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ASSESSMENT OF FUGITIVE EMISSIONS & DEVELOPMENT OF ENVIRONMENTAL GUIDELINES FOR CONTROL OF FUGITIVE EMISSIONS IN CEMENT MANUFACTURING INDUSTRIES

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FOREWORD

The Central Pollution Control Board has published a number of documents under the Programme Objective Series (PROBES), regarding environmental issues and preventive & control measures for pollution. The present document, on the Assessment of Fugitive Emissions and Development of Environmental Guidelines for Control of Fugitive Emissions in Cement Manufacturing, is in continuation of the PROBES. The Study for this document was undertaken by Central Pollution Control Board through the National Productivity Council, New Delhi and the Indian Institute of Technology, Kanpur, during which depth examination of selected cement plants was conducted.

Most of the cement plants in India have made appreciable efforts in controlling the stack emissions using efficient control technology systems like Bag filter and ESP. However, fugitive emissions from various sources in the cement plants still remain an area of concern. This Report provides detailed information on various types of fugitive dust emission sources, estimation and quantification of fugitive emissions, prevalent control practices in India, regulation in developed countries and evolving guidelines for prevention and control of fugitive emissions from cement plants. This Report will enable the cement units to adopt various measures and control the fugitive emissions on a sustainable basis.

I would like to express our sincere appreciation for the work done by the team of NPC, New Delhi and IIT, Kanpur. I also appreciate the efforts made by my colleagues Sh. P.K. Gupta, Environmental Engineer and Sh. J.S. Kamyotra, Additional Director for coordinating the Study and for finalizing the Report under the guidance of Dr. B. Sengupta, Member Secretary, CPCB.

We in CPCB hope that this Study will be useful to the cement units, regulatory agencies, research organizations and to all those interested in pollution control.

6th July, 2007

(J. M. Mauskar)

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CHAPTER 1.0
INTRODUCTION

1.1 Background

Cement manufacturing Industries is one of the important sectors of the Indian Economy. The sector has experienced phenomenal growth especially after the decontrol regime from 1999 and due to greater thrust by Government on Infrastructure development and spurt in housing construction sector, which has led to increased demand for cement. The cement sector has been rapidly growing at a rate over 8% and it is expected to grow further. The planning commission has projected a 10% growth rate during the 11th Plan Period (2007-2012). In view of the growth rate it is expected that more & more cement plants would come up and also the existing plants may expand their capacities through up gradation/modernization. Usage of more fly ash, slag etc is also increasing to create additional production capacity. In order to meet the increasing demand, most cement plants are making efforts to achieve higher production levels, at times by stretching the existing production facilities and by adding additional capacities.

On the other hand, the environmental concerns in terms of emissions to atmosphere are also growing. Most cement plants have made considerable efforts in controlling the stack emissions using most efficient control systems like bag filter and ESP & these plants generally meet the environmental regulations for stack emissions. However, fugitive emissions from various sources in cement plants still remain an area of concern. Till date there have been no environmental regulations/guidelines in terms of preventing/controlling fugitive emissions. Many cement plants though have taken initiatives in controlling fugitive emissions with varying degree of effectiveness. However in general more efforts are required in this area to satisfactorily control the fugitive emissions on sustainable basis.

It is in this connection, the Central Pollution Control Board (CPCB) undertook a study through the National productivity Council, New Delhi (NPC) and Indian Institute of Technology, Kanpur (IIT) on “Assessment of Fugitive Emissions and Development of Environmental Guidelines for Control of Fugitive Emissions in Cement Manufacturing Industries”.

This report details the outcome of the project findings.

1.2 Project Scope of Work

The scope of work for the project is as follows

i) Identification of all fugitive emission sources in cement manufacturing plants. (The various indicative areas could be storage areas or raw material and finished products, coal, cement kiln dust etc, transfer operation, loading and unloading operations, vehicular movements on paved roads etc)

ii) Literature survey on fugitive emissions control practices adopted within and outside India, guidelines/standards, if any, in developed countries etc.

iii) Selection of 10 cement plants for the purpose of conducting detailed field studies in 6 units and general observation in 4 more units

iv) Conduction of field studies in 6 number of cement plants for the following aspects
   - Detailed observation of various fugitive dust generating areas/sources and types of controls adopted to pinpoint specific problem areas and causes of emissions
   - Classification of fugitive emission sources
   - Generation of first hand data on system specifications adopted and their operation & maintenance practices
   - Conduction of air quality monitoring at representative locations for SPM and RSPM for assessing existing controls
   - Generation of data through stack measurement such as flow, pressure, particle size distribution, dust concentration, appropriateness of system layout, duct sizing etc for existing representative fugitive dust control systems installed in some cement plants and through literature survey of data/information from international organizations.

v) Analysis of the collected samples for the purpose of estimation/quantification & characterization of fugitive dust emissions as per the identified suitable methods

vi) Analysis of various technology options for its suitability to control fugitive emissions

vii) To evolve technical suggestions/schemes for achieving effective fugitive dust emission control

viii) Development of environmental guidelines/standards for prevention/control of fugitive emissions.

(Respective scope of work of NPC and IIT Kanpur is separately given at Annexure 1.1)

1.3 Methodology followed for Execution of Project

The following methodology has been adopted while executing the scope of work

- Project initiation, planning, identification and selection of representative cement plants
- Establishing contacts with identified representative cement plants through communication for lining up the field study visits
- Collection of preliminary information from the selected cement plants through questionnaire.
- Literature survey through various sources including internet sites for fugitive emissions management practices in developed countries and concerned regulations.
- Conduction of field visits to 2 cement plants for identification of fugitive emission sources
- Evolving appropriate sampling plan for conducting field studies
- Conduction of field studies in the selected units
- Compilation of Field Data
- Laboratory analysis of samples and compilation of field study data
- Technical analysis of field study data/observations
- Estimation of Fugitive Emissions
- Evolving technical suggestions/schemes etc
- Evolving Environmental Guidelines/Standards for Prevention/Control of Fugitive Emissions
- Preparation of draft report comprising compilation of the above information
- Incorporation of comments of stake holders and preparation of final report.
- The methodology for assessment of fugitive emissions is separately discussed.

1.4 Criteria for selecting representative Cement Plants

For the purpose of selecting the representative cement plants the selection criteria was based on following criteria.

- **Age of the plant**

The environmental regulation especially with respect to control of fugitive emission hardly existed during the pre 1980 era. Therefore the older plants commissioned before 1980 are expected to have lesser degree of control measures for fugitive emissions. The emissions are expected to be higher and hence a few units in this category are selected for field studies

The units, which came up during 1980 to 2000, are expected to be having a medium level of environmental controls and hence a few units are selected in this category.

It has been assumed that the new and modern plants commissioned in post 2000 era are expected to have the latest type of technologies and also the level of environmental control for stack as well as fugitive emissions is expected to be the best amongst the cement plants in the country. Hence a few units are also considered for selection under this category.

Amongst the old and medium plant some plants have not modernized while some have modernized/upgraded, some are even taken over by multinational companies. These aspects are considered while selecting representative units for detailed studies

- **Production capacity (Small, Medium & Large)**

Out of the 129 cement plants, as per CMA statistics 2005, the number of units under various categories is as below

Capacity-wise categorization of cement plants

MTPA	Number of Cement Plants
<1.0	60
1.0 to 2.4	53
>2.4	16

Based on the above proportion representing maximum units represented in <1.0 MTPA category, three units have been considered out of this category, two in 1.0 to 2.4 MTPA category and one in the >2.4 MTPA category. The smaller capacity cement plants are expected to have lesser investment for control of fugitive emissions as compared to large capacity cement plants.

- **Type of Technology**

In terms of technology, majority of cement plants currently operating are based on dry process (more than 96%) and that the wet process plants are either closing down or modernizing to adopt dry process in view of economic aspects. Therefore, the plants in dry category only are considered. As regards to kiln technology, the major share of the cement production is by rotary kiln technology with pre-calcinations and hence the plants in this category are considered

- **Geographical location in Clusters**

In order to cover the regional variations in terms of type of raw material, atmospheric conditions etc consideration was given to select cement plants in various clusters. *(Refer Cement Map of India provided at Annexure 1.2 for details of locations of various cement clusters).*

Considering the limitations of taking up six numbers of units for detailed studies, the best possible combinations were considered for final selection of units. The list of selected cement plants is given below.

Table 1.1: List of Cement Plants Selected for Field Visits

S.No.	Name of the unit	Category/ Capacity	Age of Plant/Year of commissioning
1.	Chittaurgarh Cement Works, Chittaurgarh, Rajasthan	3300 TPD	Mid-Age (1986)
2.	ACC Jamul Cement Works Chattisgarh	2400 TPD	Old (1965)
3.	UltraTech Awarpur Cement, Chandrapur, Unit I Maharastra	3300 TPD	Mid Age (1983)
4.	ACC Gagal Cement Works Himachal Pradesh (Unit II)	4500 TPD	Mid-age (1984) (Modernized) (2003)
5.	Lafarge Cement, Sonadih Chattisgarh	4000 TPD	Mid-age (Taken over by Multinational) 1993
6.	Maratha Cement Works, Upparwahi, Maharastra	7300 TPD	New (2001)

The detailed field studies were conducted in the above mentioned representative cement plants, which involved detailed observations of all fugitive emissions sources and its management practices, conduction of field measurements for estimation of fugitive emissions etc. In addition, a few more cement plants were also visited for general observations. (Birla Cement Works, Chittaurgarh, ACC Gagal Cement Works (Unit 1), Gujarat Ambuja, Darlaghat)

CHAPTER 2.0

CEMENT MANUFACTURING & FUGITIVE EMISSIONS – AN OVERVIEW

2.1 An overview of Cement Sector in India

The cement-manufacturing sector has about 129 cement plants with an installed capacity of 154 MTPA. Interestingly and unlike other major sectors like steel, power, petroleum etc, majority of production is by "private sector" companies and the share of public/Government sector is only marginal (6%). Amongst the private sector, the owner-ship of the cement plants is held by 54 companies, out of which only 5 companies own almost half the units (M/s ACC, M/s Ultratech, M/s Gujarat Ambuja, M/s Grasim Industries and M/s India Cements). *(Refer Annexure 2.1 for the list of cement plants in India)*

In terms of type of manufacturing process, majority share (>96%) is by dry-process, and the contribution from the wet and semi-dry process is only marginal. Out of total cement production, only about 6% production is from Mini and White cement plants which are large in number but has lesser significance in terms of capacity.

General information about the cement sector has been provided in the following Table 2.1 below.

Table 2.1: General Information about Cement Plants in India

Particulars (as of September, 2005)	**Data**
Total Number of cement plants	129
Installed Capacity	153.59 Mn.T
• Private Sector	145.23 Mn.T
• Public Sector	8.36 Mn.T (6%)
Cement Production	127.57 Mn.T
Process wise capacity	
• Dry	122.83 Mn. T (96.3%)
• Wet	1.53 Mn.T (1.2%)
• Semi-Dry	0.19 Mn.T (0.1%)

Source: Cement Statistics 2005, Cement Manufacturers Association

2.2 Description of Typical Cement Manufacturing Process

Typically, the cement manufacturing process can be divided into the following primary process components:

- Raw materials acquisition and handling,
- Kiln feed preparation,

- Pyro processing, and
- Finished cement grinding.

The first step in cement manufacturing is raw materials acquisition. Raw material includes limestone, chalk, seashells, and an impure limestone known as “natural cement rock” is obtained from open-face quarries. Other elements included in the raw mix are silicon, aluminum and iron. Either gypsum or natural anhydrite is introduced to the process during the finish grinding operations. The cement manufacturing industry also uses blended materials that include fly ash, metal-smelting slags, etc. The second step in cement manufacture is preparing the raw mix, or kiln feed, for the pyro processing operation. Raw material preparation includes a variety of blending and sizing operations that are designed to provide a feed with appropriate chemical and physical properties. Materials transport associated with dry raw milling systems can be accomplished by a variety of mechanisms, including screw conveyors, belt conveyors, drag conveyors, bucket elevators, air slide conveyors, and pneumatic conveying systems. The dry raw mix is pneumatically blended and stored in specially constructed silos until it is fed to the pyro processing system.

The heart of the cement manufacturing process is the pyro processing system. This system transforms the raw mix into clinkers, which are gray, glass-hard, spherically shaped nodules. Rotary kilns are long, cylindrical, slightly inclined furnaces that are lined with refractory. The raw material mix enters the kiln at the elevated end, and the combustion fuels generally are introduced into the lower end of the kiln in a countercurrent manner. The materials are continuously and slowly moved to the lower end by rotation of the kiln. The most commonly used kiln fuels are coal. After pyro processing, clinker produced is cooled in clinker grate cooler. In these coolers, the clinker is cooled from about 1100^0C to 93^0C by ambient air that passes through the clinker and into the rotary kiln for use as combustion air.

The final step in cement manufacturing involves a sequence of blending and grinding operations that transforms clinker to finished cement. Up to 5 percent gypsum or natural anhydrite is added to the clinker during grinding to control the cement setting time, and other specialty chemicals are added as needed to impart specific product properties. This finish milling is accomplished almost exclusively in ball or tube mills. Typically, finishing is conducted in a closed circuit system, with product sizing by air separation. Each of these process components is described separately at Annexure 2.2.

Schematic diagram of the cement manufacturing process is shown in Figure 2.1

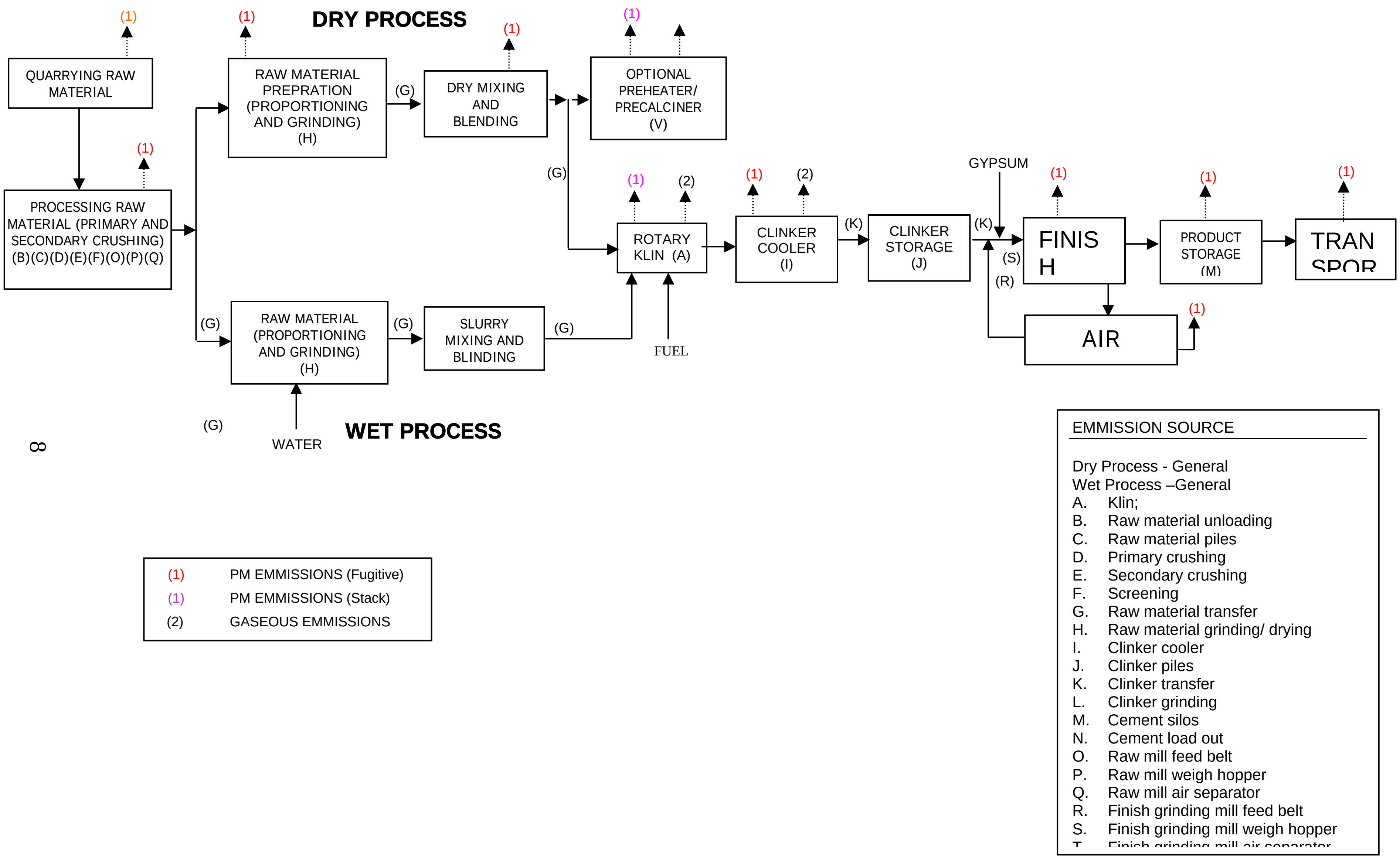


Figure 2.1: Process flow Diagram for Cement Manufacturing showing points of emissions

2.3 General about Fugitive Dust Emissions

In cement industries, the fugitive dust is emitted primarily from the following operations

- When raw materials and clinker is broken by impact, abrasion, crushing, grinding, etc.
- Through release of previously generated dust during operations such as loading, dumping, and transferring
- Through re-circulation of previously generated dust by wind or by the movement of workers and machinery

The amount of dust emitted by these activities depends on the physical characteristics of the material and the way in which the material is handled.

The USEPA define fugitive dust as "*any solid particulate matter that becomes airborne by natural or man-made activities, excluding particulate matter emitted from an exhaust stack*".

The fugitive emissions (i.e. emissions other than "Stack emissions") occur from various sources and due to various activities. They can be broadly divided as primary, secondary or tertiary emissions from the generation aspect.

The primary emissions are the emissions getting airborne from an operation or process step during production. These sources are broadly process related. The secondary emissions are the dust settled along with the material getting air borne from stationary sources like stockpiles due to "external factors" like wind blowing, vehicle movement, etc.

The tertiary or repetitive emissions are the emissions, which occur repetitively everyday, throughout the year, like emissions of settled dust on roads due to vehicular movement. Airborne dust, eventually settles on ground, may be after a long duration depending on particle size and wind direction, velocity etc. This dust gets airborne again and again, every time movement of wind or vehicles disturbs it. Dust emitted from one area, gets airborne and settles in another area, some distance away. It again gets airborne after some time and settles in some other area. This repetitive occurrence of emission is unproductive and causes unnecessary/unwanted air pollution.

- **Dispersion aspects of fugitive dust emission**

The impact of a fugitive dust source on air pollution depends on the quantity and drift potential of the dust particles injected in to the atmosphere. In addition to large dust particles that settle down near the source (often create a local nuisance problem), considerable amounts of fine particles also are emitted and dispersed over much greater distances from the source. PM10 represents relatively fine particle size range and, as such, is not overly susceptible to gravitational settling.

The potential drift distance of particles is governed by the initial injection height of the particle, the terminal settling velocity of the particle, and the degree of atmospheric turbulence. Theoretical drift distance, as a function of particle diameter and mean wind speed, has been computed for fugitive emissions. Results indicate that, for a typical mean wind speed of 16 km/hr, particles larger than about 100 micron are likely to settle down within 6 to 9 meters from the edge of the road or other point of emission. Particles that are 30 to 100 micron in diameter are likely to undergo impeded settling. These particles, depending upon the extent of atmospheric turbulence, are likely to settle within a few hundred feet from the road. Smaller particles, particularly PM 10 have much slower gravitational settling velocities and are much more likely to have their settling rate retarded by atmospheric turbulence.

Dust consists of tiny solid particles carried by air currents. These particles are formed by disintegration or fracture process, such as grinding, crushing, or impact. The dust is primarily finely divided solids that may become airborne from the original state without any chemical or physical change other than fracture. A wide range of particle sizes is produced during a dust generating process. Particles that are too large to remain airborne settle while others remain in the air indefinitely.

2.4 Categories/Types of Fugitive Dust Emissions Sources in Cement Industry

The fugitive dust emission in cement manufacturing plant can be broadly divided in two categories, Process related fugitive dust emissions & Non-process fugitive dust emissions. The sources in each category have been separately discussed below.

Process fugitive emission sources include emissions from process related essential operations like material handling and transfer, raw milling operations, and finish milling operations. Because the dust from these units is returned to the process, they are considered to be process units as well as air pollution control devices. Typically, emissions from these processes are captured by a dust extraction system and collected in air pollution control systems. Some facilities use systems comprising one or more mechanical collectors with a fabric filter in series. The industry uses shaker, reverse air, and pulse jet filters as well as cartridge filter units, but most newer facilities use pulse jet filters.

Non Process Fugitive dust emission sources include emissions from activities not essential for process such as vehicle traffic at the cement manufacturing site, raw materials storage piles, and clinker storage piles etc.

The fugitive emission sources in cement manufacturing plant are categorized in Table 2.2 below.

Table 2.2: Fugitive Emission Source Categories

Type of Fugitive Emission Category	Type of Operations/Activities	Category Code
Process Related	Material Handling and Transfer	C_1
	Raw Milling Operations	C_2
	Finish Milling Operations	C_3
Non-Process Related	Vehicle Traffic in Manufacturing Site	C_4
	Raw Material Storage	C_5
	Clinker and other Blending Materials Storage	C_6

For a typical cement plant, the fugitive emission sources under the process and non-process category have been elaborated in Table 2.3 & 2.4 below.

Table 2.3: Process related Fugitive Emission Sources

S. No.	Types of Operation	Activity	Materials Handled
C_1	Material Handling and Transfer	Unloading Operation	Limestone
			Coal
			Gypsum
			Iron-ore/Shale/Clay
			Clinker
			Fly ash
		Loading Operation	Clinker
			Cement
			Gypsum
			Coal
			Iron-ore/Shale/Clay/Additives
		Transfer Operation (Transfer Points)	Limestone
			Coal
			Gypsum
			Clinker
		Silo (Vents/Discharge)	Raw Meal
			Clinker

			Cement
			Fly Ash
C_2	Raw Milling Operations	Primary Crushing	Limestone
			Coal
			Iron-ore/Shale/Clay/slag
		Secondary Crushing	Limestone
			Coal
			Iron-ore/Shale/Clay/slag
C_3	Finish Milling Operations	Grinding Operation	Clinker
			Flyash/Slag
			Gypsum

Table 2.4: Non-Process Fugitive Emission Sources

S.No	Types of Operation	Activity	Material
C_4	Vehicle Traffic at manufacturing site	Movement of raw materials by trucks/dumpers	Limestone (from mines to primary crusher)
			Coal (From gate to Coal yard)
			Coal (From gate to dump hopper)
			Gypsum (From gate to storage)
			Additives (From gate to storage)
			Fly Ash (From gate to storage)
		Movement of finished goods by truck/trailer	Clinker (From storage to Gate)
			Cement (From packing to gate)
			Clinker (From Transfer Point to Open Stockpile)
		Movement of pay loaders	Clinker (From Open stockpiles to load in trucks)
			Coal (From coal yard to Dumpers)
			Gypsum (From Storage to feed hopper)
		Movement of other vehicles	Personnel Vehicles like four and two wheelers and other vehicles
C_5	Raw Material Storage	Limestone	Open Stock Yard
			Covered Shed
		Coal	Open Stock Yard
			Covered Shed
		Gypsum	Open stock Yard
			Covered storage
		Additives	Open stock yard
			Covered shed
		Fly Ash	Silo
			Open stock yard
C_6	Product storage	Clinker	Covered Storage
			Open stock piles
		Cement	Silos

A Schematic giving "birds eye view" in the form of an "ECOMAP" of a typical Medium and Large cement plant showing various fugitive emission sources is given at Figure 2.2 & 2.3

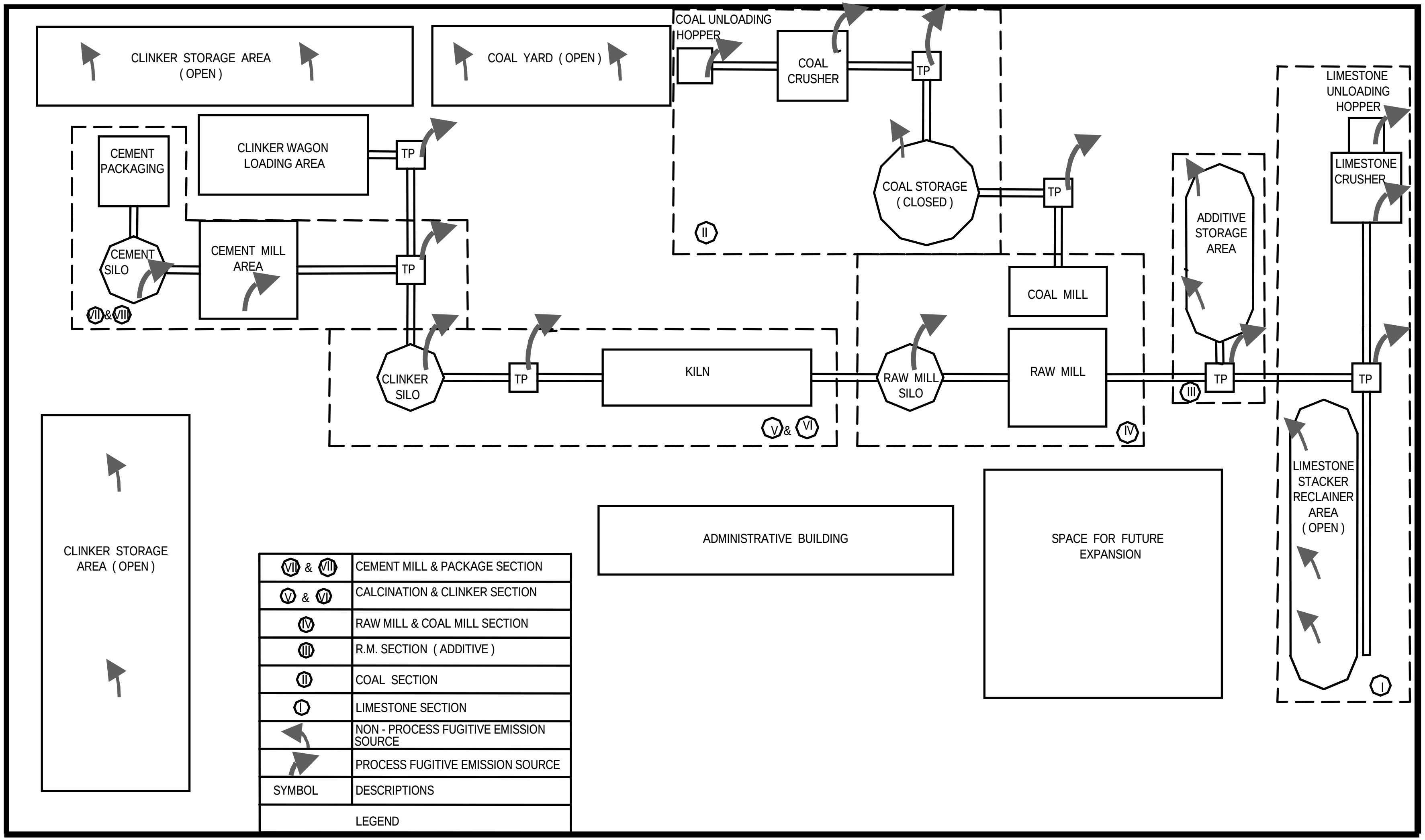


FIG.2.2 ECO – MAP OF CEMENT PLANT (SMALL/MEDIUM) SHOWING LOCATIONS OF VARIOUS FUGITIVE EMISSION SOURCES SPREAD ACROSS THE PLANT AREA

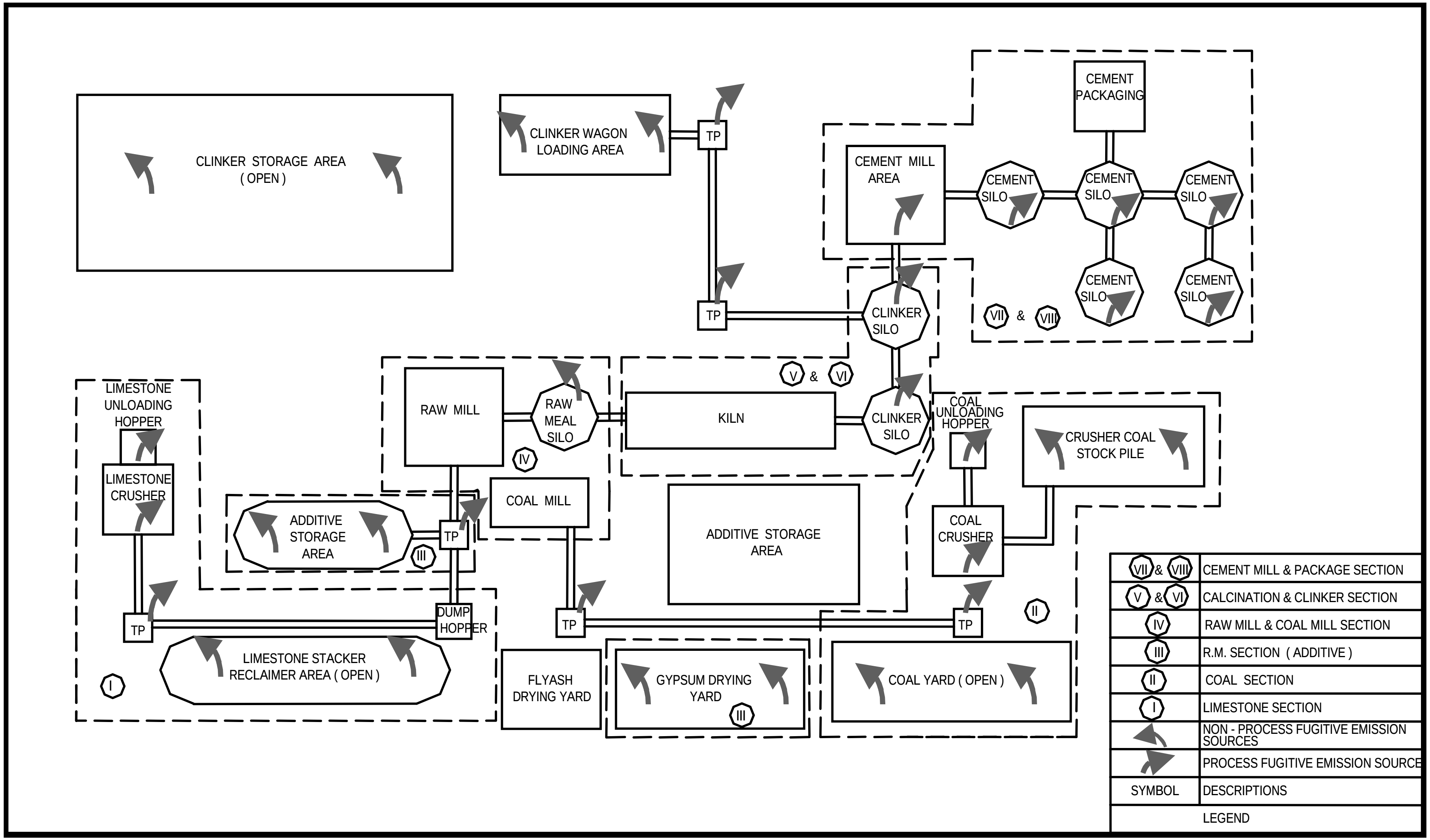


FIG. 2.3 ECO – MAP OF CEMENT PLANT (LARGE) SHOWING LOCATIONS OF VARIOUS FUGITIVE EMISSION SOURCES SPREAD ACROSS THE PLANT AREA

2.5 Health effects of Cement Dust

The dust generated from cement plant could be categorized as inert dust or nuisance dust & can be defined as dust that contains less than 1% quartz. Because of its low content of silicates, nuisance dust has a long history of having little adverse effect on the lungs. Any reaction that may occur from such dust is potentially reversible. However, excessive concentrations of nuisance dust in the workplace may reduce visibility, may cause unpleasant deposits in eyes, ears, and nasal passages, and may cause injury to the skin or mucous membranes by chemical or mechanical-action

From an occupational health point of view, dust is classified by size into three primary categories: Respirable, Inhalable & Total. Respirable dust refers to those dust particles that are small enough to penetrate the nose and upper respiratory system and deep into the lungs. Particles that penetrate deep into the respiratory system are generally beyond the body's natural clearance mechanisms of cilia and mucous and are more likely to be retained. The Inhalable dust is that size fraction of dust, which enters the body, but is trapped in the nose, throat, and upper respiratory tract. The median aerodynamic diameter of this dust is about 10 microns. Total dust includes all airborne particles, regardless of their size or composition.

2.6 Section-wise fugitive emissions sources under various categories

2.6.1 Process Sources

In terms of independence of operations of various sections/processes the cement process could be divided into following sections:

- Limestone acquisition Section (Unloading to Stacker)
- Coal acquisition Section (Unloading to Stacker)
- Raw Mill Preparation Section (Reclaimer to Blending Silo)
- Coal Mill Section (Reclaimer to Fine Coal Dosing Bin)
- Calcination Section (Raw Meal Silo to Clinker Cooler)
- Clinker section (Clinker Cooler to Storage Silo)
- Cement Mill (Clinker Silo to Cement Silo)
- Packing Section (Cement Silo to Dispatch of Bags)

Each of the above sections works almost independently with respect to other operations. For example, while the kiln is shut down, limestone or coal crushing & stacking in the stacker could go on or grinding of clinker to cement may also go on.

Some sections work only in two shifts while some sections like kiln has necessarily non-stop round the clock operation. Therefore, the emissions from different sections may vary with time depending on whether it is in operation or otherwise.

Also in terms of type of dust control measures adopted for controlling fugitive emissions in different sections are different. For example, dust suppression type could be adopted in the limestone section whereas only dry bag filter type control is adopted in clinker section etc. In view of the above-discussed issues, the fugitive emission sources in a typical cement industry are divided section-wise into 8 independent sections. The same are highlighted in the Table 2.5 below.

Table 2.5: Category wise Details of Process related Fugitive Emission Sources in Cement Manufacturing Plant

Sl. No.	Type of Emission Source in various sections	Category Code	Estimated Number of Fugitive emission sources
I	**Limestone Section (Unloading to Stacker)**		
1	Unloading Dump Hopper	C_1	1-2
2	Limestone Crusher	C_2	1-2
3	Transfer point (Crusher to Stacker)	C_1	1-2
II	**Coal Section (Unloading to Stacker)**		
1	Unloading Dump Hopper	C_1	1-2
2	Coal Crusher	C_2	1-2
3	Transfer Point (Crusher to Stockpile)	C_1	1-2
III	**R. M. Section (Reclaimer to R. M. Blending Silo)**		
1	Transfer Point (LS Reclaimer to Day Silo)	C_1	2
2	Additive Unloading Dump Hopper	C_1	1-2
3	Transfer Point (Additive Dump Hopper to Day Silo)	C_1	1-2
4	Transfer Point (Day Silo to VRM)	C_1	1-2
5	Vent-Raw Meal Airlift	C_1	2
6	Vent-Raw Meal Blending Silo	C_1	1-2
IV	**Coal Mill Section**		
1	Reclaimer Tunnel (Upstream/Downstream)	C_1	1-2
2	Transfer Point (Tunnel to Coal Bin)	C_1	1-2
3	Vent - Mill Buffer Hopper/Raw coal hopper	C_1	1-2
4	Vent- Fine Coal Dosing Bin to Kiln/PC	C_1	1-2
V	**Calcination Section**		
1	Vent- Raw Meal Day Bin	C_1	1-2
2	Vent-Air slide to Kiln	C_1	2
3	Vent-Kiln Feed Preheater cyclone	C_1	1-2

VI	**Clinker Section (Clinker cooler to Clinker Silo/Stock pile)**		
1	Transfer Point (Cooler to Clinker Silo/Stockpile)	C_1	1-3
2	Vent-Clinker Silo	C_1	1-2
VII	**Cement Mill to Silo**		
1	Transfer Point (Clinker Silo Dump to Surge Bin)	C_1	1-2
2	Vent-Clinker Surge Bin	C_1	1-2
3	Vent-Cement Silo	C_1	1-4
4	Vent-Cement Separator	C_1	1-2
VIII	**Packing Section (Silo to Cement Bags)**		
1	Packing Machines	C_3	2-6
	Grand-Total		30-55

The number of fugitive emissions sources varies from plant to plant and depends on production capacity e.g., some plants have only one crusher while some may have two or more crushers. As regards to types of process fugitive emission sources there are about 26 types of sources. As regards to the number of fugitive emission sources that could be identified as "physically separate locations", the number may vary from 30 to 55 sources.

2.6.2 Non Process Sources

Sl. No.	**Type of Emission Source in Various Sections**	**Category Code**
1	Raw Material Stock Piles (Limestone, Coal, Additives)	C_5
2	Product Stock Piles (Clinker, Gypsum, Fly Ash, Slag)	C_6
3	Emission from Roads	C_4

For the non-process emission source location, the number of emission points cannot be quantified as the emission occurs from various areas where the activity goes on like from road, from stock pile area etc.

CHAPTER 3.0

Prevalent Fugitive Emission Management Practices

3.1 Prevalent Types of Control Systems adopted

For the purpose of controlling fugitive emissions from different sections, various cement industries have adopted different combination of control measures with varying degree of effectiveness. On the basis of the field observations made in 6 cement plants, the types of systems adopted are highlighted in the Table 3.1 below.

Table 3.1: Types of Fugitive Dust Control Systems in Various Cement Plants

Fugitive Emissions sources	Type of APCD					
	ACC Gagal	Chanderia Chhitaurgarh	Lafarge Sonadih	ACC Jamul	Ultra Tech Awarpur	Maratha Cement
Limestone Unloading	DSS	DSS	DSS	DSS	DSS	DSS
Limestone Crushing	DSS	DSS	Bag filter	Bag filter	Bag filter	Bag filter
Limestone belt conveyor transfer point	DSS	Bag filter	Bag filter	DSS	Bag filter	Bag filter
Limestone stacker/ Gantry	DSS	DSS	DSS	DSS	DSS	DSS
Coal Unloading	DSS	DSS	Bag filter	DSS	DSS	DSS+ Bag filter
Coal Crushing	DSS	Bag filter	Bag filter	DSS	No Control	DSS+ Bag filter
Coal belt conveyor transfer point	DSS	Cassette Bag filter	Bag filter	DSS	Bag filter	Bag filter
Coal stacker/ Gantry	DSS	DSS	Bag filter	NA	NA	DSS
Gypsum unloading operation	DSS	No control	No control	No control	No control	No control
Gypsum crusher	-do-	No control	No control	No control	No control	No control
Gypsum belt conveyor transfer point	DSS	Bag filter	Bag filter	No Control	No control	Bag filter
Additive unloading	No control	No control	Bag filter	No control	Dust containment	Covered Shed
Road Dust	Mobile road cleaner	Wetting of roads	Wetting of roads	Wetting of roads	Wetting of roads	Mobile cleaner
Coal Yard	DSS	DSS	DSS	DSS	DSS	DSS
Clinker TP	Bag filter	Bag filter	Bag filter	Bag filter	Bag filter	Bag filter
Clinker Open Stock Piles	Tarpaulin cover	Tarpaulin cover	Tarpaulin cover	Tarpaulin cover	Tarpaulin cover	Tarpaulin cover
Silo Vents	Bag filter	Bag filter	Bag filter	Bag filter	Bag filter	Bag filter

The above table indicates that most plants have either dust suppression systems or dust extraction cum bag filter systems. Especially for operation like unloading of limestone/coal most units have adopted dust suppression system, whereas for other sources, bag filter type control system has been installed for operations like transfer point, crushing operation etc.

3.2 Numbers of fugitive emissions control systems installed in 6 cement plants studied

For the purpose of controlling process related fugitive emissions, generally, there are separate Bag filters or dust suppression systems provided for each point. In terms of number of bag filters or dust suppression systems, the number varies widely from one cement plant to other. The number of APCD's in six cement plants studied is given in Table 3.2 below.

Table 3.2: Number of APCD's in 6 Cement Plants for various process Emission

Name of Cement Plant	Maratha Cement	Lafarge Cement	UltraTech Cement	ACC Gagal	Chittaurgarh Cement	ACC Jamul	Average Number
Limestone	4	3	4	1	5	2	3
Coal	3	4	-	-	3	-	3
Raw Mill	13	9	10	5	10	6	8
Coal Mill	3	7	5	8	12	2	6
Clinker	6	3	6	8	8	1	5
Cement Mill	25	8	10	17	14	10	14
Calciner	1	3	2	3	3	3	2
Packaging	10	1	10	4	5	7	6
Total	65	36	47	46	60	31	47

The number varies from 31 bag filters to 65 bag filters. Especially the newer cement plants have more number of bag filters than the older plants and hence more capital investment towards control of emissions in newer plants. As some bag filters are small in size, but large in numbers and some are of bigger size and few in number, for better comparison the total filtration area provided is compared in the Table 3.3.

Table 3.3: Details of Bag filter Filtration Area (m^2)

Name of Cement Plant	Maratha Cement	Lafarge Cement	UltraTech Cement	Average	Percentage (%)
Limestone	127	93	160	127	9.62
Coal	165	35	-	100	7.58
Raw Mill	348	293	334	325	24.62
Coal Mill	59	88	54	67	5.08
Clinker	134	109	118	120	9.09
Cement Mill	333	108	407	283	21.44
Calciner	30	61	60	50	3.79
Packaging	450	75	220	248	18.79
Total	1646	862	1353	1320	100

For the six cement units studied in detail, the information regarding type of dust control systems, its locations and other basic specifications like filtration area and electricity consumption have been given for each unit separately at Annexure 3.1.

3.3 Fugitive Emissions Management Practices for various Unit Operations

The following section describes about the prevalent management practices adopted for controlling fugitive emissions by various cement industries. The practices mentioned below are based on the detailed field studies conducted in 6 cement plants.

3.3.1. Management Practices for Process Fugitive Emission Sources

- **Limestone unloading operation**

Quarried limestone from the captive mines is transported to crusher house through dumpers of capacity 25 –30 T. The limestone is unloaded in the dump hopper by hydraulic tilting and conveyed to primary crusher for size reduction. Most cement plants have provision of dumping from three sides of the hopper, and the dumping generally occurs one after another from all three sides.

Emission Aspects:

As the mined limestone contains substantial quantity of fines plus some additional fines get generated due to breaking of stones during transportation and by impact while free fall, hence, during unloading operation significant quantity of fugitive emission is generated. The dust gets airborne and spreads in the vicinity in the form of a cloud. These emissions are intermittent and continue for a short duration of about a minute for each unloading operation. This dust if not effectively controlled (suppressed or extracted), the cumulative effect of dust emission may lead to substantial fugitive emissions. The dust emissions are substantial when the limestone is dry, whereas the emissions are lesser with wet stones.

A Photograph 3.1 is showing limestone-unloading operation by two dumpers.

Prevalent Fugitive Emission Management Systems:

For control of emissions from limestone unloading section the “dust containment cum suppression systems” is prevalent in almost all cement plants. Most of the units have provided shed over the dump hopper, except one old unit. For containment of dumping sides, generally cut pieces of worn-out belt conveyors (flexible rubber based) are provided in a form like curtain on 3 sides of the shed. The curtains are provided up to dumper top level from the shed ceiling. Some typical prevalent arrangements at unloading section are shown at Figure 3.1.

For the purpose of dust suppression, water is sprayed through nozzles during unloading. Most cement plants have installed remote sensor based on-off switch arrangement for water sprays. The sprays get operational only during unloading operation and stops as the dumper moves away. Some units spray water over limestone carried by dumper before unloading. Water is sourced from the mines and stored in HDPE tank with pumping arrangement. In one unit, centralized pumping arrangement was provided. There is hardly any “filtration arrangement” provided to filter out suspended dust/solids. The spray pattern is generally found non-uniform, some sprays are appropriate while some sprays don’t operate or the sprays are incomplete.

It is generally reported that the spraying pattern gets affected due to choking of nozzles, as there is no maintenance schedule to clean or replace nozzles periodically. The number of spray nozzles provided varies from plant to plant, and it is found to be in the range of 8 – 56 nos. The spray nozzles are generally placed above the unloading hopper at a height so that the spray covers the hopper cross section. In some units, the spray nozzles are located sideways, adjacent to the unloading hopper. It is generally reported that the apron feeder gets jammed/choked frequently due to excess water sprayed. The amount of water sprayed in various plants is given in Table 3.4.

Table 3.4: Details of Dust Suppression System & Water Consumption for 6 Cement Plants

S.No.	Name of the Cement Plant	Material unloaded	Type of spray arrangement	Total Water consumption	Specific. Water Consumption	
		TPH		Lit/Hr	Lit/T	%
1.	Chanderia Cement Works	950	56 nozzles	6720	7	0.7
2.	ACC Gagal	1600	39 nozzles	6000	4	0.4
3.	Sonadih Lafarge Cement	400	8 nozzles	2000	5	0.5
4.	ACC Jamul	425	Perforated holes	4000	9	0.9
5.	UltraTech Cement, Awarpur	1250	36 nozzles	4000	4	0.4
6.	Maratha Cement Works,	1300	24 nozzles	8640	7	0.7

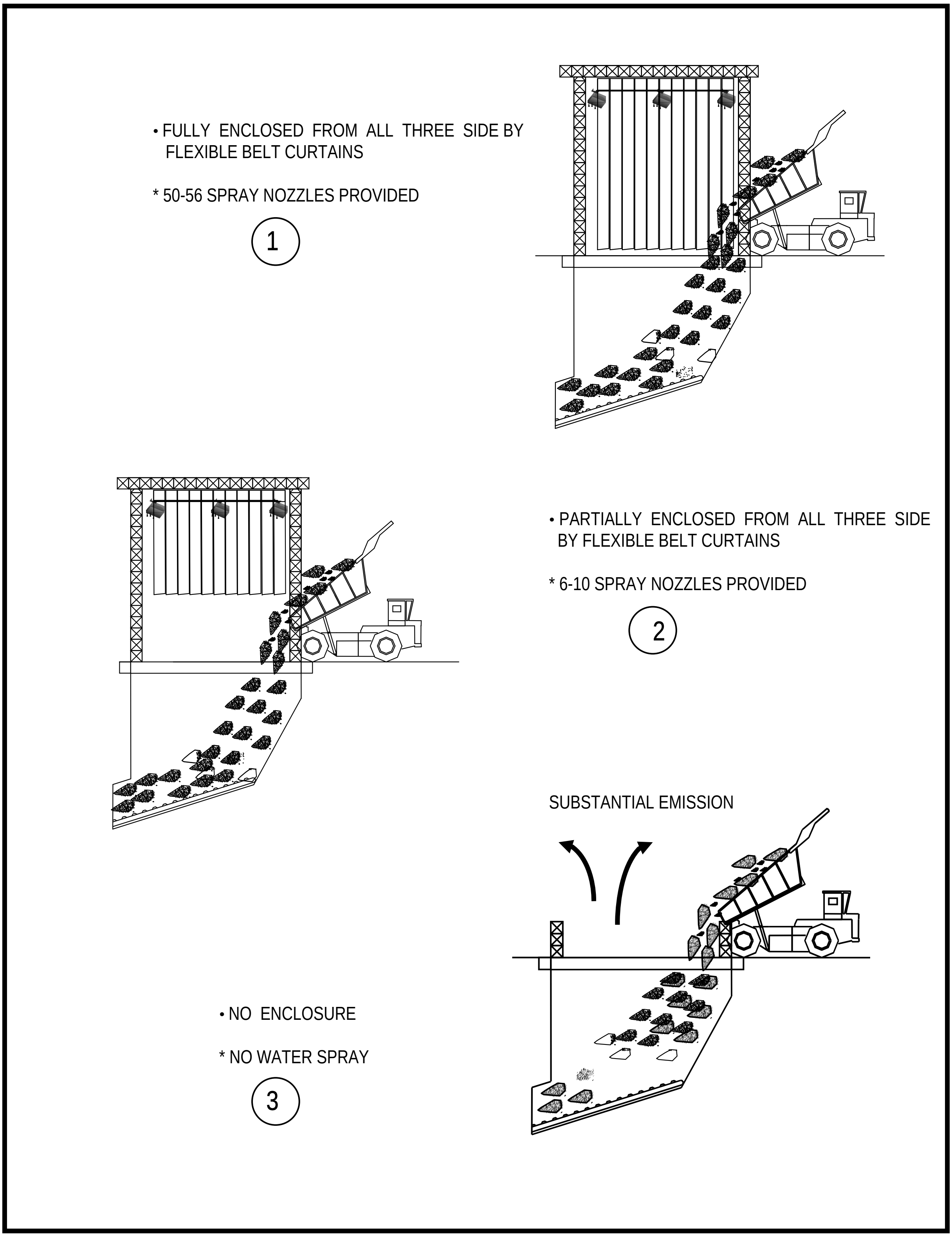


FIG. 3.1 PREVALENT FUGITIVE EMISSION CONTROL MEASURES FOR LIMESTONE UNLOADING AREA

Lime Stone Crushing Operation

The limestone is conveyed from dump hopper to primary crusher by apron feeders/chain conveyors. The Jaw Crusher/Impactor type crusher is generally used for crushing to a size of 25 –35 mm. The crushing capacity is generally in the range of 500 to 1000 TPH. Generally the primary crusher is located close to the mining area in many plants. However some plants have crusher located at manufacturing site. The crushed limestone is transported to limestone storage area (stacker/reclaimer) via belt conveyor/overhead bucket conveyor.

