the course of the overall project an ongoing search was made for any additional information relevant to the project. Furthermore, the findings and information to be discussed in subsequent sections of this report are intended to reflect the best available information available as of the time of writing. The emissions estimates and the estimated control efficiencies presented and discussed in Sections 3.0 and 4.0 reflect the results of the complete review of literature and are recommended as the most appropriate information available for this application. A complete bibliography of references obtained during the study to date is included in Section 7.2.

3.0 FUGITIVE EMISSION SOURCE IDENTIFICATION/CHARACTERIZATION

This section provides a discussion of the various sources of fugitive dust emission associated with the operation of a coal-fired power plant. These sources are a direct result of the handling and on-site storage of large quantities of coal (and in some cases limestone), as well as the handling and disposal of fly ash. For the purpose of this report, each major source of fugitive dust emissions at a coal-fired power plant has been considered on an individual basis in order to provide additional insight into their relative significance, both in terms of the magnitude of the emissions and the extent (severity) of the resulting impacts on ambient air quality.

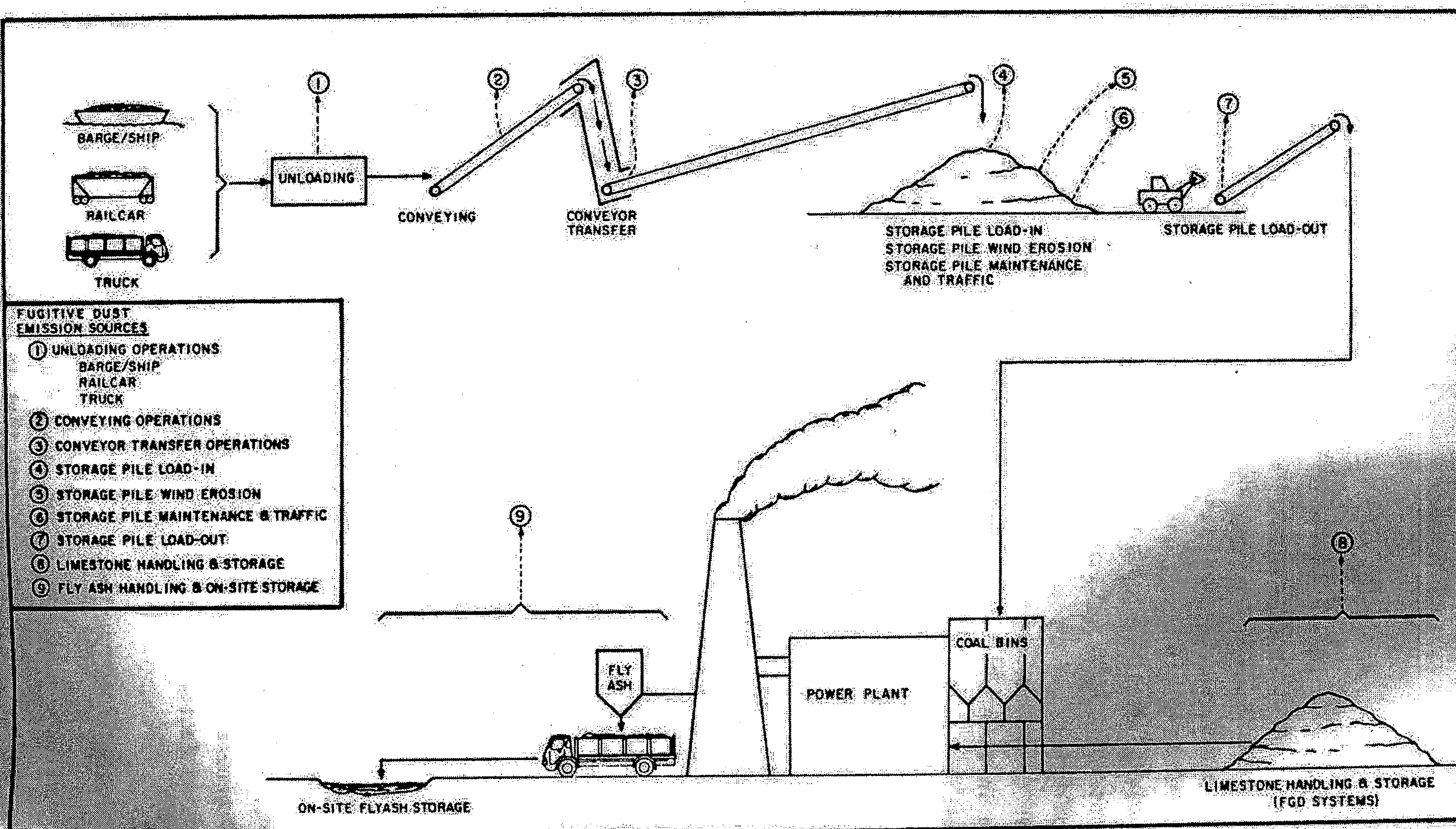
A schematic representation of the coal handling and storage process at a coal-fired power plant is shown in Figure 3-1. Typical major sources of fugitive dust emissions are shown in the figure and given below as follows:

