

Comprehensive Industry Document

Stone Crushers



Central Pollution Control Board

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FOREWORD

The series of publication entitled “Comprehensive Industry Document Series” (COINS) is designed to cover the status of each specific type of Industry in the country incorporating all environmental issues to facilitate concerned units in the Sector to improve their environmental performance and attain compliance with the National Environmental Standards.

The Comprehensive Industry Document on Stone Crushers is latest among Central Pollution Control Board publication in the above series with the main objective of this to impart an overall view of Stone Crushers operating in the country, to develop the National Environmental Standards, to provide cleaner technologies and to specify Guidelines / Code of Practice for Pollution Prevention & Control. The Report has been finalized after a series of discussion with the industry representatives, industry associations, State Pollution Control Boards and other statutory bodies associated with the Stone Crushing Sector.

Central Pollution Control Board conceived the study on MoU basis with, National Productivity Council (NPC), New Delhi. The assistance rendered by the State Pollution Control Boards, the Stone Crushing Units and their Association during the Study is gratefully acknowledged.

I commend the efforts engrossed by Shri R. C. Kataria, Senior Environmental Engineer for co-ordinating the study / finalizing this document under the guidance of Shri J. S. Kamyotra, Member Secretary, CPCB and Dr. B. Sengupta, Former Member Secretary of CPCB. Shri Mahendra Kumar Gupta, Senior Laboratory Assistant, contributed in preparing the manuscript is gracely acknowledged.

Hopefully the Document will be useful to the Industry, Regulatory Agencies, Consultants and other interested stakeholders in pollution control in Stone Crushing Sector.

(S. P. Gautam)

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CHAPTER 1

BACKGROUND

1.1 INTRODUCTION

Stone Crushing Industry is an important industrial sector in the country engaged in producing crushed stone of various sizes depending upon the requirement which acts as raw material for various construction activities such as construction of Roads, Highways, Bridges, Buildings, Canals etc. It is estimated that there are over 12,000 stone crusher units in India. The number is expected to grow further keeping in view the future plans for development of infrastructure of roads, canals and buildings that are required for overall development of the country. In India, the Stone Crushing Industry sector is estimated to have an annual turnover of Rs. 5000 crore (equivalent to over US\$ 1 billion) and is therefore an economically important sector. The sector is estimated to be providing direct employment to over 500,000 people engaged in various activities such as mining, crushing plant, transportation of mined stones and crushed products etc. Most of these personnel are from rural and economically backward areas where employment opportunities are limited and therefore it carries greater significance in terms of social importance in rural areas. It is a source of earning for uneducated poor unskilled rural people.

The stone crusher is one such industry that exists in the vicinity of almost all major cities/towns throughout the country in all the states because the construction activities go on throughout the country. As transportation of stone over long distances adds to cost of the crushed stone products, the crushers need to be necessarily located nearer to the demand centers such as Cities, Bridges, Canals etc. Stone Crushers also need electricity supply and large number of man power for its operation. It also needs access roads for the movement of mined stone as well as crushed stone products. It is for these reason that most Stone Crushers are located along the periphery of Cities or in the vicinity of major construction projects. In most cases the Stone Crushers come up in clusters of number of units ranging from five to fifty in one cluster. The crushers are located nearer to the source of raw material such as Stone mines, River Beds etc.

These stone crushers though socio-economically an important sector, gives rise to substantial quantity of fine fugitive dust emissions which create health hazards to the workers as well as surrounding population by way of causing respiratory diseases. The dust also adversely affects visibility, reduces growth of vegetation and hampers aesthetics of the area. In order to prevent/control these emissions, CPCB has already evolved Emission Standards and guidelines in 1989, which has been notified under Environment (Protection) Act, 1986 by Ministry of Environment & Forests vide Notification No. G.S.R. 742(E) dated 30th August 1990 & S.O. 8(E) dated December 31, 1990 based on techno-economic feasibility to achieve the standards. But over the years, as the need for more effective control and enforcement has been felt and to provide more specific guidelines to

the stone crushers to enable them control emissions satisfactorily, CPCB has signed a Memorandum of Undertaking (MoU) with National Productivity Council (NPC) and commissioned the study with the work of reviewing the existing standards, guidelines and siting criteria and to evolve a Comprehensive Industry Document (COINDS) for Stone Crushers. This report is an outcome of the in-depth studies carried out by NPC jointly with CPCB on a representatives cross section of Stone Crushers throughout the country and a series of meeting held with State Pollution Control Boards, Stone Crushers Associations / Stone Crushers unit representatives etc..

1.2 PROJECT OBJECTIVES

The project was undertaken with following objectives:

- Review of the National Emissions Standards and Guidelines for Pollution Prevention/Control for Stone Crushers
- Evolving improved advanced design
- Development of Siting Criteria
- To prepare a Comprehensive Industry Document for Stone Crushers

CHAPTER 2

AN OVERVIEW OF STONE CRUSHING SECTOR IN INDIA

2.1 Inventorisation of Stone Crushers in Various States

Stone Crushers are primarily small scale industries mostly owned and operated by less educated individuals and are scattered all over the country. This sector primarily being an un-organized sector & has only local level (district/region level) associations. In the absence of any centralized National or State Level association, the source to get a list of stone crushers in the state was identified as the State Pollution Control Board.

It was therefore, for the purpose of collecting information on number of stone crushers in various states, their capacities, technologies used etc, request letters were sent to all State Pollution Control Board offices through CPCB. Many SPCB have responded with the list of stone crushers in their respective states, some states have sent only partial list for some districts/region and some states have not responded. The compilation of the information received from various states has been made and is given at table below for information.

State-wise Number of Stone Crushers

Sr No	State	Number of Stone Crushers	Remarks on responses from SPCBs
1.	Rajasthan	488	Complete List
2	Gujarat	578	Complete List
3	Andhra Pradesh	169	Partial List received
4..	Goa	112	Complete List
5.	Karnataka	755	Complete List
6	Uttar Pradesh	N.A.	Responded, but the list was not enclosed
7	Assam	64	Complete List
8	Haryana	456	Complete List
9	Madhya Pradesh	N.A.	Not Responded
10	Tamil Nadu	71	Responded. But lists sent only for few districts
11	Kerala	N.A.	Not responded
12.	Orissa	N.A.	Not responded
13.	Maharastra	N.A.	Not responded
14	Himachal Pradesh	15	Only partial List sent
15.	Bihar	N.A.	Not Responded
16.	West Bengal	N.A.	Not Responded
17.	Punjab	N.A.	Not Responded
18.	Jammu & Kashmir	N.A.	Not Responded
19.	North Eastern States (Mizoram, Meghalaya, Nagaland, Tripura, Manipur, Arunachal, Sikkim)	18	List received only from Meghalaya, others not responded

Note : List of units is not yet sent by some SPCBs while some SPCBs have sent only partial list and therefore the total number of stone crushers in the country is incomplete.

2.2 Typical Set-up & Sizes of Stone Crushers

There are large variations in the types of stone crusher setup across the country depending on geographical locations, type of demand for crushed products, closeness to urban areas, type of raw material, availability of plant and machinery locally etc. Primarily the stone crusher industry sector could be divided in three categories small, medium & large. The typical characteristics of each category of stone crushers are briefly discussed below.

2.2.1 Small Size Stone Crushers

There are different types of small crushers in various states with a production capacity ranging from 3 to 25 TPH. Typically, the units having only one Jaw type crusher used as primary or secondary crusher along with one or maximum 2 screens are grouped as small stone crushers. A few most representative types of small crushers are described below.

- **Crushers with completely manual breaking/feeding/retrieving/stocking operation with single jaw and single rotary screen**

In these types of small stone crushers, the mined raw stones are transported to the crusher site by trailers or truck and unloaded & stocked at ground level near the crusher. Big boulders are manually broken one by one to about 8-10 inch size. Typically a team of about 15-20 workers does breaking throughout the day. The coloured stones are manually sorted and separately stocked, this is done to avoid mixing of different coloured stones in the crushed products, else it may fetch less price. The broken stones are manually carried on head load to feed in the Jaw Crusher. About 10-15 workmen are engaged for the purpose. The crushed stones are discharged through a chute in to a rotary screen. The screened products of various sizes are discharged on the ground below the rotary screen and the products are manually retrieved and taken to stock piles. These type of crushers typically operate with crushing capacity in the range of about 2-5 TPH. Such crushers are highly labour intensive and about 50 to 60 persons are involved in the operations such as breaking, feeding, retrieving and stocking. These crushers claim to produce stones of good quality due to manual sorting, uniform breaking etc and lesser quantity of fines.

- **Crushers with manual breaking manual/gravity feeding belt conveyors single jaw & rotary screen type**

In some crushers the rotary screens are installed at elevated position and the screened products are separately collected and transported via belt conveyors to stock piles. The dust product smaller than 6 mm size is stored mostly in closed

silos. Such crushers typically operate with crushing capacity range of about 5 - 15 TPH.

The above two types of small crushers are mostly found in the state of Orissa, Bihar, West Bengal, North Eastern States, Himachal Pradesh & Tamil Nadu, Andhra Pradesh.

- **Mechanical/Gravity feeding, single jaw with vibratory type screens with belt conveyors**

In these type of crushers the mined raw stones are transported to site by trailers/trucks and are unloaded in an elevated stone well. The stones are retrieved from the stone well through a chute at the bottom side end and the stones are fed by gravity in to the primary jaw crusher. The crushed stones are conveyed to rotary/vibratory type screens by belt conveyor. The oversize from the screen is returned either to the stone well or directly in to the crusher for further size reduction. These type of crusher generally have production capacity in the range of 15-25 TPH.

These types of crushers are widely found in almost all the states & the most common type of crusher set up.

- **Single Jaw Bucket Elevator, Elevated vibratory screen with storage bunkers type compact units**

In some crushers the crushed stones from the jaw crusher are raised to a high elevation with the help of bucket elevators which discharges the material in vibratory screens and screened products are directly discharged in various storage hoppers. The Products are directly loaded in to trucks standing below the storage hopper. There are no belt conveyors in the units.

These type of crusher are generally found in the States of Maharashtra & MP etc.

2.2.2. Medium Size Crushers

Typically those crushers having than one crusher i.e., one primary and one secondary or one/two primary & two secondary crushers along with one or more vibratory screens are categorized as medium size crushers. The mined stones are transported mostly by trucks/dumpers and unloaded in to elevated stone wells. The stones are fed by gravity to primary crushers. The Crushed stones are conveyed to vibratory screens. The screened products of various sizes are conveyed to stock piles by belt conveyors. The oversize is returned to secondary crushers for further crushing and back to the vibratory screen. Such type of medium type crushers have a production capacity in the range of 25 – 100 TPH.

These type of crushers are mostly located near to the bigger cities and in the vicinity of major construction projects such as Highways, Canals, Dams etc.

These type of crushers are found in the States like Maharashtra, Andhra Pradesh, Tamil Nadu, Punjab, Haryana, Gujarat, Madhya Pradesh, Rajasthan, etc.

2.2.3. Large Stone Crushers

Those crushers typically having two or more numbers each of primary, secondary & tertiary type crushers with at least 2 or more vibratory screens with mechanized loading, unloading conveying operations and producing more than 100 TPH crushed stones are categorized as large crushers. Typically large stone crusher are owned by bigger construction companies like L&T, Dodsal Construction, etc who have their own large construction projects demand. Such crushers have a capacity range of 100 –200 TPH. These type of crusher generally have their own/leased open-cast stone mines and a fleet of mechanical mining equipment , trucks and dumpers, loaders etc. These crushers involve high capital investment and mostly operate round the clock. All conveying operations are done through proper belt conveyors.

*Photographs showing Typical set up of small, medium & large crushers are presented at **Photoplate-1** to get a visual impression of various sizes of stone crushers.*

2.3 Types of Technologies used

Various types of technologies are used for mining, transporting, crushing and screening operations, which are briefly described below. As mining and transporting operation are an integral part of the stone crushing industry, it is briefly discussed below:

2.3.1. Technologies used for Mining

The technologies used for mining of stones vary from manual excavations up to highly automated large scale blasting with mechanical excavations. The smaller stone crushers source the raw material generally from river beds, or small hillocks in the local region or at times they procure/purchase raw stones from mine owners in the vicinity. Such small crushers crush only a few truck loads (typically less than 2 to 10 truck loads per day).

The medium size stone crusher mostly have their own open-cast mines adjacent or in close vicinity to the crusher site. The mining is done by drilling holes in the rock strata and blasting it generally once in a day. The drilling is done mostly manually or by mechanical means. The blasted rock boulders are at times manually broken to about 10 to 20 inch size so as to suit and are manually the primary jaw crusher, loaded in to trailers or trucks. Mechanical Loaders are also used for retrieving mined stones and loading in the vehicles.

TYPICAL SET-UP & SIZES OF STONE CRUSHERS



SMALL

MEDIUM



LARGE

In large stone crushers, the mines are generally owned or leased for long term. Scheduled and frequent blasting are carried out. A combination of primary and secondary blasting techniques are followed. In the primary blasting, substantially large area is blasted to loosen big boulders from the earth strata. The bigger boulders are further blasted during secondary blasting. The drilling is generally carried out either pneumatically or hydraulically. After blasting, the stones are excavated with the help of excavators and loaders and are loaded in to dumpers.

2.3.2. Transportation Technologies

The mined stones are transported to the crusher sites using vehicles of various capacities starting from bullock carts, trailers up to automatic dumpers. Most of the transportation vehicles have hydraulically operated tilting arrangement for easy and faster unloading of stones at the crusher sites.

The capacity range of smaller vehicle like trailers is about 4 tonnes whereas bigger dumpers can carry in the range of 15 – 20 tonnes materials per trip. The loading operations are manual in smaller vehicles and are mostly mechanical using material handling equipment for large dumpers and trucks. There are no continuous material handling system like long belt conveyors or trolley type conveyors to carry stones from mines to crusher sites, even in the largest stone crushers in the country and therefore transportation by vehicle is most common.

2.3.3. Crushing Technologies

Various types of crushers are used in the stone crushing industry such as Jaw Crushers, Roller Crushers, Cone Crushers, Impactor, Rotopocor etc. Generally, only Jaw crushers are used as Primary crushers. For secondary and tertiary crushing application either of Jaw, cone, roller, Impactor or Rotopocor type crushers are used. Various types of crushers are briefly described below.

I) Jaw Crushers:

These are the oldest type of and most commonly used crushers in use and have changed little from the original design. In Jaw Crusher the feed is compressed between a stationary and a movable surface. A few of common types of Jaw crushers, in use, are described below.

- **Double Toggle Crusher:** The Blake jaw crusher has a fixed jaw and a moving jaw pivoted at the top. The crushing faces themselves are formed either of manganese steel or of chilled cast iron. The maximum pressure is exerted on the large material, which is introduced at the top. These crushers are made with jaw widths varying from about 2" to 48" and the running speed varies from about 100 to 400 RPM.

- **Single toggle Jaw crusher:** The single-toggle crusher is the simplest and the lightest of the jaw crushers but is suitable only for producing low crushing forces and therefore used for soft rocks.
- **Impact Jaw Crushers:** In this type of crusher the crusher cavity is inclined. As there is larger stroke and higher rotation speed (about 400 rpm) a stronger impact is achieved. As a result, hard, tough materials can be processed.

Typical Production Capacities of Various sizes of Jaw Crushers commonly used in India & Energy Consumption/ TPH is given in the table below.

Jaw Crusher Size	Discharge Opening Range	Production Capacity Range	Drive Motor Power	Electricity Consumption/TPH
InchesxInches	inch	TPH	HP	HP/TPH
36X24	3 - 5	75 - 160	75	1 – 2.1
24X15	2 - 5	30- 80	35	0.9 – 2.3
16X10	1.5 - 4	15 - 45	15	1.0 – 3.0

II) Gyratory (Cone) Crushers

In Gyratory Crushers the stress to the feed is applied between a stationary and a movable surface. The crushing head is employed in the form of a truncated cone, mounted on a shaft, the upper end of which is held in a flexible bearing, whilst the lower end is driven eccentrically so as to describe a circle. The crushing action takes place around the cone.

- **Primary Gyratory Crusher:** In the primary gyratory crusher the stress is applied to the feed by pressure as the conical head periodically approaches the bowl. The primary Gyratory Crusher is a large, heavy and expensive machine. It is used only for special materials and high through put. As the crusher is continuously in action, the fluctuation in the stresses are smaller compared to the jaw crusher but the power consumption is lower. It gives a finer and more uniform product compared to the jaw crusher.
- **Cone Crusher:** Cone crusher have shallower cavity than that of the primary gyratory crusher. This crusher produces higher reduction ratios of up to 18. A uniform product size and good shape is ensured because of the long parallel gap before aperture. The stroke is large and the speed of rotation is 200 - 300 rpm, which ensures a cubical shape to the product. The shallow cone crushers are mainly used for the fine crushing of hard and moderately hard materials.

iii) Roller Crushers

The roller crushers operate on the principal that the stress (to the feed) is applied between the rollers or between a roller and a crushing surface.

- **Double Roll Crusher:** Double roll crusher consists of two rollers, which rotate towards each other and are separated by an adjustable gap. The gap can be adjusted according to the size of the feed and the required size of the product. Rollers with diameters up to 2m can handle feed sizes up to 1m. With soft to moderately hard materials, throughputs as high as 3500T/hr can be achieved.
- **Single-Roll Crusher:** In the single roll crusher, a crushing roller acts against a crushing plate, which is held either by springs or a hydraulic system. This design helps in coarse crushing of moderately hard to soft materials.

iv) Hammer Crusher

In hammer crushers the hammers are attached to the rotor via pivots so that they are deflected when they hit strong and particularly large stones. In most cases the crushing zone is surrounded by grate bars so that fragments which are larger than the openings of the grating are retained in the crushing zone. Huge hammer crushers with rotor diameters up to 3 m are available which have throughput of even 1500T/hr.

Although hammer crushers wear more quickly than impact crushers, they can process moist materials more efficiently. Only soft to moderately hard materials can be processed because of wear considerations. These crushers are simpler than jaw and cone crushers and units with equivalent throughput are much smaller in size.

v) Impactor/Impact Breakers:-

The Impactor or Impact Breaker or double impeller breaker crusher uses the energy contained in falling stone, plus the power imparted by the massive impellers. Rock fed into the breaker falls directly on to the impellers (which weigh up to 6.5 tons) and rotate away from each other, turning up and outward, at speeds from 250 to 1000 rpm depending on the desired size of finished product. Pieces of rock are sent crashing against steel breaker bars mounted in specific positions around the breaking chamber or crash against other rocks hurtling through the chamber and are further reduced without the use of extra horsepower. The stone falls again onto the impellers to repeat the cycle until reduction is complete. Size is controlled by impeller speeds and the vertical and horizontal spacing of adjustable breaker bars.

vi) Rotopactor

Rotopactor is an impact crusher in which the feed is reduced through the impact imparted by a revolving manganese steel rotor, and manganese steel breaker plates which form its outer housing. Feed up to 150 mm enters the rotor centre, axially. The change in the rotor speed varies the range of output size. The crushing chamber is designed to provide 90° impact to the material being crushed, which contributes to excellent particle size of the finished product.

(Refer Annexure 2.1 for schematic diagrams of various types of crushers discussed above)

2.3.4. Screening Technologies

Screening is a process of separating into groups of different products of various sizes. Each group consists of products of approximately same size. The mass, which remains, on a screen is called the oversize of the screen and the material, which passes through the screen is, called the undersize. The screens in between the primary and the secondary crusher help in separating the oversize. The oversize goes to the secondary crusher while the undersize is discharged through a chute on to the same conveyor belt, which receives the discharge from the secondary crusher. This saves considerable power in the second crushing stage and also increases the capacity of the secondary crusher, as it eliminates possible choking of material in the crusher, particularly during wet weather or wet material.

Screening is generally classified into two types. (i) Coarse screening, which is achieved through Grizzlies, Vibratory Screens, Revolving Screens or Shaking Screens and (ii) fine screening which is achieved through Vibrating screens, Shaking Screens. Brief description of various screening technologies is given below.

i) Grizzlie type Screens

The Grizzlies are normally used to remove "undersize" before primary or secondary crushing. The width of a Grizzly should be about 3 times that of the largest piece of material. The bars are usually iron or steel castings, tapered towards the lower end to avoid clogging. Grizzlies are of three types, Stationary, Cantilever and Mechanically vibrated types.

- **Stationary Grizzlies:** Coarse screening of dry type material is done with the help of stationary grizzlies. It is inclined (plus or minus 30°) so that the feed slides down appreciably. The grizzly is made self-clearing by having bars placed in such a way that there is maximum width at the top and minimum width at the bottom. The same can be achieved by having suitable cross-section of the bars.

- **Cantilever Grizzlies:** The grizzly is fixed at one end and the discharge end overhangs and is free to vibrate. The vibration of the bars result from impact of the material. This type of grizzly is more effective than the stationary type due to its design. (there are no cross rods which are found in the stationary type). The cross rods lead to clogging in the stationary grizzly. This type of grizzly can handle larger tonnages, it is simple to use and easy to repair and operate.
- **Mechanically Vibrated Grizzlies:** These grizzlies are simply bars mounted on the eccentrics. The entire assembly is given to and fro motions at some 100 strokes per minute. This is the most common type of grizzly used.

ii) Vibrating Screen

Vibrating Screens save space and weight, and operate on little power because the screening surface may be actuated by vibrating, gyrating or pulsating movement of small amplitude, but at frequencies that normally exceed 3000 cycles per minute. Combination of frequency of vibration (speed) and amplitude (throw), affects performance of any vibrating screen. A correct combination of slope and direction of mechanism of rotation is vital for inclined screens. The larger the opening the greater the amplitude needed for a screen. Vibrating screens are mainly divided into two classes. Mechanically vibrated and electrically vibrated.

The mechanical shaking screen comprises of a rectangular frame with perforated steel or wire cloth. It is usually inclined and suspended on loose rods or cables. They are used mainly for special tasks of coarse screening. The screening media that are normally in use are of many classes. Following are some of the commonly used media in the stone crushing industry.

- Bars or rods of the grizzly vibrator or feeder.
- Perforated screen plates, sheets, or plates of metal with round or squares openings.
- Wire cloth (woven of metal wires or fabric) for very fine screening,
- Rubber-clad perforated screen plate
- Profile screens having small parallel tapered bars for de-watering and fine screening
- Polyurethane modular panels
- Polyurethane tensioned mats
- High tensile steel wire screen decks.

iii) Rotary Screen

Rotary Screens are cylindrical shape perforated steel cylinders, which keeps rotating during screening operation. The crushed stones from the crusher are fed

at one end and travels to the other end and during process material of various sizes gets screened as per the diameter of the perforated screen. The production capacity of the rotary screens is limited and therefore predominantly used by small crusher and these are hardly used by medium and large capacity stone crusher. *Various types of screening devices are presented in Annexure –2.2*

2.3.5. Washing Technologies

Sand and gravel often can be washed during the screening process but if the material carries undesirable matter a scrubber washer should precede the screening process. When the stone from the crushing plant is coated with clay or other sticky substances they are put through rotary scrubber to scour the gravel before it goes to the screen. Material that contain smaller amount of clay and silt may be cleaned satisfactorily by a log washer. Washing is very rarely employed in Indian crushers, but it is common in developed countries.

Annexure 2.3 shows various types of Washing Screen.

2.3.6 Material Handling Technologies used in Stone Crushing Units

Various types of material handling technologies are used in the stone crushing industry for the purpose of moving the stones from one equipment to other, right from the point of raw material unloading upto stockpiles of products. Primarily, feeders and conveyors are used in almost all crushers, which are briefly described below.

i) Feeders

Feeder is used for conveying raw, mined stones from the stone well to the Primary Crusher. Feeder movement is controlled by electrically operated switch. Some of the common feeders in use are apron, belt and vibratory type feeders, which are briefly described below.

- **Apron feeder:** This type consists of uniform overlapping pans attached on to chains or joined by integral links to form an endless conveying medium that travels over supported rollers. The underside of these pans is reinforced to withstand impact and pressure.
- **Belt feeders:** Belt feeders can handle a wide range of materials including sand, gravel, crushed stone, crushed rock, and other bulk materials.
- **Vibratory feeders:** This type vibrates at relatively high frequency and small amplitude.

Various types of feeders are shown in Annexure 2.4

ii) Conveyors

Types of Conveyors are as follows:

- **Apron Conveyor:** This type comprises overlapping beaded metal apron for carrying non granular hot or abrasive materials, horizontally or at inclinations dictated by economy and allowed by flowability. Normally these conveyors are supported and moved by a pair of matched roller chains with the usual head and foot sprockets. To withstand the severe impacts involved when receiving very heavy loads, the aprons may be of shock resistant alloy-steel and slightly under their path at the loading point, rails or other means may be installed to help curb permanent deformations of those that yield under shock.
- **Belt Conveyor:** Comprising an endless belt operating over idlers, this type is the most widely used conveyor in stone crushers.

*The sketches of various types of belt conveyors are given at **Annexure 2.5***

iii) Bucket Elevators

Bucket Elevators are used for lifting crushed stone from crusher to the vibratory screen installed at high level well above the storage bins. The bucket elevators arranged in a slight taper angle of about 75 to 80 degrees. These are commonly used where there is space constraint while installing a stone crusher.

2.4 Types of Raw Material and Supply Zones

Various types of raw material are used in stone crushing unit such as Granite, Black Trap, River Bed Pebbles, Semi Grade Stone, Soft Rock etc & varying in different geographical locations and as per the local demand requirements. The type of material varies depending on the colour, hardness, inherent moisture content etc.

The supply zones for the various types of raw materials range from local hillocks, open-cast mines, river bed, cliffs and other miscellaneous sources. Mostly small size stone crushers source their raw materials from the supply zones like local hillocks, river bed and other miscellaneous sources. Medium and large size units with permanent type setup source their raw material from leased or owned open cast mines. Royalty, as imposed by the Geology and Mining department is paid on mined stones as per rates fixed in respective regions. Open cast mines upto even 80 to 90 meter depth are quite common. Overburden is removed from the mine top layers and stacked along periphery of mined area.

*Typical Stone Mines found in various states in India are shown at **Photoplate 2**.*

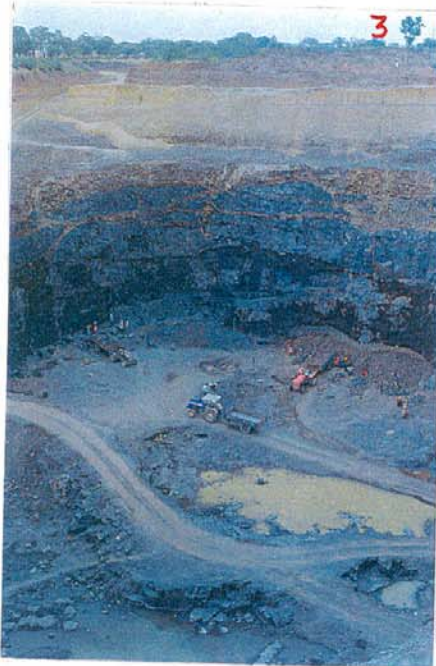
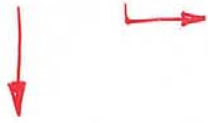
TYPICAL RAW MATERIAL STONES SUPPLY ZONES



MINING FROM HILLOCKS



OPEN-CAST STONE MINES



RIVER-BED MINING



2.5. Typical Economics of a Stone Crusher

During the field studies, the economic aspects of the stone crusher was discussed with several crusher owners in terms of fixed capital investment of setting up a stone crusher unit and typical annual operating costs and profit margins etc. Based on the information provided by the crusher owners (as reported), following tables are prepared which provide typical details on capital investment and annual operating costs of a small size stone crusher unit having production capacity of 20 Tons per hour.

A) Fixed Capital Investment

INVESTMENT IN PLANT AND MACHINERY

S.No	ITEM	Cost (lakh Rs.)	Sub-Total (Lakh Rs.)	% Share
A	Crusher & Screen Jaw Crusher (20 x 12) Jaw Crusher (16 x 9) Vibratory Screen Handling Material Eqpt: Belt Conveyors (tyre) Motors Structural Miscellaneous electricals, starters Miscellaneous Structural, chutes etc Lab & office equipment	2.50 2.00 1.20 0.25 0.30 1.50 1.00 2.00 1.25	12.00	34.25%
B	Transportation vehicles (Minimum) 2 Tractors 2 Dumpers	4.00 9.00	13.00	37.15%
C	DG set 62 KVA (Captive Power Generation)	3.00	3.00	8.6%
D	Civil work Ramp, stone well etc Office sheds	3.00 3.00	6.00	17.6%
	Total Capital Investment (A+B+C+D)	34.00	34.00	100%
E	Cost of dust control System (enclosures, tank, pump, pipes, nozzles etc)	1.00	1.00	2.9 %

B) Annual Operating Costs

i) Electricity consumption Costs

Belt conveyor	15 HP
Crushers	45 HP
Screen	10 HP
Miscellaneous, Lightings	5 HP
Total	75 HP(56 Kwh)
Operating Cost @ Rs 4.50 = Rs 252/- per hr	
Cost/Ton = 2.8 KWh/ton or Rs 12/ton	

ii) Typical Manpower/Employee Salary Costs

Type of Employment	Purpose	Average No of Employees	Average Salary (Rs.)	Total expenditure/ month
Direct	Plant operation	8	Rs 50/- (per day)	Rs 12,000/-
	Office staff(1 electrician, 1 Supervisor,1 manager.1 office boy)	4	Rs 4,375/- (per month)	Rs 17,500/-
	Transport,(2 Tract. Driver 2 Truck. Driver,2 Casual Labour	6	Rs 2,500/- (per month)	Rs 15,000/-
Indirect	Mining	40	Rs 70/- (per day)	Rs 84,000/-
Total employment				Rs 1,28,500/-
Total production per month				6000 T/month (20 TPH x 10hrs x 30)
Man power cost per ton of production				Rs 1,28,500 / 6000 Tons (Rs 21/- per ton)

- iii) Royalty costs = Rs 5/- per ton of stone crushed
 iv) Transportation cost (diesel cost) = Rs. 2/- per ton
 v) Miscellaneous cost (spares, maintenance & others) = Rs. 5 Lakhs per year
 = Rs.10/Ton(avg.)

Overall Annual operating costs/ton

Type of operating cost	Rs/Ton	Cost/year
i. Electricity	Rs 12/ton	Rs 7 lakh
ii. Man power	Rs 21/ton	Rs 12 lakh
iii Royalty	Rs 05/ton	Rs 2 lakh
iv.Transportation (Diesel)	Rs 02/ton	Rs 1 lakh
v. Misc.Costs	Rs.10/ton	Rs.5 lakh
Total	Rs 50/ton	Rs 32 lakh

C) Typical Profit to Expenditure Ratio of a Stone Crusher

S.No.	Various costs	Rs. In Lakhs
1	Capital investment in plant & machinery, building, transp. Vehicles, etc	35.00
2	Annual operating cost	32.00
3	Depreciation (15%) on 35 lakhs	05.25
4	Repayment of interest @18% on 35 lakh	06.30
	Sub -total	43.55
5	Annual sales(160 ton/day x 225 days/yr @ Rs 160/ton (at site)	57.60
6	Profit after interest and depreciation	14.05

Note: Costs of stocking raw material & products, cost of land for plant site and mine site etc are not considered.

CHAPTER 3

ENVIRONMENTAL PROBLEMS IN STONE CRUSHERS

3.1 Sources of Emissions

All quarrying and stone processing operations including surface mining, crushing, screening, material handling and transfer operations are potential sources of particulate emissions. These sources may be categorised as either process sources or fugitive dust sources. Process sources include those sources for which emissions are amenable to capture and subsequent control. Fugitive dust sources generally involve the re-entrainment or settled dust by wind or machine movement. Factors effecting emissions from either source category include the type, quantity and the moisture content of the rock processed, the type of equipment and operating practices employed as well as topographical and climatic factors.

The typical emission sources during stone processing are given in the table below.

Table: Stone-Processing Emission Sources

Activity	Process Sources	Fugitive Sources	Dust
Mining	Drilling	Blasting	
		Loading and hauling	
Transportation	N/A	Haul roads	
Stone Crushing	Crushing	Stockpiles	
	Screening	Conveying	
	Conveyor transfer points		

Emission During Mining Activity

Fugitive Emissions are generated during various mining activities such as drilling, blasting, excavation, breaking and loading etc. In some bigger mines the primary blasting emissions are quite substantial over a large area. The emissions during secondary blasting are also substantial but lesser compared to primary blasting. These emissions last only for a few minutes. There are hardly any controls adopted world over for controlling blasting emissions.

Emission During Transportation

During transportation of mined stones by heavy vehicles like trailers, trucks, dumpers, fugitive dust emission occur due to movement of heavy vehicles on

earthen roads. The quantity of emissions depend on various aspects like climatic conditions, moisture in the soil, speed of the vehicle, frequency of the vehicles etc. Generally such emissions can be controlled to a great extent by spraying water on these roads intermittently.

Emission During Crushing Operation

During crushing operation, generation of particulate emissions is inherent and the emissions are most apparent at crusher feed and discharge points. The greater the reduction in size during subsequent crushing stages from primary, secondary to tertiary crushing, the higher the emissions. Primary jaw crushers produce more dust than comparable gyratory crushers because of the bellows effect of jaw and because gyratory crushers are usually choke-fed, thus minimising the open spaces from which dust may be emitted. For subsequent reduction stages, cone or roller type crushers produce more fines as a result of attrition and consequently generate more dust.

Emissions During screening

In the screening section, the mixture of stones is classified and separated according to size. Generally the screening efficiency is considered to be in the range of 60 to 75%. The screening equipments commonly used include grizzlies, shaking screens, vibrating screens and revolving screens. Although screening may be performed wet or dry, dry screening is the most common. Dust is emitted from screening operations as a result of the agitation of dry stone. The screening of fines produces higher emissions than the screening of coarse sizes. Also screens agitated at large amplitudes and high frequency emit more dust than those operated at small amplitudes and low frequencies.

Emissions During material handling

In the material handling section, various handling devices like feeders, belt conveyors, bucket elevators and screw conveyors are used to transport crushed materials from one point to another. Particulates may be emitted from any of the material handling operations. Most of the emissions occur at transfer points. Since transport of material on the conveyor causes little disturbance of air and emissions that occur due to the wind are judged to be minimum. The transfer points include transfers from a conveyor on to another, into a hopper and on to a storage pile. The amount of uncontrolled emissions depends on the size distribution of the material handled, the belt speed and the free fall distance.

3.2 Nature and Spread of Emissions

The dust is generated primarily due to size reduction and handling of the stones at various stages. The major source of dust generation is during size reduction in the primary, secondary & tertiary crushers. The fines in the dust generated increases with subsequent stages of crushing i.e., more fines are generated in secondary crusher as compared to primary crusher. The dust is also generated

during handling of stones, especially at the point where the stones fall through a height from places like one belt to another or from belt to hopper or stock piles etc. During vibratory screen large quantity of fine dust is emitted.

Coarser part of the dust settles down within the premises but the finer particles get air borne and get carried away with wind to longer distances. The actual area of the source of the dust generation is quite small (about 0.5 to 1 square meter) at each source, but as the dust rises it spreads and typically the area in which it spreads is more than 10 –15 times larger than the area of actual emissions at about 3 to 4 metres height. This rising dust column shifts from left to right or north to south etc. depending on wind direction and current and eventually it gives an appearance that the dust is emitted from almost every inch of area in the stone crusher. *A schematic figure showing the spreading of dust emissions is given at **Figure.3.1***

3.3 Factors that Influence Emissions

Factors affecting emissions that are common to most operations include moisture content in the rock, type of rock processed, type of equipment, and operating practices employed. These factors apply to both process (primary) sources and fugitive (secondary) sources in quarry and plant operations.

Depending on geographic and climatic conditions, the inherent moisture content or wetness of quarried rock may range from nearly zero percent to several percent. The effect of moisture content is especially important during quarrying, material handling, and initial plant operations such as primary crushing. Surface wetness causes fine particles to agglomerate or adhere to the faces of larger stones, resulting in a dust suppression effect. However, as new fine particles are created by crushing and attrition and since moisture content is reduced by evaporation, this suppressive effect diminishes in later stages.

