The electric utility industry continues to face the challenge of controlling fugitive dust problems. Environmental laws are tougher and clean air compliance has become a top priority in most plants, especially when plants are located near populated neighborhoods. Management focus is aimed at reducing the amount of dusting and dust accumulation throughout the plant in order to provide a clean and safe environment. A well-executed dust control plan allows for continuous preventive and corrective actions, without the disruptive efforts necessary to satisfy specific compliance violations.

The switch to low-sulfur sub-bituminous coals provides cleaner burning fuel properties in exchange for different material characteristics. The PRB coals contain more moisture and have a higher propensity for spontaneous combustion. They also contain higher amounts of fine particulate. Because PRB coal is friable, it breaks down quickly with time and degrades throughout the transit process so that it typically arrives at the plant drier and finer than when it was mined. The lower BTU rating also requires at least 15 to 25 percent higher handling rates for plants designed to burn higher rank coals. The challenge for systems converted from bituminous coal operation is to provide effective control of the additional dust and to insure safety against fire and explosion hazard.

The purpose of this paper is to provide a basic understanding of the sources of dust generation and the practices necessary to contain, control, and collect dust. Methods are offered for evaluating dust collection equipment and system performance. Case studies are also presented to illustrate typical solutions to problems.

**Dust Collection Systems**

Dust collection systems are designed to capture fugitive dust that would ordinarily escape from the perimeter of the operating equipment. Collected fugitive dust is fuel and should be returned safely to the system for burning. Dust collection problems should be defined by stepping back to view the complete system. Too often personnel point at the source of a dusting condition and begin working in that specific area to solve the “problem”, only to find out later that the real cause was elsewhere in the system. In most cases, what is being observed is the result of a problem that is more general in nature and may be the result of equipment or operation issues, or faults in the ducting and hood design. Consulting with an experienced dust control expert may assist the plant in developing an assessment of the overall condition of the dust collection system.

When dusting occurs in a plant, the common response is to blame the dust collector. Like many things in life, the dust collector gets a bad rap for any problem associated with dusting. The dust collector is a steel shell containing filter media and is located at the end of the circuit, but the dust collector is only a part of the larger dust collection system. When investigating performance problems, study all the elements of the system, not just the dust collector.
The dust collection system includes the pickup hoods, ducting, branch lines, dust collector, fan, and a dust return system. See the component descriptions shown in Figure 1. If any part of this system is flawed, the system will fail to perform properly. Historically, the pickup hoods and ducting design are more commonly at fault than the fan and dust collector.

Dust control systems are constructed in many different configurations. In the typical power plant, the area of the coal unloading station to the outside stockpile storage is one region, the coal yard to the crusher station is another region, and the crushed coal to the tripper room and bunker storage is a third region. Each area has unique requirements and is handled by specific dust control techniques. The railcar unloading system, whether a rotary style or bottom dump system, will usually have a ducted dust collection system, a passive enclosure chamber, or some form of control spray. Coal conveyed to the storage pile typically receives some form of conditioned water spray or surfactant. Crushed coal from the crushing station will contain a higher fraction of fine particulate and typically requires a ducted dust collection system. Conveyor transfers into the tripper room area will usually have dust collection hoods, and may also use secondary dust control systems such as fog spray systems. See Figure 2.

Typical Dusting Complaints

Dust will be present at many locations through the system. Dust may be seen coming from the fan stack, or from around the pickup hoods at conveyors and transfer stations. Poor or missing seals around conveyors allow easy escape paths. Cross-winds on open conveyors or stockpiles will disperse dust. Conveyor belt cleaners and poor loading areas contribute to material spillage and consequent buildup and dusting. Improperly designed dust return systems from the dust collector hoppers can disperse dust into the environment or recirculate the dust back into the dust control circuit. The end result from dust escaping into the environment is the undesirable layer of accumulated dust on most horizontal surfaces in the affected area.

Equipment operational procedures can also cause dusting problems and excessive maintenance. Dust collector cleaning cycles that overclean will allow bleeding through the bags and may result in shortened bag life. Undercleaning bags typically causes higher pressure drop across the baghouse, resulting in lower fan volumes and loss of collection efficiency at the pickup hoods. Adjusting blast gates at pickup hoods without a central plan will disturb the system balance.

