Reducing the Cost and Risk of Dust Collection in Coal

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1. Background

Spillage has always been a problem in the bulk solids handling industry. As long as there have been conveyors, there has been spillage. Spillage is material that falls off a conveyor belt and creates a hazard in the environment around a conveyor belt.

Figure 1.1 Spillage

Considerable advances have been made in the control of spillage.

Dust is spillage that has become airborne. This airborne spillage, or dust, becomes airborne due to fracturing of material upon impact and is usually generated when a material is moved in bulk.

Figure 1.2 Dust

Just as spillage has a unique set of hazards associated with it, so does dust. There are many consequences of dust. The most prevalentare: Health Risks, Explosion potential, safety risks, neighbor relation problems, increases regulatory pressures, and the loss of productivity of those needing to clean it up. Because of these consequences, dust is justifiably drawing the attention of many regulatory agencies.

Included below are some brief synopses of some of the consequences of dust.

Health Risks

Airborne dust poses a health risk in the form of lung damage caused by reparable dust. Any particle smaller in diameter than 10 microns has the potential to cause permanent damage to the lungs.

Explosion Hazards

Many substances that are not flammable will explode when airborne. Coal is, by function, flammable. This greatly increases the explosion potential. When this is combined with float dust accumulations, coal's ability to spontaneously combust, and spark sources in an industrial environment, there is a potential for a catastrophic incident.

Figure 1.3 Dust Explosion Aftermath

Safety risks

The PPE (personal Protection Equipment) required to protect a worker from the dangers of airborne dust will lower worker reaction time. Any time a worker's reaction time is slowed, due to limited visibility or excessive equipment being worn, that worker is put at risk in a very dangerous environment.

Figure 1.4 PPE in a coal environment

Good neighbor relations

Coal is a very dirty and visible pollution source. It draws the attention of activists groups and neighbors of coal facilities desiring a clean personal environment. Given the airborne nature of dust and the color of coal, the contamination may be easily visible miles from the offending dust source. Several coal facilities have had to alter their operations due to complaints from a neighboring town.

Regulatory agencies

Historically, spillage and bad practices are known only to the operation and tend to be invisible outside of the operation except in the case of an outside inspection. A dust cloud is much more visible from outside the facility. Because of this, complaints over dust issues are easier and more frequent. Enforcement of these complaints falls to the governing regulatory agency. Jurisdiction and authority vary based on region. Consequences of violations can range from a warning, to massive fines.

Clean-up costs

If dust is present, costs and energy must be expended to control said dust. An operation must pay an internal worker or an outside contractor to clean the affected areas. The recourses used to react to this could be applied to other, revenue generating, activities.

Lost Product

If a material is producing dust, a small percentage is being lost as dust. The dust becomes airborne, it will settle out outside of the material stream. If the material is lost, it cannot be exchanged for revenue.

Figure 1.5 Lost Product

Dust Collection Methods

Much energy could be, and is, spent lamenting on the evils of these consequences. A more proactive approach to managing these consequences is to eliminate the root cause. The root cause is the fact that there is dust in the air and it is generated by industrial processes usually associated with the movement of coal.

Control of airborne is accomplished in one of two ways; either prevent the dust from being created or removing the created dust from the air. As dust is created whenever coal is moved and handled, it is difficult to prevent the creation of dust. Because of this, the industry has focused a majority of its energies on gathering and filtering the dust once it has become airborne. The industry preferred method to accomplish this is a central dust collector. A central dust collector is commonly called a baghouse by industry professionals.

A central dust collector consists of a single assembly containing all fans, filters, and a collection hopper. This assembly is located at a central location and would be connected to all the individual collection points by means of ducting. This filtration system would handle all the dust extracted from the entire conveying system, collecting it for disposal, or feeding it back onto the conveyor or into the process at a convenient point.