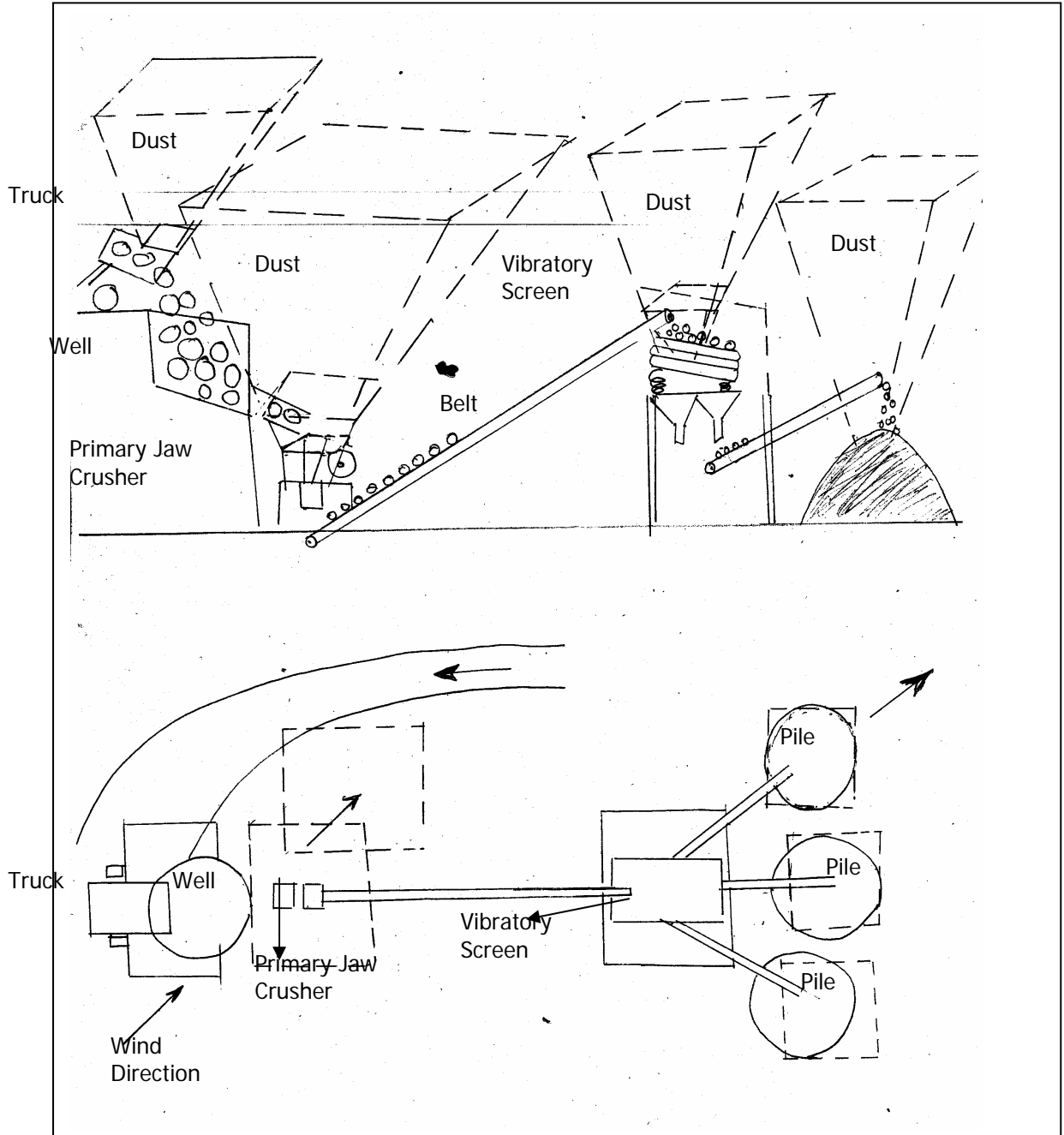
The type of rock processed is also important. Soft rock produces a higher percentage of fines than do hard rocks because they are more friable. Therefore, processing of soft rocks has greater potential for emissions.

The type of equipment and operating practices employed also affect uncontrolled emissions. Equipment selection is based on a variety of parameters, including quarry characteristics, rock type processed, and desired end products. Emissions from process equipment such as crushers, screens and conveyors are generally a function of the size distribution of the material, and the amount of mechanically induced velocity imparted to it.

Photoplates 3 & 4 show various sources of dust Generation in a typical stone crusher and the photographs provide a visual impression of the gravity of environmental pollution due to emissions from stone crushers if uncontrolled.

FIGURE NO. 3.1

SPREADING OF DUST FROM VARIOUS SOURCES



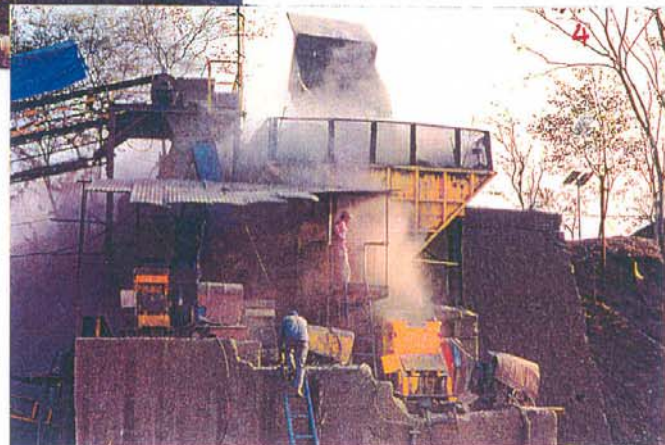
SOURCES OF DUST GENERATION IN STONE CRUSHER



TRANSPORTATION
←



UN LOADING
↓



CRUSHING →

SOURCES OF DUST GENERATION IN STONE CRUSHER



OVERALL SCENARIO



POOR VISIBILITY IN ENTIRE AREA



SCREENS (PARTIALLY ENCLOSED)



SCREENS (OPEN AIR)



PAGE No 316

3.4 Environmental, Health and Safety Problems due to Emissions

Some percentage of the fugitive dust emissions may get settled down within the unit premises itself, but a substantial percentage of airborne emissions are carried away to the surroundings by wind currents. Dust that settles within the plant gets air borne again due to vehicular movement or by wind and acts as a secondary emission source. Dust settled over the equipments may cause rapid wear and tear of the rotating parts and may lead to frequent breakdowns and higher maintenance costs.

Dust emissions affect the climate, damage the material, human health and vegetation. When the total amount of particulates in the atmosphere increases, particulates may absorb incoming solar radiation, causing an increase in the atmospheric and land surface temperature. With the deposition of aerosols on materials, especially buildings, although little damage is caused to the materials, the effect is expensive to remove deposited particulates which damages vegetation by preventing them from photo synthesis. The physical properties of atmospheric particulates affect human health either by allowing penetration of the lung and causing irritation to the internal membrane, or by transporting absorbed toxic gases and vapors deeper into the lung than they would normally travel. The work place environment at stone crusher sites contain millions of suspended mineral particles of respirable size that get deposited in lungs following inhalation.

A survey¹ study carried out at a stone crusher cluster comprising 14 units in Trichy District of Tamil Nadu State evaluates the adverse health impacts on workers employed in stone crushers. The study was directed to evaluate the gravity of problems and serious nature of health impacts. The survey reveals that there is an adverse impact on health of the stone crusher workers in terms of diseases like respiratory, eye & skin irritation, diarrhea and lung ailments etc. Also, substantial number of workers suffer from headache, fever, chest pain etc.

3.5 Noise Pollution Problems

There are a number of sources from which high noise level are generated, some continuously and some intermittently. The vibratory screen is the most predominant source of continuous noise. Especially vibratory screens are operated at higher frequency and without enclosures can give rise to abnormally high noise levels. Intermittent noise level is also generated at the crusher during the time of the breaking of stones. Intermittent noise is also generated during un-loading and loading operations. Belt conveyor movement is also a source of continuous noise, especially the ill-maintained and cheaper end conveyor system make more noise.

Reference 1: An article on "Impact of crusher pollution on workers in Trichy" by Dr. T. semban, Reader in Economics and Mr S. Chandrasekhar, Research Scholar, Faculty of Economic, Urumu Dhanalakshmi College, Trichy, in "Environment & People" Journal, December, 2000 issue

CHAPTER NO. 4

AN OVERVIEW OF STONE CRUSHERS IN DEVELOPED COUNTRIES

4.1 General

The crushed stone industry in developed country like USA is the largest non-fuel, non-metallic mineral industry with respect to both total volume and value of production with about 901 million tons production valued at over 2 billion US \$ in year 1975. The industry is geographically highly dispersed with all states. The stone production by individual states is proportional to population and industrial activity. There are over 5400 crushers in the USA located in urban, suburban and rural areas. Plans are either stationary or portable type in the capacity range varying from 100 tons to several thousand tons per hr. The various rock type processed are lime stone, granite, trap rock and sandstone. Important products include construction related material such as specified and unspecified construction aggregates and road stone, concrete aggregate, bituminous aggregate etc. As per USEPA data, the crushed stone industry was ranked third highest among the nations 56 no. of largest particulate source emitting category industries in the year 1975.

Size and Capacity-wise Distribution of Quarries in USA

Annual Production Capacity	No. of Quarries	% of total number	Total production in 1000 tons	% production of total
Less than 25000 tons (small)	2030	38.9	14580	1.6
25000 to 900000 tons/yr. (medium)	3015	57.9	606727	67.4
More than 900000 tons (large)	169	3.2	278950	31
Total	5214	100	900260	100

The above table shows that out of the total 5214 quarries, about 39% are small scale quarries which contribute only 1.6% of total production, on the other hand the large quarries are only 3.2% in number but contribute 31% of total production. Typically a large number of small, locally owned farms account for a minor proportion of national production whereas a small number of larger firms which are regionally or nationally diversified account for a large percentage of overall production. *A typical layout of a large stone crusher in USA and the types of crushers, screens and handling equipments used is shown at Figure 4.1.*

FIGURE 4.1

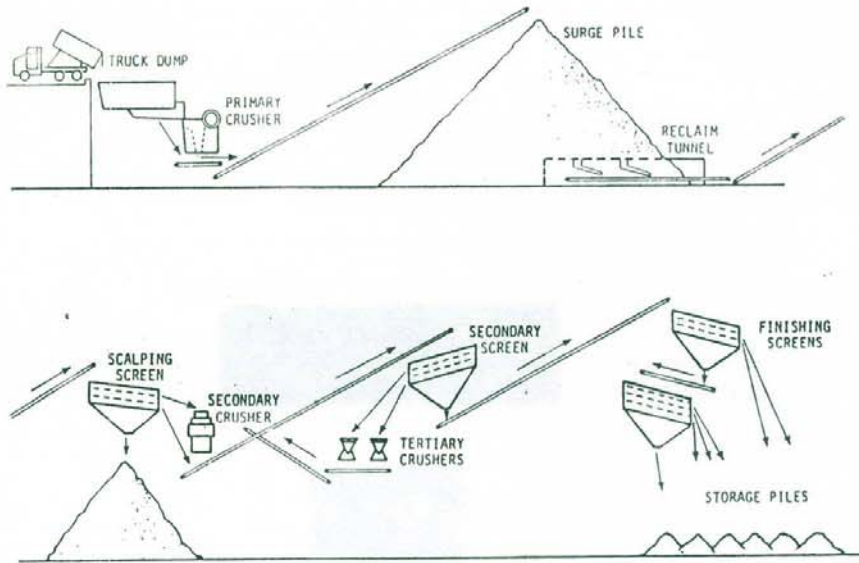


Figure 1 - Flowsheet of typical crushed-stone plant.

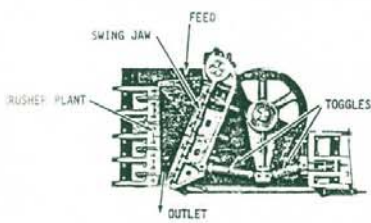


Figure 2 - Double-toggle jaw crusher
(Courtesy of Pit and Quarry Handbook).

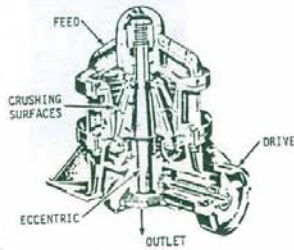


Figure 3 - Gyratory crusher
(Courtesy of Pit and Quarry Handbook).

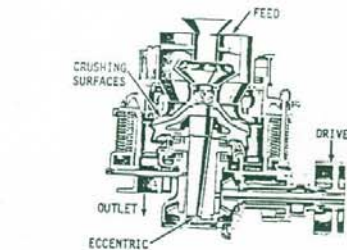


Figure 4 - Cone crusher
(Courtesy of Pit and Quarry Handbook).

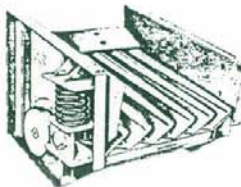


Figure 5 - Vibrating grizzly
(Courtesy of Pit and Quarry Handbook).

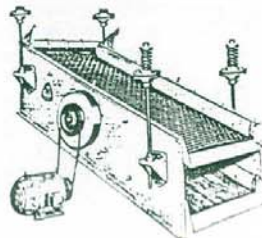


Figure 6 - Vibrating screen
(Courtesy of Pit and Quarry Handbook).



Figure 7 - Belt conveyor
(Courtesy of Pit and Quarry Handbook).

The prices of the crushed stone in USA vary from place to place depending on the transportation involved, costs of raw material, size of crushed stone etc. Typically the prices range (converted in equivalent Rs.) from Rs.90 to Rs.370/ton for 1.5" size stones and about Rs.250/- per ton for 0.75" size stones. Typically the transportation costs range from Rs.25/- to Rs.75/- per ton from the quarry to city.

The financial profile of typical stone crusher plants indicates the industry sector operates on an average profitability of about 7%, the industry is capital intensive, depreciation and depletion represent major sources of funds for capital expansion and a major portion of the industry's assets is tied up in working capital, primarily inventories and accounts receivable.

Crushed stone is generally distributed directly from the quarry to the user with no intermediary involved. It is readily available in most metropolitan areas because transportation and distribution are predominantly by truck. Inventories are held almost entirely at the quarry location because double handling would be prohibitively expensive, and customers maintain only sufficient inventory to ensure uniform production rates over a pre-determined time. Typically the crushers operate for 9 months in a year in USA.

As per USEPA estimates, a typical crusher process (excluding quarry and other fugitive dust sources) may emit up to 5.5 kg. of dust per ton of crushed stone produced equivalent to 0.55 %. In the absence of any air pollution controls, the particulate emissions from the crusher industry countrywide were estimated to have exceeded 4.9 million tons during 1975.

4.2 Typical emission factors from various sources

The typical particulate emission factors for various stone processing operations as per the USEPA study are given in the table below:

Table: Particulate Emission Factors for Stone-Processing Operations

Process operation	Uncontrolled Emission Factor, Kg/ton	% Contribution
Primary crushing	0.25	4.5
Secondary crushing and screening	0.75	13.6
Tertiary crushing and screening	3.0	54.5
Recrushing and screening	2.545.5	45.5
Conveying and material handling	1.0	18.2
Total	5.5	100

The above table indicates that maximum emissions occur during tertiary crushing and screening operations, followed by re-crushing, material handling and conveying followed by secondary crushing and screening and primary crushing.

In the washing section, sometimes to meet specifications of some aggregate products such as concrete aggregates require washing to remove fines. Because it is wet process, it essentially produces no particulate emissions.

In USA, several processing units are portable plants consisting of a single chassis on which all the crushing equipments are mounted. Emissions from each processing unit in a portable plant are the same as those from a unit of equivalent size in a stationary plant.

4.3 Emission reduction techniques adopted in crushers in USA

Diverse particulate emission sources in stone processing operations have resulted in the use of a variety of control methods and techniques. Dust suppression techniques are the most commonly used. They are designed to prevent particulate matter from becoming air borne and are applicable to both process and fugitive dust sources. Particulate emissions such as those generated by crushing operations can be captured in collection systems. The applicable control options for various types of emission sources are listed in the table below:

Table: Emission Sources and Control Options

Operation or source	Control options
a) Mining Operations	
i) Drilling	Liquid injection (water or water plus a wetting agent). Capturing and venting emissions to a control device.
ii) Blasting	No control
iii) Loading	Water wetting
iv) Hauling (emissions from roads)	Water wetting, Treatment with surface agents, Soil stabilization, Paving, Traffic control.
b) Plant operations	
i) Crushing	Wet-dust suppression systems. Capturing and venting emissions to a control device.
ii) Screening	Same as for crushing
iii) Conveying (transfer points)	Same as for crushing
c) Fugitive dust sources	
i) Stockpiling	Stone ladders. Stacker conveyors. Water sprays at conveyor discharge
ii) Conveying	Covering. Wet dust-suppression
iii) Windblown dust from stockpiles	Water wetting. Surface active agents. Covering. Windbreaks.
iv) Windblown dust from roads	Oiling. Surface active agents. Soil stabilization. Paving. Sweeping

The various types of dust control measures are briefly discussed below.

1) Control of Mining/ Quarrying Operations

i) Control of drilling operations

For controlling emissions during drilling operations, generally two methods are adopted, water injection and aspiration to control device. In water injection, water or water plus a wetting agent or surfactant, usually a liquid detergent is forced into the compressed air screen that flushes the drill cuttings from the hole and the moisture missed dampens the stone particles which causes them to agglomerate. In the dry collection system, a hood encircles the drill rod at the whole collar and a vacuum capture emissions which are vented through flexible duct to a control device such as cyclones or fabric filters, at times preceded by a settling chamber. Air volumes required for effective control may range from 850 to 3400 m³/hr depending on the type of rock drilled, hole size and penetration rate.

ii) Control of blasting operations

During blasting operations, no effective method is available for controlling particulate emissions. Good blasting practices are generally employed to minimize noise, vibration and air shock and the blasting operations are scheduled to occur only during conditions of no wind and no inversion potential so as to reduce the impact of emissions substantially.

iii) Control of quarry loading operations

The particulate emissions from the loading operations are controlled by using water trucks equipped with hoses or portable watering systems to wet down the piles prior to loading.

iv) Control of hauling operations

The emissions from hauling operations are proportionate to the condition of the road surface and the volume and speed of vehicular traffic. The control measures include methods to improve road surfaces or suppress dust and operational changes to minimise the effect of vehicular traffic. The various treatment methods applied to control fugitive emissions from haul roads include watering, surface treatment with chemical dust suppression, soil stabilisation and paving. The road dust is also controlled commonly by treatment with oil usually supplemented by watering. Waste oils such as crankcase drainings are spread over roadways at a rate of about 0.23 ltrs/m² of roadways, but such oil treatment is used judiciously to avoid slippery and dangerous conditions due to excessive application. Other treatments such as application of hygroscopic chemicals such as organic sulphonates and calcium chloride spread directly over unpaved road surfaces are used where these chemicals dissolve in the moisture

absorbed from the air and form a clear liquid i.e. resistant to evaporation. An alternative to surface treatment is soil stabilisation where water dilute emulsions of either synthetic or petroleum resins are used which act as adhesive or binder. Apart from the above measures, some operational measures such as reduction of traffic volume and control of traffic speed are taken to reduce emissions from the hauling roads.

2) Control of plant operations (Crushing, Screening and Conveying)

The emissions from the plant operations contain a multiplicity of dust producing points including numerous crushers, screens, conveyor transfer points and storage facilities. Control methods generally applied to control plant generated emissions include wet dust suppression, dry collection and a combination of the two. Wet dust suppression consists of introducing moisture into the material flow to restrain fine particulate matter from becoming air borne. Dry collection involves hooding or enclosing dust producing points and exhausting emissions to a collection device. In combination systems, both methods are applied at different stages throughout the process. Completely enclosing process equipment is another very effective technique.

(i) Wet dust suppression systems

Typically the wet dust suppression system contains basic components such as a dust control agent, proportioning equipment, a distribution system and control actuators. A pump is required to provide adequate pressure. Distribution is accomplished by spray headers fitted with pressure spray nozzles. The nozzle types used are hollow cone, solid cone or fan type depending on the spray pattern desired. Screen filters are used to prevent nozzle plugging. **Figure 4.2** shows a schematic of wet dust suppression system and typical arrangement for installation of nozzles at crusher discharge location.

Spray actuation and control are important to achieve effective control and to reduce waste and undesirable muddy conditions especially when the material flow is intermittent. Spray headers at each application point are normally equipped with an on – off controller i.e. interlocked with a sensing mechanism so that sprays will be operating only when material is flowing.

FIGURE 4.2

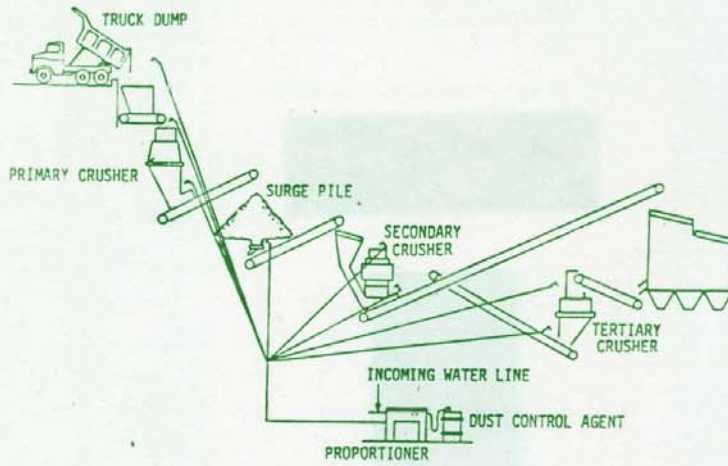


Figure . Wet dust-suppression system. 11

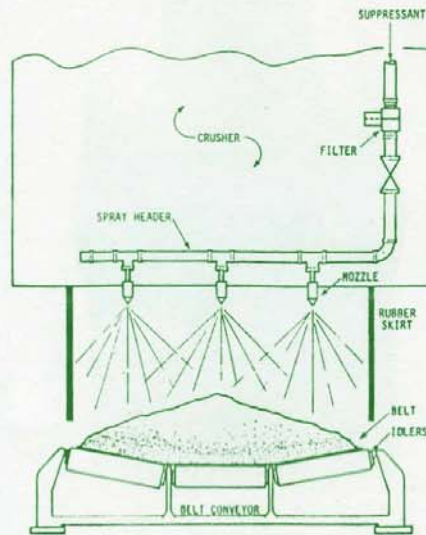


Figure Dust suppression application at crusher discharge.

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(ii) Dry Collection Systems

Particulate emissions generated from crushers, screens, conveyor transfer points and bins are at times controlled by capturing and exhausting emissions to a collection device. Collection systems consist of hoods and enclosures to confine & capture emissions and ducting & fans to convey the captured emissions to a collection device where they are removed before the air stream is exhausted to the atmosphere. For the collection system to be effective in preventing emissions from being discharged to atmosphere, its hooding and ducting must be properly designed and balanced. Process equipment should be enclosed as completely as practicable, yet allow excess room for routine maintenance and inspection requirements. In general, a minimum in draft velocity of 1 m/s is maintained through all open hood areas. The conveying velocities range from 18 to 23 m/s.

The most commonly used dust collection device in the crushed stone industry is the fabric filter or bag house equipped with mechanical shaker type or pulse jet type cleaning mechanism and normally equipped with cotton sateen cloth bags. The air to cloth ratios generally employed range from 2:1 to 3:1 for mechanical shaker and higher ratios of 6:1 to 10:1 for pulse jet type bag filters are employed. Other collection devices such as cyclones and scrubbers are used for primarily controlling coarse particles of 20 micron or higher size in the past, but these devices are not used currently in the industry. **Figure.4.3** shows a schematic of dry dust suppression system.

(iii) Combination Control Systems

The wet dust suppression and dry collection techniques are often used in combination to control particulate emissions from stone crushers. The wet suppression is generally used to control emissions at the primary crushing stage and at subsequent screens, transfer points and crusher feeds. The dry collection is generally used to control emissions from the remaining points such as secondary and tertiary crusher discharges where new dry stone surfaces and fine particulates are formed. A large portion of the fine particulates is removed by dry collection but subsequent dust suppression applications become more effective with the minimum of added moisture. **Figure 4.3** for a schematic of combination dust suppression system.

3) Control of fugitive dust sources

Significant fugitive dust emissions, seen as visible emissions, result during formation of new aggregate piles and erosion of previously formed stock piles during which

FIGURE 4.3

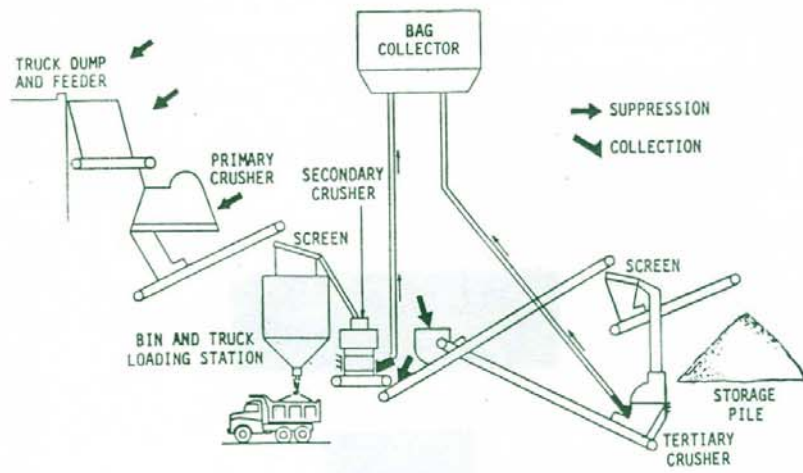


Figure 4.3. Combination control system. 11

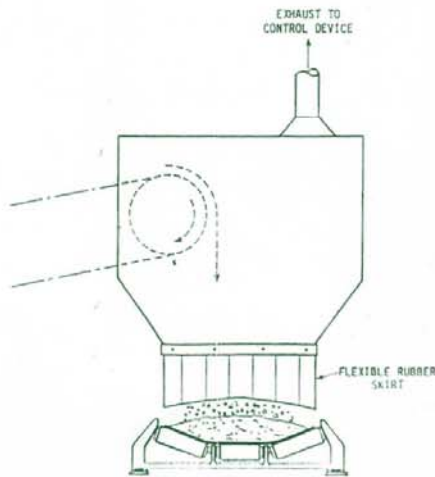


Figure 4.4. Hood configuration for a transfer point having a fall less than 0.91 m (3 ft).

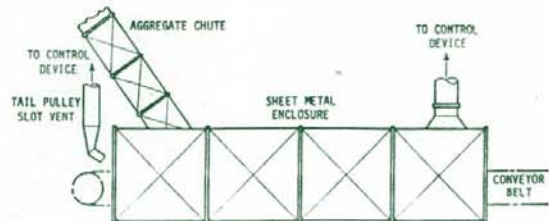


Figure 4.5. Hood configuration for a transfer point having a fall greater than 0.91 m (3 ft).

PAGE No. 4.9

emissions are generated by wind blowing across the streams of falling stone and segregating fine particles from coarse particles. Emissions are also generated when the falling stone impacts on the piles. Control methods include wet dust suppression and devices designed to minimise the free fall distance to which the material is subjected, thus lessening its exposure to wind. Control devices include telescopic chutes, stone ladders and hinged boom stacker conveyors. Stone ladders consist of a section of vertical pipe into which stone from the stacking conveyor is discharged. Watering is the most commonly used technique for controlling wind blown emissions from active stockpiles. Locating stockpiles behind natural or artificial wind breaks (walls) also aids in reducing wind blown dust.

Fugitive dust emissions are also generated from conveying operations for which the dust control alternatives include chemical suppression and covering.

Fugitive emissions are also generated during transfer of fine materials from stockpiles into open dump trucks. The dust formation may be reduced by keeping the stones wet on the stockpiles and the loaded buckets are emptied as close as possible to the truck beds. At some installations water spray systems are used to wet the stone in the truck while loading.

Fugitive dust emissions are also generated from the plant yard areas due to vehicular traffic and wind. These emissions generally are not controlled at crushed stone plants. It can be minimised through good house keeping practices. Street sweeping equipment has been effective for paved or other smooth yard surfaces.

4.4 Costs Of Control Technologies Adopted

a) *Costs of controlling process sources*

A typical data for all the above 3 types of control systems along with the installation and operational costs are given in the table below for a typical capacity plant in USA.

Typical data of Dry Type Dust Collection System

Process Parameter	Units	Plant Capacity (tons/hr.)		
		200	300	600
Exhaust gas volume	m ³ /hr.	55800	96120	139300
Gas extracted per TPH	m ³ /TPH	279	320	232
Type of control system	Dry Type	Bag filter	Bag filter	Bag filter
Filter Area	m ²	470	690	1180
Specific filter area per TPH	m ² /TPH	2.35	2.3	2.0
Fixed capital investment	US \$	144800	202000	339800
Fixed capital investment	Rs. in lakhs	68	101	170
Specific capital investment per TPH	Rs. / TPH	36200	33670	28320
Annual operating costs	US \$	41000	50110	85020
Specific annual operating cost per ton	Rs./ton	6.00	5.60	4.75
Electric power consumed	HP	103	144	260

Typical details of Wet Dust Suppression Systems for Various Capacities

Process Parameter	Units	Plant Capacity (tons/hr.)		
		200	300	600
Fixed capital investment	US \$	66500	70000	75560
Fixed capital investment	Rs. in lakhs	31	35	37.8
Specific capital investment per TPH	Rs. / TPH	15500	11670	6300
Annual operating costs	US \$	13545	15100	18340
Specific annual operating cost per ton	Rs./ton	2.00	1.65	1.00
Electric power consumed	HP	2	3	5

Typical data for combination of Wet and Dry Control Systems

Process Parameter	Units	Plant Capacity (tons/hr.)		
		200	300	600
Exhaust gas volume	m ³ /hr.	18720	28080	42480
Gas extracted per TPH	m ³ /TPH	93.6	93.6	70.8
Type of control system		Bag filter	Bag filter	Bag filter
Filter Area	m ²	160	240	360
Specific filter area per TPH	m ² /TPH	0.8	0.8	0.6
Fixed capital investment – Dry	US \$	72000	92000	120000
- Wet		59000	63000	68000
Total (Dry + Wet)		131000	151000	188000
Fixed capital investment	Rs. in lakhs	65.5	75.5	94.0
Specific capital investment per TPH	Rs. / TPH	32750	37750	15670
Annual operating costs	US \$	31710	36690	45870
Specific annual operating cost per ton	Rs./ton	4.80	3.70	2.30
Electric power consumed	HP	40	55	90

b) Costs For Controlling Fugitive Dust Sources

The costs for controlling fugitive dust sources include areas such as blasting, loading and hauling, open conveyors and storage piles. The estimated costs of this emission reduction for various capacity plants are given in the table below. The costs include items such as paving of roads, vacuum cleaning of roads, oiling and watering of roads and stock piles and speed reduction etc.

Typical costs of controlling fugitive dust emissions

Process Parameter	Units	Plant Capacity (tons/hr.)		
		200	300	600
Fixed capital investment	US \$	94000	94000	94000
Fixed capital investment	Rs. in lakhs	47	47	47
Specific capital investment per TPH	Rs. / TPH	23500	15670	7830
Annual operating costs	US \$	80000	80000	80000
Specific annual Oper. cost /ton	Rs./ton	13	9.0	4.5

4.5 Environmental Impacts Of Various Control Technologies

Application of emission reduction systems are associated with both beneficial and adverse impacts on air, water, solid waste, energy and noise that may be directly or indirectly attributed to the operation of these emission control systems.

a) Impact on Air

Impacts on air emissions associated with the application of the alternative emissions reduction systems for the control of particulate emissions from both process and fugitive dust sources are discussed here. Because emissions from fugitive dust sources are typically large in area and are discharged directly to the atmosphere in an unconstrained manner rather than through a stack, such a quantitative measurement of these emissions is considered to be difficult, if not impossible. Similarly because of the nature of wet dust suppression systems, no data are available that permit a quantitative comparison of the control capabilities of wet systems versus dry collection systems on process sources. Typically the uncontrolled emissions from 200 to 600 tons/hr. crushers range between 1000 to 3000 kg./hr which after reduction by over 99% in dry type collection systems such as bag filters reduce to as low as 3 to 6 kg/hr

b) Impact on Water Pollution

Dry collection control techniques generate no water effluent. When wet dust suppression techniques are used, the water is absorbed by the material processed and therefore, does not produce any water effluent either. The application of air pollution control technology in the stone crushers has little impact on water quality.

c) Impact on Solid Waste Disposal

The method of disposal of quarry, plant and dust collector waste materials depends somewhat upon state and local government and corporate policies. When dry type bag filter systems are used, the solid waste (dust) collected can be sold or used for a variety of purposes. Collected fines are sometimes disposed of in an isolated location in the quarry if no market is available which generally in the range of 0.5% of the total production. If such waste piles are properly controlled by any of the techniques discussed above, no subsequent air pollution problems develop. Thus, the solid waste generated by the application of dry collection methods can be dispersed without any adverse impact on the environment. When wet dust suppression is used, no solid waste disposal problem results over that produced by normal operation.

d) Impact on Energy Consumption

Application of the alternative control techniques in stone crushers necessarily result in an increase in energy consumption over that required to operate a plant without air pollution control. Typical energy consumption with various types of air

pollution control technologies used in different capacity stone crushers is given in the table below

Energy requirements (HP) for stone crushers in USA

Plant size (tons/hr.)	Types of Air Pollution Control Technologies Employed						
	Uncontrolled	Dry collection with bag filter house			Wet dust suppression		Combination of wet and dry Control
200	640	743	(+103)	642	(+2)	663	(+23)
300	845	989	(+144)	847	(+2)	896	(+51)
600	1392	1652	(+260)	1397	(+5)	1478	(+86)

Note: Figures in bracket indicate additional HP required for dust control.

The application of dry collection system results in the highest increase in energy usage. Typically for a 200 TPH plant, the increase in energy consumption with dry system is about 103 HP whereas in wet type suppression system, the increase is only 2 HP and in a combination of wet and dry system, the increase is about 23 HP. This shows the impact of increase in energy consumption by adopting wet dust suppression systems is negligible whereas it is substantial in the range of 16 to 17% when dry control systems are adopted.

e) Impact on Noise

Allowable noise levels and employee exposure times are specified by the mining enforcement and safety administration department. These limits require that potential noise problems be assessed and sound dampening equipment be installed as required. By application of either of the above air pollution control techniques, no significant noise impact is anticipated.

4.6 Compliance Test Methods and Monitoring Techniques

a) Emission Measurement Methods

For particulate matter and visible emission measurements from stacks attached to dry type control systems like bag filter, the USEPA requires use of methods 5 and 9 for the measurement of process source emission. No established procedures are available for quantifying or assigning visibility readings to emissions from fugitive dust sources. Sampling costs of a stack test requiring a minimum of 3 particulate samples is generally in the range of about Rs.1.5 to 2.5 lakh per set of measurement.

b) Monitoring Systems and Devices

The emission streams from various sources within the stone crusher are essentially at ambient conditions, therefore, the visible emission monitoring instruments used for application such as power plants are applicable for stone crusher industries. The type of instruments to be used are suggested by EPA Performance Standards contained in Appendix B of 40 CFR Part 60 document. Typically the monitoring equipment and installation costs are estimated to be in

the range of Rs.3 to 4 lakhs and the annual operating costs including data recording are in the range of Rs.4 to 4.4 lakh for each stack.

4.7 Enforcement Aspects related to Stone Crushers in USA

When formulating air pollution control regulation, it was considered a must to consider the aspect of enforcing that regulation. A regulation may be set for a specific operation, a combination of operations, or the entire processing or manufacturing facility. From a compliance evaluation point of view, USEPA has separate standards for each affected operation in the industry. In practice however, it often may be difficult to do so. The enforcement aspects of regulations for alternative air pollution control methods are discussed below.

a) Process Considerations in Enforcement Aspects

The stone crusher industry is characterised by a number of separate processing operations and emission sources, a variety of equipment types and configurations, and feed rate and composition variations. Some of the particulate emission sources such as quarrying, dumping and storage are open sources. Other operations such as conveying and loading are frequently only partially enclosed, while crushing and screening are more completely enclosed. In addition, the moisture content of the stone has a great effect on the particulate emissions. Process feed rates are not generally measured and some of the individual processes may operate on a very intermittent basis.

The process parameters that should be monitored to ensure that facilities are operated normally during enforcement tests or inspections include, the process production rate, the moisture content of the feed material and the approximate size distribution of the raw material and product but generally stone crushers are not equipped with devices for measuring process weight rates. An analysis of moisture content is important to ensure that dust control at the time of the test is effected by the control system and not the result of unusually high moisture levels that are not normal for the plant. When the addition of moisture is part of the control system (wet dust suppression), a record should be kept of the amount of added moisture required to effectively control emissions under the worst operating and climatic conditions. Moisture would have to be determined by taking samples of the feed streams for subsequent analysis.

b) Formats for Enforcement

Air pollution regulations for the stone crusher industry can be expressed in terms of (1) Quantitative particulate emission limits in terms of concentration, mass rate or process weight type units, (2) Limits on visible emissions, (3) Ambient air concentrations at the plant property line, (4) Equipment standards that include specifications on process and/or control equipments, operating conditions and monitoring requirements, and (5) Compatible combinations of such measures.

c) Enforcement of Quantitative Emission Limits

The quantitative emission limits based on measured concentrations could be applied to the enclosed sources such as crusher or screen. Determination of particulate emission concentrations where control devices are used requires a source test on the exhaust of each control device as per USEPA methods.

