TABLE 3-1 (Continued)

Operation	Uncontrolled Emission Factor	Reliability[a] Rating	Reference(s)
6. Limestone Handling and Storage	Use similar activity for coal handling and storage (see text)	--[b]	--[b]
7. Fly Ash Handling and Storage	Use similar activity for coal handling and storage (see text)	--[b]	--[b]

where: S = silt content (percent)
u = wind speed (mph)
H = drop height (feet)
M = moisture content of material (percent)
Y = dumping device capacity (yd^3)
d = no. of dry days per year (<0.01 inches of precipitation)
f = frequency of occurrence of wind speeds greater than 12 mph at the mean pile height (%)
W = mean vehicle weight (tons)
s = mean vehicle speed (mph)
K = activity factor (defined as unity for operation tested)

[a] Reliability Rating System:

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

[b] Refer to emissions from a similar activity for coal handling and storage (see text).

3.9 MATERIAL PROPERTIES OF COAL

As previously discussed, specific variables have been observed or have been hypothesized to affect the emission rate of fugitive dust from various handling and storage facilities. The most prevalent approach reported in the literature on the development of emission factors has been to modify experimentally observed and/or calculated emissions with correction factors for material properties that are thought to affect fugitive dust emissions. The variables that are currently thought to have the most important effects are:

- silt (fine particle) content of material (Silt content is defined as the percentage of material that will pass through a 200 mesh standard sieve screen and is a measure of particle size; it is not an indication of mineral content.)
- surface moisture content of material
- density of material
- wind speed
- frequency of occurrence of high wind speeds
- number of dry days per year or season
- height at which material has been dropped (fall distance)
- batch size (i.e., loader capacity)

Of these variables, all but the first three are dependent on the climatology of the facility/location or the characteristics of the operation of the facility itself. The first three variables are dependent only on the characteristics of the material.

The Phase I review of literature illustrated that there have been many reported values of silt and moisture content of coal. Most of the reported values are based on actual measurements obtained during in-field observations of fugitive dust emissions resulting from coal handling/storage emissions. A summary of some of these observations is given below:

Reference		Coal Silt Content (%)	Coal Moisture Content (%)
Bohn, et al. (1978)	Average	4.0	6.0
	Range	2.0-6.0	5.6-7.0
Cuscino (1979)	Average	5.0	4.8
	Range	2.0-7.7	2.8-11.0
TRW (1982)	Average	4.4	2.8

On the basis of these observations it is recommended that average values of silt and moisture content of coal of 5 percent be utilized unless site-specific data are available to indicate otherwise. These average values should be sufficient for use as input to the emission factor equations previously presented in Section 3.0.

Typical densities of coal have also been reported in the literature. A summary of some of the various observations of coal density is given below:

Reference		Coal Density (g/cm^3)
TRW (1982)	Range	1.25-1.45
Cowherd, Bohn & Cuscino (1979a)	Average	1.4
Cuscino, Cowherd & Bohn (1980)	Average	2.5
Ohio EPA (1980)	Range	2.0-2.5

On the basis of these observations, it is recommended that an average density of 1.5 g/cm^3 be assumed for coal unless site-specific data are available to indicate otherwise.

Very little information has been published regarding the silt and moisture content of fly ash or limestone. Limited measurements of fly ash silt content that were made by Bohn, et al. (1978) and Cowherd and Cuscino (1977) have indicated a range of silt contents for fly ash of 14-23 percent with an average value of 18 percent. No measurements were made of the moisture content. One would expect that measurements of the moisture content of fly ash would be variable and very dependent on the amount of water used to control fly ash emissions after removal from the system. A single measurement of limestone silt content made by Bohn, et al. (1978) indicated an average value of 0.4 percent. No values of moisture content are known to have been reported. In light of the sparsity of the information available for the material properties of fly ash and limestone, it is recommended that, if an estimate of fly ash and/or limestone emissions are required, then they should be made on a case-by-case basis on the basis of the material properties for coal.

4.0 EMISSION CONTROL TECHNOLOGY

As discussed in the previous section, the emission factors recommended for use in estimating fugitive dust emissions from various coal handling operations are generally intended to be representative of uncontrolled emissions. The purpose of this section is to provide a review of previously reported dust control efficiencies that have been published in the literature and thereby provide a means of estimating net controlled emissions from a particular activity. This information was obtained during the Phase I review of literature which is discussed elsewhere in this report.

The control technology available for fugitive dust emission sources at coal-fired power plants generally fall into four categories:

1. Containment
2. Collection
3. Wet supression
4. A combination of each of the above.

The various techniques for emission control have a wide variation in control efficiencies depending on the particular combinations of control processes and the specific operations to which they are applied. The control efficiency values reported in the literature for various industrial applications are in general agreement, although supporting documentation as to the specific conditions under which these values were obtained are typically unavailable. Without this supporting information, the determination of the best estimate of control efficiency is difficult.