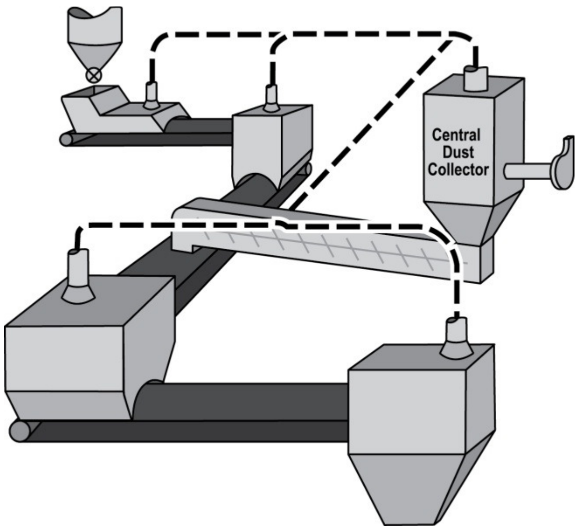

Figure 1.6 Central Collection System

An alternate to the central collector is the integrated air cleaner system. An integrated air cleaner system is an assembly containing a suction blower, filtering elements, and a filter cleaning system. This assembly is incorporated in the dust generation point itself. The dust is not "extracted"; it is collected within the enclosure and periodically discharged back into the material stream. The integrated system utilizes a series of independently operating assemblies at each dust generation point.

Figure 1.7 Integrated Air Cleaner System

A decision must be made between the use of a central dust collection system and an integrated air cleaner system. Diligence must be used to quantify the cost and power savings, so a systematic evaluation can be applied to this decision.

2. Procedure

The results presented in this paper were calculated from several combinations of collector placement on the same application.

The application consists of a pair of enclosed conveyors next to an 80 foot tall building. Each conveyor has two pick up locations. The first pickup location is 10 feet from the building and requires 1000 cubic feet per minute (CFM) of air. The second pick up point is 65 feet downstream from the first and requires 2000 CFM of air.

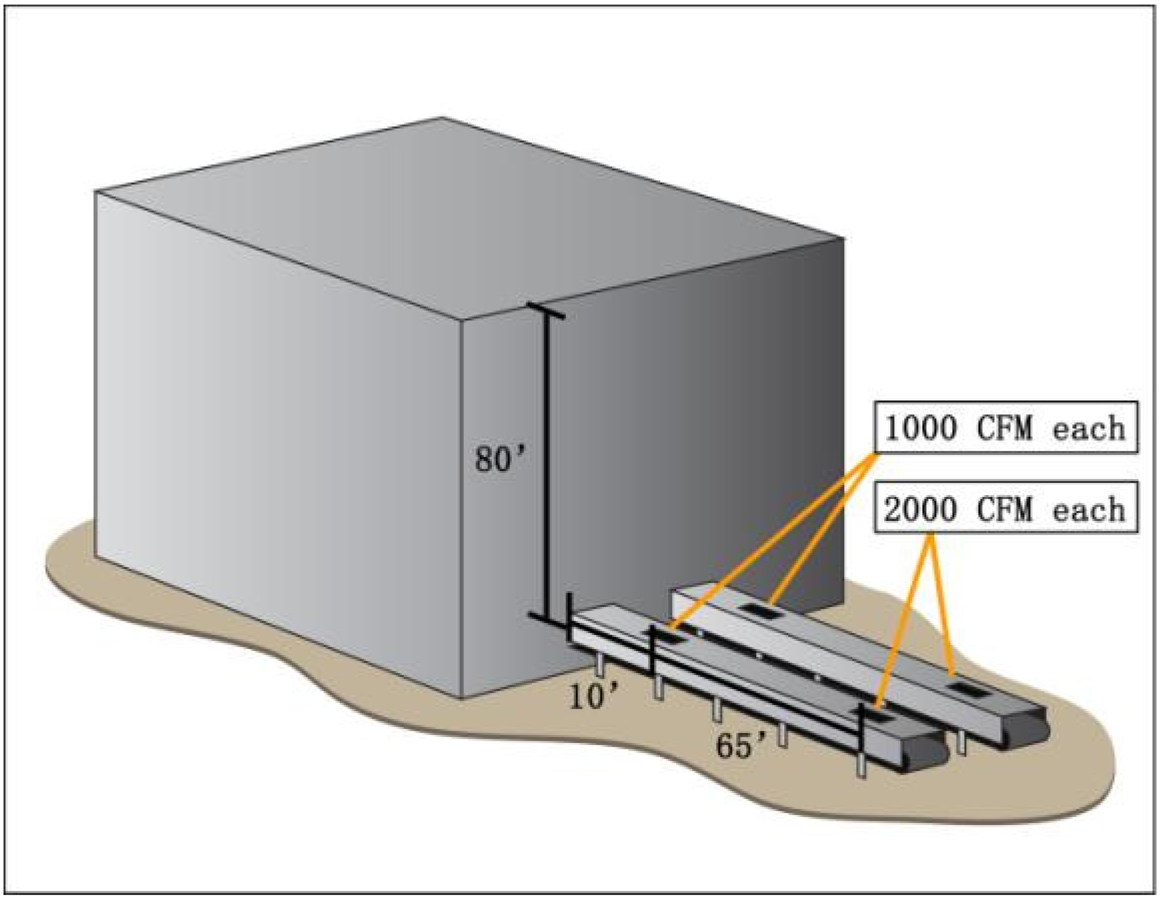

Figure 2.1 Dust Collection Application

Four situations were simulated by placing a central collector at one of four locations. The collector application points are as follows.