1. coal unloading operations - rail, truck, barge
2. coal conveying
3. conveyor transfer operations
4. storage pile load-in operations
5. storage pile wind erosion
6. storage pile maintenance and traffic
7. storage pile load-out
8. limestone handling (flue gas desulfurization systems)
9. fly ash handling and disposal operations

It should be noted here, that fugitive dust emission sources 8 and 9 (limestone and flyash storage and handling) are not quantitatively considered in this report since they are not part of the coal handling process. They are, however, presented here and considered in a qualitative manner for completeness. A discussion of each of the above fugitive dust emission sources is contained in the following subsections. Each subsection includes: (a) a description of the operations that generate fugitive dust emissions, and (b) the most representative emission factor for estimating emissions available from the literature.

3.1 UNLOADING OPERATIONS

Coal unloading operations, as discussed in this report, refer to all methods of unloading the coal that is delivered to a power plant.



SCHEMATIC REPRESENTATION OF MAJOR SOURCES OF FUGITIVE DUST AT A COAL-FIRED POWER PLANT.

The three most common means of coal delivery are by rail, barge/ship, and truck. Other methods such as by coal slurry pipeline or by pneumatic conveyor are sometimes utilized, however they do not result in a significant quantity of fugitive dust emissions and will therefore not be discussed further. Since full-load consumption of coal at power plants can require a relatively high frequency of unloading of railroad cars, barges, or trucks, fugitive dust can become a potential problem as a result of unloading operations.

The most common method of coal delivery to a power plant is by rail (Midkiff, 1979). Railcars are unloaded at side dump, rotary dump, or bottom-hopper dump stations. Due to the very high rate of unloading coal from a railcar (for example, a 100-ton car is typically unloaded in approximately 10-20 seconds), the potential for fugitive dust generation at the point of unloading is very great. Dust control is normally achieved by utilizing a wet suppression (water spray) system, enclosing the unloading operation, negatively aspirating the unloading area, reducing the fall distance of the coal, or a combination of the above.

Barge and ship delivery of coal to power plants is on the increase and a variety of unloading methods are presently being used. Bridge-type unloaders, rail-mounted clamshell unloaders, and bucket elevators are the most common methods of unloading; however, other more efficient methods are becoming popular such as self-unloading colliers and screw-type auger unloaders. Typical control methods for the reduction of fugitive dust generation from barge and ship unloading operations are wet suppression, partial enclosures and wind screens, and the reduction of fall height.

The delivery of coal by truck is typically uncomplicated. The coal is dumped directly onto an outdoor storage pile or, in some cases, directly into a bin or hopper. Fugitive dust emissions associated with truck dumping operations are generally considered to be less significant than for rail or barge unloading due to the smaller quantities involved and the more localized nature of the operation. The most frequently used dust control method is wet suppression. This method is not always practical, however, for an open and widespread dumping operation on an outdoor storage pile.

Fugitive dust emissions from unloading occur primarily as a result of the combined action of mechanical agitation of the coal as it strikes the sides and bottom of the delivery vehicle/device and the turbulence created by the air which the coal displaces as it is unloaded. Wind generated losses are generally considered to be relatively minor during unloading. The rate of fugitive dust emissions from unloading operations may differ substantially from one facility to another due to a wide variation of significant factors including the following:

- coal characteristics (particle size distribution, silt or fine particle content, moisture content, density, etc.)
- unloading rate
- unloading method and procedure
- climate (wind, precipitation)
- method of fugitive dust control utilized

