# PRB Coal Users' Group Annual Meeting

## DUST MANAGEMENT WASHDOWN SYSTEMS CASE STUDY

**Electric Power 2004 Baltimore, MD**


Presenters: **Dave Hopkins, KCP & L**

David Hopkins is the fuel yard superintendent at La Cygne Generating Station for Kansas City Power & Light.

**Michael Harris, Air-Cure Inc.**

Michael Harris of Air-Cure Inc. has 30 years of experience in designing and supplying PRB Coal Dust Systems.


The following was presented by Michael Harris of Air-Cure, Inc.

My experience, as many of you know, is in coal dust collection and processing. I have worked on dust handling since 1970 and have a long history in observing, analyzing and implementing solutions to improve the safety of handling PRB coal. We are now in another step of this evolution with the application of fixed-pipe washdown systems; a system of spray nozzles which will remove the fine coal dust from all surfaces within the coal handling areas.

My interest in washdown comes from its common goal with dust collection. Both technologies focus on reducing the dust concentrations to below the "minimum explosible concentration" (MEC), or alternatively called the "lower explosible limit" (LEL). Dust collection accomplishes this with the introduction of dilution air. Its purpose is to reduce the probability of a deflagration during operation, as well as to minimize dust emissions to coal handling areas reducing employee exposure and settling dust that can cause secondary deflagrations. Washdown removes accumulations of settling dust, which when disturbed, cause an airborne minimum explosible concentration. So with this short explanation as to why, let us examine the reasoning in more detail.

Mr. Dave Hopkins will be discussing the real world operating performance as a case history at KCP & L - LaCygne Station, an application of the fixed-pipe washdown system. My discussion will focus on the general need for the application, design considerations and the expectations of performance.

### The need for washdown - safety

In handling PRB coal there are three main differences compared to bituminous coals:

- Tendency of spontaneous combustion
- Increased quantity of dust
- Higher moister content

This means we are handling a fuel that has a large amount of fine dust, which easily becomes air entrained or airborne while handling, exposing the dust to more oxygen. The prevalence of spontaneous combustion provides a ready source of ignition, completing the necessary components to have frequent deflagrations. With an ignition source and oxygen available, the only remaining requirement is sufficient fuel. This is where MEC, "minimum explosible concentrations" (NFPA 68, also referred to as LEL, "lower explosible limit"), or the fact the mixture is too "lean" to combust comes into affect. Dr. Michael Rodgers (Presentation, 2001) explained the deflagration as a chain reaction. Before an unbroken chain occurs there has to be sufficient fuel mixed with air to generate a critical mass of free radicals which form the chain.

I have referenced three listings for the MEC for coal dust.

| | | | |
|---|---|---|---|
| **NFPA** | Bituminous | 60-g/m³ | 24u |
| (NFPA 68-50) | Lignite | 60-g/m³ | 32u |
| **K.N. Palmer** | Coal | 50-g/m³ | |
| (Appendix 2) | Lignite | 30-g/m³ | |
| **Michael Rodgers, Ph.D.** | PRB Coal | 20-g/m³ | |
| (Presentation, 2001) | | | |

These values are dependent on moisture, particle size and strength of the ignition source, as well as chemistry and shape. The above chart also states the average particle size in microns assumed for achieving the MEC value. From our analysis of PRB coal dust, the average particle size listed is consistent with the dust collected in dust collectors.

Dr. Michael Rodgers of Georgia Tech presented the results of an EPRI sponsored study in 2001, indicating that particles above 400 microns will not deflagrate and the big change in explosiblity is between 7 and 40 microns for PRB coal dust. Our results have indicated that 10% of the collected dust from PRB coal handling is at or below the 10 micron diameter.

Now with our understanding of MEC, I want to direct your attention to the NFPA Guidelines as an accepted reference to explain the application to coal handling areas.