Dust may be present at the dust return system. Dust should not be allowed to collect in the dust collector hopper. The dust return system should be sized to adequately handle peak collection rates, with the collected dust either being conditioned or delivered safely back to the conveying system outside of the collection perimeter. The density of coal dust can be half that of coal, so issues with irregular dumping might be symptomatic of rotary airlock sizing, bridging, or aeration problems. Factors such as moisture, condensation, dew point, and freezing weather will all have an effect on the performance of the collection system.

Evaluating Performance

When transporting and processing coal through a plant, each piece of equipment and conveying device has the ability to agitate some level of fine particles. If there is containment around this motion, the fine particles that are stirred up cannot escape and thus stay within the system. When rapid changes in direction and speed occur, fine particles are easily carried by air currents and will pass through available openings and gaps. The experienced designer will
locate pickup hoods and suction points at key points in a system to effectively minimize dust escape.

Not only must the system components be reasonably sealed, the collection hoods must be properly sized and located. Industrial ventilation handbooks provide general guidelines for determining typical dust loads for different equipment and operating conditions. General duct and hood velocity guidelines are stated for a wide variety of conditions. While this can provide a basic starting point, it is only with the judgment, experience, and attention to detail of the dust control engineer that a system can be made to operate effectively.

When dust is observed streaming from a ducted conveyor transfer point, for example, the simple response would be to provide more suction air at the collection hood to control the problem. While this may work in certain situations, it signals that the hood or the duct may not be the correct size, positioned in the best place, or that the equipment generating the dust may not be sealed or contained properly.

Overdrafting collection hoods to solve a dust problem often results in drawing unnecessary coal into the dust collection system without fixing the problem. Adjusting blast gates to redirect air changes the balance of collection ductwork and creates problems elsewhere in the circuit. Remember that the dust collection system is designed to capture only the dust that would otherwise escape to the environment. High hood drafts that draw material off the conveyor belt should be avoided.

**System Audit**

A system audit provides an assessment of both the dust collection system and the material handling system. Determining the performance of a collection system begins with measuring the airflows and pressures. A water manometer and a series of selected holes in the ductwork is all that is required to perform a static pressure mapping of a system. Velocity pressures in the ducts are measured by pitot tube readings and translate to air volume in the system. The results of a typical system are shown in Figure 3. Power readings of the collector fan drive should be evaluated against the fan performance curve to determine the operating point of the fan. With new filter media installed, data should be recorded when the system has been properly balanced so it can be used as a benchmark to judge future performance. Good record keeping provides insights into the trend patterns of the system and can aid in troubleshooting.

Evaluating static pressure readings can quickly identify problems and deficiencies that may exist in the dust control circuit. High pressure differential across the baghouse generally means that the filter media is partially blinded. If the baghouse differential is normal but the inlet suction is high, the ducting circuit has problems. Some ducts may be partially plugged, or some hoods blocked completely, forcing higher volumes of air into the remaining ducting. Mapping the pressure readings at the hood inlets can quickly provide a check of the ducting circuit, although airflow readings would be required to make a thorough assessment of the system. Blast gates at inlet hood locations are a convenient way to adjust airflows to balance a system, but care must be taken not to optimize one hood and upset the balance of the rest of the system.

High suction pressures will greatly affect collector fan operation. As static pressures go up, fan airflow goes down. Ducting can easily be checked for material buildup by tapping with a hammer and listening. As duct plugging and bag blinding occur, the performance of the system is further compounded by lower air volumes. This translates to poor collection efficiency.
Sources of Dust Generation

Mastering dust control requires fundamental knowledge of how dust is generated. Dust is created when fine particulate material becomes separated from the coal stream. Coal received at unloading stations already contains a fair percentage of fine particles. Typically the fraction passing 4 mesh (.187 inch) can be as much as 40 or 45 percent for PRB coals.

As coal flows and changes direction through the plant, it undergoes accelerations and impacts as a result of feeding, conveying, crushing, and storing. Flowing streams of material interact with the surrounding air through aerodynamic drag forces. For example, material falling from a distance will create air currents along the way. As material particles accelerate, the flowing stream expands until the moment of impact. Energy is quickly released and the recompression of the space between the material particles creates pressure waves that cause dust clouds to be released. Further complicating the dusting issues, material must also displace an equal amount of air. Other factors affect dust dispersion, including drafts and turbulence from process equipment, such as crushers or vibrating feeders.