Emission Aspects

Fugitive dust emission occurs at 3 stages, firstly during feeding, secondly during crushing and thirdly during free fall on belt conveyor. The magnitude of dust generation depends on the hardness, moisture content and feed size of limestone. During feeding, the dust is emitted due to movement of material and friction of the material resulting in breaking or loosening of particles, thereby the fines getting air borne. During crushing, breaking of lumps results in generation of newer fines. During discharge of the material over belt conveyor, dust gets air borne due to free fall of material through a height. A typical view of Lime stone crusher house is given in Photo 3.2.

Prevalent Fugitive Emission Management Systems:

Dust generated during crushing operation is generally captured with dust extraction cum pulse jet bag filter type control system. In some of the units, combination of dust suppression system along with bag filter is provided. In one unit, the Bag filter type control system was replaced with dust suppression system. This was done from energy conservation point of view as informed by the management during field studies. The ID fan capacity provided is in the range of 30 – 90 HP. The dust collected in bag filter is returned at immediate down stream location. At this point, an extraction is provided to suck the air borne fines back to bag filter.

Table 3.5: Details of Fugitive Emission Management for Limestone Crusher

S.No.	Name of the cement plant	Type of APCD	Specifications		
			Flow rate (m^3/hr)	Filtration area (m^2)	Power (KW)
1.	Chanderia Cement Works, Chittaurgarh	Pulse jet bag filter	48800	440	30
2.	ACC Gagal	Dust Suppression	6.5 LPS	NA	11
3	Sonadih Cement Plant Lafarge	Pulse Jet Bag filter	27500	302	11
4	UltraTech Cement Works, Awarpur	Pulse Jet Bag filter	60,000	771	110
5	Maratha Cement Works	Pulse Jet Bag filter	90,000	1047	90
6.	ACC Jamul	Pulse Jet Bag filter	11,000	267	30

Photo 3.1: Limestone unloading operation

Photo 3.2: Emission from Lime Stone Crusher House

- ### Lime Stone Transfer Point

Conveying of limestone after primary crushing to storage (stacker/ reclaimer) and further to kiln, involves number of transfer points like one belt to other belt or from belt to surge bins/ hoppers etc. The height through which the material falls/ drops varies from plant to plant and depends on land topography, layout of plant etc. Generally, these transfer points are housed inside an enclosure/shed which is called as "transfer tower". For limestone, the number of such transfer towers varies from two to five depending on the layout of the plant.

Emission Aspects

During transfer operation involving free fall of material from a higher to a lower level, emissions are generated. These emissions contain primarily the fine dust generated during upstream crushing operation. In addition, some fresh fine dust is also generated as a result of breaking of lumps due to impact during the free fall and by breaking due to movement/ conveying of material.

Prevalent FEMS

Dust extraction cum pulsejet bag filter type control system is generally adopted by cement industries. For limestone transfer points, the specification details of bag filter such as volume of air handled, number of filter bags employed, air to cloth ratio and ID fan capacity are provided in the following Table 3.6.

Table 3.6: Unit wise Details of FEMS provided for Limestone Transfer Point

S.No.	Name of the cement plant	Type of control system	Specifications of control system			
			No. of Bags	Air to cloth ratio ($m^3/m^2/min$)	Air flow (m^3/hr)	ID fan capacity (KW)
1.	Chanderia Cement plant, Chittaurgarh	Pulse Jet Bag filter Control system	84	1.23	11000	20 HP
2.	ACC Gagal	--do--	360	1.38	70,000	90
3.	Sonadih Cement Plant-Lafarge	--do--	160	1.2	20,000	50
4.	UltraTech Cement Works, Awarpur	Pulse jet Bag filter	54	1.3	10,000	22
5.	Maratha Cement Works, Gujarat Ambuja	--do--	72	1.23	10,000	18.5

Note: Major Transfer tower was not available at ACC Jamul.

The number of extraction points from the transfer tower depends upon the height of free fall. The extraction point vary from 2 to 10 numbers, in some units, the extraction hood is also connected along with crushing equipment. The collected dust from bag filter is emptied over conveyor belt at a downstream point leading to re-entrainment causing fugitive emissions at next points.

- **Lime stone Stacker and Reclaimer**

The raw material is deposited by a stacking device moving continually to and fro over the longitudinal centerline of the stockpile. The material discharged from the stacker slides and rolls down the sides of the pile, in the process the fines tend to be retained at the top surface and bigger particles roll down due to momentum.

All front-acting reclaimers, i.e., machines for "end-on" removal of material from stockpiles, are equipped with some form of handling device which is only able to carry away the material from the toe of the pile. The material is dislodged from the pile by the action of raking-down device, which sweeps across the cross-sectional face. Each cycle of the device removes a thin “slice” comprising all the layers in the pile and in the process of sliding and tumbling down the sloping face the material of the various layers is mixed together. To obtain a good homogenizing effect it is of course essential that the raking-down device involve the entire face of the pile.

Emission aspects

Quantity of fugitive emissions generation depends upon moisture maintained in the limestone received from the crusher house. Part of the moisture also evaporates with time due to atmospheric evaporation effect. If sufficient wetting not regularly done, the fines get air borne due to wind currents. The dust generation is more in the case of open storages than the closed one. The emissions are excessive especially during summer seasons if frequent wetting of limestone is not carried out. Some units also have gantry type arrangement where the level of fugitive emissions is generally higher. The typical limestone stacking arrangement is shown in Photo 3.3.

Prevalent Fugitive Emission Management Systems

To control emissions, a set of water spray nozzles are provided over the conveyor belt in the stacker feed point. In some units, bag filter is placed in stacker for control of emissions from the operation of stacker. For gantry type storage there is no arrangement of water sprays as there is no fixed location of material falling. At a time water is sprinkled by hosepipe on the conveyor belt if excess emissions are observed.

Photo 3.3: Views of various Limestone Storage arrangements

- **Coal Unloading Operation**

The coal is unloaded into coal crusher dump hopper for size reduction. Most units have hydraulic lifting platform for unloading purposes. Generally the dumpers are of 15 to 25 T capacities. Some units have wagon unloading arrangement to unload coal into dump hopper directly from Wagons.

Emission Aspects

This operation is intermittent and generates substantial quantity of fugitive emissions. The emissions last for a short duration of a minute or two during each unloading, but in terms of quantity the emissions, it is substantial.

Prevalent Fugitive Emission Management Systems

The dump hopper is generally enclosed in a shed. Most units have dust suppression arrangement for suppressing the fugitive emissions while some units have dry extraction cum bag filter or a combination of wet and dry systems. The spray nozzles are arranged either overhead or opposite to the side of unloading operation. The water stored in mines is normally used for dust suppression. The numbers of spray nozzles vary from one or two nozzles to over 100 nozzles. The details of type of control systems installed and specifications are mentioned in the following Table 3.7. Photo 3.4 shows coal unloading operation.

Table 3.7: List of FEMS Details Installed for Coal Unloading Operation

S.No	Name of the units	Type of APCD	Specifications
1	Chanderia Cement Works	Dust Suppression system	Nozzles: 108 nos; Water qty/loading: 1080 lit
2.	ACC Gagal	--do--	Nozzles : 24 nos Water qty/unloading: 72 lit
3.	Lafarge Sonadih Cement	Pulse jet bag filter system	Quantity : 6500m3/hr No.of bags : 75 Motor :15 KW
4.	UltraTech Awarpur Cement Works	Dust suppression system	Shower type spray
5.	Maratha Cement Works	Dust suppression along with bag filter	Flow: 40,000 m3/hr No. of bags : 288 Motor: 75 Nozzles: 6 Nos Water consumption: 60 LPH Pump HP : 3.7 KW

- **Coal Crushing Operation**

From the dump hopper, the coal is fed to primary crusher for size reduction. Generally the crusher is of Impactor/Hammer mill type. Size reduction of coal is effected in at least two stages; crushing (primary reduction) and grinding (fine reduction). Primary crusher reduces the bigger lumps to a size between 20 and 80 mm. Typically coal crushing capacity ranges from 300 to 400 TPH. Uniform feed of material is normally done through belt conveyor/apron conveyor. In some plants, the crusher is located at certain distance from the dump hopper while in some plants; the crusher is located below the dump hopper.

Emission Aspects

Substantial fugitive emissions are generated during coal crushing operation. The degrees of emissions depend on hardness, moisture content and size of feed. The shape and arrangement of breaker plates & the circumferential velocity of rotor also plays a major role. Low velocity results in coarse product. With higher velocity the size reduction energy is greater and the material is broken into correspondingly smaller fragments resulting in substantial fugitive emissions. The emissions also occur during feeding of coal in to crusher and at the crusher discharge location.

Prevalent Fugitive Emission Management Systems

Most units have provided bag filter type control system for capturing the dust emissions. The collected dust is recycled on conveyor belt. Some units have provided dust suppression system with random location of water sprays over the conveyor belt. Typical Emissions from crushing and water spray arrangement for controlling fugitive dust is shown in Photograph 3.5 (a) & (b) below.

- **Coal Transfer Points (Primary Crusher to Stacker/stockpiles)**

Coal conveying after primary crushing to storage (stacker/ reclaimer) and further to kiln, involves number of transfer points (one belt to other belt or from belt to raw coal hopper). The height through which the material falls/ drops varies from plant to plant and depends on land topography, layout of plant etc. For coal, the numbers of such transfer points vary from one to four depending on the layout of the plant.

Emission Aspects

During transfer operation, involving free fall of material from a higher to a lower level, emissions are generated. These emissions contain primarily the fine dust generated during upstream crushing operation. In addition, some fresh fine dust is also generated as a result of breaking of lumps due to impact during the free fall and by breaking due to movement/ conveying of material.

Photograph 3.4: Typical Emissions during Coal Unloading

Photo 3.5 (a): Fugitive emissions from Coal Crushing Operation

Photo: 3.5 (b): Typical Water spray system of coal dump hopper

Prevalent Fugitive Emission Management Systems

The type of prevalent emission control arrangement varies widely from plant to plant for the coal transfer towers. Some plants do not have either of the dust suppression or bag filter type systems. Some plants have dust suppression sprays or cassette type bag filters. But in general, hardly any cement plant has a full-proof dust control system for the coal transfer points. Even in the best possible system, puffs of black coal dust were frequently observed.

- **Coal Stacker & Reclaimer**

The process of coal stacker and reclaimer is similar to the process of limestone storage operations. After primary crushing, the coal is stacked either in open or closed storage. Few units have indoor storage facility. The capacity of closed stacking generally ranges from 20,000 MT to 40,000 MT.

Emission aspects:

Substantial fugitive emissions are generated from the coal stockpile during wind currents. The degrees of emissions depend upon moisture content, fines present in the coal.

Prevalent Fugitive Emission Management Systems :

To control emissions, generally a set of water spray nozzles are provided over the conveyor belt in the stacker feed point. Typical coal stacker is shown in Photograph 3.6

Photo 3.6: Typical emissions at Indoor coal stacker area

- **Clinker Transfer Point (Clinker Cooler to Clinker Stock Piles)**

After clinker cooler, the clinker is transferred to clinker storage section by deep bucket redler conveyors. The transfers are generally to various locations like closed storage areas, silos, open storage areas or to wagons/trucks etc. Depending on the route of transfer, there are number of transfer points.

Emission Aspects:

The fine dust associated/adhered with clinker gets loose and get air borne due to free fall from certain height during transfer operation. As the clinker is dry in nature and the quantity of fines is substantial, significant fugitive emissions occur at transfer points. There are substantial spillages of clinker at the transfer towers, part of which settles on the floor, partly falls to ground and during the process substantial fugitive emissions are generated which escapes through leakages in the enclosure of transfer towers.

Prevalent Fugitive Emission Management Systems:
No cement plants has wet type dust suppression arrangement for suppressing fugitive dust emissions as water cannot be added to clinker as it would adversely affect the quality of cement and hence wet suppression is not a prevalent measure.

Most cement plants have dry type dust extraction cum bag filter systems installed for transfer points. Due to longer distances between transfer points, separate bag filters are installed for each transfer point. Generally Pulsejet bag filter are employed. From all these bag filters the collected fine dust is recycled in to the system at an immediate downstream location, which has a potential to get air borne at the next transfer point. Typical Bag filter systems installed in various cement plants for clinker transfer tower are mentioned in the Table 3.8.

Table 3.8: List of FEMS Details installed at 6 Plants for clinker transfer tower

S.No.	Name of the cement plant	Type of control system	Specifications of control system
1.	Chanderia Cement plant, Chittaurgarh	Pulse Jet Bag filter Control system	Filtration area: 183.6 m^2 Air flow: 21000 m3/hr ID fan capacity: 18.5 KW
2.	ACC Gagal	--do--	Flow: 5000 m3/hr ID fan: 5 HP
3.	Sonadih Cement Plant-Lafarge	--do--	Flow: 11000 m3/hr Filtration area 121 m^2 No. of Bags: 100,ID fan: 18.5 KW
4.	UltraTech Cement Works	--do--	Data Not Available
5.	Maratha Cement Works	--do--	Flow: 20000 m3/hr Filtration area 226 m^2 No. of Bags: 132,ID fan: 37 KW

Note: Major Transfer tower was not available at ACC Jamul.

- **Packing Section**

The cement is conveyed from cement silo to the packing machines pneumatically. Generally rotary packer type machines are employed for packing cement in bags. The packed bags are conveyed on roller conveyors directly to trucks or railway wagons. At times some bags are damaged or torn which result in spillage of cement in the packing section.

Emission Aspects:

As cement contains substantial quantity of fines below 10 micron and it is in dry condition, any leakage or spillage leads to fugitive emission. During conveying of the cement bags also emissions are generated. At times cement bags are manually loaded in trucks during which bags are dropped from a height which causes emissions. In general substantial quantity of fines is seen in suspension throughout the packing hall. In many cement plants spilled cement is found in large quantities lying on the floor. In the absence of regular cleaning and sweeping operation this spilled cement on floor causes potential fugitive emissions during movement of trucks or due to wind blowing effect.

Prevalent Fugitive Emission Management Systems:

In some plants, exhaust fans are provided on the walls of the building. Natural ventilation is generally prevalent for dust dispersion in shop-floor. Conveyor belts are fitted with rubber flaps and brushes for continuous surface cleaning of cement bags. The Packer machines are provided with dust extraction cum bag filter arrangement.

- **Silo Vents**

The finely ground material are generally conveyed pneumatically to silos where the material is stored. Though the coarser particles fall in the silo directly, the fines get airborne. The air entering the silo along with pneumatic conveying needs to be vented out. It is generally vented through bag filter. The silos are generally provided for finely ground raw material like raw meal, fly ash, as well as finished products like clinker and cement. Apart from the storage silo there are also some smaller capacity silos (day silo) to handle feed for a day capacity.

Emission Aspects:

As only dry and finely ground material is stored in silos it has great potential to generate fugitive emissions. The emission escapes through silo vents or any other leakages. At times if some of the filter bags are torn, substantial emission occurs from the bag house chimney also. Emission also occurs from the bottom end of the silo during retrieval operation, through leakages if any.

Substantial fugitive emissions also learnt to occur during silo cleaning activity, taken up during major planned shutdown time.

Prevalent Fugitive Emission Management Systems:

All the silo vents are provided with bag filters. For larger silos, separate bag filter is provided for each silo. For smaller capacity silos a common bag filter is provided for number of silo vents.

A typical set up of silos with bag filter is shown at Photograph 3.7.

Photo 3.7: Typical Fugitive Emissions from Cement Silo Tops

3.3.2. Management Practices of Non-Process Fugitive Emission Sources

- **Coal Open Stock Yard**

Coal is sourced from outside and transported by truck and railway wagon. The coal is first weighed on weighbridge and is off-loaded either in dump hopper or in open area. The general practice for coal is to store the extra coal in open yard, which is primarily stored to take care of eventualities such as non-availability of coal in the market or transport problems etc. Generally the covered coal storage is limited to the extent of only a few days of coal requirement (15 to 30 days) but almost all cement plants have extra coal stored in open, the quantity may vary from plant to plant. The coal is normally stored in heaps of small height (unlike limestone) and hence occupies larger area in terms of number of heaps. Generally a truckload of coal is dumped in one heap. Every truck, which needs to unload the coal, has to travel to coal yard in a zigzag fashion to access the location for dumping.

The stacked coal is periodically retrieved from the coal yard by pay loader. The pay loaders retrieve coal from heaps and loads in dumper. Then dumper moves to the coal crusher dump hopper and unloads the coal. The capacity of each dumper range from 10 to 20 T. Normally 2 to 4 dumpers is employed for transportation of coal. In one shift, the number of trips ranges from 25 – 30 trips. In older units, the dump hopper is located inside the coal gantry; overhead crane is employed for lifting coal and unloading in to the hopper.

Emission Aspects:

Coal generally contains substantial amount of fines coming from the mines as well as fresh fines are generated during transportation also. These fines get air borne from the open stock piles due to wind currents. The quantity of emission depends on the moisture content present in the coal.

The emissions due to movement of dumpers/trucks in the coal yard area generate substantial emissions. The dust generated from the coal stockpiles (which gets air borne) settles eventually in the coal yard area. This happens every hour, over a number of day's duration. There is hardly any cleaning or regular sweeping of the dust from the coal yard. As a result the dust keeps on building on the open ground areas. It has been observed that knee-deep dust exist in the coal yard of many cement plants. At times due to self-ignition effect, there is smoking of coal in various heaps, which also gives rise to dust emission apart from gaseous emissions.

Prevalent Fugitive Emission Management Systems:

In some coal yards, water spray arrangement is provided with flexible hosepipe connection. Water spray is randomly operated for reducing the emissions. The coal required for captive power plant is also stored in open coal yard and handling operations such as retrieving, loading and unloading makes it a difficult task for controlling fugitive emissions. Though some water spray arrangement is provided there is hardly any system for dust suppression, (as installed in areas like limestone unloading, stacker/reclaimer etc.) A typical outdoor and indoor coal storage area is shown in Photo 3.8 & 3.9 below.

- **Gypsum Handling and Storage**

Gypsum is generally procured from outside. It is normally stored in enclosed sheds but in some plants it is found to be partially stored in open areas. Front-end pay loader does the gypsum retrieval operation from the storage facility. The retrieved gypsum is unloaded in to gypsum hopper for onward processing.

Emission Aspects:

Due to high percentage of fines is gypsum, substantial fugitive dust emission occurs, especially during loading and unloading operation. The movement of the pay loader and truck over the gypsum floor leads to fugitive emissions. Fines also get air borne due to wind. During summer season the wind carryover from open stockpiles leads to substantial fugitive emissions.

Prevalent Fugitive Emission Management Practices:

Generally, the only type of control measure for preventing/controlling fugitive emissions for gypsum is the enclosure provided for the storage. Gypsum being highly hygroscopic in nature, water is not spread for dust suppression purposes else it may form lumps which further needs to be broken and therefore dust suppression measure is not practiced. Even the dry extraction cum bag filter type systems is hardly practiced for controlling the emissions. A typical partially open gypsum storage area is shown in Photo 3.10.

Photograph 3.8: Coal outdoor storage

Photograph 3.9: Coal Indoor Storage

Photo 3.10: Typical Gypsum storage area (Partly open, Partly Indoor)

- **Additives Handling and Storage**

Additives such as Iron-ore, Shale, Clay, Sand, Bauxite, Hematite, Quartzite are generally procured from outside. Some of these additives are stored either in closed sheds while some are stored in open. The pay loader retrieves the material and feed to crusher hoppers for size reduction as per requirement. Some of the additives like fly ash, slag are received in wet condition at times. These are left open for sun drying and subsequently retrieved after it is dried, and sent to storage places.

Emission Aspects:

Handling and storage of additives give rise to substantial fugitive emissions if the material is dry. The emission occurs primarily due to operations like loading and unloading, movement of pay loaders and due to wind currents, carrying away fines from the stockpiles.

Prevalent Fugitive Emission Management Systems:

As such no control measures are prevalent. Only enclosures wherever possible are provided for controlling emissions.

- **Clinker Storage (Open and closed stockpiles)**

Belt conveyors through various transfer points from the clinker cooler to the storage areas transport the clinker. There are four options available for storage of clinker, either in silos or in enclosed dome shaped structure or in Gantry or in open areas. Generally cement plants have closed storage capacity of 30-40 days production. Depending on the market fluctuations and seasonal demand variations large quantities of additional clinker is required to be stored at site in almost all cement plants, such clinker is stored in generally open areas. These open stockpiles are partially covered with tarpaulin/HDPE type cloth for protecting from rainwater.

Emission Aspects:

As the clinker is associated with substantial quantity of fines and that it has to be stored in dry condition and no water can be applied for suppressing the dust, it is a potential source of fugitive emissions. The fines from stockpiles get air borne due to wind blowing effect. The emissions are excessive in the case of open stockpiles.

Prevalent Fugitive Emission Management Systems:

For closed stockpiles, generally the fines are extracted to vent out the enclosures and it is collected in bag filters. For open stockpiles, only prevention measure such as partially covering stockpiles is practiced but there is hardly any control measure to prevent emissions during retrieval by pay loaders and loading operation. Other measures such as wind breaking wall, green belt etc are not generally found in such type of open storage.

A typical open storage of clinker partially covered with tarpaulin sheet is shown at Photograph 3.11.

Photograph 3.11(a): A Typical view of the Clinker Storage

Photograph 3.11(b): Typical open stock pile of Clinker

- **Clinker Handling from stock piles (Open/ Indoor)**

Handling of clinker from enclosed stockpiles involves a series of operations such as retrieval, belt conveying, transfer to day silo etc. For open stock piles the handling operations typically involve retrieval from stockpiles by pay loaders, feeding to dumpers, and transportation by dumpers for milling or for dispatch of clinker.

Emission Aspects:

Clinker contains substantial quantity of fines (<10 microns) and its handling causes significant fugitive dust emissions. From enclosed stockpiles the airborne fines inside the enclosure escape through leakages or open doors etc in the form of fugitive emissions. During retrieval, due to free fall of material from a height and due to conveying action the fines get air borne. The fines are also generated while feeding retrieved clinker to the day silo through transfer point.

The fugitive emission during clinker handling from open stock piles is substantial. Due to haphazard and to and fro movement of pay loaders while retrieving and loading operations excessive dust emission occurs due to disturbed ground dust as well as disturbed fines in the stockpiles. These emission spread rapidly due to wind currents in the open areas.

Prevalent Fugitive Emission Systems:

In closed storage for retrieval and transfer operations, dust extraction cum bag filter systems is employed. Enclosures are provided for belt conveyors, transfer points etc to contain the emissions. For open stock piles there is hardly any prevention cum control measures practiced for controlling fugitive emissions during retrieval loading, transportation & unloading activities and is a potential problem area.

- **Emissions from Road**

Vehicle traffic within the plant premises is routine operation of the cement plant. The raw materials such as limestone, coal, additives (clay, Laterite, shale, iron-ore etc) and blending materials such as fly ash, gypsum, and slags are generally carried by trucks/dumpers. The vehicles enter the gate, and move to unloading locations in the respective sections of the storage facilities. Generally all the major roads in the cement plants are paved roads and other service roads may be paved or unpaved roads.

Emission Aspects:

During movement of loaded vehicles on the roads, fine dust settled on the roads get airborne and remains suspended for a long time. Repetitive movement of vehicles throughout the day leads to substantial fugitive emissions.

Prevalent Fugitive Emission Management Systems:

Mostly the cement plants have provided concrete paved roads. Many cement plants have wheel mounted mobile vacuum cleaner for sweeping the road dust periodically. In addition intermittent wetting of roads is also practiced. In some units manual cleaning of roads was observed. But such practice of regular cleaning/vacuum sweeping etc is prevalent only on the main roads from main gate to administrative block and around kiln section. The service roads for coal, limestone, additives etc are not regularly cleaned and substantial deposits are found on these roads, which have, potential to get airborne again and again. Water is sprayed periodically to wet the roads.

The analysis of prevalent fugitive emissions management practices discussed above and some important discussions for evolving guidelines/standards are given in the Chapters 7 and 8.

CHAPTER 4.0

Fugitive Emissions Management Practices & Regulations in Developed Countries

Literature survey was conducted in order to collect information on rules, regulations and management practices followed in developed countries for control of fugitive emissions. It was generally experienced that not much relevant information is available especially in the context of fugitive emissions regulations for cement plants. The most relevant information has been gathered through Internet survey of various related sites, which has been compiled in this chapter.

4.1 Fugitive Emission related Rules and Regulations in Developed Countries

4.1.1 Prevalent Rules and Regulations in USA

In USA, for the purpose of air pollution control there are nine regulations covering aspects such as general provisions, permits, fees, prohibitions, toxic air pollutants, fugitive PM-10 prohibitions etc. The fugitive emission related regulations are covered under regulation-VIII, under which, there are number of rules, amended from time to time. The same are described below.

Regulation VIII: Fugitive PM-10 Prohibition

The purpose of regulation-VIII is to reduce the amount of fine particulate matter (PM-10) entrained in the ambient air as a result of emissions generated from anthropogenic (man-made) fugitive dust sources by requiring actions to prevent, reduce, or mitigate PM-10 emissions. The Rules contained in this regulation are required to reduce PM-10 emissions, which violate the National Ambient Air Quality Standards for PM-10.

The Rules contained in this Regulation are applicable to specified man-made fugitive dust sources. Fugitive dust emissions are used as an indicator of PM-10 emissions. Fugitive dust contains PM-10 and particles larger than PM-10. Controlling fugitive dust emissions when visible emissions are detected will not prevent all PM-10 emissions, but will substantially reduce emissions.

The following exemptions are applicable to all Regulation VIII Rules:

- Actions required to protect the environment by Federal or State law or regulation.

- Any source or operations already under Air Pollution Control District permit to operate with requirements for PM-10 control provided the control of fugitive PM-10 emissions required by the permit is at least as stringent as required by this Regulation.

- Emergency operations performed to ensure public health and safety. Emergency operations lasting more than 30 days shall be subject to this regulation, except where compliance would limit the effectiveness of the emergency operation performed to ensure public health and safety.

- Removal of weeds and dried vegetation related to fire prevention required by a Federal, State, or local agency, but not including removal for construction activities.

- Activities conducted at an elevation of 3000 feet or higher above sea level but not including reporting requirements specified in Rule 8060.

- Activities conducted during freezing conditions.

Some of the relevant rules that could be applicable for cement manufacturing activity are mentioned below.

Rule Number	**Title**
403	Fugitive Dust
1158	Storage, Handling, and Transport of Coal
8010	Fugitive Dust Administrative Requirements for Control of PM-10
8030	Fugitive Dust Requirements for Control of PM-10 from Bulk Materials
8051	Open Areas
8060	Fugitive Dust Requirements for Control of PM-10 from Paved and Unpaved roads
8070	Fugitive Dust Requirements for Control of PM-10 from Vehicle and/or Equipment Parking, Shipping, Receiving, Transfer, Fueling and Service Areas

Highlights of some of the rules are mentioned in the following pages.

• **Rule 1158: STORAGE, HANDLING, AND TRANSPORT OF COAL**

The purpose of this rule is to reduce the emissions of airborne particulate matter from the storage, handling, and transport of coal; and to reduce the potential for the storage, handling and transport of these materials to violate AQMD Rules 402 – Public Nuisance and 403 – Fugitive Dust. This rule applies to the operator of a facility that produces, stores, handles, transports, or uses coal.

• Any facility that stores coal solely for use at the facility as a fuel in manufacturing process shall comply with all of the following requirements:

(1) The operator shall not cause, or allow the discharge into the atmosphere of, fugitive dust for a period or periods aggregating more than three minutes in any one hour which is equal to or greater than 10% opacity.
(2) The operator shall maintain all piles in enclosed storage. Any openings shall have overlapping flaps, sliding doors or other equivalent devices(s) approved by the Executive Officer, which shall remain closed except to allow the vehicles to enter or leave.
(3) For facilities existing the operator may achieve compliance with outdoor storage provided the executive Officer approves, in advance, an open storage pile control plan, or complies at all times with at least one of the following:

- Installs and maintains a three-sided barrier equal to the height of the material, with no more than fifty percent porosity to provide wind sheltering;
- Maintains and operates water spray bars, a misting system, water hoses and or water trucks to control fugitive dust emissions;
- Applies chemical stabilizer(s) to control fugitive dust emissions;
- Installs temporary covers; or
- Other equivalent measures approved by the Executive Officer.

(4) Within four hours after material is delivered to the facility by truck trailer, the facility operator shall inspect and clean up any spilled material on any paved road inside or outside the facility up to a quarter mile.
(5) The facility operator shall use a street sweeper to clean any paved road used for material transport, inside or outside the facility, up to a quarter mile from the material delivery site at least once a week or after every 100 truck material deliveries, whichever results in the most frequent street sweeping.
(6) The operator shall pave and maintain as paved, except for railroad tracks, the following areas:

- All non-road ground surfaces within the facility where material accumulation occurs; and,
- All roads and vehicle movement areas within the facility that are used to receive material by truck trailer.

(7) The operator shall pave or chemically stabilize and maintain all roads and vehicle movement areas within the facility that are used for transporting coal.

(8) The operator shall prevent, or remove within four hours; any coal deposit higher than three inches on all paved ground surfaces, unless the accumulations are either moist material or completely covered.

(9) The operator of an AQMD permitted facility shall not allow any truck trailer, while on the AQMD permitted facility, to transport material unless the trailer is covered in one of the following manners, sufficient to prevent material from escaping from the truck onto the facility property.

- A solid sliding cover on the top of the truck that is kept completely closed, or;
- A slot-top type cover that reduces the uncovered open surface area by at least 50% and extends above the trailer top edges, without gaps, and either the material contained in the trailer is moist material, or a chemical stabilizer is applied to the surface of the material in sufficient amounts and concentration so as to prevent fugitive dust emissions during transport, or
- A continuous tarp that completely covers the trailer top, and does not contact the material within the trailer. In addition, the tarp shall be installed or the trailer constructed to prevent wind from entering over the leading edge of the trailer rim into the interior of the trailer.

(10) When transport is by truck trailer, the facility operator shall not receive or transfer material in truck trailers unless such truck trailers, that within one-quarter mile of the perimeter of the facility, drive only on paved roads.

(11) The facility operator shall:

- Record daily, any material delivery by truck trailer and any related street sweeping;
- Record the application of chemical stabilizer;
- Record the time of discovery, condition (moist or dry and or depth of material) and removal of any accumulations.

- Open Storage Pile Control Plan

The Executive Officer shall disapprove an Open Storage Pile Control Plan unless the operator demonstrates that the plan requires the operator to implement best available control measures on the pile(s) and provides that no material accumulates beyond the boundaries of the pile and provides that the facility will comply with all applicable AQMD rules. The Plan shall be submitted as a Rule 1158 Open Pile Control Plan in a complete and approvable form and by the compliance deadline.

(12) In evaluating the proposed plan, the Executive Officer may reasonably require tests and sampling as necessary to determine the likelihood of emission reductions and compliance.

(13) The operator upon approval by the Executive Officer shall implement the plan.

(14) The plan shall contain as a minimum:

- A contour map showing the location of the facility, the location of all piles, the perimeter boundary of the piles, and the surrounding land use and types of roadways within one quarter mile of the perimeter of the facility.
- The maximum daily amount of each material stored within the facility and the maximum daily throughput.
- <u>A list of each applicable best available control measure for each fugitive dust source associated with the pile</u>, including sources associated with moving the pile with mechanical equipment, <u>and detailed documentation demonstrating how implementation of each measure will achieve compliance with all applicable AQMD rules under all conditions</u>, including high wind conditions.

(15) In approving a plan, the Executive Officer may require any reasonable conditions deemed necessary to ensure the operation complies with the plan and AQMD Rules. The conditions may include, but shall not be limited to, <u>application frequency and location of water spray systems</u>, frequency of chemical stabilizer treatments, limits on handling, storage and transport of crushed materials, the placement, construction or modification of permanent perimeter boundaries for each pile or group of piles, monitoring wind conditions, advance notification to the Executive Officer, and performing ambient air monitoring.

(16) In approving a plan, the Executive Officer may require any records deemed necessary to be maintained by the operator to demonstrate compliance with the plan. Such <u>records shall be retained for at least 2 years</u> and be made available to the Executive Officer upon request.

(17) The Plan is only valid for one year. If the Executive Officer denies approval, the facility will have 120 days to submit the necessary applications and two years from the date of the initial denial, to comply with the enclosed storage requirement. In the interim between before the storage pile(s) are enclosed, the Executive Officer may issue an interim plan that requires control measures deemed reasonably necessary to ensure the operation complies with all applicable AQMD Rules.

(18) Compliance with the provisions of the approved plan does not exempt a person from complying with the requirements of the Health and Safety Code, or any other AQMD Rule.

- Compliance Schedule

(19) The operator of a new facility shall immediately comply with all rule provisions.

(20) The operator shall notify the Executive Officer in writing within seven days after removing all open piles. In order to ensure adequate measures are taken to reduce fugitive dust emissions, the operator shall submit a clean-up plan to the Executive Officer and the plan shall be approved by the Executive Officer for approval prior to the operator commencing clean up of open pile pads. The clean-up plan shall comply with all of the following:

- The operator shall submit the clean-up plan within 60 days of notification of removal of open piles.
- The provisions of the approved clean-up plan may differ from the requirements of Rule 1158 if the facility operator demonstrates to Executive Officer satisfaction that all reasonably feasible mitigation to prevent particulate emissions in violation of District rules will be employed.
- No material may be added to the facility after the notification to the Executive Officer.
- The completion date for clean up shall be determined by the Executive Officer as part of clean-up plan approval.

(e) Test Method

(1) ASTM Methods D-3302, D-4931, or equivalent methods approved by the USEPA shall be used to determine the material moisture content.

(2) Appendix C.1, Procedures for Sampling Surface/Bulk Dust Loading, and Appendix C.2, Procedures for Laboratory Analysis of Surface/Bulk Dust Loading Samples, as contained in Compilation of Air Pollutant Emission Factors (AP-42), as published by the U.S. EPA, shall be used to determine the silt loading value.

(3) A method approved as accurate by the Executive Officer shall be used to determine the weight of truck exterior surface material and material silt deposits.

- Compliance Determination and Performance Information

(4) For facilities subject to sub-division (d), each calendar quarter, if the operator selects the silt loading standard for that calendar quarter, and for all other operators once every calendar year, the operator shall perform the following tests. Records of tests shall be maintained for a period of two years and shall be made available to District personnel upon request. Results of the test shall be submitted to the Executive Officer within 45 days after completion of each test. For operators testing once each calendar year, the test results shall be for information only, not for compliance determination. Silt loading tests shall be performed on the following roads or surfaces:

- On one paved road outside the facility, used by trucks transporting material, within one quarter mile of the exit of the facility; and
- On one road between the truck wash or truck cleaning area and the facility exit;

(5) The operator shall conduct a test to show compliance by sampling truck-trailer exterior surface material on one out-going material transport truck.
(6) The operator shall keep records of all applications and permits to construct or modify, needed to meet the deadlines in this rule.

(f) Record keeping Requirements: The Operator shall maintain all records at the facility for a period of two years and make them available to AQMD staff upon request.

RULE 8030: FUGITIVE DUST REQUIREMENTS FOR CONTROL OF FINE PARTICULATE MATTER (PM-10) FROM HANDLING AND STORAGE OF BULK MATERIALS

(Adopted October 21, 1993; Amended November 15, 2001)

The purpose of this Rule is to limit emissions of fine particulate matter (PM-10) from the handling and storage of bulk materials through control of fugitive dust emissions. This Rule applies to the outdoor handling and storage of any bulk material, which emits visible dust when stored or handled. This Rule applies to both new and existing operations and activities. If compliance with this Rule requires the installation or modification of equipment under existing District permit, it should be done within twelve months from the date of issuance of the Authority of Construct.

- Requirements to be met by industries: -

1.1 Transport of a bulk material in an outdoor area for a distance of twelve feet or greater with the use of a chute or conveyor device must comply with the following requirements.

- The chute or conveyer must be fully enclosed, or
- Spray equipment sufficiently wets materials to limit visible dust emissions, or
- All materials conveyed have been washed, separated, or screened to remove materials having an aerodynamic diameter of 10 microns or less.

1.2 No person shall transport any non-exempt bulk materials in open vehicles, trailers, rail cars, or containers without utilizing appropriate control measures. This section is not applicable to earth movers, skip loaders and similar equipment exclusively used to add or remove bulk material from storage piles while conducting operations on the site. Cleanup of accumulation mud or dirt deposited onto public adjacent paved roads is required at the end of the workday, or at a minimum of once every twenty-four hours when operations are occurring. These requirements shall not be construed to supersede any other federal, state, or local requirements relating to the transport of materials on public roads. Appropriate control measures shall be by means of the following:

- Wetting of the material to a moisture content sufficient to limit VDE, or
- Providing at least six inches of freeboard space from the top of the transport container sides, or
- Covering the top of the open container, vehicle, or material transported.

1.3 No person shall store, or cause to be stored, any bulk materials outdoors without stabilizing or covering said bulk materials in accordance with the following provisions:

- Within a period of time, not to exceed seven calendar days following the addition of materials to or removal of materials from an outdoor bulk storage pile, the surface of said outdoor storage piles shall be either covered or stabilized as follows:
- Where water is used for stabilization, sufficient water shall be applied to limit VDE.

- Where chemical stabilizers are used, the stabilizer shall be applied as required to limit VDE.
- Where planting of trees and vegetative ground cover is utilized, vegetation shall be planted in sufficient density and watered with sufficient frequency to effectively stabilize the disturbed area and limit VDE.

2.0 Alternative Compliance Plan: If special conditions exist which will unreasonably prevent compliance. The owner/operator may submit and request approval of an Alternative Compliance Plan which must specify the special circumstances, which unreasonably prevent compliance and provide an alternative program of control measures. Failure to implement control measures specified in an approved Alternative Compliance plan constitutes a violation of this Rule.

- **RULE 8051 OPEN AREAS: -**

(Adopted November 15, 2001; Amended August 19, 2004)

The purpose of this rule is to limit fugitive dust emissions from open areas. This rule applies to any open area having 0.5 acres or more within urban areas, or 3.0 acres or more within rural areas; and contains at least 1000 square feet of disturbed surface area.

- Requirements:

Whenever open areas are disturbed or vehicles are used in open areas, an owner/operator shall implement one or a combination of control measures to comply with the conditions of a stabilized surface at all times and to limit VDE to 20% opacity. In addition to the requirements of this rule, a person shall comply with all other applicable requirements of Regulation VIII.

RULE 8060: -FUGITIVE DUST REQUIREMENTS FOR CONTROL OF FINE PARTICULATE MATTER (PM-10) FROM PAVED AND UNPAVED ROADS -

The purpose of this Rule is to limit emissions of fine particulate matter (PM-10) from paved and unpaved roads through control of fugitive dust emissions by implementing design criteria for paved and unpaved roads. This Rule applies to any paved, or unpaved public or private road, street, highway, freeway, alley, way, access drive, access easement, or driveway. Road construction and repair activities are subject to the requirements set forth in Rule 8020.

- Requirements for industries: -

- Any agency, or owner, or operator having jurisdiction over, or ownership of, public or private paved roads shall construct, or require to be constructed, all new or modified paved roads in conformance with the American Association of State Highway and Transportation Officials (AASHTO) guidelines for width of shoulders and median shoulders as specified below:
- New construction, modification, or approvals of paved roads with projected average daily vehicle trips of 500 vehicles or more shall be constructed with paved shoulders having the following minimum widths: Annual Average Daily Vehicle Trips Minimum Shoulder Width 500-3000 should be 4 feet, 3000 or greater 8 feet.
- Where curbing is constructed adjacent to and contiguous with the travel lane or paved shoulder of a road, the shoulder width design standards specified above shall not be applicable.
- The paved shoulder width requirements set forth are not applicable at intersections or where auxiliary entry and exit lanes are constructed adjacent to and contiguous with the roadway.
- The paved shoulder width requirements set forth are not applicable where the requirements would conflict with environmental, historical, or archaeological considerations. Examples of environmental conflicts include the need to minimize road width when constructing a road through mountainous terrain or wetlands areas.
- Where paved roads are constructed, or modified with medians and have projected annual average daily vehicle trips of 500 vehicles or more, the medians shall be constructed with paved shoulders having a minimum width of four feet adjacent to the traffic lanes unless:

    - The medians are solidly paved, or
    - Medians of roads having speed limits set at or below 75 km per hour are constructed with curbing, or
    - Medians are landscaped and maintained with grass or other vegetative ground cover.
- In lieu of the paving and landscaping requirements, the agency, owner, or operator may use application of oils or other approved dust suppressant chemicals to control shoulder and median areas to the specified required width. The material shall be reapplied and maintained in accordance with the manufacturer's recommendations.

- No person shall construct or otherwise utilize a new unpaved road or road segment, after the effective date of this regulation, without application of one of the control measures set forth in subsections below. Where soil moisture is sufficient to limit dust emissions equal to or less than the 40% opacity level, no action is required. Where control measures are required, unpaved roads or road segments shall not be subject to the Visible Dust Emissions (VDE) limits as defined in Rule 8010.

- At least 50% of the length of the new unpaved road surface is controlled by application of chemical suppressant or other equivalent stabilization in accordance with manufacturer's recommendations, or
- The entire new unpaved road surface is controlled by application of water at least one time per week, or
- At least 25% of the length of the new unpaved road surface is paved to provide a permanent stable surface.

- Alternative Compliance Plan: If special conditions exist which will unreasonably prevent compliance with the requirements of this Rule, the owner/operator may submit and request approval of an Alternative Compliance Plan. The Alternative Compliance Plan must specify the special circumstances, which unreasonably prevent compliance and provide an alternative program of control measures. Failure to implement control measures specified in an approved Alternative Compliance Plan constitutes a violation of this Rule.

RULE 403. FUGITIVE DUST

(Adopted May 7, 1976) (Amended June 3, 2005)

The purpose of this Rule is to reduce the amount of particulate matter entrained in the ambient air as a result of anthropogenic (man-made) fugitive dust sources by requiring actions to prevent, reduce or mitigate fugitive dust emissions. The provisions of this Rule shall apply to any activity or man-made condition capable of generating fugitive dust.

Requirements to be met by industries: -

(1) No person shall cause or allow the emissions of fugitive dust from any active operation, open storage pile, or disturbed surface area such that:

(A) The dust remains visible in the atmosphere beyond the property line of the emission source; or

(B) The dust emission exceeds 20 percent opacity, if the dust emission is the result of movement of a motorized vehicle.

(2) No person shall conduct active operations without utilizing the applicable best available control measures included in Table 1 of this Rule to minimize fugitive dust emissions from each fugitive dust source type within the active operation.
(3) No person shall cause or allow PM 10 levels to exceed 50 micrograms per cubic meter when determined, by simultaneous sampling, as the difference between upwind and downwind samples collected on high-volume particulate matter samplers or other U.S. EPA-approved equivalent method for PM 10 monitoring. If sampling is conducted, samplers shall be:

(A) Operated, maintained, and calibrated in accordance with 40 Code of Federal Regulations (CFR), Part 50, Appendix J, or appropriate U.S. EPA-published documents for U.S. EPA-approved equivalent method(s) for PM 10.
(B) Reasonably placed upwind and downwind of key activity areas and as close to the property line as feasible, such that other sources of fugitive dust between the sampler and the property line are minimized.

(4) No person shall allow track-out to extend 25 feet or more in cumulative length from the point of origin from an active operation. Notwithstanding the preceding, all track-out from an active operation shall be removed at the conclusion of each workday or evening shift.
(5) No person shall conduct an active operation with a disturbed surface area of five or more acres, or with a daily import or export of 100 cubic yards or more of bulk material without utilizing at least one of the measures listed in subparagraphs (d)(5)(A) through (d)(5)(E) at each vehicle egress from the site to a paved public road.

(A) Install a pad consisting of washed gravel (minimum-size: one inch) maintained in a clean condition to a depth of at least six inches and extending at least 30 feet wide and at least 50 feet long.
(B) Pave the surface extending at least 100 feet and at least 20 feet wide.
(C) Utilize a wheel shaker/wheel spreading device consisting of raised dividers (rails, pipe, or grates) at least 24 feet long and 10 feet wide to remove bulk material from tires and vehicle undercarriages before vehicles exit the site.
(D) Install and utilize a wheel washing system to remove bulk material from tires and vehicle undercarriages before vehicles exit the site.
(E) Any other control measures approved by the Executive Officer and the USEPA.

- Additional Requirements for Large Operations

(1) Any person who conducts or authorizes the conducting of a large operation subject to this Rule shall implement the applicable actions specified in Table 2 of this Rule at all times and shall implement the applicable actions specified in Table 3 of this Rule when the applicable performance standards can not be met through use of Table 2 actions; and shall:

(A) Submit a fully executed Large Operation Notification (Form 403 N) to the Executive Officer within 7 days of qualifying as a large operation;
(B) Include, as part of the notification, the name(s), address (es), and phone number(s) of the person(s) responsible for the submittal, and a description of the operation(s), including a map depicting the location of the site;
(C) Maintain daily records to document the specific dust control actions taken maintain such records for a period of not less than three years; and make such records available to the Executive Officer upon request;
(D) Install and maintain project signage with project contact signage that meets the minimum standards of the Rule 403 Implementation Handbook, prior to initiating any earthmoving activities;
(E) Identify a dust control supervisor that:

- (i) Is employed by or contracted with the property owner or developer;
- (ii) Is on the site or available on-site within 30 minutes during working hours;
- (iii) Has the authority to expeditiously employ sufficient dust mitigation measures to ensure compliance with all Rule requirements;
- (iv) Has completed the AQMD Fugitive Dust Control Class and has been issued a valid Certificate of Completion for the class; and

(F) Notify the Executive Officer in writing within 30 days after the site no longer qualifies as a large operation.