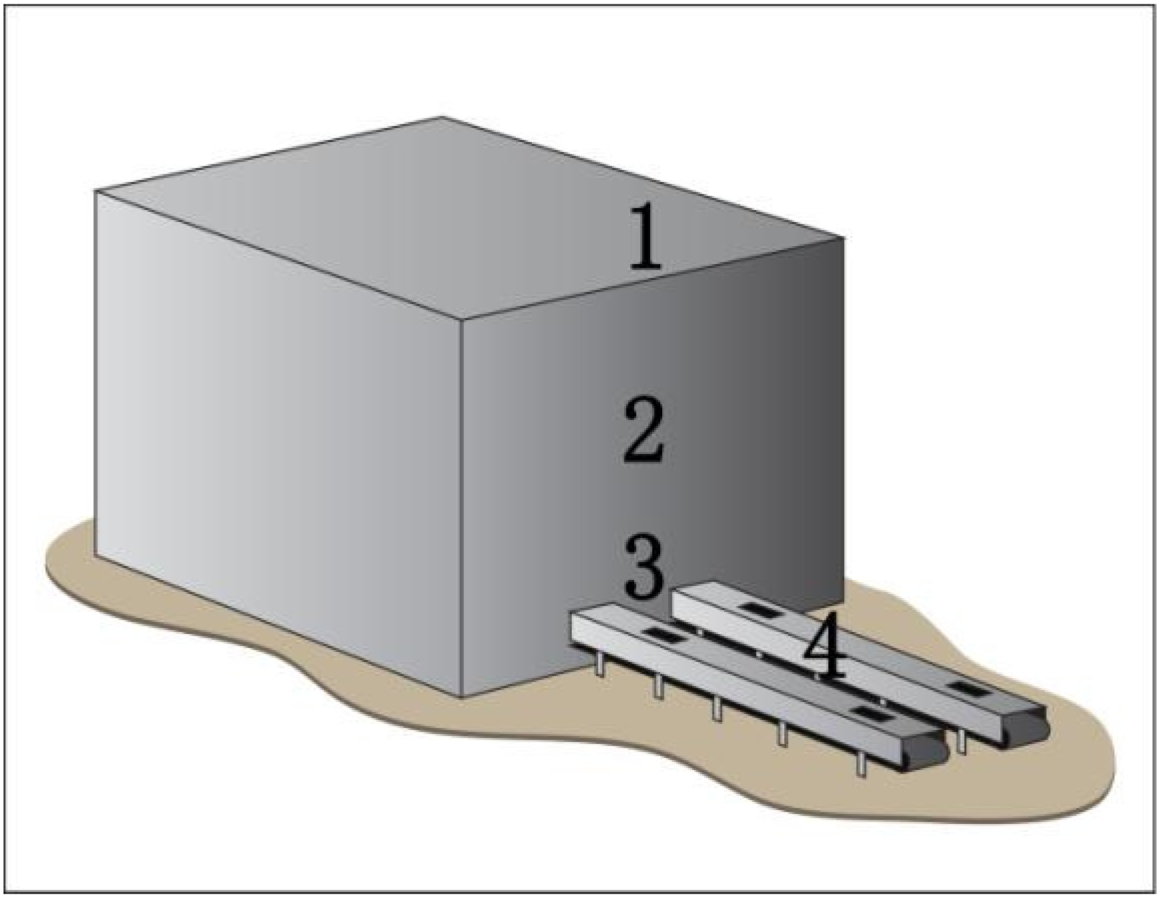

Figure 2.2 Central Dust Collector Locations

Situation	Collector Locations
1	On Top of Building
2	40' up building
3	At first pickup point
4	Halfway between pickup points

Table 2.1 Central Dust Collector Locations.