Where feasible, it is possible to reduce dust generation by limiting the distances that material must fall, and minimizing the impacting forces. Conveyor velocities could be reduced, where possible, and covers applied to prevent the effects of cross winds. Material transfer chutes and diverters can be modified to provide better sealing and containment, with attention to creating more streamlined flow and reduced impact.

Containment

The common belt conveyor transfer chute has become the subject of much technical discussion. The traditional design discharges material from one conveyor to the next without much consideration to loading zones, impact, or control of the material stream. The operating result has typically been dusting, wear, spillage, noise, and increased maintenance expense. Attempts to add dust collection hoods and other expensive cures at the inlet and discharge of these chutes have not really made up for weaknesses in design.

An ideal transfer chute consists of a tight enclosure where discharged material can be smoothly guided and directed by an accurately placed target plate down through a segmented chute, with a minimum of impact. The downward energy of the material stream is converted to a flow in the direction of the downstream conveyor allowing the material stream to enter at a shallow angle requiring minimal acceleration to match the belt speed. A well-sealed enclosure will also inhibit air from being drawn into the chamber as a result of the induced air generated from the flowing stream. Ample enclosure volume is necessary to allow internal pressure gradients to equalize so pressurized dust escape is minimized.

Properly designed transfer chutes will also produce center loading of feed material onto the receiving belt. Off-center conveyor loading is responsible for poor belt tracking and consequent spillage, dusting, and wear at the skirtboard area and throughout the length of the conveyor. A comparison of a common conveyor transfer arrangement and an improved arrangement is shown in Figure 4.

Sophisticated flow modeling software tools are available that allow engineers to simulate flow performance in chutes and transfers. Computer models are constructed for the basic geometry of the transfer, and flow characteristics chosen to represent the material being handled, such as
flow rate and particle size distribution. Because continuous iteration of interacting particles is necessary, significant calculation time is required to deliver meaningful results. The resulting models provide a general representation of the flow performance of the model, often illustrating areas that could be problematic. In experienced hands, these tools can be used to alter existing plant equipment to provide more efficient and streamlined flow in chutes and transfers. The recognized benefits of implementing results from accurate flow modeling are better flow control of the material, reduced impact, reduced material degradation and dust, less chute wear, and better matching of material and belt velocities.

The flow examples shown in Figure 5 show how changing the material flow pattern in the chute create a better guided and more controlled flow profile. The flow on the left results from a common transfer, and the one on the right has been modified to provide a more streamlined pattern with less scatter. Note that the modified chute directs more energy into the forward movement. In Figure 6 it can be seen that a modified right-angle transfer chute allows the material flow to be more effectively delivered through the transition, without scattering material along the way. Any motion that is not focused on directing flow from one conveyor to another results in wasted energy.

Elsewhere in the system, every attempt should be made to isolate and contain areas where dust is created. Use of better seals at chutes, transfers, and enclosures, and providing shielding or wind screens to prevent drafts will all help against dispersing dust throughout the plant. Dust should be confined to the areas where it originates and be allowed to passively disperse back into the product stream. Unloading stations often require better confinement of air currents that are created during dumping cycles. Airborne dust should be given every chance to settle back into the product stream.

**Ducting**

The greatest source of problems with dust collection systems typically is poorly applied or improperly designed ducting and hood arrangements. Handbooks provide guidelines for vent air quantity required at each dust source, duct velocity, and the placement and dimensions of hood pickups. Duct layout for a system, however, requires skill in arranging trunk and branch lines, suitable junction designs, and preferences for vertical lines over horizontal lines in order to achieve proper system balance.

Ducts are used to transport captured dust and accelerate it to the dust collector without disruption. The NFPA Standard 120 states that the minimum acceptable velocity for coal dust is 4500 FPM. Other references cite duct velocity requirements between 4000 and 5000 FPM. These values are based on providing enough speed in the duct to prevent buildup and pluggage. While long horizontal ducts may require higher velocities, short vertical runs may require less velocity. The practical sizing of a dust collection system becomes an economic balance of using the smallest amount of airflow to perform effective collection against a reasonable ducting arrangement that does not require excessive fan pressure.