The results of the literature survey performed as Phase I of this project (described in Section 2.0) have illustrated that there is a relatively wide variation in the reported magnitude of the emissions and emission factors recommended for use in estimating emissions from unloading operations. On the basis of this review of literature, specific recommendations regarding the most appropriate emission rate or emission factor for unloading operations have been developed. In some cases, the recommendations have been supported by personal communications with the investigators responsible for publishing the information available. The recommended emission rates and factors are given below for each of the previously discussed modes of coal delivery to power plants. A relative estimate of the reliability of each emission factor has also been provided using the following rating system:

excellent
good
average
below average
poor

Ratings above average are considered to be supportable by in-field measurements of emissions, whereas below average and poor ratings may have been based all or in part on engineering judgment or visual observations. It should be noted that these ratings are intended to be relative to each other, rather than absolute ratings. They are in no way intended to be relative to those given by EPA for stack emission factors which are generally considered to be much more reliable.

Railcar Unloading

Figure 3-2 presents the most representative emission factor (EF) formula available for estimating emissions from railcar unloading operations. As indicated in the figure, this emission factor was derived from a comprehensive field test performed by Davis, et al. (1983) at an enclosed rotary railcar unloading operation. Also indicated in the figure are emission factors projected by Meyer (1983) for a bottom dump, overhead trestle railcar unloading operation. Meyer (1983) estimated that these emissions should be approximately the same as those observed for the rotary dumper operation. It is also noted that these emission factor estimates are in the absence of any control device (for example, other than the rotary dump enclosure implicitly included in the observations made by Davis, et al. (1983). The reliability of the emission factor for rotary railcar unloading operations is considered to be good. The reason for this better than average rating is the exhaustive in-field measurements made by Davis, et al. (1983) at an enclosed rotary railcar dumper. The emission factor for the overhead railcar trestle unloader is considered to be below average in terms of reliability. This emission factor was projected by Meyer (1983) on the basis of the measurements made by Davis, et al. (1983) of the rotary railcar dumper emissions.

Truck Unloading

The recommended emission factor for estimating fugitive dust emissions for enclosed truck dumping operations is given in Figure 3-3. This emission factor was projected by Meyer (1983) to be approximately an order of magnitude lower than enclosed rotary railcar dumping

Fugitive Dust Source: RAILCAR UNLOADING

EF = 0.001* lb/ton (Rotary Railcar Dumper)
EF = 0.001** lb/ton (Overhead Trestle Dumper)

where: EF = uncontrolled suspended particulate (<30 μm in diameter) emissions (lb/ton of material unloaded)

*Emission factor based on field measurements performed by Davis, et al. (1983) at an enclosed rotary railcar dumping operation

**Emission factor projected by Meyer (1983) on the basis of the measurements of the rotary railcar rotary dumper emissions reported by Davis, et al. (1983)

Reliability Rating: Rotary Railcar Dumper - Good
Overhead Trestle Dumper - Below Average

Figure 3-2. Predictive Fugitive Dust Emission Factors for Rotary- and Trestle-type Railcar Dumping Operations

Fugitive Dust Source: TRUCK UNLOADING (Enclosed)

$$EF = 0.0001^{*} \text{ lb/ton}$$

where: EF = uncontrolled suspended particulate (<30 μm in diameter) emissions (lb/ton of material dumped from truck).

*Emission factor projected by Meyer (1983) on the basis of the measurements of rotary dumper emissions reported by Davis, et al. (1983)

Reliability Rating: Below Average

Figure 3-3. Predictive Fugitive Dust Emission Factors for Truck Unloading Operations emissions. In light of this, the emission factor for truck unloading is considered to be below average in terms of reliability.

Barge/Ship Unloading

Fugitive dust emission factors reported in the literature for barge or ship unloading operations are, to a great extent, based on measurements of fugitive dust emissions resulting from the load-in and load-out of material to storage piles. Two types of emission formulae are recommended for barge/ship unloading operations, both of which are given in Figure 3-4. The two emission factors given in the figure are for batch unloading operations (clamshell and similar type unloaders) and continuous unloading operations (bucketwheels or bucket elevators). Both emission factors were developed by Cowherd, et al. (1979a) of Midwest Research Institute (MRI). Their reliability is considered to be above average.

3.2 CONVEYING AND TRANSFER OPERATIONS

The review of literature performed as Phase I of this project has indicated that the information available to help quantify fugitive dust emissions from conveying operations is very limited. The information that is available indicates that the emissions associated with conveying operations are generally considered to be insignificant when compared with other fugitive dust sources, particularly with the more recent use of enclosed conveyor systems. Emissions associated with the transfer of material from one conveyor to another has, however, been more thoroughly studied and reported in the literature. That information indicates that conveyor transfer emissions are significantly greater than the emissions associated with the operation of the conveyors themselves. In light of this, only conveyor transfer emissions will be considered here.