At times more than one process may be vented to a common control device and only the total emissions from the connected processes need to be determined. For open sources such as drilling, open conveying and storage, quantitative emission limits are not applicable since there is no accurate method of measurement.

ii) Enforcement of Visible Emission Limits

The enforcement of visible emission limits in terms of opacity or as a percent of time when emissions are visible is a feasible approach and is especially useful for fugitive sources of particulates and open processes that are controlled by wet dust suppression. Visible emission limits can also be applied to enclosed sources and used in conjunction with a quantitative emission limits or as a single limit. The visible emission determinations can be made with established procedures as per EPA method 9 by a single trained and certified observer. The readings can be taken in one or two days and usually not during night time or during very inclement weather conditions.

iii) Enforcement of Equipment Standards

Equipment standards relating to the design and installation of both process equipment and control devices are feasible alternatives for limiting emissions from some of the crushing processes. For example, enclosure of conveyor belts, the hooding of screens and crushers and venting through a fabric filter system, or utilisation of water spray systems may be specified. This format for regulation is not quantitative but does ensure that emissions will be minimised through proper selection and utilisation of equipment. Due to the variations in stone crusher plants, an overall equipment standard may be difficult to apply. Such a regulation can be used in conjunction with both quantitative and visible emission limitations. Enforcement of equipment standards is accomplished through plant inspections and observation by an experienced and trained person. An inspection can be completed in one day by one or two person team. Proper operation and maintenance of specified equipment is also required to minimise emissions. Frequent plant inspections and review of maintenance records are required to assume proper operation.

iv) Enforcement of Fence Line Standards

Ambient air particulate measurements made at a plant's boundary can be used as an enforcement tool to help assess a plant's overall impact on particulate concentration. The feasibility of such an enforcement method is dependent on the plant configuration, the operating schedule and on other particulate emission sources in the area. A number of samplers up and down wind of the property are required and these must be operated by trained personnel. Standard procedures must be carefully followed and documented during ambient monitoring & should include following details:

- a) Location of sampling station(s)
- b) Records of meteorological conditions
- c) Use of recommended sampling equipment
- d) Careful determination of gas flow rate and sample time
- e) Noting of any unusual conditions which may affect sample
- f) Proper handling of the collected sample and recording of container and filter numbers

The presence of other particulate sources in the area, especially fugitive sources such as earthen roads or construction activities will also influence the usefulness of any measurements along a plant boundary. Wind speed and variability also affects the results and electrical supply is required to operate the samplers which may present a problem at remote locations unless a portable electricity generator is available.

4.8 Regulatory Options

The various available regulatory options for the control of particulates from stone crushers are discussed below for both process sources and fugitive dust sources. The regulatory options are formulated based on the application of alternative control systems. Each option is discussed from the view point of its applicability, emission reduction, cost, environmental impacts and enforcement. In addition, applicable regulatory formats are given and also achievable emissions are cited.

a) Regulatory Options for Process Sources

Implementation of effective dry control requires installation of fabric filter type system. Alternative formats for such dry collection systems include quantitative emission limits in concentration, mass rate and process weight rate units, limits on opacity of visible emissions and equipment standards. The regulations limit both emissions discharged by the collection devices as well as fugitive emissions at the point of generation which escape capture. A limit of 50 mg/Nm³ is enforced for stack of bag filters. The visible emission limits of less than 5% opacity and no visible emissions for 90% of the time are enforced. For equipment

standards for the bag filter house, parameters such as air to cloth ratio, cleaning method, pressure drop, configuration of capture hoods and enclosures and capture velocity are required to be specified. These equipment standards are periodically checked by the control agency as a part of their permit or consent system.

For wet controls the regulation limits emissions at the point of its generation. The standard requires no visible emissions for 90% of the time. Quantitative emission limit is not suggested due to absence of any accurate measurement method and it may call for constructing a capture system for enabling measurements which would be costlier. The visible emission limit of 5% opacity are suggested to ensure that sufficient water is used in the wet suppression system to provide effective control of particulates. The equipment standard requires specifying details such as configuration of nozzles, spray pressure and the amount of moisture to be added.

b) Regulatory Options for Fugitive Dust Sources

Quantitative emission limits are not considered applicable to fugitive dust sources in stone crushers because there is no accurate method of measurement. Visible emission limits in terms of opacity and as percent of time when the emissions are visible are enforced. In addition, the equipment standard or type of work practices regulation is enforced. The performance standard specifies the manner in which the sources should be constructed or operated and specifies standards for some fugitive dust sources such as enclosures for open conveyor belts. In addition, the fence line ambient standards are applied to assess a plant's overall impact including fugitive emissions on particulate concentration. Typically the regulation recommends that "reasonable precautions" be taken to minimise the potential of fugitive dust emissions and suggests some general techniques to achieve this goal. For example, the regulation requires that all conveyors be covered but at discretion depending upon factors such as proximity of dust emitting operations to human habitation etc.

CHAPTER 5

REVIEW OF EXISTING ENVIRONMENTAL STANDARDS, GUIDELINES AND LOCAL CONSTRAINTS IN IMPLEMENTATION

5.1 Review of existing Environmental Standards notified under Environment (Protection) Act (EPA), 1986

For the purpose of review of the notified standards Standards and subsequent amendment rules the relevant text from the rules is mentioned below.

The standards consist of two parts

i) Implementation of following pollution control measures

- a. Dust containment cum suppression system for the equipment.
- b. Construction of wind breaking walls.
- c. Construction of the metalled roads within the premises.
- d. Regular cleaning and wetting of the ground within the premises.
- e. Growing of a green belt along the periphery.

ii) Quantitative standard for the SPM

The Suspended Particulate Matter contribution value at a distance of 3-10 metre from a controlled isolated as well as from a unit located in a cluster should be less than $600 \mu\text{g}/\text{m}^3$.

5.2 Siting criteria fixed by Various State Pollution Control Board / State Govt.

5.2.1 Siting criteria specified by Punjab Govt. For Siting/Shifting of Stone Crushers

1. All Stone Crusher units shall install pollution control measures which will include construction of sheds and installation of sprinklers.
2. All stone crusher units shall comply with restrictions and provisions of the department of Town & Country Planning of the State Government
3. That no stone crusher unit shall be allowed to operate within the limits of
 - a) 1.5 KM of the National Highway
 - b) 1 KM of State Highway
 - c) 300M of link road

- d) 5 KM of the boundary of metropolitan cities
 - e) 3 KM of district head quarters
 - f) 1.5 KM from the town abadis, other district headquarters, approved residential colonies and any existing tourist complexes.
 - g) 1 KM of village abadis or any land recorded as forest in Government Records or any areas which come under the controlled area
4. Each stone crusher shall be located in the minimum area of one acre which should be owned by the stone crusher unit and should not be owned on lease from panchayats
 5. That each stone crusher unit shall install suitable pollution control measures to satisfaction of State Pollution Control Board

5.3 Review of the existing standards and siting criteria

On review of the above rules and guidelines and based on the discussions with a large number of crusher owners and state pollution Control Board Officials the following lacunae/shortfalls have been identified which needs to be addressed while revising the Environmental Standard Guidelines.

A) Lack Of Details On Specific Areas/Sources To Be Enclosed

The Standard does not specifically points out as to what to be contained, what kind of equipment's need enclosures, where suppression system should spray water etc. In the absence of specific guidelines many stone crushers in many states follow different types of enclosure and suppression arrangements. Some enclose only the crusher in a big shed leaving front end open and without any enclosure to the vibratory screen, some crushers provide enclosures of crushers only above the crusher and screen platform level leaving the discharge areas open, some crushers enclose belt conveyors while others do not. It may therefore may be required to specify which items should necessarily be enclosed and which items may be optionally enclosed.

B) Lack Of Details on Specific Locations of Spraying

As regards to the suppression system, some crushers have installed large number of nozzles (10 - 30 nos) all around the enclosures directing water sprays on to the crusher equipments and screens. These systems often are hardly operated due to following reported reasons.

- Too much water consumption
- Nozzles gets choked thereby no spray, water only drips drop by drop.
- Too much of water sprayed creates muddy condition inside enclosure
- Too much water affects quality of products adversely
- Excessive water affects screening adversely

C) Lack Of Details on Avoiding Choking of Spray Nozzles Affecting Sprays Adversely:

- There are no water filters used thereby dust/dirt carried along with water chokes the small holes in the nozzles
- Most crushers sites have hard water which corrodes low quality GI pipes and forms salts deposits which eventually lead to choking of valves, pipes and nozzles.
- There are too many nozzles installed on one header water pipe and the pump capacity is not enough to supply to water all nozzles at desired pressure thereby affecting the spray formation.
- The sprays are located couple meters away from the actual source of dust generation. The dust spreads all over as it rises and covers larger area and for the spray to be effective at that height, spray is required.

Keeping in view of the above, the environmental standards to be effective, it would be required to specify as where to spray water and should not be left to the discretion of the crusher owners or the SPCB officials. The standards prescribed in the developed countries like USA include such specifications of dust control equipments (refer chapter 4.0 for details of US EPA requirements)

5.4 Review of Prevalent Dust Control Measures adopted by some SCU's & Constraints in implementation

Based on field survey of several stone crushers, it has been observed that the level of dust control arrangement differs widely from one crusher to other and state to state. Some units have comparatively better arrangement of enclosures and water sprays etc but largely most of the stone crushers across the country have only partial enclosures or at times without any enclosures and some water spraying arrangement but generally not in operation. The reasons for inadequate arrangement are non-operation of the sprays etc.

5.4.1 Review of Dust Containment Enclosures

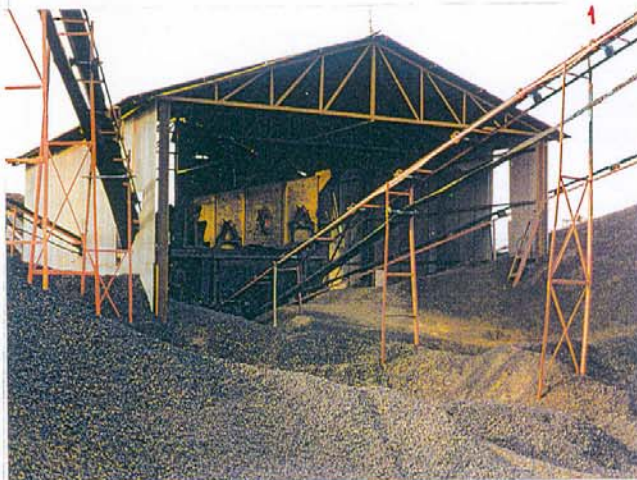
The enclosures are commonly found for the crushing equipment's and the vibratory screens. Some units have also provided enclosures to belt conveyors. The appropriateness of the type of enclosures provided is discussed below.

*A few photographs showing typical prevalent containment enclosures is given at **Photoplate 5***

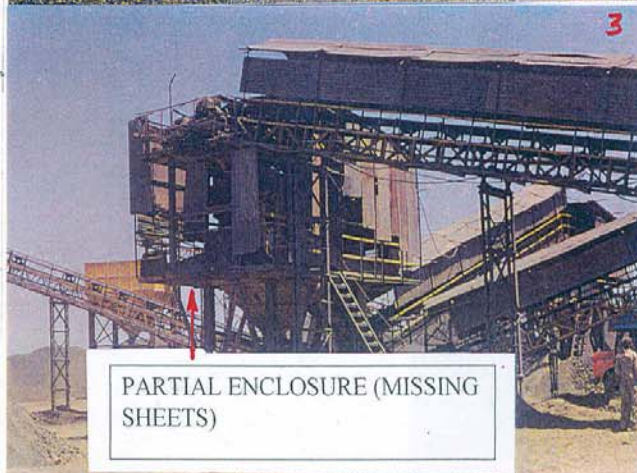
a) Enclosures for Crushing & Screening Equipment's and Constraints Reported

In some crushers the crushing equipment's (primary or secondary) are enclosed inside a big shed. The shed is closed from 3 sides and top but leaving the front end completely open. This type of shed cannot stop wind currents carry the emission away from the crusher and therefore such enclosure does not serve any useful purpose unless enclosed from all sides. The constraints were reported in completely enclosing the shed such as during maintenance it is required to take

PREVALENT DUST CONTROL MEASURES (ENCLOSURES)



BIG SHED ONE SIDE OPEN
(COSTLIER, BUT LESS USEFUL)



PARTIAL ENCLOSURE (MISSING SHEETS)



GOOD ENCLOSURE OF SCREEN
& HOPPERS



JUTE/PLASTIC ENCLOSURE
(LOW COST BUT INADEQUATE)



out large components using cranes, loaders etc and this becomes difficult if the front access is closed. The general practice is to remove some sheets from the enclosure to create an opening to take out material during repairs. These removed sheets never get replaced again anticipating the occurrence of the similar problem again. This ultimately results into partial enclosures

b) Constraints in Enclosing Crusher/Screen Discharge Areas

At the discharge of screen and crushers some stones spill over from the belt conveyor and get accumulated on the floor. This spilled over material needs to be periodically removed or else the piled up material beyond the height of the system drive component may hamper the operation of the belt conveyors etc. Such spillages are so frequent and large in quantity that almost once in a day it needs to be cleaned. This spilled material also contains large quantity of stone dust. It is due to this reason, in order to provide easy access for removal of material, one side of the enclosure is generally left open or even if a door is installed it always remains in open condition.

Such spillages happen due to systems faults or design lacunae such as misalignment and improper angles of discharge and belt conveyors, use of locally available material like used truck tyre tread pieces joined together to form the belt conveyor, lack of provision of rubber skirting etc. The possible solution to overcome this problem could be to provide well designed layout, proper/standard belt conveyor material, rubber skirting on the side of the belts, proper alignment and angle of the crusher discharge chute and belt conveyor etc

The product spillages also occur due to holes formed in the discharge chute of crushers and screens at the point of free fall of stones as the steel plate gets punctured due to wear and tear and eventually gives way for spillages. This could be minimized by adopting a step wise design of the chutes to reduce free fall height or by strengthening the steel at the point of impact. In the step design, a layer of stones always remains above the steps and the free fall impact is taken by these accumulated stones which saves the steel from direct wear and tear and increases its life.

c) Enclosures for Belt Conveyor & Dust Hopper and Constraints Reported

Some crushers use Jute Cloth in place of GI steel sheets as material of construction for enclosures to reduce the cost. But wind current can pass through jute cloth enclosure thereby reducing the usefulness of the enclosure in terms of containment of dust. At times plastic/PVC sheets are used for enclosure especially for the belt conveyors and vibratory screens but it gets torned frequently due to high velocity wind currents and therefore not effective enclosures.

Many units provide an enclosed hopper for collection and storage of less than 6mm size dust product, but a large opening is kept at the point of discharge from

belt conveyor in to the hopper and fine dust escapes through this opening. To achieve effective containment the belt discharge opening should be kept closed as much as possible by providing rubber flab type flexible materials in contact with the moving belt conveyor.

- Partial enclosures with GI sheets provided for Primary and Secondary Screens. However, large gaps/window opening etc is provided through which dust escapes outside the enclosure. Some smaller units have enclosures made of Gunny Bag Cloths or Plastic Sheet etc.
- G.I. Sheet/Polythene Sheet provided over the belt conveyors in some large stone crushers. Small and medium size SCUs generally do not have such enclosures.
- Hardly any Crushers have enclosures for crusher discharge area, from where substantial dust emission occur.

In the State of Andhra Pradesh, all the products of various sizes are prominently stored in fully enclosed elevated hoppers made of steel and the material is directly loaded from the hoppers into the trucks. This arrangement eliminates secondary dust emissions from open stock piles which generally is quite predominant in most states. However, the dust suppression arrangements for controlling the emissions from the crusher area is generally not satisfactory.

5.4.2. Review of Dust Suppression Arrangements

Most of the SCUs were found to have some water spray arrangement, though not satisfactory. The water is generally drawn from nearby bore-well and stored in a water tank. The water tank is generally located at an elevated level where raw material is unloaded. Water is supplied by gravity, through GI pipes, to various locations where dust is generated. Generally, simple holes are made in the pipes through which water is sprinkled. Some Crushers have installed "domestic showers" to get better spray. None of the unit was found to have filtering arrangements to clean the water. In such cases, in the absence of adequate pressure the spray formation is not appropriate and thereby to achieve the same effect as spray by nozzle more quantity of water is required to be sprayed, which again is unacceptable as it may increase moisture in the product excessively affecting quality adversely. Sprays are required to generate large number of fine water droplets which in turn come in contact with large number of fine dust particles, ideally each dust particle should get in contact with each water particle, only then the dust gets suppressed, otherwise suppression effect would only be partial.

a) Typical arrangement adopted for Dust Suppression:

Following arrangements generally exist in stone crushers.

- A borewell as source of water
- A domestic water storage tank, placed at an elevated level .
- GI pipes for water circulation by gravity
- Generally holes are made in the pipes through which water get sprinkled on stone, some units have domestic showers for spraying.
- Some units have additional arrangements such as Water Sprinklers around the plant, along with a pump and G.I. Pipeline network in and around the plant.

b) Sprinkler Arrangement

Some stone crusher have installed water sprinklers all around the plant premises which spray water at a height of about 5-7 meters in 360 degrees periodically. Such system consumes a large quantity of water and if operated continuously it can create muddy conditions all over the plant due to accumulation of water in low lying areas. With regard to effectiveness of dust suppression, as discussed earlier the airborne dust emissions spread to a very large area as it raises and the sprinklers can spray water covering a small percentage of this area and therefore the airborne emissions hardly get suppressed by sprinklers. On the other hand the sprinklers wet the floor area as well as the stock piles and hauling roads and therefore help minimize only the secondary fugitive dust emissions but are ineffective in suppressing/controlling primary process dust emissions which are air borne.

*Refer **Figure 5.1** showing prevalent water spraying arrangement and **Figure 5.2** showing sprinkler arrangement*

*A few Photographs showing prevalent dust suppression arrangements are shown at **Photoplates 6 & 7**.*

5.4.3. Brick making from Stone dust

A few units in Orissa and Himachal Pradesh have adopted a practice of making bricks from stone dust. This practice consumes the dust which otherwise have to be disposed and this might have caused secondary fugitive dust emissions.

*A few photographs showing typical setup and machinery installed in such stone brick manufacturing plant at **Photo plate 8**.*

5.5 Comments on Adequacy of Prevalent Dust Control Arrangements

Comments regarding prevalent dust emission scenario and adequacy of dust containment enclosures, suppression arrangement, sprinklers etc. are provided below.

FIGURE NO. 5.1
VARIOUS TYPES OF WATER SPRAYS A COMPARISON

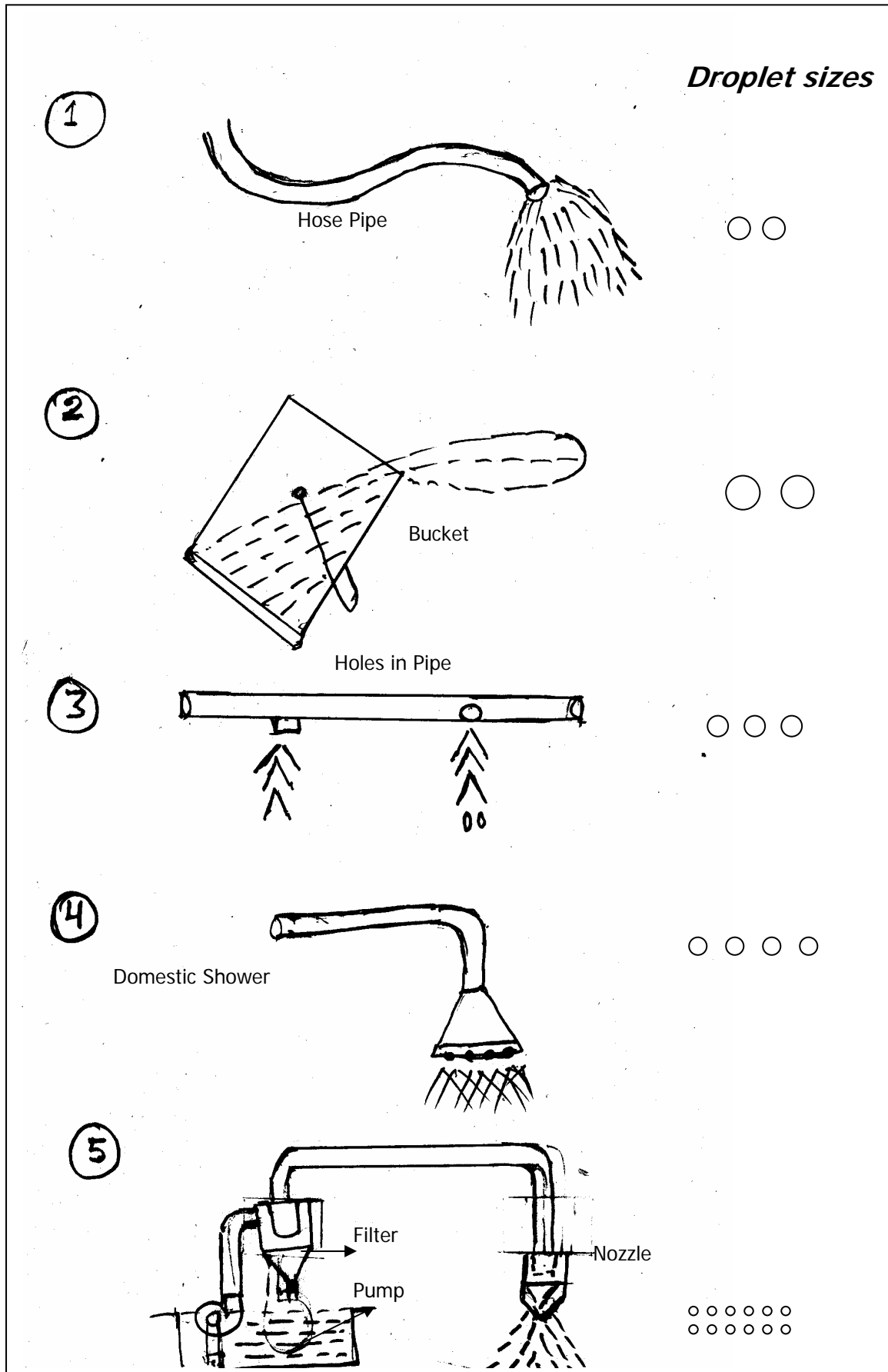
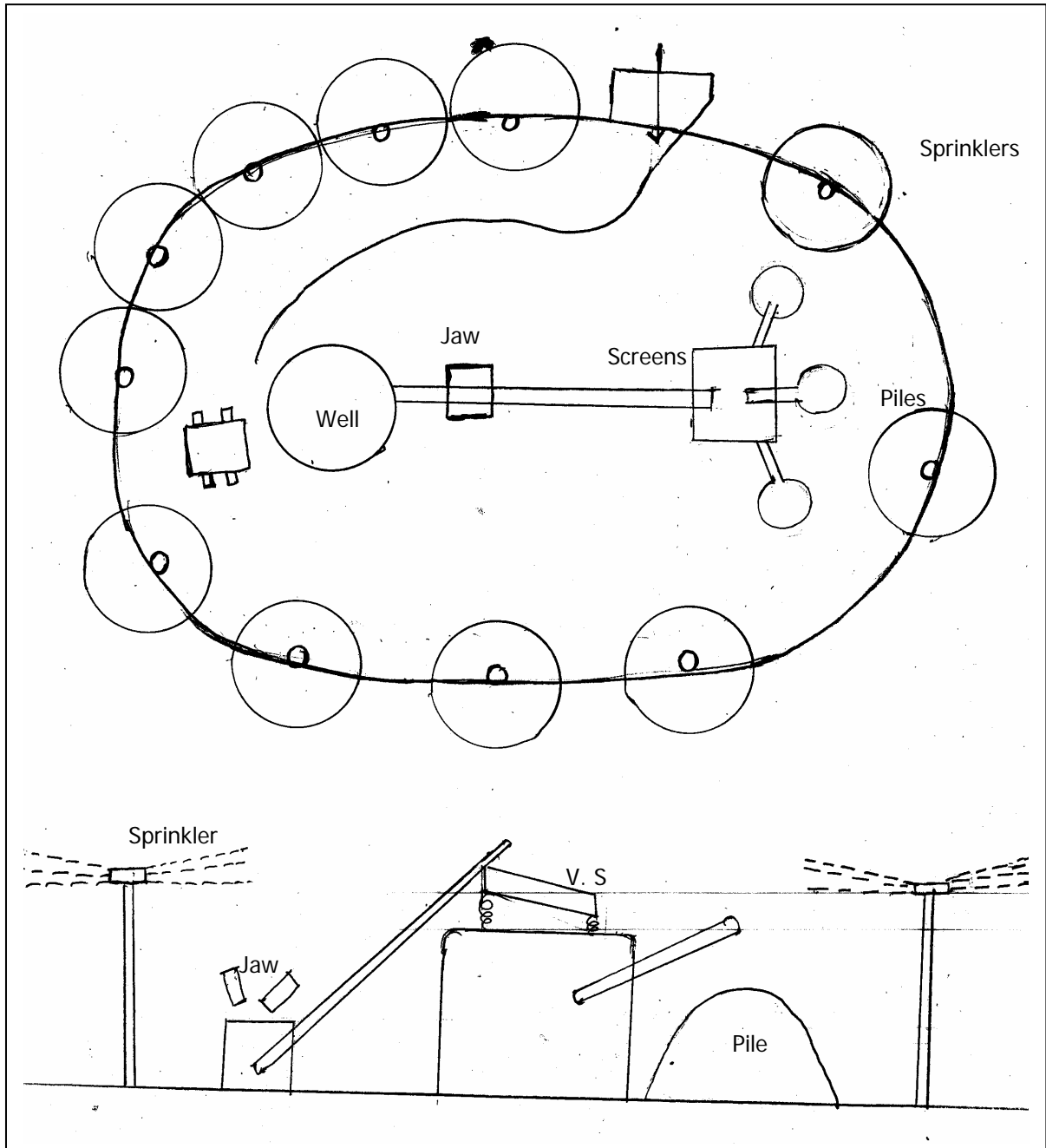


FIGURE NO. 5.2

TYPICAL SPRINKLER INSTALLATION & ITS USEFULNESS



COMMENTS :

- i) Too much water required
- ii) Very expensive, high operating cost
- iii) Muddy conditions due to too much water
- iv) Dust still not controlled

PREVALENT DUST CONTROL MEASURES-WATER SPRAYS

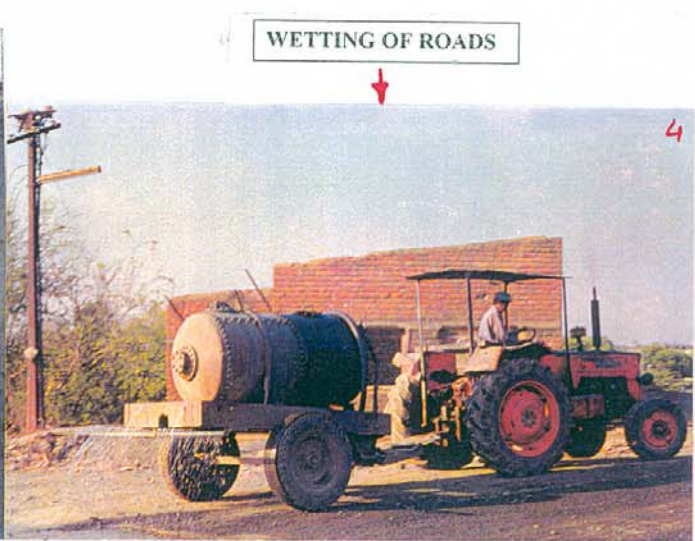


MANUAL WETTING OF STONES

WHILE UNLOADING



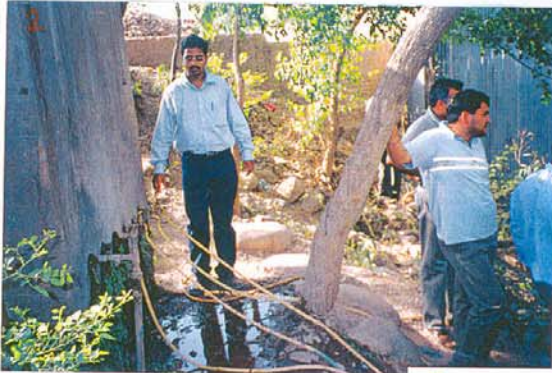
HOUSE SHOWER TYPE SPRAYS AT CRUSHER



WETTING OF ROADS

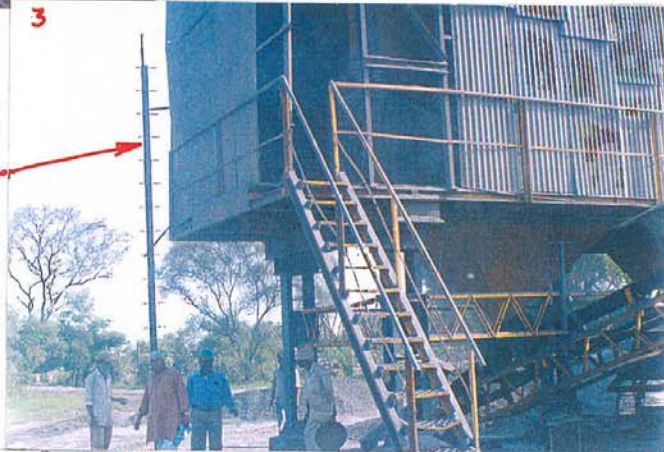
PREVALENT DUST CONTROL MEASURES-SUPPRESSION

PARTIAL ENCLOSURES



GRAVITY SPRINKLING

SRINKLERS



GREEN BELT SURROUNDING CRUSHER

A RARELY FOLLOWED BUT SUSTAINABLE DUST CONTROL PRACTICES- CONVERTING DUST TO BRICKS



STONE BRICK MAKING MACHINERY



A MIXER & PRESS MACHINE



BATCH PREPARATION TOOLS



MOULD BOXES



CRUSHER UNIT

BRICKS FROM STONE DUST

READY FOR CONSTRUCTION USE



5.5.1 Comments on Adequacy of Dust Suppression Arrangement

As the water is sprayed through the holes in G.I. Pipes or by domestic shower by gravity the sprays are not fine due to the absence of sufficient pressure and nozzles, rather the water falls in big droplets.

As there is hardly any control over the quantity of water sprayed, it results in addition of excess moisture in the product. As large quantity of water gets sprayed, which results in poor product quality, thereby forcing the units to put off the water sprays.

Also, in the absence of any filter, the dust/dirt etc chokes the holes of the showers and the spray gets further hampered due to obstructions/choking. The showers were hardly cleaned for choking.

In overall, the performance of the prevalent dust suppression arrangement is far from satisfactory & there is hardly any suppression/ control of fugitive dust emissions, even though substantial quantity of water is used. Adversely, it increases the moisture content in the product beyond allowable limits and as a result, the units hardly operate the water sprays.

5.5.2 Comments on adequacy of Dust Containment Enclosures

Generally the stone crushers have partial enclosures over the vibratory screens. But mostly, large open areas are seen in the enclosure as doors, windows, gaps in the corners etc. In the absence of proper Dust Containment System, substantial quantities of dust emissions are observed at the Vibratory Screen section. Some units have partial enclosures over belt conveyors, as well. The enclosures are generally made of tarpaulin or plastic sheet material. As, the fine dust is mostly generated at Crushers discharge points, at belt conveyors discharge point, the enclosures over belt conveyors though made airtight, could hardly assist in controlling / suppressing dust emissions without proper water sprays.

Most crusher units do not have enclosures at the Crusher section, specially covering the discharge points from crushers where large quantity of fine dust is generated.

5.5.3 Comments on Adequacy of Sprinklers

A number of sprinklers are installed all around the plant premises by few units. A pump supplies water to the sprinklers. The sprinkler sprays water all around in about 15 to 20 feet radius, covering entire circle once in couple of minutes. Eventhough such a large quantity of water was sprayed, it hardly served the purpose of suppressing/controlling fugitive dust emissions from the process. The

sprinklers mainly serve the purpose of irrigating the green belt plants and wetting of land in the premises to the extent of creating muddy conditions, The unit had spent about Rs. 3 lakhs towards sprinklers, but could hardly serve its purpose.

Though large quantity of water is sprayed for controlling emission, it does not control the fugitive emissions satisfactorily due to following reasons.

- Excess/inadequate quantity of water sprayed at wrong places.
- No proper nozzles, only holes in pipes, or domestic showers, which can not give fine sprays
- Water sprayed at Crusher point by gravity only (no pump used, pressure / head not sufficient for fine sprays).
- No filters, dirt in water chokes holes, affects spraying.
- No control over quantity of water sprayed, results in excess water in product.
- Dust control far from satisfactory.

5.6 Local Problems In Implementation Of Pollution Control Measures

Discussions were made with number of stone crusher owners to know and learn about the local problems faced by them in controlling dust emissions. A few of the reported problems are highlighted below.

- High investment cost for providing dust containment like G.I. sheet enclosure for Vibratory Screen, Belt Conveyors etc for small size SCU's, for Medium and Large size SCU's it is not.
- Huge quantity of water has been used for suppression of dust resulting in poor product quality forcing SCU to abandon it
- Lack of appropriate nozzles for proper spray resulting in excess moisture added to the product and thereby increasing the water consumption
- Lack of knowledge of pollution control measures by SCUs
- Lack of availability of water for dust suppression forcing the SCU's to purchase the same at higher cost
- Financial constraints to implement the pollution control measures for small units

CHAPTER 6

FIELD STUDIES – RESULTS & DISCUSSIONS

The field studies were conducted covering following aspects

- Unit level detailed field Studies including Ambient Air Quality Monitoring
- General Assessment and Review Studies in Additional Units
- A Cluster based study for a Crusher Zone
- Sieve Analysis Study to quantify the dust generation in various types of Stone Crushers

For the purpose of conducting detailed field studies and assessment studies in additional units, the methodology for selecting most representative units is discussed below. Refer **Photoplate 9** showing field study in progress

6.1 Selection of Representative SCU's for Field Studies

For the purpose of selecting the most representative stone crushers for the study, following criteria were considered.

- Type of Crushers (Jaw, Rotopactor, Impactor)
- Size (Small, Medium, Large)
- Type of Raw Material (Mined Black trap, River Basin, Hilly area)
- Representation of Geographic Region
- Water Availability (Acute water shortage, no acute shortage)
- Willingness of Crusher Units to participate and co-operate in the field studies (for easy implementation, co-operation)
- Status of Dust Emission Control Measures (Enclosure, Sprays, etc.)

Requests were made to various SPCB's to suggest a few names in their respective region. Also, various Stone Crusher Association and Unit Owners were contacted. Detailed field studies covered study of Plant & Machinery details, Dust Generating Problems and Dust Control Systems adopted, Local Problems faced by units and Ambient Air Quality Monitoring to evaluate SPM concentration, Noise Monitoring, Sieve Analysis etc.

Following eight units were selected for the purpose of carrying out detailed field studies.

Consolidated Table of Selected Units for Detailed Field Studies.

Sr. No	State/Region	Unit Size	Type of Technologies	Cap. TPH	Control System	Name of Unit	Raw Material	New /Old
1.	Gujarat	Large	One Primary Jaw, Two Secondary Jaw, Two Tertiary Jaw, Two Vibratory Screen.	>100	Partial Enclosure + Sprinkling + Gravity Spraying by holes in pipes	Sadbhav Quarry	Mined Black Trap	New

Comprehensive Industry Document on Stone Crushers

Sr. No	State/ Region	Unit Size	Type of Technologies	Cap. TPH	Control System	Name of Unit	Raw Material	New /Old
2.	Gujarat	Medium	One Primary Jaw, Two Secondary Jaw, One Vibratory Screen.	45	Partial Enclosure, Sprinklers, Domestic showers, Green Belt	JMC Mining & Quarrying	River Bed Stone	New
3.	Gujarat	Small	One Primary Jaw, Two Secondary Jaw, One Vibratory Screen.	25	Jute Cloth, plastic Enclosure for Screen / Belt, Manual wetting at Unloading, Domestic Showers at PC	SI Quarry Works	Mined Black Trap	Old
4.	Rajasthan	Small	One Primary Jaw, One Secondary Jaw, One Vibratory Screen	15	Partial Enclosure, No dust Suppression System	Charbhujia Minerals	Mined Black Trap	New
5.	Goa	Small	One Primary Jaw, Two Secondary Jaw, One Vibratory Screen	20	Partial Enclosure, No Dust Suppression System	Tamba Stone Crusher	Hillock Mined	Old
6.	Madhya Pradesh	Large	One Primary Jaw, One Secondary Cone, One Tertiary Cone, One Grizzle Feeder, One Vibratory Screen	100	Partial Enclosure, Spray Pump Suppression System	Oriental Constructions Limited	Mined Black Trap	New
7	Haryana	Medium	One Primary Jaw, Two Secondary Jaw, One Tertiary Roller, Two vibratory Screen	50	Partial Enclosure, Pump, Nozzles Spray System, Sprinklers	New Neelgiri Stone	Hillock Black Trap	New
8.	Haryana	Medium	One Primary Jaw, One Secondary Roller, One Vibratory Screen	30	Partial Enclosure, Manual Wetting	Haryana Grit	Black Trap	New

In addition to above, visits were also made to additional stone crusher units for assessment study of process, plant layout, dust control systems and their performance and to review the local constraint and problems etc. The details of these additional eight units are also given in the following Table.