Situation 1 was selected as the baseline as it is the most common arrangement in industry. The pressure losses for each situation were calculated using a standard Donaldson ductulator. These pressure losses were used to select a collector with adequate power.

As a final comparison, an integrated air cleaner was placed at each pickup point and the power required to filter required amounts of air was calculated. The costs for this system were also calculated.

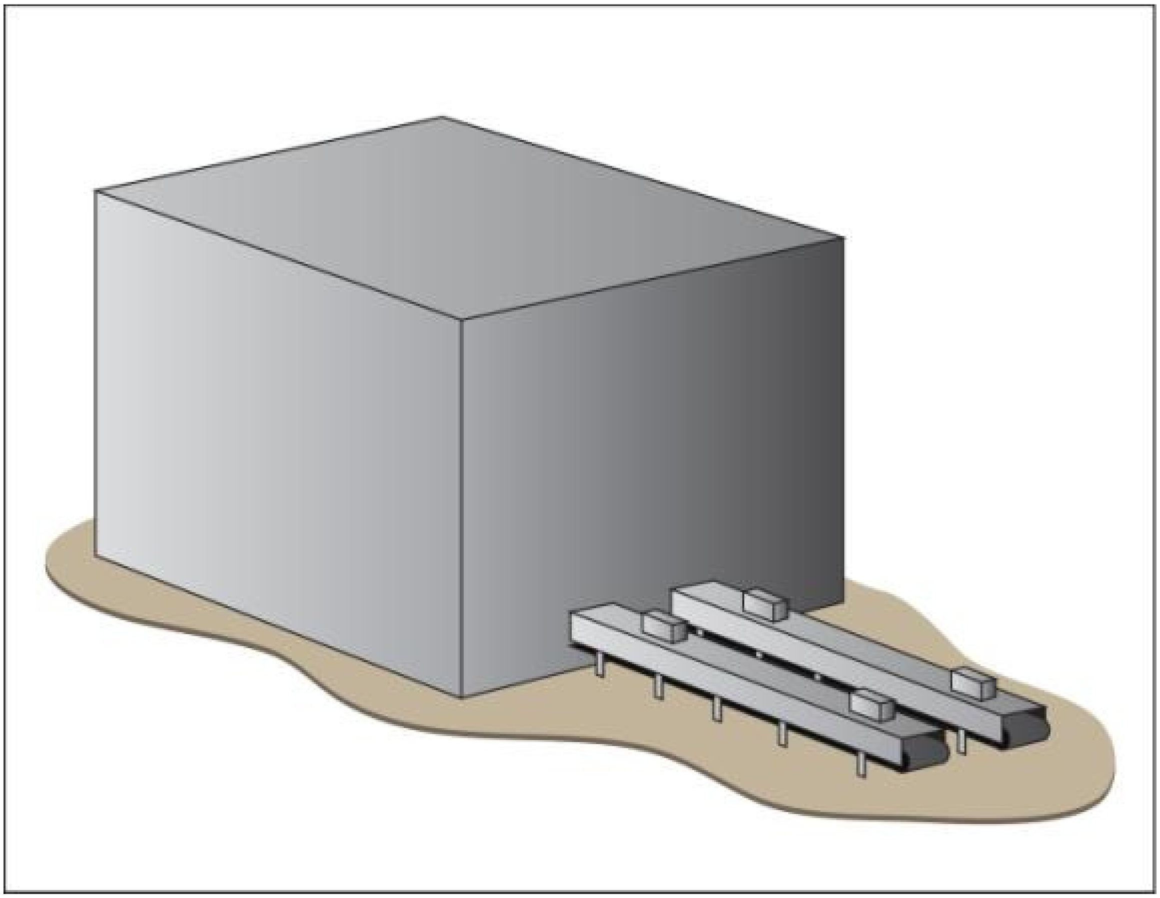

Figure 2.3 Integrated Air Cleaner Locations

All powers and costs of hardware were compared. Advantages and disadvantages of each system were also compared.

3. Results

The following figures and tables show the calculated pressures and flows for each situation beginning with situation 1 (collector on top of building). The system was broken into segments shown below.