There are many causes for poor performance. Problems arise when one source designs the system layout, a second source supplies the equipment, and a fabricator makes and installs the ducting. The system is run, with perhaps favorable results, but performance may falter when peak loads or upset conditions occur. Airflow is adjusted with blast gates, some hoods are blanked off, or additional hoods and ducting added. New process equipment is eventually added to the plant, so additional ducting circuits may be added to existing systems, sometimes using booster fans. Investigation of troubled dust collection systems often reveals that the initial
system design was altered due to modifications, deletions, and additions. Corrections become expensive when the new dust loads exceed the capacity of the installed equipment.

**CASE STUDY 1** - This dust collection system serviced a crusher house and underground reclaim area and was plagued with constant dust accumulation in the crusher house, high duct wear, and continuous collector maintenance. The system arrangement contained 24 pickup points coupled through eight fans to five dust collector units. See Figure 7. Because of system complexity, it was not possible to properly balance the system.

Dust loads for all the equipment were determined. Effective hoods were designed for conveyors and transfer points. Ducts and inlets were re-sized based on the dust loads. To illustrate the new airflow balance, a schematic model was developed. See Figure 8. From the load requirements the model showed that excess collection capacity was available, allowing one collector and two fans to be retired. Improper bottom-connected Ducting into the bank of collectors was modified to lateral junctions to remove poorly designed bottom connections. Ducting sizes were also adjusted for corrected airflows. See Figure 9.

This compound system was simplified and balanced by removing one dust collector unit and two fans, and by implementing a series of suction hood and ducting changes.

Dust hoods are enclosures that allow fugitive dust to be captured and drawn into a ducted collection system. Hood location and placement are key factors that determine suitable capture velocity, and require hoods to be positioned close to the dust source. The required capture velocity is a function of the type of emission and the orientation of the hood and typically ranges between 200 and 500 FPM. NFPA suggests the hood take-offs have a minimum area of four times the area of the duct. Positioning a hood too close to a dust source will result in too much dust (and product) being collected. Pickup effectiveness drops off very quickly as hoods are positioned away from the source. Where possible, try to position the hoods over rising dust streams.

**CASE STUDY 2** – Severe dusting was experienced for a combination railcar and open truck loadout facility handling powder bulk materials. Better sealing was designed for the belt conveyors and loading spout, and an enclosure was designed to surround the truck/railcar station for protection against strong wind currents during the loadout process. Slotted dust collection hoods were positioned on each end of the enclosure along with a pickup hood mounted high in the center. These were ducted to a dust collector unit and fan mounted outside. See Figure 10. Hanging curtains were used to provide a partial barrier for air currents through the enclosure. Photographs of the installation before and after the modification are shown in Figure 11.

The new enclosure and dust collection system reduced dust emissions to an acceptable level.
Shrouding and containment within a dusting environment are used to provide channeling of dust to hoods for more effective pickup. Hoods can be extended to provide better capture and guiding of dust streams, but care should be taken not to place hoods too close to interfere with the process action. Within practical limits, a minimum number of properly placed hoods is generally the accepted practice.

**CASE STUDY 3** – This railcar rotary dump unloading system exhibited excessive dusting during the dumping cycle. Ample dust collection air volume was available but not effectively arranged to draw fugitive dust into the system. A dynamic dust load study was performed to determine how generated dust escaped the existing collection hoods. To confine the dust, a contoured containment section was designed to seal against the dumper carriage during rotation while unloading. See Figure 12, which illustrates the railcar rotation during unloading positions. Slotted hoods were arranged on the dumping side to capture any dust escaping in that direction. Keeping the hopper mostly full also contributed to less dust generation.

The modifications were aimed at containing dust liberated by the dumping process and providing better routing to the dust hoods.

**Dust Collectors**

A dust collector is basically a steel enclosure that contains porous filter media used to separate fine dust particles from a flowing stream of dirty air. The most common filter media used in collectors is filter bags, although bags and cartridges can be used interchangeably. Dust particles build up on the outside of the filter bag and form a coating called “dust cake”. It is the dust cake layer that actually performs the efficient filtration of the fine particles. As the cake builds up, the pressure drop across the filter bag goes up. The cleaning cycle of the collector is designed to periodically clean most of the cake off the filter bag to prevent bag blinding. Overcleaning the filter bags is generally bad because it contributes to bag wear and will remove all of the dust cake and allow dust to possibly bleed through. Flow aid products are commonly used to help pre-coat new bags to provide a uniform coating that shortens the break-in time for efficient collector operation.