It should also be noted that reported control efficiencies were obtained by a variety of methods ranging from comprehensive in-field measurement programs to visual estimates. In many cases several different efficiencies have been reported by different investigators. These differences have been retained here to provide a range of values from which an engineering judgment can be made to determine the most appropriate control efficiency for a particular activity. A summary of the various reported control efficiencies that have been reported in the literature is contained in the following subsections.

4.1 UNLOADING OPERATIONS

Table 4-1 presents a summary of the estimated control efficiencies for railcar, barge/ship, and truck unloading operations. These estimated efficiencies are presented without recommendation as to accuracy or reliability and are intended to provide the reader with a guideline for estimating net controlled emissions from unloading operations. Where a range of control efficiencies is given, either by a single author or by two or more authors, the determination of which control efficiency to use should be based on the relative condition of the equipment and the extent of its use.

4.2 CONVEYING AND TRANSFER OPERATIONS

Table 4-2 presents the summary of estimated control efficiencies for conveying and transfer operations. The control efficiencies for conveyor systems given in Table 4-2 are poorly supported in the literature. The estimates given appear to have been largely based on qualitative judgments rather than actual measurements. They are included here only for completeness. As generally seems to be the case, a wide range of control efficiencies has been reported for several methods of control. Where such a range is given, it will be necessary to make an engineering judgment as to the applicability of a stated efficiency to a particular process. Typical control methods for conveyor and transfer operations consist of partial or full enclosures, enclosures with dust removal devices such as baghouses, wet suppression, chemical sprays, and foam.

4.3 STORAGE PILE LOAD-IN OPERATIONS

Table 4-3 presents the estimated control efficiencies for storage pile load-in operations. The three basic control methods utilized to reduce fugitive emissions from storage pile load-in operations are enclosure, wet suppression, and reduction of drop distance.

TABLE 4-1

ESTIMATED DUST CONTROL EFFICIENCIES FOR UNLOADING OPERATIONS

Activity	Control Method	Estimated Control Efficiencies (%)	References
A. Railcar Unloading	- enclosure with bag filter	99	Bohn, et al. (1978), Currier & Neal (1979)
	- enclosure with chemical sprays	95	Davis, et al. (1981)
	- water sprays	80 95	Currier & Neal (1979), Bohn, et al. (1978) EPA (1979a)
	- telescopic chutes & chemical wetting	75	Davis, et al. (1981)
B. Barge/Ship Unloading	- water sprays	80	Currier & Neal (1979)
	- chemical wetting	80	Davis, et al. (1981)
	- telescopic chute & chemical wetting	75	Davis, et al. (1981)
	- partial enclosure with baghouse	90-99	TRW (1982)
C. Truck Unloading	- enclosure with control device	90-95	Ohio EPA (1980)
	- negative aspiration over dump area	85	EPA (1979a)
	- water sprays	50	Collins (1979), EPA (1979a)

TABLE 4-2

ESTIMATED DUST CONTROL EFFICIENCIES FOR CONVEYING AND TRANSFER OPERATIONS

Activity	Control Method	Estimated Control Efficiencies (%)	References
A. Conveyor Systems	- partial enclosure	70	Bohn, et al. (1978), Currier & Neal (1979)
		90	EPA (1979a)
	- full enclosure	99	Bohn, et al. (1978), TRW (1982)
		100	EPA (1979a)
	- wet conveyor belt	15	Jutze, et al. (1977)
B. Conveyor Transfer Stations	- full enclosure	70	Bohn, et al. (1978)
		90	Currier & Neal (1979), Szabo (1978)
	- enclosure with baghouse	99	Bohn, et al. (1978), EPA (1979a), TRW (1982)
		99.5	Davis, et al. (1981)
	- water spray	35	Jutze, et al. (1977)
		50	Currier & Neal (1979)
		70-95	Bohn, et al. (1978)
	- micron droplet spray	90	Kretch (1983)
	- chemical spray	85	Currier & Neal (1979)
	- foam	75	Jutze, et al. (1977)
	- micron-sized foam spray	99	Cole & Ayers (1983)

TABLE 4-3

ESTIMATED DUST CONTROL EFFICIENCIES FOR STORAGE PILE LOAD-IN OPERATIONS

Activity	Control Method	Estimated Control Efficiencies (%)	References
Storage Pile Load-In			
	A. Conveyor Systems		
	- general enclosure	70-99	Jutze, et al. (1977)
	- baghouse on silo	95	EPA (1979a)
	- stone ladder	80	Bohn, et al. (1978)
	- wind guards	50	Bohn, et al. (1978)
	B. Spray Systems		
	- chemical wetting agents	80-90	Jutze, et al. (1977), Currier & Neal (1979)
	- water spray	50	Currier & Neal (1979), Ohio EPA (1980)
	- micron-sized foam spray	99	Cole & Ayers (1983)
	- micron-droplet spray	90	Kretch (1983)
	C. Reduce Drop Distance		
	- variable height stacker	25	Bohn, et al. (1978), TRW (1982)
	- telescopic chute	75	Bohn, et al. (1978), Jutze, et al. (1977)
		95	EPA (1979a)
	- telescopic chute plus chemical dust supressant	75	Davis, et al. (1981)