Additional Units Where Assessment Study Visits Were Made								
Sr No	State	Unit Size	Type of Technologies	Cap. TPH	Existing Dust Control System	Name of Unit	Raw Material	New/ Old
9	Orissa	Small	One Primary Jaw, One Rotary Screen, Manual Feeding	8	No Enclosures, No Suppression System, Stone Dust Brick Plant	Lingaraj Stone Crusher	Granite	New
10	Orissa	Small	One Primary Jaw, Two Rotary Screen.	12	No. Enclosures, No Suppression.	Pushpa Stone Crusher	Granite	New
11	Orissa	Small	One Primary Jaw, One Rotary Screen	6	No Enclosure, No Suppression, Near Highway	Maakali Stone Crusher	Granite	New

Additional Units Where Assessment Study Visits Were Made								
Sr No	State	Unit Size	Type of Technologies	Cap. TPH	Existing Dust Control System	Name of Unit	Raw Material	New/Old
12	Orissa	Small	One Primary Jaw, One Rotary Screen	6	No. Enclosure, No Suppression Near Highway	Champak Stone Crusher	Granite	New
13	Himachal Pradesh	Small	One Primary Jaw, One Rotary Screen	10	No. Enclosure, Suppression, Located Between Highway and River	Dhamtal Stone Crusher	River Bed Pebbles	Old
14	Maharashtra	Small	One Primary Jaw, One Vibratory Screen with Bucket Elevator & Belt conveyor	25	All Products Stored in Hoppers, Partial Encl., Manual wetting, Near Highway.	Hariant Stone Crusher	Mined Granite	New
15	Punjab	Small	One Primary Jaw, One Secondary Roller, One Vibratory Screen	20	Sprinkling system by gravity flow, Partial Enclosure, Near Highway	Jaspal Singh stone crusher	Wet grit & River Pebbles	Old
16	Chattisgarh	Small	One Jaw , one Vibratory Screen, Belt conveyor	20	No Enclosure, dust suppression, Located near State Highway	Orient Stone Crusher	Soft Stone (Semi Grade)	Old

6.2 General Details of Selected Representative Stone Crusher Units

The brief details of each unit studied/visit made are given below.

Unit No. 1: M/s. Sadbhav Quarry Works, Gujarat

i) Basic Details

This unit is located in the Tulsigam village of Vadodara district in Gujarat. The raw material is Black Trap stone which comes from the company's own open cast mines located nearby. The units are in operation for 3 shifts/day. The basic details of the unit are given below.

Type & Size of Primary Crusher	:	Jaw (36" X 24"), 1 No
Type & Size of Secondary Crusher	:	Jaw (30" X 15"), 2 Nos.
Type & Size of Tertiary Crusher	:	Jaw (30" X 9" & 30" X 6"), 2 Nos.
Crushing Capacity:	:	2200 T/Day(>100 TPH)
Type & No. of Screens	:	Vibratory, 2 No. (Prim. & Sec.)
Type of Raw Material	:	Black trap stone from open-cast mines

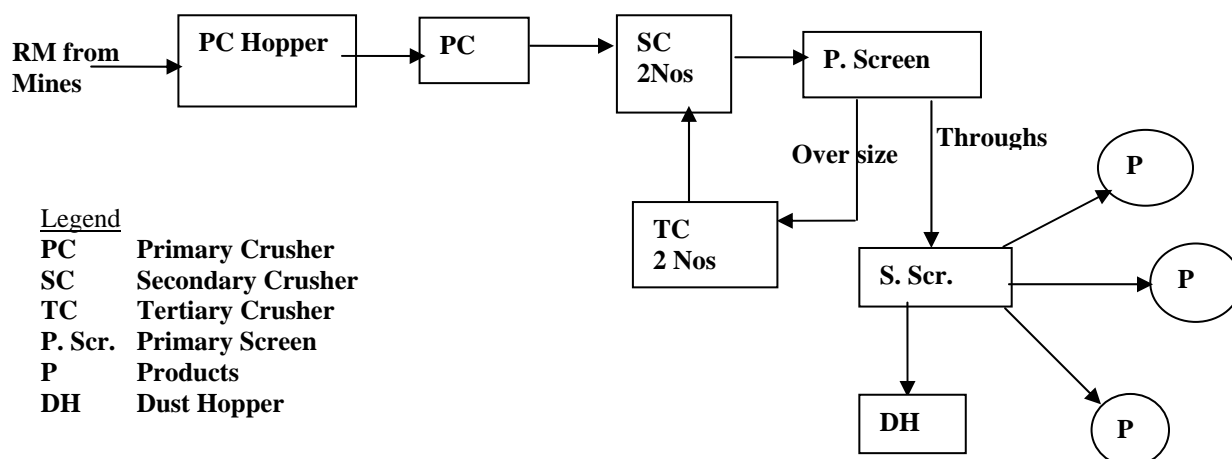
ii) Products

Size in mm	Local name
+ 40	Metal
+ 20	Kappchi
10-20	Grit

iii) Process Description

The raw material (Black Stone) from the mines consists of stones of various sizes from fines to large boulders. It is unloaded into the primary crusher hopper. The material is fed to the primary crusher via feeder. After primary crushing the material is conveyed to the hopper of the secondary crusher by belt conveyor. The material is further crushed and transferred to the screen for first screening. The 'oversize' from this screen goes to the tertiary crusher for crushing. The crushed material goes to the primary screen via the same belt conveyor (conveyor used to transfer the secondary crusher material). The 'throughs' from the first screen goes to the secondary screen for further screening and separation of different products and Dust. The dust is stored in hopper and directly unloaded into the truck. The products are discharged from the screen via conveyor belts to various stockpiles. From stockpiles the product is loaded into the trucks with the help of loaders and delivered at the point of use.

iv) Process Flow Diagram.



v) Existing Dust Containment & Suppression System

The unit management in its bid to reduce dust emanating from different points has made some arrangements to contain it. The water for suppressing the dust comes from a water tank at an elevated point, which provides the head. Perforated water pipe is provided over the unloading pit to suppress the dust emitted during unloading of the trucks. Partial housing using GI sheets has been provided over both the Screens & Partial covering of the conveyor belts.

UNIT No.2 : M/s. J. M. C. Mining & Quarry Works Ltd., Gujarat

i) Basic Details

This unit is located in the Thasra Taluka of Kheda district in Gujarat state. The raw material is Black Trap stone from the river bed of Mahi river. The unit normally operates in 2 shifts a day. The basic details of the unit are given below.

Type & Size of Primary Crushers :Jaw, 1 No., 30" X 15"
 Type & Size of Secondary Crushers :Jaw, 2 Nos. Size 34" X 6" & 30" X 15"
 Crushing Capacity :900 T/Day (45 TPH)
 Type & No. of screens :Vibratory, 1 No.
 Type of Raw Material :Black trap stone from river bed

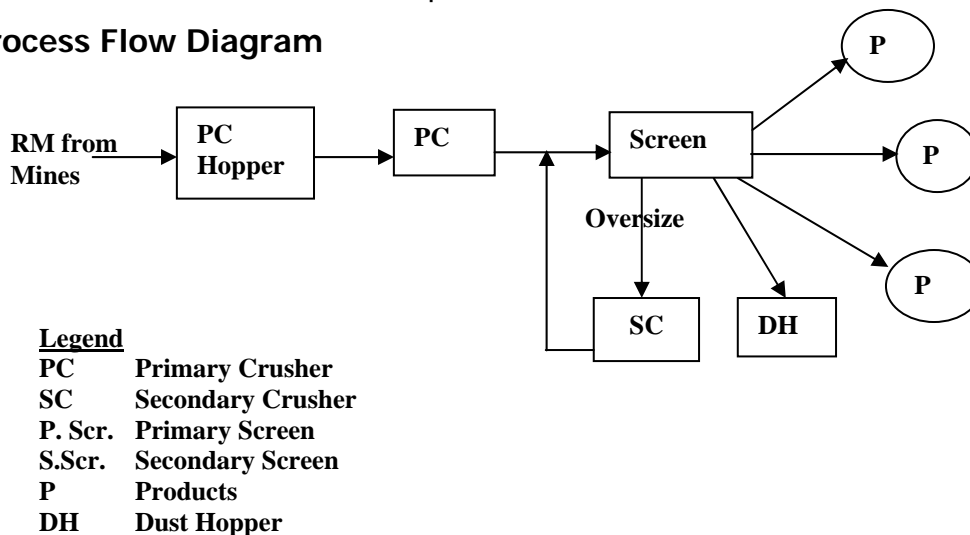
ii) Products

Size in mm	Local name
+ 20	Kappchi
10-20	Grit
6-10	Grit

iii) Process Description

The raw material (Black stone) is sourced from the riverbed from fines to large boulders. The stones are unloaded into the primary crusher hopper. The material is fed to the primary crusher via a feeder. After primary crushing the material is conveyed to the primary screen. The oversize from this screen goes to the Secondary Crushers for further crushing. The crushed stone from this Sec. crusher then goes to the screen along with the crushed stone from the primary crusher. The less than 20 mm size from the crushers goes for screening of products like Grit I (10 mm), Grit II (6 mm) & Dust. The dust is stored in hopper and directly unloaded into the truck. The products are conveyed via conveyor belts to the stockpiles from where the product is loaded into the trucks with the help of loaders and delivered at the point of use.

iv) Process Flow Diagram



v) Existing dust containment & suppression system

The unit management in its bid to reduce dust emanating from different points has made the following arrangements to contain/ suppress the dust.

Water is sprayed with the help of flexible hosepipe over the raw material inside the hopper. 15 Nos of water sprinklers of capacity 30 LPM each are placed at different locations so as to cover the entire plant area including product stockpiles. Water is pumped by 5 H P pump. Partial enclosure of GI sheets provided over the screens and belt conveyors.

Unit No. 3 : M/s. S. I. Quarry Works Pvt. Ltd., Gujarat

i) Basic Details

This unit is located in the Gothada village, Timba Road, in Panchmahal district of Gujarat. The raw material is Black Trap stone which comes from company's own open cast mines located nearby. The unit generally operates in 2 shifts a day. The basic details are given below.

Type & Size of Primary Crusher	:	Jaw 1 No, 30" X 15"
Type & Size of Secondary Crushers	:	Jaw 2 No., 16" X 9"
Crushing Capacity	:	500 T/Day (25 TPH)
Type & No. of screens	:	Vibratory, 1 No.
Type of Raw Material	:	Black trap stone from open-cast mines

ii) Products

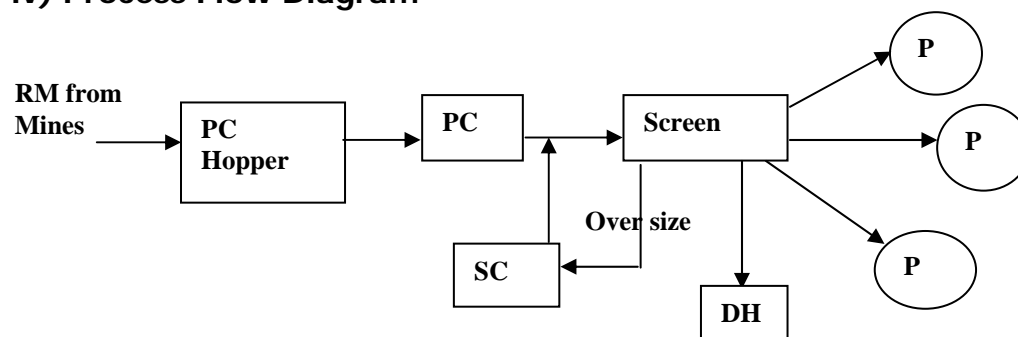
Size in mm	Local name
+ 50	Metal
+ 20	Kapchi
10-20	Grit

iii) Process Description

The raw material (Black stone) from the mines consisting of stone of various sizes from fines to large boulders is unloaded into the primary crusher hopper. The material is fed to the primary crusher via a feeder. After crushing the material is conveyed to the vibratory screen for screening. The 'oversize' from screen goes to secondary crusher via belt conveyor and chute. The crushed material from secondary crusher goes to the same screen via the same belt conveyor (conveyor used to transfer the primary crushed material). The 'throughs' are further screened to separate products. The dust is stored in hopper and directly unloaded into the truck. The screened products are conveyed

via conveyor belts to stockpiles. From stockpiles the product is loaded into trucks with the help of loaders and delivered at the point of use.

iv) Process Flow Diagram



Legend

PC Primary Crusher
SC Secondary Crusher
P Products
DH Dust Hopper

v) Existing Dust Containment & Suppression System:

The unit management in its bid to reduce dust emanating from different points has made some arrangements to contain/ suppress the dust. Jute cloth housing over the Screens & Polythene sheet type covering on belt conveyors are provided. Also water is thrown manually by bucket over the raw material in the hopper as well as in the truck before unloading. Sprinkling of water with the help of perforated pipe connected to a tractor mounted water tanker, which sprinkles water over the internal hauling roads where there is frequent movement of vehicles. Water sprinkling arrangement over the crushers, by gravity flow through an elevated tank.

Unit No. 4 : M/s. Charbujia Minerals, Udaipur, Rajasthan

i) Basic Details

This unit is located in Udaipur district of Rajasthan. The raw material is Black Trap stone that comes from the company's leased open cast mines located nearby. The unit generally operates in one shift a day. The basic details are given below.

Type & Size of Primary Crusher	:	Jaw (20" X 12"), 1No.
Type & Size of Secondary Crusher	:	Jaw (16" X 9"), 1 No.
Crushing Capacity:	:	90 T/Day (<15 TPH)
Type & No. of screens	:	Vibratory, 1 No.
Type of Raw Material	:	Black Trap Stone

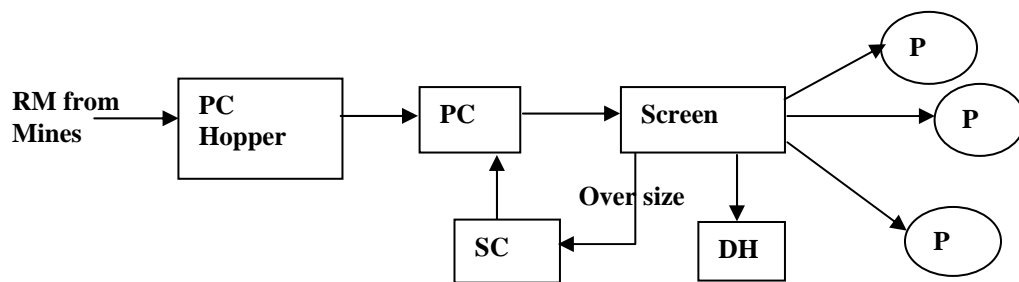
ii) Products

Size in mm	Local name
+ 40	Metal
+ 20	Kappchi
10	Grit
6	Dust

iii) Process Description

The raw material (Black stone) from the mines consisting of stones of various sizes from fines to large boulders are unloaded into hopper. The material is fed to the primary crusher via chute. After crushing the material is conveyed to the vibratory screen for screening. The 'oversize' from screen goes to secondary crusher via belt conveyor and chute. The crushed material from the secondary crusher goes to the same screen via the same belt conveyor (conveyor used to transfer the primary crushed material). The 'throughs' are further screened to separate products. The dust is stored in hopper and directly unloaded into the truck. The products are conveyed out of the screen via conveyor belts to stockpiles. From stockpiles the product is loaded into trucks with the help of loaders and delivered at the point of use.

iv) Process Flow Diagram.



Legend
PC Primary Crusher
SC Secondary Crusher
P Products
DH Dust Hopper

v) Existing dust containment & suppression system:

Following arrangements are in place to contain the dust.

- Partial covering over Screens using GI Sheets, no system for dust suppression due to reported water scarcity.

Unit No. 5 : M/s. Tamba Stone Crusher, Goa.

i) Basic Details

This unit is located in Concolim, Old Goa in the State of Goa. The raw material is Black Trap stone which comes from the company's own open cast mines located within the unit premises. The unit generally operates in one shift a day. The basic details are given below.

Type & Size of Primary Crusher	:	Jaw (30" X 15"), 1No.
Type & Size of Secondary & Tertiary Crusher	:	Jaw (16" X 9"), 2 No.
Crushing Capacity:	:	160 T/Day (20 TPH)
Type & No. of screens	:	Vibratory, 1 No.
Type of Raw material	:	Hillock mined stone

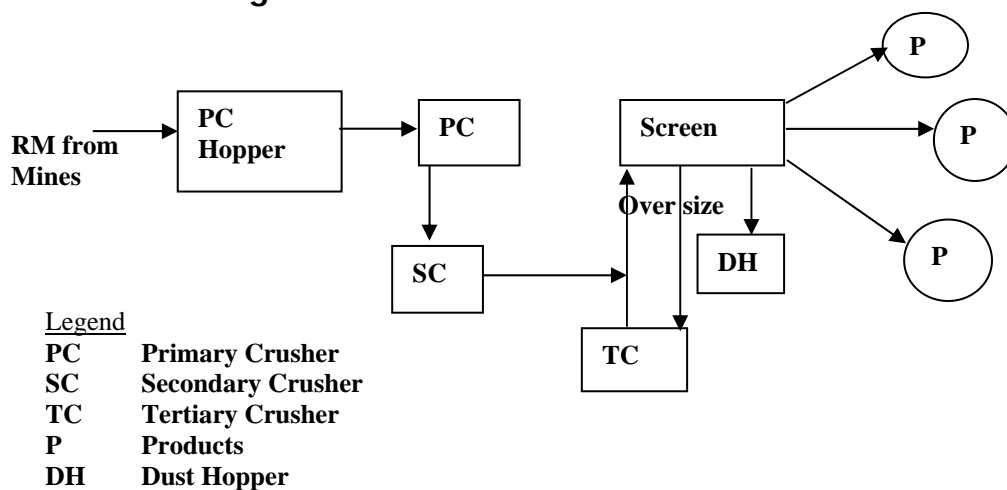
ii) Products

Size in mm	Local name
+ 40	Metal
+ 20	Kappchi
10	Grit
6	Dust

iii) Process Description

The raw material (Hillock Mined stone) from the mines consisting of stones of various sizes and are unloaded into a hopper. The material is fed to primary crusher via chute. After crushing, the material is conveyed to the secondary crushers for further reduction in size. The 'oversize' from this screen goes to the tertiary crusher via belt conveyor and chute. The crushed material from the secondary & tertiary crushers goes to the same screen via the belt conveyor. The 'throughs' are further screened to separate products. The dust is stored in hopper and directly unloaded into the truck. The products are conveyed via conveyor belts to stockpiles. From stockpiles the product is loaded into trucks with the help of loaders and delivered at the point of use.

iv) Process Flow Diagram



v) Existing dust containment & suppression system:

Following arrangements are in place to contain the dust.

- Partial covering over the Screens & Crusher Discharge (primary) with GI Sheets
- Secondary and Tertiary Crusher are housed in shed type structure
- No system for dust suppression found in place & lack of awareness about such.

UNIT No.6 M/s. Oriental Constructions Ltd., Indore, Madhya Pradesh.

i) Basic Details

This unit is located in the outskirts of Indore city of Madhya Pradesh State. The raw material is Black stone comes from nearby leased mining and the unit normally operates 2 shifts a day. The basic details of the unit are given below.

Type & Size of Primary Crusher	:	Jaw, 1 No. 36" X 48"
Type & Size of Secondary Crusher	:	Cone, 1 No., 32" X 16"
Type & Size of Tertiary Crusher	:	Cone, 1 No, 32" x 16"
Crushing Capacity:	:	900 T/Day (100 TPH)
No. of screens:	:	2 (Primary & Secondary)
Type of Raw Material:	:	Black Stone

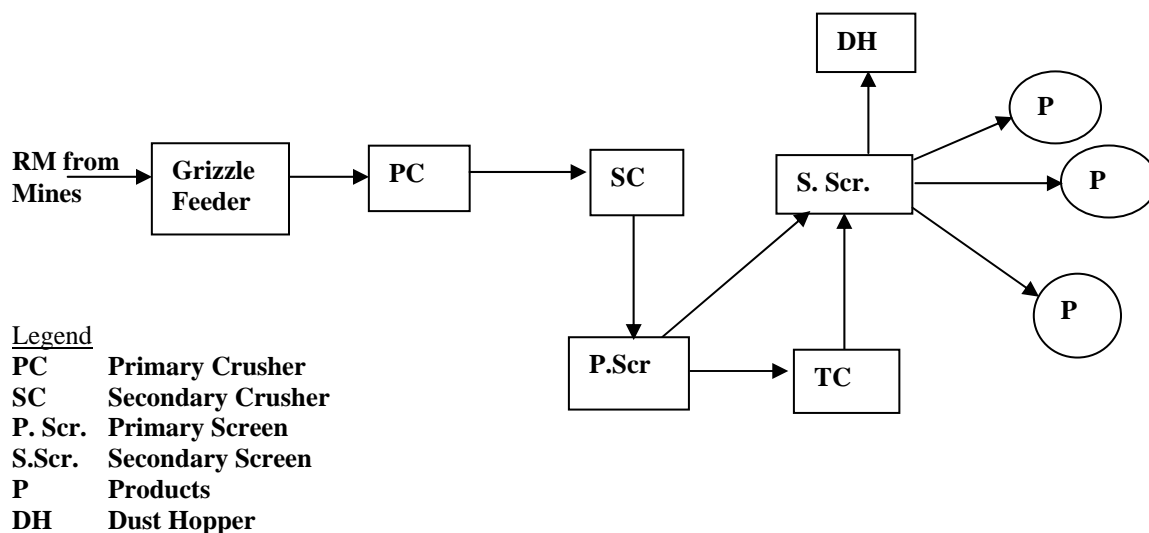
ii) Products

Size in mm	Local name
+ 20	Kappchi
+10	Grit
6-10	Semi Grit
-6	Dust

iii) Process Description

The raw material (Black stone) from the mines consists of stone of various sizes from fines to large boulders. It is unloaded into hopper. The material is fed to the primary crusher via a Grizzle feeder. The oversize from the grizzle feeder is considered as rejects and is sent for further breaking by manual. After primary crushing the material is conveyed to the secondary cone crusher. From the secondary cone crusher the material is sent to primary vibratory screen. The 'throughs' from the primary screen are screened to separate the "+ 40 mm" which goes to the tertiary crusher for further crushing. The crushed stone from this tertiary crusher then goes to the secondary screen. The less than 20 mm size from the primary screen then goes to the secondary screen for further screening and the separation of different products like Grit I (10 mm), Grit II (6 mm) & Dust. The dust is stored in hopper and directly unloaded into the truck to be disposed off. The products are taken out of the screen via conveyor belts to the stockpiles. From here the product is loaded into the trucks with the help of loaders to be delivered at the point of use.

iv) Process Flow Diagram



v) Existing dust containment & suppression system

The unit management in its bid to reduce dust emanating from different points has made the following arrangements to contain/ suppress the dust.

- A 5 H.P.pump with 1000 lit water tank capacity with the help of nozzle sprayed at primary jaw crusher. Enclosure with GI sheets over the Screens.Enclosures to conveyor belts was provided

Unit No. 7 : M/s. New Neelgiri Stone, Sohna, Haryana

i) Basic Details

This unit is located in Raisina Crushing Zone of Sohna district in Haryana. The raw material is Black Trapstone, which comes from leased open cast mines located at about 20 KM away from the crushing plant. The unit operates for 1 shift in a day. The basic details of the unit are given below.

Type & Size of Primary Crusher	:	Jaw (32" X 20"), 1 No
Type & Size of Secondary Crusher	:	Jaw (42" X 8"), 2 Nos.
Type & Size of Tertiary Crusher	:	Roller(38" X 22"), 1 Nos.
Crushing Capacity:	:	50T/Hr
Type & No. of Screens	:	Vibratory, 2 No. (Prim. & Sec.)
Type of Raw material	:	Hillock Black trap stone

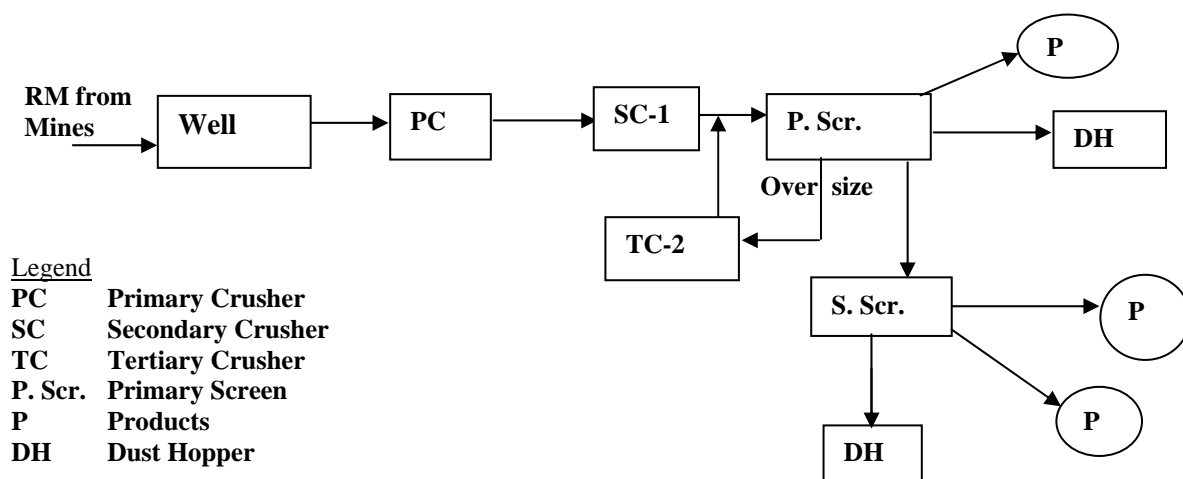
ii) Products

Size in mm	Local name
+ 40	Metal
+ 20	Kapchi
10-20	Grit
6-10	Coarse Dust
-6	Fine Dust

iii) Process Description

The raw material (Black stone) from the mines consisting of fines to large boulders and unloaded into well/hopper. The material is fed to the primary crusher via chute. After primary crushing the material is conveyed to secondary crusher through belt conveyor. The material is further crushed and transferred to primary screen. The 'throughs' go to the secondary screen for further screening and separation of different products and Dust. The 'oversize' from the primary vibratory screen goes to the tertiary crusher for further crushing. The coarse dust and 40mm products are taken out from the primary screen. The crushed material goes to the secondary screen via belt conveyor. The products are taken out of the screen via conveyor belts to stockpiles. From stockpiles the product is loaded into the trucks using loaders to be delivered at the point of use.

iv) Process Flow Diagram



v) Existing dust containment & suppression system:

The following systems are kept in place for controlling the dust. They are

- A small water tank, pump and Nozzle for dust suppression arrangement kept in place. About 36 nozzles were used at various locations of the plant. Partial housing with GI sheets over the Screens. Roller Crusher was housed in a shed like structure

Unit No. 8 : M/s. Haryana Grit, Sohna, Haryana

i) Basic Details

This unit is located in Raisina Crushing Zone of Sohna district in Haryana. The raw material is Black Trap stone which comes from leased open cast mines located at 20 KM away from the crushing plant. The unit operates for 1 shift in a day. The basic details of the unit are given below.

Type & Size of Primary Crusher : Jaw (32" X 20"), 1 No
 Type & Size of Secondary Crusher : Roller (38" X 22"), 1 Nos.
 Crushing Capacity : 30T/hr
 Type & No. of Screens : Vibratory, 1 No.
 Type of Raw Material : Hillock Black trap stone

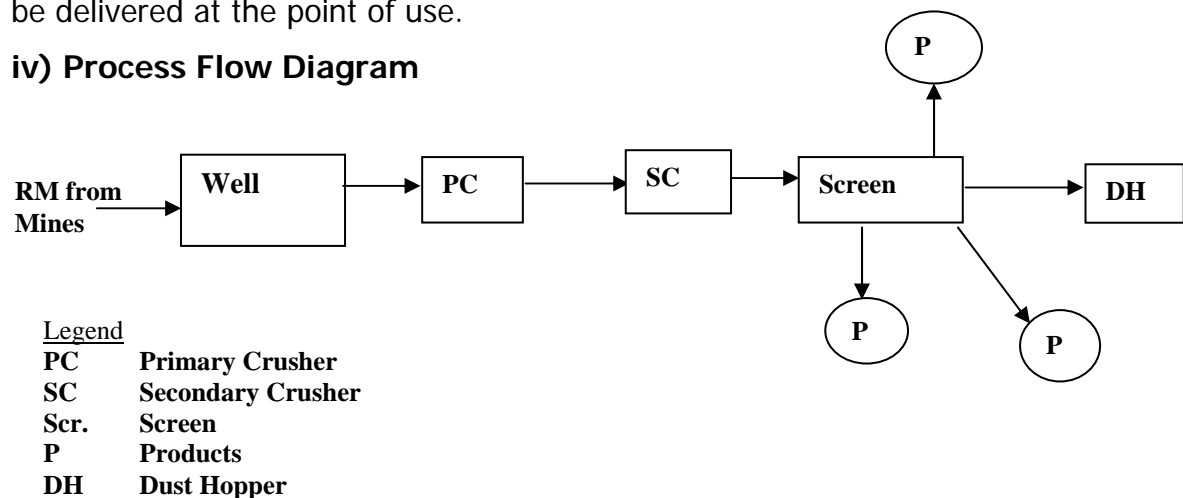
ii) Products

Size in mm	Local name
+ 40	Metal
+ 20	Kappchi
10-20	Grit
-10	Dust

iii) Process Description

The raw material (Black stone) from the mines consisting of fines to large boulders and unloaded into well/hopper. The material is fed to the primary crusher via chute. After primary crushing the material is conveyed to secondary roller crusher by belt conveyor. The material is further crushed and transferred to vibratory screen. The 'throughs' from the screen are screened and separated into different products. The products are taken out of the screen via conveyor belts to stockpiles. From stockpiles products are loaded into the trucks using loaders to be delivered at the point of use.

iv) Process Flow Diagram



v) Existing dust containment & suppression system:

The following systems are kept in place for controlling the dust. They are

- A water tank, Pump & Nozzle arrangement for dust suppression was found in place. Partial housing with GI sheets over the Screens Roller Crusher was housed in a shed like structure.

Unit No. 9 : M/s. Lingraj Stone Crusher, Bhubaneswar, Orissa

i) Basic Details

This unit is located near Bhubaneswar close to highway. The raw material is Black Granite stone which comes from open cast mines located nearby. The unit generally operates one shift a day. The basic details are given below.

Type & Size of Primary Crusher	:	Jaw (16" X 6"), 1No.
Crushing Capacity	:	90 T/Day(8 PH)
Type & No. of screens	:	Rotary, 1 No.
Type of Raw Material	:	Black Granite stone

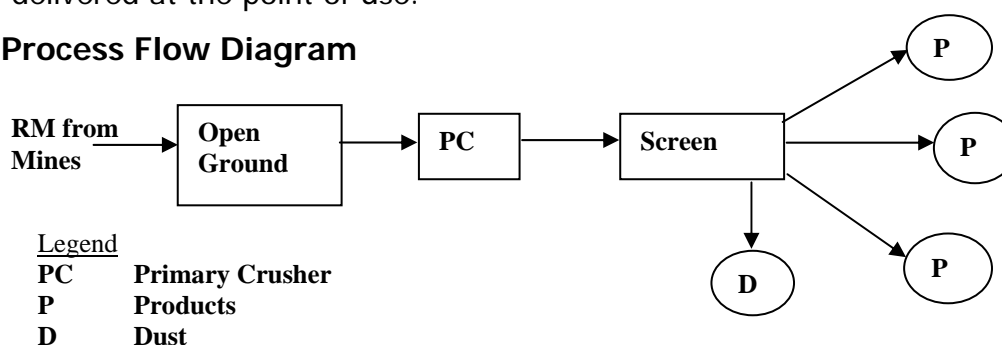
ii) Products

Size in mm	Local name
+ 20-40	Metal
12-20	Aggregate
8-12	Grit
4-8	Jeera

iii) Process Description

The raw material (Black granite stone) from the mines consisting of stones of various sizes are unloaded on ground. Labourers break the larger size boulders manually. The small size boulders are carried overhead with the help of small containers for feeding into Crusher. After crushing the material is discharged via a chute in to the rotary screen. The screened products are taken from below the screen manually. From stockpiles the product is loaded into the trucks manually and delivered at the point of use.

iv) Process Flow Diagram



v) Existing dust containment & suppression system:

- No dust containment enclosures or suppression arrangement was found in place

Unit No. 10: M/s Pushpa Stone Crusher, Bhubaneshwar, Orissa

i) Basic Details

This unit is located in Khurda district of Orissa. The raw material is Black Granite stone, which comes from leased open cast mines located nearby. The unit generally operates in two shifts a day. The basic details are given below.

Type & Size of Primary Crusher	:	Jaw (16" X 6"), 1No.
Crushing Capacity	:	12 TPH
Type & No. of screens	:	Rotary, 2 No.
Type of Raw Material	:	Black Granite stone

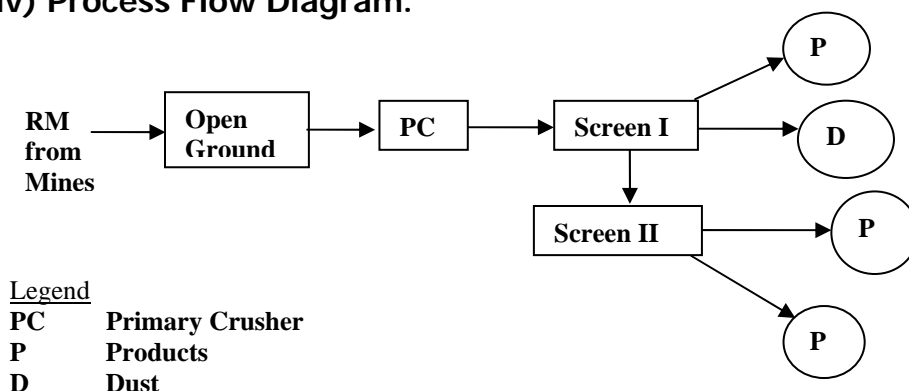
ii) Products

Size in mm	Local name
+ 20-40	Metal
12-20	Aggregate
8-12	Grit
4-8	Jeera

iii) Process Description

The raw material (Black granite stone) from the mines is unloaded on ground level. The larger size boulders are broken manually by labourers to smaller sizes. The small size boulders are carried in small containers for feeding into crusher manually. After crushing the material is conveyed two rotary screens for two stage screening. The screened products from the screen are retrieved and taken to stockpiles by manually. From stockpiles the product is manually loaded into trucks delivered at the point of use.

iv) Process Flow Diagram.



v) Existing dust containment & suppression system:

- No dust containment enclosures or suppression arrangement was found in place

Unit No.11 : M/s. Maakali Stone Crusher, Bhubaneshwar, Orissa

i) Basic Details

This unit is located in Bhagavanpur Industrial Estate, in Bhubaneshwar district of Orissa. The raw material is Black Granite stone, which comes from leased open cast mines located nearby. The unit generally operates in one shift a day. The basic details are given below.