Figure 3-5 presents the recommended emission factor for use in estimating fugitive dust emissions from conveyor transfer stations. The reader will note that this emission factor is representative of uncontrolled emissions (with the exception of the transfer house enclosure which is typically utilized at conveyor transfer points). The emission factor shown in Figure 3-5 is based on an emission factor

Fugitive Dust Source: BARGE/SHIP UNLOADING

Batch unloading operations (clamshell type unloader)

$$\boxed{EF^* = \frac{0.0018\ (\frac{S}{5})\ (\frac{u}{5})\ (\frac{H}{5})}{(\frac{M}{2})^{2}\ (\frac{Y}{6})^{1/3}}\ \text{lb/ton}}$$

Continuous unloading operations (bucketwheel, bucket elevator, etc.)

$$\boxed{EF^* = \frac{0.0018\ (\frac{S}{5})\ (\frac{u}{5})\ (\frac{H}{10})}{(\frac{M}{2})^{2}}\ \text{lb/ton}}$$

where: EF = uncontrolled suspended particulate (<30 <μm diameter) emissions (lb/ton of material unloaded)
S = material silt content (%)
u = wind speed (mph)
H = material drop height from unloading device (ft)
M = material moisture content (%)
Y = batch dumping device capacity (yd^3)

* Emission factors developed by Bohn, et al. (1978), and Cowherd, et al. (1979a) of Midwest Research Institute (MRI).

Reliability Rating: Above Average

Figure 3-4. Predictive Fugitive Dust Emission Factors for Batch and Continuous Barge/Ship Unloading Operation

Fugitive Dust Source: CONVEYOR TRANSFER STATION (ENCLOSED)

$$EF^* = \frac{0.00018\ (\frac{S}{5})\ (\frac{u}{5})\ (\frac{H}{10})}{(\frac{M}{2})^2} \text{lb/ton}$$

where: EF = uncontrolled* suspended particulate (<30 <μm diameter) emissions (lb/ton of material transferred)
S = material silt content (%)
u = wind speed (mph)
H = material drop height (ft)
M = material moisture content (%)

*Uncontrolled emissions with the exception of the conveyor transfer station enclosure which is projected to have an effective control efficiency of 90%. For an open conveyor transfer operation, increase emissions by a factor of 10. Emission factor developed by Bohn, et al. (1978) and Cowherd, et al. (1979a)

Reliability Rating: Average

Figure 3-5. Predictive Fugitive Dust Emission Factor for Conveyor Transfer Station Operation developed by Cowherd, et al. (1979a) of MRI for use in estimating emissions from continuous load-in operations. To account for the use of a full enclosure around the point of transfer, the emission factor developed for continuous load-in emissions was reduced by an order of magnitude to account for the controlling influence of the enclosure. To estimate the emissions for a conveyor transfer station without an enclosure, the magnitude of the emissions should therefore be increased by an order of magnitude. The reliability of this emission factor is considered to be average.

3.3 STORAGE PILE LOAD-IN/LOAD-OUT OPERATIONS

The most visible source of fugitive dust emissions at a coal-fired power plant is the coal storage pile. Emissions from the pile can result from the transfer of coal to and from the pile as well as from the wind erosion of the fine particles on the surface of the pile. This section specifically addresses the fugitive dust emissions associated with the transfer of material to and from the pile (load-in and load-out).

Fugitive dust emissions attributable to the load-in of coal to the pile typically occur as a result of the opertion of a continuous conveyor/stacker method or a batch-type method such as a front end loader or similar device. Fugitive emissions generated during these load-in activities occur as a result of the combined effect of ambient winds and the material being dropped from the device onto the pile. The most common method of load-out from the storage pile to a conveyor or receiving hopper is by front end loader, although many other methods are available and are in use. Other, more complicated methods, include under-pile conveyor systems and under-pile gravity feed hoppers which virtually eliminate fugitive dust emissions from load-out operations.