The dust collector size is based on the required airflow of the system. The quantity of bags determine the filtration area and is a function of the air-to-cloth ratio (expressed in FPM) based on the type of dust material. For coal dust, the range would typically be between 4 and 6 FPM, depending on the concentration of dust loading. The geometry of the collector housing and the number of bags establish the operating parameters of the unit.

The open space between all the bags in the housing is the flow area where the dirty air travels. The average airstream velocity through this space is called “can velocity”. The upper limit of can velocity for coal dusts ranges between 200 to 300 FPM. If the velocity is higher, fine dust that is purged from bags during the cleaning cycle will have the tendency to be re-entrained in the airflow and collected back onto the bags. This is especially evident on collectors with long bags. Because can velocity is directly related to air-to-cloth ratio, choosing a lower cost dust collector with a high air-to-cloth ratio will often lead to operating problems.
Case Study 4 – Modifications to this crusher house required re-balancing to alleviate high dust loading that resulted in bag maintenance and duct wear problems. Analysis indicated that very high can velocities resulted from the original collector design, negatively affecting bag cleaning operation and bag life. Modifications to ducting lowered the airflow requirement, allowing the air-to-cloth ratio to be set lower by slowing down the fan. To further reduce the air-to-cloth ratio, 25% of the bags were removed from the collector, mostly in the outer rows. See Figure 13 for a schematic diagram. Blank disks were used to cover the empty bag spaces. These changes reduced the high can velocity and lowered the air-to-cloth ratio to 3.8 to 1.

The new system provides better dust collection performance, extended bag life, and greatly reduced the dust removal rates from the collector.

Bag cleaning methods vary between models and manufacturers, but typically involve reverse air cleaning through the bags with low or high pressure air. Bags should be visually inspected when there is suspicion of bag cleaning problems or continual bag blinding. Commercial services are available to evaluate failed filter bags. Analysis could determine whether there is a system problem or a need to switch to a different filter media to better match the dust characteristics.

To maximize the benefits of a good dust collection system, the collected dust must be disposed of in an effective manner. The dust handling capacity should be greater than the maximum collection rate in order to prevent storage in the hopper. Returning dry dust immediately back to the coal system can often result in re-entraining the dust downstream in the system. Pneumatic conveying is one method to transport the dust to a controlled location such as a coal silo. Conditioning the collected dust with water using agglomerators or pin mixers can also be effective, given the right climate and control system.

Alternative Solutions

The primary alternative to dust collection is dust conditioning with water and/or chemicals. This process is called dust suppression because it reduces emissions at designated points but does not eliminate the generation of dust. Several types of dust suppression systems are available, each having a different water usage rate and operating cost effect.

Spraying water or wetting agents onto a dusting pile increases particle cohesion, which stabilizes the surface of the coal. Cohesion forces keep particles together to lower the dusting potential. Water droplets attach to particles to increase their weight and decrease their ability to become airborne. As particles become very fine, the water droplet size must be equally fine to be effective.

Direct water spray is the most common form of suppression but carries the greatest thermal penalty by adding 3 to 4 % of water to the coal mass. Water spray systems consist of simple circuits of pumps, piping and spray heads and are operated with automatic or semi-automatic controls. They have a low initial capital cost when compared to dust collection systems but have the drawback of requiring additional heat during combustion to evaporate the water, thus the lower thermal efficiency.
Chemical additives such as surfactants are used to improve the wetting properties of water in order to allow better contact and interaction with the fine dust. These additives lower the surface tension of water and are used to provide finer droplet sizing and more effective interaction with fine particles. They also lower the water usage rate to less than half of straight water sprays. In coal yards, chemical binders are often used to stabilize the coal piles for several days.

Foam systems use foaming surfactants combined with water and compressed air to blanket flowing streams of material. In many cases this provides better and longer lasting coverage to the mass of particles. While water usage rate is significantly reduced compared to surfactant sprays, chemical usage is higher and the requirement for compressed air adds cost and installation considerations.

Fogging systems use compressed air and special spray nozzles to produce a fine mist made up of tiny atomized water droplets approximately the size of the dust particles. The atomization process increases the number of droplets in a given area, and the smaller water droplet size has a better chance to interact with the dust. Because the lighter fog spray is very subject to air currents, these systems are best applied to a controlled environment where drafts and cross flows are minimized. Fog systems use the least amount of water and do not require a chemical additive. Also, the fine mist will not freeze. The system requires compressed air and a filtered water pumping circuit to keep the water source free of impurities and allow the spray nozzles to remain clean.