Type & Size of Primary Crusher	:	Jaw (14" X 5"), 1No.
Crushing Capacity	:	6 TPH
Type & No. of Screens	:	Rotary, 1 No.
Type of Raw Material	:	Black granite stone

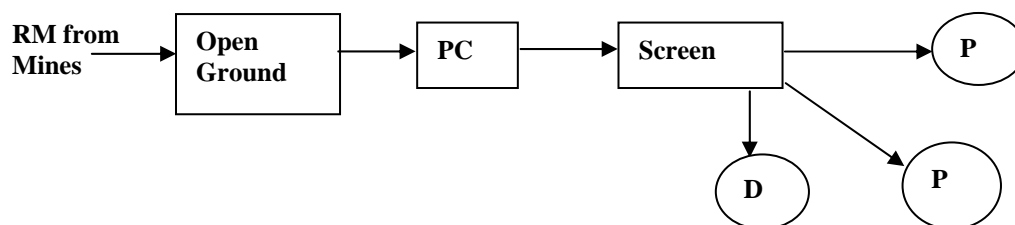
ii) Products

Size in mm	Local name
12-20	Aggregate
8-12	Grit
4-8	Jeera

iii) Process Description

The raw material (Black stone) from the mines is unloaded on ground level. The larger size boulders are broken manually by labourers to smaller sizes. The small size boulders are carried over head in small containers for feeding into Crusher. After crushing the material is conveyed to rotary screen for screening. The screened products from the screen are retrieved and manually taken to stockpiles. From stockpiles the product is manually loaded into trucks and delivered at the point of use.

iv) Process Flow Diagram



Legend

PC Primary Crusher
 P Products
 D Dust

v) Existing dust containment & suppression system:

- No dust containment enclosures or suppression arrangement was found in place

Unit No.12 : M/s. Champak Stone Crusher, Bhubaneshwar, Orissa

i) Basic Details

This unit is located in Bhagavanpur Industrial Estate, in Bhubaneshwar district of Orissa. The raw material is Black Granite stone, which comes from leased open cast mines located nearby. The unit generally operates in one shift a day. The basic details are given below.

Type & Size of Primary Crusher	:	Jaw (16" X 6"), 1No.
Crushing Capacity	:	6 TPH
Type & No. of screens	:	Rotary, 1 No.
Type of Raw Material	:	Black Granite stone

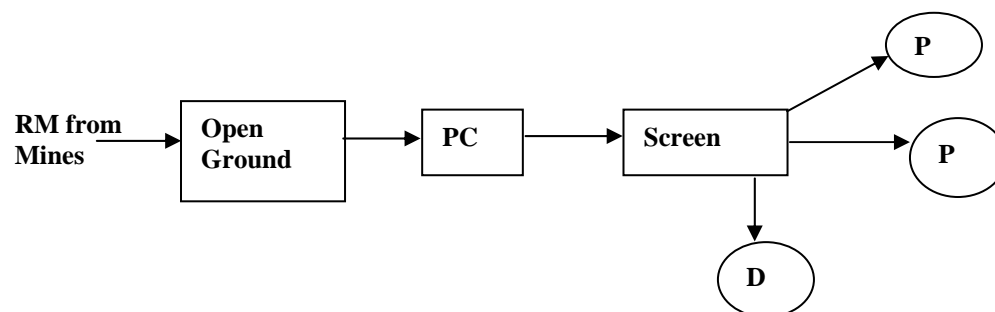
ii) Products

Size in mm	Local name
12-20	Aggregate
8-12	Grit
4-8	Jeera

iii) Process Description

The raw material (Black stone) from the mines consists of stone of various sizes from fines to large boulders. The larger size boulders are broken manually by labourers of smaller sizes. The small size boulders are carried over the head with the help of small containers for feeding into Crusher. After crushing the material is conveyed to the rotary screen for screening. The screened products are taken out of the screen by manually to stockpiles. From stockpiles the product is loaded into the trucks with the help of loaders to be delivered at the point of use.

iv) Process Flow Diagram



Legend

PC Primary Crusher
P Products
D Dust

Existing dust containment & suppression system:

- No dust containment or suppression arrangement was found in place

Unit No.13 : M/s. Dhamtal Stone Crusher, Kullu, Himachal Pradesh

i) Basic Details

This unit is located between state highway and river in Kullu district in the State of Himachal Pradesh. The raw material is Pebble stone, which comes from nearby riverbed. The unit generally operates in one shift a day. The basic details are given below.

Type & Size of Primary Crusher : Jaw (20" X 12"), 1No.
 Crushing Capacity: : 5 TPH
 Type & No. of screens : Rotary, 1 No.
 Type of Raw Material : Pebbles stone from river bed

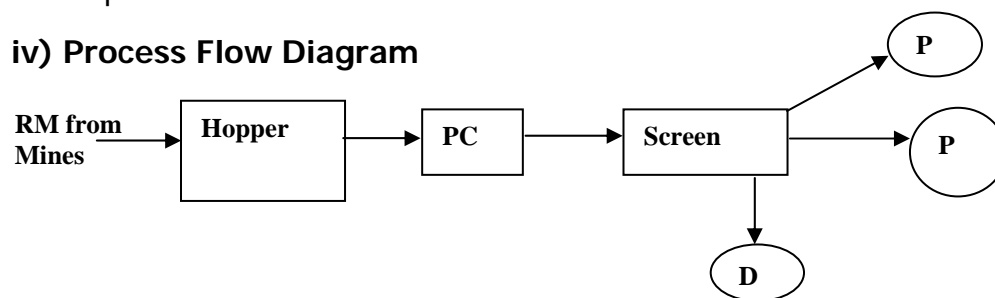
ii) Products

Size in mm	Local name
12-20	Aggregate
8-12	Grit
4-8	Dust

iii) Process Description

The raw material from the river consists of stone of various sizes from fines to large boulders and unloaded into hopper. The material is fed to the primary crusher via chute. After crushing the material is conveyed to rotary screen. The 'throughs' from the screen are screened and separated into different products. The products are taken out of the screen via and Conveyor Belts to stockpiles. From stockpiles products are loaded into the trucks using loaders to be delivered at the point of use.

iv) Process Flow Diagram



Legend

PC Primary Crusher
 P Products
 D Dust

Existing dust containment & suppression system:

- No dust containment or suppression arrangement was found in place

Unit No.14 : M/s. Hariant Stone Crusher, Nagpur, Maharashtra

i) Basic Details

This unit is located near state highway taluka Umred, District Nagpur in the State of Maharashtra. The raw material is Granite stone, which comes from leased open cast mines located nearby. The unit generally operates in one shift a day. The basic details are given below.

Type & Size of Primary Crusher : Jaw (20" X 12"), 1No.
 Crushing Capacity : 25 TPH
 Type & No. of screens : Vibratory with Bucket Elevator 1 No.
 Type of Raw Material : Granite stone

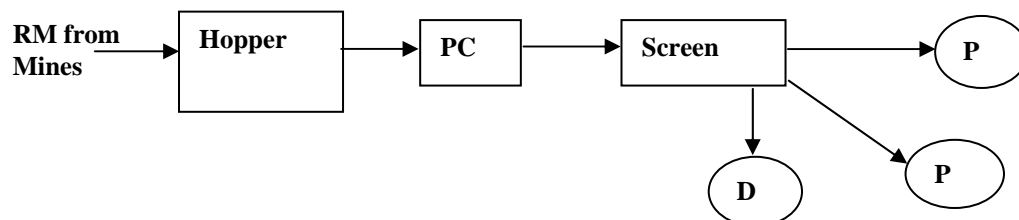
ii) Products

Size in mm	Local name
12-20	Aggregate
8-12	Grit
4-8	Dust

iii) Process Description

The raw material (granite stone) from the mines consists of stone of various sizes from fines to large boulders and unloaded into hopper. The material is fed to the primary crusher via chute. After crushing the material is conveyed to vibratory screen. The 'throughs' from the screen are screened and separated into different products. The products are taken out of the screen via Bucket Elevator and Conveyor Belts to stockpiles. From stockpiles products are loaded into the trucks using loaders to be delivered at the point of use.

iv) Process Flow Diagram



Legend

PC Primary Crusher
 P Products
 D Dust

Existing dust containment & suppression system:

- Partial Enclosure provided to the vibratory screen and manual wetting of suppression arrangement was found in place

Unit No. 15: M/s. Jaspal Singh Stone Crushers, Ropar, Punjab

i) Basic Details

This unit is located in Ropar-Nangal Highway of Ropar district in Punjab. The raw material is Wet Grit and Pebbles stone that comes from riverbed Lohand and adjoining rivers located at 8- 10 KM from the crushing plant. The unit operates for 1 shift in a day. The basic details of the unit are given below.

Type & Size of Primary Crusher	:	Jaw (30" X 15"), 1 No
Type & Size of Secondary Crusher	:	Roller Crusher, 1 Nos.
Crushing Capacity:	:	20T/hr
Type & No. of Screens	:	Vibratory, 1 No.
Type of Raw Material	:	Wet Grit & Pebble Stone

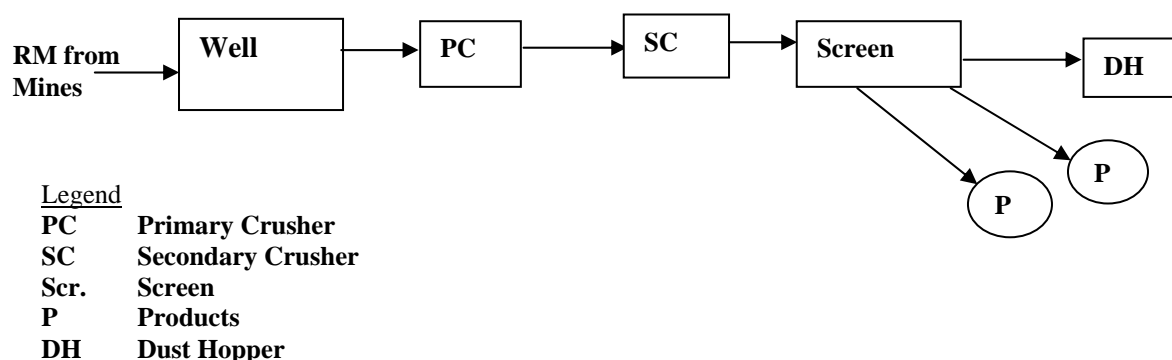
ii) Products:

Size in mm	Local Name
+ 20	Kappchi
10-20	Grit
-10	Dust

iii) Process Description

The raw material from the river consisting of fines to large pebbles and unloaded into well/hopper. The material is fed to the primary crusher via chute. After primary crushing the material is conveyed to secondary roller crusher by belt conveyor. The material is further crushed in roller crusher and transferred to vibratory screen. The 'throughs' from the screen are screened and separated into different products. The products are taken out of the screen via conveyor belts to stockpiles. From stockpiles products are loaded into the trucks using loaders to be delivered at the point of use.

iv) Process Flow Diagram



v) Existing dust containment & suppression system

The following systems are kept in place for controlling the dust. They are

- An overhead water tank with gravity flow arrangement for dust suppression was found in place. Partial housing with GI sheets over the Screens Roller Crusher was housed in a shed like structure.

Unit No.16: M/s. Orient Stone Crusher, Durg, Chattisgarh

i) Basic Details

This unit is located near state Highway, district Durg in the State of Madhya Pradesh. The raw material is Granite stone, which comes from leased open cast mines located nearby. The unit generally operates in one shift a day. The basic details are given below.

Type & Size of Crusher	:	Jaw (30" X 15"), 1No.
Crushing Capacity	:	20 TPH
Type & No. of screens	:	Vibratory,1 No.
Type of Raw Material	:	Soft stone(Semi Grade)

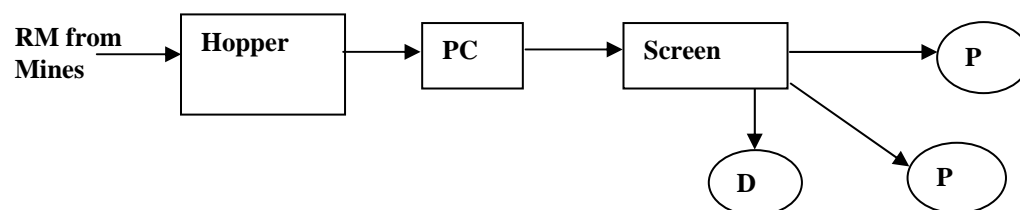
ii) Products

Size in mm	Local name
12-20	Aggregate
8-12	Grit
4-8	Dust

iii) Process Description

The raw material (Soft stone) from the mines consists of stone of various sizes from fines to large boulders and unloaded into hopper. The material is fed to the jaw crusher via chute. After crushing the material is conveyed to vibratory screen. The 'throughs' from the screen are screened and separated into different products. The products are taken out of the screen conveyor belts to stockpiles. From stockpiles products are loaded into the trucks using loaders to be delivered at the point of use.

iv) Process Flow Diagram



Legend

PC Primary Crusher
 P Products
 D Dust

Existing dust containment & suppression system:

- No dust containment or suppression arrangement was found in place

6.3 Details of Fugitive emissions Monitoring in Selected SCU's

Fugitive emission monitoring was carried out in a few units with an objective to generate information on the existing level of the emission from uncontrolled/partially controlled stone crushing operations, which could form a baseline data for comparison after incorporation of the CP measures.

The fugitive emission monitoring was conducted using two sets of High Volume Sampler (HVS), one placed at the upwind location and the other on the downwind direction during the operation of the crusher. The downwind HVS were located at appropriate locations covering emission from all the source of dust generation. However, depending upon layout of SCU's, two HVS were located appropriately in down wind apart from the upwind HVS.

The upwind side HVS is so located that it gives the background concentration which is due to the dust from other sources i.e. operation of crushing unit does not contribute the SPM concentration measured at upwind direction.

The downwind side HVS measures the dust emission from the unit under the study as well as the other sources. The difference between the downwind concentration and the upwind concentration gives the concentration actually contributed by virtue of operation of the stone crushing unit.

$$(\text{Downwind reading}) - (\text{Upwind reading}) = (\text{Contribution by the unit})$$

A typical sketch showing the location of both the High Volume Samplers in the unit layout is shown in the following pages.

The measurements were carried out at 6 units predominantly having Jaw Crushers. The results of the ambient air monitoring are as given below.

Table - 6.1 : Fugitive emission Monitoring Data for Selected SCU's

Unit No	Downwind µg/m³	Upwind µg/m³	Contribution by the unit µg/m³
	2	3	(2-3)
UNIT 1	25224	1313	23911
UNIT 2	36826	420	36406
UNIT 3	3222	880	2342
UNIT 4	10118	705	9413
UNIT 5	10975	858	10117
UNIT 6	21157	2015	19142
Average	17920	1032	6888

The above data reveals that the contribution in SPM by the stone crusher units with varying degree of dust control measures varies widely from 2342 to 36406 µg/m³ microgram/m³ with an average SPM contribution of 16888 µg/m³, which is about 28 times higher than the existing standard of 600 µg/m³.

(Refer Annexure 6.1 for Data sheets of fugitive emission monitoring for all 8 units)

Fugitive emission monitoring was carried out using respirable dust sampler for Unit 7 & Unit 8. The data indicates very high values of SPM contribution in the range of 81840 to over 113,000 $\mu\text{g}/\text{m}^3$ and more alarmingly, it contains high percent respirable range (about 25%) and the SPM value is more than 100 times higher than the existing standards. This is primarily due to inoperative suppression system and inadequate control. The high SPM values in Unit 7 & 8 is primarily contributed by use of roller type crushers as tertiary crushers for tertiary stage crushing which generates more dust product and it has higher sellable value due to locational advantages. The results and monitoring are given below:

Unit No	Downwind $\mu\text{g}/\text{m}^3$		Upwind $\mu\text{g}/\text{m}^3$		Contribution by the unit, $\mu\text{g}/\text{m}^3$
	SPM	PM ₁₀	SPM	PM ₁₀	
UNIT 7	121143	21800	23425	6350	113168
UNIT 8	92542	22239	24570	8371	81840

6.4 Noise Monitoring Details

The following tables shows results of noise monitoring conducted at following units:

Unit. No.	Max, dB(A)	Min, dB(A)	Leq	Remarks
Unit 1	102.6	100.1	101.9	Measured near vibratory screen
Unit 2	105.3	101.9	103.1	Measured near Primary, Secondary and vibratory screen
Unit 3	99.6	71.7	88.4	Measured near primary & secondary crusher
Unit 4	70.2	61.6	65.0	Measured near vibratory screen
Unit 5	97.6	95.5	96.5	Measured near vibratory screen and crusher
Unit 6	102.2	100.6	100.3	Measured near secondary crusher
Unit 7	77.8	74.4	75.6	Measured near vibratory screen
Unit 8	82.7	73.9	76.4	Measured near vibratory screen and crusher

The above readings indicate noise level beyond acceptable limit of 75 dB(A) in many crushers. The noise source like crushers, screens or either only partially enclosed or open and it aggravates the noise levels.

6.5 Details of a Cluster Based Fugitive Emissions Monitoring Study

Field Studies were carried out in Raisina Crusher Zone, Sohna, Gurgaon District of Haryana State. The Cluster has 36 Stone Crushers, each occupying 1 acre area of plot size. Most crushers have roller type tertiary crushers so as to produce more percentage of fine dust (<4 mm) as it has saleable value being near to the National Capital Region. All the crushers do have partial enclosures and dust suppression arrangement such as many nozzles and sprinklers spraying water at various places. Unfortunately, during the study period it was observed that hardly any crusher unit operates the water sprays. The reported reason was excessive water consumption and formation of dust layer on the crushed stone gravels affecting its quality adversely. Ambient Air monitoring using RSPM samplers were conducted both upstream and downstream of the clusters considering the prominent wind direction and results of measurements indicates alarming situation in terms of very high level of SPM contribution by the cluster. The results are given in the table below. *A figure showing layout of the crusher zone and RDS locations are given **Figure 6.1***

(A set of monitoring were also carried out with in the cluster area to know general ambient air quality level within the cluster). The SPM was found to be 55926 $\mu\text{g}/\text{m}^3$ with respirable content of 8215 $\mu\text{g}/\text{m}^3$.

Sampling Location	SPM, $\mu\text{g}/\text{m}^3$	PM10, $\mu\text{g}/\text{m}^3$	Comments
Upwind direction	5069	1004	
Centre of the cluster	37571	6044	
Downwind direction	55926	8215	
Contribution by the cluster	50857	7211	Difference between downwind and upwind

This high concentration calls for stricter measures to be enforced on stone crushers in such zones. If wet suppression systems are not acceptable, dry type control systems as adopted widely in crushers in developed countries and practically feasible should be enforced.

6.6 Sieve Analysis Field Studies for Estimating Dust Generation at Various Stages

The Sieve Analysis of the crushed products was carried out with an objective to estimate the percentage mix of different products from the outlet of the crushers especially the percentage of fines generated during crushing. Several Grab samples weighing approximately 10 kg each were collected from crusher outlets using shovel. The sampling at each point was conducted for a period of 2 hrs. All the collected samples were mixed manually and weighed. Out of the mixed quantity, representative portion of the sample was taken as per standard method followed in crusher. Sieving of the sample was done using standard sieves of different sieve sizes, starting with the largest size up to 6mm size. The results of the sieve analysis for three units are given in the table below

Final Product Size, mm	Percentage Wise Distribution of Total			Average (%)
	Unit 1 (100 TPH)	Unit 2 (50 TPH)	Unit 3 (30 TPH)	
+40	7.91	16.7	19.0	14.5
25 - 40	41.2	36.5	17.9	31.9
10-25	22.8	26.4	31.3	26.8
6-10	15.0	8.1	12.9	12.0
<6(Dust)	13.0	12.3	18.9	14.7
Total	100	100	100	100

The above table indicates that the fines below 6mm size are generated in the range of about 12 – 19 % of the total quantity of stone crushed, with an average of 14.7%. Out of this dust, the dust below 100 micron (0.1mm) is the one which gets airborne and spread as fugitive emissions. Typically for a medium capacity unit crushing about 50 TPH and operating of about 10 hours a day generates about 75 tonnes of dust less than 6mm size and as reported and referred in literature about 1 –2 % dust (Equivalent to 5 –10 tonnes/day) gets airborne.

NPC FIELD STUDIES IN PROGRESS

PHOTOPLATE 9



SETTING UP RESPIRABLE/
HIGH VOLUME SAMPLERS
AMBIENT AIR MONITORING

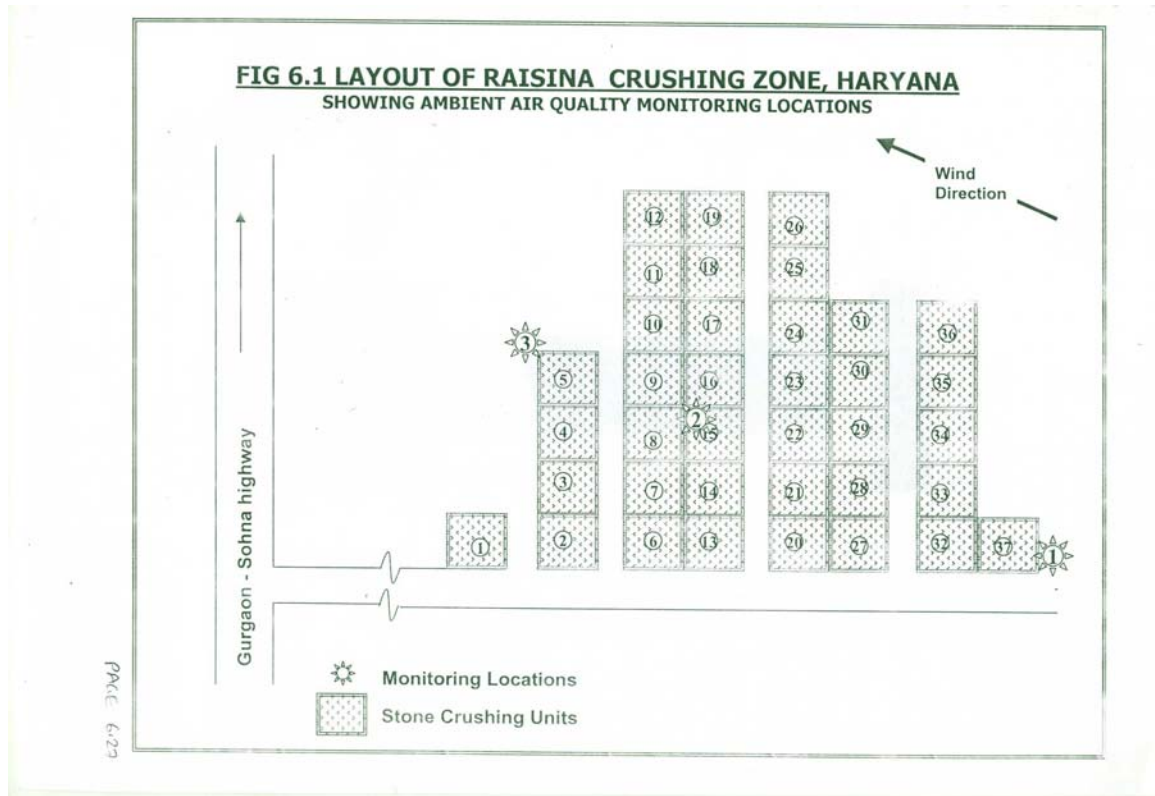


SIEVE ANALYSIS OF CRUSHED STONES

FROM VARIOUS STAGES



PAGE 6.26



CHAPTER NO.7

DISCUSSIONS ON EVOLVING STANDARDS GUIDELINES & SITING CRITERIA

Based on the in-depth study / monitoring data and discussions with various State Pollution Control Board officials, as well as stone crusher unit owners in various states, the most prominent issues are discussed briefly below.

7.1 Discussion Issues

The discussions are based on the following aspects:

- i) Practical difficulties faced by the stone crushers in adopting the guidelines to meet the standards.
- ii) Practical difficulties faced by the State Pollution Control Board officials in enforcing the standards and judging adequacy of the system installed.
- iii) How the standards are developed and enforced in developed countries like USEPA & is it applicable to Indian crushers.
- iv) Practical problem in various states in siting/shifting existing crushers.
- v) Practical aspects for siting new crushers.

Some important observations and discussions on above-mentioned practical aspects are provided below which could form a basis for evolving the modified environmental standards and appropriate advanced designs.

7.1.1. Practical difficulties faced by the stone crushers in adopting the guidelines to meet the standards.

- a) **Lack of specific details/knowledge of what area to be enclosed/contained**

Some have a large shed over crushers but one side open, but keep screens open, some enclose screens but partially, some enclose using jute cloth, plastic etc., some enclose belt conveyors. The decision of what to enclose & what not is based on individuals knowledge & understanding.

Comment: To overcome this, items to be enclosed should be specified by the State Board. Awareness program and workshop should be organized periodically by the State Boards to educate the crusher owners on such issues.

b) Lack of details/knowledge of where exactly to spray and how much

Some crushers have 20 to 30 nozzles spraying at various places like the entire enclosure of vibratory screen & crusher house, some spray with gravity fed pipes by making holes in pipes, some use domestic showers, some use sprinklers and spray very large quantity of water all around the plant boundary. These practices either use too much water or it makes stones too wet to be acceptable and for these reasons, even if the water spray systems are installed, the crushers do not operate, mostly due to valid reasons that it spoils the quality due to excessive moisture.

Comment: The standard/guidelines should be such that it should not hamper the process or product quality adversely. Standard should specify key locations where water would be required to be sprayed.

c) Nozzles get frequently choked and prevent spray formations:

Most crushers use either bore well water or mine water which is generally hard/salty, which corrodes the pipes and form salt deposits in the pipes, eventually leading to corrosion/choking of pipes and holes in the nozzles.

Comment: Some cheap and affordable softening treatment should be given to the hard water. This could be done by adding some alum or lime inside the water storage tank before pumping. In addition, there should be an online backwash type self-cleaning fine filter unit to filter dirt/dust going to nozzles. In place of GI pipes, PVC pipes could be used to eliminate the corrosion problems, but care should be taken to protect the PVC pipes from damage due to truck movement, falling stones or mishandling by workers. Pipes concealed inside C-shape sections or angles etc. can be possible.

d) Some crusher owner's claim that they do spray lot of water by nozzle, pipes and also by sprinklers, but still dust control not satisfactory.

Many crushers spray water by low or high level sprinklers all around the boundary, which mostly only creates muddy/marshy ground conditions, but dust still remains uncontrolled in some portions of plant. To avoid muddy conditions, crushers have to stop using sprinklers. Also, they complain of having invested large amount of money in sprinklers (few lakhs) and also have high operating cost (5 to 10 HP), and they feel still the state authorities are not happy.

Comment: The first and prime important technical considerations in dust suppression is that "the dust should be suppressed immediately after it is generated at the closest possible point" and second" the water droplets should be as fine as the dust particles. These two basic facts are not at all addressed by

sprinklers, holes in pipes, gravity spraying through domestic showers or manual spraying by bucket etc. and therefore they are not effective. Therefore, water spraying closest to the point of its generation is required and not sprinklers. The standard should address this issue. Sprinkler arrangement could serve the purpose of suppressing secondary fugitive dust emission by wetting stockpiles and hauling roads inside premises.

7.1.2. Practical difficulties faced by the State Pollution Control Board officials in enforcing the standards and judging adequacy of the system installed

a) Where to do fugitive emission monitoring

Some SPCB officials raise a point that where exactly to locate the sampler and at what distance, some PCB's measure SPM at 40 M distance, and some at 10 m, but it is not specified from which reference locations the distance is measured. Upwind concentrations are not measured and subtracted from the down wind concentration to represent contribution by the unit. Whether absolute value to be taken or contribution to be taken is not clear to a number of officials.

Comments: In a typical most representative layout of a crusher, the screen is somewhat centrally located equipment. Typically the crusher layout from unloading point to crusher to screen and to stockpiles is spread over 20M x 20M (or more) area and the most centrally located equipment is the screen.

Also, should the dust suppression be effective, as a result of moisture carry over by stones up to screen, the screen enclosure becomes dust free. Rather, it is an easy visual testing that if there are no emissions in the screen enclosure area, it would mean the dust suppression is adequate.

Keeping the above two facts in view (i) that the screen is most centrally located & (ii) dust free screen area is an ultimate test of good dust suppression system, the screen should be considered as reference point for fixing sampler distance and location.

As regards to the distance, USEPA recommends ambient measurement standard at "fence line" i.e. at boundary of the unit premises – The revision of standards should therefore be clear and address these issues.

- b) **Wind direction changes often & therefore it is difficult to place the upwind and downwind samplers at a fixed representative location neither they can be shifted from one place to other every now and then as the wind direction changes.**

Comments: It is practically true that wind direction changes often and it is difficult to shift sampler from one place to other. The most predominant wind direction should be considered as the most representative locations for sampler.

Many SPCB's monitor only downwind value using only one HVS sampler and the upwind is hardly monitored. This point should be clear in the revised standards.

Carrying at least 2 HVs samplers to the crusher sites and conducting measurements for a period of at least 8 hours and to periodically observe and note the flow rate and to provide uninterrupted power supply to both the samplers in itself is quite tedious, time consuming and cost intensive task for an appropriate ambient monitoring test. The standard should address this practical constraints.

And at times, as the crushers often operate at lower production rate during testing so as to minimize the dust emissions to the extent possible which in the absence of any continuous production rate measurement tool or instrument, relying only on the SPM value for deciding adequacy of dust control, may not be appropriate. It is, therefore, the standard should ensure that there exists a "system hardware" (such as water tank, filter, pump, nozzles, GI pipe network etc.) and it functions, which in turn is most likely to ensure effective dust control and it is therefore the "system hardware" part should be a part of the proposed standard, as done by USEPA in their standards.

7.1.3. How the standards are developed and enforced in developed countries like USEPA & is it applicable to Indian crushers.

- a) System hardware requirements & opacity limit on emissions:-

In USA, the environmental standard developed by USEPA includes the system hardware requirements and opacity measurements. The standard prescribes that no visible emissions should be seen from any of the dust emitting sources and the "visibility of emissions" is not left to the judgment of the observers but it needs to be measured using "opacity measuring instruments" such that the opacity not to exceed 5% range.

Comments: In Indian context, system hardware requirements can be very well be specified like USEPA and is a must to ensure adequacy of dust control. As regards to opacity measurement, as it involves use of expensive instruments which are not currently available in the country at affordable prices, the opacity

reading may or may not be proposed in the standard, however fence line SPM value could ensure the same.

7.1.4 Practical problem in various states in siting/shifting existing crushers.

- a) **Shifting/siting of existing crushers to new locations have several complications and difficulties and the gravity of the problem and type of directives from various state authorities vary widely**

Comments: The existing crushers, which when came up and started its operations few years back, were once away from any inhabitations and major roads etc., later came the habitation in the vicinity and since crushers came up first, they should not be asked to go away now is the opinion of crusher owners. This is a general argument all over the country and has valid reasons. To solve the dust problem, there could be two alternatives, one that the crushers install adequate dust control system and reduce their emissions to acceptable levels, or secondly shift the crushers to a new site, away from inhabitation. The second (shifting) alternative does not eliminate the root cause that is dust emissions, it only shifts the problem from present location to new location. The first option (controlling dust emissions adequately) would be more practical and acceptable option. Mere shifting of crushers without infrastructure facilities may eventually lead only to closure of the units. As every crusher requires (i) Pakka access roads for movement of loaded vehicles/trucks for raw materials as well as product movement, (ii) electricity supply to operate the machinery, (iii) closeness to the demand centre/city so that transportation costs are minimum and (iv) large piece of plain land and (v) a source of water for drinking and for spraying purpose and (vi) closeness to stone mines.

Constructing a pakka road (on their own) a few kilo metres interior of existing roads is certainly un-affordable to small crusher units. Existing set ups involve high investments on civil structures such as elevated ramp for unloading of stones from trucks into stone well, foundations for the crushers and screens and office building etc., which cannot be physically shifted/moved and therefore goes waste and more expenditure is involved to make new civil structures at new locations, which may not be affordable to small crushers. It is, therefore, shifting of existing crushers, especially small ones, may not be a techno-economically feasible option & this aspect should be considered for deciding on shifting of crushers.

On the other hand, as demonstrated by NPC, it is very much possible to achieve dust free operations of crusher units by adopting proper dust suppression system and this option may be insisted upon which if denied or not satisfactorily implemented, then shifting option can be implemented.

b) Acceptability by State Govt. of Improved Dust Control System against Shifting

In the State of Punjab, the regulatory authorities had issued notices for shifting of stone crushers located in the vicinity of state or national highways. In the areas where shifting was physically not possible due to undulated terrain, the crusher units gave representation to the regulatory authorities mentioning their willingness to install necessary dust control systems in all units in the cluster so as to reduce dust emission problems of the entire cluster. Subsequently, all the units implemented measures such as providing enclosures, gravity type water sprinkling arrangement, construction of metalled roads within premises, construction of dust hopper and more prominently development of green belt. The green belt developed by many stone crushers in Punjab has by now grown to heights above the belt conveyor discharge points and mostly leafy trees covering the roadside area are giving a proper green belt appearance. Subsequent to the successful implementation of above measures, the regulatory authorities have considered their continuing operation at the same place subject to substantial reduction in dust emissions by all the units in the cluster.

In the state of Maharashtra and Orissa, notices have been issued to the crushers located in the vicinity of state/national highways (within 100 meters.) for shifting or closure. However, the notices have not been generally sent for having ineffective dust control systems but against the siting criteria of vicinity to roads. Of late, upon knowing the successes achieved in states like Gujarat in terms of substantial reduction in dust emission levels from stone crushers by adopting cleaner production schemes, many states are considering representations from stone crushers against shifting subject to adoption of cleaner production schemes by these units.

In the state of Tamil Nadu, notices have been issued to stone crushers nearer to major city and airport areas subsequent to public complaints and judicial interventions. However, the pollution control authorities are facing difficulties in implementing the relocation orders for existing crushers who claim that when the crushers came up there hardly was any population surrounding it which has grown only afterwards.

7.1.5 Practical aspects in Siting New Crushers

a) Crusher zone approach for siting new/shifted crushers

In the State of Haryana, the Pollution Control Board has adopted the strategy of relocating stone crusher units in a planned/organised zone, each being given about acre land and 40 to 50 units located in a single zone. The basic infrastructure and land development has been carried out by the state government. This attempt has been made to eliminate scattered stone crusher units in the state. Though the authorities have made their efforts to implement

adoption of water spray type dust control systems by the stone crusher units, the environmental scenario remains far from satisfactory. Most units have installed dust suppression systems comprising water tank, pump, GI pipelines and many nozzles spraying at many locations, but the dust control is hardly satisfactory. This could be primarily due to some faults in the designing of spray systems such as improper layouts, improper location of sprays, inadequate knowledge about spray systems, too many nozzles thereby improper sprays, inadequate water pressure, absence of water filter leading to choking of nozzles etc. On one hand there are advantages of having planned crusher zone by ways of concentrating the emission generation activities but on the other hand, it has disadvantage in terms of very high level of ambient SPM concentration in and around crusher zone. The existing dust control systems in the zone are not adequate enough to control the fugitive emissions from the crusher operations.

In the absence of appropriate dust control mechanism, the gravity of environmental problem from such clusters is quite alarming and the ambient SPM levels are quite high in these clusters and since the airborne emissions in the respirable (<PM10) range can spread and get carried away by wind to long distances (several kilometers), the environment downstream of the cluster may get substantially affected in several kilometer stretch.

A study done by NPC at the Raisina Crusher Zone in Haryana reveals that the contribution by the zone in the ambient SPM level is 50857 $\mu\text{g}/\text{m}^3$, which is more than 80 times higher than the prescribed standard of 600 $\mu\text{g}/\text{m}^3$. This problem could be overcome by insisting on adoption of the advanced designs of dust containment cum suppression or dry collection systems by all units. Once each unit attains dust free operations, then the "crusher zone" approach would be the best approach for siting of new crushers, provided basic infrastructure of road, electricity and water is provided by the State Government.

b) Non availability of plain land in hilly areas

In the hilly states like Himachal Pradesh there is hardly any citing criteria applied for locating stone crushers. The stone crushers are widely found along side the river and at times located in the vacant space between major river and national/state highways. As regards to pollution control measures, hardly any crusher have dust separation arrangement installed.

This aspect of non availability of plain land in hilly areas may be considered while fixing siting criteria.

CHAPTER 8

EVOLVING IMPROVED & ADVANCED DESIGNS OF DUST CONTROL SYSTEMS FOR STONE CRUSHERS

Upon reviewing the existing Environmental Standards & Guidelines, subsequent Amendments and after reviewing status of dust control systems installed by many stone crushers and reasons for their failure to achieve desired level of dust control & local constraint etc., new improved designs of dust control system have been evolved which would be simple to install, operate and maintain. Various aspects of the designs are discussed in following pages

8.1 Basis/Criteria for evolving the Advanced Designs

1. The system should be low cost and affordable by stone crushers
2. The system should operate in the dusty condition
3. The system should be easy to install, operate & maintain
4. The system should not affect the product stone quality adversely
5. The system should be indigenously available or fabricated preferably locally

Based on the above criteria three types of design have been evolved for different types & sites of stone crushers. The types of design namely (i). Wet type system (ii). Dry type systems (iii). A combination of Wet and Dry Type System. The design details of each of the systems along with its applications areas are briefly described below.

8.2 Wet Type Dust Control System

This design has two components (1). Dust Containment Enclosure Component & (2). Dust Suppression System Component, which are separately discussed below.