(2) Any Large Operation Notification submitted to the Executive Officer or AQMD-approved dust control plan shall be valid for a period of one year from the date of written acceptance by the Executive Officer. Any Large Operation Notification, excluding those submitted by aggregate-related plants and cement manufacturing facilities must be resubmitted annually by the person who conducts or authorizes the conducting of a large operation, at least 30 days prior to the expiration date, or the submittal shall no longer be valid as of the expiration date. If all fugitive dust sources and corresponding control measures or special circumstances remain identical to those identified in the previously accepted submittal or in an AQMD-approved dust control plan, the resubmittal may be a simple statement of no-change.

(f) Compliance Schedule: The newly amended provisions of this Rule shall become effective upon adoption. Any existing site that qualifies as a large operation will have 60 days from the date of Rule adoption to comply with the notification and recordkeeping requirements for large operations. Any Large Operation Notification or AQMD-approved dust control plan which has been accepted prior to the date of adoption of these amendments shall remain in effect and the Large Operation Notification or AQMD-approved dust control plan annual resubmittal date shall be one year from adoption of this Rule amendment.

4.1.2 Regulation in Hong Kong

Relevant rules and regulations applicable for control of emissions from cement manufacturing plants are described below (Most relevant regulations related to fugitive emissions are shown as underlined.).

1.0 INTRODUCTION

1.1 This note covers specified processes and associated processes for the manufacture of cement, described as "Cement Works" in Schedule 1 to the Ordinance. Cement Works are works in which the total silo capacity exceeds 50 tonnes and in which cement is handled or in which argillaceous and calcareous materials are used in the production of cement clinker, and works in which cement clinker is ground.

2.0 EMISSION LIMITS

2.1 All emissions to air, other than steam or water vapour, should be colourless, free from persistent mist or fume, and free from droplets.

2.2 Smoke emission from a combustion process should not, when compared in the appropriate manner with the Ringelmann Chart or an approved device, appear to be as dark as or darker than Shade 1 on the Ringelmann Chart.

2.3 The concentration limits specified below should apply to the emissions from the manufacture of cement and associated processes. All pollutant concentrations are expressed at reference conditions of 0oC, 101.325 kPa and dry conditions without correction for oxygen content, and compensated for any effect of dilution air to the concentration.

(a) The kiln system for clinker production	
Particulates	50 mg/m3
Sulphur dioxide	400 mg/m3
Oxides of nitrogen (expressed as nitrogen dioxide)	800 mg/m3
(b) Other processes	
Particulates	50 mg/m3

3.0 FUEL RESTRICTION

3.1 Unless otherwise agreed by the Authority, fuels to be used should be conventional fuels that comply with the provisions of the Air Pollution Control (Fuel Restriction) Regulations.

4.0 CONTROL OF EMISSIONS

4.1 Emission of air pollutants should be minimised to prevent:

(a) Harm to the environment, adverse effects to human health, or creation of any nuisance situation;

(b) Threatening the attainment or maintenance of the relevant air quality objectives;

(c) Giving rise to an objectionable odour noticeable outside the premises where the process is carried on; and

(d) Imposing undue constraint on the existing and future development or land use.

4.2 To satisfy the emission limits set out in section 2.0 of this note, prevention or reduction of emissions at source is the choice. Where the emission cannot be prevented or reduced at sources to sufficient extends to meet these requirements, air pollution control equipment should be provided.

- *Dispersion*

4.3 Chimneys include vents, structures and openings of any kind from or through which air pollutants may be emitted. The applicant will need to demonstrate that the proposed chimney will provide sufficient dispersion of air pollutants.

4.4 A chimney should be at least 3 metres above the roof of any building to which it attaches and above the roof of any adjacent buildings.

4.5 Emissions from chimneys should be directed vertically upwards and not restricted or deflected by the use of, for example, plates or rain caps.

4.6 The efflux velocity of the exhaust gas stream emitted from a chimney should not be less than 15 m/s at full load condition.

4.7 For a combustion process, the temperature of the exhaust gas stream emitted from the chimney should not be less than the acid dew point.

- *Clinker and Cement Production*

4.8 Exhaust gases from the main processing equipment (kilns, clinker coolers, mills, driers, etc.) should be vented to a suitable gas cleaning equipment to meet the emission limits set out in section 2.0 of this note. 3

4.9 Dust emissions from ancillary processing equipment (crushing, screening, blending, packing, loading, etc.) should be properly contained and vented to suitable arrestment plant to meet the emission limit set out in section 2.0 of this note.

- *Materials Handling*

4.10 Handling and storage of fuel, raw materials, products, wastes or by-products should be carried out in such a manner to prevent the release of:

(a) Visible dust emissions;
(b) Emissions of organic vapours; and/or
(c) Other noxious or offensive emissions.

4.11 The receipt, handling, storage of all materials should be carried out in such a way to minimise the emission of dust to the air.

4.12 Stock of clinker, bulk cement, other cementitious materials, dry pulverised fuel ash, pulverised coal and other pulverised materials should be stored in silos. Stock of other dusty materials should be stored in silos or covered storage. Dust laden air from silos and covered storage should be vented to suitable equipment to meet the emission limit set out in section 2.0 of this note.

4.13 Conveyance of cement, other cementitious materials, dry pulverised fuel ash, pulverised coal and other pulverised materials should be by ducts or pneumatic pipelines. Dust laden air from the conveying system should be vented to suitable arrestment plant to meet the emission limit set out in section 2.0 of this note.

4.14 Conveyance of clinker and other dusty materials inside buildings should be carried out so as to prevent or minimise airborne dust emissions. Where conveyors are used, they should be provided with protection against wind whipping, for example by fitting side broads. Conveyor discharges should be arranged to minimise free fall at all times.

4.15 Conveyance of clinker and other dusty materials outside buildings should be by fully covered or totally enclosed systems. Transfer points should be totally enclosed.

4.16 Other materials, which may generate airborne dust emissions, for example crush rock, coarse aggregate, or coal should be delivered, stored and handled so as to prevent or minimise dust emissions.

4.17 The packing of cement into bags and loading of cement into bulk tankers and barges should be carried out using purpose-designed plant fitted with extraction for displaced air ducted to suitable arrestment plant, for example bag filters, to meet the emission limits set out in section 2.0 of this note.

- *Miscellaneous*

4.18 Traffic areas, including roads and areas with regular vehicle movements, should be paved with a suitable roadway covering and be kept clean constantly by means of sweeping machines or other facilities.

4.19 All spillages should be cleaned up promptly using, for example, a vacuum cleaner or vacuum system. Particular attention should be paid to preventing and cleaning up deposits of dust on support structures and roofs in order to minimise wind entrainment of deposited dust.

4.20 Silos should be fitted with high-level alarm to prevent overfilling. Seating of pressure relief valves to all silos should be checked periodically.

5.0 MONITORING REQUIREMENTS

5.1 The applicant should satisfy the Authority that–

(a) He will provide the necessary instrumentation, process controls and monitors to demonstrate that the process is being properly controlled;

(b) The scope, manner and monitoring frequency will be sufficient to demonstrate compliance with the terms and conditions imposed to the licence at all times; and

(c) He will have sufficient staff to service these requirements.

Results of all monitoring and inspections should be recorded in such a manner specified by the Authority. This record should be retained at the premises for a minimum of two years, or other period specified by the Authority, after the date of last entry and be made available for examination as and when required by the Authority.

5.2 Indication of the satisfactory of air pollution control equipment should be provided. For example, the pressure drop across filters should be displayed.

5.3 Continuous monitoring of the exhaust gas emissions from the kiln system for clinker production should be made for:

(a) Particulates;
(b) Sulphur dioxide; and
(c) Oxides of nitrogen.

The continuous monitoring instruments to be provided should meet the specifications required by the Authority. They should be maintained and calibrated according to the manufacturer's recommendations. Unless otherwise agreed by the Authority, zero and span checks should be carried out every 24 hours.

5.4 Ambient monitoring should be made for total suspended particulates, and respirable suspended particulates if required by the Authority, in such a manner and at such locations and frequency specified by the Authority.

6.0 COMMISSIONING

6.1 Commissioning trials, to be witnessed by the Authority whenever appropriate, should be conducted to demonstrate the performance and capability of the air pollution control measures. Unless otherwise agreed by the Authority, the report of the commissioning trial should be submitted to the Authority within 1 month after completion of the trial.

7.0 OPERATION AND MAINTENANCE

7.1 Best practicable means requirements include not only the provision of the appliances, but the proper operation and maintenance of equipment, its supervision when in use, and the training and supervision of properly qualified staff.

7.2 Equipment should be repaired as soon as practicable. Specific operation and maintenance requirements should be specified for individual pieces of equipment used in the specified processes.

7.3 Malfunction, breakdown or failure of any process or air pollution control equipment that may result in abnormal emission of air pollutants should be reported to the Authority by telephone or facsimile as soon as possible, followed by a written report within 3 working days after the incident.

TABLE 4.1: BEST AVAILABLE CONTROL MEASURES (Applicable to All Construction Activity Sources)

Source Category	**Control Measure**	**Guidance**
Crushing	• Stabilize surface soils prior to operation of support equipment; and • Stabilize material after crushing.	• Follow permit conditions for crushing equipment • Pre-water material prior to loading into crusher • Monitor crusher emissions opacity • Apply water to crushed material to prevent dust plumes
Importing/exporting of bulk materials	• Stabilize material while loading to reduce fugitive dust emissions; and • Maintain at least six inches of freeboard on haul vehicles; and • Stabilize material while transporting to reduce fugitive dust emissions; and • Stabilize material while unloading to reduce fugitive dust emissions; and • Comply with Vehicle Code Section 23114.	• Use tarps or other suitable enclosures on haul trucks • Check belly-dump truck seals regularly and remove any trapped rocks to prevent spillage • Comply with track-out prevention/mitigation requirements • Provide water while loading and unloading to reduce visible dust plumes
Landscaping	• Stabilize soils, materials, slopes	• Apply water to materials to stabilize • Maintain materials in a crusted condition • Maintain effective cover over materials • Stabilize sloping surfaces using soil binders until vegetation or ground cover can effectively stabilize the slopes • Hydroseed prior to rain season
Road shoulder maintenance	• Apply water to unpaved shoulders prior to clearing; and • Apply chemical dust suppressants and/or washed gravel to maintain a stabilized surface after completing road shoulder maintenance	• Installation of curbing and/or paving of road shoulders can reduce recurring maintenance costs • Use of chemical dust suppressants can inhibit vegetation growth and reduce future road shoulder maintenance costs
Stockpiles/ Bulk Material Handling	• Stabilize stockpiled materials. • Stockpiles within 100 yards of off-site occupied buildings must not be greater than eight feet in height; or must have a road bladed to the top to allow water	• Add or remove material from the downwind portion of the storage pile • Maintain storage piles to avoid steep sides or faces

	truck access or must have an operational water irrigation system that is capable of complete stockpile coverage.	
Truck loading	• Pre-water material prior to loading; and • Ensure that freeboard exceeds six inches (CVC 23114)	• Empty loader bucket such that no visible dust plumes are created • Ensure that the loader bucket is close to the truck to minimize drop height while loading
Unpaved roads/parking lots	• Stabilize soils to meet the applicable performance standards; and • Limit vehicular travel to establish unpaved roads (haul routes) and unpaved parking lots.	• Restricting vehicular access to established unpaved travel paths and parking lots can reduce stabilization requirements
Vacant land	• In instances where vacant lots are 0.10 acre or larger and have a cumulative area of 500 square feet or more that are driven over and/or used by motor vehicles and/or off-road vehicles, prevent motor vehicle and/or off-road vehicle trespassing, parking and/or access by installing barriers, curbs, fences, gates, posts, signs, shrubs, trees or other effective control measures.	

Table 4.2: DUST CONTROL MEASURES FOR LARGE OPERATIONS

FUGITIVE DUST SOURCE CATEGORY	CONTROL ACTIONS
Inactive disturbed surface areas	• Apply water to at least 80 percent of all inactive disturbed surface areas on a daily basis when there is evidence of wind driven fugitive dust, excluding any areas which are inaccessible to watering vehicles due to excessive slope or other safety conditions; OR • Apply dust suppressants in sufficient quantity and frequency to maintain a stabilized surface; OR • Establish a vegetative ground cover within 21 days after active operations have ceased. Ground cover must be of sufficient density to expose less than 30 percent of unstabilized ground within 90 days of planting, and at all times thereafter; OR • Utilize any combination of control actions (3a), (3b), and (3c) such that, in total, these actions apply to all inactive disturbed surface areas.
Unpaved Roads	• Water all roads used for any vehicular traffic at least once per every two hours of active operations [3 times per normal 8 hour work day]; OR • Water all roads used for any vehicular traffic once daily and restrict vehicle speeds to 15 miles per hour; OR • Apply a chemical stabilizer to all unpaved road surfaces in sufficient

	quantity and frequency to maintain a stabilized surface.
Open storage piles	• Apply chemical stabilizers; OR • Apply water to at least 80 percent of the surface area of all open storage piles on a daily basis when there is evidence of wind driven fugitive dust; OR • Install temporary coverings; OR • Install a three-sided enclosure with walls with no more than 50 percent porosity, which extend, at a minimum, to the top of the pile. This option may only be used at aggregate-related plants or at cement manufacturing facilities.
All Categories	• Any other control measures approved by the Executive Officer and the U.S. EPA as equivalent to the methods specified in Table 2 may be used.

TABLE 4.3: CONTINGENCY CONTROL MEASURES FOR LARGE OPERATIONS

FUGITIVE DUST SOURCE CATEGORY	CONTROL MEASURES
Disturbed surface areas	• On the last day of active operations prior to a weekend, holiday, or any other period when active operations will not occur for not more than four consecutive days: apply water with a mixture of chemical stabilizer diluted to not less than 1/20 of the concentration required to maintain a stabilized surface for a period of six months; OR • Apply chemical stabilizers prior to wind event; OR • Apply water to all unstabilized disturbed areas 3 times per day. If there is any evidence of wind driven fugitive dust, watering frequency is increased to a minimum of four times per day; OR • Take the actions specified in Table 2, Item (3c); OR • Utilize any combination of control actions (1B), (2B), and (3B) such that, in total, these actions apply to all disturbed surface areas.
Unpaved roads	• Apply chemical stabilizers prior to wind event; OR • Apply water twice per hour during active operation; OR • Stop all vehicular traffic.
Open storage piles	• Apply water twice per hour; OR • Install temporary coverings.
Paved road track-out	• Cover all haul vehicles; OR • Comply with the vehicle freeboard requirements of Section 23114 of the California Vehicle Code for both public and private roads.
All Categories	• Any other control measures approved by the Executive Officer and the U.S. EPA as equivalent to the methods specified in Table 3 may be used.

4.2 Control Efficiencies evolved by USEPA for various Fugitive Dust Control Technologies

This section describes the estimation of control efficiencies for the fugitive dust control technologies considered. The primary sources of information and equations used as a basis for estimating the efficiency of each control are described in detail below.

In conducting research on CKD and the cement manufacturing industry for the past several years, EPA conducted extensive literature searches on CKD and potential fugitive dust control options. Since these initial searches were conducted, subsequent literature searches and interviews with experts reveal that little new material has been published on fugitive dust emissions and controls. Even recent publications on fugitive dust tend to focus on manufacturing processes, rather than bulk material handling and disposal operations. Even with the recent proposal of the new PM2.5 National Ambient Air Quality Standards (NAAQS), new data regarding control technologies are limited because EPA's focus for the NAAQS revision has been on the health effects of PM and 2.5 not the potential control requirements, anticipated level of reductions, and the associated costs. For many of the technologies, EPA relied upon its knowledge of cement facility operations and air emissions, especially fugitive dust and the associated control technologies, to develop control efficiencies using their best engineering and professional judgement.

- **Water Addition for Storage Piles / Landfills**

Wind erosion emissions are known to be strongly correlated with the inverse square of the moisture content, so EPA uses the following relationship to relate controlled and uncontrolled emissions with controlled and uncontrolled moisture content:

$$E_c = E_u \left(\frac{M_u}{M_c} \right)^2$$

where

E_c = controlled emission rate;

E_u = uncontrolled emission rate;

M_u = controlled moisture content (%); and

M_c = uncontrolled moisture content (%).

Accordingly, for a given control efficiency, EPA calculates the ratio of uncontrolled moisture content to controlled moisture content as shown in table below. Doubling the moisture content results in a 75 percent reduction in emissions. This corresponds well with the control efficiencies predicted by another relationship for watering of unpaved road surfaces, in which the instantaneous control efficiency is related to the ratio of controlled to uncontrolled surface moisture content according to the following bilinear relationship:

CE = 75(M-1) for 1 M 2
CE = 62 +6.7M for 2 M 5
where
CE = control efficiency (%), and
M = ratio of controlled to uncontrolled moisture content (equal to M_c/M_u).

Table 4.4: Estimated Moisture Content ratios for Various Control Efficiencies

CE	M_c/M_u	CE	M_c/M_u
10%	1.05	70%	1.83
20%	1.12	75%	2.00
30%	1.20	80%	2.24
40%	1.29	85%	2.58
50%	1.41	90%	3.16
60%	1.58	95%	4.47
65%	1.69	99%	10.00

M_c= controlled moisture content (%)
M_u= uncontrolled moisture content (%)
CE = control efficiency

This relationship predicts that between one and two times the average uncontrolled moisture content (a small increase in moisture content) yields a large increase in control efficiency. Beyond this point, control efficiency increases more slowly with moisture content.

For any particular situation, the required water application rate will be dictated by the desired control efficiency. Based on the above, a 75 percent reduction in emissions appears readily achievable. For this analysis, EPA assumed a low-end control efficiency of 55 percent corresponding to a 50 percent increase in moisture content and a high-end control efficiency of 75 percent corresponding to a doubling of moisture content because these appeared achievable. Higher control efficiencies (e.g., 90 percent) should also be achievable, but would require doubling of the moisture content.

- **Water Addition for Roadways**

EPA estimated the control efficiency for water addition to unpaved roads using the following relationship:

$$CE = 100 - \frac{0.8pdt}{i}$$

where

CE = average control efficiency (%);

p = potential average hourly daytime evaporation rate (mm/hr);

d = average hourly daytime traffic rate (hr^{-1});

i = application intensity (liters per square meter [L/m^2]); and

t = time between applications (hr).

The potential average hourly daytime evaporation rate in mm/hr is estimated which varies from site to site, by multiplying the mean annual Class A Pan Evaporation (in inches) by 0.0049 for annual conditions and by 0.0065 for summer conditions. The mean annual Class A Pan Evaporation for various areas of the US are available as isopleths. The potential average hourly daytime evaporation rates are shown in Table 4.5 below.

Table 4.5: Parameters Needed to Estimate Control Efficiency for Unpaved Road Watering

Cement Plant	Class A Pan Evaporation (inches)	Potential Average Hourly Daytime Evaporation rate (mm/hr)		Hourly Vehicular Traffic rate (hr^{-1})
		Annual	Summer	
A	70	0.34	0.46	4.08
B	65	0.32	0.42	0.05

Generally, the target control efficiency for dust suppression from unpaved roads is used to determine the amount and frequency of water application required. Control efficiencies can fall from approximately 95 percent for total suspended particulates (TSP) (with higher efficiencies for finer particles) shortly after application to approximately 50 percent within five hours of application for unpaved roads with heavy traffic.

As an example, the estimated average control efficiencies for annual and summer conditions for is shown in Table 4.6 below. At an application rate of 1 L/m^2, the average control efficiency for 2 watering every 24 hours is 73 percent for annual conditions and 64 percent for summer conditions.

Table 4.6: Example Control Efficiency Matrices for Watering of Unpaved Roads (%)

Annual Conditions								
Application Intensity	Time Between Applications (Hours)							
L/m^2	2	4	6	8	12	16	20	24
0.10	77.6	55.3	32.9	10.5	-	-	-	-
0.20	88.8	77.6	66.5	55.3	32.9	10.5	-	-
0.30	92.5	85.1	77.6	70.2	55.3	40.4	25.5	10.5
0.40	94.4	88.8	83.2	77.6	66.5	55.3	44.1	32.9
0.50	95.5	91.1	86.6	82.1	73.2	64.2	55.3	46.3
1.00	97.8	95.5	93.3	91.1	86.6	82.1	77.6	73.2
2.00	98.9	97.8	96.6	95.5	93.3	91.1	88.8	86.6
3.00	99.3	98.5	97.8	97.0	95.5	94.0	92.5	91.1
4.00	99.4	98.9	98.3	97.8	96.6	95.5	94.4	93.3
5.00	99.6	99.1	98.7	98.2	97.3	96.4	95.5	94.6
6.00	99.6	99.3	98.9	98.5	97.8	97.0	96.3	95.5
Summer Conditions								
Application Intensity	Time Between Applications (Hours)							
L/m^2	2	4	6	8	12	16	20	24
0.10	70.3	40.7	11.0	-	-	-	-	-
0.20	85.2	70.3	55.5	40.7	11.0	-	-	-
0.30	90.1	80.2	70.3	60.4	40.7	20.9	1.1	-
0.40	92.6	85.2	77.8	70.3	55.5	40.7	25.8	11.0
0.50	94.1	88.1	82.2	76.3	64.4	52.5	40.7	28.8
1.00	97.0	94.1	91.1	88.1	82.2	76.3	70.3	64.4
2.00	98.5	97.0	95.6	94.1	91.1	88.1	85.2	82.2
3.00	99.0	98.0	97.0	96.0	94.1	92.1	90.1	88.1
4.00	99.3	98.5	97.8	97.0	95.6	94.1	92.6	91.1
5.00	99.4	98.8	98.2	97.6	96.4	95.3	94.1	92.9
6.00	99.5	99.0	98.5	98.0	97.0	96.0	95.1	94.1

- **Enclose Temporary Storage Pile**

Enclosure of material transfer points and storage piles can result in particulate emission reductions ranging from 70 to essentially 100 percent control, depending on the type of enclosure (partial or full), the type of operation, and whether or not the enclosure vent is routed to a control device such as a bag house. For this analysis, EPA estimated emissions for both 70 percent control efficiency (partial enclosure) and 99 percent control efficiency (full enclosure).

- **Cover Truck/Clean Truck and Cover**

EPA found no data regarding the effectiveness of these control measures. The Agency estimated the control efficiencies for covering the truck and cleaning the truck and cover after each use at 90 percent and 95 percent, respectively based on engineering judgment and discussions with vendors.

4.3 USEPA Standards for Fugitive Emissions for Cement Kiln Dust (CKD)

- **Performance Standard**

Under EPA's proposal, unit design and operation must ensure that wind dispersal of particulate material (PM) is controlled. The specific performance standard for air is that the owner or operator of a facility must cover or otherwise manage the unit to control wind dispersal of CKD waste. This standard would apply to solid PM that becomes airborne directly or indirectly as a result of CKD handling procedures. The most common sources of PM at cement manufacturing facilities to which this standard applies include vehicular traffic on unpaved roads or on CKD waste management units, and wind erosion from waste management units. This standard would not apply to CKD emitted from an exhaust stack. The Agency understands that methods for controlling fugitive dust will vary depending on factors such as geographic location, climate, facility design, and CKD management method. Therefore, the proposal provides owners and operators, working with State agencies, with substantial flexibility do determine the appropriate method to control fugitive emissions based on facility specific conditions.

To demonstrate compliance with the performance standard for the protection of air, EPA has proposed that owners or operators of new and existing CKD landfills employ the technology-based standards described below for controlling fugitive dust. For example, an owner or operator may employ all of the following to demonstrate compliance with the performance standard for the protection of air:

- Emplace CKD waste in a landfill as conditioned CKD;
- Cover the waste in the landfill at the end of each operating day with material sufficient to prevent blowing dust;
- Water unpaved roads with sufficient frequency to prevent blowing dust;
- Use covers on trucks transporting CKD; and
- Place CKD destined for temporary storage prior to recycling, sale, or disposal in tanks, containers, or buildings.

- **Technical Standards that Meet the Performance Standard**

- **Conditioning:** For facilities complying with the technology-based standards, EPA has proposed that CKD managed in landfills must be emplaced as conditioned CKD. Proper conditioning includes mixing the CKD with water on a continuous or batch basis, such as pug milling, followed by compaction.
- **Covers:** The Agency has proposed that disposed CKD be covered with material at the end of each operating day sufficient to prevent blowing dust.
- **Wetting:** EPA believes that consistent wetting and watering of unpaved roads can sufficiently reduce releases of fugitive emissions from facilities that manage CKD. Increasing the moisture content of the dust can significantly reduce fugitive dust emissions from unpaved roads.
- **Temporary Storage:** The Agency has proposed that CKD destined for temporary storage prior to recycling, sale, or disposal not be placed in land-based units, but in tanks, containers, or buildings.

4.4 Fugitive Particulate emission Control Plan for various Sources/Areas: -

- Storage and Handling of Primary Crushed Raw Materials at Plant Site - Underground Reclamation System and Front End Loader Activity.
- When feeding the primary crusher at the plant, material drop height from the front-end loaders shall be minimized, and the drop height shall not exceed 3 feet above the top edge of the hopper.
- The stockpile work area on which the front-end loaders operate shall be treated with chemical dust suppressants and/or water to minimize the generation of fugitive emissions. The operation of front-end loaders in this area will be suspended whenever the average wind speed exceeds 30 m.p.h.
- Paved travel areas used by the front-end loader shall be regularly swept with a high efficiency vacuum sweeper to minimize material buildups. In addition, these areas will be watered as necessary and vehicle traffic suspended or rerouted if fugitive emissions become a concern.
- Required a minimum 4.5 percent moisture content of the materials handled by the front-end loader.

- **Cement Storage Silos/Packhouse/Loadout**

- Height of fall of material shall be minimized during front-end loader handling.
- Clinker shall be reclaimed from the storage pile(s) as soon as possible, consistent with seasonal product demands and covered storage constraints.
- Paved areas shall be swept regularly with a high efficiency vacuum sweeper to minimize material buildups. In addition, these areas will be watered as necessary and vehicle traffic suspended or rerouted if fugitive emissions become a concern.

- The drop of clinker to the outside chute shall be managed with a seal between the hopper and material during operating to allow effective operation of the dust collector such that emissions are minimized.

- **Handling and Processing of CKD and Raw Material Waste Dust**
- Transfer points shall be enclosed with the exception of the drop from the pug mill to the truck. Emissions shall be controlled in the drop to the truck through effective moisture control in the pug mill.
- CKD exposed at the disposal site, shall be minimized, and no more than 7 acres shall be exposed or used for disposal at a time. Fugitive particulate matter emissions from areas not being actively used shall be minimized using a shale cover.
- A sprinkler system shall be in operation as much as necessary to effectively control emission at the disposal area. Emissions shall be controlled during dumping by effective moisture control during pugging.
- Spillages and accumulations of particulate matter on roadways shall be watered, cleaned up regularly, and managed to insure they do not contribute to fugitive emissions during operation. Vehicle traffic will be suspended or rerouted from spillage areas as necessary to minimize fugitive emissions.
- Compliance inspections of the CKD pugging, hauling, and storage operations shall be conducted at least 2 times per shift (at no less than 2 hour intervals). Records of such inspections shall be maintained at the site.
- The haul trucks of 95 tons capacity or greater shall be used.

▪ **Clinker Handling and Transfer:** The clinker and off-spec clinker should be stored in enclosed silos. Clinker should be transported in trucks that utilize soft covers.

▪ **Raw Material Blending:** Raw Material Blending Hall should be totally enclosed structure with the exception of the door to it that is subject to the visible emission standard.

▪ **Raw Mill System:** The raw mill system should work under negative pressure, thereby preventing pressurization that could result in fugitives.

- **Cement Kiln Dust:** The CKD will be recycled back into the system at all possible times.

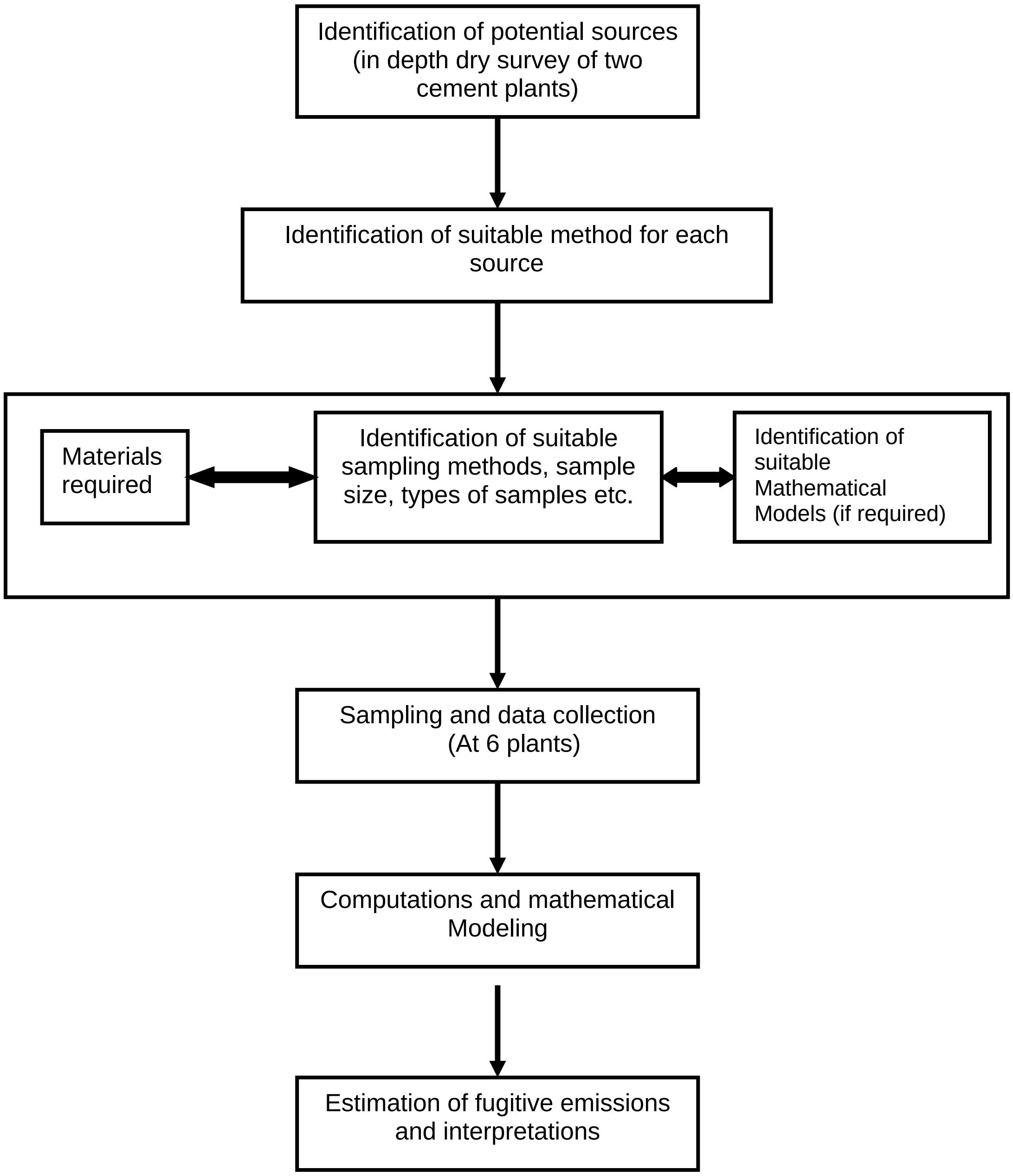
▪ **Bag house Hopper Collection Points:** The collected dust from the bag house hopper collection points will return to enclosed locations.

CHAPTER 5.0
Sampling Plan for Estimation of Fugitive Emissions

5.1 Approach For Fugitive Emissions Estimation

Potential sources of fugitive emissions were identified through dry survey of two cement plants (Gujarat Ambuja, Darlaghat and ACC Gagal). Suitable sampling methods were then identified along with the mathematical models. Six cement plants were selected for sampling and data collection. Computational and mathematical models were applied to the data to estimate the fugitive emissions. Approach for fugitive emissions estimation for cement plants presented in Figure 5.1.

Fig 5.1 Approach for Estimation of Fugitive Emissions from Cement Plant



5.2 Various Methods for Fugitive Emissions Estimates

The following methods ((a) through (d)) can be used for estimation of fugitive emissions in any industrial process. However, the applicability of these methods for individual sources depends on type of source (e.g. storage, crushing), material being handled and resources available. These methods are briefly described below.

(a) Upward flux method

In order to quantify the emissions from area sources employing crushing, loading and unloading, upward flux method can be used. This method assumes that the fugitive emission goes vertically up from the area of operation. The upward flux of particles and their vertical velocity is used to estimate the emission from the area. The emissions rates can be estimated using the following relationship:

$$\text{Emission (Kg/hr)} = 3.6\times10^{-6}\times\text{PM concen. }(\mu g/m^3)\times\text{area }(m^2)\times\text{vertical vel. }(m/s)$$

(b) Upwind and downwind method

In order to quantify the emissions from isolated area receptor-based mathematical models can be used. Suitable monitoring stations can be located in the upwind and downwind of the source and ambient dust concentration can be measured during the activity period. Based on the meteorological data and ground level concentration, source strength can be estimated using simple Gaussian model or fugitive dust model.

The Gaussian model for estimating the central line ground level concentration (i.e. y and z equal to zero) from a ground level point source is given by

$$Q = C \pi \sigma_y \sigma_z u$$

Where,
x, y,z are the coordinates of a point in a space with origin at the point of release;

C (x, 0, 0) is the central line ground level concentration contributed by the source (measured on the field);
Q is the uniform emission rate of pollutant (to be estimated);
σ_y and σ_z are the standard deviations of plume concentration in horizontal and vertical directions

u is the mean wind speed affecting plume.

Possible source category: open stock piles, loading and unloading area, Raw material preparation sections and mining operations.

(c) Quasi stack sampling

In this method, providing suitable temporary hoods and sample extraction holes makes proper arrangements for capture of the emissions from the sources. Then regular stack sampling is employed to estimate the fugitive emissions. This ensures minimum interference from the other sources. Based on the flow rate and iso-kinetic dust sampling the dust emissions rate can be computed.

Source category: Packing plant, Clinker Stockpile etc.

(d) Silt load method for paved road emission

USEPA (2001) (http://www.epa.gov/ttn//chief/ap42) has proposed a method to estimate the emissions from road due to movement of vehicles. This can be referred to as silt load method as silt loading per unit area (of road) is used to determine the road dust emissions. The mathematical method that uses silt loading is presented below (other details of method can be seen in the reference):

$$E = k\,(SL/2)^{0.65}\,(W/3)^{1.5}$$

Where E : Emission rate of size specific PM
SL : Silt load (g/m^2) on the road
W : Mean weight of vehicle fleet (Tonne)
K : Constant in g/VKT (Vehicle kilometer travel) (Table 5.1)

Table –5.1: Particle size Multiplier for Paved Road Equation

Size Range	K (g/VKT)
PM2.5	1.1
PM10	4.6
PM15	5.4
PM30	24.0

In this work value of k is taken as 24.

(e) Finger printing technique

In case of complex area sources, where there is large interference from multiple sources, fingerprinting technique can be used for the estimation of source emission matrices. Under this exercise various prominent metals to represent source category can be identified and analyzed in the air particulate samples. Details of the receptor modeling are presented below:

- Receptor model start with observed ambient airborne pollutant concentrations at a receptor and seeks to apportion the observed concentrations between several source types based on the knowledge of the compositions of the sources and receptor materials. There are two generally recognized classes of receptor Models:

- Chemical elemental balance or chemical mass balance (CEM/CMB), and
- Multivariate or a statistical.

While (CEM/CMB) methods apportion sources using extensive quantitative source emission profiles, statistical approaches infer source contribution without a prior need of quantitative source composition data. The CMB method assumes that aerosol mass is conserved from the time a chemical species is emitted from its source to the time it is measured at a receptor. That is, if p sources are contributing M_j mass of particulates to the receptor,

$$m = \sum_{j=1}^{p} M_j$$

$$F'_{ij} = F_{ij}$$

where, m is the total mass of the particulate collected on a filter at a receptor site, F'_{ij} is the fraction of chemical species i in the mass from source j collected at the receptor and F_{ij} is the fraction of chemical i emitted by source j as measured at the source. The mass of the specific species, m_i, is given by the following:

$$m_i = \sum_{i=1}^{p} M_{ij} = \sum_{i=1}^{p} F'_{ij} M_j$$

where, M_{ij} is the mass of element i contributed to the receptor from source j. Dividing both sides of equation by the total mass of the deposit collected at the receptor site, it follows that

$$C_i = \sum_{j=1}^{p} F_{ij} S_j$$

where, C_i is the concentration of chemical component i measured at the receptor (air filter) and S_j is the source contribution; that is, the ratio of the mass contributed from source j to the total mass collected at receptor site.

If the C_i and F_{ij} at the receptor for all p of the source types suspected of affecting the receptor are known, and $p \leq n$ (n = number of the species), a set of n simultaneous equations exist from which the source type contribution S_j may be calculated by least square methods.

The Table 5.2 shows types of samples and resource requirement for each of the above methods.

Table 5.2 : Material and resources required for each method

Method	Types of Samples
Upward flux Method	Indoor PM sampling and vertical exit velocity
Upwind and Downwind method	At least two-air quality sampling stations in the downwind and one station in the upwind of the source is employed. Type of sampling is suggested based on the source type and interference from other sources. Possible air sampling methods are high volume or handy samplers; high volume sampler is preferred.
Quasi-stack sampling	Temporary suction hood arrangement, stack sampler and consumables
Silt Load Method	(1) Estimation of silt Load on paved and unpaved roads (2) Vehicle tonnage (3) No of vehicles
Finger portioning technique	Dust samples several and analysis of metals/ions in particulate on filter paper.

5.3 Selected Methods For Emission Monitoring For Various Fugitive Emission Sources:

The selected methods for various sources are given in the Table 5.3 below.

Table- 5.3: Fugitive Emission Sources and Method for Emission Monitoring

Sources	Method for Monitoring
Limestone Unloading Operation	Upward Flux
Limestone Crusher House	Upward Flux
Limestone Intermediate Storage	D/W & U/W
Limestone Stacking	D/W & U/W
Coal Stock Yard	D/W & U/W
Cement Packing (Room)	Upward Flux
Cement Packing (Conveyer Belt)	Upward Flux
Cement Packing (Truck Loading Operation)	Upward Flux
Fly Ash Unloading	Upward Flux
Gypsum Unloading	Upward Flux
Clinker Belt Conveyer	Upward Flux
Road Dust	Silt load Method

(i) Sampling Method for Unloading of Limestone

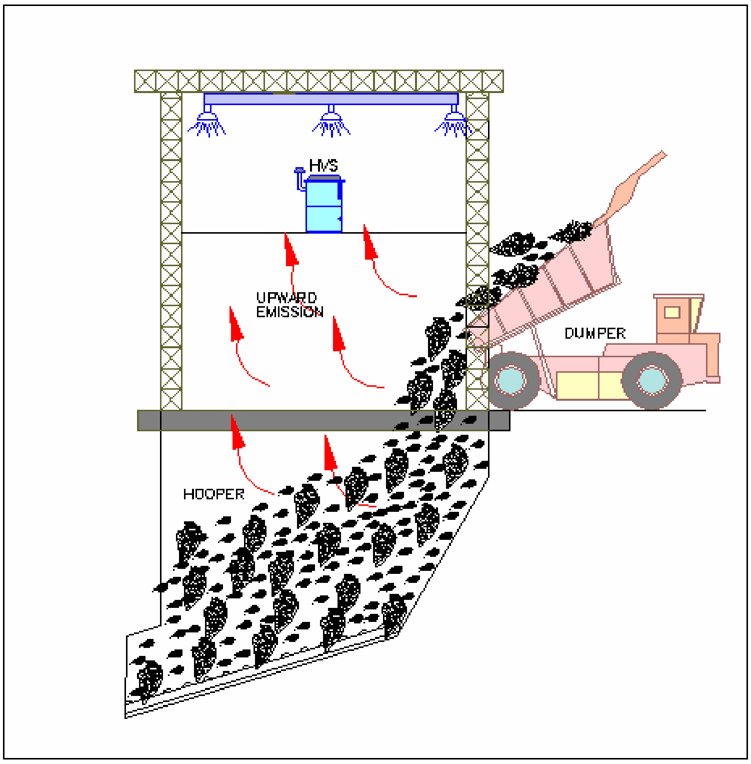


Fig 5.2 Schematic of Lime Unloading Area showing Location of Sampler

Methodology

- Installation of high volume sampler inside the shade at the height 2-3m above ground level
- Duration of sampling - minimum 6-hours which covers minimum of 20 unloading
- Count number of unloading during the period of sampling
- Install another High Volume Sampler at a distance of minimum 30m from the shade where no local source of pollution exists.
- During the period of unloading measure up flow velocity of dust inside shade at least five times using hand held anemometer
- Take the dimension of the shade (Length, width and Height)

(ii) Lime Stone Crushing

- Conduct stack sampling at the inlet to the stack before pollution control device

(iii) Raw material/Product Storage

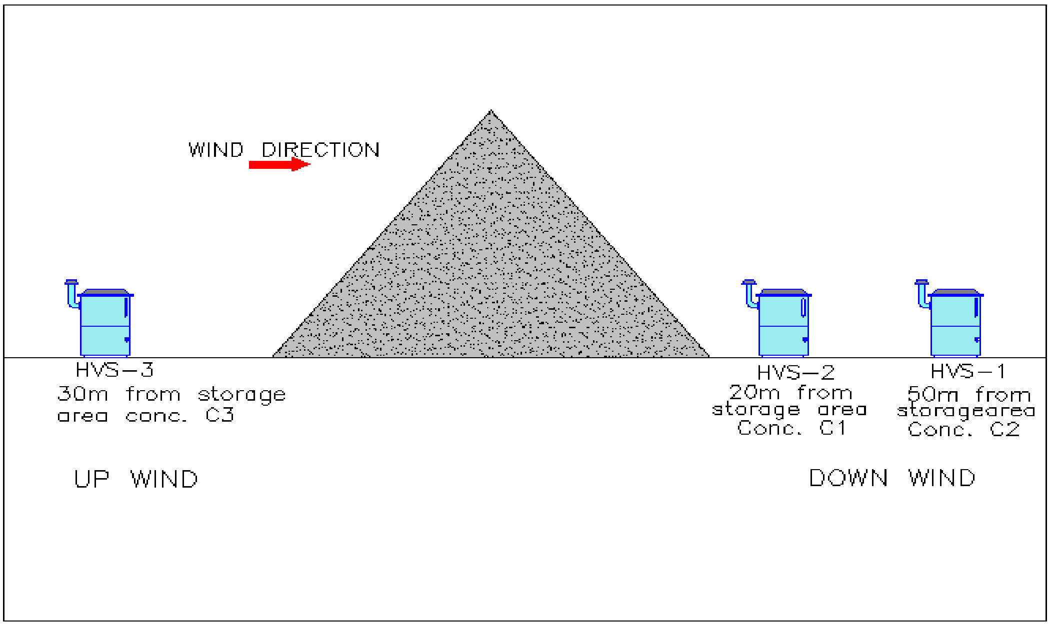
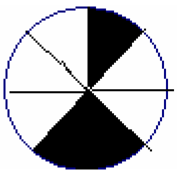


Figure 5.3 Schematic Diagram of Limestone Stacker showing location of sampler

Methodology

- Install two HVS in down wind direction and one in upwind direction as shown in Figure 5.3
- Duration of sampling at least- four hours
- Measure the following parameter in-situ.
    - o Wind speed
    - o Wind Direction
    - o Time of the day
    - o Temperature during sampling
    - o Dimension of the storage area including height
    - o Is the loading continuous or in batches
    - o Cloud cover (see example)

Example- Look at the sky and examine out of 8 equal parts, how many are filled with cloud and report cloud cover.



Above Figure 5.4 represent 3/8-cloud cover diagram

Emission Estimation Rate Calculation Method

The Gaussian Model for estimating the central line ground level concentration (i.e. y and z equal to zero) from a ground level point source is given by:

$$Q1 = (C_1 - C3)\, \pi\, \sigma_y \sigma_z U$$
$$Q2 = (C2 - C3)\, \pi\, \sigma_y \sigma_z U$$

Where,

x ,y, z are the coordinates of a point in space with origin at point of release;
C (x, 0, 0) is the central line ground level concentration (measured on the field)
Q is the uniform emission rate of pollutant (to be estimated)
σ_y and σ_z are the standard deviations of plume concentration in horizontal and vertical directions; and
u is the mean wind speed affecting the plume.

(iv) Coal Stock yard

The same method as in (iii) for raw material storage is applicable for open stock yard.

(v) Coal Unloading and Crushing operation

For Coal unloading operation, Method (i) is applicable.

For Coal Crushing operation, stack sampling at the inlet and outlet of the control system is air pollution control system like bag filter is provided

(vi) All Other Transfer Points

Stack sampling be conducted at representative transfer points at the inlet to pollution control device

(vii) Cement Packing Area

Conduct roof monitoring at the exhaust fan with high volume sampler – A three-hour high volume sampler in duplicate is suggested. Measure

- Exhaust air speed coming out from exhaust fan
- Diameter of the exhaust fan hole/duct
- Note Number of such fans

(viii) Road Dust Emission

Dust emissions from roads have been found to vary with what is termed as “silt loading” present on the road surface as well as the average weight of vehicles traveling on the road (mean vehicle fleet weight). The term silt loading (sL) refers to the mass of silt-size material (equal to or less than 75 µm in physical diameter) per unit area of the travel surface. The total road surface dust loading is that of loose material that can be collected by broom sweeping and vacuuming of the traveled portion of the paved road. The silt fraction is determined by measuring the proportion of the loose dry surface dust that passes through a 200-mesh screen. The quantity of dust emissions from vehicle traffic on a paved road may be estimated using the following empirical expression (USEPA, 2001):

$$E = k\ (sL/2)^{0.65}\ (W/3)^{1.5}$$

Where

E : Emission rate of size specific Pm (same unit as "K")

SL : Silt load (g/m^2)

W : Mean weight of the vehicle fleet (Tons)

k : Constant (function of particle size) in g/VKT (Vehicle Kilometer Travel)

It is important to note that above equations calls for the average weight of all vehicle fleet weight traveling on the road. For example, if 99 percent of traffic on the road is 2 T cars//trucks while the remaining 1 percent consists of 20 T trucks, then the mean weight "W" is 2.2 T. More specifically, the equation is not intended to be used to calculate a separate emission rate for each vehicle weight class. Instead, fleet average weight of vehicles traveling the road shall be taken for the computation of FRD emissions. The particle size multiplier (k) varies with aerodynamic size range for which the emission rate shall be computed (Table 5.1).