Figure 3-6 presents the most representative emission factor (EF) formula available for estimating fugitive dust emissions from continuous and batch load-in and load-out operations. These emission factors were developed by Bohn, et al. (1978), and Cowherd, et al. (1979a) of MRI on the basis of the results of several field studies designed to isolate the emissions associated with this particular

Fugitive Dust Source: STORAGE PILE LOAD-IN/LOAD-OUT OPERATION

Continuous unloading operations (bucketwheel, bucket elevator, etc.)

$$EF^* = \frac{0.0018\ (\frac{S}{5})\ (\frac{u}{5})\ (\frac{H}{10})}{(\frac{M}{2})^2}\ \text{lb/ton}$$

Batch unloading operations (clamshell type unloader)

$$EF^* = \frac{0.0018\ (\frac{S}{5})\ (\frac{u}{5})\ (\frac{H}{5})}{(\frac{M}{2})^2\ (\frac{Y}{6})^{1/3}}\ \text{lb/ton}$$

where: EF = uncontrolled suspended particulate (<30 μm diameter) emissions (lb/ton of material unloaded)
S = material silt content (%)
u = wind speed (mph)
H = material drop height from unloading device (ft)
M = material moisture content (%)
Y = batch dumping device capacity (yd^3)

*Emission factors developed by Bohn, et al. (1978), and Cowherd, et al. (1979a) of Midwest Research Institute (MRI).

Reliability Rating: Above Average

Figure 3-6. Predictive Fugitive Dust Emission Factors for Continuous and Batch Storage Pile Load-In and Load-Out Operations activity. The overall predictive reliability of these emission factors is considered to be above average. As is noted in the figure, fugitive dust emissions are expected to be dependent on several material and site dependent properties such as silt and moisture content of the coal, drop height from the unloading device, dumping device capacity, and wind speed. These emission factors are intended to be representative of total suspended particles (i.e., particles less than about 30 μm in diameter), and there has been no accounting for emission control.

3.4 STORAGE PILE WIND EROSION

The review of approximately 250 documents identified as being relevant to this project has indicated that storage pile wind erosion can be a significant source of fugitive dust emissions. Furthermore, due to the relative significance of their emissions, storage piles have received much more investigative attention in the literature than perhaps any other coal handling activity.

For wind generated erosion from coal storage piles, a variety of emission factors have been developed in terms of mass per unit area per day, as well as in terms of mass per unit of mass placed in storage. Most investigators in this area agree that the most plausible method of estimating wind generated fugitive dust emissions from coal storage piles should be based on the areal extent of the pile rather than the quantity of material stored or placed in storage.

Figure 3-7 presents the recommended emission factor formula for estimating fugitive dust emissions from wind erosion of storage piles. This emission factor has been suggested by Cowherd, et al. (1974), Cowherd (1982) and Bohn, et al. (1978) of MRI as being the most appropriate. The reliability of this emission factor is considered to be below average because the correction terms in the equation have not been verified for storage piles and because the equation was developed originally for the sand and gravel industry.

Fugitive Dust Source: WIND EROSION FROM STORAGE PILES

$$EF^{*} = 1.7\left(\frac{S}{1.5}\right)\left(\frac{d}{235}\right)\left(\frac{f}{15}\right) \text{ lb/day/acre}$$

where: EF = uncontrolled suspended particulate (<30 μm in diameter) emissions (lb/day/acre of pile area)
S = material silt content (%)
d = number of dry days per year (<0.01 inches of precipitation per day)
f = frequency of occurrence of wind speeds greater than 12 mph at the mean pile height (%)

*Emission factor suggested by Cowherd, et al. (1974), Cowherd (1982) and Bohn, et al. (1978) of Midwest Research Institute (MRI).

Reliability Rating: Below Average

Figure 3-7. Predictive Fugitive Dust Emission Factor for Estimating Wind Erosion Emissions from Storage Piles

3.5 STORAGE PILE TRAFFIC AND MAINTENANCE

For estimating fugitive dust emissions associated with equipment traffic movement on or between storage piles, as well as equipment traffic involved in maintaining the shape and distribution of the pile, empirical expressions are available which have been developed for estimating emissions from medium duty vehicles traveling on dry unpaved roads. These expressions are generally given in terms of pounds of fugitive dust emission per vehicle mile traveled (VMT) and are considered to be fairly reliable, provided adequate information is available, such as the distance traveled and the weight of the vehicle.