8.2.1 Dust Containment Enclosures

For the wet type dust control system to be effective, it is a pre-requisite to provide containment enclosure for following key locations

1. Enclosure for Crusher Discharge Area

The crusher discharge area from the crusher platform down to ground level has to be enclosed using permanent GI sheet type structure leaving only an opening for belt conveyor to pass through. One or two maintenance access doors can be provided but with an arrangement of keeping the doors closed (with a latch and handle arrangement) during crushing operation. Flexible rubber flaps should be provided near the belt opening to minimize the open gaps.

The area above the crusher need not be compulsorily enclosed in this design however it is recommended to provide a rain protection shed. Many crushers do provide a big and permanent shed over the crushers but the discharge area is left open and therefore ineffective to contain dust. Refer **Figure 8.1** for dust containment enclosure for crusher discharge area.

2. Enclosure of Vibratory/Rotary Screen

The vibratory screen should be compulsorily enclosed from the screen supporting platform level up to top of the screen. The enclosure should be provided either with maintenance walkway around or without walkways with a compact enclosure of the size of the screen only. In such cases whenever there is a maintenance requirement, a provision should be kept either to take out some of the enclosure sheets or provide door type opening access for maintenance. Care should be taken to put back the sheets and close the door after maintenance is over. In all circumstances the enclosure has to be kept closed during operation of the crusher. The enclosure should have only one opening for the belt conveyor and it should be provided with flexible rubber flaps to minimize the gap all around. A maximum of two inches gap on either sides of the belt conveyor should be kept

It is generally reported that the units have to take out the screen plate and other big parts out of the enclosure for maintenance and therefore they need to keep one side permanently open. A proper opening of required size with a door type opening and closing arrangement can very well be provided. Even an arrangement like rolling shutter can be installed to open and close large area as per maintenance requirement.

It is also reported that the operators are often required to physically see the vibratory screen and therefore they need to keep one side open. Technically this cannot be acceptable reason. Once people get used to proper enclosure arrangement they may also get used to doing away with one side open concept. The experience in many other crushers who have installed full enclosures of the screen can certainly support this argument that the screen can be kept closed and would not have any operational problem.

The enclosure of the screen is a must for all small, medium and large category units and for all types of screens i.e., vibratory or rotary. For small capacity crushers with single rotary screen with manual retrieval from below the screen, the side enclosure can be provided with openable doors from either sides. Depending on the wind directions, the retrieval of material can be done on the side downwind to the wind direction by opening of the door of that side but the other side door should be kept closed that means during crusher operation one side of the enclosure has to be always kept closed. Refer **Figure 8.2** for a sketch of a typical enclosure for vibratory screen

8.2.2. Dust Suppression System

The Wet type dust suppression system comprises of introducing moisture into the material flow by spraying water at key dust generating locations so as to restrain fine particulate matter from becoming air borne. The objective of wet dust suppression is not to fog an emission source with a fine mist to capture and remove particulates emitted, but rather to prevent their emission by keeping the material moist at all process stages. Excessive moisture can cause blinding of screen surfaces and thereby reduce both their capacity and effectiveness, or it can cause coating of stone surfaces and result in a marginal or non-specification product. Small quantities of specially formulated wetting agents or surfactants are often blended with water to reduce its surface tension and improve its wetting efficiency so that dust generation may be suppressed with a minimum of added moisture. (In adding moisture to the process flow, it is usually necessary to apply it at several points beginning as soon as possible after the stones are introduced into the plant).

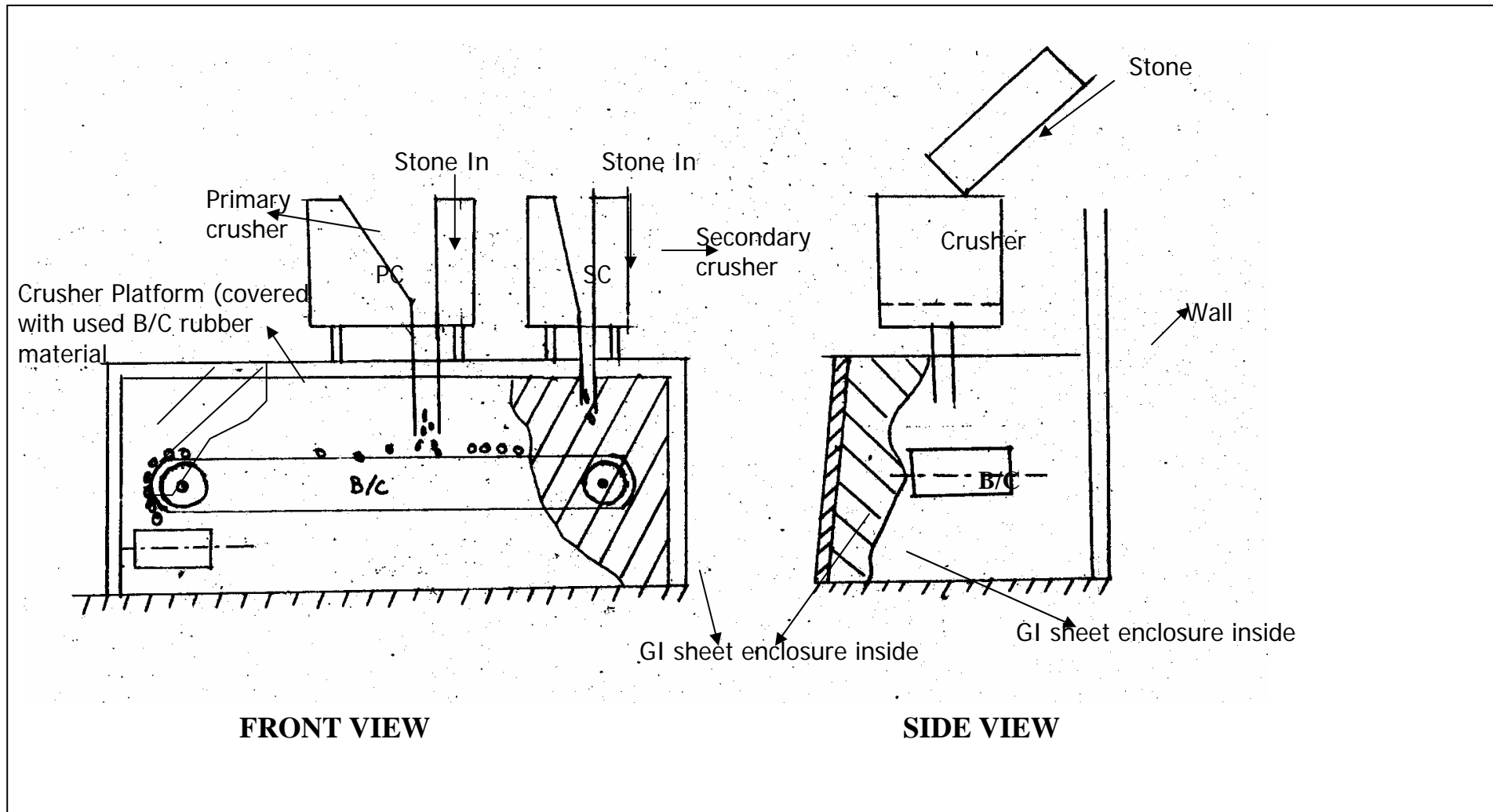
The application points where moisture is introduced in the process flow in stone crushers in developed countries are highlighted below:

- Primary crusher truck dump hopper
- Primary crusher feeder chute
- Primary crusher discharge
- Secondary/tertiary crusher feeder chutes
- Secondary/tertiary crusher discharge locations

If the material is conditioned properly at the above points, further applications at screens, conveyor transfer points, conveyor and screen discharges to bins and conveyor discharges to storage piles may not be necessary because moist stone exhibits a carry over dust control effect that permits it to be handled through a number of operations without dusting. The amount of moisture required at each application point depends on the type of wetting agent used, the type and size of process equipment, the characteristics of the material processed, size distribution, feed rate and moisture content present in the stones.

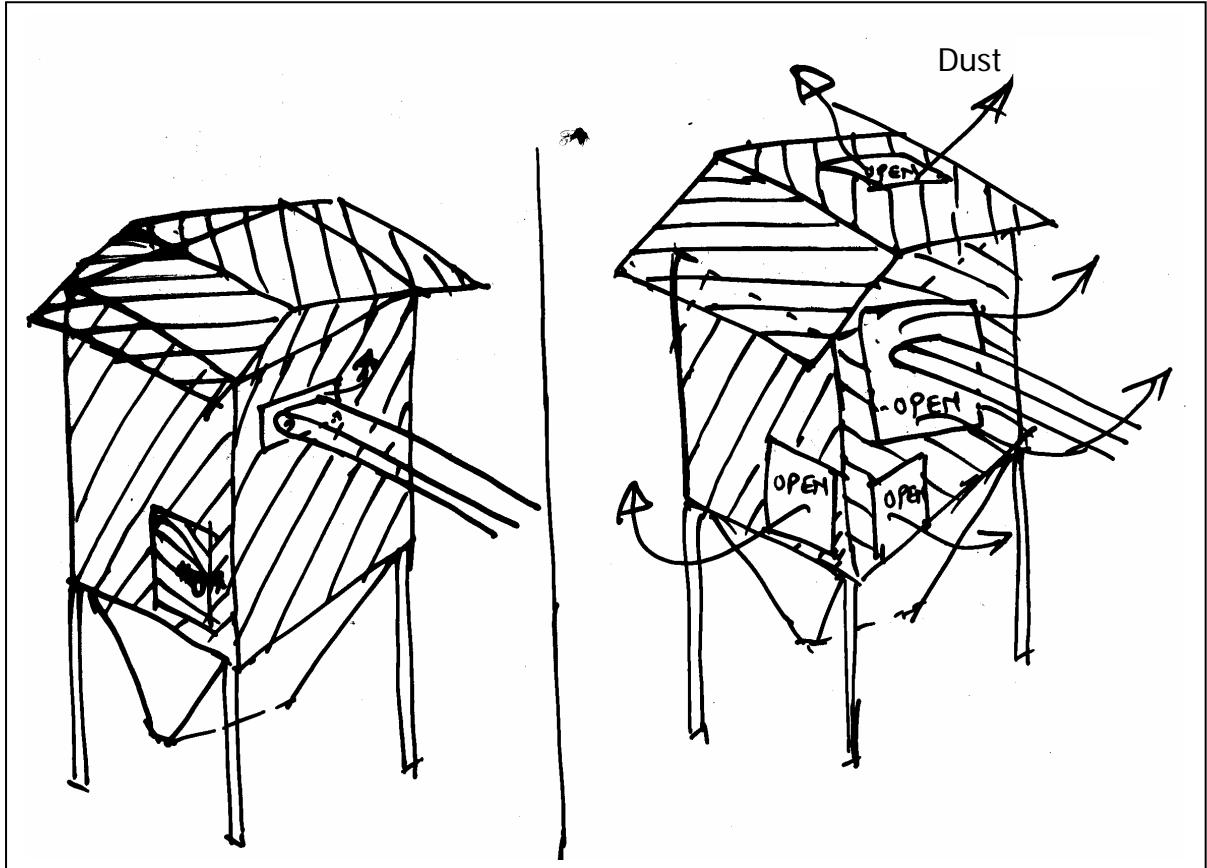
The dust emissions are suppressed closest to the source of its generation before allowing it to spread. This requires an arrangement to provide clean and pressurized water supply to the nozzles which is ensured through installation of various components such as closed water tank, pump, filter, pressure gauges, flow meter and a network of pipeline, fitted alongwith regulating valves and spray nozzles. A schematic of the dust suppression scheme is given at **Figure 8.3**

FIGURE No: 8.1



DETAILS OF DUST CONTAINMENT ENCLOSURES FOR CRUSHER DISCHARGE CHUTE AREA

Figure No. 8.2
TYPICAL DUST CONTAINMENT ENCLOSURES



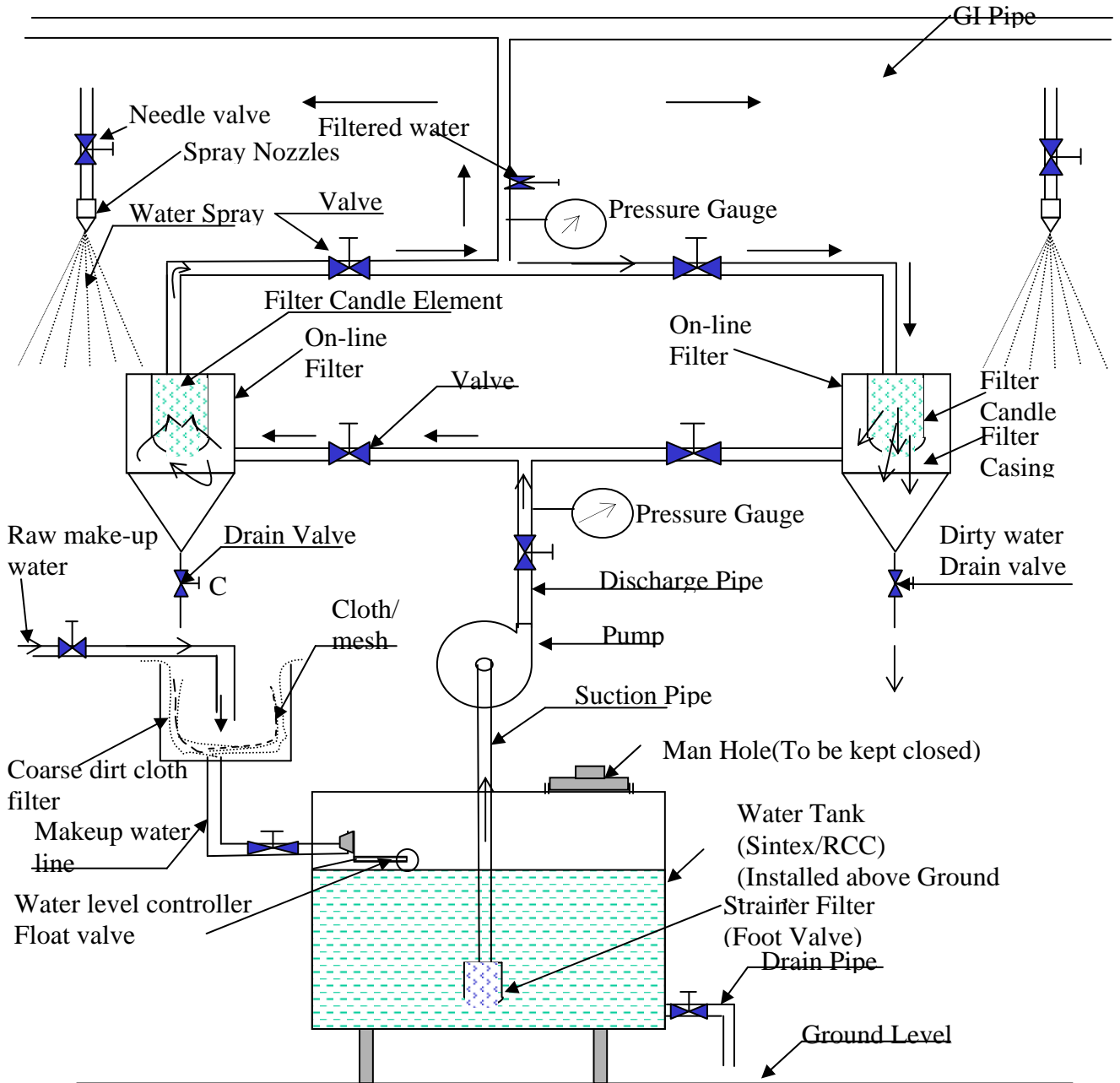
GOOD

- Minimum required opening for B/C
- All sheets in place
- Very little escape of dust
- Money spent & useful

BAD

- Larger opening for belt conveyor
- Some sheets missing/fallen
- Substantial escape of dust
- Money spent but no use

Fig 8.3 Schematic Diagram of Wet Dust Suppression System for Stone Crushers



This type of design is suitable for stone crushers having Jaw Type Crushers as Primary, Secondary & Tertiary Crushers in all sizes of crushers such as Small, Medium & Large Categories.

a) Description of System Components

The wet type dust Suppression system has following hardware components

1) A Closed Water Tank

There should be a water tank closed from all sides with a manhole cover for any maintenance. It is preferable to have a syntex type plastic tank or alternatively a RCC tank with man-hole with cover. This tank should only be used for water spraying purpose and not for any other domestic use. It is recommended that a separate tank for domestic drinking, washing etc for the workman should be installed. The tank should have a drain valve at the bottom to take out settled dirt or mud periodically. The tank should have a make-up water line along with a coarse filter and preferably a level controller arrangement and an over flow arrangement. The water tank should be preferably installed at a location where it is less exposed to dust emission. It is preferred if the tank could be installed at the maximum height location such as unloading location. It is necessary to keep the tank always closed to avoid dust entering the water.

- **Softening Treatment to Hard Water**

For the crusher using hard water from sources such as bore-well it is preferable to add some lime water or alum to enable settle the solids such as salts etc or else this would lead to salt formation along the GI pipelines which eventually lead to choking of nozzles and therefore ineffective sprays and ineffective dust control. The crusher units should test their water for hardness and fix up the lime/alum dosing requirement suiting their applications.

2) Pump

A pump is required for supplying pressurized water to the nozzles for formation of good desired sprays. The pump should be installed on the tank. In the suction line a foot valve along with a fine mesh filter should be installed. The pump outlet is to be connected to a filter unit. The size of the pump in terms of horse power, suction/delivery diameter and pressure and water flow rate varies depending on size of the Crusher. Typical pump requirement for various sizes of stone crushers are given in the table below.

Typical Pump Requirement for various sizes of Stone Crushers

Crusher Size	Typical Crushing rate	Water consumption lit/hr	Pump HP	Pump pressure Requirement (Metres)	Suction/ discharge pipe dia (inches)
Small	Less than 25 TPH	100-200	1-2	20-25	0.75
Medium	25 - 50 TPH	200-450	2-3	25-30	1-1.5
Large	More than 50 TPH	450-700	3-5	30-40	1.5 - 2

Note:

Above values are typical and representative values only. Actual consumption may vary depending on type of raw material, crushers, screen, product size etc.

3) On-line self cleaning Type twin micro filter

Even though the water tank is enclosed, some amount of dust/dirt comes along with water and this can eventually choke the small holes in the nozzle affecting the spray formation. It is therefore a fine mesh (about 100 micron) type water filter is necessary. The filter mesh candle should be of stainless steel material. Any other steel like mild steel mesh gets corroded and gives way in due course. A double filter unit is suggested such that while one filter is in operation, the other is backwashed using pressurized water in the reverse direction. The filters can be used alternatively, this eliminates opening and cleaning of the filters which eventually creates problems in the filter unit due to manual interventions. A set of valves are provided to put in operation or in cleaning either of filter units as required. A drain plug is provided at the bottom of the filter unit to take out backwashed dirt water.

4) Pressure Gauges

Two numbers of pressure gauges are required to be installed, one at the pump discharge before the filter and other after the filter. The pressure gauge indicates the pressure drop across the filter pointing out excessive choking and also ensures adequate pressure at the pump outlet. The pressure reading act as an indicative arrangement in trouble shooting in case of improper sprays. Dial type mechanical pressure gauges in the range of 0-8 Kg/cm² are required.

5) Connecting GI Pipelines & Regulating Valves

A network of GI pipeline is required to be laid from pump/filter outlet up to all the nozzle spray locations. The dimensions of the pipes of header and branch connection varies depending on the size of the crusher. It is recommended to use PVC pipes to avoid corrosion related problems but such PVC pipes need to be properly protected and supported to avoid damage and breakage to the pipes.

6) Control Panel

A control panel is required to be installed to switch the pump on or off pump as required. The control panel should be permanently installed on a wall at easily accessible location.

7) Water Spray Nozzles

Nozzles are of various types (such as full cone, fan jet, Impingement type etc) of various sizes (1/4th, 1/2, 3/4" diameter size etc) need to be installed at the various locations. The nozzles have to be located exactly at a height as required such that the spray covers the entire emission area as close to the point of generation. The spray should not be obstructed by any fixed solid object such as steel plate etc or else the spray formation would get affected. A Needle type valve is to be installed for each nozzle to control flow quantity and pressure as per requirement.

8) Flow Meter

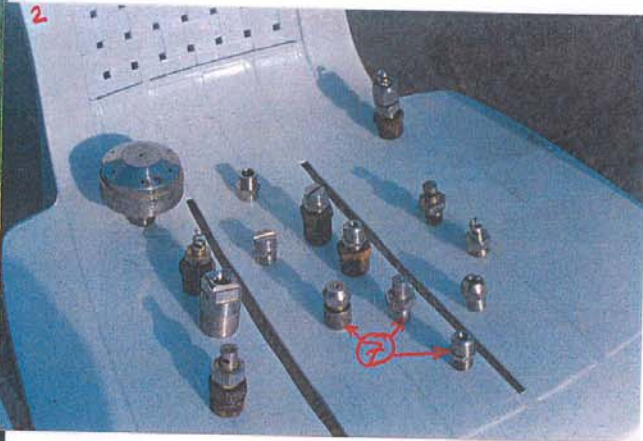
A see through type water flow meter is recommended to be installed on-line after the filter unit. This meter indicates the water quantity being sprayed during operation of the system. This could provide assistance to the management to open the pump discharge adequate to enable control the dust with minimum water.

*Photographs showing the above discussed system components installed at some stone crushers during NPC demonstrations are shown at **Photoplate 10***

b) Locations of Water Spray Nozzles

The sizes and capacities of the system components discussed above may vary depending on the size of the stone crushers, number of spray locations, the distances between water tank the nozzle locations, height of the nozzle spray locations etc. A typical spray locations are given in the table below.

COMPONENTS OF NPC DESIGNED DUST SUPPRESSION SCHEME FOR STONE CRUSHERS



- 1. COVERED WATER TANK
- 2. PUMP
- 3. ON-LINE SELF CLEANING TWIN MICRO FILTER
- 4. PRESSURE GAUGES
- 5. CONNECTING GI PIPES & VALVES
- 6. CONTROL VALVES
- 7. SPRAY NOZZLES
- 8. WATER FLOW METER



Table 8.1 Water Spray Location for Dust Suppression

Sr. No.	Location of Water Spray	Spraying Time	Types of Spray	Remarks	Must/Operational
1.	Unloading of Raw Stone in Stone Well	Intermittent	Full Cone	The spray to be operated manually only during the unloading operation	Must
2.	Inlet Feeder/Chute to Primary Jaw Crusher	Intermittent	Full Cone	Spray to be operated manually at the time of feeding stones	Must
3.	Belt conveyor discharge/transfer points	Continuou s	Fan-Jet type (Curtain Type)	The spray to operate during entire time of crusher operation	Must
4.	Crusher Discharge Location	Continuou s	Full Cone	The spray to be operated if required	Optional
5.	Inlet Feeder/ Chute to Secondary/ Tertiary Jaw Crusher	Continuou s	Full Cone	The spray to be operated if required	Optional

(Refer **Figure 8.4** showing a few key locations for spraying water)

c) Dust Control System design for various sizes of Stone Crushers

The wet type dust control systems have been designed for small, medium & large type crushers. For various sizes of crushers the typical number of spray locations with break-up of must and optional locations along with approximate quantity of water requirement is given in the Table below.

Table 8.2 Number of Key Spray Locations for different sizes of stone Crushers

Sr. No.	Crusher Category	Typical Machinery	Typical Production Capacity	Number of Spray Locations	Optional Spray Locations	Water quantity (max.)
			TPH	Number	Number	Lit/Hr
1.	Small	Single Jaw, Single Screen, Manual Feeding & conveying	5-10	Two	One	150
2.		Single Jaw, Single Screen, Mech. Feeding & Conveying	10-15	Three	--	200
3.		Two Jaws, Single Screen, Mech. Feeding & Conveying	15-25	4	1	250
4.	Medium	One Primary & Two Secondary Jaw, 2 Screens, Mech. Feeding & Conveying	25-60	5	2	300
5.		Two Primary, Two Secondary Jaw, 2 Screen, Mech. Feeding & Conveying	60-100	6	2	400
6.	Large	1 Primary, 2 Secondary, Two Tertiary Jaw, 2 Screens, Mech. Feeding & Conveying	>100	7	3	700

The above table provides the approximate number of locations where water spray needs to be applied. The size of the nozzles and water quantity sprayed at each location may vary depending on the capacity of the crusher, higher the crushing capacity bigger would be the spray size and higher water consumption. In general the water quantity sprayed would be in the range of 0.5 to 1% of the

crushing capacity (for example, for 20 TPH crusher 1% water equals to 200 Lit/Hr).

There is no requirement of spraying water on to the vibratory or rotary screens in this advanced design, neither there is a requirement to spray water at the final product discharge ends where crushed stones fall into stock piles. This wet type of scheme can be satisfactorily adopted in the most widely practiced crushers using Jaw type crushers as primary, secondary or tertiary crushers (for other type of crushers such as cone, gyratory, impactor, rotapocctor etc a combination system of dry and wet is separately suggested)

*Schematic layout of wet type dust suppression system for small, medium and large capacity stone crusher are given through **Figure 8.5, 8.6 & 8.7.***

d) Typical Costs of Wet Type Dust Suppression System

The typical cost of various system components of the wet type dust control system are given in the table below. The Costs are based on actual cost incurred by the units at the time of installation and may subject to change from place to place and with time. The fixed initial capital investment and operating cost have been provided. All costs are approximate only. The cost for Dust Suppression systems components, Dust Containment Enclosure & Green Belt Development are given separately below.

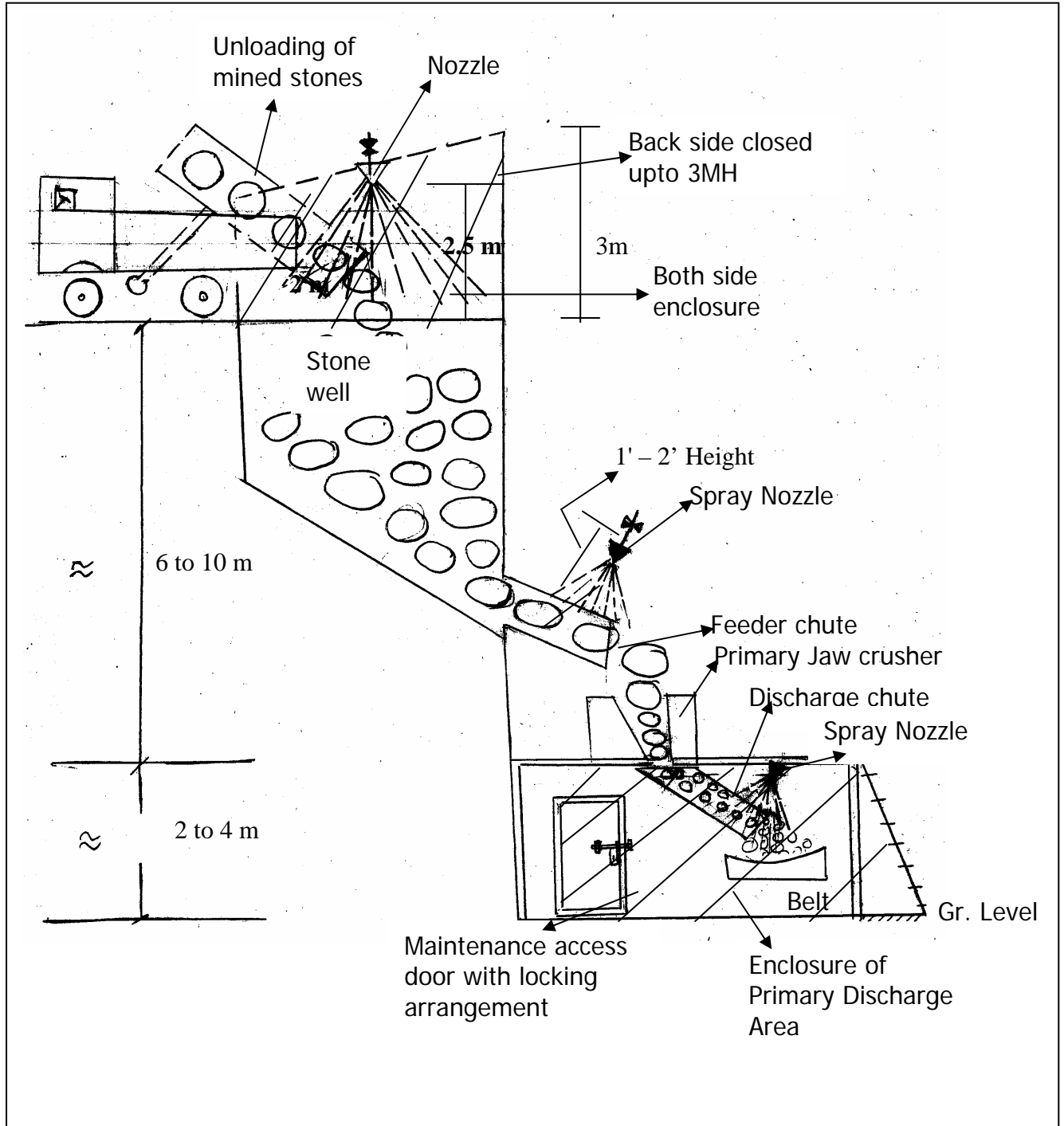
Cost Estimates of Dust Suppression System components for Stone Crushers

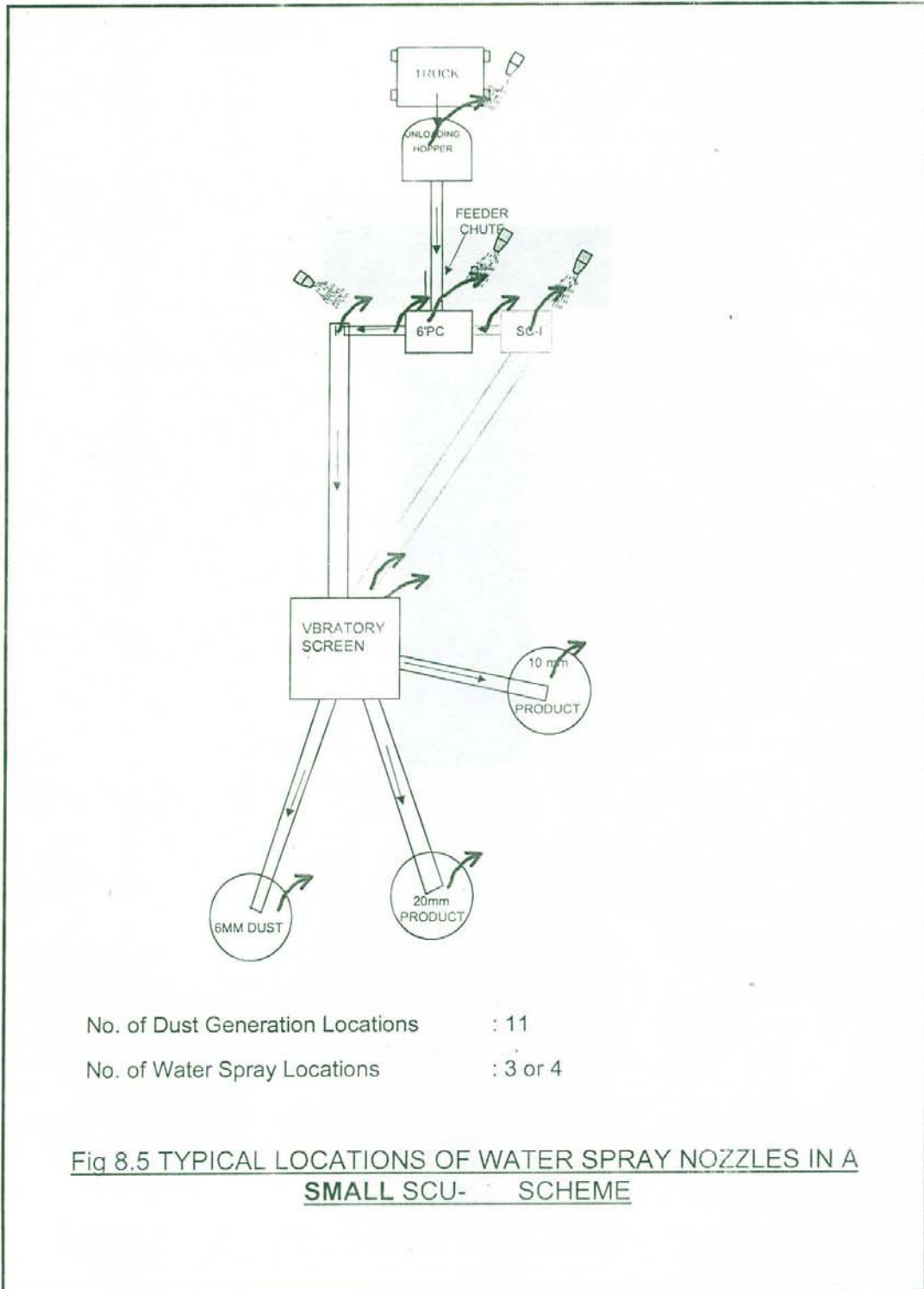
S. No.	Item	Specifications	Estimated Costs
1.	Pump	1.5-5-H.P 25 to 60 lpm 40 to 60 m head	Rs.5,000/- to Rs 12,000/-
2.	Water Filter Unit	Mesh 100	Rs.7,000/- to Rs 12,000/-
3.	G.I. Pipes, Valves & Fittings	Various sizes such as 2", 1.5", 1", 3/4", 1/2" dia etc of different lengths alongwith necessary fittings & valves	As per plant layout & actual length required
4.	Nozzles	Various sizes 1/2" Full Cone, 1/4" Full Cone & 1/4" Impingement type, giving fine spray at about 20 to 30 m head	Rs.400/- to Rs 600/-

For evolving the costs for small stone crushers, the lower range could be considered while for large crushers higher range may be considered. The cost towards the GI pipe lines would vary from plant to plant depending on its layout, location of water source etc & therefore can not be provided.

