CHAPTER 11.—CONTROL OF METHANE IN COAL SILOS

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In This Chapter

- ✓ Measuring the gas emission from the coal
- ✓ Methane at the top of the silo
- ✓ Methane at the load-out area

and

- ✓ Actions taken after a silo explosion

Methane accumulations in coal silos have resulted in the occasional silo explosion. These can be quite violent and dangerous because coal dust adds to the strength of the blast. However, with the appropriate precautionary measures, methane accumulations in silos can be greatly reduced.

Mine Safety and Health Administration (MSHA) regulations at 30 CFR[2] 77.201 require that the methane content in the air of any coal silo be maintained below 1.0 vol %.[3] Also, MSHA requires that methane tests be conducted before any electrical equipment is energized, unless a continuous monitor capable of deenergizing the electrical equipment is used.[4]

Measuring the gas emission from the coal. The first necessary step in dealing with silo methane issues is to measure the gas emission from the coal going into the silo. Such measurements allow one to estimate the silo ventilation needs and permit a comparison with the methane controls used at other mines that have similar gas levels.

The gassiness of the coal can be measured by taking conveyor belt grab samples.[5] Matta et al. [1978] measured the gas emission from conveyor belt grab samples using a simple desorption test. To conduct the test, they collected several grab samples of coal, weighing a few pounds each, from the conveyor belt entering the silo.[6] They then sealed the coal into an airtight sample container that was equipped with a valve and short hose along with a pressure gauge. Every few hours they opened the valve and bled the emitted gas into a water-filled graduated cylinder that had been inverted and placed in a pan of water (Figure 11–1). The results are shown in Figure 11–2.

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[2]*Code of Federal Regulations.* See CFR in references.

[3]The presence of coal dust reduces the methane lower explosive limit (LEL) value below 5%, and so the safety factor from the specification of a 1% value can be less than 5. For more information, see Chapter 12 on dust explosions.

[4]Equally important, monitor heads must be placed in locations where methane is likely to accumulate.

[5]This must be done safely, i.e., the belt must be stopped before the sample is removed.

[6]Most of these mines had an overall mine emission rate exceeding 1million ft^3 per day, placing them in the ranks of the gassiest U.S. mines.

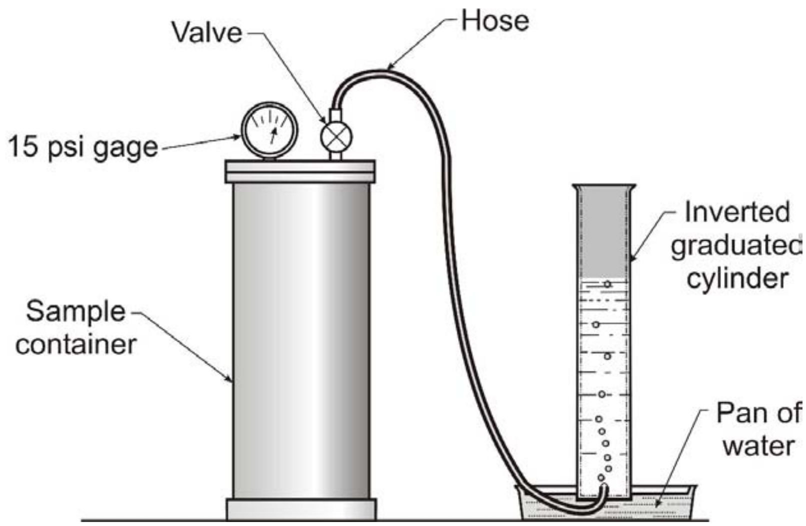

Figure 11–1.—Desorption test apparatus.

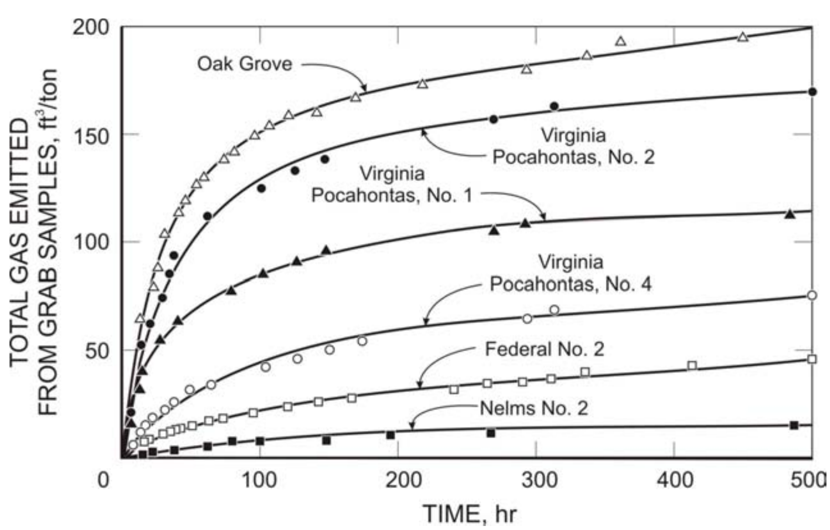

Figure 11–2.—Gas emitted from conveyor belt grab samples.