The equation is based on a regression analysis of numerous emission tests. Sources tested include public paved roads, as well as controlled and uncontrolled industrial paved roads. The conditions for which the equation is applied are given below:

Silt Loading	: 0.02 – 400 g/m^2
Mean Vehicle weight	: 1.8 –38 Tons (T)
Mean Vehicle speed	: 16 –18 Kilometers per hour (kph)

The field studies were accordingly taken up as per the above-discussed sampling plan in six cement plants. The results of the monitoring are given in the following chapter.

CHAPTER 6.0

Estimation & Quantification of Fugitive Emission

6.1 Field Monitoring HVS Data for Estimating Fugitive Emissions

Field measurements were conducted in six cement plants (as identified in chapter 1) as per the sampling plan evolved and following the methodologies of sampling. The measurements were conducted using HVS or RDS instruments, at various potential fugitive emission sources. The measured data for estimating fugitive emissions is compiled in various Tables below.

a) Lafarge - Sonadih Cement Plant

Activity / Operation	Run Time "min"	Average Flow	Ambient Temp (Avg) "°C"	Wind Velocity "m/sec"	Distance from hopper, m		SPM "μg/m³"
					'x"	'z"	
Limestone Unloading Operation	60	1	37	1.5	1	0	6556
	57	1	37	1.5	1	0	3519
						Average	5037
Coal Unloading Operation	50	0.925	34	2.95	1.2	-	93344
Packing Plant	185	1.20	35	-	-	-	17226
Stacker & Reclaimer	250	1.25	30	1.5	-	-	519
	402	1.225	30	2.5	-	-	111
						Average	315

b) ACC - Jamul

Section	Run Time "min"	Avg. Flow "m³/min"	Ambient Temp (Avg) "°C"	Wind Velocity "m/sec"	Distance from hopper, m		SPM "μg/m³"
					'x"	'z"	
Limestone Unloading	115	0.82	43	2.7	1	0	8166
	120	1.30	43	2.7	1	0	8938
						Average	8552
Crusher House	198	1.10	39	1.0	0	5	6516
	60	1.10	38	0.9	0	5	5272
						Average	5894
Clinker Gantry	85	1.20	39	1.45	0	8	5407
	180	1.10	37	2.00	0	8	9521
						Average	7464
Limestone Gantry	240	1.15	36	1.20			454.58
	162	1.10	38	1.00			9220.16
	123	1.00	38	1.00			12320.90
						Average	7332
Coal Gantry	165	1.15	38	1.00	0	5	4315
	120	1.30	38	1.00	0	5	2947
						Average	3631
Packing Section	120	1.00	37	1.00	3	0	453.61
	305	1.00	37	1.00	3	0	3587.08
						Average	2020

c) UltraTech - Awarpur Cement Works

Section	Run Time "min"	Avg. Flow "m^3/min"	Ambient Temp (Avg) "^oC"	Wind Velocity "m/sec"	Distance from hopper, m		SPM "$\mu g/m^3$"
					'x'	'z'	
Limestone Unloading Hopper	90	1.1	44	2.5 – 3.0	0.5	2.5	16209
Coal Unloading operation	95	1.05	43	3.7	0.5	0	15915
Coal Crushing operation	180	1.06	45	3.7	1	1	1478
Gypsum Unloading operation	155	1.06	45	3.0	0	0	4808
Limestone stacker and reclaimer	180	1.0	43	1.0	2	0	1145
Packing Plant	90	1.05	44	1	3	0	10893
	80	1.015	44	1	3	0	553
						Average	5723

d) Gujarat Ambuja - Maratha Cement Works

Section	Run Time "min"	Avg. Flow "m^3/min"	Ambient Temp (Avg) "^oC"	Wind Velocity "m/sec"	Distance from hopper, m		SPM "$\mu g/m^3$"
					'x'	'z'	
Limestone Unloading	120	1	38	2	1	0	698
Limestone stacker	75	1	40	3	0	2	1099
Limestone reclaimer	180	1	39	2	0	2	572
Packing Plant	120	1	36	1	3	1	4480
Gypsum unloading	120	1	38	1	0	2	2785
Laterite Unloading	120	1	39	1	0	0	2169
Coal Unloading	120	1	40	1	1	0	3222
Coal Stacking	120	1	37	1	3	0	46259
Coal Reclaimer	120	1	36	1	3	0	25767

e) ACC Gagal Cement Works

Section	Run Time "min"	Avg. Flow "m³/min"	Ambient Temp (Avg) "°C"	Wind Velocity "m/sec"	Distance from hopper, m		SPM "µg/m³"
					'x'	'z'	
Limestone Unloading	60	1	36	2	1	0	3883
Limestone crushing	240	1	37	3	3	0	11949
Limestone stacking	480	1	36	2	4	0	803
Coal Unloading	40	1	37	1	0	0	30513
Gypsum unloading	300	1	34	1	0	0	42172
Packing Plant	240	1	35	1	3	0	7598
Clinker Belt conveyor	420	1	38	1	4	0	12856
Flyash pneumatic conveying	420	1	36	1	1	0	7983

e) Birla - Chanderia Cement Works

Section	Run Time "min"	Avg. Flow "m³/min"	Ambient Temp (Avg) "°C"	Wind Velocity "m/sec"	Distance from hopper, m		SPM "µg/m³"
					'x'	'z'	
Limestone Unloading	95	0.82	37	0.2	6.2	0.5	23791
Limestone crushing	98	0.8	35	0.2	3	1	12072
Coal unloading	139	0.75	35	0.2	6	0	176438
Packing Plant	150	0.975	37	5.3	0.24	0.9	11890
Packing plant Belt conveyor	171	0.82	37	0.1	2	0.5	30525
Limestone stacking	183	1.13	33	0.5	16	0.83	3803
Coal Stacker	60	0.96	35	0.6	14	0	10722

A few photographs showing field measurements in progress at various sections are shown at Photo 6.1 below.

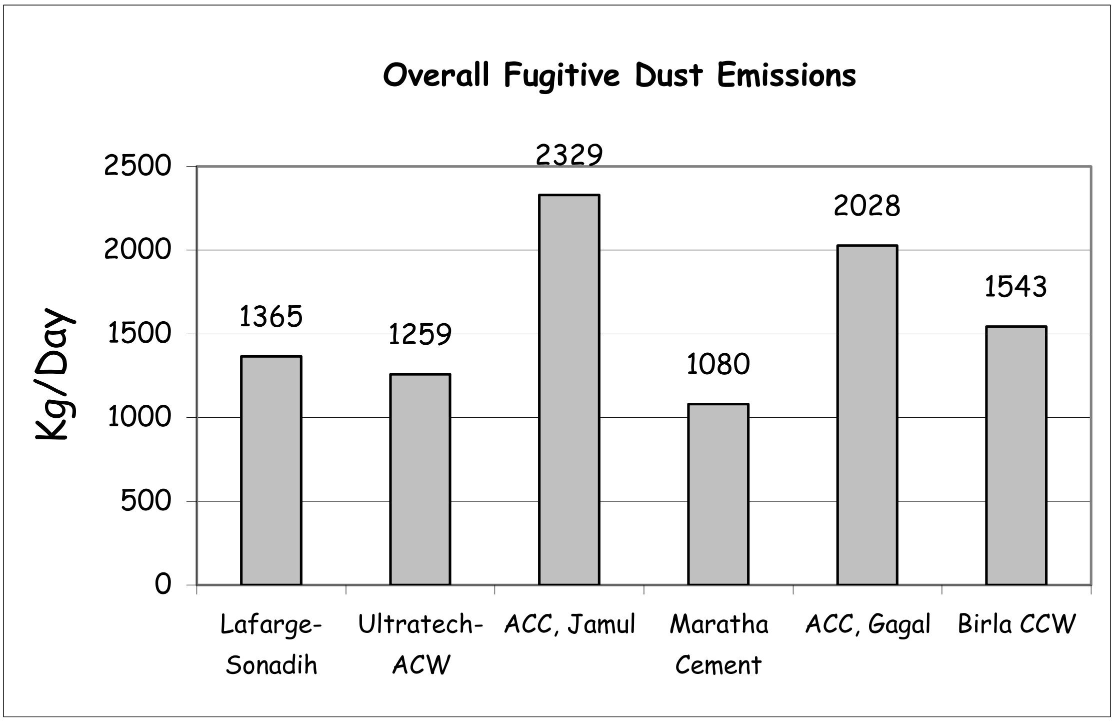
Photographs 6.1: showing HVS/RDS Monitoring in Progress

6.2 Estimations of Fugitive Emissions

The measured values of SPM concentrations were interpreted to evolve fugitive emission rates. The relevant calculations are given at Annexure 6.1.

Figure 6.1 shows the total fugitive emissions from all 6 cement plants studied.

Figure 6.1: Overall Fugitive Emissions Including Road Dust Emission



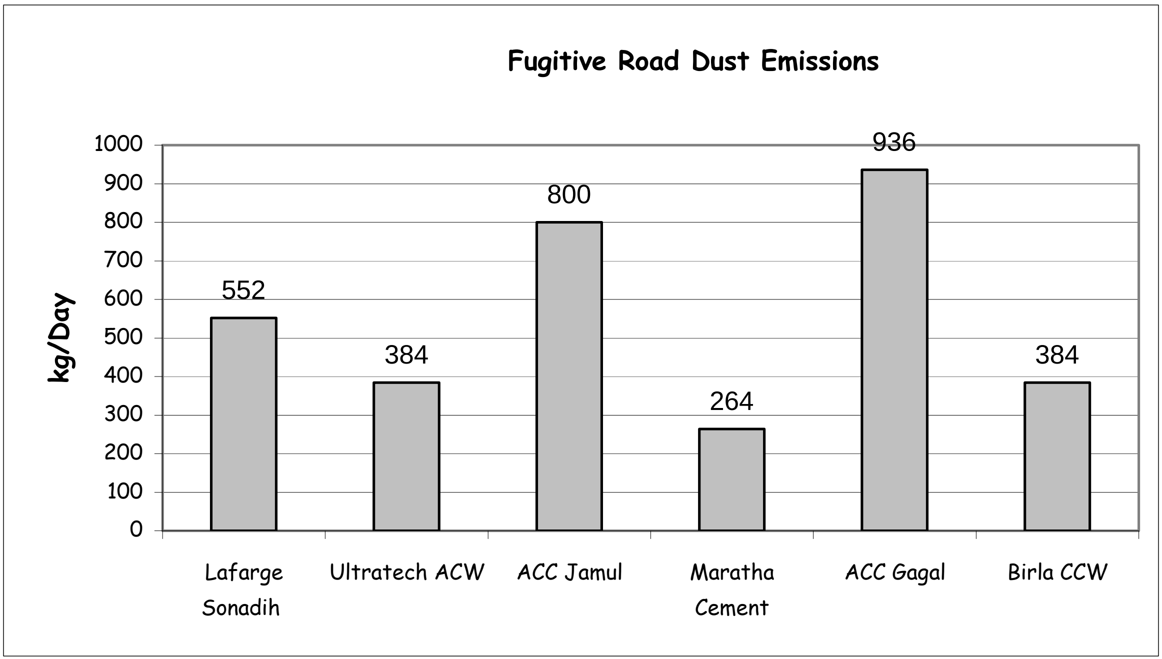
The following inferences can be drawn from above figure.

- Overall fugitive emission from all the plants ranges from 1080 kg/day to 2329 kg/day.
- ACC Jamul showed the highest total fugitive emissions of 2329 kg/day whereas the lowest total fugitive emissions were from Maratha Cement works i.e. 1080 kg/day.
- The newer plants give rise to lesser fugitive emissions as compared to older plants.

6.3 Specific Emissions
6.3.1 Fugitive Road Dust Emissions (FRD)

Figure 6.2 presents the emission from road dust due to movement of heavy trucks on the roads inside the plant.

Figure 6.2: Road Dust Emissions from Six Cement Plants



The following inferences can be drawn from above figure.

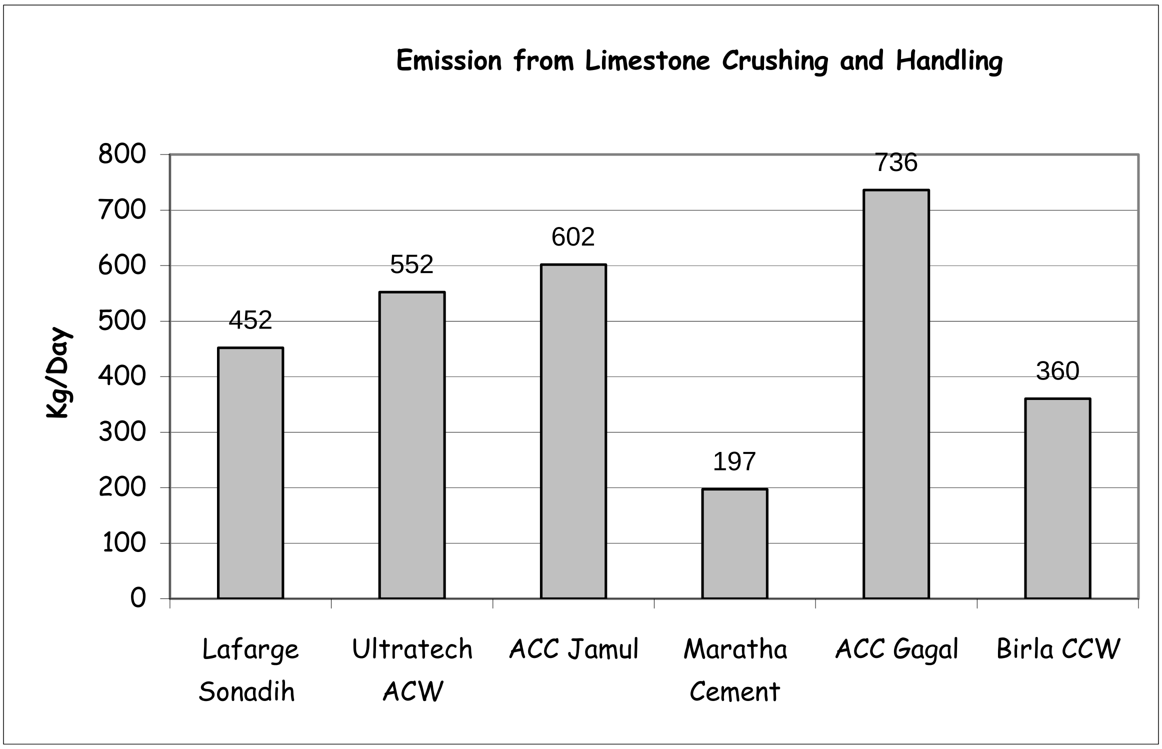
- Road dust fugitive emissions from all the plants range from 264 Kg/day to 936 Kg/day. The older plant showed the highest road dust fugitive emissions of 936 kg/day whereas the lowest road dust fugitive emission was observed at the new plant i.e., 264 Kg/day.

- The interesting point from this analysis is that FRD is an important source contributing 16% to 44 % of total emission.

6.3.2 Limestone Crushing and Handling Emissions

Figure 6.3 presents the emission from limestone crushing, storage and handling operations in six plants considered in this study.

Figure 6.3: Emissions from Lime Stone Crushing, Storage and Handling



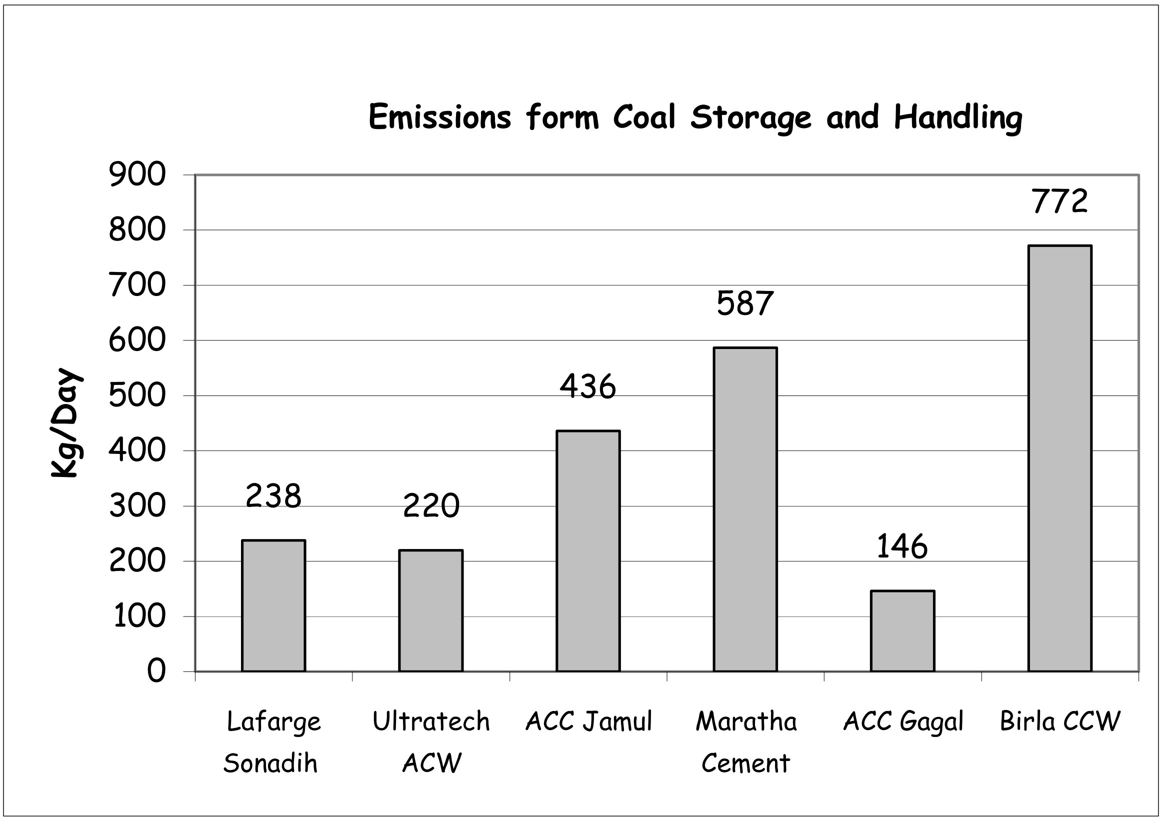
The following are the noteworthy points of emissions from limestone handling and crushing operations:

- Overall limestone handling fugitive emissions from all the plants ranges from 197 kg/day to 736 kg/day. ACC Gagal showed the highest limestone crushing and handling fugitive emissions of 736 kg/day whereas the lowest limestone handling fugitive emission was observed by Maratha Cement works i.e., 197 kg/day

6.3.3 Coal Handling Emissions

Figure 6.4 presents the emission from coal handling operations in six plants considered in this study.

Figure 6.4: Emissions from Coal Storage and Handling



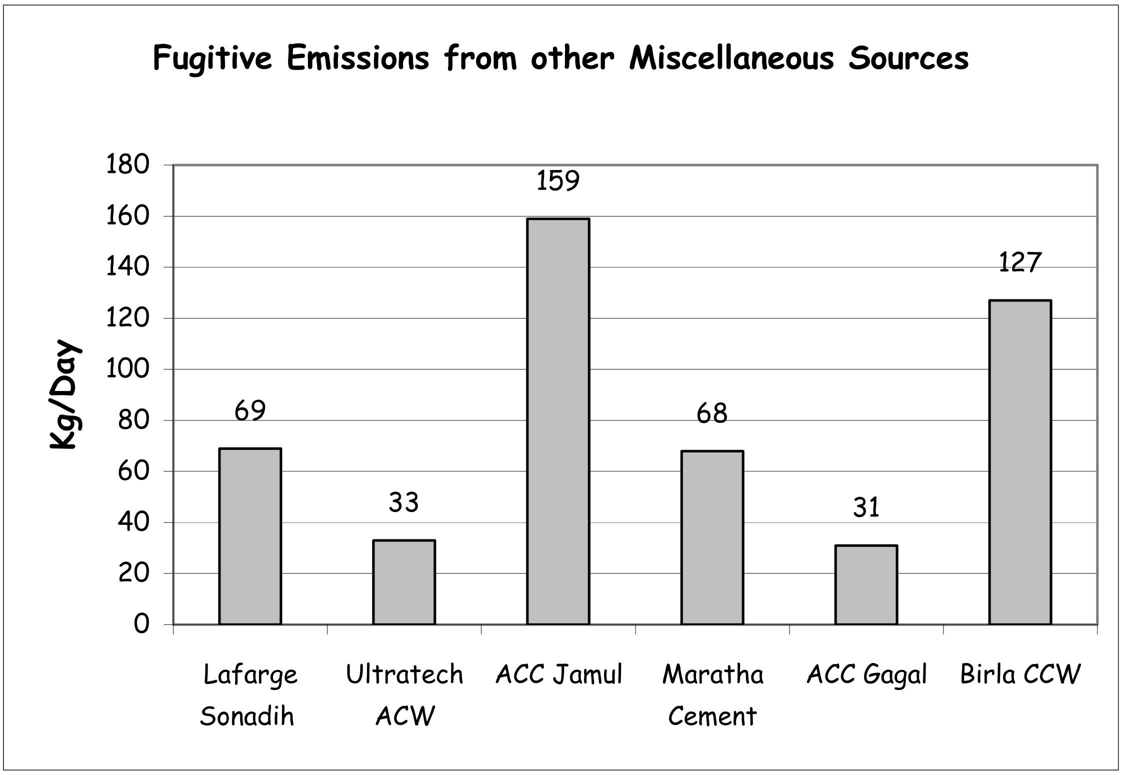
The following inferences can be drawn from Figure 6.4

- Overall coal handling fugitive emissions from ranges from 146 kg/day to 772 kg/day. CCW showed the highest coal handling fugitive emissions of 772 kg/day whereas the lowest coal handling fugitive emissions were observed at Maratha Cement works i.e., 146 kg/day

6.3.4 Other Fugitive Emissions

Figure 6.5 presents the emissions from other miscellaneous fugitive sources (Gypsum handling, Packing plant etc)
Miscellaneous sources are provided separately in section 6.5 Plant-wise emissions

Figure 6.5: Fugitive Emission from Other Miscellaneous Sources



The following inferences can be drawn from above figure.

- Overall miscellaneous fugitive emissions from all the plants range from 31 kg/day (ACC, Gagal) to 159 kg/day (ACC Jamul).
- At ACC Jamul, the main component of other miscellaneous sources is Limestone Crushing.
- At Birla Chanderia Cement Works, it was Limestone Stacking that contributed most in the miscellaneous source category.

6.4 Plant Capacity Specific Emissions

Figure 6.6 presents the plant specific emission per ton of cement produced so to understand the emissions in a relative sense with respect to plant capacity.

Figure 6.6: Plant capacity Specific Emissions

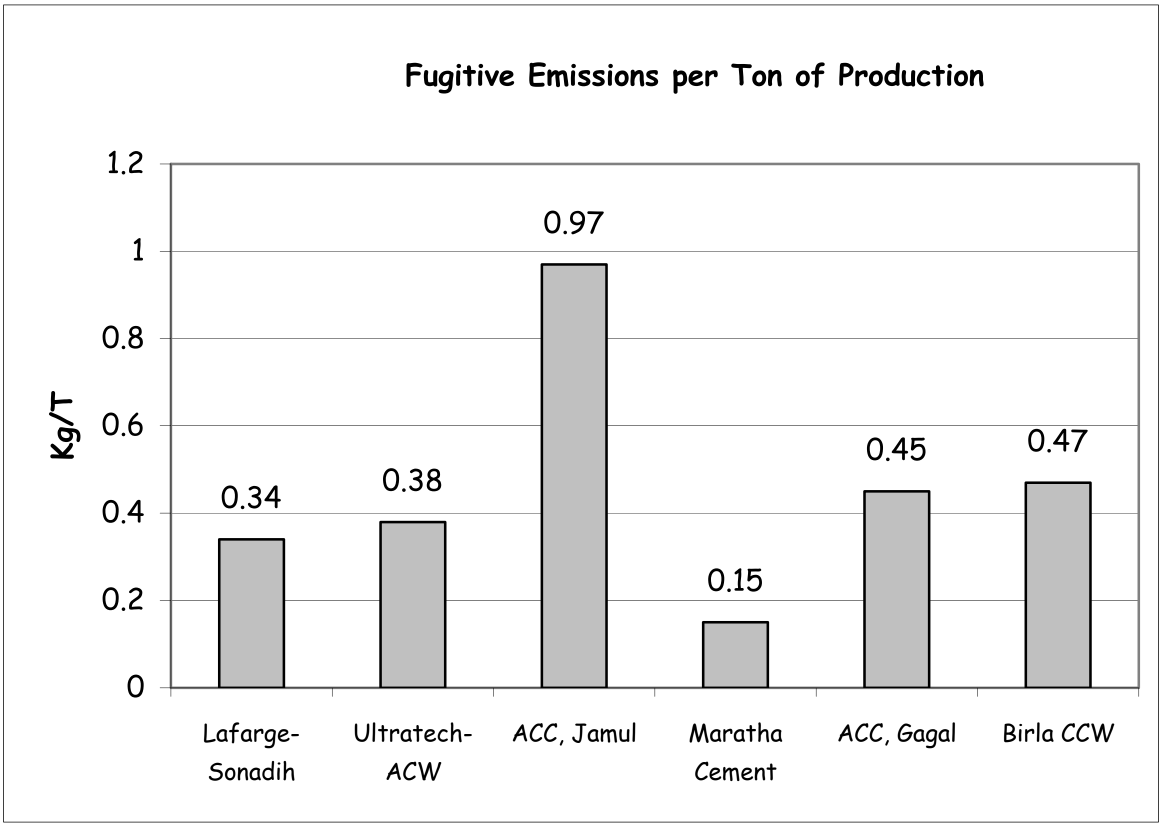


Figure 6.6 shows the fugitive emissions from all 6 cement plants in terms of kg per ton of production capacity; the following points are noteworthy of this analysis:

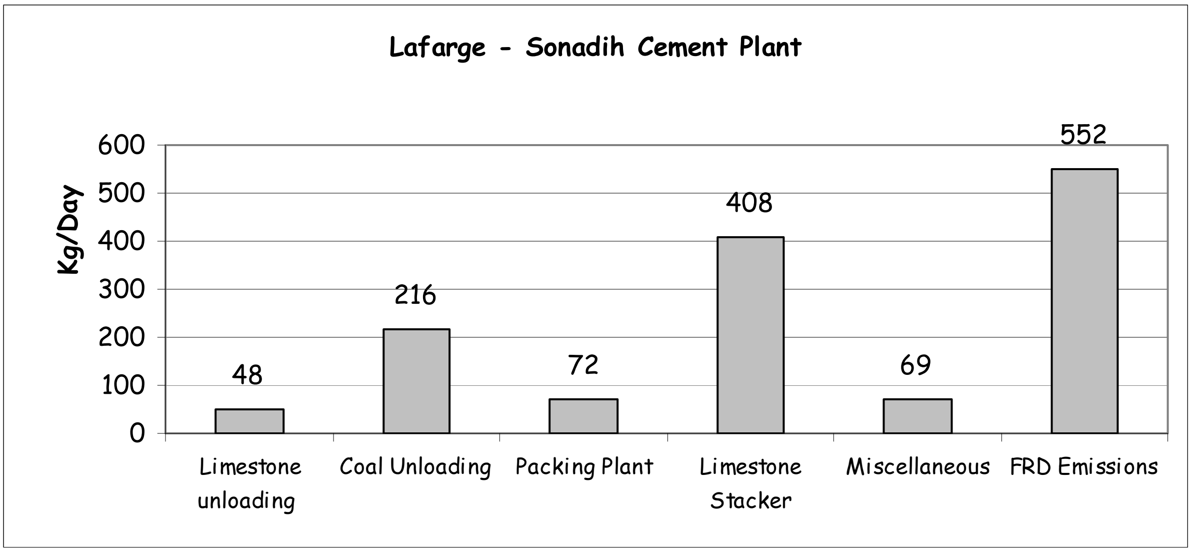
- The fugitive emissions from all the plants per ton of their production capacity range from 0.15 Kg/Ton – 0.97 Kg/Ton.
- The highest fugitive emission per ton of production is observed at ACC Jamul due to higher overall fugitive emissions and lower capacity. In addition, the old technology used in raw material handling (Gantry Operations) results in higher emission.
- The new cement plant (MCW) showed lower fugitive emission per ton of production (0.15 Kg/T).

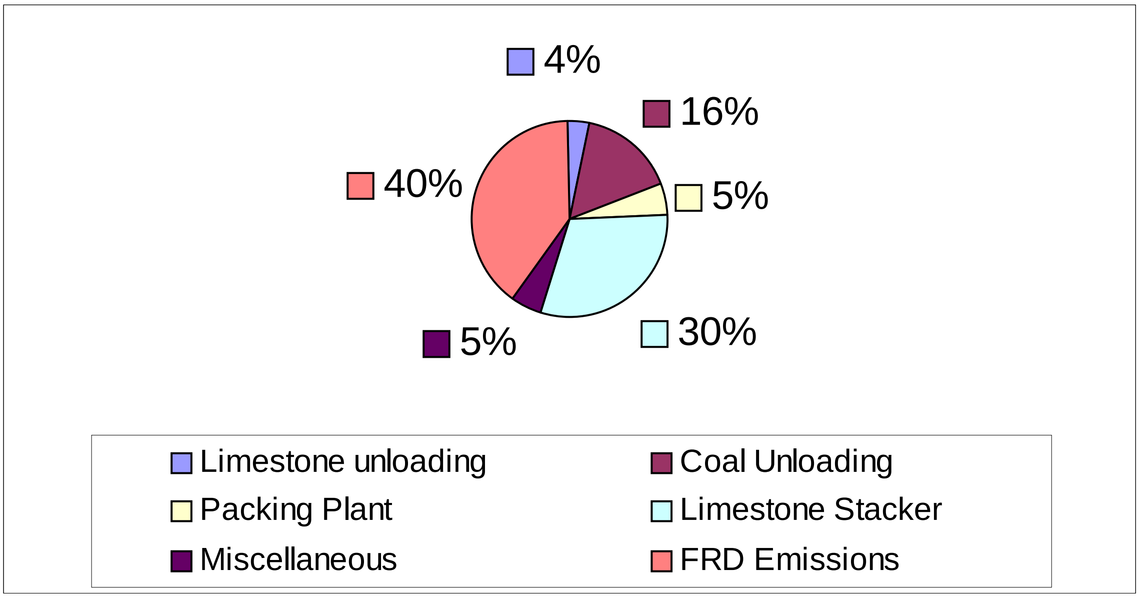
6.5 Plant wise emissions

The estimated emissions from six cement plants are shown in Figures 6.7 through 6.12.

6.5.1 Lafarge – Sonadih Cement Plant

Figure 6.7 : Fugitive Emissions from Lafarge – Sonadih Cement Plant





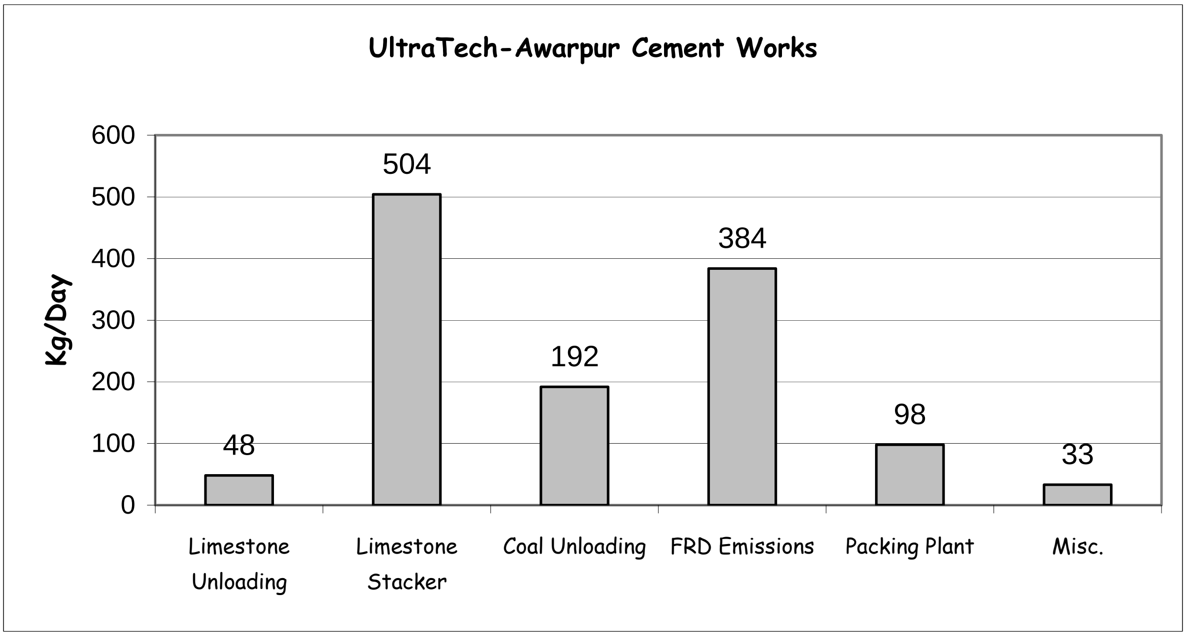
The following inferences can be drawn from the above charts

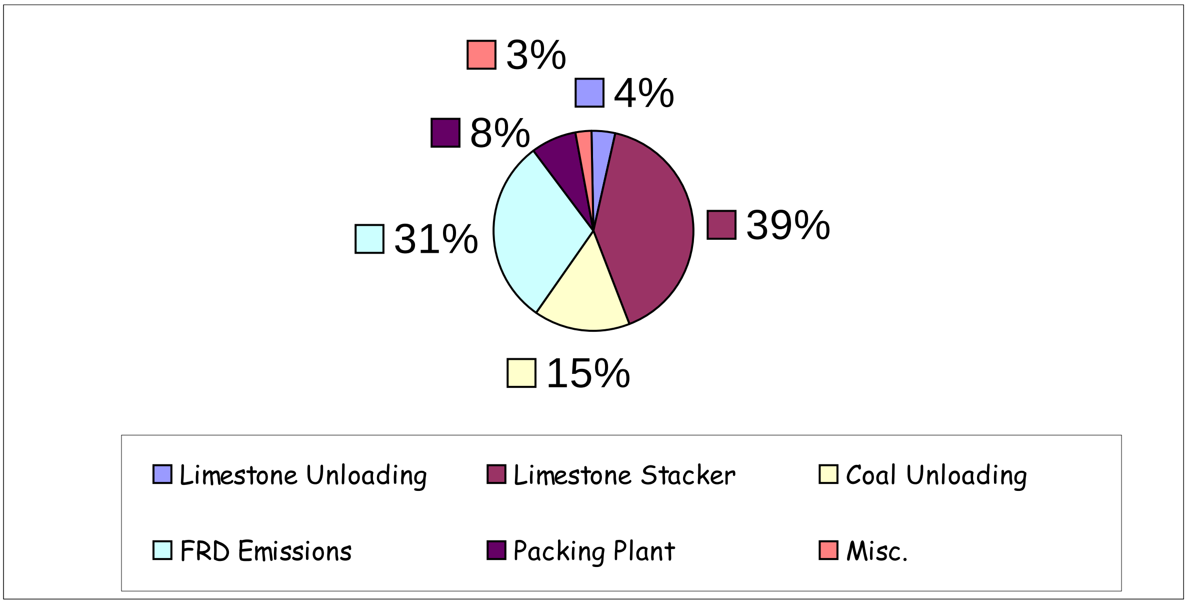
- Fugitive road dust emission account for about 40% of all the other sources followed by limestone stacker contributing 30%.
- The lowest contributions were observed from the limestone unloading operation, miscellaneous sources and packing plant.
- The reasons for higher contribution from the fugitive road dust emission could be attributed to higher silt load observed from coal service road due to wind carryover of dust from open stock piles.

(Miscellaneous Sources include Coal Stock pile, Gypsum, Sand, Iron-ore, clinker)

6.5.2 UltraTech – Awarpur Cement Works

Figure 6.8: Fugitive Emissions from UltraTech – Awarpur Cement Works





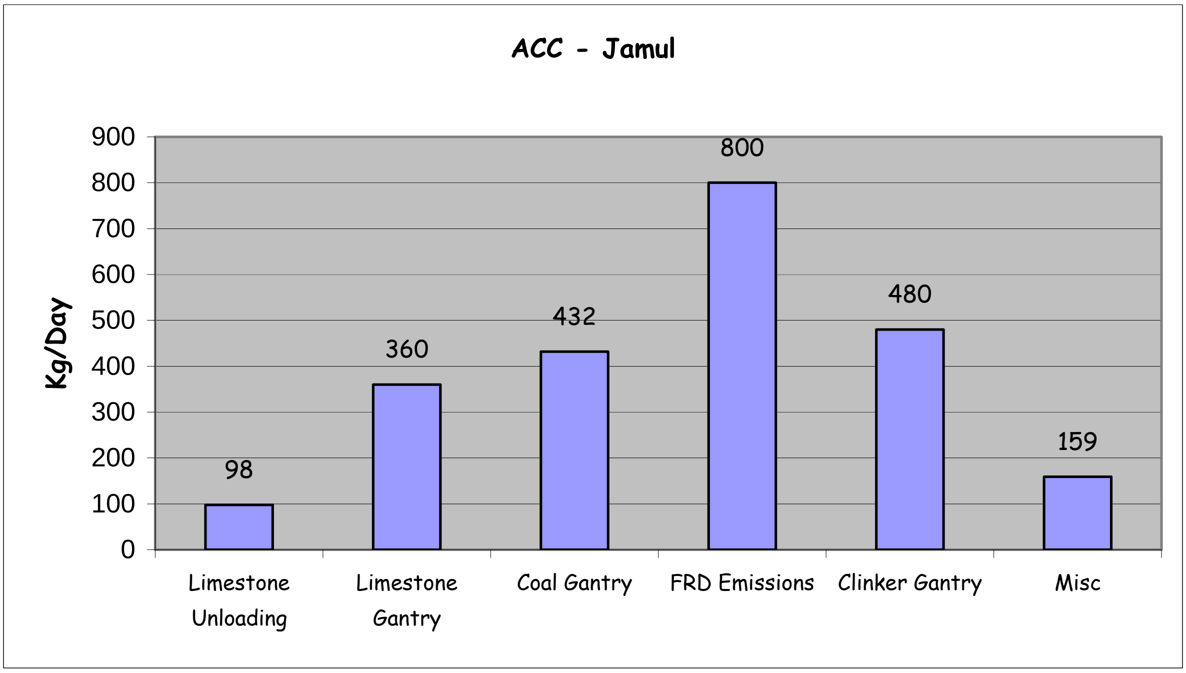
The following inferences can be drawn from the above charts

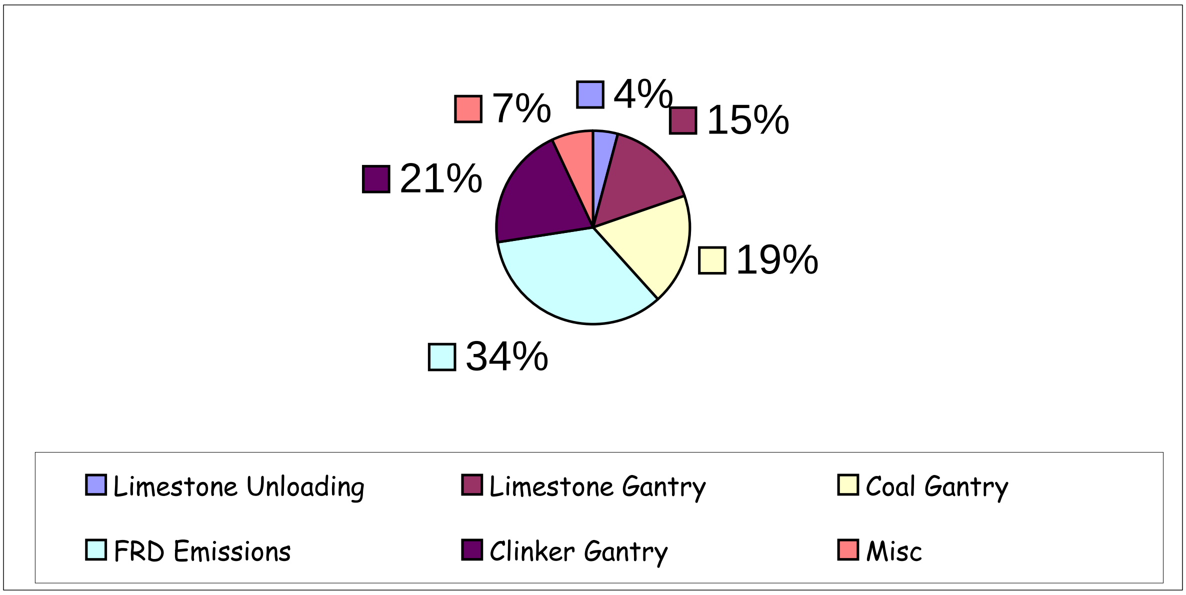
- The maximum emission was observed from limestone stacker and reclaimer, accounting for nearly 39% of all the other sources followed by fugitive road dust emission contributing 31% to total emission.
- The lowest contributions were observed from the miscellaneous sources and limestone unloading (3 to 4%).
- The reasons for higher contribution from the limestone stacker and reclaimer and road dust emission could be attributed to the large circular area (diameter 120 m) and significant leakage of fine dust emissions from the covered shed.

(Miscellaneous sources includes open stock pile of coal, Gypsum, Shale, Clinker, Coal crushing & gypsum unloading)

6.5.3 ACC - Jamul

Figure 6.9: Fugitive Emissions from ACC – Jamul Cement Works





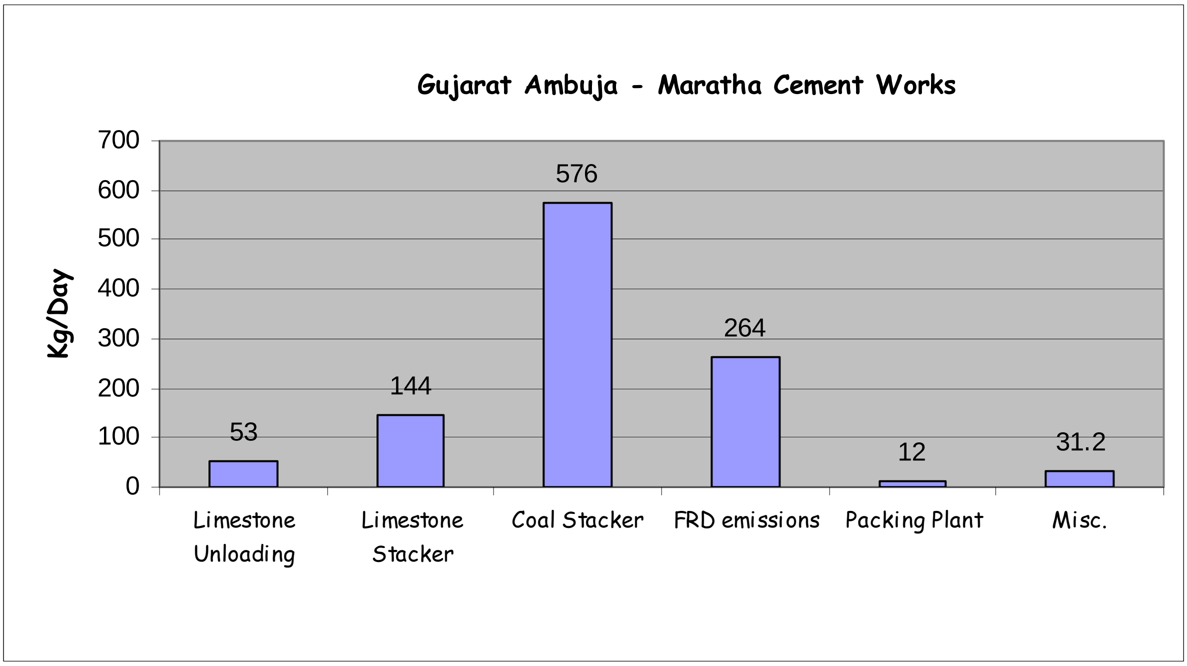
The following inferences can be drawn from the above charts, which are indicated below.

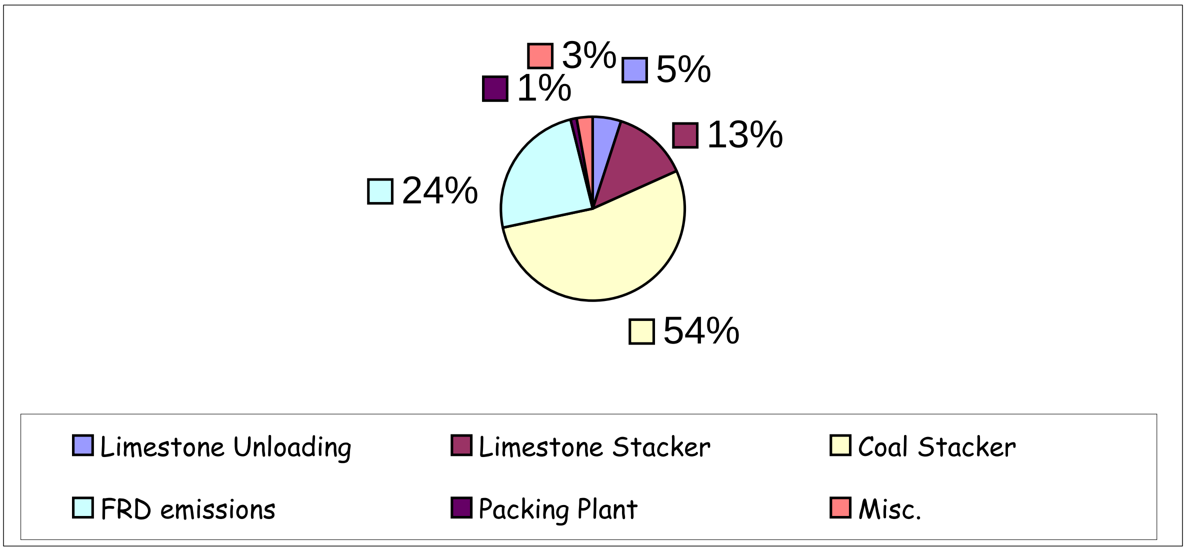
- The maximum emission was observed from road dust emission, accounting for 34% of all the other sources followed by fugitive emission from clinker gantry emission contributing 21%.
- The lowest contribution was observed from the limestone unloading, and miscellaneous sources 4 to 7%.