The NFPA guideline 654, "Prevention of Fire and Dust Explosions from the Manufacturing, Processing and Handling of Combustible Particulate Solids", is clearly applicable to this discussion. In Appendix A paragraph A.2.2.3.1, the NFPA states directly:

> A relatively small initial dust deflagration can disturb and suspend in air dust that has been allowed to accumulate on the flat surfaces of a building or equipment. This dust cloud provides fuel for the secondary deflagration, which can cause damage. Reducing significant additional dust accumulations is therefore a major factor in reducing the hazard in areas where a dust hazard can exist.
>
> Using a bulk density of 75-lb/ft³ (1200-kg/m³) and an assumed concentration of 0.35-oz/ft³ (350-g/m³), it has been calculated that a dust layer averaging 1/32-in. (0.8-mm) thick and covering the floor of a building is sufficient to produce a uniform dust cloud of optimum concentration, 10-ft (3-m) high, throughout the building. This situation is idealized; several factors should be considered.

(NFPA guideline continued on next page)

First, the layer will rarely be uniform or cover all surfaces, and second, the layer of dust will probably not be dispersed completely by the turbulence of the pressure wave from the initial explosion. However, if only 50 percent of the 1/32-in. (0.8-mm) thick layer is suspended, this material is still sufficient to create an atmosphere within the explosible range of most dusts.

Consideration should be given to the proportion of building volume that could be filled with a combustible dust concentration. The percentage of floor area covered can be used as a measure of the hazard. For example, a 10-ft x 10-ft. (3-m x 3-m) room with a 1/32-in. (0.8-mm) layer of dust on the floor is obviously hazardous and should be cleaned. This same 100-ft² (9.3-m²) area in a 2025-ft² (188-m²) building is also a moderate hazard. This area represents about 5 percent of a floor area and is about as much coverage as should be allowed in any plant. To gain proper perspective, the overhead beams and ledges should also be considered. Rough calculations show that the available surface area of the bar joist is about 5 percent of the floor area. For steel beams, the equivalent surface area can be as high as 10 percent.

From the preceding information, the following guidelines have been established:

(a) Dust layers 1/32-in. (0.8-mm) thick can be sufficient to warrant immediate cleaning of the area [1/32-in. (0.8-mm) is about the diameter of a paper clip wire or the thickness of the lead in a mechanical pencil].

(b) The dust layer is capable of creating a hazardous condition if it exceeds 5 percent of the building floor area.

(c) Dust accumulation on overhead beams and joists contributes significantly to the secondary dust cloud and is approximately equivalent to 5 percent of the floor area. Other surfaces, such as the tops of ducts and large equipment, can also contribute significantly to the dust cloud potential.

(d) The 5 percent factor should not be used if the floor area exceeds 20,000-ft² (1860-m²). In such cases, a 1000-ft² (93-m²) layer of dust is the upper limit.

(e) Due consideration should be given to dust that adheres to walls, since it is easily dislodged.

(f) Attention and consideration should also be given to other projections such as light fixtures, which can provide surfaces for dust accumulation.


Washdown Matrix

(g) Dust collection equipment should be monitored to ensure it is operating effectively. For example, dust collectors using bags operate most effectively between limited pressure drops of 3-in. to 5-in. (0.74-kPa to 1,24-kPa) of water. An excessive decrease or low drop in pressure indicates insufficient coating to trap dust.

Guidelines (a) through (g) will serve to establish a cleaning frequency.

## Analysis of the Guideline.

The guideline begins by briefly stating the requirement to remove dust layers from coal handling facilities and considers it a major factor in reducing the hazard.

It follows with a sample calculation to demonstrate the amount of dust to achieve a MEC. If we take the formula and input the values for MEC at 60 g/m3 and bulk density of PRB coal dust at 40 lbs/ft3 the resulting dust thickness is 1/100 of an inch or an inconceivably small number. This calculation is tempered in the next paragraph by a 50% factor, making the dust thickness to achieve MEC 1/50 of an inch. This is still significantly smaller than 1/32 of an inch. Thus far, we are still only referring to the floor area.