4.4 STORAGE PILE WIND EROSION

Table 4-4 summarizes the estimated dust control efficiencies for various control methods for storage pile wind erosion. The three principal methods of control are full or partial enclosure, surface stabilization, and wind speed reduction.

4.5 STORAGE PILE LOAD-OUT OPERATIONS

Table 4-5 contains a summary of the estimated control efficiencies for storage pile load-out operations. The two basic categories of emission reduction are wet suppression and reduction of material disturbance.

4.6 STORAGE PILE MAINTENANCE AND TRAFFIC/MATERIALS HANDLING AND PROCESSING

Table 4-6 contains the reported values of emission control efficiencies for storage pile maintenance and traffic activities as well as some general materials handling and processing activities such as coal crushing and screening. Typical control methods are wet suppression and full or partial enclosures.

4.7 UNPAVED ROADWAYS

Table 4-7 summarizes the reported values of emission control efficiencies for unpaved roadways. Unpaved roadway emissions may be important if there is a significant amount of traffic associated with storage pile maintenance or movement of material. Typical control methods include surface stabilization and road surface improvement.

4.8 EXPOSED AREAS

Table 4-8 summarizes the reported values of estimated emission control efficiencies for emissions from exposed areas. Exposed areas generally do not include areas such as coal piles, but the information presented may be applicable to areas of flyash and/or limestone storage and disposal. Typical control methods include surface stabilization and wind speed reduction.

TABLE 4-4

ESTIMATED DUST CONTROL EFFICIENCIES FOR STORAGE PILE WIND EROSION

Activity	Control Method	Estimated Control Efficiencies (%)	References
Storage Pile Wind Erosion			
	A. Surface Stabilization		
	- water sprays	50	Jutze, et al. (1977), TRW (1982)
		80	Bohn, et al. (1978)
	- chemical wetting agents	80-99	Ohio EPA (1980)
		85	Currier & Neal (1979)
		90	Jutze, et al. (1977)
	- surface crusting agent	95	Davis, et al. (1981)
		<99	Bohn, et al. (1978)
	- carry over wetting from load-in	80	Davis, et al. (1981)
	B. Enclosures		
	- silo with baghouse	100	Bohn, et al. (1978)
		95-99	Jutze, et al. (1977)
		99	Collins (1979), EPA (1979a), TRW (1982)
	C. Wind Speed Reduction		
	- vegetative wind breaks	30	Bohn, et al. (1978)
	- reduced pile height	30	Bohn, et al. (1978)
	- wind screens/wind fences	<80	Carnes & Drehmel (1981)
		<75	Larson (no date)
		<60 (IP* only)	Larson (no date)
	- pile shaping/orientation	<60	Martin & Drehmel (1981)

* Inhalable particulate matter

TABLE 4-5

ESTIMATED DUST CONTROL EFFICIENCIES FOR
STORAGE PILE LOAD-OUT OPERATIONS

Activity	Control Method	Estimated Control Efficiencies (%)	References
Storage Pile Load-Out			
	A. Wet Supression		
	- general water spray	50	Jutze, et al. (1977)
	- bucket wheel reclaim sprays	95	Bohn, et al. (1978)
	- micron-sized foam spray	99	Cole & Ayers (1983)
	- micron-droplet spray	90	Kretch (1983)
	B. Reduce Material Disturbance		
	- stacker reclaimer	25-50	Jutze, et al. (1977)
		<80	Bohn, et al. (1978)
	- enclosure with baghouse	99	Davis, et al. (1981)
	- gravity feed	80	Jutze, et al. (1977)
		85	Bohn, et al. (1978)
	- rake reclaimer	85	Bohn, et al. (1978)
	- bucket wheel reclaimer	80	Bohn, et al. (1978)

TABLE 4-6

ESTIMATED DUST CONTROL EFFICIENCIES FOR STORAGE PILE MAINTENANCE AND TRAFFIC/ MATERIAL HANDLING AND PROCESSING ACTIVITIES

Activity	Control Method	Estimated Control Efficiencies (%)	References
A. Vehicular Traffic Around Storage Piles	- water sprays	50	Jutze, et al. (1977)
	- chemical sprays	90	Bohn, et al. (1978)
	- carryover of water or chemical applications from load-in	60	Davis, et al. (1981)
B. Coal Crushing & Screening	- enclosure with baghouse	99	EPA (1979a)