(Miscellaneous sources includes Packing plant, open stock piles from coal, Gypsum, Slag)

6.5.4 Gujarat Ambuja – Maratha Cement Works

Figure 6.10: Fugitive Emissions from Gujarat Ambuja – Maratha Cement Works





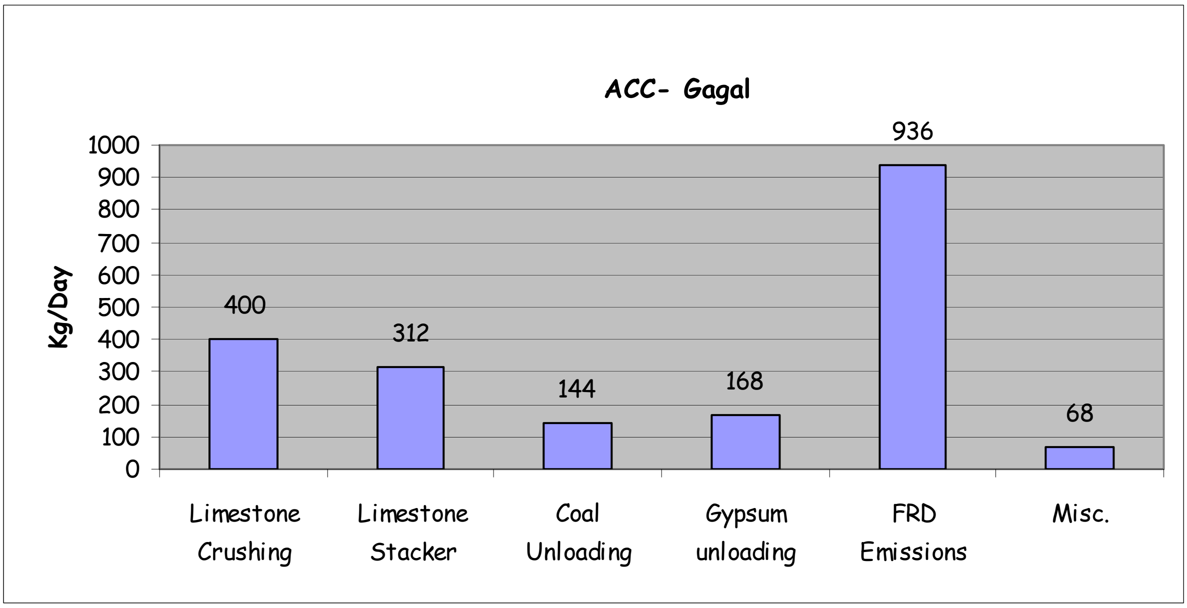
The following inferences can be drawn from the above charts.

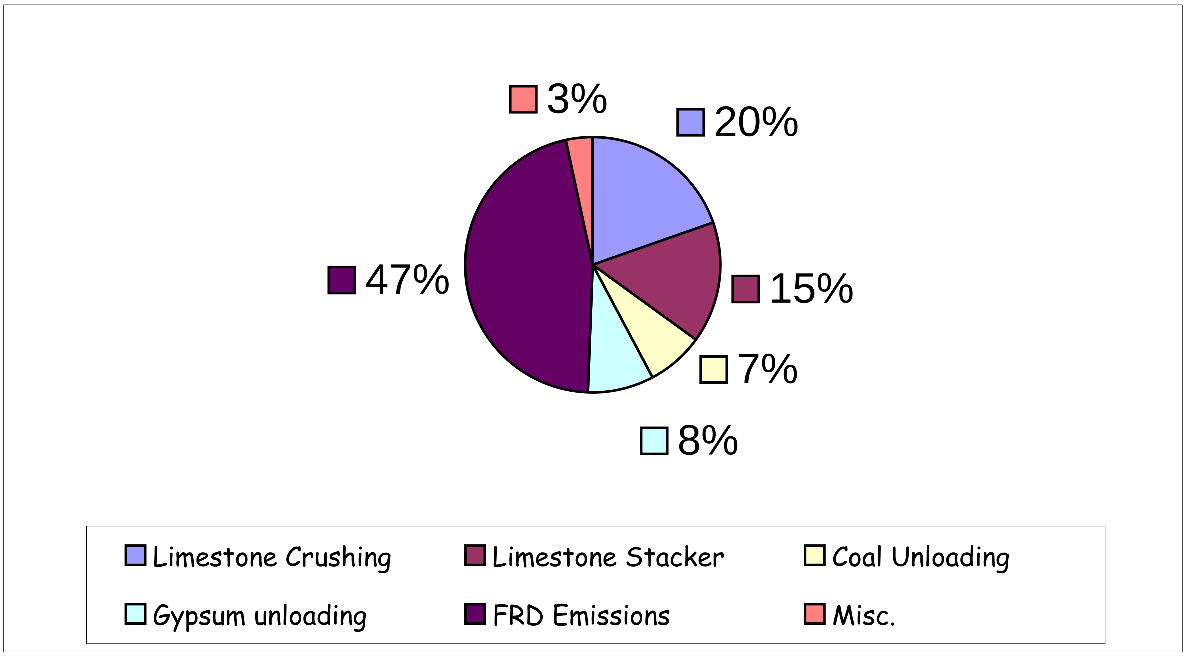
- The maximum emission was observed from Coal Stacker accounting for 54% of total emission followed by road dust emission contributing 24%.
- The lowest contributions were observed from the packing plant, miscellaneous sources and limestone unloading operations in the range 1 to 5%.
- The reasons for higher contribution from the coal stacker could be attributed to the self-ignition of coal particles during stacking operation. Also the fine particles generated from crushing may get airborne during conveying operation.

(Miscellaneous sources include Gypsum, blue dust, Coal unloading and partially covered storages of gypsum, blue dust and coal open yard)

6.5.5 ACC – Gagal Cement Works

Figure 6.11: Fugitive Emissions from ACC –Gagal Cement Works





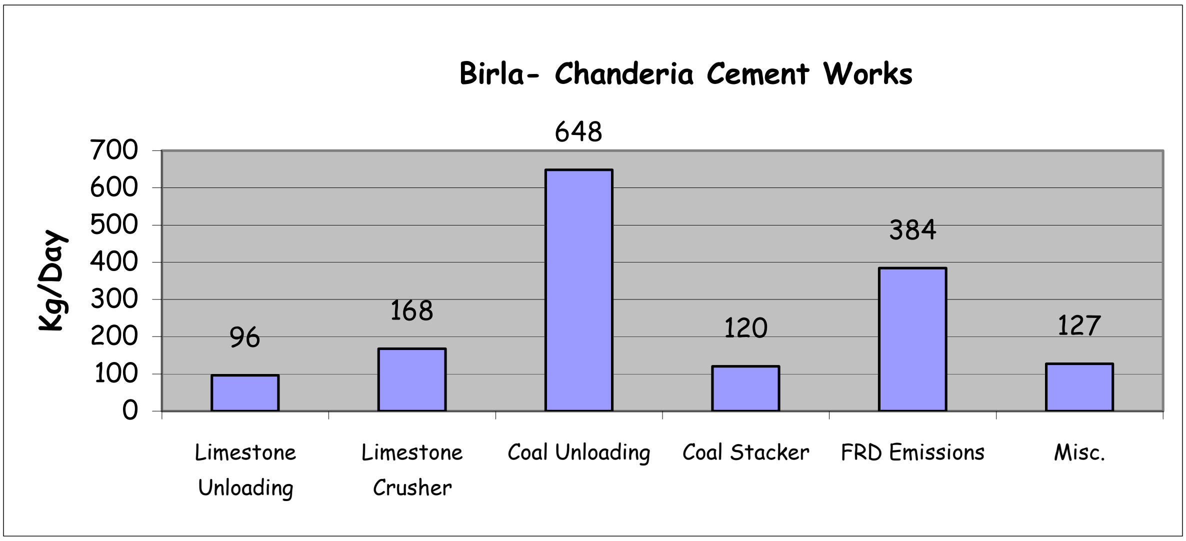
The following inferences can be drawn from the above charts.

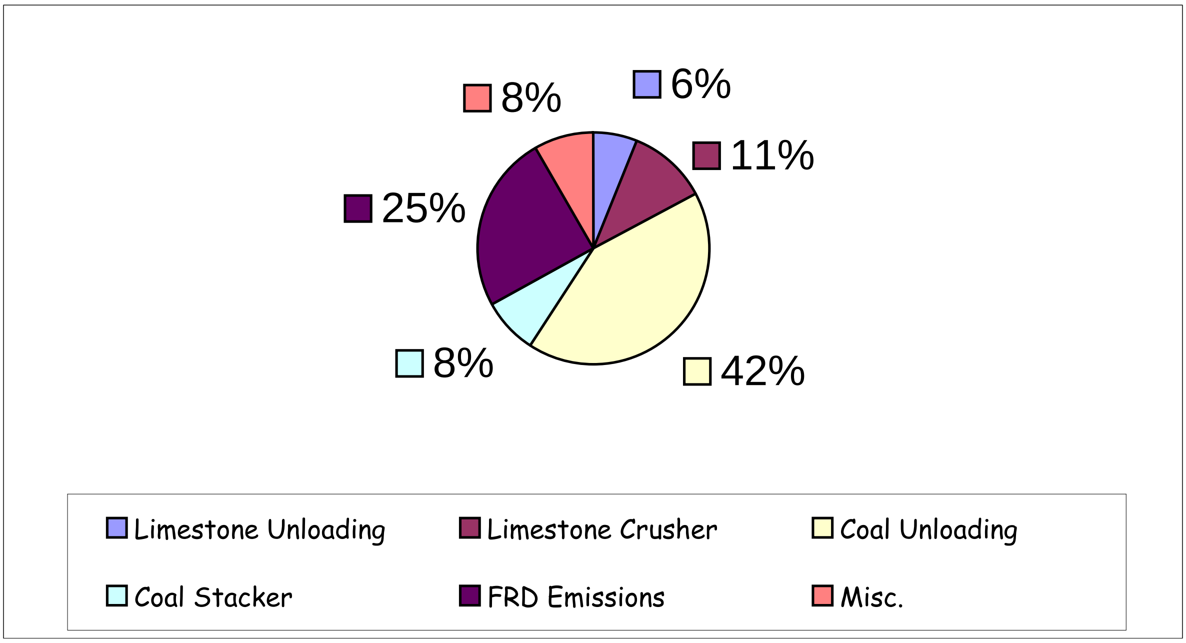
- The maximum percentage was observed from Fugitive road dust emission accounting for 47%
- The lowest contributions were observed from the miscellaneous sources, coal unloading and gypsum unloading operations, which ranges from 3 to 8%.
- The road dust emission is higher due to the movement of large number of vehicles from the main gate and re suspension of the settled dust.

(Miscellaneous sources includes stockpiles of Quartzite, Gypsum, Coal, Fly Ash, Clinker and Packing Plant, Limestone unloading)

6.5.6 Birla – Chanderia Cement Works

Figure 6.12: Fugitive Emissions from Birla – Chanderia Cement Works





The following inferences can be drawn from the above charts, which are indicated below.

- The maximum emission was observed from coal unloading accounting for 42% of all the other sources followed by road emissions 25%.

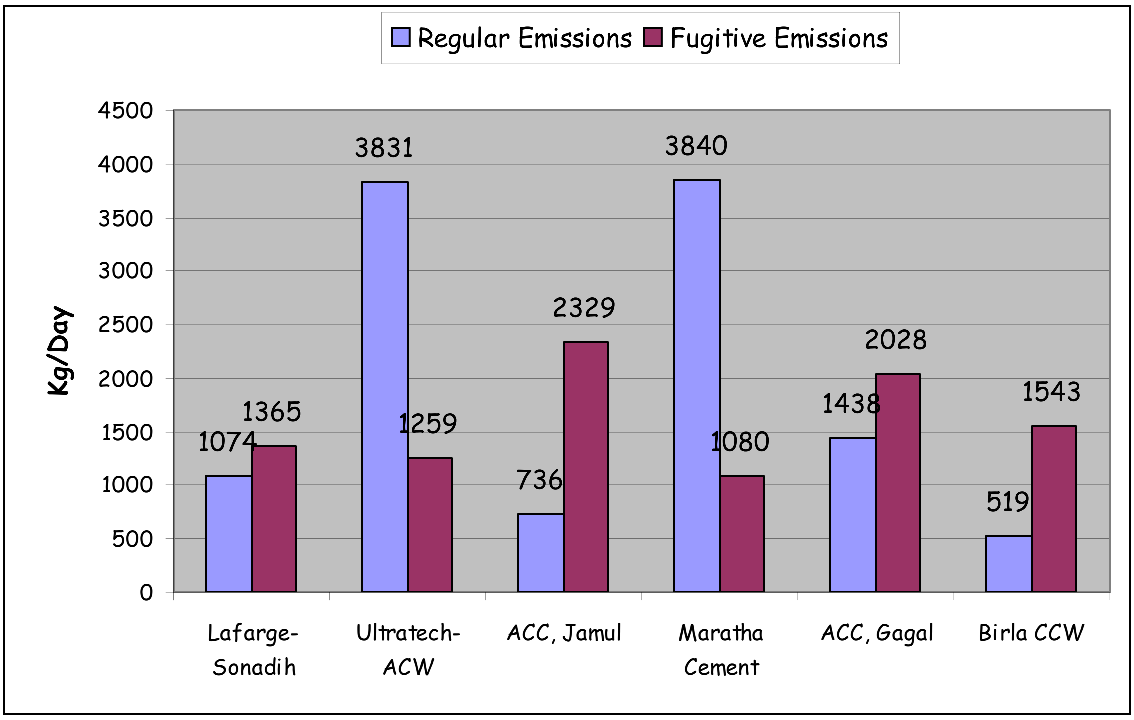
- The lowest emissions were observed from the limestone unloading, coal stacker and miscellaneous sources, which range from 6 to 8%.

(Miscellaneous sources includes Limestone stacking, Stock piles of coal, Laterite, Gypsum, Fly Ash, Clinker and Belt conveyor Transfer point of packing plant, Packing section)

6.6 Comparison of Fugitive and Regular emissions from various plants

Figure-6.13 shows comparison of fugitive and regular(stack) emissions from various cement plants.

Figure-6.13: Comparison of Fugitive and Regular Emissions from six Plants



The following inferences can be drawn from the above charts, which are indicated below.

- The fugitive emission is a significant source of pollution in all the plants, as at most of the plant, fugitive emission is either higher or comparable with regular emissions. In cement plants such as Lafarge, ACC Gagal, Birla CCW and ACC Jamul the fugitive emissions are higher than the regular emissions.

Figure-6.14: Ratio of Fugitive to Regular Emissions

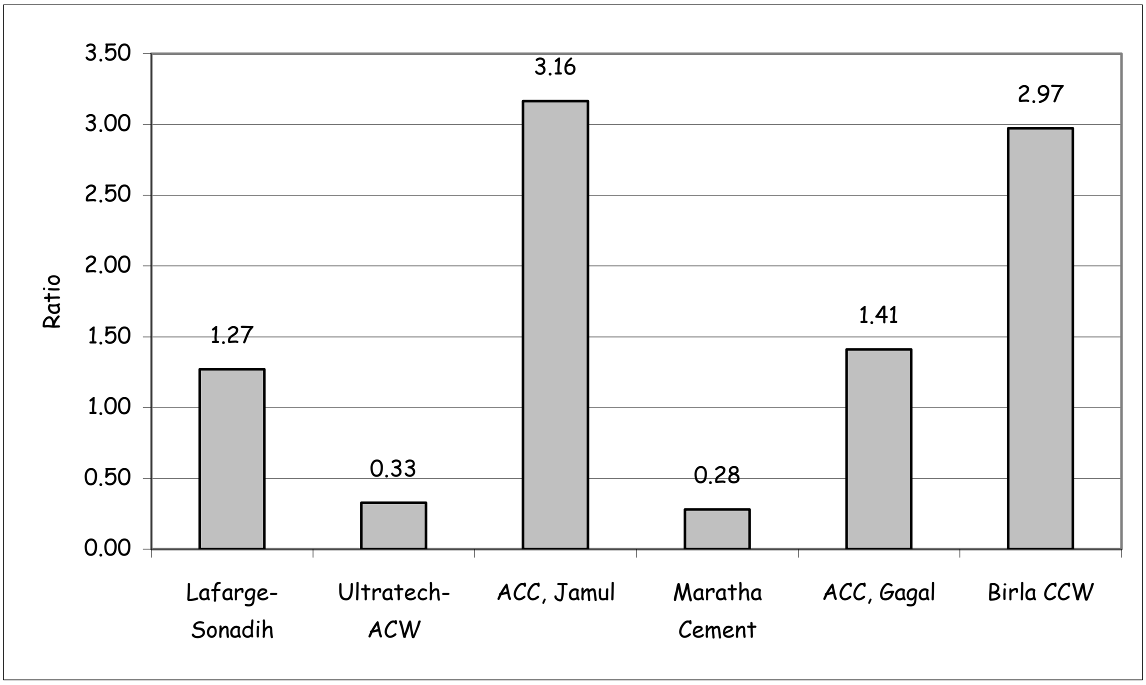


Figure 6.14 shows the ratio of fugitive to the regular emissions. The following inferences can be drawn from this figure:

- The ratio of Fugitive emissions to the regular emissions is lower in Maratha Cement, UltraTech ACW.

- Lafarge and ACC Gagal are fall in the ratio of 1.27 to 1.41.Other plants such as ACC Jamul and Birla CCW are in the ratio of 2.97 to 3.16

The ratio of Fugitive emission to total regular emission indicates that, in majority of cases, the fugitive emission contribution is much higher than the total regular emission.

6.7 Metal Analysis and Interpretation

Estimation of Metals in Air Sample and Nature of Sources

After particulate collection, chemical speciation is the next step in air quality assessment. For this purpose Ca, Mg, Ba, Cr, Pb, Fe, Ni, Al, and Na were analyzed in PM_{10}. The extraction and analysis of heavy metals was carried out as per the USEPA Method IO-3.2 (USEPA, 1999). As per the method, PM_{10} samples collected on glass fiber filters may be digested either by hot acid digestion or by microwave assisted digestion system (USEPA, 1999). The reference suggests microwave digestion process. One-fourth portion of the filter papers were digested using 15 ml hydrochloric and nitric acid mixture (3:1) by laboratory microwave digestion system (Ethos, Milestone, Italy) for 23 minutes at about 180^{o}C. The digested sample was filtered, made up to the required volume and stored in plastic bottles.

All heavy metals were analyzed on Atomic Absorption Spectrophotometer (AAS) (GBC Avanta ∑, Australia). Before analyzing the samples, instrument was calibrated. As per the USEPA method stock solution (of 1000 ppm) were prepared and diluted to the range of working standards for individual metal. The calibration graphs were prepared using these working standards in the linear range of the optical density (0.04 to 0.8). The instrument was calibrated at three different levels for each metal.

Table 6.1 presents the typical fraction of metals from emissions of a typical Cement plant. As seen, about 88 percent of metal is the calcium followed by iron, aluminum and magnesium. Lead and chromium has also been reported in the emitted dust from cement plant.

Table 6.1: Fractions of Metals in Cement Emissions (Derived from USEPA emission factor, AP 42)

S. No.	Metal	Fraction
1	Al	0.048
2	Ba	0.0013
3	Ca	0.88
4	Fe	0.0627
5	Pb	0.0026
6	Cr	0.00003
7.	Mg	0.02

Table 6.2 presents metal levels in the air particulate in a round ACC Jamul. Table 6.3 shows the fraction of metal in the dust (of metals those were analyzed) at ACC Jamul.

The metal data can be analyzed in a relative sense with respect to Table 6.1. The calcium fraction (0.55 to 0.7) is less than what is typical in the cement dust (0.88). It suggests that when it comes to the ambient air, although a larger fraction is from the cement plant (clinker dust) emissions but other sources also contribute significantly. However, fraction of magnesium is higher; this should indicate contribution of dolomite dust in the ambient air. In addition to magnesium fraction of iron is also high compared to typical fraction in the cement dust Pyrite or sea shells (if used) can also contribute to particulate pollution. It may be noted that Cr fraction in the particulate matter is same as found in the cement dust.

Metal emissions and their fraction from Lafarge Sonadih Cement Plant are presented in Tables 6.4 and Table 6.5. Similar to ACC Jamul, in ambient air fraction of Ca is less than typically in the cement dust. However fraction in terms of Ba and Fe are comparable to the fraction that is in cement dust. This also suggests that in ambient air the pollution is just not from cement kilns or raw material handling there are other sources, which may be soil origin or road dust and other raw material that do not content calcium.

Metal emissions and their fraction from Gujarat Ambuja Maratha Cement Works are presented in Tables 6.6 and Tables 6.7.

Similar to Lafarge Cement and ACC Jamul, ambient air fraction of Ca is less than that typically found in the cement dust. But it needs to be noted that the reduction in Ca is much higher (fraction: 0.08 – 0.52 which is much less than typical value of 0.88). This suggests that contribution of cement manufacturing related and other sources are equally important. This has also been shown in the estimation of fugitive emissions from Maratha Cement, which is the least compared to all other plants. Magnesium fraction is higher at the same time, which needs some explanation. Possibly, high magnesium content could be due to dolomite or the Mg levels may be high in the soil and that may contribute to particulate pollution in the ambient air.

Metal emissions and their fraction from Ultra Tech Awarpur Cement Works are presented in Tables 6.8 and Table 6.9.

At some locations Ca is close to what is source of limestone. But as one goes away from the plant, the fraction of Ca drops indicating that other sources contribute significantly. Magnesium fraction is higher at the same time, which needs some explanation. Possibly, high magnesium content could be due to dolomite or the Mg levels may be high in the soil.

CHAPTER 7.0

Analysis for Appropriateness of Prevalent Fugitive Emission Control Systems

7.1 Analysis of Prevalent FEMS for Various Fugitive Sources:

Cement plants follow various methods/systems to control fugitive dust emissions. This chapter analyzes each system for its appropriateness, suitability, operation and maintenance aspects etc and also identifies problem areas requiring improvements.

i) Lime Stone Unloading Operation

Most units have provided enclosures with a roof and flexible belt curtains for the 3 feeding sides. The quantity of water sprayed for suppressing dust is in the range of 4 to 9 lit/ton of material (0.4 to 0.9%), which is very much on a higher side, which at times leads to choking/jamming of apron feeder, crusher conveyor belt etc. As per past experience in stone crushing sector for design and demonstration of dust suppression systems, the optimum water quantity that needs to be spread at unloading section for suppressing emissions is in the range of 0.2 – 0.3% of feed material.

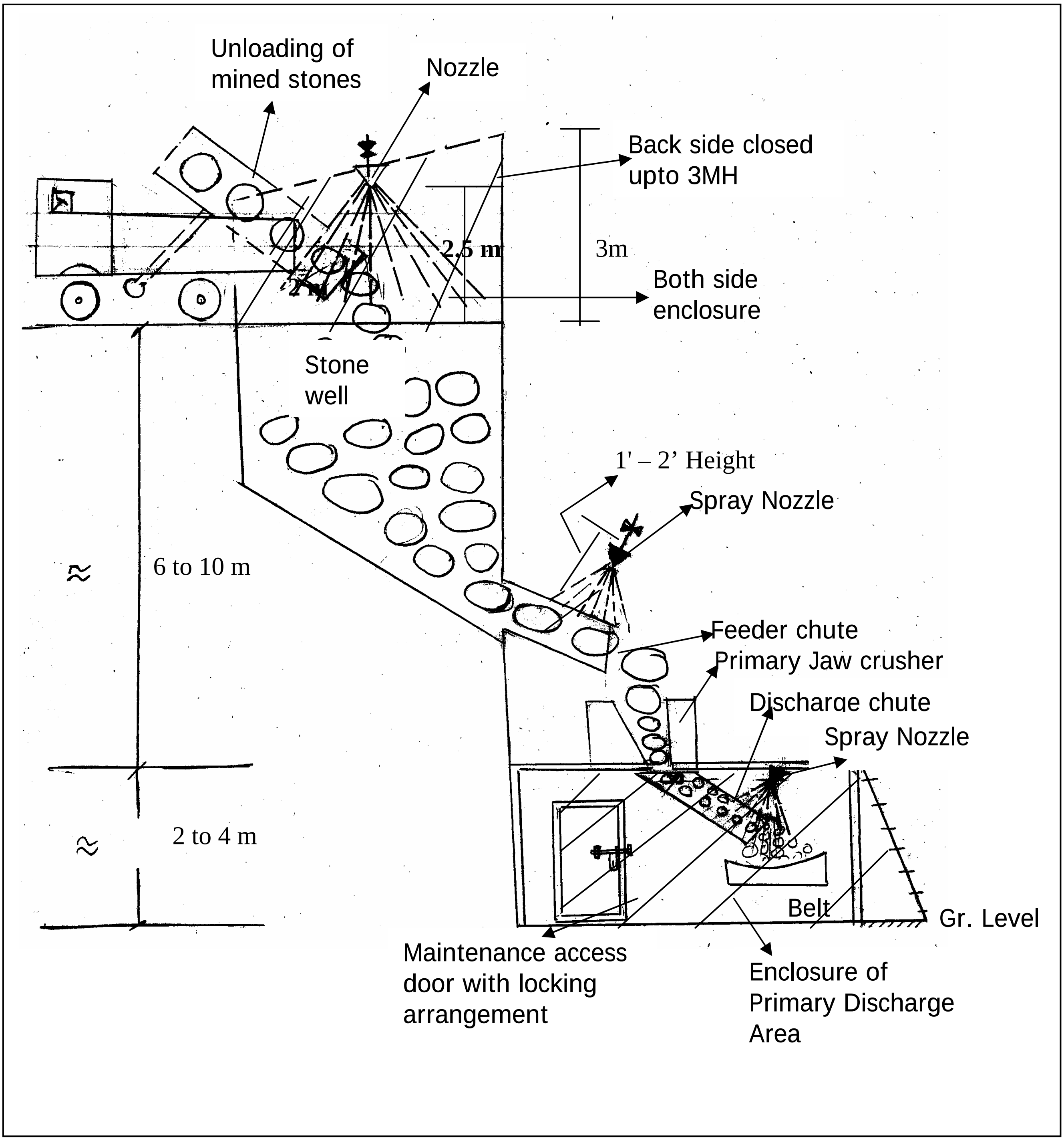
Effective dust suppression with optimum (minimum possible) water quantity could be achieved by selecting appropriate nozzles, proper spray locations covering area of emission, suppressing emissions right at source as much as possible, eliminating chocking of nozzles by using on-line micro filters etc. Ideally the spray should be located at unloading area, the chute/apron feeder feeding material to crusher and the discharge of the crusher where crushed material fall on the belt conveyor.; A schematic showing the dust spray locations is given at Figure 7.1. It has been reported by most cement industries that there is frequent choking of nozzles thereby affecting shape and particle size of sprays resulting in inadequate suppression or excessive water consumption. Also, many a times there is a problem of jamming of apron feeder, primarily due to excessive water.

ii) Lime Stone Crushing Operation

Typically the extraction of dust is done from 4 to 6 locations like top and side of the enclosure, apron feeder, discharge belt conveyor, re entry location of the collected fines etc. In many cases, the duct connections/branching are not scientifically designed like varying duct diameters with respect to flow quantity and velocity and hence flow distribution may not be uniform. The location of extraction also varies widely and even some connections are added at a later stage inappropriately as an after thought, which adversely affect the extraction efficiency.

FIGURE NO. 7.1

Water Spray Locations at unloading & Crushing Points



iii) Lime Stone Transfer Point

The effectiveness of the dust extraction arrangement and the transfer points directly depends on the appropriateness of the containment enclosure provided for the transfer point. Generally good enclosure are provided from ground level to top of the belt conveyor housed in an enclosure called transfer tower, leaving minimum openings for the belt to pass. However, there are substantial spillages of material during transfer/free fall, which spread inside the transfer tower at various levels. After clean up the openings of enclosure is left open and this adversely affects the effectiveness of the dust extraction and results into fugitive emissions from the transfer point.

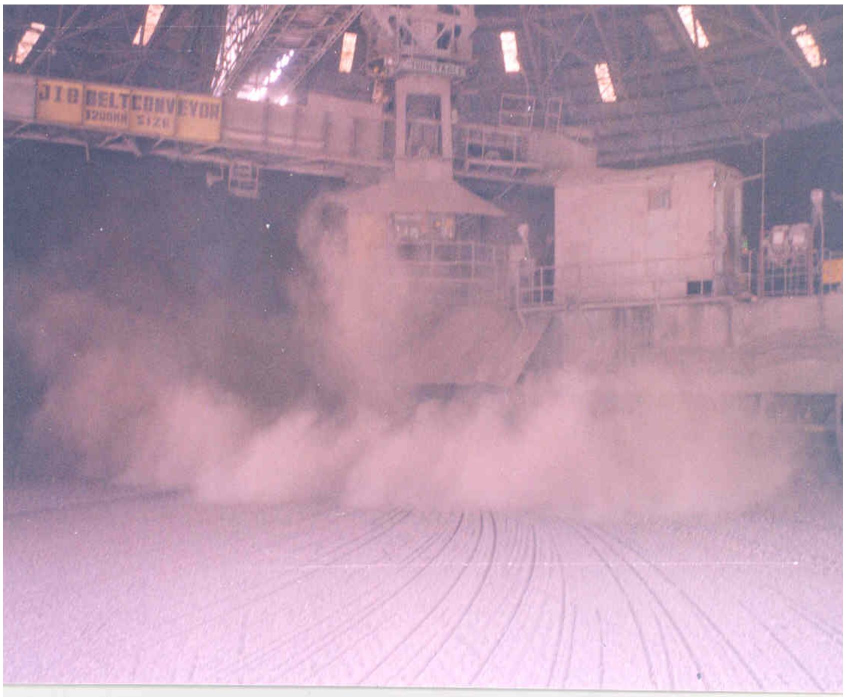
In some units, a combination of water spray as well as dust extraction cum bag filter is practiced. In some of these cases there could be possibility of sucking water droplets along with dust to the bag filter, which may lead to sticking of deposits on the filter cloth, which eventually solidifies and cannot be dislodged by pulse cleaning. This results in malfunctioning of the bag filter and leads to ineffective dust extraction and hence fugitive emissions occur.

iv) Lime stone Stacker and Reclaimer

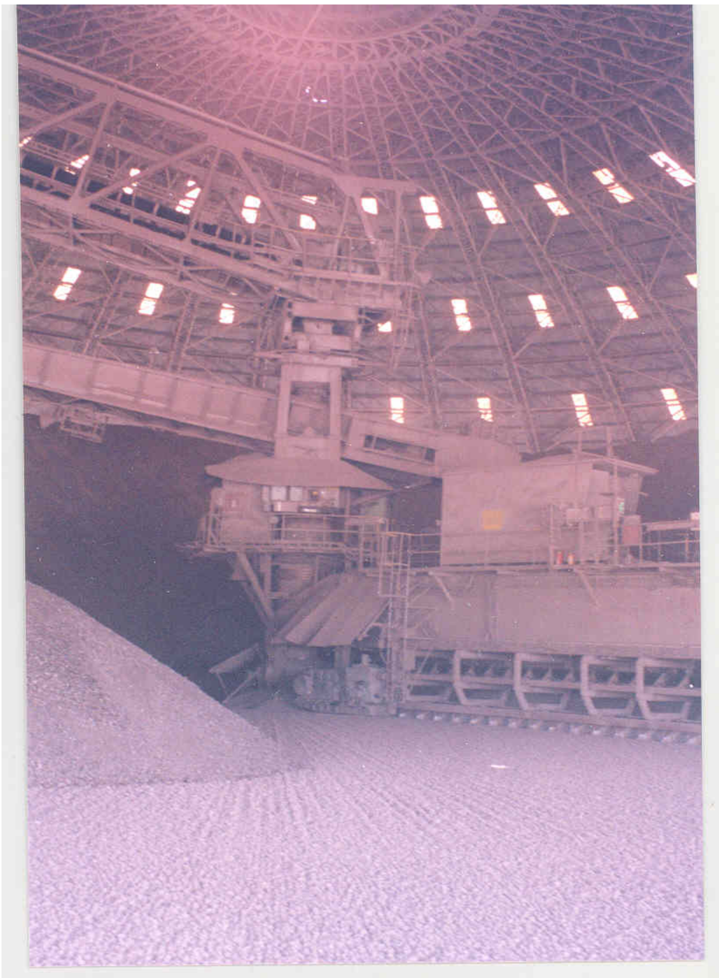
Generation of fugitive emissions depends on the type of stacking equipment used, moisture content in the material, rate of stacking, content of fines etc. As regards to quantity of water sprayed there is hardly any record or any measured data available with most cement plants. The system is operated as supplied by the supplier. There is no procedure/system to regulate the water flow rate as per the requirement, which is especially essential during various seasons and climatic conditions.

A comparison of lime stacking operation with and without water spraying is shown below at photo 7.1 (a) and (b), to provide a general understanding of how spraying water is important and how substantial the fugitive emissions could be, if water is not sprayed.

Typical photograph 7.1 (a) shows the emission during limestone stacker operation without water spraying



Typical photograph 7.1 (b) shows the limestone stacker operation with water spraying

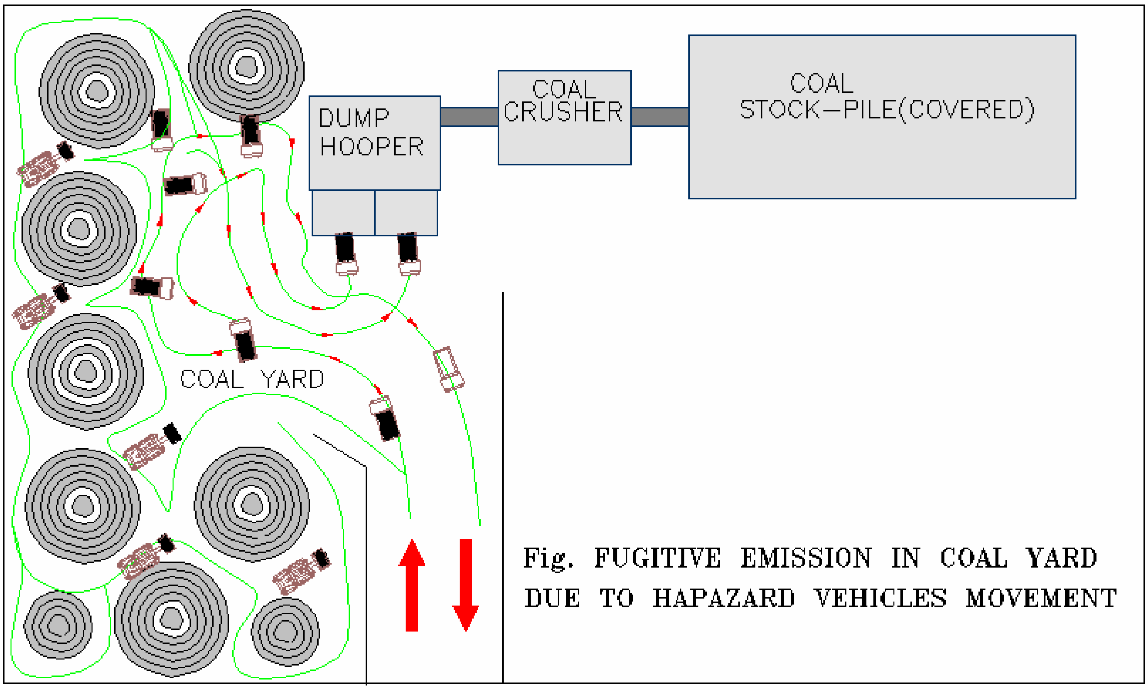


v) Emissions from open coal yards

Emission from coal yard related operations vary from plant to plant and time to time. This is due to unbalance in rate of receival of coal at site from market, the retrieval and unloading operation from the coal yard.

Typical set up of a coal yard with haphazard arrangement of open coal stockpiles and movement of dumpers is shown schematically at Figure.7.2.

Fig 7.2 Fugitive emission in coal yard due to haphazard movement of vehicles



Irrespective of the well-known fact and uncertainties in the coal procurement, most cement plants have only limited closed storages against the factual requirement of stocking extra coal to take care of the risks. Almost all cement plants do stock vast quantity of coal in open areas as "normal practice" and not as emergency short-term measure.

In the absence of (or rather possibility of having) a proper "dust prevention or suppression system", the fugitive emissions from coal yard may not be reduced satisfactorily at any given time even in future.

The "Coal yards" have been found to be one of the most "problematic areas" in almost all cement plants from "fugitive emission point of view". Due to limitations in "stacking height of heaps" in view of "self ignition of coal", and in view of the necessity to store additional/sufficient quantity of coal at site to take care of situations such as “non availability of coal or transport network” leading to stoppages of kiln (loss of production), large quantity of coal is stored in open in almost all cement plants.

The fines associated with the mixed coal (and generated additionally due to material handling operations) get airborne during unloading/loading operations and due to vehicle movements in the coal yard. These emissions eventually “get settled” in the vicinity on the nearby ground. Whenever a truck/dumper passes on these dusty roads, the dusts gets airborne, remain suspended in atmosphere for substantial time and eventually settles on ground. Next time again when another truck moves, the dust gets airborne again and the process keeps repeating again and again.

There is hardly any systematic effort to “extract” or “periodically remove/clean/sweep away” this coal dust in the yard area. As a result, at any given time, the ground area, road area is always full of (knee deep type) coal dust which keeps on accumulating endlessly and keeps on getting airborne “several times every day”. This leads to “substantial air pollution by way of fugitive emission from the coal yard area, especially due to unplanned and zigzag movement of vehicles in the coal yard and is a major short coming in most cement plant and needs to be seriously looked into in view of eliminating fugitive emission. Almost no cement plant has a convincing “system” to eliminate/prevent fugitive emissions from the coal yard area.

vi) Coal Unloading Operation

The size and specification of dust suppression system varies widely from cement plant to plant in terms of number of spray locations, quantity of water sprayed, type of nozzles, spray pattern, size of water particles etc. The degree of effectiveness also varies widely. As regards to containment, most units do not have adequate containment. In the units having inadequate containment, the emissions during unloading are excessive. As the coal dust is only partly wettable (unlike limestone dust), it cannot be effectively suppressed with water spray as like in limestone. The coal dust floats on water on the floor creates muddy and blackish floor condition.

In view of the limitation in using water sprays effectively for coal dust, it necessitates installation of dry type control system for effective control of emissions.

vii) Clinker Transfer Point (Clinker cooler to Clinker Stock Piles)

The quantity of fines in the clinker varies widely from plant to plant and directly depends on the efficiency of clinkerisation. In kilns with lesser efficiency of clinkerisation more fines are formed and leads to more fugitive emissions. It is therefore fugitive emissions from clinker has direct relationship with efficiency of the kiln.

The fines extracted from the clinker during cooling are collected at clinker cooler ESP and the collected fines are recycled into the system at the redler conveyor transporting clinker to storage area. These fines have get air borne again and again at subsequent transfer points.

7.2 Analysis of Operation and Maintenance Aspects of APCD's

<u>7.2.1 Operation And Maintenance Of Dust Suppression Systems</u>

There is hardly any preventive maintenance strategy followed in any cement plant for maintaining the spray systems. As long as the system works, no preventive maintenance is carried out. It is only corrective maintenance action taken against complaints made by the concerned workman/section.

As regards to availability of basic information about the types of nozzles used, details of water pressure for obtaining proper spray, pipelines circuit diagram, pump details and its connections, specifications, operation and maintenance guidelines for appropriate operation of dust suppression system, day to day water consumption details, electricity consumption etc is generally not readily available with most of the units and neither there is any record kept.

<u>7.2.2 Operation And Maintenance Of Pulse Jet Bag Filter</u>

Most of the dry type control systems have pulse jet type bag filter as final control system. The compressed air required for creating pulses is provided through a centralized line of compressed air with one compressor serving several bag filters. At times the length of the compressed air branch lines are quite long from the header connections and there could be reduced pressure or moisture at the end point i.e., bag filter. This can cause ineffective pulsing thereby inadequate cleaning of dust deposits.

Sometimes the compressed air supply may even stop/reduce for sometime but the dust extraction goes on and the deposits keep building on the filter bags but with out pulse cleaning. This leads to high pressure drop across filter bags may be for some duration and subsequently can lead to tearing of some bags.

The moisture in the air from compressed line or the moisture in the extracted air may lead to deposits sticking to the filter bag cloth and does not get loosened during pulsing.

7.3 Causes of Generation of Fugitive Emissions from Process Sources (Even Though Dust Control Systems Exist)

In cement industries, there are many process sources/operations where dust could be emitted are provided with either “dust extraction cum bag filter type” or suppression type dust control systems. Should these systems operate “satisfactorily”, ideally, there would not be any fugitive emissions.
But still fugitive emissions do occur. It could be due to either of the following reasons:

i) Improper Design

Design of the dust control system is the most important aspect. The system should be so designed that the dust is controlled (captured or suppressed) as close to the source as possible, once it spreads it is difficult to control.

The origin of fugitive dust generation is generally a small area. As the dust rises, it spreads to a wider area, due to dispersion effect and due to wind movements. Dust generated from various areas and its spreading leads to a cumulative effect over much wider area and appears that emissions are from everywhere. A schematic showing spreading of fugitive emissions from various sources is shown at Figure7.4

Many a times, the “bag filter suppliers” have standard “modules” (e.g. single cell with 64 bags for 5000 m3/hr flow for 2 gr/m3 dust loading, etc). The supplier supplies his standard modules (may be single or double size etc.) in multiples as per requirement. Though the “Bag filter” is a standard and proven item, extraction hoods and its right locations cannot be standardized, as it is size dependent and many systems, have improper designs in terms of extraction locations and quantity of flow etc.

ii) Improper Operation and Maintenance

There is hardly any “Preventive maintenance” plan. As most bagfilters are controlled by “pressure indicators”, which can give “false” information in terms of its operation, the maintenance is generally not proper.

- <u>Limitation of “Static Pressure Indicator type control” for Bag filter Systems</u>

In most cement plants, the main production process is controlled/monitored through electronic signals fed to computer programmes and the controls could be regulated through computer-based panels.

For dust control systems like bag filters, the static pressure at outlets of pulsejet bag filters is generally sensed/displayed through indicators on the control panel. The bag filter system is considered to be working fine as long as the “pressure indicator” does not show red i.e. pressure exceeding the pre-set value (generally set at 150 to 200 mm WC). Only if the pressure indicates “higher than set value” (which could be the case if dust deposits keep building on the filter bags due to ineffective pulse cleaning), the indicator on the control panel may give a warning signal in “Red”, only then some corrective action may be taken.

But, should even one or two bags get torn or punctured, the “pressure” at bag filter outlet may “never” cross the set value, because most of the extracted air/dist would pass through the torn bags to the stack (as gases always follow least resistant path).

It is therefore, “Pressure indication” alone is not an effective and acceptable “control” for dust extraction-cum-pulse jet bag filter system and it does not ensure that the system is functioning without emissions and hence cannot be “relied upon”.

Most of the times, if pulse jet system does not operate properly even for a short durations (a few hours), the dust deposits on filter bags keep building up and also the pressure drop across the filter bags increases and the increased pressure drop coupled with moisture resulting in sticking of dust to filter bags, some filter bags may get torn/punctured. Once a bag or two are torn, the “Pressure indication” on control panel would never show it “Red” as the pressure would not build up and hence is a false control and cannot be relied upon, but is generally practiced.

- Maintenance Aspects of various Bag filter

The main process bag filters like raw mill bag filter, cement mill bag filter etc proper preventive maintenance is generally in place. The damaged bags are regularly identified and replace and the records are maintained for such replacements. However, for bag filter installed to control fugitive emissions, importance is hardly given in terms of timely replacement of damaged bags neither its record are found to be regularly maintained. These bag filters are generally given last priority in terms of maintenance.

- Under Utilization of Bag filters due to faulty O&M Practices

To analyse the "actual effectiveness of dust extraction and its filtration" against the "design specifications", some dust extraction-cum-bag filter systems were studied in detail. Measurements of "volume" extracted by the system were conducted at inlet of various bag filter systems; the values are given in the table below:

Table: Stack Monitoring Details at Inlet of Bag Filter Inlet from Various Fugitive Emission Sources

S.No.	**Source**	**Design Flow rate**	**Actual Measured Flow rate**	**% Utilization of capacity**
		M^3/hr	M^3/hr	
1.	Limestone crusher	27500	12000	44
2.	Limestone Transfer Point	23000	7000	30
3.	Coal dump hopper	7200	4650	65
4.	Coal Crusher	8500	2300	27
5.	Clinker Transfer point	11000	9600	87

The above table indicates that the most bag filters have lesser flow rat than the designed value, which could be primarily because of reasons like improper cleaning of bags leading to deposits on bags, improper duct design thereby higher pressure drop across bag house, reduced efficiency of driving mechanism of ID fan, damaged ID fan etc. As the priority is generally not given to these bag filters, most bag filters keep operating with reduced extraction volumes and thereby inadequate extraction of emissions resulting in fugitive emissions.

A sketch showing reduced extraction capacity due to building of dust deposits on filter bags is shown at Figure 7.3.