The fourth paragraph of A.2.2.3.1 brings more reality to the subject. The dust on the beams, walls and equipment is more of a factor because of its tendency to become airborne. Since, not many coal handling facilities are constructed of bar joists, 10% additional area for steel beams is applicable. However, if we just consider the roof beam area and multiply our dust thickness by (10) because of the 10% area reduction, assuming the same 50% efficiency factor, a thickness of 1/5 of an inch on the roof beams will produce the same MEC with the floor just having been cleaned. In reality, not all of the dust on the


Cleans Steel Beams

roof beams will become airborne, however, there is the wall area, equipment, ducts and many other ledges above the floor that could move in the event of a primary deflagration to release dust into the air. Adding all aspects together (beams, walls, equipment, floors, etc.), one can begin to realize the dust thickness required to achieve MEC is very minimal and can be achieved rather rapidly during normal operation.

In summary, the NFPA states these specific guidelines for removing coal dust:

A. Any layer thickness greater than a pencil lead should be cause to warrant immediate cleaning via:
- Washdown
- Vacuum
- Sweeping

B. All surfaces should be cleaned:
- Steel beams
- Walls
- Equipment - ducts
- Floors
- Light fixtures

C. The dust collection and washdown equipment "should be monitored to ensure it is operating efficiently" (NFPA 654 Paragraph A.2.2.3.1.g).

## The need is established, so how does Fixed-pipe Washdown integrate with the system?

The design of the fixed-pipe washdown system involves some simple parameters:

1. **Drainage**. Even when using hoses, the removal of water and the associated coal dust has to be planned. Having the water flow into the silos or bunkers from an in-plant coal handling area is not a good plan. Drains and drainpipes need to be installed on flat or minimum slope surfaces. Sloped conveyors do not require drains except at the bottom of the gallery. Additional sumps and associated pumping equipment may be required to convey the water and dust. Ultimately, the site has a permitted pond for storage and processing of the coal dust.

2. **Water Supply**. Both supply volume and pressure are important in the design. The number of zones in the fixed-pipe design is determined by these values. With higher pressure and volume fewer zones are required, the washdown process takes less time, and the installed and labor operating costs are lower. A booster pump is cost effective for the in-plant silo or bunker areas. Water quality is also important. A strainer is the minimum requirement, with filtration and/or a chemical injection of anticorrosion chemicals at the other end of the spectrum.

3. **Operating Environment**.

A. *Primary Dust Control*. The fixed-pipe washdown system is generally not designed to remove large accumulations and will not perform this efficiently. This is a spot for the broom and shovel. Belt spillage must be controlled by proper skirt boards, covers, and design of the belt conveyor system. Another example of this is a car dumper, which can accumulate dust inches thick in one train with no dust control. This must be controlled by a primary means other than the washdown system.

B. *Climate*. Operation of any washdown with water below freezing temperatures is not possible. In-plant areas are generally heated providing a year around environment to operate washdown, but the drainage must also be freeze protected. Obviously, the further south your location is will provide more availability to year around operations and savings on installation.


Booster Pump

4. **Sealing**. It is necessary to keep the water and coal dust going down the drains, rather than escaping out penetrations into the remainder of the power plant. Sealing floors, walls, joints, door openings, thresholds and miscellaneous penetrations in both the building and equipment is good preventive maintenance. It may be necessary to remove metal from the bottom of access doors, especially to adjacent electrical rooms; and install higher thresholds on the floor to prevent seepage.


Primary Dust Control

### Washdown Description.

The fixed-pipe washdown system is a matrix of pipes and spray nozzles arranged into zones to systematically remove the dust from all surfaces within the coal handling areas. The spray nozzle emits a fine spray, which gently removes the dust from the ledges to the floor area where other nozzles direct the dust to the drains. Typically each zone operates for 5 to 10 minutes before sequencing to the next. After operation in each zone, the piping layout self-drains to avoid freezing. The proper arrangement will remove 95% of the coal dust particulate 1/8" or smaller. A simple concept and operation, but requires experience to achieve the correct layout and components. The layout avoids directing nozzle sprays at sensitive areas, such as motors and electrical enclosures. Even with experienced placement, the system is tested and adjusted after assembly to insure complete coverage.


