. 1 (Ohio).............	.....do..........	.66	15	1.0
Valley Camp No. 3 (West Virginia).	20,000-cfm fan...	.54	13	.78
Va. Pocahontas No. 1 (Virginia)	13,000-cfm fan...	.68	3	.75
Va. Pocahontas No. 2 (Virginia)	8,600-cfm fan...	.33	Continuous recorder.	.4
Va. Pocahontas No. 3 (Virginia)	14,000-cfm fan...	.40	6	.68
Va. Pocahontas No. 4 (Virginia)	Natural (fan off)	.32	8	.55

On occasion it was possible to obtain a measurement of the gas quantity released. For example, at the Virginia-Pocahontas No. 3 mine, all the air ventilating the reclaiming area passed through a 14,000-cfm exhaust fan. The average fan concentration during reclaiming was 0.23 pct, indicating a total methane release of 32 cfm. It is not difficult to understand why the release of methane is so high. The density of stored coal is roughly half that of solid coal, the difference being due to void space in the silo. As the coal emerges through the feeders it entrains this void space; 260 cfm of void space

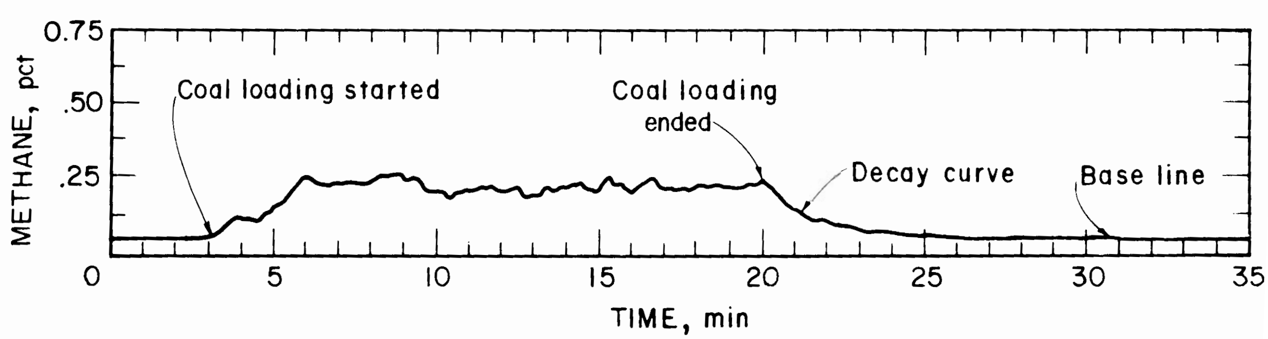

FIGURE 4. - Methane concentration as coal was loaded below silo.

corresponds to the 625 tph of coal being reclaimed. Since 32 cfm of methane was released, it follows that the void space had a methane concentration of 12 pct. A similar calculation for another silo gave 6 pct.

To check this further, a long piece of polyethylene tubing was extended from the top halfway down into an empty silo at the Federal No. 2 mine, Marion County, W. Va. It was eventually covered with coal as the silo was filled over an 8-hour period. Samples drawn from the tubing showed 14 pct methane. The calculated concentration, based on the emission from conveyor belt grab samples, was 21 pct, assuming that none of the methane migrated out of the pile (2).

VENTILATION OF THE RECLAIMING AREA

In general those mines that found it necessary to employ open-top silos (where 24-hour conveyor belt grab sample gas averaged about 14 ft^3/ton) also found it necessary to use a fan to disperse methane in the reclaiming area. Fan ventilation ranged from 5,000 to 20,000 cfm (table 1). In a few instances a tracer gas was used to measure the amount of fresh air purging the reclaiming areas. The tracer gas technique has the advantage that it can be applied with or without a fan (3). At the Federal No. 2 mine, sulfur hexafluoride (SF_6) gas was used to determine the amount of natural ventilation in the reclaiming area of a double silo. No fan was used, but openings totaling 140 ft^2 gave access to the outside. A plot of SF_6 concentration versus time (fig. 5) indicated a fresh air quantity of 11,700 cfm.

At the Virginia-Pocahontas No. 3 mine, the methane emerging from the feeders along with the coal was used as the tracer gas. When coal loading ended, the methane concentration decayed (fig. 4). A plot of the decay curve (minus the baseline concentration) is also shown in figure 5. The slope gives 8,800 cfm. The silo had a 14,000-cfm fan and it was evident that not all the air passing through the fan was ventilating the feeders. The fan was mounted above an open doorway. Although this decreased its effectiveness somewhat, there would still be considerable natural ventilation if the fan were to fail.