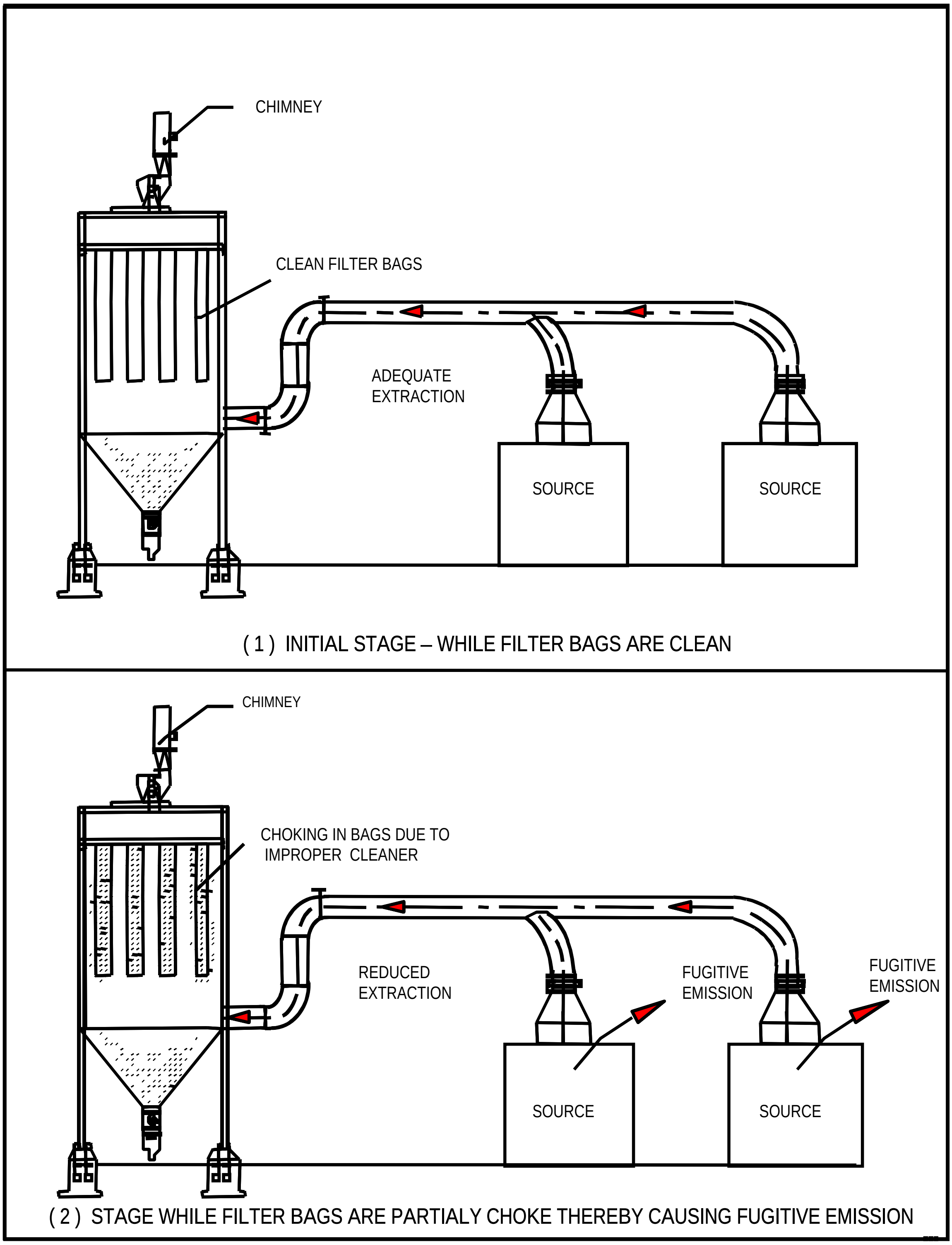
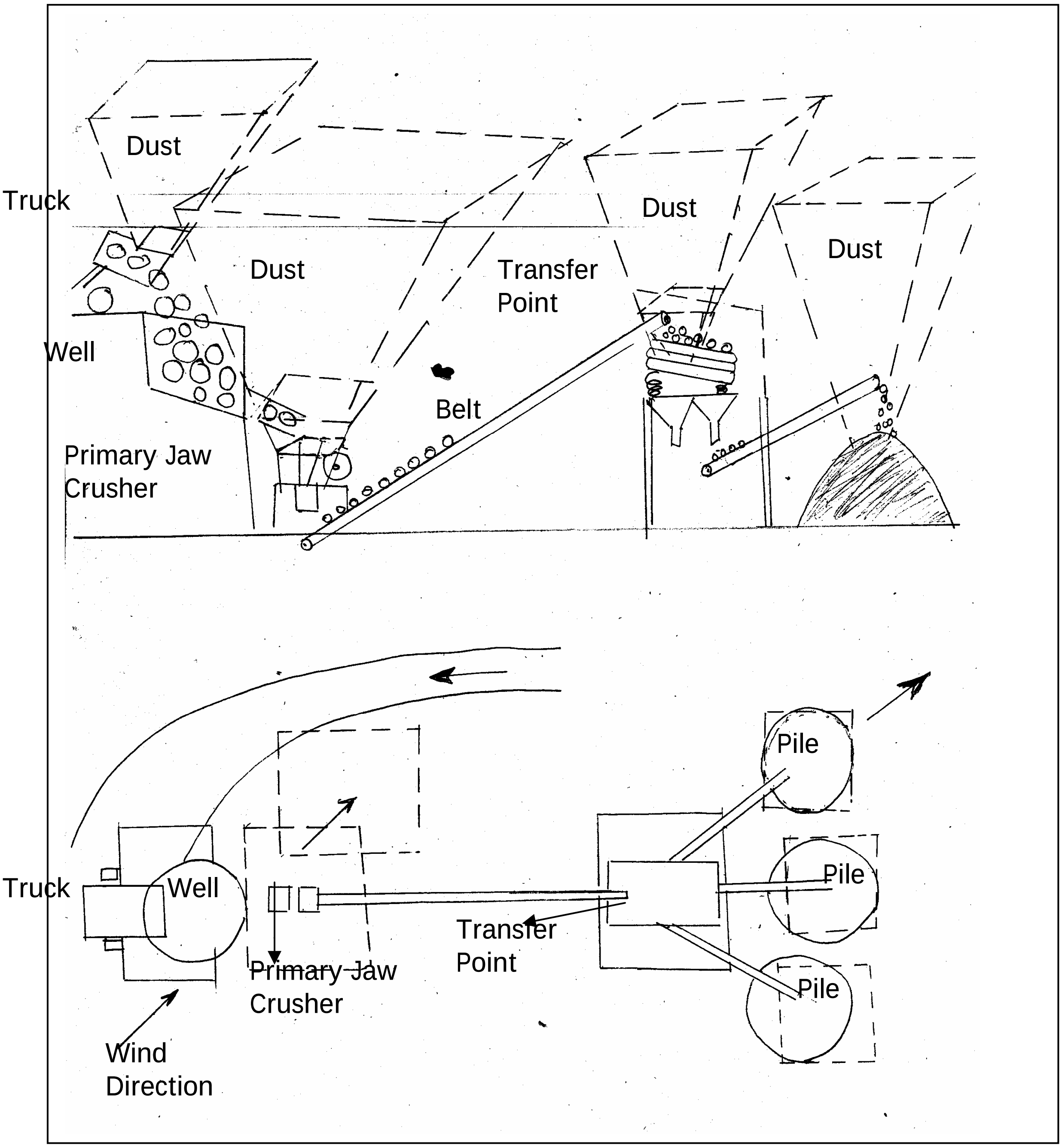


FIG. 7.3 REDUCED EXTRACTION CAPACITY OF BAG FILTER DUE TO BUILDUP OF DUST DEPOSITS

FIGURE NO. 7.4

SPREADING OF FUGITIVE DUST FROM VARIOUS SOURCES



iii) Re-entrainment of fines returned to system

In several sections/areas of cement plant, the fines/airborne dust is extracted and captured in high efficiency control systems like pulse jet type bagfilters, but the collected dust comprising largely the fines (< 10 microns, which get airborne), is “recycled” on the conveyor belts at an immediate downstream location.

This dust again gets airborne at the next point of free fall at the conveyor transfer point. It is again required to be extracted and captured, in addition to the “newer” fines generated, which means repetitive extraction and control of emissions. The ‘newer” fines means the “fresh” fines that may be generated due to “breaking” of lumps/bigger particles due to impact during “free fall” from a height at a transfer point. These “freshly” generated fines are “in addition” to the “carried forward” fines from previous/upstream sources. More the points of transfer/free fall, each time the emissions are likely to get airborne.
The measurements indicate that at many bagfilters, the actual extracted volume is much lesser than the design volume flow rate and hence the “suction” is inadequate to extract all dust emissions. Reduced extraction capacity leads to fugitive emissions.

7.4 Analysis of RSPM in Fugitive Emission

Several measurements were carried out using respirable type High Volume Samplers in various cement plants in various sections. Out of the total “SPM” monitored, the contribution of respirable particulate matter (RSPM) from various sources at various plants is given below:

Source	RSPM	SPM	TPM	RSPM %
Limestone unloading	1268	22523	23791	5
Limestone crusher	2403	9546	11949	20
Limestone stacker	364	439	803	45
Coal Unloading	23385	153053	176439	13
Coal Stacker	3186	43073	46259	7
Coal Reclaimer	7302	18465	25767	28
Gypsum unloading	8142	34030	42172	19
Laterite unloading	651	1518	2169	30
Packing Plant	1880	10269	12149	15

The above measured values of RSPM (PM10) indicates that in most of these sections, the percentage share of fines PM_{10} is substantial and hence are potential sources of fugitive emissions.

7.5 Problem areas in Prevalent FEMS

The observations and field studies of prevalent fugitive emission management systems in 6 cement plants revealed that there are several problem areas and some important issues that need to be addressed while evolving the guidelines/standards. The same are discussed below.

- Non-criticality of APCD's leading to system stoppages

As the APCD's (Bag Filters or dust suppression system) installed for controlling fugitive emissions could be stopped at any point of time without affecting the process. Unlike the main process stack APCD's, stopping which requires stoppage of processes but the same is not the case with APCD's installed for fugitive emission control. It is therefore; these APCD's are always given second priority, as it does not affect the process and production. In fact fugitive emissions have direct relation ship with stoppages of APCD's.

At times, these APCD's may be stopped due to reasons like breakdown of the system, system under maintenance, stoppage of some systems from energy conservation point of view and more importantly stoppage of systems due to related problems in the process like choking, jamming of material handling systems especially in dust suppression type systems.

- High operating costs resulting in stoppages of systems

From environmental point of view, it is essential that the system should operate. On the other hand from the energy conservation point of view there exist possibility to realign and increased use of effective dust suppression could be possible. Choosing dust suppression wherever possible could certainly bring down the operating cost in terms of electricity consumption, compressed air requirements, changing of damaged bags, reduced maintenance expenses etc.

- Design and operation related problems

In terms of design and operational aspects studied in 6 cement plants the following problem areas have been identified due to which the systems may not be sustainable

- Substantial Visible emissions during retrieval and loading of clinker from open stock piles by pay loaders. No systems exist for controlling these emissions
- Substantial Visible emissions during retrieval and loading of coal from open coal yard by pay loaders. No systems exist for controlling these emissions

- Emissions due to wind blowing of coal dust from open coal yard
- Substantial coal fines lying in the coal yard area getting air borne due to haphazard vehicular movement causing excessive emissions primarily due to re entrainment.
- In-effective water spray arrangement at coal unloading and crushing areas causing excessive emissions
- Partially covered, partially open storages of gypsum along with limitation of spraying water causing wind blown emissions
- Gantry operations (for lime stone and clinker) involving free fall of material from height and due to absence of water spraying system due to varying locations of material handling and due to absence any extraction arrangement because of large area and unregulated stacking and retrieving practices, un controlled fugitive emissions occur. The emission escape from the openings for ventilation, which cannot be completely, closed due to light and ventilation aspects for crane operation especially affecting the health of crane operators and accident hazards due to reduced visibility.
- Inoperative dust suppression systems due to problems in the suppression systems like choking of nozzles or problems due to suppression systems like excessive water causing frequent breakdowns of production equipments like apron feeder, crusher, conveyors etc.
- In operative dust extraction cum bag filter due to problems either in the system like damaged Impeller of fan, electrical short circuiting of driving motors, torn filter bags, choked filter bags, faulty cleaning mechanism, due to faulty design problem like in appropriate dust extraction locations, in adequate extraction volume, under sized fan and filtration area, non uniform distribution of flow branching and connections of ducts etc
- Lack of dedicated manpower for ensuring regular operation and maintenance of the systems. Engaging primarily contract labour for operation and maintenance related work, with out imparting proper training and knowledge about the systems resulting in poor O & M of the systems, thereby adversely affecting the effectiveness of the system
- Lack of documented information about the design specifications, operation and maintenance aspects of the APCD resulting in improper O & M practices
- Lack of records to ensure proper operation and to cross check about the APCD and other dust control action from time to time
- Due to absence of legal requirements for compliance of fugitive emission standards and non-critical operation from production point of view, generally considered as least priority area by the top management.

While evolving the guidelines/standards for prevention and control of fugitive emissions, most of the important issues discussed above need to be considered.

7.6 Comparison of Fugitive Emissions by Various Cement Plants and Discussions

The total emissions emitted from the cement plant could be broadly divided as partly from main process stacks like Kiln/Raw Mill, Coal Mill, Cement Mill, Clinker cooler etc and partly the emission released as fugitive emissions from various sources. A comparison in terms of quantity, gravity of emission is placed below.

Table Comparison of between fugitive emissions (per ton & per day)

S.No.	Name of the unit (State)	Category (TPD)	Age of Plant (Year of Installation)	No. of APCD for fugitive dust control	Quantity of Fugitive Emission	
					Kg/TPD	Kg/D
1.	Chittaurgarh Cement Works, Chittaurgarh, (Rajasthan)*	3300 TPD	Mid age (Installed 1986)	55	0.47	1543
2.	ACC Gagal Cement Works Himachal Pradesh (Unit II)	4500 TPD	Mid-age (Installed 1984, Modernized 2003)	46	0.45	2028
3.	Lafarge Cement, Sonadih Chattisgarh	4000 TPD	Mid-age (Installed 1993, Taken over by Lafarge 2001)	36	0.33	1320
4.	ACC Jamul Cement Works Chattisgarh	2400 TPD	Old (Installed 1965)	31	0.97	2329
5.	UltraTech Cement, Awarpur, Chandrapur Maharastra	3300 TPD	Mid Age (Installed 1983)	47	0.38	1259
6.	Maratha Cement Works, Upparwahi, Maharastra	7300 TPD	New (Installed 2001)	65	0.15	1080

The above table indicates the following

- The new plant, as expected to have better environmental controls, has the lowest specific fugitive emissions of 0.15 kg/T of clinker
- The old plant, as expected to have lesser degree of environmental controls, has the highest specific fugitive emission of 0.97 kg/T of clinker

- Most cement plants, especially those that came up after year 2000 or modernized/ expanded during 1990-2000 era have installed numerous bag filter system for controlling fugitive emissions from various section.
- Amongst the mid-age plant, have a medium emission rate from 0.33 to 0.47kg/T of clinker
- For a typical I MTPA plant (3300 TPD) the fugitive emission range from 495 kg/Day to 3200 kg/Day
- A typical range of total emission from controlled stack is in the range of 0.2 to 0.5 kg/TPD. For 1 MTPA plant, the controlled emission discharge to atmosphere is in the range of 660 to 1650 kg/day
- The above comparison of controlled stack emission versus fugitive emission for a 1 MTPA capacity plant indicates that the fugitive emissions are substantial and almost or even more than the regulated stack emissions
- The amount of investment and efforts in terms of installation of air pollution control devices and its operational and maintenance aspects for stack emission is much higher and has a greater priority as compared to controls for fugitive emissions.

CHAPTER 8.0

Discussion on Evolving Guidelines/Standards for Prevention/Control of Fugitive Emissions

8.1 Hierarchy of Effective & Sustainable Management/Control of fugitive emissions

Emissions, "if prevented" at source itself at the first instance of its occurrence is certainly the best approach for reducing fugitive emissions and it certainly would reduce the secondary and tertiary emissions.

For effective control of fugitive emissions the following measures in the order of priorities are recommended

Priority 1: Prevention of fugitive emission.
Priority 2: Reduction, to the extent possible.
Priority 3: Control, of only the residual emissions.

The reduction at source, to the extent possible and incorporation of process modifications, or adjusted work practices, both of which reduce the amount of dust generation, are preventive techniques for the control of fugitive dust emissions.

8.2 Possibilities of Prevention/Reduction of Fugitive Emissions and Associated Issues

For sustainable and techno-economically viable but effective control of fugitive emissions, the highest priority should be to prevent or reduce the fugitive emissions at the source of generation itself. Various possible methods to achieve prevention/reduction of fugitive emissions and associated issues are discussed below.

8.2.1. Effective Containment of key locations

The specific locations from where the fugitive emissions are originated, if identified correctly and fully enclosed, the fugitive emissions could be reduced to a great extent. In good enclosures, substantial part of the air borne dust is contained within the enclosure, which eventually settles down inside the enclosure, though after a longtime.

8.2.2. Maintaining optimum moisture in material at all times

Maintaining optimum level of moisture in the material handled prevents generation of fugitive emission at source. The moisture once added to the material, lasts for some period of time and eventually gets evaporated due to natural evaporation and therefore water needs to be added again as per requirement to maintain the moisture. The amount of moisture need to be balanced to an optimum quantity, sufficient enough just to prevent fugitive emissions, but not in excess to avoid adverse effects like jamming, choking of material handling equipments etc. improperly designed or over designed suppression systems may lead to excess water sprays and related problems.

8.2.3. Possibilities of reducing fugitive emissions by avoiding re-entrainment of once collected fines

- **Various areas where re-entrainment causes fugitive emissions**

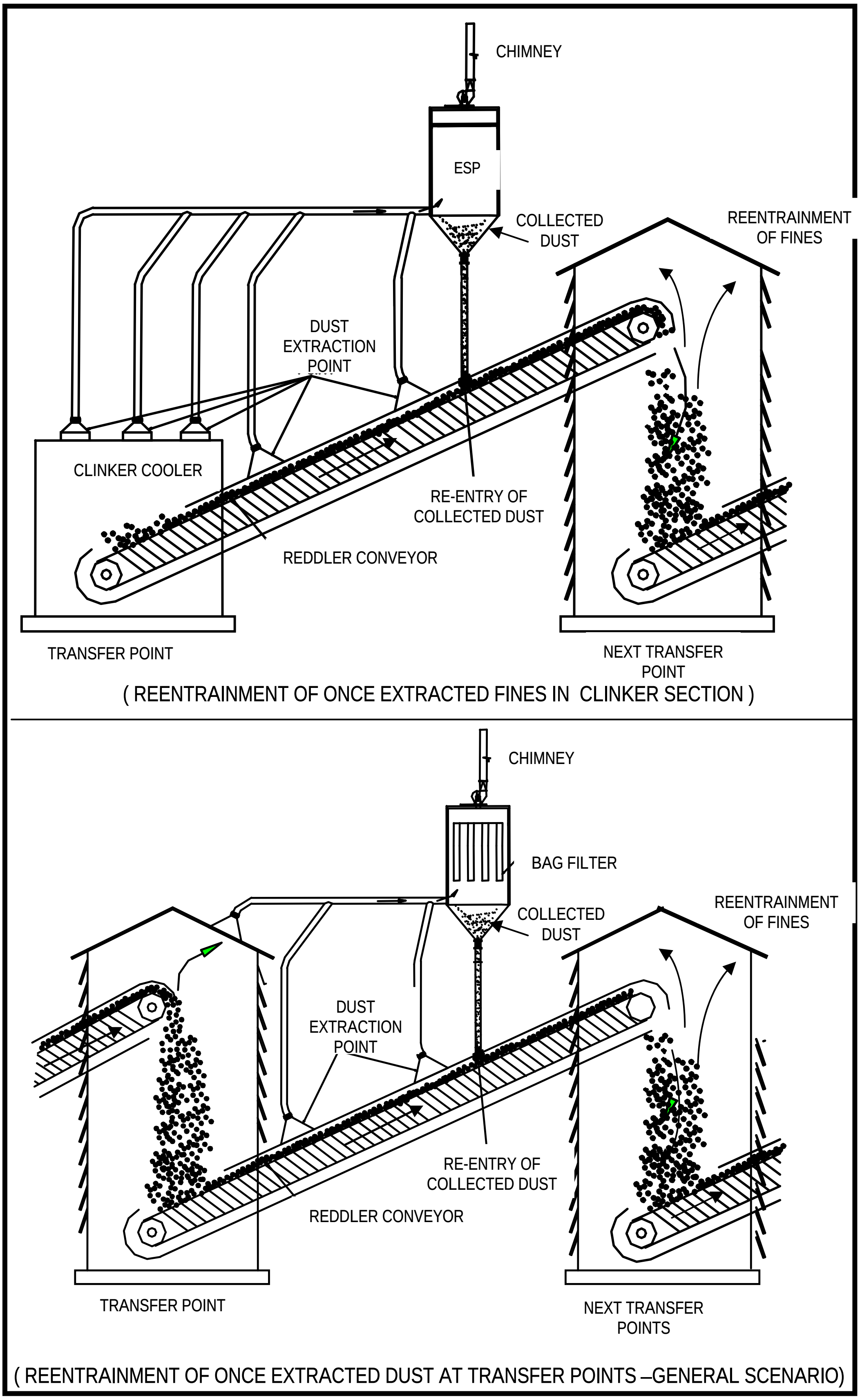
Some of the points where "extracted and collected dust" is put-back into the system are shown in the table below:

Sr.No.	Dust extraction location	Location of Dust Recycling	Point where the dust is likely to get airborne reentrained
1	Clinker cooler	Deep bucket conveyor	All downstream transfer points, open stockpiles, during retrieval, loading etc operations
2.	Limestone Primary Crusher, intermediate storages	Belt leaving crusher	All downstream Transfer Points, surge bin hoppers, stockpiles
3.	Coal primary Crusher	Belt leaving crusher	All downstream Transfer Points, stockpiles

A schematic diagram showing typical re-entrainment of "already captured fine dust" is shown at Figure 8.1 giving an overview for better understanding.

- **Issues Related To Separate Handling/Recycling of the Collected Fines**

The limitations generally posed by the cement plant, with respect to handling captured and collected fine dust, is "how otherwise to handle this dust if it is not "Recycled" into the process". The issue needs to be analysed in terms of "techno-economic feasibility aspect" versus "Environmental aspects". Most cement industries claim that there is no other feasible alternative than to "Recycled" the collected fines into the system at a immediate downstream location, as the dust is ultimately



(REENTRAINMENT OF ONCE EXTRACTED FINES IN CLINKER SECTION)

(REENTRAINMENT OF ONCE EXTRACTED DUST AT TRANSFER POINTS –GENERAL SCENARIO)

FIG. 8.1 REENTRAINMENT OF ONCE EXTRACTED FINES IN CLINKER SECTION AND AT TRANSFER POINTS converted into product (cement). But on the other hand, from environmental angle, it would be certainly and always be preferable that the "collected fines" be taken out of the system/process at the first instance of its capture so that it does not get airborne again thereby preventing fugitive emissions at downstream locations.

Against the limitations posed by cement industries, some possible alternatives for handling the collected fines are

i) Recycle the dust at an immediate downstream location like conveyor belt (current practice)
ii) Collect the fines and separately transport by pneumatic or other means on continuous basis to "last possible point of Recycle".
iii) Collect the fines, store at site temporarily and separately transport periodically by pay loader/vehicles once sizeable quantity is collected and Recycle into the system at "the last possible point".

Out of the above three options, only the first option of Recycling the collected dust on immediate downstream belt conveyor is widely followed, which though apparently considered as techno-economically most attractive option, but environmentally it is not the proper option.

The "large distances" between various process operations and requirement of providing additional system hardware are the limitations projected in adopting the second option of pneumatic conveying. As regards to the quantities of the fines that would be collected at various sources, accurate estimations are not available which may decide the "Size" of the "pneumatic system hardware" and its cost economics aspect.

While having separate pneumatic lines at all dust collecting points may not be feasible, a central "pneumatic pumping arrangement" can be possible, one system for limestone, one system for coal and one system for clinker fines. The collected fines at various locations could be brought physically to a central location (like the way fly ash is transported) from where it can be pumped into the system at the last possible location.

- **Emission Accumulation Effect Due To Re-Entrainment of Collected Dust**

The fines/dust is generated principally by actions like impact during free fall from a height leading to breaking of lumps/bigger particles (locations – transfer points) or by "size reduction" operation (locations: crushers – primary or secondary) or due to "movement" of material leading to loosening of adhered dust (locations – belt conveyors, pneumatic conveying) or due to transportation operations (locations – vehicular traffic on roads etc.)

Fines, once generated, would get airborne whenever either of the above operations are performed. In addition, some "fresh fines" would also be generated at subsequent downstream points due to reasons like breaking by impact etc. So, the fines generated at "first" point, if not taken out of system, would get "accumulated" along with the "fresh fines" that may be generated at subsequent downstream point (second point/third point etc.). This "accumulation" effect causes higher emissions and calls for "increasing" capacities of dust extraction cum control systems at downstream locations (like more filtration area, more volume to be extracted, more nozzles etc.), thereby requiring more and more and bigger "Dust control systems".

This dust accumulation concept has been schematically explained for a process section (limestone) in the table below:

Table: Dust Accumulation effect (example: Limestone Section)

First Source of Emission and Downstream Locations	**Reason for Emission generation**	**Qty. of fresh Emission generated**	**Qty. of Emission by Accumulation Effect due to Recycling of Collected Dust**	
			Option I	**Option II –**
			At immediate downstream location	**At last possible destination**
		(kg/hr)	**(kg/hr)**	**(kg/hr)**
Unloading of limestone	Free fall of material, fines carried from mines and generated during transportation and due to impact during free fall	a	a	a
Primary Crusher	Generation of fresh fines due to breaking action	b	a+b	b
Transfer point (Crusher to stacker)	Generation of additional fines due to free fall of material, breaking, loosening action	c	a+b+c	c
Stacking of limestone	- do -	d	a+b+c+d	d
Reclaiming of Limestone	- do -	e	(a+b+c+d)+e	e
Transfer point	- do -	f	(a+b+c+d+e)+f	f
Secondary crushing/grinding	Generation of additional fines due to breaking of larger particles	g	(a+b+c+d+e+f)+g	g
Raw Meal Blending Silo	Emission through vent	h	a+b+c+d+e+f+g + h	(a+b+c+d+e+f+g)+h

The above table shows that the quantity of fugitive dust to be handled at downstream locations gets "accumulated" if dust is put back at "immediate downstream location" (Option – I). Whereas, there is no accumulation effect if the fines are separated from the system and recycled at the last possible location in the system, like raw material blending silo (option-II).

- **Option Of Separating Coarser Particles To Reduce Dust Load To Be Sent Directly To Last Possible Destination:**

At the locations where generation of emissions is quite high (in terms of kg/hr), the dust load collected at bag filter could also be high. In such cases, a pre-collector cyclone could be installed before bag filter. The coarser particles collected at cyclone can be put back on the belt conveyor whereas the fines collected at bag filter could be handled via separate central pneumatic pumping system.

This would enable separation of only the fines (which have potential to get/remain airborne again and again, thereby creating fugitive emissions), with a reduced/optimum quantity, thereby requiring smaller capacity pneumatic pumping system. At the same time, the coarser particles (which could be substantial in quantity by weight) could be recycled into system as practiced currently. Even a 50% efficiency of collection at the cyclone would reduce the total fines quantity (to be separately handled) by half and hence certainly useful.

In most bag filters, the quantity of fines collected would be of the order of "a few tons a day (or say maximum one truck load a day). So, transporting once a day through container similar to that used for fly ash handling to the central pneumatic pumping station could transport such collection.

8.3 Achieving effective dust suppression on sustainable basis

8.3.1 Basis for a Successful Dust Suppression System

Dust Suppression System could only be operated effectively and continuously if sprayed water does not pose problems like choking/jamming etc. downstream. If "excess" water is sprayed, it can create problems and if "less" water is used, the emissions may not be adequately suppressed. So, even if water is cheap or freely available and there is not much operating cost too (like for dry bag filter type systems), the "dust suppression" system can "be used without problems" with optimum (or minimum possible) water and not by spraying "any amount or uncontrolled amount" of water because it is free. A "balance" is essential in terms of quantity of water spread and is the key to success and it does require frequent intervention of "skilled person" which is generally missing.

8.3.2. Too Much or too less water unsustainable or ineffective

Water being in abundant quantity and cheap, it is generally used generously for spraying purposes, with an assumption that more the water spray better the dust suppression effect would be. Accordingly many suppliers have different type of nozzles and numbers of nozzles for a particular applications and quantity of water to be sprayed is hardly given due importance. In practice, excess quantity of water sprayed creates problems for the operation of the system itself by way of jamming/choking of moving parts. And hence such practice of spraying excess water is unsustainable and not practical to operate on a regular basis. As a result many plants use the suppression systems sparingly.

Too less water on the other hand cannot moist the material enough so as to suppress the fines and hence may not be effective.

From unloading point, as the material passes downstream through crusher and transfer points etc, the material fractures and breaks into more and more pieces as a result more surfaces open up as the material travels downstream. The water sprayed at first location of unloading wets the outer surface, but when the material breaks, the new (inner) surfaces are dry and may give rise to emissions, so these newer surfaces also need to be wetted as and when they are formed to keep all material moist. It is therefore water sprays need to be applied at several key locations downstream wherever newer surfaces are formed. Quantity of water depends on material feeding rate, initial moisture in material etc.

8.3.3. Reduced Moisture in Material causes higher fugitive emission an example

Type of monitoring :Fugitive emissions monitoring using RDS & HVS
Location of monitoring :Coal Yard stacker
Ambient Temperuatre :35°C

Condition	Run Time "min"	Avg. Flow "m^3/min"	Distance from stacker, m		PM_{10} "μg/m^3"	SPM "μg/m^3"	Total SPM "μg/m^3"	Contribution, "μg/m^3"
			'x"	'z"				
Upstream (HVS)	57	0.9	16.53	0	--	--	1593	3728
Downstream (RDS)	45.6	0.96	14.15	0	5105	216	5321	

For typical open coal yard with water spraying type prevalent measure the SPM contribution was measured to be 3728 $\mu g/m^3$ (measured at 14 M distance downstream).

For the same coal yard after 2 hours (when some of the moisture was evaporated due to atmospheric evaporation) without additional water spray, higher SPM contribution of 10722 $\mu g/m^3$ was measured, with higher PM10 content increased from 5105 to 11363 $\mu g/m^3$ (almost double).

Condition	**Run Time "min"**	**Avg. Flow "m^3/min"**	**Distance from stacker, m**		**PM_{10} "$\mu g/m^3$"**	**SPM "$\mu g/m^3$"**	**Total SPM "$\mu g/m^3$"**	**Contribution, "$\mu g/m^3$"**
			'x'	**'z'**				
Upstream (HVS)	55.2	0.825	16.53	0	--	--	1522	10722
Downstream (RDS)	57	0.96	14.15	0	11363	881	12244	

The above measurement indicates an important aspect that if water is not regularly sprayed, though initially fugitive emissions would be lower the emission would increase with time due to evaporation of water and the fines (PM10) content getting air borne would increase many fold. It is therefore important to ensure and have a proper system of regular and controlled water spraying instead of random spraying of water by workman by hosepipe and the casual approach generally followed currently.

It is necessary that the proposed guidelines/standards address this issue have to how it can be ensured that the fugitive emission control systems installed are first appropriately designed and secondly they are regularly operated.

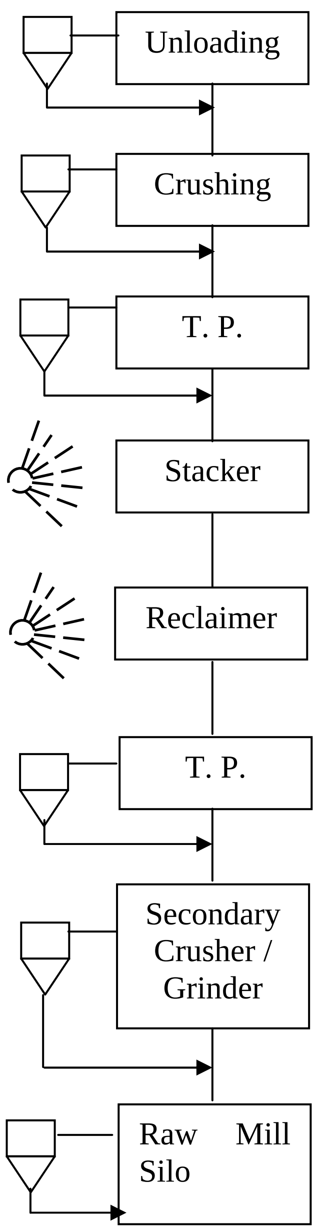
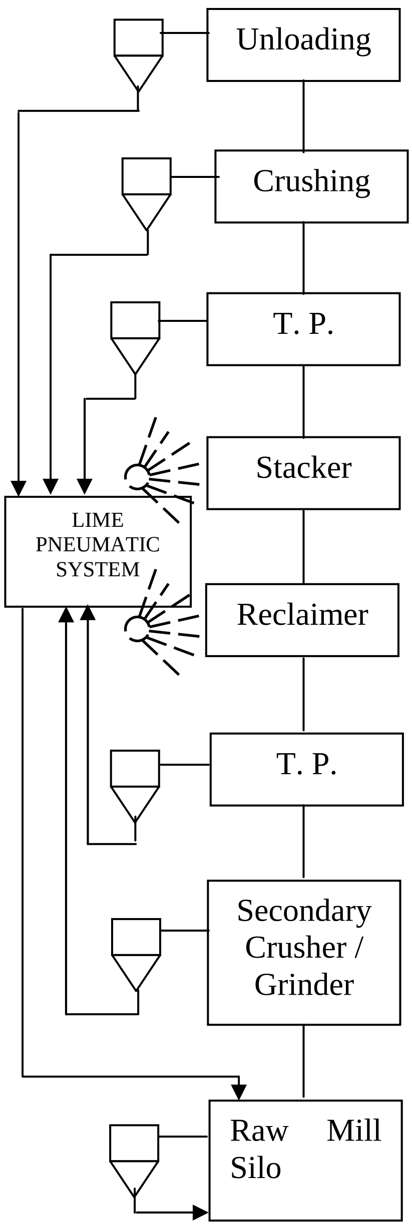
8.4 OSHA guidelines for prevention/control of fugitive emissions

The OSHA has published valuable literature as guidelines for achieving effective control of fugitive emissions from various sources. Some of the recommended methods of controlling fugitive emissions by dust suppression or dust extraction for various sources relevant to cement manufacturing can be obtained from the link **http://www.osha.gov/SLTC/silicacrystalline/dust/chapter_5.html** [Dust Control Handbook for Minerals Processing: Chapter 5]

8.5 Possible Scheme/Arrangement for Recycling Extracted and Captured Fines at Last Possible Destination

When compared with the prevalent practice of "Recycling", the collected fines at immediate downstream locations, the preferred practice could be "removal of fines from the system and recycle only at last possible location". A comparison, using schematic presentation for one section of cement plant (lime) is given in the Figure 8.2 below.

Figure 8.2: Comparison of Prevalent Vs Proposed "emission Management" Practice (example: limestone section)

Prevalent Practice (Limestone)	Proposed Practice	Remarks
		• Fines extracted from various locations first stored at site to substantial quantity • Transported by vehicle in closed containers to a central limestone pneumatic pumping station. • Fines directly pumped into "Raw Meal Silo" (the last possible point) • Lesser fugitive emissions at all locations, reduced dust load, reduced extraction volume. • It may eliminate necessity of dust extraction-cum-bag filter system (or at least substantially reduce the size of bag filter & ID fan) for downstream locations. • Lesser secondary emission from the lime stockpiles due to wind blowing as fines are taken out.

T.P. Transfer Point

8.6 Suitability of type of fugitive emission control technologies for various sources

Control techniques for fugitive dust sources generally involve watering, chemical stabilization, or reduction or surface wind speed with windbreaks or source enclosures. Watering, the most common and, generally, least expensive method, provides only temporary dust control. The use of chemicals or treat-exposed surfaces provides longer dust suppression, but may be costly. Windbreaks and source enclosures are often impractical because of the size of fugitive dust sources.

Effective control of fugitive emissions could be achieved by either of the following ways, in isolation or in combination.

1. By providing adequate containment enclosures to the dust-generating source (thereby isolating/containing the source from wind currents) to contain the airborne emissions within the enclosures.
2. By suppressing the dust by spraying water so that the dust settles down & remain suppressed till the moisture evaporates.
3. By "extracting" the airborne dust emissions out of the system and capturing in APCD (primarily bag filter house). Such extraction systems are associated with providing additional enclosures secondary to specific points of dust generation.

Either or a combination of the above measures are required for adequate control of fugitive emissions. Generally, the combination of 1st and 2nd measures i.e. containment and suppression, is the "cheapest" & "effective" way of controlling fugitive emissions.

Generally, in most cement plants, the amount of water sprayed for dust suppression purpose is not "optimum" quantity (<1%), may be due to in appropriate design of spraying systems or improper locations of sprays etc. which ends up in "higher" moisture content in the raw materials, after clinkerisation, there is a limitation on spraying water, as it would adversely affect the quality of final product (cement). "Dry extraction cum bag filter" systems are the only suitable systems for post clinkerisation material (Clinker and Cement) and for all vents of storage silos.

- **Suitability Analysis of Dust suppression System for Coal Unloading section**

To assess the efficiency of the prevalent control systems of suppressing dust for controlling fugitive emissions from coal unloading section, a detailed study was carried out which involved measurement of controlled and un-controlled emissions at the same location, quantity of water sprayed etc. The measurements are given below.

Type of monitoring :Fugitive emissions monitoring using RDS

Location of monitoring :Coal unloading hopper

Ambient Temperature :35^{o}C

Wind Velocity :0.2 m/s

Condition		Avg. Flow "m^3/min"	Distance from source, m		Content of PM_{10} "		SPM μg/m^3"	Total SPM "μg/m^3"
			'x"	'z"	"μg/m^3"	%		
Controlled	S1	0.78	0	6	13429		99235	112664
	S2	0.813	0	6	31778		183812	215590
	S3	0.738	0	6	24949		176113	201062
				Average	**23385**	**13%**	**153053**	**176439**
Uncontrolled	S4	0.638	0	6	116131		392540	508671
	S5	0.67	0	6	58797		532231	591028
	S6	0.75	0	6	62785		310341	373126
				Average	**79237**	**16%**	**411704**	**490942**
				Control efficiency	**29%**		**37.2%**	**36%**

Samples Numbers S1 to S3 are collected during controlled condition when approximately 540-lit/ min of water was sprayed using 108 nozzles each of 5 Lit/min rate and approximately for 2 minutes per unloading. This amounts to total water quantity of 1080 lit per unloading. Sample Numbers S4 to S6 are collected during un-controlled condition during which water sprays was stopped.

The Weight of truck and material unloaded are given below (Weight of S6 truck not available)

For S1: Gross wt: 21.97 T
Tare wt: 7.25 T
Net wt: 14.72 T

For S2: Gross wt: 40.710
Tare wt: 9.22
Net wt: 31.490

For S3: Gross wt.: 25.92 T
Tare wt.: 6.60 T
Net wt.: 19.32 T

For S4: Gross wt: 22.22 T
Tare wt: 7.36 T
Net wt: 14.86 T

For S5: Gross wt: 38.23 T
Tare wt: 9.40 T
Net wt: 28.83 T

Basic Data of coal unloading hopper and dust suppression system is given below

Unloading hopper dimension	: 5000x5000 mm^2
Shed dimension	: 6500x6500x6000, mm
Average consumption of coal	:14490 T/month
Average capacity of each truck	:28 T

- Total number of trucks monitored for controlled and un-controlled condition: 3 each
- Duration of each unloading : 2 min

Dust suppression System Details	
No of nozzles located over unloading hopper	: 108 nos
Type of nozzles	: Full cone
Type of material	: Stainless steel
Rate of water spray per nozzle	: 5 LPM
Total water consumption per minute	: 540 litres
Time of unloading per truck	: 2 min
Total water consumption per unloading	: 1080 litres
Total water consumption for 13 trucks	: 14040 litres
Type of valves	: Solenoid valves, 2 Nos, Gate Valves, 2 nos
Main Pipeline diameter	: 3 inches
Brach pipeline diameter	: 2 inches

Pump Details	
No. of pumps	: 2 Nos
Discharge	: 350 LPM
Type	: Centrifugal multi stage pump
Suction diameter	: 2.5 inches
Discharge diameter	:2.5 inches
Discharge pressure	: 9 kg/cm^2
Motor H.P.	:215 (centralized)
Speed of the motor	:1440 rpm
Other Details:	
Source of water	: Mine water
Water tank dimension	: 2x2x2,m^3

The above monitoring and observations has been analyzed for various aspects below.

- The control efficiency of suppressing coal dust emissions by water spraying is only 36%, even though more than 100 nozzles are spraying water'

- The quantity of coal unloaded every time varies but the water sprayed remains the same. This leads to varying percentage of moisture carryover in the coal as shown below.

Weight of Material	**Quantity of water sprayed/unloading**	**Total SPM**	**Percentage of Moisture**
Tonnes	Litres	**"μg/m³"**	%
14.72(S1)	1080	112664	7.3
31.49(S2)	--do--	215590	3.4
19.32(S3)	--do--	201062	5.6

- The above table shows that by fixing the water quantity per unloading, the moisture percentage is much higher for smaller quantities unloaded. The amount of moisture sprayed is in the range of 3.4% to 7.3%.

- Against desired optimum value of 0.2 to 0.5%, which is several times (7 to 14 times) higher and therefore excessive which would certainly cause downstream choking problems.

- Even though such excessive water is sprayed, the control efficiency is only 36%, which is too low as compared to the control efficiency desired for stack emissions in the range of 99%, plus to get the final discharge below 150 mg/Nm3. this low efficiency is primarily due to faulty design.

- The low efficiency of suppressing coal dust also indicates that the suppression system may not be suitable for coal dust application. Especially the control efficiency is even lower for PM_{10} range particles, in the range of 29%.

- Even after the prevalent control, residual fugitive emission are much higher (in the range of over 150,000 "μg/m³" which are several times higher than the desired SPM level in the work area and hence even an improved dust suppression system cannot possibly reduce emission satisfactorily and hence not suitable. Alternately, dust extraction cum bag filter could be the only choice.

- A central pump of high capacity supplying pressurizing water to several dust suppression systems may not be a good option as the control on water sprays cannot be optimally achieved and due to variations in actual usage times of various sources etc.

Comparison for suitability of Dry vs Wet System

The dry extraction-cum-bag filter type system has high operational cost in terms of operation of the ID fan motor (Typically, for a 30 KW motor, the electricity costs annually works out to Rs. 7 Lakh for 6000 operating hours/year @ Rs.4.00/- kwh average). In addition, the cost towards supply of compressed air, changing of damaged filter bags and other spares etc are additional.

Generally dry system is preferred over wet suppression fearing that the add-on moisture in raw material may cause problems like choking/jamming at downstream location. But as the material is taken to the stock piles where it is stocked for substantial duration (may be few hours/days), even if water is spread (in place of dry extraction) the moisture could get dried up during the storage time due to natural atmospheric evaporation prior to it is reclaimed and hence may not cause any problems like choking etc at downstream locations. Particularly, as the collected fines by the dry system are recycled into the system which travel along with the material to the stock piles, which is also the case in dust suppression arrangement that the dust remains within the material, in terms of economics and simplicity of operation and maintenance, the wet type dust suppression could be more suitable and appropriate for areas where "spraying water" does not pose problems in terms of affecting quality of material. For areas like limestone and coal, addition of water does not degrade the material (as like clinker)

8.7 Necessity of eliminating fines from clinker, especially if to be stored in open areas

During cooling of clinker, majority of fine particles are extracted out of clinker which are captured generally at clinker cooler ESP. These collected fines are recycled to the clinker at the deep bucket conveyor, which get airborne again and again at downstream locations like transfer points, open stock piles, during retrieving, loading by pay loaders etc which cause substantial fugitive emissions.

The number of emission sources in clinker open storage and related operations are schematically shown at Figure 8.3 to provide an overview of the problems.

Substantial investments are made in terms of installing Dry extraction cum bag filter systems (as dust suppression cannot be used) for all these transfer points which also have high operating costs in terms of electricity consumption, damaged filter bags, maintenance costs etc. Plus, some areas, like open storage, does not have any control arrangement except covering.

Should the dust be not recycled, the fugitive emissions at all downstream locations would certainly be prevented (or at least greatly reduced), which would call for "smaller and fewer APCD's" or even no APCD's which would have lesser investment and also lesser operating cost. More importantly, it would create lesser problems in open stock piles of clinker, especially during its retrieval, loading by pay loaders.

8.8 Necessity of eliminating fines from coal, especially if to be stored in open areas

The coal procured from mines and transported to site contains substantial quantity of fine particles. This coal when stored in the open yards in heaps arranged haphazardly in vast area gives rise to excessive fugitive emission due to wind blowing of fines and due to retrieval, loading and unloading operations by pay loaders and due to haphazard movement of trucks unloading and taking away the coal. Neither there could be any system possible to systematically and effectively clean the fines every day or to extract the fines. Any dust suppression arrangement by water spraying is generally tentative one and causes problems of black muddy floor conditions sticking to truck tyres and spreading on roads to longer distances.

A schematic diagram showing various areas of fugitive emissions in the coal yard and related operations are shown at Figure 8.4 to give an overview of the problems.

In view of the above-discussed problems it is necessary to eliminate fines from coal especially if to be stored in open. This could be possible partly by extracting the fines during unloading and primary crushing and then only store the crushed coal in yards. The dust could be sent directly to coal mill section.

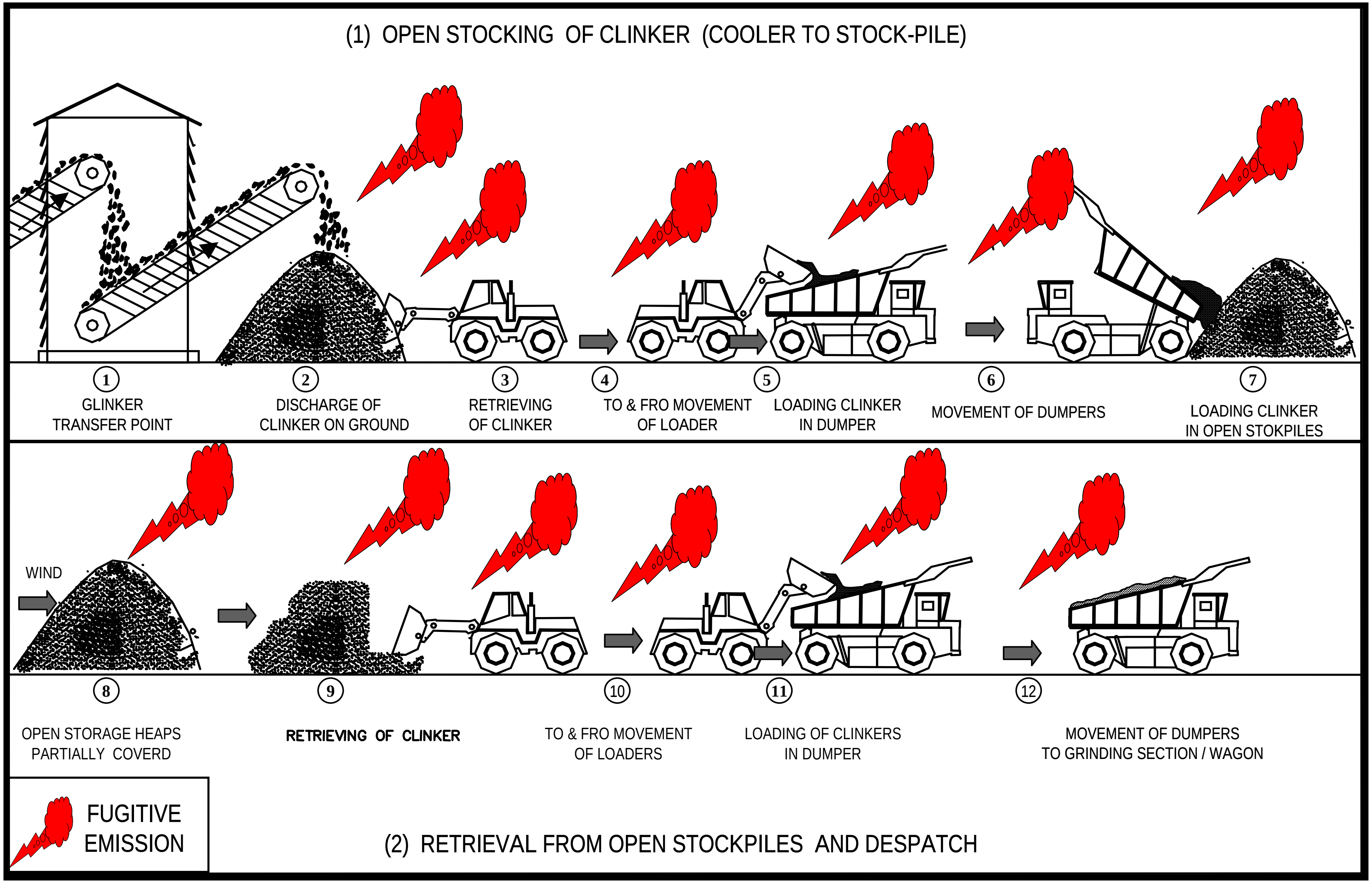


FIG. 8.3 SCHEMATIC DIAGRAM SHOWING VARIOUS FUGITIVE EMISSION LOCATIONS IN CLINKER OPEN STORAGE / HANDLING SECTION

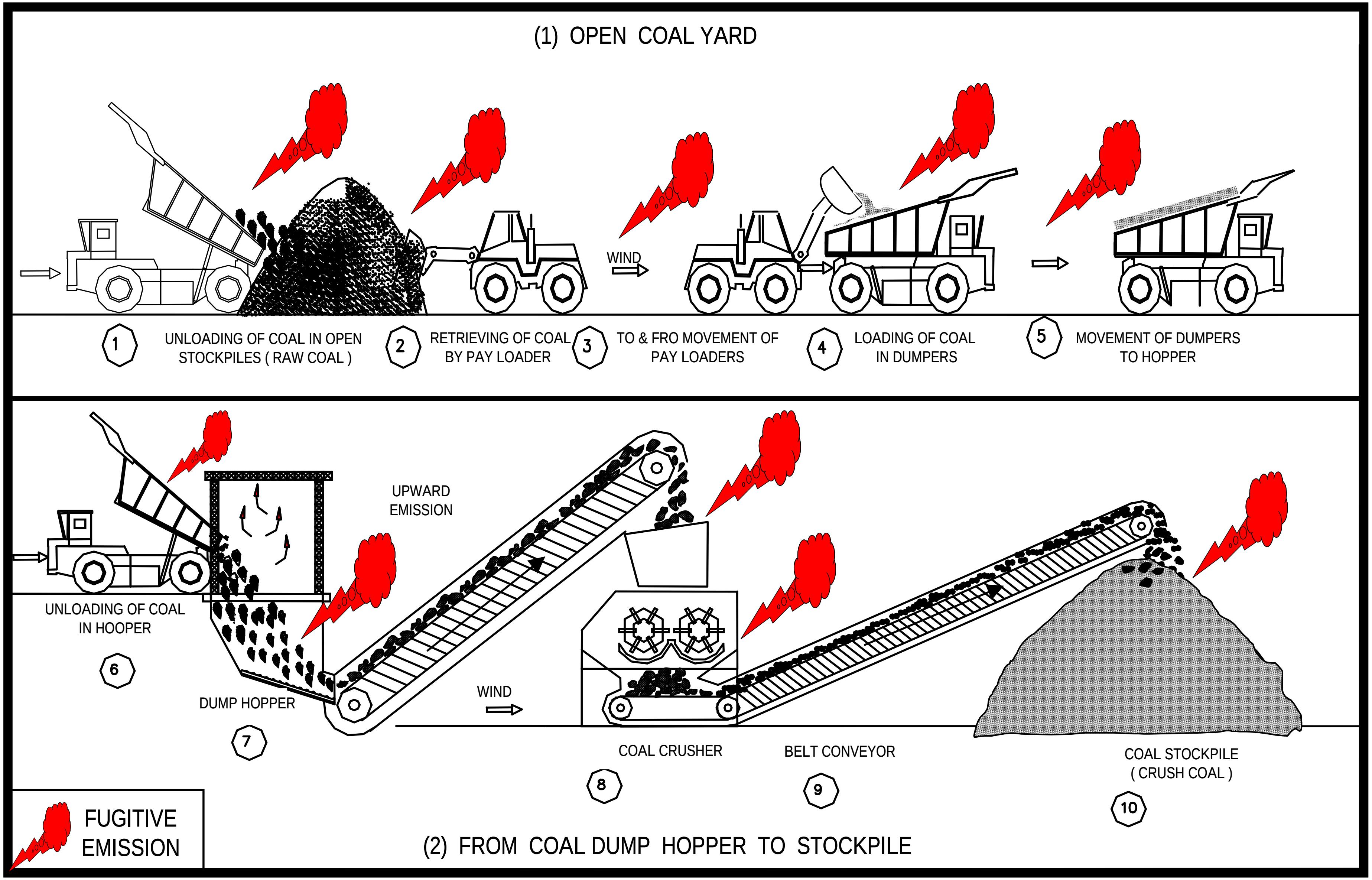


FIG. 8.4 VARIOUS FUGITIVE EMISSION AREAS IN COAL STORAGE / CRUSHING SECTION

8.9 Analysis of USEPA Rules and Regulations for its Applicability to Indian Cement Plants

The US-EPA standards for control of fugitive dust emissions are provided in rule 403 under regulation VIII. *(Refer Chapter 4.1.1 for details of rule 403)*
The rule requires industry facility to meet following requirements

- Prevention and control of fugitive dust from any active operation and storage piles or disturbed surface areas.
- Implementation of best available control measures specified by USEPA along with rule to minimize fugitive dust emission from each fugitive dust source type within the active operation.
- The industry shall not exceed PM_{10} of 50 microgram per cubic metre measured as contribution value of upwind and downwind samples for the key activity areas.
- Cleaning of spillages, arrangements for reducing track outs and other measures for cleaning of vehicles etc leaving the premises.
- Maintain daily records to maintain document specific control measures action taken which should be made available to regulatory agency upon request.
- Facility should employ or contract a dust control supervisor with a authority to expediously employ sufficient mitigation measures to ensure compliance with the rule requirement and he should have completed AQMD fugitive dust control class and had been issued valid certificate for completion for the class.
- Requires facility to submit a dust control plan for approval by regulatory authority

To control fugitive dust emissions from cement manufacturing units include a performance standard and default technical standard that meet the performance standard.