Figure 3-8 presents the recommended emission factor for estimating fugitive dust emission generated by medium duty vehicles traveling over a dry unpaved roadway. This emission factor is recommended by MRI (1982) and is intended for use in estimating uncontrolled suspended particulates. In most cases, the use of this emission factor will be inappropriate for estimating traffic and maintenance emissions due to the lack of the specific information required in order to make the estimate. Bohn, et al. (1978) of MRI also recommends the use of a generalized emission factor for estimating emissions associated with vehicular activity on and around storage piles. This generalized emission factor is presented in Figure 3-9. The activity factor K was determined from conventional upwind/downwind sampling and is defined as 1.0 for the operation tested by the reporting author. Because of the potential inaccuracies of the sampling methodology and the number of assumptions used in deriving the correction terms, this predictive emission formula is considered to have a poor reliablity rating.

As an alternative to the emission factors presented in Figures 3-8 and 3-9, it is proposed that the estimate of storage pile traffic and maintenance emissions be made on the basis of storage pile load-out emissions (see later). One could expect that, on the average, fugitive dust emissions associated with storage pile maintenance and traffic activities would be of the same order as storage pile load-out emissions. Since storage pile maintenance activities can be expected

Fugitive Dust Source: STROAGE PILE TRAFFIC AND MAINTENANCE
(Unpaved Roadway Emissions)

$$EF^{*} = 5.286 + 0.00542\ (S)(W)(s)\ \text{lb/VMT}$$

where: EF = uncontrolled suspended particulate (<30 μm in diameter) emissions (lb/vehicle mile traveled)
S = material silt content (%)
W = mean vehicle weight (tons)
s = mean vehicle speed (mph)

*Emission factor recommended by Midwest Research Institute (MRI, 1982) for estimating emissions from unpaved roadways.

Reliability Rating: Average

Figure 3-8. Predictive Fugitive Dust Emission Factor for Estimating Emissions from Storage Pile Traffic and Maintenance Activities - Unpaved Roadway Emissions

Fugitive Dust Source: STORAGE PILE TRAFFIC AND MAINTENANCE
(General Vehicular Activity on Pile)

$$EF^* = 0.1K \left(\frac{S}{1.5}\right)\left(\frac{d}{235}\right) \text{ lb/ton}$$

where: EF = uncontrolled suspended particulate (<30 μm in diameter) emissions (lb/ton of material handled)
K = activity factor (1.0 typically assumed)
S = material silt content (%)
d = no of dry days per year (days with <0.01 inches of precipitation)

*Emission factor recommended by Bohn, et al. (1978) of Midwest Research Institute (MRI)

Reliability Rating: Poor

Figure 3-9. Predictive Fugitive Dust Emission Factor for Estimating Emissions from Generalized Storage Pile Traffic and Maintenance Activities to be related to the amount of material removed from the pile, it follows that if the activity is similar (i.e., such as front end loader movement), then the emissions should somewhat be similar. Therefore, in the absence of more definitive information, it is recommended that storage pile maintenance and traffic emissions be estimated on the basis of storage pile batch load-out emissions.

3.6 LIMESTONE HANDLING AND STORAGE - FGD SYSTEMS

Fugitive dust emissions reported in the literature for limestone handling and storage operations have typically been based primarily upon those developed for similar coal handling and storage processes through engineering judgment or visual observation. The reliability of the estimates of emissions and emission factors is considered to be of questionable accuracy for site specific applications. This leads us to the recommendation that emission estimates for limestone handling and storage be based on the emissions and emission factors that have been previously presented here for similar operations (i.e., unloading, tranfer and conveying, storage pile wind erosion, etc.). Since most of the emission factors are given as functions of various material properties, it will be necessary to determine average or specific values for limestone properties such as silt content, moisture content, and density in order to make the most representative estimate. A discussion of these material properties is provided in Section 3.9.

3.7 FLY ASH HANDLING AND ON-SITE STORAGE OPERATIONS

Fugitive dust emissions resulting from the handling, storage and disposal of fly ash at a coal-fired power plant are typically considered to be a relatively minor source of fugitive dust when compared to other sources of dust at a power plant. The few emission factors for fly ash handling that have been reported in the literature for fly ash handling operations are typically nothing more than wide ranging, poorly documented engineering estimates. The lack of supporting information associated with these estimates indicates that the reliability of such estimates should be considered very poor.