LaScola et al. [1981] also collected conveyor belt grab samples. Since the coal in the silos they investigated was usually stored in the silo for about 24 hr, they used the 24-hr cumulative emission value as a comparative index. These 24-hr emission rates ranged from 3.3 to 86 ft^3/ton. LaScola et al. noted that all of the mines with 24-hr emission values exceeding 14 ft^3/ton had open-top silos to provide better ventilation at the top. Also, most had forced ventilation of the reclaiming areas, at ventilation rates ranging from 5,600 to 20,000 cfm.

Kolada [1985] reported similar gas amounts from silo conveyor belt samples at Canadian mines.[7] Interestingly, grab samples from coal entering clean coal silos sometimes gave emission rates five times higher than coal entering raw coal silos. This is not what one would expect since clean coal has been out of the mine longer. However, in these instances, the clean coal had been passed through a fluidized bed dryer to remove moisture and its temperature was 40 °C as it was being loaded into the silo. The higher temperature greatly increased the methane emission rate.[8]

[7]More information on this study is available from AMCL [1985].

[8]The breakage of coal during the cleaning process could also have been a contributing factor to the elevated methane emission. Friable coals will fracture into smaller size particles during coal cleaning, and smaller size particles will give off methane more quickly [Mikhail and Patching 1980].

Closed-top silos should always be recognized as a potential methane problem. Provision must be made for continuous mechanical ventilation if the silo has a closed top.

Methane at the top of the silo. LaScola et al. [1981] also measured the silo gas concentration above the stored coal pile at a wide variety of coal mines. Both open-top and closed-top silos were visited. Open-top silos allow large air movements above the coal pile, reducing the hazard of a methane explosion at the top. However, dust emissions during silo loading can be a problem. Closed-top silos are usually ventilated by openings at the top of the silo. These are typically 1- by 2-ft holes spaced around the perimeter immediately below the concrete roof. Some closed-top silos have ventilation fans or dust collectors.

In the LaScola et al. study, gas measurements of the open space above the coal pile were conducted by lowering flexible plastic tubing down the center line of the silo and pumping the gas to a methane detector. Measurements were made at 10-ft increments until the coal pile was reached. The results are shown in Figure 11–3. Methane concentrations were not excessive, and there was no layering[9] of methane at the top of the silos.

Kolada [1985] conducted measurements above the coal pile in Canadian coal silos following a similar procedure. The methane found was within a few inches of the coal, where the concentration ranged from 0% to 2% methane. When the silo was discharging, the methane concentration within a few inches of the coal ranged from 0% to 6% methane.

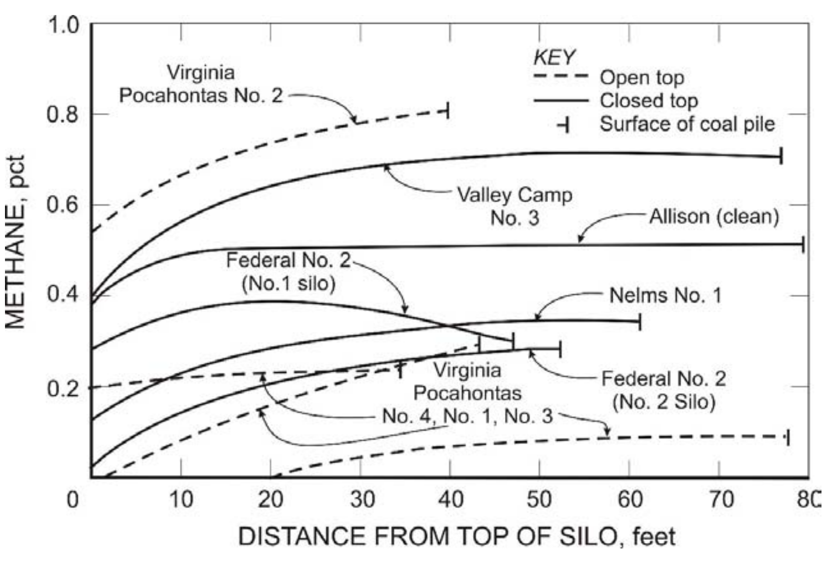

Figure 11–3.—Methane concentration gradient above the coal in coal silo.

Methane at the load-out area. The load-out area at the bottom of the silo is always a potential location for methane accumulations. These accumulations may increase if the coal has been stored for longer than normal periods. Methane detectors and adequate ventilation must be provided. Electrical switchgear should be minimized in load-out areas, especially if the load-out is

[9]The lack of layering is not surprising since the coal pile where methane is released is below the silo roof. Studies on methane layering in mine entries have usually measured mine roof layers caused by methane *released at the roof* of the mine. When methane is released at the mine rib, the tendency to layer at the roof is much less, and the tendency to layer at the roof is even less so for methane released at the mine floor. Moreover, once methane is mixed into the air, it does not unmix to form layers. See the discussion on layering in Chapter 1.

enclosed in a tunnel-like structure. Special attention should be given to railroad load-outs when electrical locomotives are used because of the additional ignition source.