<u>Performance Standard :</u>

Under the performance standard, unit design and operation must ensure that wind dispersal of particulate matter (PM) is controlled. The specific performance standard for air is that the facility must cover or otherwise manage the unit to control wind dispersal of dust emissions. This standard applies to solid PM that becomes airborne directly or indirectly as a result of various operations. To demonstrate compliance with the performance standard, the facility is required to employ the technological based standards described below for controlling fugitive dust. For example, the facility may employ all of the following to demonstrate compliance with the performance standard.

- Covering the stockpiles to present blowing of dust
- Watering roads with sufficient frequency
- Use covers on trucks for transporting material

Technical standard that meet the performance standard

Some examples of technical standards are provided below.

- Covers: The material should be covered to prevent blowing dust. The cover must be constructed of the material that have appropriate physical and chemical properties and sufficient strength and thickness to prevent failure due to physical contact with the material, climatic conditions and stress of daily operations.

Wetting: Consistent wetting and watering of paved roads to sufficiently reduce the release of fugitive emissions.

Some of the points could be applicable for Indian Cement Plants and the same has been considered while evolving guidelines.

8.10 Basis for evolving Guidelines/Standards:

8.10.1 Need For Suggesting Specific Requirements For Each Potential Emission Source:

In a cement plant, there are various sources of fugitive emissions, physically separated by some distance. Almost each source is required to have a separate fugitive emission control system. The type of control system and degree of control required varies from source to source. It is therefore felt necessary to specify requirements for controlling fugitive emission and guidelines for selection of appropriate control measures.

8.10.2 Need for Concentration Based Standard

In order to assess the effectiveness of the fugitive emission control measures installed in line with the requirements & guidelines, a concentration-based standard was felt necessary, which could be an indication of effective implementation of fugitive emission control systems. Such assessment could be carried out close to the source and any measurement at longer distances would have interferences from various other fugitive or stack sources and hence may not be indicative of effectiveness of a particular control system. In cement plants there are number of sources having fugitive emission control systems, assessment of each may be required separately, thereby requiring a number of measurements close to the sources. As in most cases, it would be difficult to assess/separate the emissions from the source and emission from other surrounding source. This may require a contribution based value, measured as difference between upstream and downstream values.

For stack emission control to about 100 mg/Nm3 level or less, generally an efficiency of 95% plus is required over uncontrolled emissions. For fugitive emission control, the uncontrolled emissions from various source ranges from 1,00,000 to 4,00,000 ug/m3. As control efficiency of 95% could reduce this level to 5,000 to 20,000 ug/m3, close to source, measured at maximum 1 M distance. By applying Gaussian Model for neutral atmospheric conditions, the effect of the SPM at different distance would be as mentioned below.

Impact at Distance, Meter	**Equivalent SPM concentration, ug/m3**
At 1 M	100% (as measured)
5 M	27 %
10 M	7.7 %
30 M	1.5 %
100 M	0.12 %
500 M	0.007 %

For an average achievable SPM concentration value at source (<1 Metre) of 10,000 microgram per cubic metre would have a projected SPM concentration in the range of 150 microgram per cubic metre at 30 M distance.

- **Relevance Of Threshold Limit Values For Fugitive Emissions Of OSHA**

The primary objective of controlling fugitive emission is to improve the work zone ambient air quality to an allowable extent. This allowable extent is generally threshold limit values. In the absence of availability of such values indigenously, the values as prescribed in USA as per OSHA could be considered. For cement manufacturing plants, the applicable are as below.

Substance	Type of Dust	Allowable concentration mg/m3	Equivalent µg/m3
Portland cement	Total Dust	10	10,000
	Respirable Dust	5	5000
Coal Dust	Respirable Fraction <5% SiO2	2.4	2400
	Respirable Fraction >5% SiO2	10	10000
Inert/Nuisance Dust	Respirable fraction	5	5000
	Total Dust	15	15000

The above are the permissible dust values for workplace atmosphere as recommended by OSHA. The standards if to be prescribed for fugitive emissions for cement plants should at least be in line with OSHA recommended values or higher as the atmospheric conditions in India are different in terms of higher temperatures, wind blown dust from deserts and waste lands etc

The boundary lines of the section such as coal yard, clinker storage etc could be considered as the workplaces where workman movement occurs and hence the limiting values of allowable particulate matter at boundary conditions of the sections could be in line with the above-mentioned values. For dust other than cement and coal, the inert or nuisance dust value can apply.

As measured in various cement plants the prevalent un controlled concentrations at various fugitive emission sources like coal unloading, crushing, lime unloading, crushing, clinker storage etc vary pre-dominantly in the range of 100,000 to 300,000 µg/m^3. As in the case of stack emission control where mostly a limit of 150 mg/Nm3 is applicable requires control efficiency in the range of 95 to 99%. Even if the same level of control efficiency is applied for controlling the fugitive emissions, for 95% efficiency the controlled concentrations could maximum be reduced to range of 5000 to 15,000 µg/m^3 which are in the range as prescribed by OSHA for workplace atmosphere.

The guidelines/standards are evolved covering following aspects:

- Technical requirements for prevention and control of fugitive emissions for various potential emission areas/sources.
- A monitoring mechanism is necessary to crosscheck whether the installed systems are effective in preventing/controlling fugitive emissions.
- Re-entrainment of "once extracted fine" should be avoided at all costs, especially for operation performed in open.
- There should be some documentation/records demonstrating the running of control measures and their effectiveness.

CHAPTER 9.0

Requirements and Guidelines for Prevention and Control of Fugitive Emissions from Cement Plants

For achieving effective prevention and control of potential fugitive emission sources in cement manufacturing plants, specific requirements along with guidelines have been evolved. In order to establish proper management practices, requirements such as Operation and Maintenance aspects, trained manpower and documents & records to be maintained are also prescribed. In addition, general guidelines are also evolved for the sources otherwise not specified.

9.1 Requirements for Prevention and control of fugitive emission for various Potential Sources

For the purpose of effective prevention and control of fugitive emissions, the cement industry is required to implement the following for the sections mentioned:

1. Unloading Section (Limestone, Coal & other relevant material)

Sr. No.	Control Measures to be Provided	Guidelines
1.	Enclosure should be provided for all unloading operations, except wet materials like gypsum	The enclosures for the unloading sides could be flexible curtain type material covering up to height of dumpers discharge from the roof.
2.	Water shall be sprayed on the material prior and during unloading	A dust suppression system should be provided to spray water. The amount of water sprayed should preferably be optimized by employing proper design of spray system. Suitable systems may be adopted to reduce the problems like choking, jamming of the moving parts.

2. Material Handling Section (Including Transfer Points)

Sr. No.	Control Measures to be Provided	Guidelines
1.	All transfer point locations should be fully enclosed.	The enclosures from all sides with the provision for access doors, which shall be kept, closed during operation. Spillages should be periodically removed.

2.	Airborne dust at all transfer operations / points should be controlled either by spraying water or by extracting to bag filter.	Either water spray system should be provided for suppressing the air borne dust or dry extraction cum bag filter with adequate extraction volume.
3.	Belt conveyors should preferably be closed.	This will avoid wind blowing of fines.

3. Coal Storage Section

Sr. No.	Control Measures to be Provided	Guidelines
1.	Coal yard / storage area should be clearly earmarked.	A board should be erected to display the area earmarked.
2.	The pathways in coal yard for vehicle movement should be paved.	Proper pathways with entry and exit point should be provided.
3.	Accumulated dust shall be removed / swept regularly and water the area after sweeping.	Any deposits of dust on the concrete roads should be cleaned regularly by sweeping machines.
4.	Coal other than coal stock pile should preferably be stored under covered shed.	Where ever blending activity is carried out by chaining in open ground, covered shed should be provided to reduce the fine coal dust getting airborne. The enclosure walls shall cover minimum three sides up to roof level.
5.	The coal stock pile should preferably be under covered shed for new plants.	The enclosure should be from three sides and roof so as to contain the airborne emissions.
6.	Instead of dust extraction cum bag filter system, If dust suppression measure is used, following additional control measures should be provided.	
a	Wetting before unloading.	Coal should be sufficiently moistened to

		suppress fines by spraying minimum quantity of water, if possible.
b	Spray water at crusher discharge and transfer points.	Water spray should also be applied at crusher discharge and transfer points.

4. Clinker Cooler Section

Sr. No.	Control Measures to be Provided	Guidelines
1.	Air borne fines extracted from clinker cooler shall be separated and sent to last possible destination directly, if possible.	The possibilities especially in new cement plant may be explored for the following: The unit may need to add on / install necessary provisions for separating fine particulates from the clinker cooler ESP collection. Fines separation may be achieved by passing collected dust through cyclone, the fines escaping cyclone to be separated, cyclone collection (coarse particles) could be recycled. The fines shall be recycled to the last possible destination (like clinker day silo) suitable or safely disposed.

5. Clinker Stock Piles Section

Sr. No.	Control Measures to be Provided	Guidelines
1.	In new cement plant, clinker should be stored preferably in silo.	Bag filter may be provided before venting out the gases.
2.	Clinker should be stored in closed enclosure covered from all sides and should have a venting arrangement along with a bag filter.	The enclosures should have a venting arrangement located at transfer point where clinker is dropped to the stockpile. The extraction / venting should be sufficient enough. Clinker stockpile access door should be covered by mechanical gate or by flexible rubber curtain. The access doors shall be kept closed at all

		possible times.
3.	The dust extracted and captured in bag filter should be avoided to feed back / recycled to the clinker stockpile, if possible.	Extracted dust should be captured in bag filter and the collected dust should be avoided to feed back to the clinker stockpile, if layout permits. It may be recycled at last possible destination i.e., cement mill section through suitable arrangement, if possible.
4.	Generally open storage of clinker should be avoided. Only in case of emergency clinker should be stored in open with following control measures.	
5.	Area for open storage of clinker should be clearly earmarked.	After earmarking the open storage area of clinker, a board should be erected to display the area earmarked.
6.	Provide cover on openly stored clinker.	During the period when the openly stored clinker is inactive, it should be covered fully by HDPE or tarpaulin type sheets to prevent wind blowing of fugitive dust.
7.	Provide windbreak walls or greenbelt on three sides of open stock piles	Install three sided enclosures, which extend to average height of the stockpile, where ever feasible.
8.	Provide partial enclosure for retrieving area.	Flexible type wind breaking enclosure should be provided covering the clinker retrieval area as wind barrier to prevent dust carry over by wind. The enclosure could be of lightweight material like moulded plastic material or similar, which could be dismantled / assembled and shifted from one place to other.
9.	The travel path of pay loaders should be paved and frequently swept.	Travel areas path used by the front – end pay loader shall be paved with concrete. It should be regularly swept by high efficiency vacuum sweeper to minimize the material build – up.
10.	Provide loading of clinker by pay loaders into trucks / trailers be carried out in an enclosure vented to a bag	The possibilities especially in new cement plant may be explored for the following: An enclosure fitted with bag filter could

	filter.	be located at the most central place adjacent to the clinker storage area. The pay loader moves to the fixed loading area from one end of the enclosure and the truck/trailer enters the enclosure from other end.

6. Storage of Limestone, Gypsum, Flyash and other additives:

Sr. No.	Control Measures to be Provided	Guidelines
1.	The storage should be done under covered shed.	The enclosure walls shall cover minimum two sides up to roof level.
2.	Dry fly ash shall be transported by closed tankers. In case of wet fly ash trucks may be used for transportation.	Flyash shall be pumped directly from the tankers to silos pneumatically in closed loop or mechanically such that fugitive emissions do not occur.
3.	Dry Fly ash shall be stored in silos only.	The silo vent be provided with a bag filter type system to vent out the air borne fines.
4.	Flyash in the dry form should be encouraged and in wet form should be discouraged. In case wet flyash is to be used, it may be stored in open temporarily for the purpose of drying with necessary wind break arrangement to avoid wind carryover of fly ash. The fly ash should be removed immediately after drying.	If possible, the dry flyash should be sent to closed silos. Otherwise, flyash should be transported through closed belt conveyors to avoid wind carryover of flyash.

7. Cement Packing Section:

Sr. No.	Control Measures to be Provided	Guidelines
1.	Provide dust extraction arrangement for packing machines.	The packing machines should be equipped with dust extraction arrangement such that the packing operation is performed under negative pressure. The dust may be captured in bag filters.
2.	Provide adequate ventilation for the packing hall.	Adequate ventilation for the packing hall should be provided for venting out suspended particulate thereby ensuring dust free work environment.
3.	Spillage of cement on floor shall be minimized and cleared daily to prevent fugitive emissions.	The spilled cement from the packing machine should be collected properly and sent for recycling. The spilled cement on the shop floor should be swept by vacuum sweeping machines periodically. Proper engineering controls to prevent the fugitive emissions may include arrangements like providing guiding plate, scrapper brush for removing adhered dust on cement bag etc.
4.	Prevent emissions from the recycling screen by installing appropriate dust extraction system.	The vibratory screen provided for screening/ recycling spilled cement should be provided with a dust extraction arrangement to prevent fugitive emission from that section.

8. Silo Section :

Sr. No.	Control Measures to be Provided	Guidelines
1.	The silo vent be provided with a bag filter type system to vent out the air borne fines.	The bag filter should be operated and maintained properly, especially the cleaning of bags to avoid pressurization of silos thereby causing fugitive emissions from leakages etc.

9. Roads:

Sr. No.	Control Measures to be Provided	Guidelines
1.	All roads on which vehicle movement of raw materials or products take place should be paved.	The paved roads should be maintained as paved at all times and necessary repairs to be done immediately after damages to the road if any.
2.	Limit the speed of vehicles.	Limit the speed of vehicle to 10 Km/h for heavy vehicles with in the plant premises to prevent the road dust emissions.
3.	Employ preventive measures to minimize dust build up on roads.	Preventive measures include covering of trucks and paving of access areas to unpaved areas.
4.	Carry out regular sweeping of roads to minimize emissions.	Mitigative controls include vacuum sweeping, water flushing.

9.2 Requirement of Maintaining Documentation and Records:

The industry shall maintain records to document the specific dust control actions taken and maintain such records for a period of not less than two years and make such records available to the regulatory authorities upon request. In addition documents of technical specifications of the control system and O&M guidelines should also be maintained. (Refer Appendix A1 for details of documents and records to be maintained)

9.3 Requirement of trained Manpower

- The industry shall employ or contract a “dust control officer” who shall be available on site during working hours and should have authority to expeditiously employ sufficient dust mitigation measures to ensure control of fugitive emissions especially in abnormal circumstances. A suitably qualified person could be designated to operate as dust control officer. But, he should be provided necessary training and should be aware of operational, maintenance aspects. He should be responsible for proper control of fugitive emissions. Environmental Officer may act as a Dust Control Officer.

- Regular training should be given to the personnel operating and maintaining fugitive emissions control systems on the operational and maintenance aspects and record keeping responsibility.

9.4 Operation and Maintenance Requirement for all Dust Extraction cum Bag filter Systems:

- A "U"-tube manometer (of minimum 400 mm length) shall be fixed at all bag filters. It shall be connected with inlet and outlet side of the bag filter through flexible rubber tubes. Coloured water should be filled to zero level mark for proper visibility of the pressure drop across bag filter.

- The minimum dust extraction volume should be based on the guidelines for ventilating various sources as per industrial ventilation hand book guidelines

- Un-interrupted supply of dry compressed air at desired pressure should be always ensured for pulsejet cleaning type bag filter.

- The flow rate and static pressure at the bag filter inlet should be monitored at least quarterly and recorded to ensure appropriate functioning of the bag filter installed.

- A sampling platform, portable and access ladder shall be provided at the final stack to carry out stack monitoring (in main stacks). Final emission should not exceed the prescribed standard.

- In systems where water is also spread, it should be ensured that water does not get carried over/sucked to the bag filter.

- The details such as bag house specifications, layout drawing, operation and maintenance guidelines are to be maintained.

9.5 Operation and maintenance Requirements for all Dust Suppression Systems:

- Basic details/specifications of the dust suppression systems installed at various locations should be maintained. The information should contain the quantity of water sprayed in LPH, number of nozzles, type of nozzles, desired water pressure, details of suppliers of spares, pipeline diagram, system layout etc.

- A fine mesh micro filter should be installed for filtering suspended solids from water prior to pumping to the nozzles to prevent choking of nozzles thereby ensuring proper sprays.

- A pressure gauge and water flow meter shall be installed at major source for on-line measurements and a record be maintained for quantity of water sprayed.

9.6 SPM Concentration Standard for Assessing Effectiveness of Control Measures Adopted:

- The effectiveness of prevention cum control measures provided for controlling fugitive emissions from any source shall be said to be satisfactory, provided the SPM concentration, measured at 10 metre distance (from the enclosure wall housing the emission source or from the edge of the stockpiles/pavement area) in downwind direction shall not exceed 2000 microgram per cubic metre and 5000 microgram per cubic metre for coal yard /coal stock pile and rest other area respectively. These standards are for one year period and will be reviewed after one year. In cases where SPM concentrations exceed the prescribed limit, necessary corrective measures in terms of improving the controls shall be taken and action taken records of improvements carried out be maintained.

- The measurement shall be carried out by High Volume / Respirable type samplers as per standard method prescribed by CPCB/BIS, covering at least 4 hours duration (240 minutes) during normal working hours with normal production rate of the operation / source being monitored on quarterly basis.

9.7 General Guidelines (For areas not otherwise specified)

Apart from the specific guidelines provided above for some specific sections/areas, for all other fugitive dust emitting areas, following general guidelines would apply.

- The industry should prevent fugitive emission from all active operation and storage piles, such that the emissions are not visible in the atmosphere beyond the boundary line of the emission source.

- The Industry shall conduct active operations by utilizing the applicable best available control measures to minimize the fugitive dust emission from each fugitive dust source type within active operation.

- Except for Gypsum and Clinker, all storage piles should be kept in moist condition by spraying water at regular intervals for controlling fugitive emission, wherever possible

- The operation of the pay loaders shall be slow down whenever the average wind speed is high exceeding 50 km/h, which may cause fugitive emission.

- All storage silos shall be vented to bag filters, which should have proper bag cleaning arrangement so as to avoid choking of filter bags, thereby to avoid pressurization of silos.

- Regular inspection at a pre-determined frequency be carried out of all fugitive dust control system and records be maintained of such inspection and corrective action taken if any.

Appendix A.1

A 1: List of Documents & records to be maintained for fugitive dust control

Title of Record to be maintained	Frequency of Recording	Information to be recorded
Documents:		
List of Fugitive Emission Management Systems (FEMS) installed	To be up-dated once in a year	Location of FEMS, marked on process flow diagram, Identity Number, Type of FEMS, Year of installation, Operating Status
Technical Specifications of FEMS installed		
Specification of Dust suppression system	As and when installed/modified	Locations of controlling emissions, Identity Number, Supplier Name, Date of Commissioning, Pump HP, flow rate in LPM, Pressure in kg/cm2, Nozzles type, numbers, LPM, O&M instruction from supplier.
Specification of Dust Extraction cum APCD	As and when installed/modified	Location of system installed, Identity Number, Name of system supplier, date of commissioning, flow rate in m3/hr, Time, flow m3/hr, static pressure mmWc, velocity m/sec, Current Drawn by ID fan motor, operation & maintenance instruction from supplier.
Capacities of Closed Storages	Annually	For coal, limestone, clinker, gypsum, cement, additives, flyash, Dimensions, bulk density, Tons
Capacities of Open Storages	Annually	For coal, limestone, clinker, gypsum, additives, flyash, Dimensions, bulk density, Tons
Records		
Replacement of Damaged filter bags	As and when replaced	Number of Bags replaced, Date, Bag filter Identification number
Measurement of	Once a month	Bag filter Number, Date of monitoring,

flow rate static pressure at bag filter inlet		Time, flow m3/hr, static pressure mmWc, velocity m/sec, Current Drawn by ID fan motor Name of the person
Stack Monitoring of bag filters stack, where ever monitoring is feasible	Quarterly	Bag filter Number, Date of monitoring, Time, Measured Data in m3/hr and mmWc, Dust concentration in mg/Nm3
Operational Details of Dust Suppression System	Once in a month	Quantity of material handled, Quantity of water sprayed, number of operational nozzles, water pressure at filter inlet and outlet, details of damaged nozzles and replacements,
Road Sweeping record	Daily	Road location swept, date, running hours of sweeping machines
Quantity of coal in open storage, if any	Quarterly	Inventory of Existing storage, add on, retrieved on quarterly basis, Date
Quantity of clinker in open storage, if any	Quarterly	Inventory of Existing storage, add on, retrieved on quarterly basis, Date
Corrective actions taken for improving controls	As and when	Details of modifications carried out, level of reduction in SPM achieved

Annexure 1.1

Scope of Work

Part-I to be executed by National Productivity Council (NPC), New Delhi

1. Identification of all fugitive emission sources in cement manufacturing plants. (The various indicative areas could be storage areas of raw material and finished products, coal, cement kiln dust etc., transfer operation, loading the unloading operations, vehicular movements on paved roads etc.)

2. Literature survey on fugitive emissions control practices adopted within and outside India, guidelines/standards, if any, in developed countries etc.

3. Selection of 10 cement plants in consultation with CPCB for the purpose of conducting detailed field studies in 6 units and general observation in 4 more units.

4. Conduction of field studies in 6 number of cement plants for the following aspects:

   (i) Detailed observations of various fugitive dust generating areas/sources and types of controls adopted to pinpoint specific problem areas and causes of emissions.
   (ii) Generation of first hand data on system specifications adopted and their operation and maintenance practices.
   (iii) Conduction of air quality monitoring at representative locations for SPM and RSPM for assessing existing controls.
   (iv) Generation of data through stack measurement such as flow, pressure, particle, size distribution, dust concentration, appropriateness of system lay out, duct sizing etc. for existing representative fugitive dust control systems installed in some cement plants and through literature survey of data/information from international organizations.
   (v) Collection of the field samples (for analysis by IIT, Kanpur for the purpose of estimation of fugitive emissions), as per sampling plan evolved by IIT, Kanpur involving sampling by various techniques such as quasi stack monitoring, roof monitoring, material balance, finger printing technique etc., as detailed Part-II of SOW. (Maximum number of samples to be collected is 60). The collected samples will be given/sent to IIT, Kanpur for its analysis for required parameters by IIT and further computations. These samples will be additional to the samples collected by NPC for Part-I study.

5. Analysis of various of technology options for its suitability to control fugitive emissions.

6. To evolve technical suggestions/schemes for achieving effective fugitive dust emission control.

7. Development of environmental guidelines/standards for prevention/control of fugitive emissions.

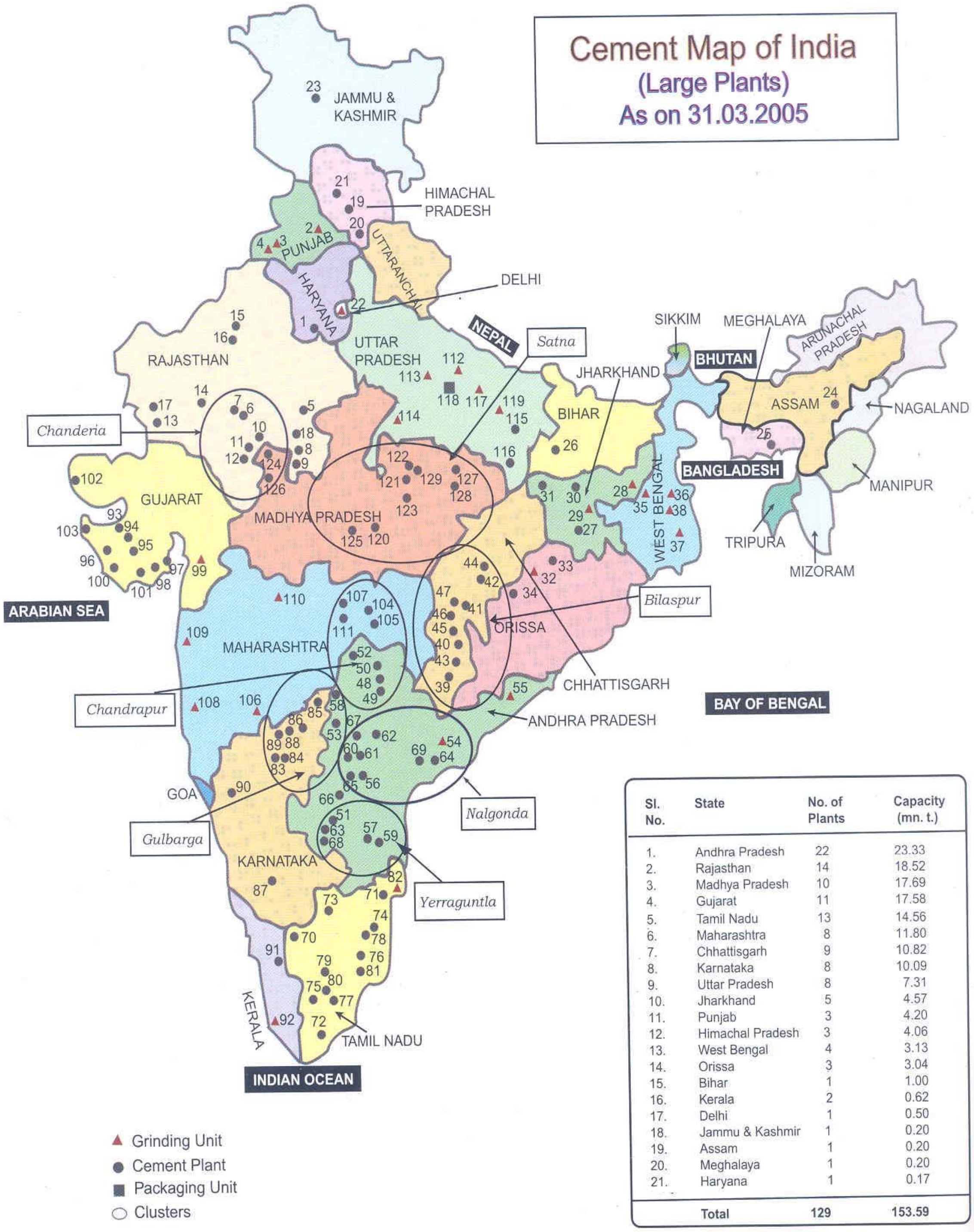
Part-II to be executed by Indian Institute of Technology, Kanpur

1. Classification of fugitive emission sources
2. Identification of one of the following suitable methods for estimation and quantification of fugitive emissions.

    - Estimations based on emission factors developed by USEPA (AP-42 Guide).
    - Up wind and down wind method
    - Material balance approach
    - Quasi-stack sampling
    - Roof monitoring method
    - Finger printing technique.

3. Characterization of the dust and analysis of the samples for metals.

Cement Map of India
(Large Plants)
As on 31.03.2005



Sl. No.	State	No. of Plants	Capacity (mn. t.)
1.	Andhra Pradesh	22	23.33
2.	Rajasthan	14	18.52
3.	Madhya Pradesh	10	17.69
4.	Gujarat	11	17.58
5.	Tamil Nadu	13	14.56
6.	Maharashtra	8	11.80
7.	Chhattisgarh	9	10.82
8.	Karnataka	8	10.09
9.	Uttar Pradesh	8	7.31
10.	Jharkhand	5	4.57
11.	Punjab	3	4.20
12.	Himachal Pradesh	3	4.06
13.	West Bengal	4	3.13
14.	Orissa	3	3.04
15.	Bihar	1	1.00
16.	Kerala	2	0.62
17.	Delhi	1	0.50
18.	Jammu & Kashmir	1	0.20
19.	Assam	1	0.20
20.	Meghalaya	1	0.20
21.	Haryana	1	0.17
	Total	**129**	**153.59**

Annexure 2.1

List of Cement Plants in India

S.No.	Region/State	Location	Installed Capacity (Million Tonnes)	Total Capacity
NORTHERN REGION				25.49
1	CCI Ltd.	Charkhi-Dadri	0.17	0.17
	PUNJAB			
2	Gujarat Ambuja Ltd. (G)	Ropar	1.34	
3	Gujarat Ambuja Ltd. (G)	Bhatinda	0.50	
4	Grasim Cement	Bhatinda	1.00	2.84
	RAJASTHAN			
5	ACC Ltd.	Lakheri	0.60	
6	Birla Cement	Chittorgarh	0.72	
7	Chittor Cement	Chittorgarh	1.28	
8	Mangalam Cement	Morak	0.40	
9	Neer Shree Cement	Morak	0.60	
10	Aditya Cement	Shambhupura	1.75	
11	J.K.Cement	Nimbahera	2.54	
12	J.K.Cement	Mangrol	0.75	
13	Lakshmi Cement	Sirohi Road	2.23	
14	J.K.Udaipur Udyog	Udaipur	0.90	
15	Ambuja Cement Raj.Ltd.	Pali	1.50	
16	Shree Cement	Beawar	2.60	
17	Binani Cement	Sirohi	1.65	
18	Shriram Cement	Kota	0.20	17.72
	HIMACHAL PRADESH			
19	ACC Ltd.	Gagal	2.70	
20	CCI Ltd.	Rajban	0.20	
21	Gujarat Ambuja Ltd.	Darlaghat	1.16	4.06
	DELHI			
22	CCI Ltd. (G)	Tughalakabad	0.50	0.5
	JAMMU & KASHMIR			
23	J & K Cements	Khrew	0.20	0.2
EASTERN REGION				22.5
	ASSAM			
24	CCI Ltd.	Bokajan	0.20	0.2
	MEGHALAYA			
25	Mawmluh Cherra	Cherrapunji	0.20	0.2
	BIHAR			
26	Kalyanpur Cement	Banjari	1.00	1

JHARKHAND				
27	ACC Ltd.	Chaibasa	0.61	
28	ACC Ltd.	Sindri	0.60	
29	Lafarge (G)	Singhbhum	3.00	
30	Lemos Cement	Khalari	0.11	
31	Sone Valley	Japla	0.25	4.57
ORISSA				
32	L & T Ltd. (G)	Jharsuguda	0.80	
33	OCL India Ltd.	Rajgangpur	1.28	
34	IDCOL Cement	Bargarh	0.96	3.04
WEST BENGAL				
35	Damodhar Cement & Slag (G)	Purulia	0.53	
36	Birla Corporation Ltd. (G)	Durgapur	0.60	
37	Ambuja Eastern - WB (G)	Sankrail	1.00	
38	L & T Industries (G)	Durgapur	1.00	3.13
CHHATISGARH				
39	ACC Ltd.	Jamul	1.58	
40	Century Cement	Tilda	1.20	
41	Grasim Cement	Raipur	1.90	
42	CCI Ltd.	Akaltara	0.40	
43	CCI Ltd.	Mandhar	0.38	
44	Lafarge Arasmeta	Bilaspur	1.60	
45	L & T Ltd.	Hirmi	1.90	
46	Ambuja Eastern - CTG	Bhatapara	1.00	
47	Lafarge	Sonadih	0.40	10.36
SOUTHERN REGION				48.6
ANDHRA PRADESH				
48	ACC Ltd.	Macherial	0.33	
49	Kesoram Cement	Ramagundam	0.90	
50	Orient Cement	Devapur	1.30	
51	Zuari Cement	Krishna Nagar	2.20	
52	CCI Ltd.	Adilabad	0.40	
53	CCI Ltd.	Tandur	1.00	
54	Andhra Cement (G)	Vijayawada	0.24	
55	Andhra Cement (G)	Vishakhapatnam	0.50	
56	Andhra Cement	Nadikude	1.00	
57	India Cements	Chilamkur	1.30	
58	India Cements - Visaka	Tandur	1.12	
59	India Cements	Yerraguntla	0.52	
60	Rassi Cement	Wadapally	2.30	
61	Sri Vishnu Cement	Sitapuram	1.20	
62	Madras Cements	Jaggayyapet	1.60	

63	UltraTECH Cement Ltd. (APCW)	Tadipatri	2.30	
64	Kistna	Kistna	0.21	
65	KCP Ltd.	Macherla	0.58	
66	Panyam Cements	Bugganipalle	0.53	
67	Rain Industries Ltd.	Ramapuram	1.00	
68	Penna Cement	Tadipatri	1.50	
69	Penna Cement	Ganeshpahad	1.00	23.33
TAMIL NADU				
70	ACC Ltd.	Madukkarai	0.96	
71	Grasim South	Reddlpalayam	1.03	
72	India Cements	Tulaiyuth	1.55	
73	India Cements	Sankaridurg	0.72	
74	India Cements	Trichy	1.30	
75	Tamil Nadu Cements	Alangulam	0.40	
76	Tamil Nadu Cements	Ariyalur	0.50	
77	Madras Cements	R.S.Raja Nagar	0.75	
78	Madras Cements	Alathiyur	3.12	
79	Chettinad Cement	Karur	0.60	
80	Chettinad Cement	Karikalli	1.20	
81	Dalmia Cements	Dalmiapuram	1.23	
82	UltraTECH Cement Ltd.- ARCW (G)	Arakonam	1.20	14.56
KARNATAKA				
83	ACC Ltd.	Wadi	2.11	
84	ACC Ltd. - New	Wadi	2.60	
85	Vasavadatta Cement	Sedam	1.20	
86	Rajashree Cement	Malkhed	2.60	
87	Mysore Cements	Ammasandra	0.57	
88	CCI Ltd.	Kurkunta	0.20	
89	HMP Cements Ltd.	Shahabad	0.48	
90	Kanoria Industries	Bagalkot	0.33	10.09
KERALA				
91	Malabar Cements	Palghat	0.42	
92	Malabar Cements (G)	Alappuzha	0.20	0.62
WESTERN REGION				29.38
GUJARAT				
93	Sikka	Sikka	1.08	
94	Saurashtra Cement	Ranavav	1.16	
95	Gujarat Sidhee Cement	Veraval	1.20	
96	HMP Cements Ltd.	Porbandar	0.20	
97	UltraTECH Cement Ltd. - GCW	Pipavav	5.30	
98	Narmada Cement	Jafrabad	0.40	
99	Narmada Cement (G)	Magdalla	0.70	

100	Ambuja Cement	Kodinar	1.50	
101	Gujambuja Cement	Kodinar	3.00	
102	Sanghi Industries Ltd.	Abdasa	2.60	
103	Tata Chemicals Ltd.	Mithapur	0.44	17.58
		MAHARASHTRA		
104	ACC Ltd.	Chanda	1.00	
105	Manikgarh Cement	Manikgarh	1.50	
106	Rajashree Cement (G)	Horgi	1.40	
107	UltraTECH Cement Ltd.(ACW)	Chandrapur	3.30	
108	Narmada Cement (G)	Ratnagiri	0.40	
109	Indo Rama Cement (G)	Raigad	1.00	
110	Orient Cement (G)	Jalgaon	0.80	
111	Maratha Cement	Chandrapur	2.40	11.8
CENTRAL REGION				25
		UTTAR PRADESH		
112	ACC Ltd. (G)	Tikaria	2.00	
113	Birla Cement (G)	Raebareli	0.63	
114	Diamond Cement (G)	Jhansi	0.50	
115	U.P.State Cement	Churk	0.47	
116	U.P.State Cement	Dalla	0.43	
117	U.P.State Cement (G)	Chunar	1.68	
118	Jaypee Cement (G)	Sadva Khurd	0.60	
119	Jaypee Cement (G)	Tanda	1.00	7.31
		MADHYA PRADESH		
120	ACC Ltd.	Kymore	1.70	
121	Birla Vikas	Satna	0.80	
122	Satna Cement	Satna	0.75	
123	Maihar Cement	Maihar	3.00	
124	Vikram Cement	Jawad Road	3.00	
125	Diamond Cement	Damoh	1.03	
126	CCI Ltd.	Neemuch	0.40	
127	Jaypee Cement	Rewa	2.50	
128	Jaypee Cement	Bela	2.00	
129	Prism Cement	Satna	2.51	17.69
	Grand Total: (129 Plants)			**153.59**

Cement Process Description

- **Raw Materials Acquisition and Handling**

The initial production step in cement manufacturing is raw materials acquisition. Calcium, the element of highest concentration in cement, is obtained from a variety of calcareous raw materials, including limestone, chalk, sea shells, and an impure limestone known as “natural cement rock”. Typically, these raw materials are obtained from open-face quarries, but underground mines are also used. Raw materials vary from facility to another. Some quarries produce relatively pure limestone that requires the use of additional raw materials to provide the correct chemical blend in the raw mix. In other quarries, all or part of the non-calcarious constituents are found naturally in the limestone. Occasionally, pockets of pyrite, which can significantly increase emissions of sulfur dioxide, are found in deposits of limestone, clays, and shales used as raw materials for portland cement.

Because a large fraction (approximately one third) of the mass of this primary material is lost as carbon dioxide in the kiln, cement plants are located close to a calcareous raw material source whenever possible. Other elements included in the raw mix are silicon, aluminum and iron. These materials are obtained from ores and minerals such as sand, shale, clay, and iron ore. Again, these materials are most commonly from open-pit quarries or mines, but they may be dredged or excavated from underwater deposits. Either gypsum or natural anhydrite (forms of calcium sulfate), is introduced to the process during the finish grinding operations. These minerals (also excavated from quarries or mines), are generally purchased from an external source, rather than obtained directly from captive operations by the cement plant.

The cement manufacturing industry is relying increasingly on replacing virgin materials with waste materials or byproducts from other manufacturing operations, to the extent that such replacement can be implemented without adversely affecting plant operations, product quality or the environment. Materials that have been used include fly ash, metal-smelting slags, etc.

- **Kiln Feed Preparation**

The second step in cement manufacture is preparing the raw mix, or kiln feed, for the pyro processing operation. Raw material preparation includes a variety of blending and sizing operations that are designed to provide a feed with appropriate chemical and physical properties. The raw material processing operations differ somewhat for wet and dry processes, as described below.

Cement raw materials are received with an initial moisture content varying from 1 to more than 50 percent. If the facility uses dry process kilns, this moisture is usually reduced to less than 1 percent before or during grinding. Drying alone can be accomplished in impact dryers, drum dryers, paddle-equipped rapid dryers, air separators, or autogenous mills. However, drying can also be accomplished during grinding in ball-and-tube mills or roller mills. While thermal energy for drying can be supplied by exhaust gases from separate, direct-fired coal, oil or gas burners, the most efficient and widely used source of heat for drying is the hot exit gases from the pyro processing system.

Materials transport associated with dry raw milling systems can be accomplished by a variety of mechanisms, including screw conveyors, belt conveyors, drag conveyors, bucket elevators, air slide conveyors, and pneumatic conveying systems. The dry raw mix is pneumatically blended and stored in specially constructed silos until it is fed to the pyro processing system.

In the wet process, water is added to the raw mill during the grinding of the raw materials in ball or tube mills, thereby producing pumpable slurry with approximately 65% solids. The slurry is agitated, blended, and stored in various kinds and sizes of cylindrical tanks or slurry basins until it is fed to the pyroprocessing system.

- **Pyroprocessing**

The heart of the cement manufacturing process is the pyroprocessing system. This system transforms the raw mix into clinkers, which are gray, glass-hard, spherically shaped nodules that range from 0.32 to 5.1 centimeters (cm) in diameter. The chemical reactions and physical processes that constitute the transformation are quite complex, but they can be viewed conceptually as the following sequential events:

    - Evaporation of free water

- Evolution of combined water in the argillaceous components
- Calcination of the calcium carbonate ($CaCO_3$) to calcium oxide (CaO)
- Reaction of CaO with silica to form dicalcium silicate
- Reaction of CaO with the aluminum and iron-bearing constituents to form the liquid phase
- Formation of the clinker nodules
- Evaporation of volatile constituents (e.g. sodium, potassium, chlorides and sulfates) and
- Reaction of excess CaO with dicalcium silicate to form tricalcium silicate

This sequence of events may be conveniently divided into four stages, as a function of location and temperature of the materials in the rotary kiln.

1. Evaporation of uncombined water from raw materials, as material temperature increases to 100^0C.
2. Dehydration, as the material temperature increases from 100^0C to approximately 430^0C to form oxides of silicon, aluminum, and iron
3. Calcination during which carbon dioxide (CO_2) is evolved, between 900^0C and 982^0C, to form CaO and
4. Reaction, of the oxides in the burning zone of the rotary kiln, to form cement clinker at temperatures of approximately 1510^0C.

Rotary kilns are long, cylindrical, slightly inclined furnaces that are lined with refractory to protect the steel shell and retain heat within the kiln. The raw material mix enters the kiln at the elevated end, and the combustion fuels generally are introduced into the lower end of the kiln in a countercurrent manner. The materials are continuously and slowly moved to the lower end by rotation of the kiln. As they move down the kiln, the raw materials are changed to cementitious or hydraulic minerals as a result of the increasing temperature within the kiln. The most commonly used kiln fuels are coal, natural gas, and occasionally oil. The use of supplemental fuels such as waste solvents, scrap rubber, and petroleum coke has expanded in recent years.

Five different processes are used in the cement industry to accomplish the pyro-processing step: the wet process, the dry process (long dry process), the semidry process, the dry process with a pre heater, and the dry process with a preheater/precalciner. Each of these processes accomplishes the physical/chemical steps defined above. However, the processes vary with respect to equipment design, method of operation, and fuel consumption. Generally, fuel consumption decreases in the order of the processes listed. The paragraphs below briefly describe the process, starting with the wet process and then noting differences in the other processes.

- **Wet Process**

In the wet process and long dry process, all of the pyro processing activity occurs in the rotary kiln. Depending on the process type, kilns have length-to-diameter ratios in the range of 15:1 to 40:1. While some wet process kilns may be as long as 210 m, many wet process kilns and all dry process kilns are shorter. Wet process and long dry process pyro processing systems consist solely of the simple rotary kiln. Usually, a system of chains is provided at the feed end of the kiln in the drying or preheats zones to improve heat transfer from the hot gases to the solid materials. As the kiln rotates, the chains are raised and exposed to the hot gases. Further kiln rotation causes the hot chains to fall into the cooler materials at the bottom of the kiln, thereby transferring the heat to the load.

- **Dry Process**

Dry process pyro processing systems have been improved in thermal efficiency and productive capacity through the addition of one or more cyclone-type preheater vessels in the gas stream exiting the rotary kiln. This system is called the pre heater process. The vessels are arranged vertically, in series, and are supported by a structure known as the Preheater tower. Hot exhaust gases from the rotary kiln pass counter currently through the downward moving raw materials in the pre heater vessels compared to the simple rotary kiln, the heat transfer rate is significantly increased, the degree of heat utilization is greater, and the process time is markedly reduced by the intimate contact of the solid particles with the hot gases. The improved heat transfer allows the length of the rotary kiln to be reduced. The hot gases from the pre heater tower are often used as a source of heat for drying raw materials in the raw mill. Because the catch from the mechanical collectors, fabric filters and/or electrostatic precipitators (ESP) that follow the raw mill is returned to the process, these devices are considered to be production machines as well as pollution control devices.