In light of the fact that there is little reliable information available for estimating fugitive dust emissions from fly ash handling operations, it is recommended that the fugitive dust emissions for this activity be estimated on the basis of the most applicable emissions and emission factors given in the previous sections for coal handling operations. For example, for estimating emissions associated with the transfer of fly ash to an on-site storage area, it would be most appropriate to use the emission factors for storage pile load-in, using the appropriate material properties for fly ash. Since most of the emission factors are given as functions of various material properties, it will be necessary to determine specific or average properties of the fly ash in order to make the most representative emission estimate. A discussion of these material properties is given in Section 3.9.

3.8 SUMMARY OF EMISSIONS AND EMISSION FACTORS

A summary of the recommended emission rates and emission factors for coal, fly ash, and limestone handling and storage operations is contained in Table 3-1. These emission factors are intended to be representative of uncontrolled suspended particulate matter emissions (for example, particles less than about 30 μm in diameter) and are considered to be the most reliable estimates available. Also shown in the table is the reliability rating for each estimate, using the previously discussed rating system:

A - Excellent - based on comprehensive field testing
B - Above Average
C - Average
D - Below Average
E - Poor

Of the emission factors given, only emissions associated with vehicular activity on the storage pile are considered to be poor in terms of reliability. All others are considered to be either above average, average, or below average. Also shown are the references from which the information was obtained.

TABLE 3-1

RECOMMENDED FUGITIVE DUST EMISSION FACTORS FOR COAL, FLY ASH, AND LIMESTONE HANDLING AND STORAGE OPERATIONS

Operation	Uncontrolled Emission Factor	Reliability[a] Rating	Reference(s)
1. Coal Unloading			
Enclosed Rotary Railcar Dumper	0.001 lb/ton	B	Davis, et al. (1983)
Railcar Trestle Unloader	0.001 lb/ton	D	Davis, et al. (1983), Meyer (1983)
Truck Dumping (enclosed)	0.0001 lb/ton	D	Davis, et al. (1983), Meyer (1983)
Barge/Ship Unloaders			
Batch Operations (clamshell, etc.)	$\dfrac{0.0018\ (\frac{S}{5})\ (\frac{u}{5})\ (\frac{H}{5})}{(\frac{M}{2})^{2}\ (\frac{Y}{6})^{1/3}}$ lb/ton	B	Bohn, et al. (1978), Cowherd, et al. (1979a)
Continuous operations (bucketwheel, etc.)	$\dfrac{0.0018\ (\frac{S}{5})\ (\frac{u}{5})\ (\frac{H}{10})}{(\frac{M}{2})^{2}}$ lb/ton	B	Bohn, et al. (1978) Cowherd, et al. (1979a)
2. Conveyor Transfer Station			
Enclosed or partial enclosure	$\dfrac{0.00018\ (\frac{S}{5})\ (\frac{u}{5})\ (\frac{H}{10})}{(\frac{M}{2})^{2}}$ lb/ton	C	Bohn, et al. (1978) Cowherd, et al. (1979a)

TABLE 3-1 (Continued)

Operation	Uncontrolled Emission Factor	Reliability[a] Rating	Reference(s)
3. Storage Pile Load-In/ Load-Out			
Batch Operations (clamshell, etc.)	$\dfrac{0.0018 \left(\frac{S}{5}\right) \left(\frac{u}{5}\right) \left(\frac{H}{5}\right)}{\left(\frac{M}{2}\right)^2 \left(\frac{Y}{6}\right)^{1/3}}$ lb/ton	B	Bohn, et al. (1978), Cowherd, et al. (1979a)
Continuous operations (bucketwheel, etc.)	$\dfrac{0.0018 \left(\frac{S}{5}\right) \left(\frac{u}{5}\right) \left(\frac{H}{10}\right)}{\left(\frac{M}{2}\right)^2}$ lb/ton	B	Bohn, et al. (1978) Cowherd, et al. (1979a)
4. Wind Erosion from Storage Piles	$1.7 \left(\frac{S}{1.5}\right) \left(\frac{d}{235}\right) \left(\frac{f}{15}\right)$ lb/day/acre	D	Bohn, et al. (1978) Cowherd, et al. (1974) Cowherd (1982)
5. Storage Pile Traffic and Maintenance			
Unpaved Roadway Emissions	$5.286 + 0.00542\ (S)(W)(s)$ lb/VMT	C	MRI (1982)
General Vehicular Activity on Pile	$0.1K \left(\frac{S}{1.5}\right)\left(\frac{d}{235}\right)$ lb/ton	E	Bohn, et al. (1978)