At the bottom of every silo, the methane emission should be measured as coal is reclaimed, and mechanical ventilation should be provided if there is any likelihood of methane buildup.

Although methane measurements taken during the reclaiming of coal are valuable, the values obtained only reflect the circumstances at the time. These measurements can be supplemented by an estimation of ventilation requirements calculated from the gas concentration in the coal pile.

Gas concentration inside the coal pile has been measured directly and also calculated from the coal emission measurements. In the study by Kolada [1985], tubing was extended down into several silos, where it was buried with coal as the silo was filled. At the same time, a conveyor belt grab sample was taken and the emission from the grab sample was measured. At one silo, the conveyor belt grab sample emitted 0.013 L/kg in the first 30 min. The coal pile was known to have a bulk density of 800 kg/m^3 and 41% void space, so the amount of gas given off by a cubic meter of coal pile was 0.013 × 800, or 10.4 L of methane. Next, the concentration of methane in the coal pile was calculated to be equal to the volume of methane divided by the volume of air plus methane, or 2.5%.[10] The measured value, which Kolada obtained by pumping air from a tube buried in the coal pile for 30 min, was about the same as this calculated concentration value.

Using the above approach at several silos, Kolada obtained methane concentration values as high as 35%. However, for any given silo the concentration will depend on both the emission rate and the amount of time the coal remains in the silo.

During the reclaiming of coal, methane gas in the void space will emerge into the coal discharge gallery. Kolada has given a sample calculation, assuming a peak coal discharge rate of 1,021 kg/sec, a bulk density of 800 kg/m^3, 41% void space, and a methane concentration of 35%[11] in the void space. A discharge rate of 1,021 kg/sec corresponds to 1,021/800 = 1.28 m^3/sec. The methane discharged is then 1.28 × 0.41 × 0.35 = 0.184 m^3/sec = 389 cfm. Reducing this flow of methane to a 1% concentration will require an airflow of 38,900 cfm.

Actions taken after a silo explosion in British Columbia. Stokes [1986] reported on the actions taken after an explosion at a closed-top silo in British Columbia, Canada. These postexplosion actions serve as a good model for mines desiring to prevent a methane explosion in a coal silo.

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[10]If 41% of the coal pile is void space, the void space in the cubic meter would be 410 L and the concentration of methane in the void space would be 10.4/(410 + 10.4), equal to a calculated concentration value of 2.5%.

[11]A value of 35% may seem high, but Kolada and Chakravorty [1987] measured methane concentrations as high as 40% in a silo coal pile within an hour of filling the silo. These concentrations are not in the flammable range, but will become so when mixed with air. See the discussion on flammability in Chapter 1.

The coal had been surface mined. Surface-mined coal normally has a very low methane emission; however, the coal had been heated in a dryer[12] to remove moisture just before being loaded into the silo. The 24-hr conveyor belt grab sample emission was measured at 14 ft^3/ton. Before the explosion, the top was ventilated with a 7,500-cfm wet dust scrubber system that operated only during loading. An unworkable[13] natural ventilation methane stack was located on the silo roof. There was also a methane detector at the roof of the silo (probably in a location where the methane did not accumulate).

After the explosion, the silo was put back into operation with these new methane control and damage prevention measures:

- Continuous ventilation was provided at the top. A 14,000-cfm dust scrubber system[14] operated when the silo was loading. When loading stopped, another fan, a 20,000-cfm forcing fan, automatically turned on, and this fresh air was deflected downward toward the coal surface.

- Other openings at the top were provided to supply fresh air in the event of fan failure.

- A new methane monitoring system that used several sensing heads was installed. Using several heads reduced the chance that a methane accumulation would be missed.

- A large portion of the roof was provided with a lightweight sheet metal cover that could provide some explosion relief without damage to the main structure of the silo.[15]

These measures provided for continuous ventilation in a quantity matched to the gas level and provided for monitoring in locations where methane was likely to accumulate. They considerably reduced the chance of a silo explosion.

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[12]Hot coals from the dryer were a probable source of the ignition. Hot coal detection systems can flag this problem and should be installed if the coal is gassy.

[13]The idea behind a natural ventilation methane stack is to use the density difference between methane and air to produce a chimney effect that ventilates the silo. However, neither the stack height nor the methane concentration at any silo would ever be high enough to make a natural ventilation methane stack function.

[14]Dust problems precluded the conversion to an open-top silo.

[15]The National Fire Protection Association has a guide for venting of deflagrations [NFPA 1998], i.e., methane and dust explosions.

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