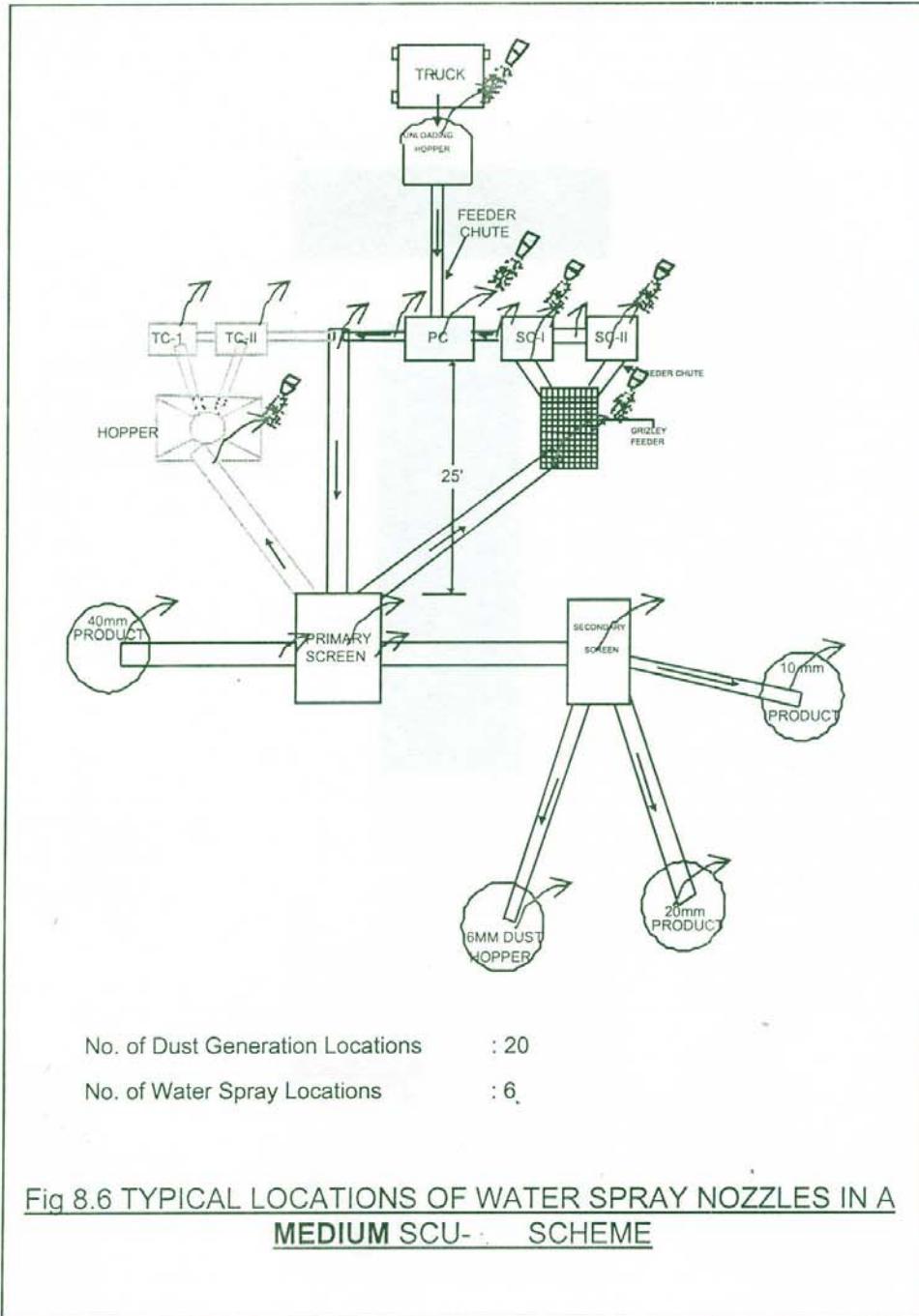
FIGURE NO. 8.4

Water Spray Locations at unloading & Crushing Points

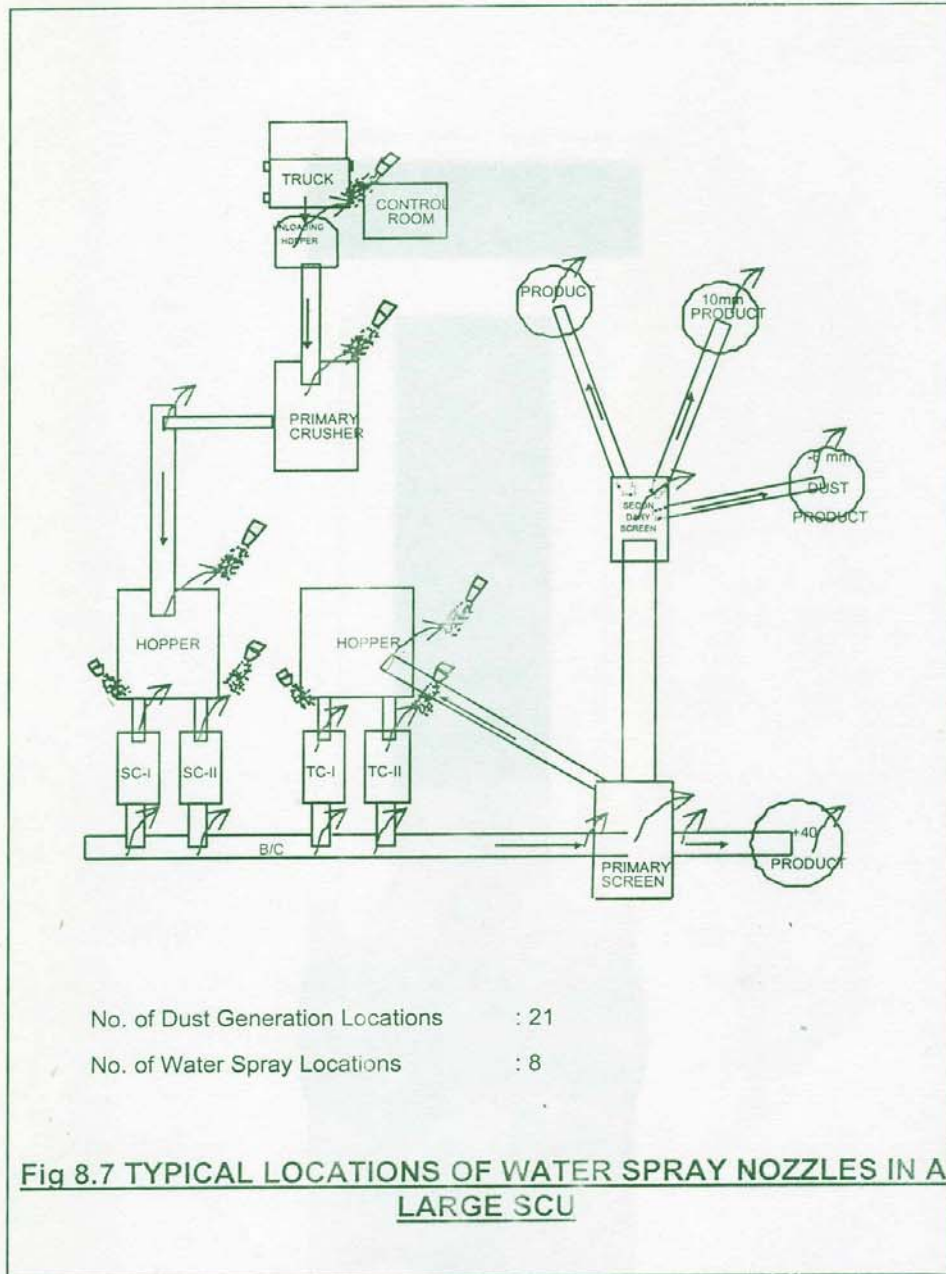




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Cost Estimates for Dust Containment Enclosures.

S.No.	Location of Enclosure	Containment Requirement	Unit cost of enclosure
1.	Vibratory/Rotary Screen	All 4 sides & top.	Rs. 450/= per sqm.
2.	Crusher Discharge Area	All 4 sides & top.	Rs. 450/= per sqm.

The size of the containment enclosure would vary from plant to plant & depending on the size of the screen, height where it is located etc. Unit cost per Sq meter of area of enclosure are provided based on which the total costs of enclosure can be worked out.

Cost Estimates for Green Belt Development

S. No	Item	Cost Estimation
1.	Plant saplings	Rs.10 to15 per Plant
2.	Fertilizers	Rs.8 to 10 per plant
3.	Misc Cost (Making pit, shelter etc)	Rs.15 to 20 per Plant
4.	Labour (Mali etc) cost	Rs.10 to 15 per plant
5	Watering cost	Depend on site to site as per availability & source of water & frequency

Typically, the green belt would contain a number of trees planted all around the plant premises. The number of trees to be planted would depend on plant area, existing plantation in the region, types of plants chosen etc.

Typical Operating Cost of CP Scheme

Size of SCU	Pump (KWh) Maximum	Operating Hrs/Day	Electrical Consumption(Kwh/Month) for 25 days	Operating Cost/ Month (@Rs.4.00/Kwh)
Small	2	8	400	1600
Medium	3	8	600	2400
Large	5	8	1000	4000

8.3. Dry Type Control System

8.3.1 Suitability of Dry Type Control System over Wet Type

Some medium and large capacity stone crushers located nearer to the larger cities which are away from Sea-Shore, intentionally produce more percentage of fine dust as one of the by-product because it can be sold in the market at higher price than the stone gravel as an alternative to sea/river sand the availability of such sand is limited or has higher transportation cost component. Such stone

Crushers use either roller type or cone type secondary/tertiary crushers. In these crushers, though the dust emission can be suppressed by wet methods, the stone crusher owners are reluctant to spray water because the higher quantity of dust would form a noticeable layer of dust on the stone gravels and would give objectionable appearance and they fear to get a lower price for such coated products. Also the dust portion once get wet may not be fully screened as dust product and the reduced production of dust, which has higher rate in the market, would reduce their profits.

Keeping in view this scenario and limitation of spraying water and also to ensure on the other hand adequate dust control, a dry type control system would be suitable for such crushers.

Also in some areas where water is reported to be a scarce commodity and therefore may not available for dust suppression system. In such a scenario, to ensure a desired level of dust control, dry type control systems is the only solution

8.3.2 Description of the dry type design

The dry type dust control system comprises of adequate Enclosure of key locations with hooding arrangement for extraction of the dust, and arrangement of Cyclone or Settling Chamber to collect the coarser portion of the dust, and a Bag-filter house to capture the finer portion of the emission not captured by Cyclone or Settling Chamber etc. The sufficient capacity of extraction and pressure drop across the system would be required to be provided by installing an induced draft fan of sufficient capacity. The details of the systems component are briefly described below.

1. Adequate Enclosure and Hooding Arrangement for Key Locations

a) Discharge from Crusher to Belt

The area where crushed stones fall over the belt conveyor needs to be adequately enclosed from all sides and the airborne dust emissions need to be sucked from the front and rear end (*refer **Figure 8.8** enclosed*) .Such enclosures would be required for all the Crusher discharges

b) Transfer Points

The areas where crushed material is discharged/transferred either from one belt to another or belt to hopper is required to be adequately enclosed from all sides. Flexible rubber flap arrangement needs to be provided at the opening around the belt conveyor to minimize the gap as less as 2 inches. (*Refer **Figure 8.9** for typical flexible rubber flaps around belt to minimize gap and **Figure 8.10** for wind breaking walls arrangement for partially enclosing stock piles to reduce wind blowing of dust*)

c) Vibratory Screen

The vibratory screen should be adequately enclosed from all sides and extracted to the control system. The enclosure should be provided such that the vibratory motion of the screen is not obstructed. The gap between the enclosure and the screen would be kept as minimum as possible and could be joined using flexible cloth type material. Smaller the dimension of the enclosure lesser would be the extraction volume and vice-versa. But with the smaller enclosures, there should be provision to dismantle the enclosure easily during maintenance of the screen and it should ensure it refitting to its original shape and size.

2. Hooding and Extraction System Arrangement

All the above enclosed locations need to be provided with hooding arrangement and it has to be extracted via a network of steel ducts. The duct sizing should be such that the velocity of the air remains in a desired range of 15-20 m/s, lower velocity would lead to settling of dust particles inside the ducts which eventually cause partial choking of the ducts. And higher velocities can cause greater erosion of the pipes and more friction losses thereby requiring more fan power. The layout of the duct network should be balanced for flow and pressure so as to provide desired extraction capacity at each locations

Typically in crusher in USA the air volume extracted is in the range of 230 to 32 m³/TPH for ensuring adequate extraction. By taking the lower side of this range for Indian crushers, the gas flow volume to be extracted for a large crusher of about 100 TPH capacity would be about 23000 m³/hr and for a medium crusher of about 50 TPH capacity, the gas volume would be 11500 m³/hr. Considering about 250 mm static pressure requirement, the ID fan required works out to about 40 HP & 20 HP for a large & medium crusher respectively.

3. Coarse Dust Control Arrangement as Pre Collector

The dust extracted from various points contains some percentage of coarse dust and some percentage of fine dust. The coarse dust can be economically controlled in equipments like a simple settling chamber or a cyclone. A settling chamber is nothing but a room enclosed from all sides with one incoming opening and another outgoing opening. The air velocity is reduced in the range of 1-2 m/s by sudden expansion from the duct cross section to a big area that of the room cross section. Due to drop in velocity, the coarse dust particles get dropped to the ground and are settled. A Cyclone is a cylindrical vessel with a conical bottom with one tangential entry and a central exit pipe from the top. The dust is made to rotate a few times inside the cyclone and due to centrifugal force the heavier coarser particles get thrown to the shell side and are collected at the bottom. The collected dust is taken out from the cyclone periodically or continuously by installing a rotary air lock type valve.

4. Bag filter type final dust collector

The above discussed settling chamber or cyclone type dust collectors are only adequate as pre-collector and a bag filter type final dust control system is

required to be installed to capture the finer dust particles escaping the pre-collector.

In case the pre-collector not to be installed, it would increase the dust load on the bag-filter house and would call for either more number of filter bags or more frequent cleaning of the filter bags and it is therefore the pre-collectors are recommended to reduce dust load on the bagfilter. In the developed countries like USA bag filter alongwith cyclone type pre collectors are commonly installed in Stone Crushers as per US-EPA requirements. The bagfilter generally employ cotton satin type filter bags which are the cheapest alongwith a manual shaking type bag cleaning arrangement even in USA. (Refer figure – for a schematic of dry type control system adopted in Stone crusher in developed countries like USA)

In some units even pulse jet cleaning type are also installed.

In Indian applications a manual shaking type bag filter using cotton bags need to be installed as final collectors.

5. Induced Draft (ID) fan

An induced draft fan is required to be installed to provide desired capacity in terms of flow rate to be extracted and to overcome the system pressure drop. The fan is a centrifugal type with single central inlet and vertical side discharge outlet. The fan is driven by an electric motor through V-belt pulley arrangement. A fan rpm about 1200 –1400 are recommended handling stone dust applications.

8.3.3. Typical Specifications of Dry Type Control Systems

The dry Control System is applicable only for medium and large capacity units producing more quantity of saleable dust product using roller or cone type crusher and having limitation of spraying water to avoid coating of dust on the crushed product. The typical specifications for medium and large type units are given in the table below.

Component	Medium Size Crusher (50 TPH)	Large Size Stone Crusher (100 TPH)
ID Fan Motor, HP	15	25
Gas flow extracted, m ³ /hr	6000 - 10000	10,000 –20,000
Pressure Drop, mmWc	200 - 250	250 –300
Filtration Area, m ²	50 -90	90 –150
Type of filter cloth	Woven Cotton	Woven Cotton
Typical Capital Cost (Rs. In Lakhs)	3.0 to 5.0	5.0 to 8.0
Cost Rs/TPH	6000 - 10000	5000 to 8000
Typical cost in USA (Rs/TPH)	Not applicable	36,000

Note: Cost do not include taxes, transportation, installation and civil costs etc and are approximate cost only and may vary depending on site condition and layout.

8.4 Combination Control System – Dry & Wet Type

As an alternative to the expensive dry type control systems in terms of capital investment as well as annual operating cost, a combination of dry and wet type control system is suggested. In the combination system the dust is suppressed at some point with water sprays and from some points the dust is extracted with the help of an induced draft fan and can be captured in dry type or wet spray chamber type control equipment. Such combination control systems are commonly used in stone crusher in developed countries like USA. (Refer figure – for a schematic of combination control system adopted in Stone crusher in developed countries like USA)

In such combination control system the water could be sprayed at the primary crushing stage and in the secondary/tertiary stages the dust could be extracted out and separately controlled. This would have benefit in terms of avoiding a coating of dust on the stone products and at the same time lesser expensive than dry type control system, however it would be expensive wet suppression control system

Typical points where water to be sprayed or dust to be extracted are given in the Table below:

Combination dust control-extraction or suppression points

Dry Extraction From	Wet Suppression at
Sec/tertiary crusher discharges	Primary crusher
Transfer points before sec/tertiary crushing	Transfer points (before secondary crushing)
	Sec/tertiary crusher feeds.

8.5 Cost Comparison of Dry, Wet & Combinations Systems

	Units	For 200 TPH-USA			For 50 TPH India		
Fixed capital Investment	US \$	66500	144800	131000	-	-	-
	Rs.Lakhs	31	68	65.5	1.0	3.0	2.0
Fixed Cost/TPH	Rs/TPH	15500	36200	32750	2000	6000	4000
Annual Op. costs	US \$	13545	41000	31710	-	-	-
Op.cost/Ton	Rs/Ton	2.0	6.0	4.80	0.22	1.50	0.84
Additional HP	HP	2	103	40	2	20	12

Op.hrs = Avg.10 hr op./day x 225 days/hr = 2250 hrs/yr operation
Tons/yr production = 50 TPH x 2250 hrs/yr = 112,500 Tons/yr.

FIGURE NO. 8.8

Typical Enclosure & Extraction arrangement for controlling discharge emissions in dry type dust control system

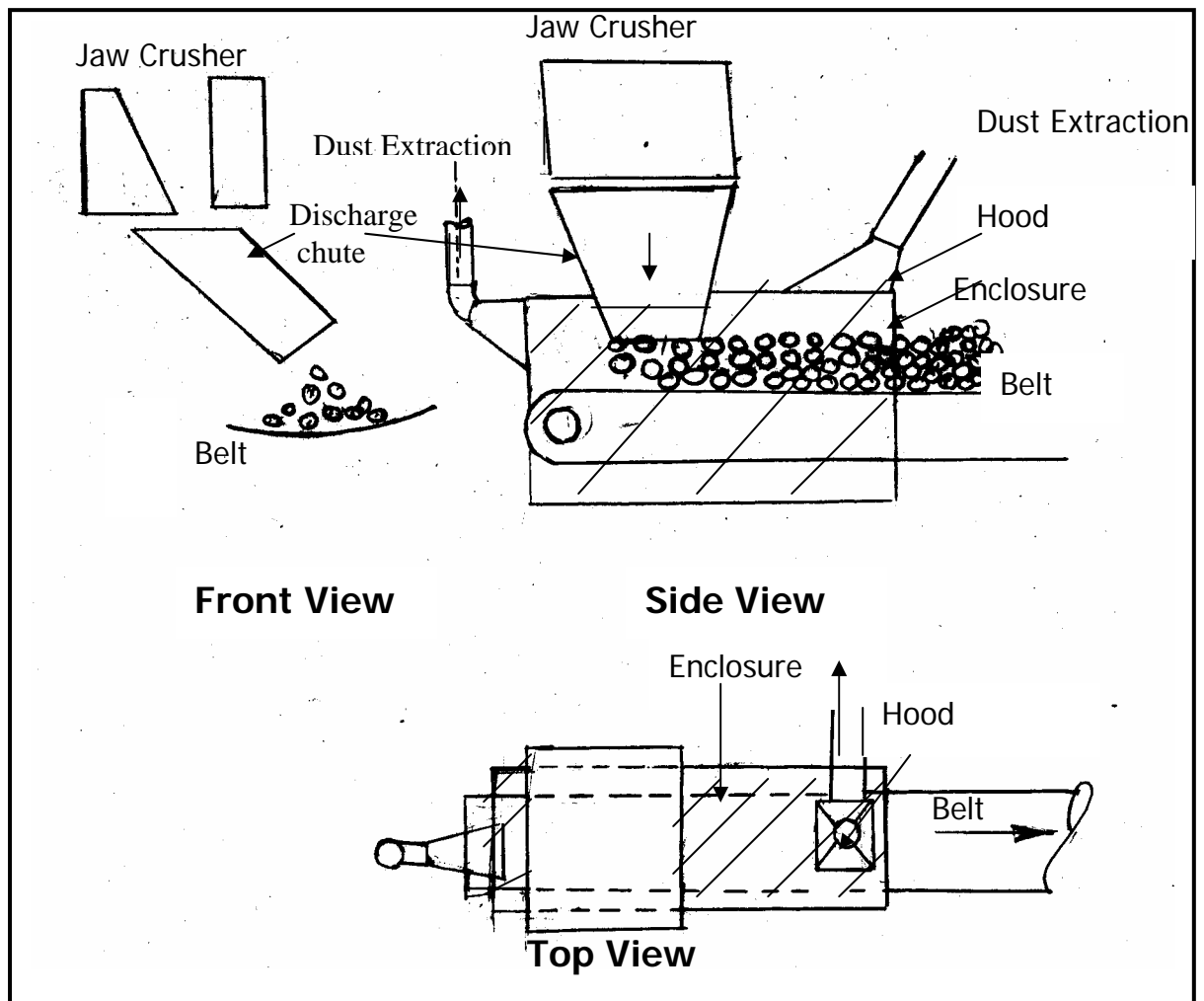


FIGURE NO. 8.9

Typical Flexible rubber flaps around belt to minimize gap

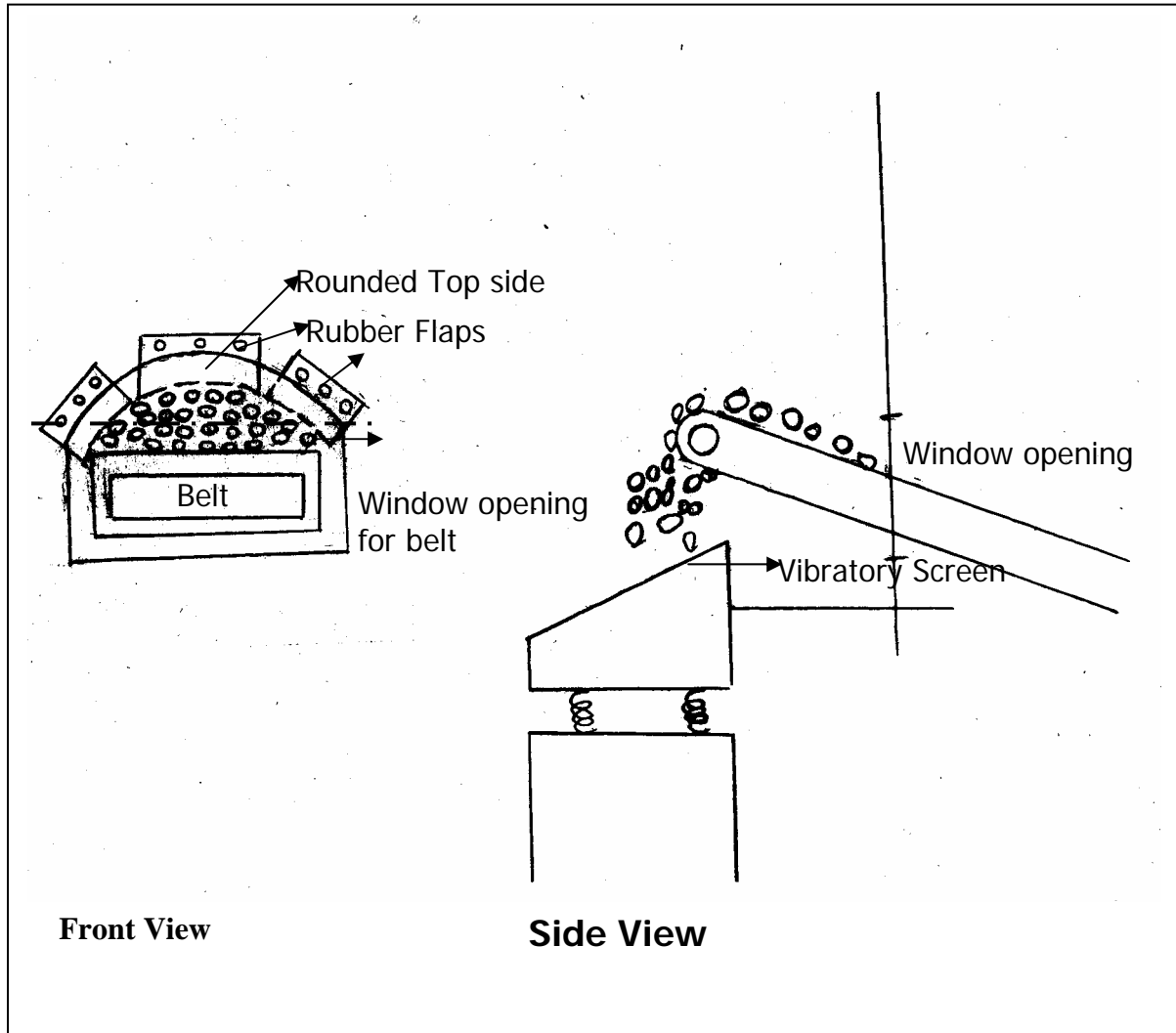
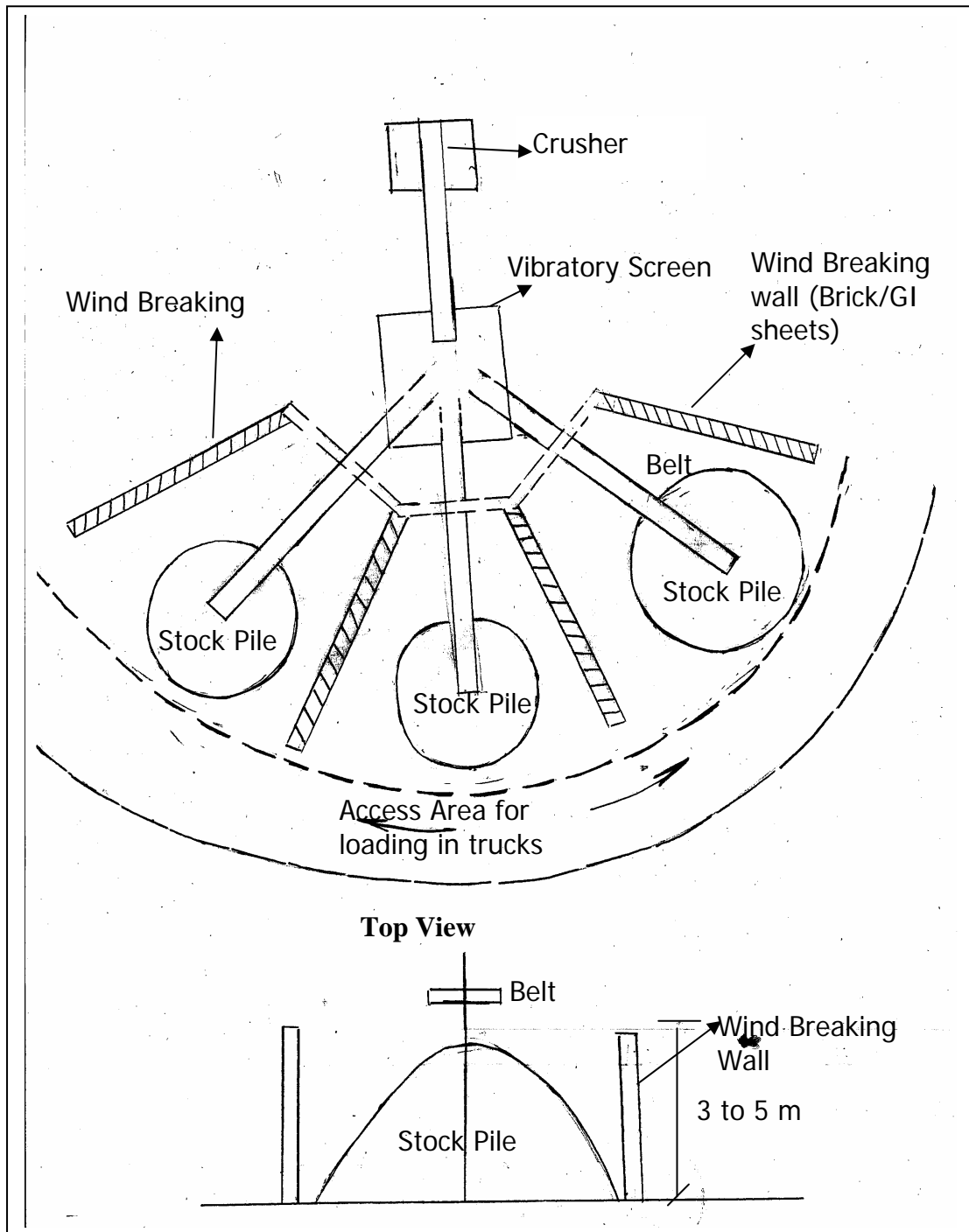


FIGURE NO: 8.10

Wind Breaking Walls arrangement for partially enclosing stock piles to reduce wind blowing of dust



Front View

Comprehensive Industry Document on Stone Crushers

TABLE -: Results of Trails Conducted For optimization of Water Consumption in Dust Suppression

S. No	Spray Nozzle Type	Location of Spray Nozzles	Trial -I			Trial -II		Trail -III	
			lpm	min/hr	lph	min/hr	lph	min/hr	lph
			Water spray Rate	Average time of Operation	Water consumption	Average time of Operation	Water consumption	Average time of Operation	Water consumption
1.	3/4" NB Full Cone	Unloading of Raw Material	30	4 (1 min per Unloading 4 unloadings/hr)	120	4 (1 min per Unloading 4 unloadings/hr)	120	4 (1 min per Unloading 4unloadings/hr)	120
2.	1/4" NB Full Cone	Pr. Crusher Feeder	2.3	60	138	60(50% Needle valve closed)	69	15 (0.5 min per feed, 30 feeds/hr)	34.5
3.	1/4" NB Full Cone	Sec. Crusher Inlet I Chute	2.3	60	138	60(50% Needle valve closed)	69	Needle valve fully closed	---
4.	1/4" NB Full Cone	Sec Crusher Inlet II Chute	3.7	60	222	60(50% Needle valve closed)	111	Needle valve fully closed	---
5.	1/4" NB Full Cone	Ter Crusher Inlet I Chute	1.97	60	118.2	60(Needle valve fully opened)	118.2	60 (40% Needle valve closed)	70.92
6.	1/4" NB Full Cone	Ter Crusher Inlet II Chute	2.33	60	139.8	60(Needle valve fully opened)	118.2	60(25% Needle valve closed)	104.85
5.	1/4" NB 120° Impingement Type	Belt Conveyor Transfer point (Sec Crusher Hopper)	3.27	60	196.2	60(50%Needle valve closed)	98.1	60(50%Needle valve closed)	98.1
6.	1/4" NB Impingement Type	Belt Conveyor Transfer point(Ter.Cru)	2.46	60	147.6	60(50%Needle valve closed)	73.8	60(50%Needle valve closed)	73.8
Total Water consumption					1219.8		777.3		502.17
%age of moisture in product					1.22%		0.77%		0.50%
Dust Emission			Controlled			Controlled		Partially Controlled	
Product Quality			Affected by moisture			Good		Good	

ANNEXURES

Figure: TYPES OF CRUSHERS - SCHEMATIC

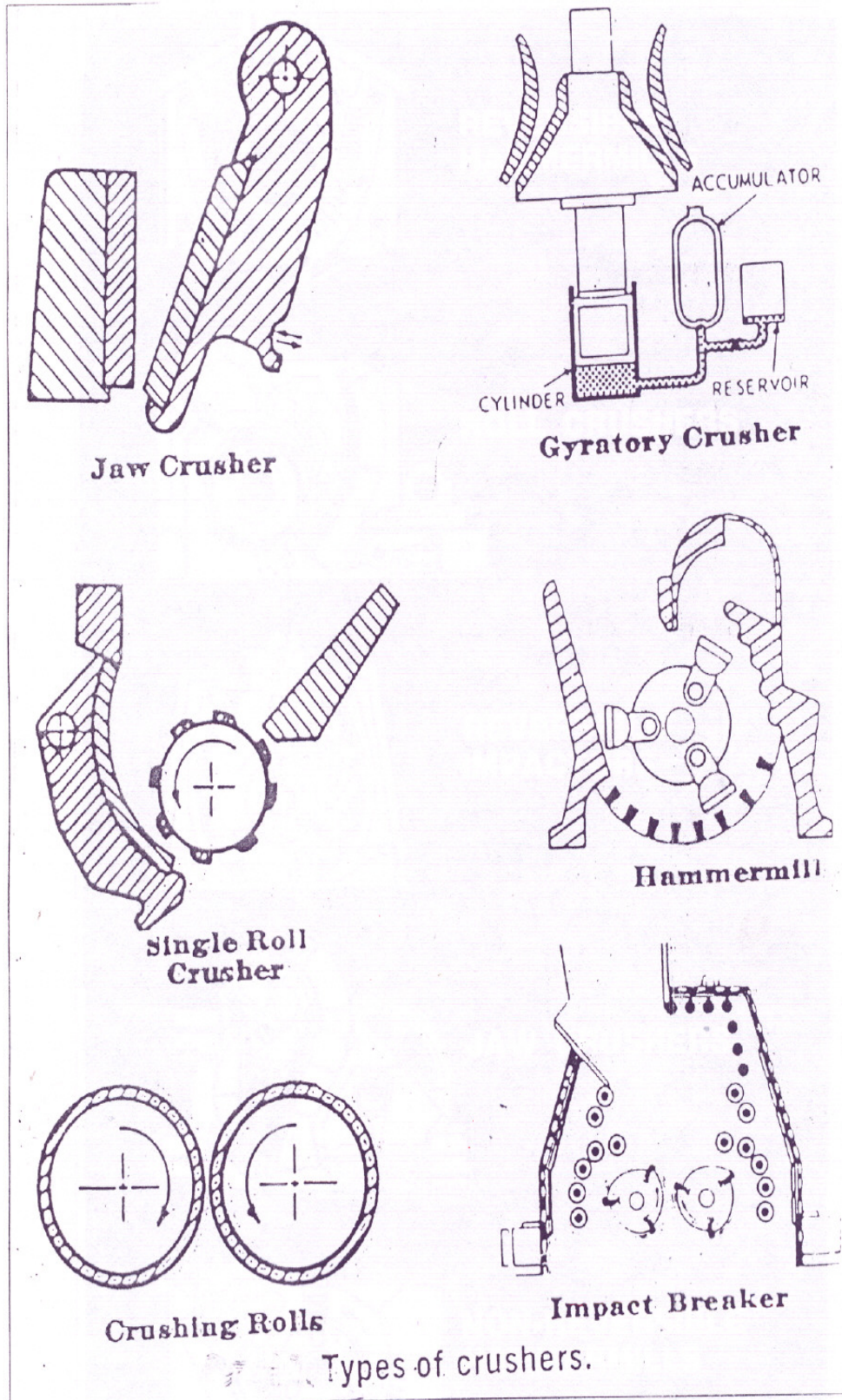


Figure: TYPES OF CRUSHERS - PRINCIPLE OF OPERATION

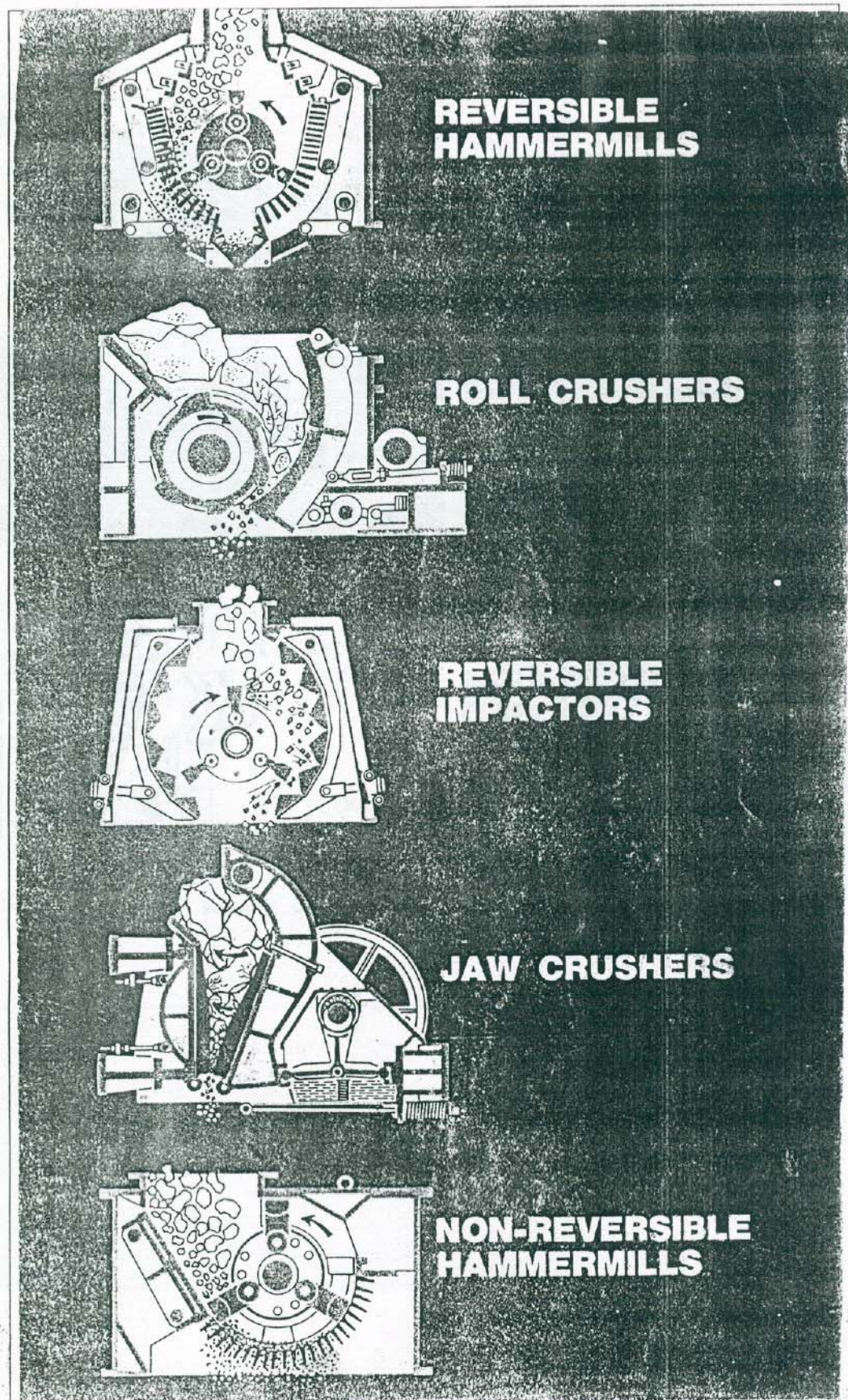
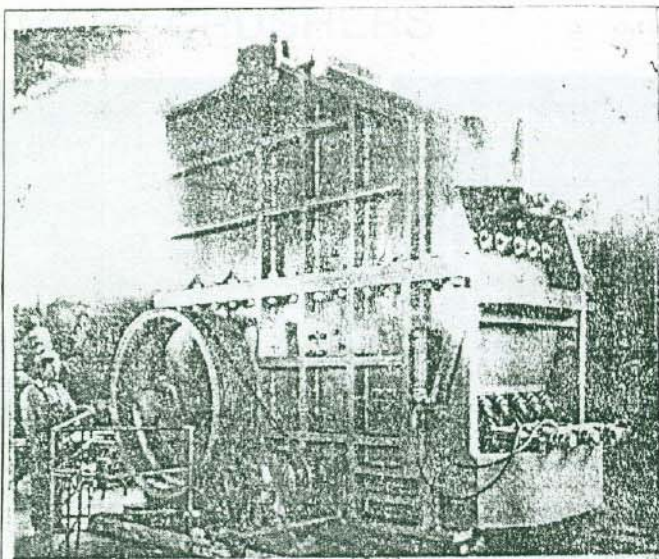
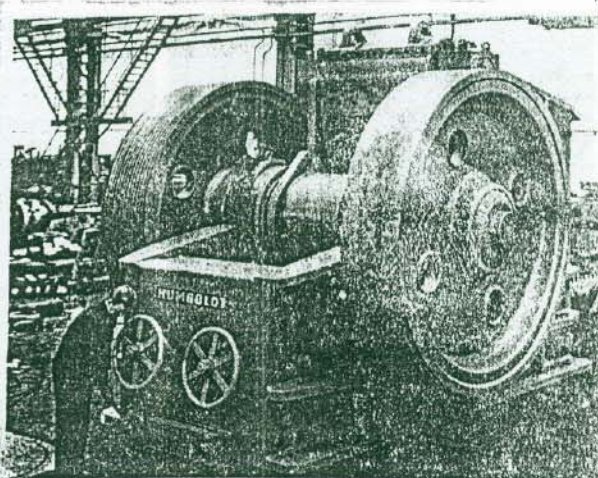


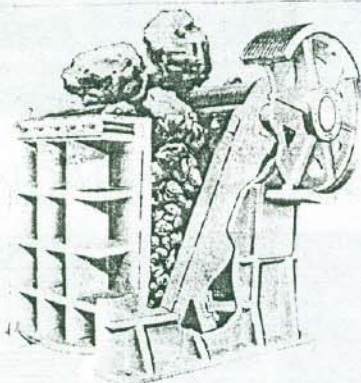
Figure: VARIOUS TYPES OF JAW CRUSHERS



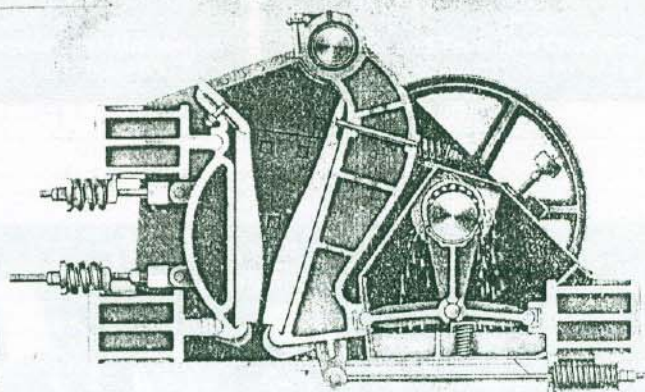
KUE-KEN jaw crusher.