**CASE STUDY 5** – The existing rotary dumper collection system did not meet plant expectations, and was replaced with an alternative water fogging system. A fogging system was selected because of the low water usage and the fact that fog mist does not freeze in the winter climate. To achieve maximum effectiveness, it was necessary to control the air displaced during unloading operation and to eliminate unnecessary drafts. Dumper containment walls and curved containment plates were designed and constructed to prevent cross draft disturbance of the fog sprays. Additional containment was provided by new catwalks at grade level that reduces the open hopper area. To minimize air currents through the dumper building, improved seals between the railcar and the building were also designed and installed. Water receiver tanks and circuit piping and controls were engineered to provide automatic operation of the system during every cycle. See Figure 14.

The system has recently been placed in service and preliminary testing shows a substantial reduction in ambient dust levels.

Washdown systems use water deluge hoses and nozzles to handle dust and spillage that has escaped the dust control system and collected around the plant. Washdown procedures should be undertaken as a general housekeeping practice on a routine basis. Semi-automated systems are expensive to install but can be regularly employed to handle dust accumulations within major plant areas. These systems require breaking plant areas down into zones to allow supply water to be distributed and to prevent overloading the plant drain capacities.
Summary

Improving dust control requires an understanding of how elements of the dust collection system work together. Sources of dust must be controlled at the point of origin by better sealing and containment. Hoods and ducting must be properly designed and located throughout the system. Having a system audit performed by an experienced dust control engineer could be beneficial in providing an assessment of performance of both the dust collection and the material handling system. Here are some key areas to consider:

- Define the real problem
- Determine the dust load for each equipment area in the system
- Emphasize containment of the initial dust
- Improve dust seals everywhere
- Develop baseline performance readings of the system
- Improve the pickup hood performance
- Balance airflows with blast gates, where possible
- Ensure effective bag cleaning
- Verify the proper choice for filter media
- Assess fan operating performance
- Verify effectiveness of the dust disposal system

References:


Bernard Schonbach is a Principal and Manager of Mechanical Engineering with CDG Engineers, 59th & Arsenal Streets, St. Louis, MO, 63139, 314-781-7770, (schonbach@cdgengineers.com). He has more than 30 years experience in engineering design, analysis, and field experience in heavy industry equipment and bulk material handling systems, and specializes in crushing, conveying systems, and dust control. He was formerly employed with Fuller Company and Pennsylvania Crusher Corporation. Schonbach has a BSME from Penn State University and an MBA from Lehigh University, is a registered Professional Engineer, and holds five US patents.
FIGURE 3

AIRFLOW AND STATIC PRESSURE DATA
FOR TYPICAL DUST COLLECTION CIRCUIT
FIGURE 4

COMPARISON OF COMMON BELT TRANSFER TO IMPROVED TRANSFER
MATERIAL FLOW COMPARISON THROUGH TRANSFER

FIGURE 5

FLOW MODEL OF RIGHT-ANGLE TRANSFER CHUTE

FIGURE 6
SCHEMATIC OF EXISTING CRUSHER HOUSE / RECLAIM AREA DUST CIRCUIT

FIGURE 7
MODIFIED CIRCUIT TO ELIMINATE TWO FANS AND ONE COLLECTOR

FIGURE 8
SYSTEM AS DESIGNED

SYSTEM AS MODIFIED

Bottom Duct Connections

One Collector Removed

Lateral Connections

CRUSHER HOUSE / RECLAIM SYSTEM DUCTING IMPROVEMENTS

FIGURE 9
COMBINATION TRUCK / RAILCAR LOADOUT

FIGURE 10
FIGURE 11

Before Modification

New Dust Collection System Added

COMBINATION TRUCK / RAILCAR LOADOUT STATION
FIGURE 12
ROTARY RAILCAR DUMPER WITH MODIFIED SEALING ENCLOSURE
Comparison Of Dust Collector Housing
And Filter Bag Arrangement

FIGURE 13
ROTARY RAILCAR DUMPER WITH FOG SPRAY SYSTEM

FIGURE 14