TABLE 4-7

ESTIMATED DUST CONTROL EFFICIENCIES FOR FUGITIVE DUST FROM UNPAVED ROADWAYS

Activity	Control Method	Estimated Control Efficiencies (%)	References
Unpaved Roadways			
	A. Surface Stabilization		
	- watering	50	Bohn, et al. (1978), Collins (1979), Jutze, et al. (1977)
	- oiling	75	Bohn, et al. (1978), Collins (1979)
		60	
		85	Jutze, et al. (1977)
	- chemicals (coherex, lignin, etc.)	90-95	Bohn, et al. (1978)
		85	EPA (1979a)
		84-97	Cuscino, et al. (1980), Jutze, et al. (1977)
		50	
	- watering (rainfall)	54-89	Cuscino, et al. (1980)
		50	Rosbury & Zimmer (1983)
	- chemicals	40-60	Rosbury & Zimmer (1983)
	B. Road Surface Improvement		
	- low silt aggregate	30	Bohn, et al. (1978)
	- oil and double chip surface	80	Bohn, et al. (1978)
	- paving	90	Bohn, et al. (1978)

TABLE 4-8

ESTIMATED DUST CONTROL EFFICIENCIES FOR
FUGITIVE DUST EMISSIONS FROM EXPOSED AREAS

Activity	Control Method	Estimated Control Efficiencies (%)	References
Exposed Areas*			
	A. Surface Stabilization		
	- watering	50	Bohn, et al. (1978)
	- chemical applications	70	Bohn, et al. (1978)
	- oiling	80	Bohn, et al. (1978)
	- paving & cleaning	>95	Bohn, et al. (1978)
	B. Wind Speed Reduction		
	- mechanical wind breaks (fences)	30	Bohn, et al. (1978)
	- vegetative ground cover	70	Bohn, et al. (1978)

* Although not generally applicable to coal handling operations, information on exposed areas may be useful in estimating emissions from flyash and/or limestone storage and disposal operations.

4.9 LIMESTONE HANDLING AND STORAGE - FGD SYSTEMS

Table 4-9 contains a summary of reported values of fugitive dust emission control efficiencies for various control methods utilized in the handling and storage of limestone. The table summarizes the estimated control efficiencies used in all phases of the limestone handling process. The principal means of dust control are surface stabilization, enclosure, and wind speed reduction.

TABLE 4-9

ESTIMATED DUST CONTROL EFFICIENCIES FOR FUGITIVE DUST EMISSIONS FROM LIMESTONE HANDLING AND STORAGE OPERATIONS

Activity	Control Method	Estimated Control Efficiencies (%)	References
A. Load-In	- water sprays	75	Bohn, et al. (1978)
		40	EPA (1977b)
	- chemicals	<99	EPA (1977b)
		80-90	Jutze, et al. (1977)
	- enclosure	70-90	Jutze, et al. (1977)
	- enclosure with chemical wetting	95	Davis, et al. (1981)
	- partial enclosure with telescopic chute	90	TRW (1982)
	- wind guards	50	Bohn, et al. (1978)
	- stone ladder	80	Bohn, et al. (1978)
	- telescopic chutes	75	Bohn, et al. (1978) Jutze, et al. (1977)
	- stacker spreader	25	Bohn, et al. (1978)
	- micron-sized foam spray	99	Cole & Ayers (1983)
	- micron-droplet spray	90	Kretch (1983)
B. Pile Traffic & Maintenance	- carryover of water/chemical from load-in	60	Davis, et al. (1981)
C. Wind Erosion	- water sprays	50	Bohn, et al. (1978)
	- chemical	70	Bohn, et al. (1978)
	- water/chemical carryover from load-in	80	Davis, et al. (1978)
	- wind breaks/fences	30	Bohn, et al. (1978)
	- vegetative cover	70	Bohn, et al. (1978)
	- partial enclosure - active pile	70	TRW (1982)

TABLE 4-9 (Continued)

Activity	Control Method	Estimated Control Efficiencies (%)	References
D. Load-Out	- water sprays	40	EPA (1977b)
	- chemicals	<99	EPA (1977b)
	- water sprays	80	Bohn, et al. (1978)
		50	Jutze, et al. (1977)
	- enclosure with bag filter	99	Bohn, et al. (1978), TRW (1982)
	- enclosure with chemical wetting	99	Davis, et al. (1981)
	- telescopic chute with dust suppressant carryover from storage pile	75	Davis, et al. (1981)
	- stacker/reclaimer	40	Jutze et al. (1977)
	- under-pile conveyor	80	Jutze et al. (1977)
	- micron-sized foam spray	99	Cole & Ayers (1983)
	- micron droplet spray	90	Kretch (1983)