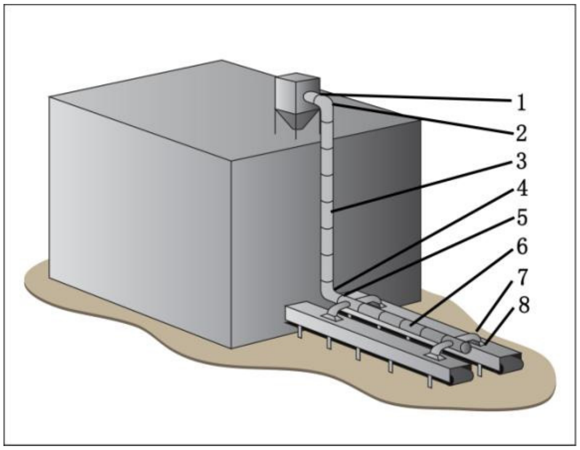

Figure 3.1 System Segments Used in Calculations in Situation 1

The pressure loss was calculated for each section.

Situation 1 at 6000 CFM Collector at top of building								
Region	Notes	Length (ft)	Pipe diameter (in)	Airflow (CFM)	Velocity pressure (VP)	friction factor (Hf)	Loss factor	Pressure loss (Inches of Water)
1	Pipe out of collector	10	16	6000	1.2	0.013		0.156
2	elbow	1	16	6000	1.2	0.27		0.324
3	drop	80	16	6000	1.2	0.013		1.248
4	elbow	1	16	6000	1.2	0.27		0.324
5	Out to first pickup	10	16	6000	1.2	0.013		0.156
6	Conveyor	65	13	4000	1.2	0.017		1.326
7	Pipe to pickup	3	9	2000	1.3	0.015		0.0585
8	Second Pickup	1	9	2000	1.3	0.026	1.7	2.21
	Filters							6
					Total			11.8025
					Round up for safety Factor			13

Table 3.1 Section Pressure losses for Situation 1

This process was repeated for situation 2 (collector half way down building).

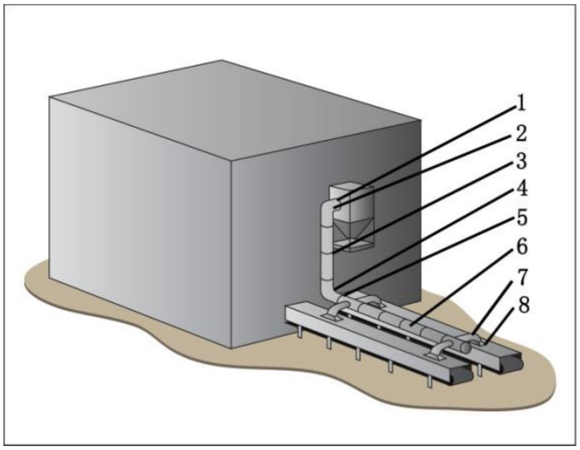

Figure 3.2 System Segments Used in Calculations in Situation 2

The pressure loss was calculated for each section.

Situation 2 at 6000 CFM Collector half way up the building								
Region	Notes	Length (ft)	Pipe diameter (in)	Airflow (CFM)	Velocity pressure (VP)	friction factor (Hf)	Loss factor	Pressure loss (Inches of Water)
1	Pipe out of collector	10	16	6000	1.2	0.013		0.156
2	elbow	1	16	6000	1.2	0.27		0.324
3	drop	40	16	6000	1.2	0.013		0.624
4	elbow	1	16	6000	1.2	0.27		0.324
5	Out to first pickup	10	16	6000	1.2	0.013		0.156
6	Conveyor	65	13	4000	1.2	0.017		1.326
7	Pipe to pickup	3	9	2000	1.3	0.015		0.0585
8	Second Pickup	1	9	2000	1.3	0.026	1.7	2.21
	Filters							6
					Total			11.1785
					Round up for safety factor			13

Table 3.2 Section Pressure losses for Situation 2

This process was repeated for situation 3 (collector at first pickup points).

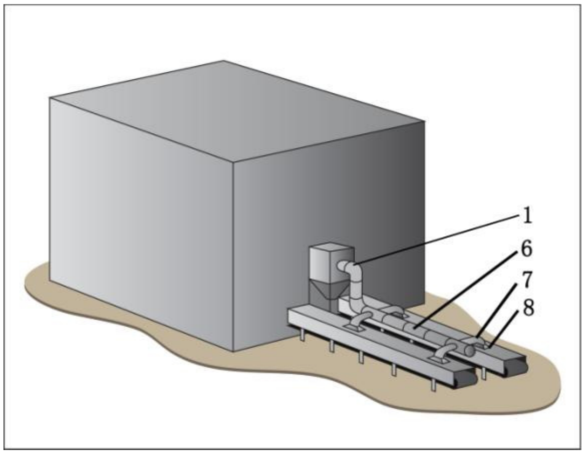

Figure 3.3 System Segments Used in Calculations in Situation 3

The pressure loss was calculated for each section.