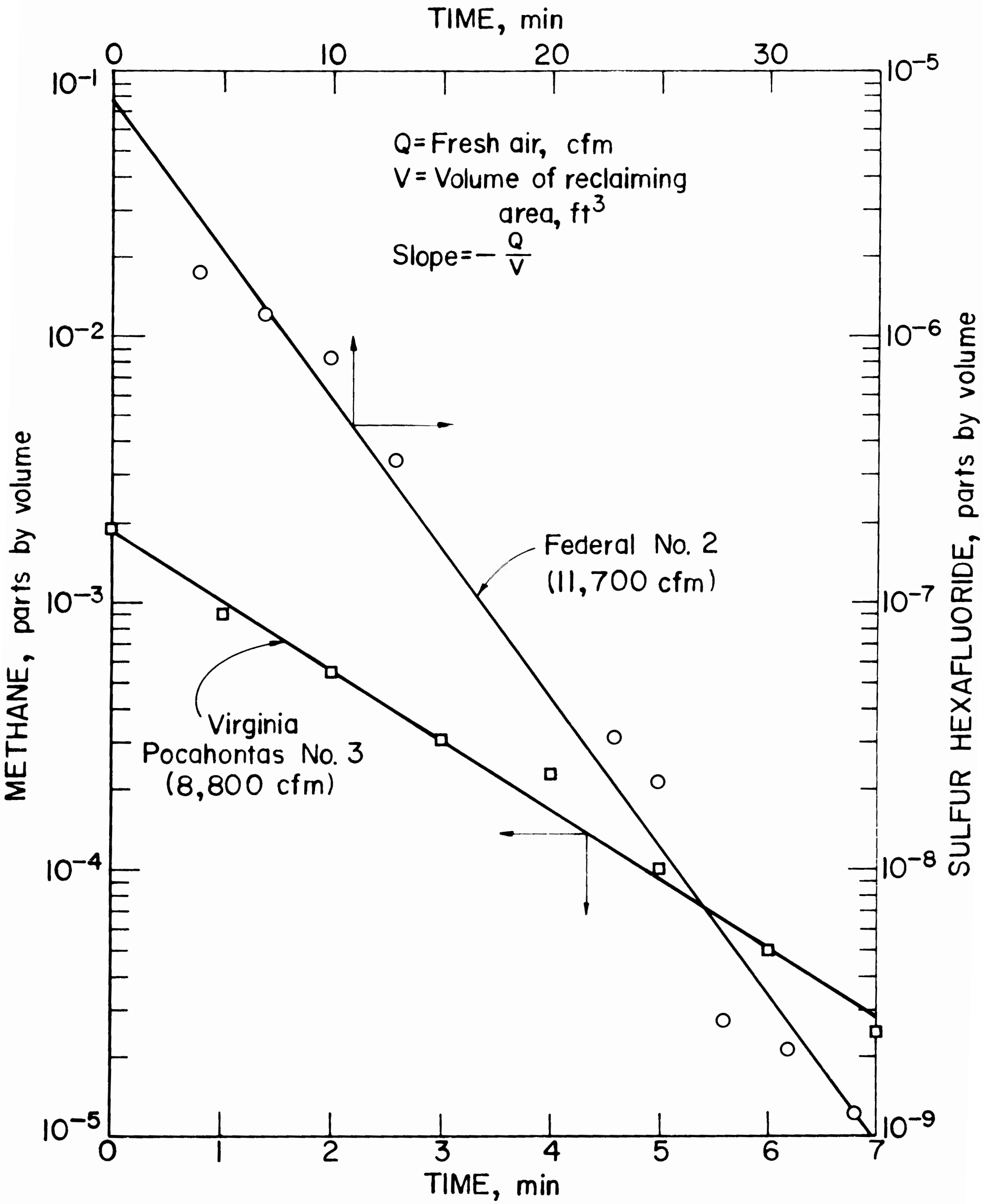

FIGURE 5. - Tracer gas decay curves.

SUMMARY

1. At mines where the average 24-hour gas emission from the conveyor belt grab samples was 14 ft^3/ton or more, ventilation was enhanced by using open-top silos or a fan at the top, as well as a fan in the reclaiming area.

2. No methane layering was found in closed-top silos. If anything, the methane concentration at the roof was less than that in the rest of the silo.

3. Reclaiming areas were as gassy as the top part of the silo. Methane is released as coal is reclaimed, and a large fraction of the methane released during storage appears to remain in the void space between the coal particles.

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