Additional thermal efficiencies and productivity gains have been achieved by diverting some fuel to a calciner vessel at the base of the pre heater tower. This system is called the preheater/precalciner process. While a substantial amount of fuel is used in the pre calciner, at least 40 percent of the thermal energy is required in the rotary kiln. The amount of fuel that is introduced to the calciner is determined by the availability and source of the oxygen for combustion in the calciner. Calciner systems sometimes use lower-quality fuels (e.g. less-volatile matter) as a means of improving process economics.

- **Semi-Dry Process**

The semidry process is a variation of the dry process. In the semidry process, the water is added to the dry raw mix in a pelletizer to form moist nodules or pellets. The pellets then are conveyed on a moving grate Preheater before being fed to the rotary kiln. The pellets are dried and partially calcined by hot kiln exhaust gases passing through the moving grate.

- **Clinker Cooler Process**

Regardless of the type of pyroprocess used, the last component of the pyro processing system is the clinker cooler. This process step recoups up to 30 percent of the heat input to the kiln system, locks in desirable product qualities by freezing mineralogy, and makes it possible to handle the cooled clinker with conventional conveying equipment. The more common types of clinker coolers are (1) reciprocating grate, (2) planetary, and (3) rotary. In these coolers, the clinker is cooled from about 1100^0C to 93^0C by ambient air that passes through the clinker and into the rotary kiln for use as combustion air. However, in the reciprocating grate cooler, lower clinker discharge temperatures are achieved by passing an additional quantity of air through the clinker. Because this additional air cannot be utilized in the kiln for efficient combustion, it is vented to the atmosphere, used for drying coal or raw materials, or used as a combustion air source for the precalciner.

- **Finished Cement Grinding**

The final step in cement manufacturing involves a sequence of blending and grinding operations that transforms clinker to finished cement. Up to 5 percent gypsum or natural anhydrite is added to the clinker during grinding to control the cement setting time, and other specialty chemicals are added as needed to impart specific product properties. This finish milling is accomplished almost exclusively in ball or tube mills. Typically, finishing is conducted in a closed circuit system, with product sizing by air separation.

Annexure 3.1

Section wise Details of APCD's Employed for control of Fugitive Emissions in Lafarge - Sonadih Cement Plant

Section wise details of APCDs Employed for control of Fugitive Emissions				
	Name of the cement Plant	Lafarge Cement		
Sl. No.	APCD Location	Flow Rate	Filteration Area	Motor Capacity
	Units	(m^3/hr)	(m^2)	(kWh)
I	**Limestone Section (Unloading to Stacker)**	**Installed Capacity: 7000 TPD**		
1	Unloading Dump Hopper			11
2	Limestone Crusher	27500	302	30
3	TP- (Crusher to Surge Hopper)	23000	23	37
4	TP (Surge Hopper to Stacker)	7200	60	15
	Sub-Total	**57700**	**385**	**93**
II	**Coal Section (U/L to Stacker)**	**Installed Capacity: 700 TPD**		
1	Unloading Dump Hopper	7200	108	15
2	Coal Crusher	8500	119	11
3	TP (Crusher to Stockpile)	5880	12	7.5
		7200	89	11
	Sub-Total	**28780**	**328**	**34.5**
III	**R. M. Section (Reclaimer to R. M. Blending Silo)**	**Installed Capacity: 7600 TPD**		
1	TP (LS Reclaimer to Day Silo)	14280	141	30
2	Additive Unloading Dump Hopper	7200	70	15
3	TP (Additive Dump Hopper to Day Silo)	6500	70	15
4	TP (Lime stone reclaimer to weigh Bins)	23100	233	45
5	TP (Day Silo to VRM)	23000	204	37
6	TP (VRM Reject to VRM)	11000	121	18.5
7	Vent-Raw Meal Airlift	5500	59	11
8	Vent- Airlift Cyclonic Seperator of Raw Meal	67500	621	110
6	Vent-Raw Meal Blending Silo	4000	44	11
	Sub-Total	**94580**	**1563**	**292.5**
IV	**Coal Mill Section**	**Installed Capacity: 700 TPD**		
1	Vent-Raw Coal Hopper	10980	167	22
2	Reclaimer Tunnel Upstream	5880	99	11
3	Reclaimer Tunnel Downstream	5880	99	11
4	TP-Tunnel to Coal Bin	5880	99	11
5	Vent - Mill Buffer Hopper	1500	19	2.2
6	Vent- Fine Coal Dosing Bin to Kiln	5500	84	5.5
7	Vent- Fine Coal Dosing Bin to PC	5500	84	5.5
	Sub-Total	**41120**	**651**	**88**
V	**Calcination Section**	**Installed Capacity: 8000 TPD**		
1	Vent- Raw Meal Day Bin	8000	78	5.5

2	Vent-Air slide to Kiln	5500	59	5
3	Vent-Kiln Feed Preheater cyclone	34500	311	50
	Sub-Total	**48000**	**448**	**60.5**
VI	**Clinker Section (Clinker cooler to Clinker Silo/Stock pile)**	**Installed Capacity: 1500 TPD**		
2	TP (Grate Cooler to Clinker Silo)	11000	121	18.5
3	Vent-Clinker Silo	10000	78	15
4	Vent- Clinker Wagon Loading Silo	57500	544	75
	Sub-Total	**78500**	**743**	**108.5**
VII	**Cement Mill to Silo**	**Installed Capacity: 1500 TPD**		
1	TP- Clinker Silo Dump to Surge Bin	12500	121	18.5
2	TP-Clinker Silo Dump to Surge Bin	12500	328	55
3	Vent-Clinker Surge Bin	6500	85	11
4	TP- Roller Press Circuit-BE/BC	10750	119	15
5	Cement Silo Vent	10750	119	15
6	Vent-Cement Separator	21500	289	30
7	Vent- Cement Silo	10750	141	5.5
8	Vent- Cement Silo	5500	70	7.5
	Sub-Total	90750	1272	108
VIII	**Packing Section (Silo to Cement Bags)**	**Installed Capacity: 1500 TPD**		
1	Packing Machine	37000	425	75

Section wise details of APCDs Employed for control of Fugitive Emissions in Maratha Cement Works

Section wise details of APCD's Employed for control of Fugitive Emissions					
	Name of the cement Plant	Maratha Cement			
Sl. No.	**APCD Location**	**No. of APCD**	**Flow Rate**	**Filtration Area**	**Motor Capacity**
Units			**(m^3/hr)**	**(m^2)**	**(kWh)**
I	**Limestone Section (U/L to Stacker)**	**Installed Capacity: 14000 TPD**			
1	Unloading Dump Hopper				
2	Limestone Crusher	1	90,000	1047	90
3	TP- (Crusher to Surge Hopper)	1	10000	123	18.5
4	TP (Surge Hopper to Stacker)	2	5000	60	9
	Sub-Total		**105000**	**230**	**117.5**
II	**Coal Section (U/L to Stacker)**	**Installed Capacity: 1105 TPD**			
1	Unloading Dump Hopper	2	40000	492	75
2	Coal Crusher	1	12000	154	15
3	TP (Crusher to Stockpile)	No APCD			
	Sub-Total		**52000**	**646**	**90**
III	**R.M Section (Reclaimer to R.M Blending Silo)**	**Installed Capacity: 15000 TPD**			
1	TP (LS Reclaimer to Day Silo)	1	Data Not available		
2	Additive Unloading Dump Hopper	No APCD			
3	TP (Additives Dump hopper to Day Silo)	1	Data Not available		
4	Lime stone - Day Silo	1	18000	226	30
5	TP (Limestone reclaimer to weigh Bins)	2	15000	185	30
6	TP (VRM Reject to VRM)	1	10000	124	Not Available
7	Vent-Raw Meal B/E	1	15000	185	30
8	Vent-Raw Meal Blending Silo	1	20000	247	30
9	Blending silo	1	15000	185	30
10	Vent Points	1	10000	124	Not Available
11	Glass Bag House dust bin vent	3	18000	226	
	Sub-Total		**121000**	**1502**	**150**
IV	**Coal Mill Section**	**Installed Capacity : 1105 TPD**			
1	Vent-Raw Coal Hopper	1	5000	68	22
2	Reclaimer Tunnel Upstream	Not Applicable			
3	Reclaimer Tunnel Downstream	Not Applicable			
4	TP-Reclaimer to Coal Bin	1	5000	68	22
5	Vent - Mill Buffer Hopper	Not Applicable			
6	Vent- Fine Coal Dosing Bin to Kiln	Not Applicable			
7	Vent- Fine Coal Dosing Bin to PC	1	8000	124	15
	Sub- Total		**18000**	**260**	**59**

V	**Calcination Section**	**Installed Capacity: 16005 TPD**			
1	Vent- Raw Meal Day Bin	Not Applicable			
2	Vent-Air slide to Kiln	1	15000	185	Not available
3	Vent-Kiln Feed Preheater cyclone	Not Applicable			
	Sub-Total		**15000**	**185**	
VI	**Clinker Section (Clinker cooler to Clinker Silo)**	**Installed Capacity : 8000 TPD**			
2	TP (Grate Cooler to Clinker Silo)	N.A			
3	Vent-Clinker Silo	2	18000	226	37
4	Vent- Clinker Wagon Loading Silo				
	Clinker Hopper	4	20000	246	15
	Sub-Total		**38000**	**472**	**52**
VIII	**Cement Mill to Silo**	**Installed Capacity: 9000 TPD**			
1	TP- Clinker Silo to Surge Bin	N.A			
4	TP- Cement Silo Bucket elevator	3	5000	60	11
	Cement Mill Bucket Elevator Vent	3	20000	246	
7	Vent- Cement Silo Extraction	2	10000	124	11
	Cement Silo Vent	2	10000	124	11
	Cement Silo Vent	2	5000	60	11
8	Cement Mill Hoppers		18000	226	30
	Fly ash Silo Vent	2	10000	124	11
9	Fly ash bin Vent	3	10000	124	11
10	Cement Silo Extraction	4	5000	60	11
	Auxiliary Vents	4	20000	246	
	Sub-Total		**113000**	**1384**	**107**
IX	**Packing Section (Silo to Cement Bags)**	**Installed Capacity: 9000 TPD**			
1	Packing Machine	5	20000	246	45
		5	18000	226	45

Section wise details of APCDs Employed for control of Fugitive Emissions in ACC Jamul Cement Works

Section wise details of APCD's Employed for control of Fugitive Emissions					
	Name of the cement Plant	**ACC Jamul**			
Sl. No.	**APCD Location**	**No. of APCD**	**Flow Rate**	**Filtration Area**	**Motor Capacity**
Units			**(m3/hr)**	**(m2)**	**(kWh)**
I	**Limestone Section (U/L to Stacker)**	**Installed Capacity: 4000**			
1	Unloading Dump Hopper	DSS			
2	Limestone Crusher (Primary)	1	11,000	267	30
	Limestone Crusher (secondary)	1			
3	TP- (Crusher to Surge Hopper)	Not applicable			
4	TP (Surge Hopper to Stacker)	Not applicable			
	Sub-Total		**11000**	**267**	**30**
II	**Coal Section (U/L to Stacker)**	**Installed Capacity: 550**			
1	Unloading Dump Hopper	No APCD			
2	Coal Crusher	No APCD			
3	TP (Crusher to Stockpile)	No APCD			
	Sub-Total				
III	**R. M. Section (Reclaimer to R.M Blending Silo)**	**Installed Capacity: 3550**			
1	TP (LS Reclaimer to Day Silo)	No APCD			
2	Additive Unloading Dump Hopper	No Additives			
3	TP (Additives Dump hopper to Day Silo)	No Additives			
4	Lime stone - Day Silo	No APCD			
5	TP (L/s reclaimer to weigh Bins)	No APCD			
6	TP (Ball Mill reject to Ball Mill)	3	60000	678	180
7	Vent-Raw Meal B/E	Not applicable			
8	Vent-Raw Meal Blending Silo	Not applicable			
9	Blending silo	3	60000	678	180
10	Vent Points	Not applicable			
11	Glass Bag House dust bin vent	Not applicable			
	Sub-Total				
IV	**Coal Mill Section**	**Installed Capacity: 550**			
1	Vent-Raw Coal Hopper	No APCD			
2	Reclaimer Tunnel Upstream	Not applicable			
3	Reclaimer Tunnel Downstream	Not applicable			
4	TP-Reclaimer to Coal Bin	Not applicable			
5	Vent - Mill Buffer Hopper	No APCD			
6	Vent- Fine Coal Dosing Bin to Kiln	Connected to process bag filter			

7	Vent- Fine Coal Dosing Bin to PC	Connected to process bag filter			
	Sub-Total				
V	**Calcination Section (Lepol Grate)**	**Installed Capacity: 3550**			
1	Vent- Raw Meal Day Bin (surge hopper)	1	Data Not available		
2	Vent-Air slide to Kiln	Connected to cyclone			
3	Vent-Kiln Feed Preheater cyclone	Connected to Gas Condition tower			
	Sub-Total				
VI	**Clinker Section (Clinker cooler to Clinker Silo)**	**Installed Capacity: 2000**			
2	TP (Grate Cooler to Clinker Silo)	Connected to process bag filter			
3	Vent-Clinker Silo	Not Applicable (Clinker Gantry)			
4	Vent- Clinker Wagon Loading Silo	Not Applicable			
	Clinker Hopper	Not Applicable			
	Sub-Total				
VIII	**Cement Mill to Silo**	**Installed Capacity: 4500**			
1	TP- Clinker Silo Dump to Surge Bin	Data Not available			
2	TP- Cement Silo Bucket elevator	Data Not available			
3	Cement Mill Bucket Elevator Vent	Data Not available			
4	Vent- Cement Silo Extraction	Data Not available			
5	Cement Silo Vent	Data Not available			
7	Cement Mill Hoppers	Data Not available			
8	Slag Silo Vent	Data Not available			
9	Slag Bin Vent	Data Not available			
10	Cement Silo Extraction	Data Not available			
	Sub-Total				
IX	**Packing Section (Silo to Cement Bags)**	**Installed Capacity: 4500**			
1	Packing Machine 1	1		192	
2	Packing Machine 2	1		63	
3	Packing Machine 3	1		63	
4	Packing Machine 4	1		256	
5	Packing Machine 5	1		192	
6	Packing Machine 6	1		256	
7	Packing Machine 7	1		256	
	Sub-Total			**1278**	

Section wise details of APCDs Employed for control of Fugitive Emissions in UltraTech - Awarpur Cement Works

Section wise details of APCD's Employed for control of Fugitive Emissions					
	Name of the cement Plant	UltraTech Cement			
Sl. No.	**APCD Location**	**No of APCD**	**Flow Rate**	**Filtration Area**	**Motor Cap.**
Units			**(m^3/hr)**	**(m^2)**	**(kWh)**
I	**Limestone Section (U/L to Stacker)**	**Installed Capacity: 15000 TPD**			
1	Unloading Dump Hopper	DSS			
2	Limestone Crusher	1	60,000	771	110
3	TP- (Crusher to Surge Hopper)	1	12000	129	13
4	TP (Surge Hopper to Bifurcation point)	1	16100	193	24
5	TP (Bifurcation to Stacker)	1	12000	93	13
	Sub-Total		**100100**	**1186**	**160**
II	**Coal Section (U/L to Stacker)**	**Installed Capacity: 800 TPD**			
1	Unloading Dump Hopper	DSS			
2	Coal Crusher	DSS			
3	TP (Crusher to Stockpile)	No APCD			
	Sub-Total				
III	**R.M Section (Reclaimer to R.M. Blending Silo)**	**Installed Capacity: 16200 TPD**			
1	TP (Limestone Reclaimer to Tertiary Crusher)	1	66500	100	110
2	TP (Tertiary Crusher to Limestone Reclaimer Belt Conveyor TP)	1	10000	78	22
3	TP (Reclaimer TP to Raw Mill)	1	10000	78	22
4	Additive Unloading Dump Hopper	No APCD			
5	TP (Additives Dump hopper to Day Silo)	1	Data Not available		
6	Lime stone - Day Silo	1	Data Not available		
7	TP (VRM Reject to VRM)	1			Not Available
8	Vent-Raw Meal Bucket Elevator	1	Data Not available		
9	Vent-Raw Meal Blending Silo	1	Data Not available		
10	Blending silo	1			
11	Vent Points	1			
12	Glass Bag House dust bin vent	Not Applicable			
	Sub-Total		**86500**	**266**	**166**
IV	**Coal Mill Section**	**Installed Capacity: 800 TPD**			
1	Vent-Raw Coal Hopper	1	Data Not available		
2	Reclaimer Tunnel Upstream	Not Applicable			
3	Reclaimer Tunnel Downstream	Not Applicable			

4	TP-Reclaimer to Coal Bin	1	Data Not available		
5	Vent - Mill Buffer Hopper		Data Not available		
6	Vent- Fine Coal Dosing Bin to Kiln	1	Data Not available		
7	Vent- Fine Coal Dosing Bin to PC	1	Data Not available		
	Sub-Total				
V	**Calcination Section**	**Installed Capacity: 17000 TPD**			
1	Vent- Raw Meal Day Bin		Data Not Available		
2	Vent-Air slide to Kiln	1			Not available
3	Vent-Kiln Feed Preheater cyclone	Not Applicable			
	Sub-Total				
VI	**Clinker Section (Clinker cooler to Clinker Silo)**	**Installed Capacity: 10000 TPD**			
1	TP (Grate Cooler to Clinker Silo)	Not available			
2	Vent-Clinker Silo	1	Data Not available		
3	Vent- Clinker Wagon Loading Silo	Not Applicable			
4	Clinker Hopper	4			
	Sub-Total				
VIII	**Cement Mill to Silo**	**Installed Capacity: 11000 TPD**			
1	TP- Clinker Silo Dump to Surge Bin	Not available			
2	TP- Cement Silo Bucket elevator				
3	Cement Mill Bucket Elevator Vent				
4	Vent- Cement Silo Extraction				
5	Cement Silo Vent				
6	Cement Silo Vent				
7	Cement Mill Hoppers				
8	Fly ash Silo Vent				
9	Fly ash bin Vent				
10	Cement Silo Extraction				
	Auxiliary Vents				
	Sub-Total				
IX	**Packing Section (Silo to Cement Bags)**	**Installed Capacity: 11000 TPD**			
1	Packing Machine	10	14000	97	22

Section wise details of APCD's Employed for control of Fugitive Emissions in ACC Gagal Cement Works

Section wise details of APCD's Employed for control of Fugitive Emissions					
	Name of the cement Plant		ACC Gagal		
Sl. No.	APCD Location	No. of Bag filters	Flow Rate	Filtration Area	Motor Capacity
Units			(m^3/hr)	(m^2)	(kWh)
	Section I - Unloading to Limestone Stacker				
I	**Limestone Section (Unloading to Stacker)**	**Installed Capacity: 6500**			
1	Unloading Dump Hopper		**Dust Suppression system (DSS)**		
2	Limestone Crusher	1	70000	195	90
3	TP- (Crusher to Surge Hopper)	DSS			
4	TP (Surge Hopper to Stacker)	DSS			
	Sub-Total		**70000**	**195**	**90**
II	**Coal Section (U/L to Stacker)**	**Installed Capacity: 1300**			
1	Unloading Dump Hopper		DSS		
2	Coal Crusher		DSS		
3	TP (Crusher to Stockpile)		DSS		
	Sub-Total				
III	**R. M. Section (Reclaimer to R. M. Blending Silo)**	**Installed Capacity: 7500**			
1	TP (LS Reclaimer to Day Silo)	DSS			
2	Additive Unloading Dump Hopper	DSS			
3	TP (Additive Dump Hopper to Day Silo)	DSS			
4	TP (Lime stone reclaimer to weigh Bins)	DSS			
5	TP (Day Silo to VRM)	Data Not available			
6	TP (VRM Reject to VRM)	Data Not available			
7	Vent-Raw Meal Airlift	1	45000		
8	Vent- Airlift Cyclonic Seperator of Raw Meal	Data Not available			
6	Vent-Raw Meal Blending Silo	1	30000		
	Sub-Total		**75000**		
IV	**Coal Mill Section**	**Installed Capacity: 1300**			
1	Vent-Raw Coal Hopper	1	16000		
2	Reclaimer Tunnel Upstream	Not Applicable			
3	Reclaimer Tunnel Downstream	Not Applicable			
4	TP-Tunnel to Coal Bin	Not Applicable			
5	Vent - Mill Buffer Hopper	1	6000		

6	Vent- Fine Coal Dosing Bin to Kiln	1	8500		
7	Vent for Air lift	2	2000		
	Sub-Total		**16500**		
V	**Calcination Section**	**Installed Capacity: 8800**			
1	Vent- Raw Meal Day Bin	1	6000		
2	Vent-Air slide to Kiln	1	6000		
3	Vent-Kiln Feed Preheater cyclone	1	9600		
	Sub-Total		**19600**		
VI	**Clinker Section (Clinker cooler to Clinker Silo/Stock pile)**	**Installed Capacity: 4200**			
2	TP (Grate Cooler to Clinker Silo)	5	5000		
3	Vent-Clinker Silo	1	24000		
4	Vent- Clinker Withdrawal system	2	6000		
	Sub-Total		**35000**		
VIII	**Cement Mill to Silo**	**Installed Capacity: 4900**			
1	TP- Clinker Silo Dump to Surge Bin	4	5000		
2	Vent-Clinker Surge Bin	1	5000		
	Vent Clinker loading chute	1	12000		
3	Vent Cement Mill Auxiliaries	2	30000		
4	Vent-Cement Separator		Data N.A		
5	Vent- Cement Silo	2	27000		
6	Vent- Gypsum Belt	1	6500		
		2	4000		
7	Fly ash Silo Vent	1	12000		
8	Fly ash Load Cell Hopper	1	6000		
9	Fly ash FK Pump Hopper	2	1000		
	Sub-Total		**108500**		
IX	**Packing Section (Silo to Cement Bags)**	**Installed Capacity: 4900**			
1	Packing Machine	2	25000		
		2	15000		
	Sub-Total		**40000**		

Section wise details of APCDs Employed for control of Fugitive Emissions in Chanderia Cement Works

Section wise details of APCD's Employed for control of Fugitive Emissions					
	Name of the cement Plant	Chanderia Cement			
Sl. No.	**APCD Location**	**No. of APCD**	**Flow Rate**	**Filtration Area**	**Motor Capacity**
Units			**(m^3/hr)**	**(m^2)**	**(kWh)**
I	**Limestone Section (Unloading to Stacker)**	**Installed Capacity: 5000 TPD**			
1	Unloading Dump Hopper	DSS	-	-	-
2	Limestone Crusher	BDC (2)	64120	605	-
3	TP- (Crusher to Surge Hopper)	BDC	11000	149	15
4	TP (Surge Hopper to Stacker)	CBDC	-	-	5.5
	Sub-Total	**-**	**75120**	**754**	**20.5**
II	**Coal Section (U/L to Stacker)**	**Installed Capacity: 500 TPD**			
1	Unloading Dump Hopper	DSS (3)	-	-	-
2	Coal Crusher	BDC	22000	202	33
3	TP (Crusher to Stockpile)	CBDC (9)	-	-	5.5
	Sub-Total	**-**	**22000**	**202**	**38.5**
III	**R. M. Section (Reclaimer to R. M. Blending Silo)**	**Installed Capacity: 5700 TPD**			
1	TP (LS Reclaimer to Day Silo)	CBDC	-	-	5.5
2	Additive Unloading Dump Hopper	CBDC (4)	-	-	5.5
3	TP (Additives Dump hopper to Day Silo)	CBDC	-	-	5.5
4	Lime stone - Day Silo	BDC	14400	119	22
5	Vent-C. F. Silo Air Lift	BDC	3495	30	3.7
6	TP (Ball Mill rejects to Ball Mill)	BDC	3300	24	5.5
7	Vent-C. F. Silo Dedusting	BDC	17400	139	-
8	Raw Mill O-Sepa separator	BDC	55000	593	90
9	Tertiary Crusher	BDC	25000	242	30
	Sub-Total	**-**	**118595**	**1147**	**167.7**
IV	**Coal Mill Section**	**Installed Capacity: 500 TPD**			
1	Vent-Raw Coal Hopper	CBDC	-	-	5.5
2	Vent - Mill Buffer Hopper	CBDC	-	-	5.5
3	Coal Mill Process	BDC (2)	104000	1463	-
4	Vent- Fine Coal Dosing Bin to Kiln	CBDC	-	-	5.5
5	Vent- Fine Coal Dosing Bin to PC	CBDC	-	-	5.5
	Sub-Total	**-**	**104000**	**1463**	**22**

V	**Calcination Section**	**Installed Capacity: 5700 TPD**			
1	Vent- Raw Meal Day Bin	BDC	3500	30	3.7
2	Vent-Air slide to Kiln	BDC	17400	139	-
3	Kiln Feed Air Lift	BDC	4500	43	7.5
	Sub-Total	**-**	**25400**	**212**	**11.2**
VI	**Clinker Section (Clinker cooler to Clinker Silo/Stock pile)**	**Installed Capacity: 3500 TPD**			
1	TP (Grate Cooler to Clinker Silo)	BDC (2)	35400	340	38
2	Vent-Clinker Silo	BDC	2160	18	-
3	Clinker Hopper	BDC	20300	200	38
	Sub-Total	**-**	**57860**	**558**	**76**
VII	**Cement Mill to Silo**	**Installed Capacity: 4500 TPD**			
1	CM Separator Vent	BDC (2)	29000	320	37
2	Vent- Cement Silo Extraction	BDC (2)	11700	116	22.5
3	Cement Silo Vent	BDC	22600	180	30
4	Fly ash Silo and Bin Vent	BDC (2)	22000	307	30
5	Gypsum Transfer Point	CBDC (2)	-	-	5.5
	Sub-Total	**-**	**85300**	**923**	**125**
VIII	**Packing Section (Silo to Cement Bags)**	**Installed Capacity: 4500 TPD**			
1	Packing Machine	BDC (4)	76000	143	-
	Sub-Total	**-**	**76000**	**143**	**-**
	Total	**-**	**564275**	**5402**	**460.9**

Annexure 4.1

USEPA Definitions

- *Accumulation* is any surface deposit of material greater than three ounces in one square foot other than inside an approved storage area, conveyor, transport vehicle,
- *Annual Average Daily Vehicle Trips*: annual average 24-hour total of all vehicle trips counted on a road segment.
- *AQMD Permitted Facility* is a facility that has material storage or handling equipment required to have permits to operate from the AQMD.
- *Best Available Control Measures* represent fugitive dust control actions, which are required to be implemented within the boundaries of the South Coast Air Basin. A detailed listing of best available control measures for each fugitive dust source type shall be as contained in the most recent Rule 403 Implementation Handbook, now or hereafter adopted by the Governing Board.
- *Bulk Material* is sand, gravel, soil, aggregate material less than two inches in length or diameter, and other organic or inorganic particulate matter.
- *Cement Manufacturing Facility* is any facility that has a cement kiln at the facility.
- *Chemical Stabilizers* are any non-toxic chemical dust suppressant, which must not be used if prohibited for use by the Regional Water Quality Control Boards, the California Air Resources Board, and the U.S. Environmental Protection Agency (U.S. EPA), or any applicable law, rule or regulation. The chemical stabilizers shall meet any specifications, criteria, or tests required by any federal, state, or local water agency. Unless otherwise indicated, the use of a non-toxic chemical stabilizer shall be of sufficient concentration and application frequency to maintain a stabilized surface.
- *Coal* is a solid, brittle, carbonaceous rock classified as anthracite, bituminous, sub bituminous, or lignite by ASTM Designation D388-77.
- *Disturbed Surface Area* means a portion of the earth's surface, which has been physically moved, uncovered, destabilized, or otherwise modified from its undisturbed natural soil condition, thereby increasing the potential for emission of fugitive dust. This definition excludes those areas which have:

    - Been restored to a natural state, such that the vegetative ground cover and soil characteristics are similar to adjacent or nearby natural conditions;
    - Been paved or otherwise covered by a permanent structure; or
    - Sustained a vegetative ground cover of at least 70 percent of the native cover for a particular area for at least 30 days.

- *Dust Control Supervisor* means a person with the authority to expeditiously employ sufficient dust mitigation measures to ensure compliance with all Rule 403 requirements at an active operation.
- *Enclosed Conveyor* is a conveyor, which is totally enclosed in a tube or encompassed 360 degrees within a solid plane structure, or an equivalent conveying system as approved by the Executive Officer.
- *Enclosed Storage* is any completely roofed and walled structure or building surrounding an entire coal pile.
- *Enclosed Structure*: a building or structure enclosed with walls on all sides covered with a roof.
- *Freeboard* is the distance from the top of the material storage section of the truck trailer to the top of the material load at its highest point.
- *Fugitive Dust* means any solid particulate matter that becomes airborne by natural or man-made activities, excluding particulate matter emitted from an exhaust stack.
- *High Wind Conditions* is when wind speed exceeds 15 miles per hour.
- *Inactive Disturbed Surface Area* means any disturbed surface area upon which active operations have not occurred or are not expected to occur for a period of 20 consecutive days.
- *Modified Road*: any road, street, highway, alley, way, access easement, or driveway which is widened or improved so as to increase traffic capacity or which has been reconstructed. This term does not include road maintenance, repair, chip seal, or surface overlay work.
- *New Paved Surfaces*: any road segments or other paved surfaces constructed or modified after the effective date of this Rule.
- *Non-Lump Material* means any coal material, which can pass through a 6.3-millimeter sieve (1/4 inch opening).
- *Open Storage* is any material coal pile that is not in enclosed storage.
- *Outdoor handling and storage*: handling or storage of bulk materials outside of an enclosed structure.
- *Paved* means improved by covering with concrete, asphaltic concrete, recycled asphalt, or asphalt.
- *Pile* means any amount of coal material, which attains a height of three feet or more, or a total surface area of 150 square feet or more.
- *PM 10* means particulate matter with an aerodynamic diameter smaller than or equal to 10 microns as measured by the applicable State and Federal reference test methods.
- *Property Line* means the boundaries of an area in which either a person causing the emission or a person allowing the emission has the legal use or possession of the property. Where such property is divided into one or more sub-tenancies, the

property line(s) shall refer to the boundaries dividing the areas of all sub-tenancies.

- *Road* means any route with evidence of repeated prior travel by vehicles.
- *Rule 403 Implementation Handbook* means a guidance document that has been approved by the Governing Board on April 2, 2004 or hereafter approved by the Executive Officer and the U.S. EPA.
- *Silt* is any particulate, including but not limited to coal, with a particle size less than 75 micrometers in diameter as measured by a No. 200 sieve.
- *Simultaneous Sampling* means the operation of two PM 10 samplers in such a manner that one sampler is started within five minutes of the other, and each sampler is operated for a consecutive period which must be not less than 290 minutes and not more than 310 minutes.
- *Street Sweeper* is, if purchased or contracted for before January 1, 2000, a vacuum or regenerative air street sweeper, and if purchased or contracted for on or after January 1, 2000, is a PM10 street sweeper pursuant to Rule 1186 – PM10 Emissions from Paved and Unpaved Roads & Livestock Operations.
- *Telescoping Loading Chute* is a length adjustable chute, which completely encloses the material during ship loading operations.
- *Track-Out* means any bulk material that adheres to and agglomerates on the exterior surface of motor vehicles, haul trucks, and equipment (including tires) that have been released onto a paved road and can be removed by a vacuum sweeper or a broom sweeper under normal operating conditions.
- *Transfer Point* is the point in the storage, handling or transport process where conveyed material is dropped.
- *Vehicle* is any car, truck, in-service transportation, or off-road mobile heavy equipment.
- *Visible Dust Emission (VDE)*: visible dust of such opacity as to obscure an observer's view to a degree equal to or greater than opacity of 40%, for a period or periods aggregating more than three (3) minutes in any one (1) hour, except as set forth in Rule 8030 section 5.1.2.
- *Water Spray System* means a dust suppression technique that uses water or water-based solutions delivered through pipes, tubes, or hoses that are fitted with one or more nozzles and operated at pressures ranging from 1 to 1500 psi.
- *Wind-Driven Fugitive Dust* means visible emissions from any disturbed surface area, which is generated by wind action alone.
- *Wind Screens* are structures that are sufficient to deflect the wind away from conveyed material and reduce fugitive dust emissions, and are adjacent to both sides of and extend along the entire length of the conveyor, tall enough to extend above and below the conveyor and material.

Annexure 6.1

Sampling Results and Calculations

Quantification of Fugitive Emissions				
Lafarge Sonadih Cement Plant				
Sources of Emission	**Area (m^2)**	**Velocity m/s)**	**Dust Concentration (µg/m^3)**	**Emission Rate, kg/hr**
Lime stone unloading operation	124.2	1	5037.4	2.25
Coal Unloading Operation	25	1	93344.2	8.40
Packing Plant	40	1	17226.93	2.48
Limestone stacker and Reclaimer	1965	1.5	314.55	3.33

UltraTech Awarpur Cement Works				
Sources of Emission	**Area (m^2)**	**Velocity (m/s)**	**Dust Concentration (µg/m^3)**	**Emission Rate, kg/hr**
Lime stone unloading operation	34.65	1	16209.04	2.02
Coal Unloading Operation	25	1	15915.78	1.43
Primary Coal Crushing Operation	180	1	1477.98	0.96
Gypsum Unloading Operation	12	1	4808.46	0.21
Packing Plant Operation	198	1	5722.79	4.08
Lime stone stacker and reclaimer operation	5025	1	1131.9	20.48

ACC Jamul Cement Works				
Sources of Emission	**Area (m^2)**	**Velocity (m/s)**	**Dust Concentration (µg/m^3)**	**Emission Rate, kg/hr**
Lime Stone Unloading operation	80.4	1	8552	2.48
Lime stone crushing operation	158.62	1	5894.1	3.37
Clinker Gantry operation	745.88	1	7464.44	20.04
Lime stone Gantry operation	573.75	1	7331.64	15.14
Coal Gantry operation	1375.35	1	3631.95	17.98
Packing Plant operation	32	1	2020.34	0.23

Gujarat Ambuja - Maratha Cement Works				
Sources of Emission	**Area (m^2)**	**Velocity (m/s)**	**Dust Concentration (µg/m^3)**	**Emission Rate, kg/hr**
Limestone Unloading operation	36	1	698.33	0.09
Limestone Stacker Operation	1000	1	1099.9	3.96
Lime Stone Reclaimer Operation	1000	1	572	2.06
Packing Plant Operation	30	1	4480.8	0.48
Gypsum unloading operation	16	1	2785.83	0.16
Laterite Unloading operation (blue dust)	25	1	2169.16	0.20
Coal Unloading operation	36	1	3222.29	0.42
Coal Stacker operation	100	1	46259.16	16.65
Coal Reclaimer operation	100	1	25767.49	9.28

ACC Gagal Cement Works				
Sources of emission	**Area (m^2)**	**Velocity (m/s)**	**Dust Concentration (μg/m^3)**	**Emission Rate, kg/hr**
Limestone unloading operation	80	1	3884	1.12
Lime stone crushing operation	397.5	1	11949	17.10
Limestone stacking operation	13680	1	803	39.55
Coal Unloading operation	180	1	30512	19.77
Gypsum unloading operation	42.25	1	42174	6.41
Packing Plant operation	153	1	7597	4.18
Clinker Belt conveyor	6	1	12846	0.28
Fly ash pneumatic conveying operation	15.8	1	7983	0.45

Birla Chanderia Cement Works				
Sources of emission	**Area (m^2)**	**Velocity (m/s)**	**Dust Concentration (μg/m^3)**	**Emission Rate, kg/hr**
Limestone unloading operation	49	1	23791	4.20
Limestone crushing operation	600	1	12072	26.08
Coal Unloading operation	42.2	1	176438	26.80
Packing plant operation (Exhaust fan outlet)	1.48	1	11890	0.06
B/C Transfer Point of Packing Plant	4	1	30525	0.44
Limestone stacking operation	84	1	3803	1.15
Coal Stock yard	40	1	10722	1.54

Annexure 6.2

Metal Emission and their Fraction from various cement plants

Table 6.2: Metal Levels in Air Dust around ACC Jamul Cement Works

S. No.	Location	Al (ug/m^3)	Pb (ug/m^3)	Ni (ug/m^3)	Cr (ug/m^3)	Mg (ug/m^3)	Fe (ug/m^3)	Ca (ug/m^3)
1	Lime Stone Gantry	9.93	2.83	--	9.24	63.10		199.16
2	Coal Plant Gantry	2.42	ND	ND	0.10	22.06	27.00	78.34
3	Primary Crusher House	3.33	ND	ND	7.20	112.27	26.06	120.62
4	Packaging Section	2.19	1.42	ND	2.43	228.31	38.90	199.68
5	Guest House Roof top	0.47	ND	ND	-	4.09	6.17	17.73
6	Engineering Office	2.66	ND	ND	9.17	25.68	18.11	50.36
7	Guest house roof top	0.38	ND	ND	1.22	5.12	1.47	9.88
8	Engineering office	1.14	ND	4.16	6.09	7.75		20.20
9	Guest House Roof top	0.31	ND	ND	0.44	7.15	4.79	16.10

Table 6.3: Fraction of Metal in Dust-laden Filter Paper (Out of Seven Metals)

Location	Al	Pb	Ni	Cr	Mg	Fe	Ca
Lime stone Gantry	0.0349	0.0100	0.0000	0.0325	0.2220	-	0.7006
Coal plant Gantry	0.0186	ND	ND	0.0007	0.1698	0.2078	0.6030
Primary Crusher house	0.0123	ND	ND	0.0267	0.4166	0.0967	0.4476
Packaging section	0.0046	0.0030	ND	0.0051	0.4827	0.0823	0.4222
Guest House Roof top	0.0091	ND	ND	-	0.0791	0.1194	0.651
Engineering Office	0.0133	ND	ND	0.1993	0.2743	0.0708	0.4423
Engineering Office	0.0251		ND	0.0865	0.2423	0.1709	0.4752
Guest House Roof Top	0.0209	ND	ND	0.0673	0.2835	0.0813	0.5470
Engineering Office	0.0290	ND	0.1058	0.1547	0.1969	0.0000	0.5136
Guest House roof top	0.0106	ND	ND	0.0154	0.2483	0.1665	0.5591

Table 6.4: Metal in the air around Lafarge - Sonadih Cement Plant

Location	Al (ug/m^3)	Pb (ug/m^3)	Ni (ug/m^3)	Cr (ug/m^3)	Mg (ug/m^3)	Ba (ug/m^3)	Fe (ug/m^3)	Na (ug/m^3)	Ca (ug/m^3)
Packing Plant	2.62	ND	ND	0.0407	11.31	1.96	8.26	8.41	39.16
Limestone Unloading	7.15	ND	ND	0.022	194.75	0.351	40.31	11.65	524.21
Stacker Reclaimer	3.16	ND	ND	0.0006	33.64	2.67	7.54	23.07	103.43
Stacker Reclaimer	5.40	ND	ND	0.21	25.73	0.80	18.35	26.34	113.84

Table 6.5: Lafarge - Sonadih Fraction of Metal in Dust-laden Filter Paper (Out of Nine Metals)

Al (ug/m^3)	Pb (ug/m^3)	Ni (ug/m^3)	Cr (ug/m^3)	Mg (ug/m^3)	Ba (ug/m^3)	Fe (ug/m^3)	Na (ug/m^3)	Ca (ug/m^3)
0.036596	ND	ND	0.000567	0.157	0.027332	0.115	0.117161	0.54559
0.009193	ND	ND	2.82E-05	0.250	0.000451	0.051	0.014968	0.673393
0.018249	ND	ND	3.75E-06	0.193	0.015393	0.043	0.132985	0.596035
0.028335	ND	ND	0.001106	0.135	0.004	0.096	0.138158	0.597002

Table 6.6: Metal in Air around Gujarat Ambuja - Maratha Cement Works

Location	Al (ug/m^3)	Pb (ug/m^3)	Ni (ug/m^3)	Cr (ug/m^3)	Mg (ug/m^3)	Ba (ug/m^3)	Fe (ug/m^3)	Ca (ug/m^3)
Gypsum Shed	3.85	ND	ND	0.05	65.32	5.82	33.97	98.36
Laterite shed	3.84	ND	ND	1.18	68.32	4.04	13.26	107.64
Near CSP	0.52	ND	ND	ND	35.21	4.33	207.54	69.35
Coal Dump (Stack)	0.72	ND	ND	0.01	26.44	3.36	179.57	65.84
Coal Dump (Hopper)	14.63	ND	ND	0.09	34.14	10.79	19.88	64.26
Coal stacker	13.21	ND	ND	0.04	65.52	9.76	76.68	141.11
Coal Reclaimer	2.07	ND	0.22	0.05	25.16	5.98	88.74	55.27
Near Belt Packer	2.53	ND	0.24	0.00	57.90	6.07	11.85	42.79
L.S. Stacker	5.17	ND	ND	0.00	33.40	8.56	23.02	24.17
L. S. Stacker	7.65	ND	ND	0.00	34.17	7.22	67.05	32.09
Water Pond	2.47	ND	ND	0.00	19.83	3.46	54.28	7.08

Table 6.7: Maratha Cement Works: Fraction of Metal in Filter Paper Dust (Out of Eight Metals)

Location	Al	Pb	Ni	Cr	Mg	Ba	Fe	Ca
Gypsum Shed	0.0186	ND	ND	0.0002	0.3150	0.0281	0.1638	0.4743
Laterite shed	0.0194	ND	ND	0.0059	0.3446	0.0204	0.0669	0.5428
Near CSP	0.0016	ND	ND	ND	0.1111	0.0136	0.6548	0.2188
Coal Dump (Stack)	0.0026	ND	ND	ND	0.0958	0.0122	0.6508	0.2386
Coal Dump (Hopper)	0.1017	ND	ND	0.0006	0.2374	0.0750	0.1383	0.4469
Coal stacker	0.0431	ND	ND	0.0001	0.2139	0.0318	0.2503	0.4607
Coal Reclaimer	0.0116	ND	ND	0.0003	0.1418	0.0337	0.5000	0.3114
Near Belt Packer	0.0209	ND	ND	ND	0.4770	0.0500	0.0977	0.3525
L.S. Stacker	0.0548	ND	ND	ND	0.3541	0.0908	0.2440	0.2563
L. S. Stacker	0.0516	ND	ND	ND	0.2306	0.0487	0.4524	0.2166
Water Pond	0.0284	ND	ND	ND	0.2276	0.0397	0.6230	0.0813

Table 6.8: Metal in Air around UltraTech – Awarpur Cement Works

Location	Al (ug/m^3)	Pb (ug/m^3)	Ni (ug/m^3)	Cr (ug/m^3)	Mg (ug/m^3)	Fe (ug/m^3)	Ca (ug/m^3)
ACW colony	0.3393333	0.00356	ND	ND	1.2321111	0.1073333	3.943556
Minar substation	0.2964444	0.00211	ND	0.000556	0.1284444	0.1352222	2.805667
Naokari village	0.6455238	0.01267	ND	0.000889	0.434	0.0432222	2.321667
Coal yard (Unloading)	0.3814737	ND	ND	0.004571	2.3702857	13.150286	0.131048
Limestone unloading	0.9310734	ND	ND	0.002316	2.7875789	4.3566316	27.74442
Near Packer No.4	1.5852874	ND	ND	0.003705	0.5578105	6.3624421	21.60825
Lime Stone reclaimer & Stacker	0.8456048	ND	ND	ND	2.2973793	0.5386667	4.22308
Gypsum Hopper	1.7706897	ND	ND	ND	3.5344277	-0.019792	3.36037
Lime stone crusher	2.0558298	ND	ND	ND	24.545517	0.8013793	1.727931
Scrap Yard	1.2418884	ND	ND	0.00034	4.4098723	2.2066383	2.675745

Table 6.9: UltraTech Awarpur Fraction of Metal in Dust-laden Filter Paper (Out of Nine Metals)

S. No.	Location	Al (ug/m^3)	Pb (ug/m^3)	Ni (ug/m^3)	Cr (ug/m^3)	Mg (ug/m^3)	Fe (ug/m^3)	Ca (ug/m^3)
1	ACW colony	0.0603	0.0006	ND	ND	0.2190	0.0191	0.7010
2	Minar substation	0.0880	0.0006	ND	0.0002	0.0381	0.0401	0.8329
3	Naokari village	0.1867	0.0037	ND	0.0003	0.1255	0.0125	0.6714
4	Coal yard (Unloading)	0.1321	ND	ND	0.0016	0.8209		0.0454
5	Limestone unloading	0.0260	ND	ND	0.0001	0.0778	0.1216	0.7745
6	Near Packer No.4	0.0526	ND	ND	0.0001	0.0185	0.2113	0.7175
7	Lime Stone reclaimer & Stacker	0.1070	ND	ND	ND	0.2906	0.0681	0.5342
8	Gypsum Hopper	0.2043	ND	ND	ND	0.4079		0.3878
9	Lime stone crusher	0.0706	ND	ND	ND	0.8426	0.0275	0.0593
10	Scrap Yard	0.1179	ND	ND	0.0000	0.4186	0.2095	0.2540

List of Abbreviations used

CPCB	:	Central Pollution Control Board
NPC	:	National Productivity Council, Delhi
IIT	:	Indian Institute of Technology, Kanpur
SPM	:	Suspended Particulate Matter
RSPM	:	Respirable Suspended Particulate Matter
HVS	:	High Volume Sampler
RPM	:	Respirable Particulate Monitor
USEPA	:	United States Environment Protection Agency
SCU	:	Stone Crusher Unit
TPH	:	Tons per Hour
LPM	:	Liters per minute
mmWC	:	Millimeter Water Column Pressure
DSS	:	Dust Separation System
APCD	:	Air Pollution Control Device
FEMS	:	Fugitive Emission Management System
HP	:	Horse Power
TPD	:	Tonnes per Day
MMTPA	:	Million Metric Tonnes per Annum
Mn. T	:	Million Tonnes
NA	:	Not Applicable
LPM	:	Liters per Minute
FRD	:	Fugitive Road Dust emissions
ACC	:	Associated Cement Companies
OSHA	:	Occupational Safety and Health Association
RDS	:	Respirable Dust Sampler
MTPA	:	Million Tonnes Per Annum
LS	:	Limestone
PC	:	Precalciner
VRM	:	Vertical Roller Mill
R. M	:	Raw meal
TP	:	Transfer Point
HDPE	:	High density Polyethylene
KW	:	Kilowatts
PM 10	:	Particulate Matter Less Than 10 microns in Size.
USA	:	United States of America
AQMD	:	Air Quality Management District

ASTM	:	American Society of Testing Materials
VDE	:	Visual Dust Emissions
CFR	:	Code of Federal Regulations
CKD	:	Cement Kiln Dust
EPA	:	Environmental Protection Agency
NAAQS	:	National Ambient Air Quality Standards
PM2.5	:	Particulate Materials less than 2.5 microns in Size.
TSP	:	Total Suspended Particulates
PM	:	Particulate Matter
D/W	:	Down Wind
U/W	:	Up Wind
CCW	:	Chanderia Cement Works
MCW	:	Maratha Cement Works
ACW	:	Awarpur Cement Works
TPM	:	Total Particulate Matter
O & M	:	Operation and Maintenance
ESP	:	Electrostatic Precipitator
LPH	:	Liters per Hour
BIS	:	Bureau of Indian Standards
SOW	:	Scope of Work
CCI	:	Cement Corporation of India Limited
L & T	:	Larsen and Tubro
UP	:	Uttar Pradesh
CF	:	Kiln Feed Silo
BDC	:	Bag Dust Collector
CBDC	:	Cassette Bag Dust Collector
CEM/CMB	:	Chemical Elemental/Material Balance

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