Situation 3 at 6000 CFM Collector at first pickup points								
Region	Notes	Length (ft)	Pipe diameter (in)	Airflow (CFM)	Velocity pressure (VP)	friction factor (Hf)	Loss factor	Pressure loss (Inches of Water)
1	Pipe out of collector	10	16	6000	1.2	0.013		0.156
6	Conveyor	65	13	4000	1.2	0.017		1.326
7	Pipe to pickup	3	9	2000	1.3	0.015		0.0585
8	Second Pickup	1	9	2000	1.3	0.026	1.7	2.21
	Filters							6
					Total			9.7505
					Round up for safety factor			11

Table 3.3 Section Pressure losses for Situation 3

This process was repeated for situation 4 (collector half way between pickup points)

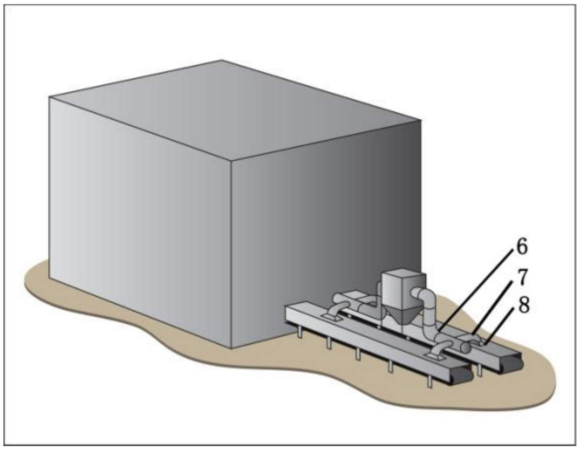

Figure 3.4 System Segments Used in Calculations in Situation 4

The pressure loss was calculated for each section.

Situation 4 at 6000 CFM Collector half way up the building								
Region	Notes	Length (ft)	Pipe diameter (in)	Airflow (CFM)	Velocity pressure (VP)	friction factor (Hf)	Loss factor	Pressure loss (Inches of Water)
6	Conveyor	65	13	4000	1.2	0.017		1.326
7	Pipe to pickup	3	9	2000	1.3	0.015		0.0585
8	Second Pickup	1	9	2000	1.3	0.026	1.7	2.21
	Filters							6
					Total			8.9315
					Round up for safety factor			10

Table 3.4 Section Pressure losses for Situation 4

These values were used to size central dust collectors and ducting systems. Each central dust collector system requires a collector, a blower fan, a material disposal system, ducting, and explosion isolation on the ducts. The collector was assumed to be a bag style collector using fabric bags as filters and an integrated hopper. The blower is a backwards inclined blower capable of producing 6000 CFM at the required pressure. The disposal system is a 30 foot screw conveyor. The ducts are standard round galvanized tube sized to produce an appropriate air velocity. The isolation system is a solenoid type with an integrated controller.

The power producing components were tabulated in the table below.

		Collector	Blower	Disposal System	Totals
Situation	Notes	Power (hp)	Power (hp)	Power (hp)	Power (hp)
1	Collector at top of building	0.5	20	1	21.5
2	Collector half way down building	0.5	20	1	21.5
3	Collector at pickup point 1	0.5	20	1	21.5
4	Collector midway between pickup points	0.5	15	1	16.5

Table 3.5 Power Consumption for Each Situation

The costs for each component were tabulated in the table below.

		Collector	Blower	Disposal System	Ducting	Explosion Isolation Valve	Totals
Situation	Notes	Cost ($)	Cost ($)	Cost ($)	Cost ($)	Cost ($)	Cost ($)
1	Collector at top of building	39,523	6,848	15,213	6,428	52,338	113,502
2	Collector half way down building	39,523	6,848	15,213	5,142	52,338	112,216
3	Collector at pickup point 1	39,523	6,848	15,213	4,114	52,338	111,187
4	Collector at midway between pickup points	39,523	5,782	15,213	3,291	52,338	110,365

Table 3.5 Component Costs for Each Situation

The final situation was an integrated air cleaner located at each pickup point. The required airflow, power consumption and cost were tabulated.