Fixed-Pipe Washdown

After understanding the design concept of a fixed-pipe washdown system, we can evaluate the advantages and concerns regarding its application.

**Our earlier review explains how safety is the major advantage, but there are others worth mentioning:**

1. *Consistent Quality*. The human factor is removed from performing a tedious task. The fixed-pipe system performs a consistent washdown every time. Quality can be checked and necessary spray nozzles can be adjusted to ensure all accumulations are addressed. This assures that safety is accomplished.

2. *Labor Reduction*. The labor savings is substantial since only one operator is required to accomplish fixed-pipe washdown, even with some hose clean-up of the remaining 5%, which Mr. Dave Hopkins of KCPL can address in more detail. Labor savings at LaCygne Station was ¼ of the time it took for hose cleaning, and the hose cleaning did not provide the same consistent quality.

Zones

3. *Gentle Rain*. The spray nozzles generate a gentle rain effect, which can be directed at sensitive equipment, avoiding the high pressure hose. Correct placement of the nozzles will also further limit direct impingement on equipment.

4. *Eliminates use of Fire Protection Systems as Washdown*. Sometimes Fire Protection Systems are employed as a makeshift washdown system. Obviously, the quality of the washdown is not as efficient, but there is also the wear on the fire system components (i.e. deluge valve, sprinkler heads), which are designed and there to function for other safety concerns.

5. *Work Environment*. A cleaner work environment promotes more efficient operation.



**There are disadvantages or concerns regarding fixed-pipe washdown also:**

1. *Accessibility for maintenance*. The addition of the pipe matrix makes access to the mechanical equipment such as belt conveyors more difficult. Although care is taken during installation to avoid this problem, addition of any equipment in a retrofit will impact maintenance of your existing equipment.

2. *Electrical System*. Water entering into the electrical system is a concern. Although any form of washdown will have this problem. There are sites where vacuum removal of dust is the only practical means of clean-up due to poor electrical design.


Consistent Quality

3. *Equipment Inspection*. An automatic washdown system does not require any operator attention. There is no one to walk the handling system for casual inspection, for operational problems.

4. *Time limitations*. There are coal handling systems which have a duty cycle which precludes sufficient time for the number of zones to be cleaned.

5. *Freezing*. A problem in freezing climates.

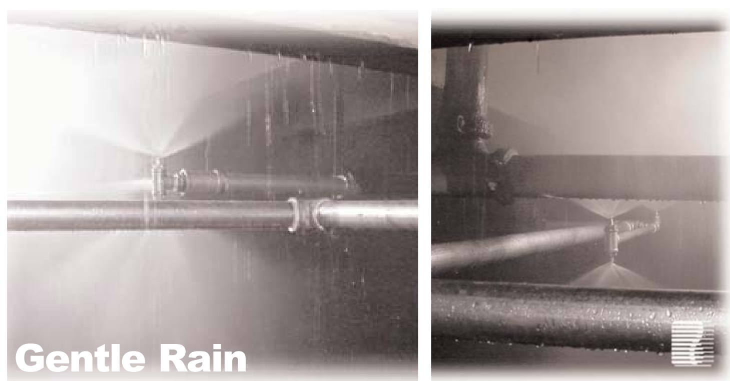
6. *Additional Maintenance*. All equipment requires maintenance and it is recommended that a yearly inspection be performed to insure all nozzles are operating and nozzle adjustments are correct. this is best performed in the spring to correct any problems that may have occured due to freezing.

## Washdown Performance

We hope at this point in the discussion we have formulated the concept of fixed-pipe washdown. However, the proof is in the actual operation. Mr. Dave Hopkins will review their operating perspective after more than one year of experience at the LaCygne Station for Kansas City Power and Light. In our opinion, the experience at KCP&L is representative of other installations on fixed-pipe washdown.■

*-Michael Harris, Air-Cure Inc.*

(Mr. Hopkins' speech is not included in this publication)


Gentle Rain

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