Pickup Point	Airflow (CFM)	Power Required (HP)	Cost ($)
1	1000	3	10,800
2	1000	3	10,800
3	2000	5	15,200
4	2000	5	15,200
	Totals	16	52,000

Table 3.6 Integrated Air Cleaner Data

4. Discussion

The components of a central dust collection system are: the collector, the blower, the disposal system, the ducting, and the isolation valve. Analysis of the central collector data, combined with a thorough understanding of each component leads to a complete understanding of the attributes, advantages, and disadvantages of a central dust collection system.

Collector

The collector is the assembly that contains the filter media bags, a system to clean these bags, a collection hopper and a rotary airlock to empty the hopper. An explosion blast panel must be incorporated into the collector due to the explosive nature of Coal. Due to the large size and various permitting limitations, these units have to be located outside of a building. Since these collectors are sized based on the airflow, the collector is identical for each situation.

Blower

A collector uses a pressure blower to produce a negative pressure to draw air and dust to the filter media, and draw air through the media. The blower is sized based on a combination of the airflow required and the pressure drop the air must overcome. In addition to filter media, the blower must overcome all of the pressure losses of the ducts connecting the collector and the farthest pickup point from the collector. The data shows the pressure losses from the ducting only account for between 49%, for situation 1, and 33%, for situation 4, of the total power required. The collector had to be within 30 feet of the pickup point to require a low enough pressure to allow a smaller blower. Because of this, the blower was identical for most situations.

Disposal System

Once the dust is collected, it must be redeposited into the material stream. To accomplish this, a 30 foot auger, or screw conveyor, was used. This screw conveyor used a 1 hp motor, so the power addition due to the disposal system was small in comparison to the system. Due to the explosive nature of the material, this auger conveyor must be designed to meet the requirements of a hazardous environment.

Ducting

The duct used to connect the collector to the pickup point must be sized to prevent any dust from settling out of the airstream. This is a straightforward process, unless there are multiple pickup points. The flow in each section of the duct must be analyzed and sized so the velocity in every branch of the system maintains high velocity. Pressure losses are proportional to velocity, so a large velocity will cause a large pressure drop. These ducts are susceptible to dust settling out of the stream if the flow is altered. This alteration can come in the form of the flows being altered by worker or the failure of a duct. This failure will not only release dust into the environment, but it will change the balance of the system.

If dust is accumulated in the duct, due to design error or alterations, and the material ignites, or self-ignites, there is potential for fire in the duct system.

Isolation Valve

Because a collector is considered an enclosed apparatus, it must be protected from flames traveling to the collector though the ducts. The method used to stop flames, if present, is an isolation valve. This is a valve that senses an increase in pressure or temperature, and closes the duct if one of these conditions is detected. This is required for any central collection system.

System

Individual branches of the collection system cannot be isolated, as a change in flow in one branch will impact the other parts of the system. Because of this, individual pickup point cannot be maintained without either shutting off the system or impacting the effectiveness of other branches.

As a central dust collector is a complex system with many interdependent parts, the purchase price is impacted by this complexity. Table 4.5 shows the price of a central collector used in this application. This table shows a slight difference in price for each situation of this application, but the variance is less than 4%.

Because of the almost identical losses in the duct systems, the power requirement is consistent in all situations except situation 4, where the collector is closest to the pickup points.

Integrated Air Cleaner

Similar to the analysis of the central collection system, an integrated air cleaning system was analyzed. The components of an integrated air cleaning system are: the filter housing and the blower. These two components are repeated at each application point.

Filter Housing

The filter housing is an apparatus designed to support the filter elements, while allowing dirty air to enter the filter and clean air to exit.

Study of explosions has yielded the knowledge that an explosion needs five components to occur; an ignition source, fuel, oxygen, dispersion and confinement. This is known as an explosion pentagram.

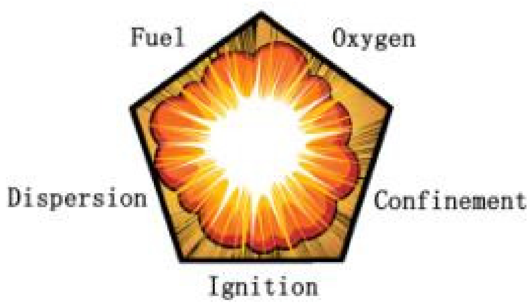

Figure 4.1 Explosion Pentagram

To eliminate an explosion, one or more of these factors needs to be eliminated. Fuel and oxygen cannot be eliminated in a coal handling operation, but the other components can be.

A consequence of the integrated approach, is the fact that the filter housing is no longer an enclosed system. The inlet of the enclosure is made up of the filters. If there is any pressure build up, like in the case of an explosion, the pressure is vented out of the filters. The integrated system is usually built into a transfer point, and the transfer point is open at each end, so the cleaner is part of an open system. The potential for containment is eliminated; therefore, the potential for explosion is removed.

The filter housing only needs to be large enough to hold the filters for the individual collection point. Because of this, the filter housing is usually small enough to fit at the pickup point. The integrated system does not need to be located outside and ducts are not necessary for the dirty air. If the air ducts are eliminated, a potential source of stagnant, self igniting fuel is eliminated. An isolation valve is also unnecessary. As the filter housing is at the application point and the filtered material is placed back into the material stream, no storage or disposal system is necessary.

The integrated air cleaner contains an apparatus to clean the filters using a pulse of compressed air. As material is captured by the filters it agglomerates against the filter media. When the filter media is pulsed, the material will fall. If it is agglomerated and large enough, it will fall back into the material stream. The pulse system is designed to alternate pulses to each filter element. When one filter is being pulsed, the adjacent filter is still drawing air. If a pulsed particle is too small to drop out of the airstream, it is immediately pulled into an active filter. This alternated pulsing eliminates the potential for a pulse to create a momentary plume of airborne dust.

Blower

A negative pressure and airflow is created with a blower. This blower is sized to provide the airflow needed for each pickup point. As there is no ducting, there are no pressure losses in addition to the filters that must be accounted for. Because of this, the power requirements of an integrated air cleaning system are lower than central collection system for the same application. Power usage is a major factor in the over-life cost of ownership.

The blowers are available in versions that are rated for a hazardous duty location. This eliminates the blower as a possible ignition source for an explosion.

System

The integrated air cleaning system utilizes a series of independently operating assemblies at each dust generation point. The loss of a single unit to maintenance will not result in an operation wide shutdown of the dust collection system. This decentralized arrangement allows cleaners to be put into a maintenance cycle and each unit can be maintained at a time other than a plant wide outage.

The very nature of the design of the integrated air cleaner eliminates many of the disadvantages of a central dust collector while providing the same level of filtration.

A central dust collection system, though it is an industry standard, has several attributes that make it undesirable to the coal community. These attributes include, but are not limited to: buildup of dust in the ducts, system wide downtime when maintenance is required, high initial capital investment, high power usage, difficulty in maintaining ducts, difficulty in “balancing” airflow in ducts, and the fact that filtered dust must be accommodated with recirculation or direct disposal.

The integrated approach eliminates many of the disadvantages of a central collector. The integrated system eliminated ductwork, so there is no chance of dust buildup, no balancing and no duct maintenance. As the integrated system is a decentralized system, the loss of one of these cleaners to maintenance will not result is an outage of the dust control system. As the static pressure is much lower and there are no losses in pressure due to the ductwork, the fan motor is normally smaller than other systems. The system will operate only when needed which reduces energy requirements. Because it can return the dust the process, there is no need for a separate dust disposal system.

When the integrated air cleaner system is compared to the central collection system, in one case, the integrated approach realizes a 54% reduction in capital cost and a 26% reduction in power required. In this case, the integrated system was more economical than the centralized or unit system.

5. Conclusion

Spillage has always been a recurring issue in the bulk material handling industry. Dust has been present as long as spillage, but the consequences of dust have been focused on recently. The consequences of dust include, but are not limited to; Health Risks, Explosion potential, safety risks, neighbor relation problems, increases regulatory pressures, and the loss of productivity of those needing to clean it up. These consequences are drawing more attention from regulatory agencies.

The industry standard for removing dust from the air is the central collection system, or baghouse as it is known in industry. An alternate method of removing dust from the air has been developed in the form of an integrated air cleaning system.

Diligence must be utilized when comparing options and selecting a dust control solution. Consideration must be given to power usage, cost, and advantages or disadvantages of each option.

In the case shown above, an integrated air cleaning system is superior to a central dust collection system in the areas of power usage and cost of ownership, initial capital investment, and in comparison of advantages and disadvantages. The integrated approach realizes a 54% reduction in capital cost and a 26% reduction in power required over the central system in a typical example.

6. References

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