Humboldt Wedag single-toggle jaw crusher.



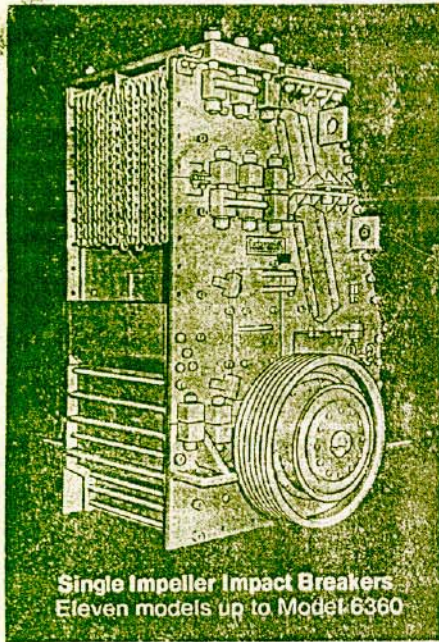
Cross section of KVS overhead eccentric type jaw crusher.



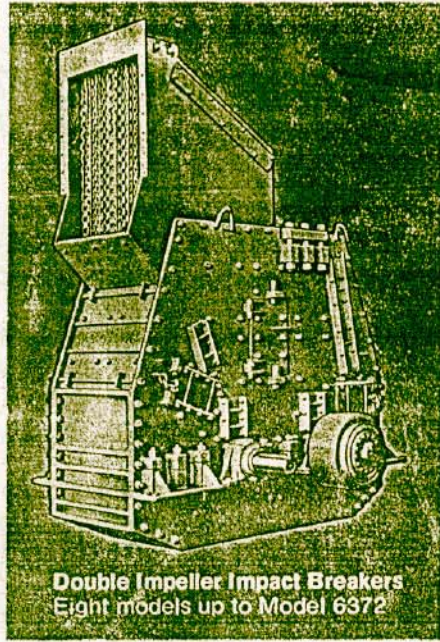
Cutaway view of Pennsylvania jaw crusher.

Figure: VARIOUS MODELS OF PRIMARY & SECONDARY CRUSHERS

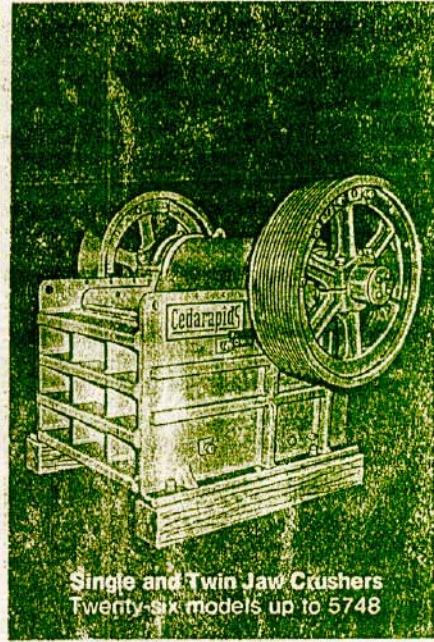
PRIMARY CRUSHERS



Single Impeller Impact Breakers
Eleven models up to Model 6360

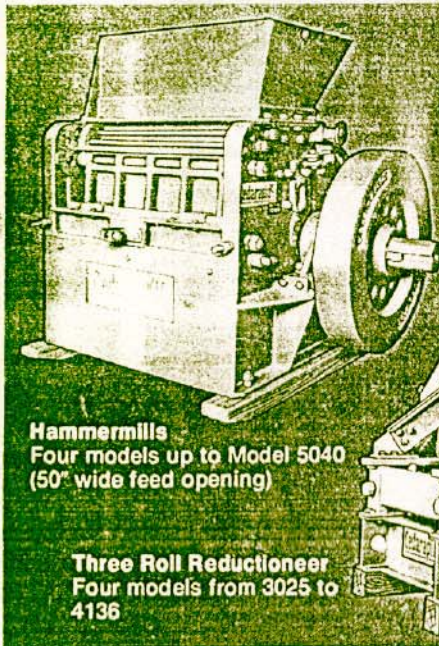


Double Impeller Impact Breakers
Eight models up to Model 6372

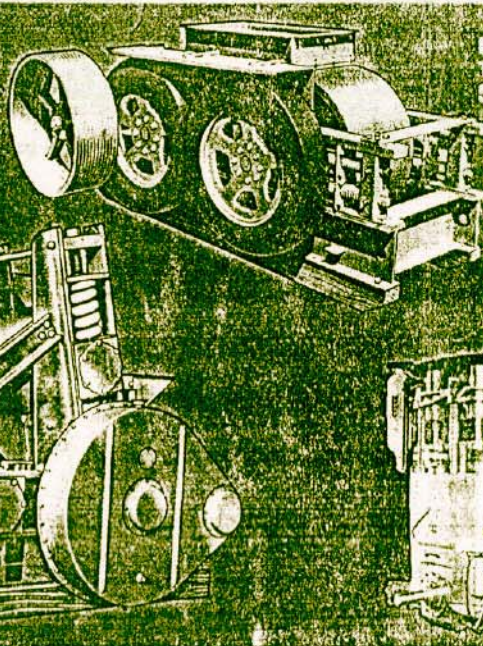


Single and Twin Jaw Crushers
Twenty-six models up to 5748

SECONDARY CRUSHERS



Hammermills
Four models up to Model 5040
(50" wide feed opening)



Three Roll Reducioneer
Four models from 3025 to
4136

Roll Crushers
Ten models up to Model
5530 (55" diameter and
30" width)

Cedarapids
Rollercone®
Crusher
Ten models
including standard,
fine heads and the
sandcone.

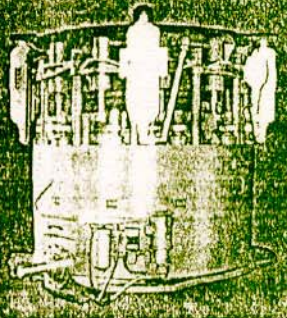
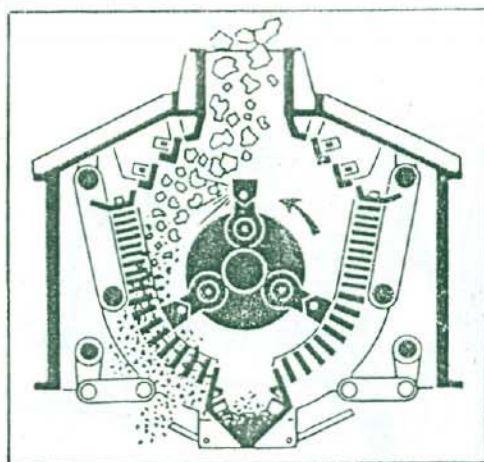
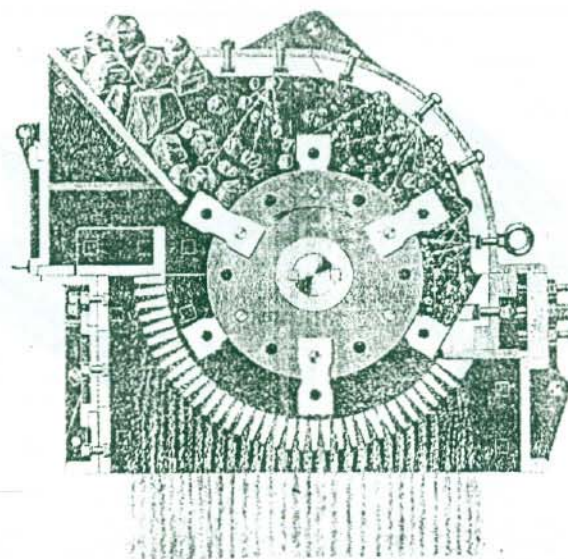


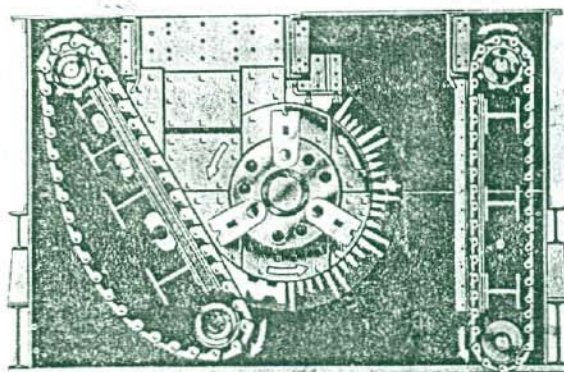
Figure: TYPES OF HAMMER MILLS



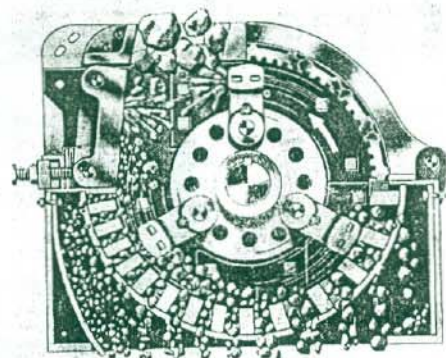
Pennsylvania Reversible Hammermill — cutaway view.



Stedman swing hammer type of mill.

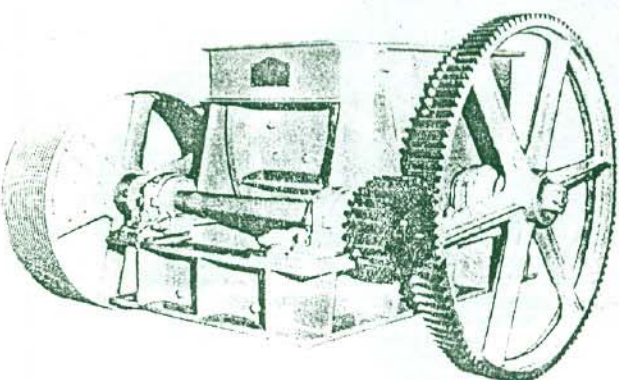


Cutaway view of Hammermills Bulldog non-clog (moving breaker plate) hammermill.

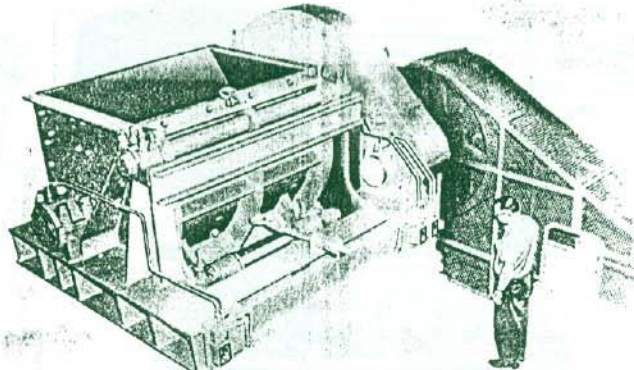


Cedarapids hammermill with road rock gate

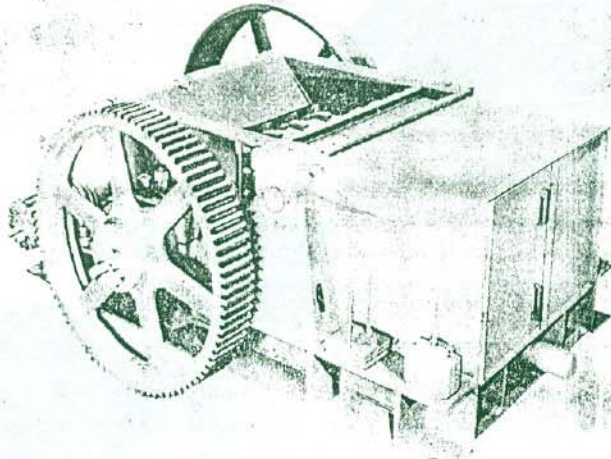
Figure: TYPES OF SINGLE ROLL CRUSHERS



iv. Pennsylvania "Atlas" single roll crusher.

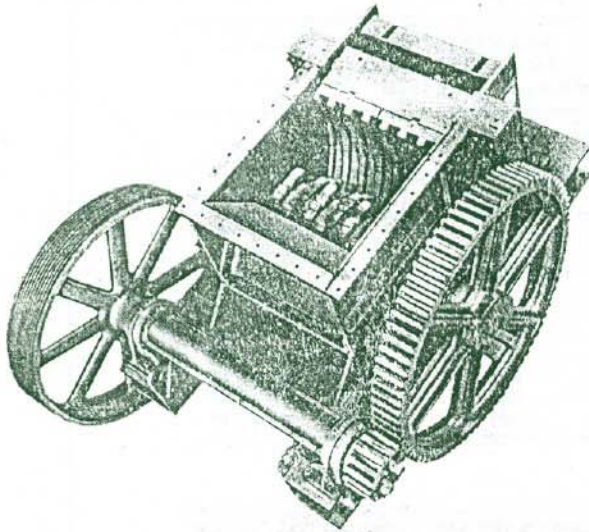


v. Pennsylvania "Hercules" single roll crusher.

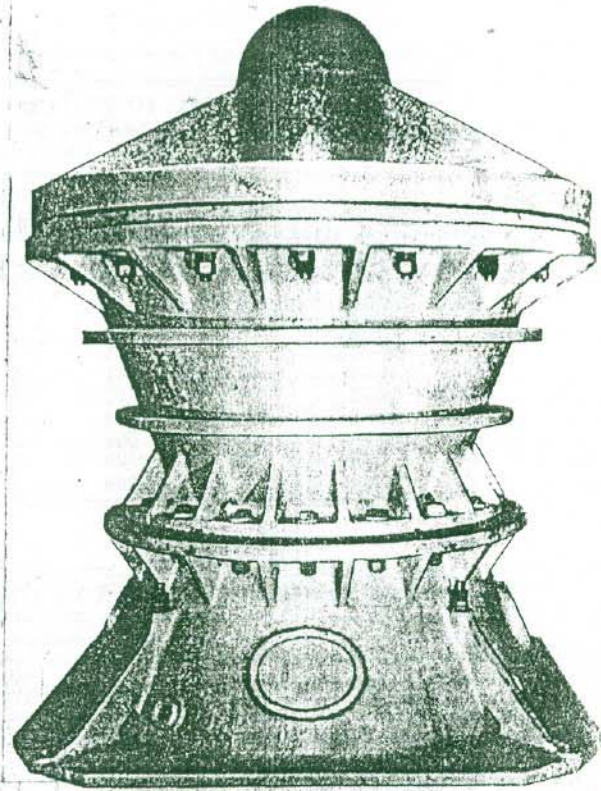


vi. McLanahan 24" x 48" Super Black Diamond Single Roll Crusher

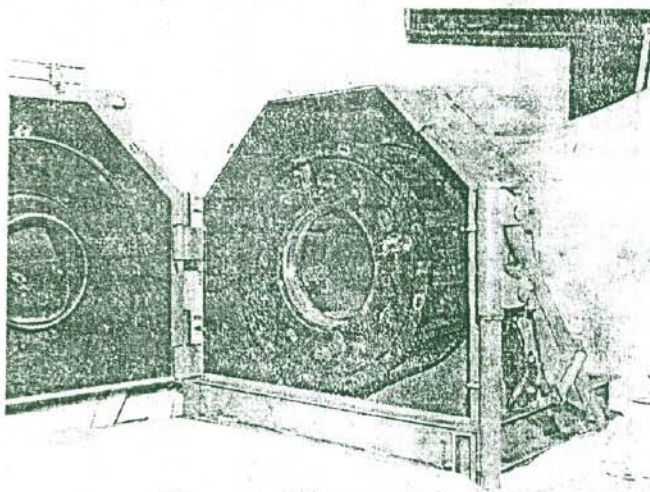
Figure: TYPES OF SECONDARY CRUSHERS



Rockmaster single roll crusher.



KVS 36" primary gearless gyratory crusher.



Gundlach Cage-Paktor Impact Crusher.

TABLE SHOWING CAPACITIES OF JAW, GYRATORY & SINGLE ROLL CRUSHERS

Table — APPROXIMATE CAPACITIES OF JAW CRUSHERS
Material weighing 100 pd. per cu. ft.
Discharge opening, closed, in inches.

Size (in.)	Smallest Discharge Opening (in.)	Capacity (tons per hr.)	Largest Discharge Opening (in.)	Capacity (tons per hr.)	Horse-power	Height (ft. and in.)
16 by 10	1½	15	4	45	15	2-4
24 by 15	2	30	5	80	35	3-6
36 by 24	3	75	6	160	75	4-11
42 by 40	4	130	8	250	125	7-9
48 by 36	5	175	8	275	150	7-6
48 by 42	5	175	8	275	150	8-6
60 by 48	5	240	9	450	200	9-2
84 by 56	8	350	12	600	200	10-7
84 by 60	8	350	12	600	250	10-7
84 by 66	8	400	12	600	250	11-8

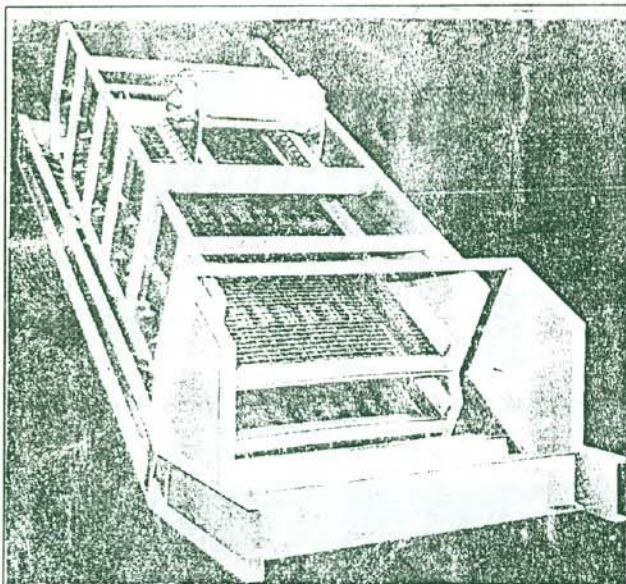
Table — APPROXIMATE CAPACITIES OF GYRATORY CRUSHERS
Material weighing 100 pd. per cu. ft.
Discharge opening—open side.

Size (in.)	Smallest Discharge Opening (in.)	Capacity (tons per hr.)	Largest Discharge Opening (in.)	Capacity (tons per hr.)	Horse-power	Height (ft. and in.)
2½	¾	.5	½	.75	3	1-1
8	1	15	2	40	20	5-6
12	2	40	2½	70	45	7-6
16	2½	100	4½	160	80	8-3
20	3	150	5	250	125	10-1
26	3½	225	6	400	150	11-0
30	4	250	6½	450	175	12-2
36	4½	370	7	600	225	14-0
42	5	420	7½	700	250	15-5
48	5½	750	9	1,200	300	18-6
54	6¼	900	9½	1,600	350	19-0
60	7	1,200	10	2,000	400	20-0
72	9	2,000	12	3,000	500	20-0

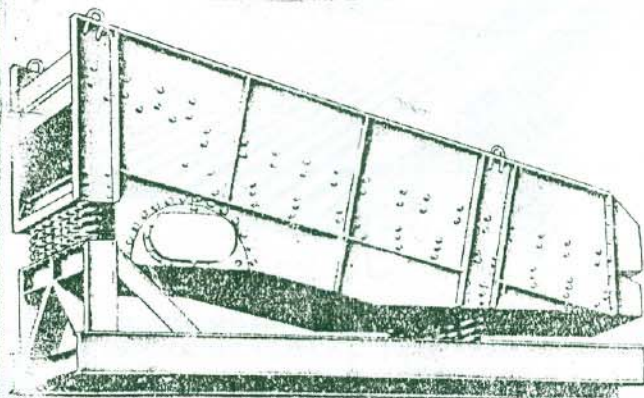
Table — APPROXIMATE CAPACITIES OF SINGLE-ROLL CRUSHERS
Material weighing 100 lbs. per cu. ft.

Size (in.)	Capacity in Net Tons per Hour			Horse-power	Height (ft. and in.)
	4 in.	6 in.	10 in.		
21 x 48	125-150	200-250	300-375	75-100	3-10
21 x 60	150-175	225-275	325-400	100-125	3-10
24 x 48	150-175	225-275	325-400	100-125	4-5
24 x 60	175-200	250-300	350-425	125-150	4-5
30 x 48	175-200	250-300	350-425	125-150	5-0
30 x 60	200-225	275-325	375-450	150-175	5-0
36 x 48	200-225	275-325	375-450	150-175	6-0
36 x 60	225-250	300-350	400-475	175-200	6-0
42 x 48	225-250	300-350	400-475	175-200	7-0
42 x 60	250-275	325-375	425-500	200-225	7-0

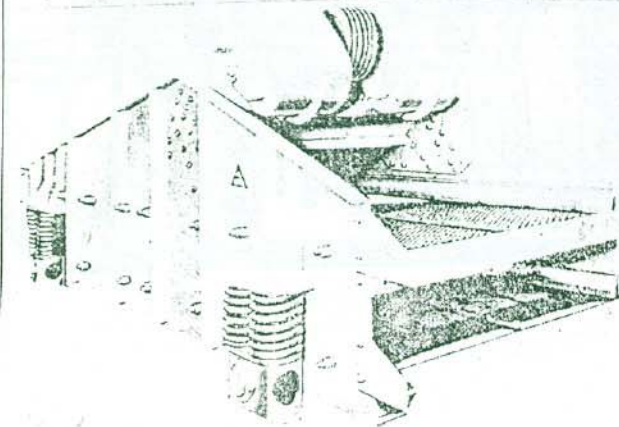
Figure: VARIOUS TYPES OF SCREENING DEVICES



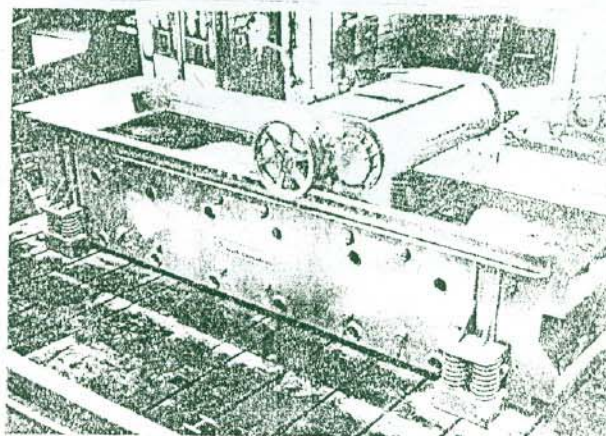
Derrick basic Type B sizing screen.



Cedarapids VIS 53" x 12' double deck scalping screen



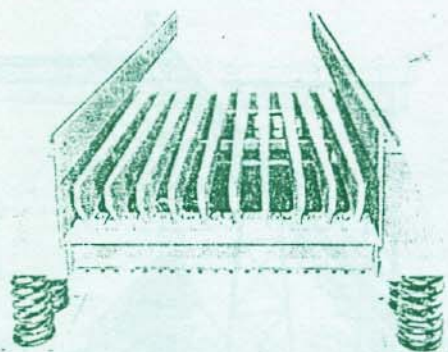
Allis-Chalmers Low-Head vibrating screen. Single or multiple deck models are suspended or floor mounted. Screen sizes 3 by 8 ft to 10 by 28 ft. Separations — Dry: $\frac{1}{8}$ to 2 $\frac{1}{2}$ in.; Wet: 48 mesh to 2 $\frac{1}{2}$ in. Special up to 4 in.



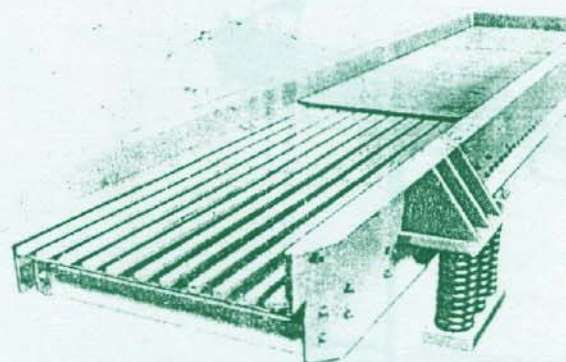
Levl-Flo Vibrating Screen

Figure: VARIOUS TYPES OF CONVEYORS

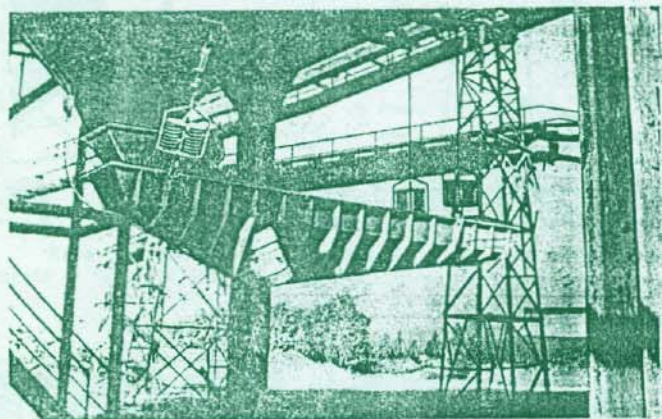
Figure: VARIOUS TYPES OF FEEDERS



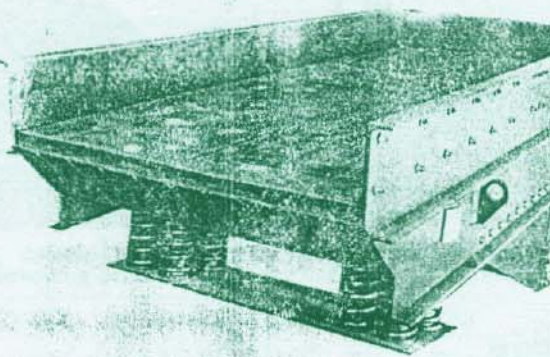
Teismith 42" x 16' vibrating grizzly feeder. Individually adjustable manganese steel grizzly bars are replaceable without dismantling entire section.



Allis-Chalmers standard Low-Head vibrating feeder. Non-rig tapered grizzly bar section field-convertible to carrying.

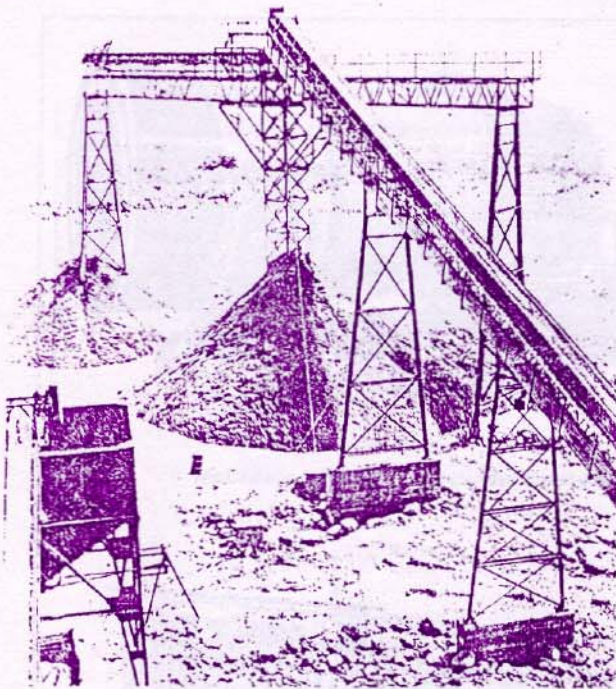


Beumer vibratory feeders.



Simplicity vibrating heavy-duty pan feeder, 74" x 1

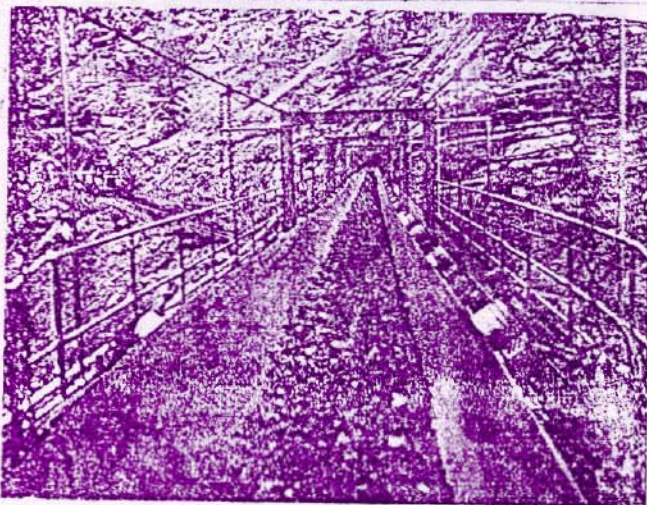
Figure: VARIOUS TYPES OF CONVEYORS



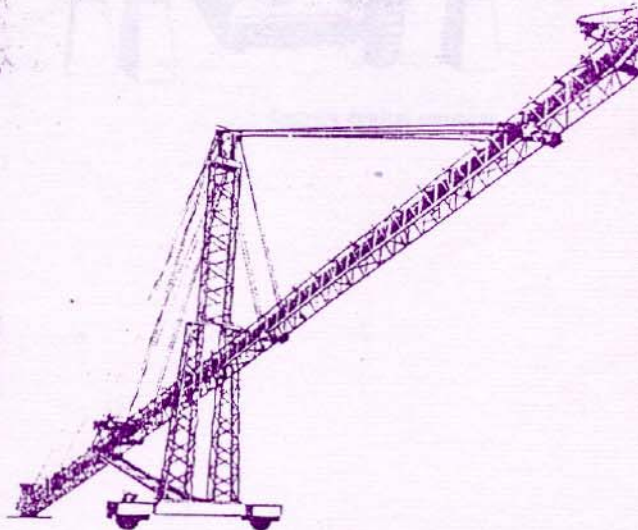
Reversing shuttle conveyor stores different sizes of aggregate in separate stockpiles. (Pioneer Div. of Portec, Inc.)



Cylindrical, telescoping support for outboard end stockpiling conveyor. (Eastern Eng'g and Sales Co.)

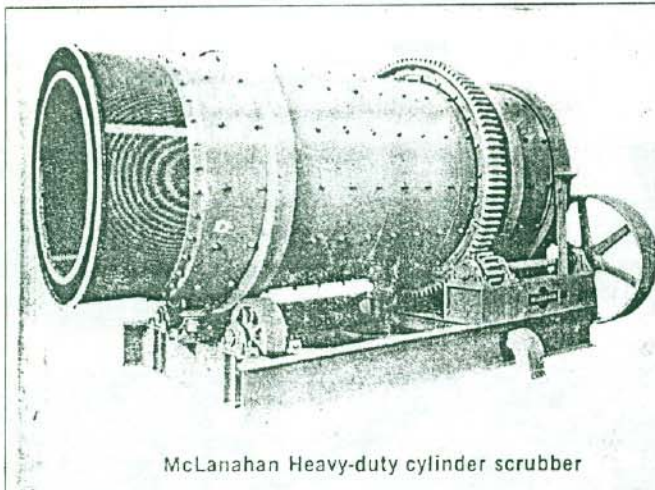


Mercer Rubber Polyton all polyester conveyor belt combines strength with stability.

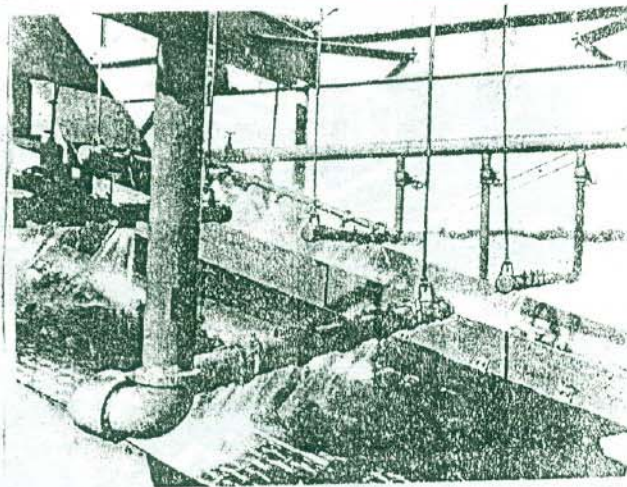


Cedarapids 24" x 150' self-elevating radial stacking conveyor with powered pneumatic tires.

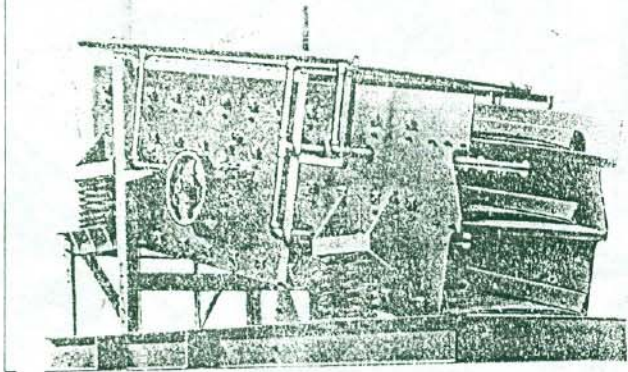
Figure: VARIOUS TYPES OF WASHING SCREENS



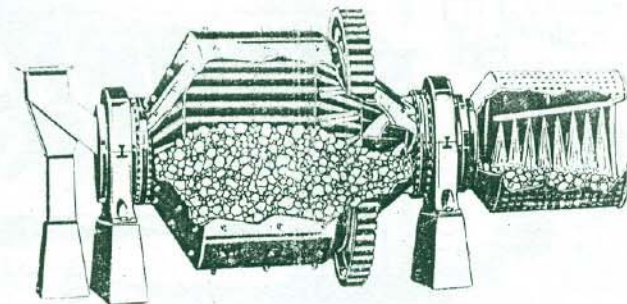
McLanahan Heavy-duty cylinder scrubber



Spray bars installed on vibrating screens.



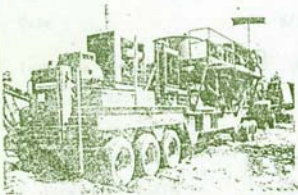
Pioneer washing screen.



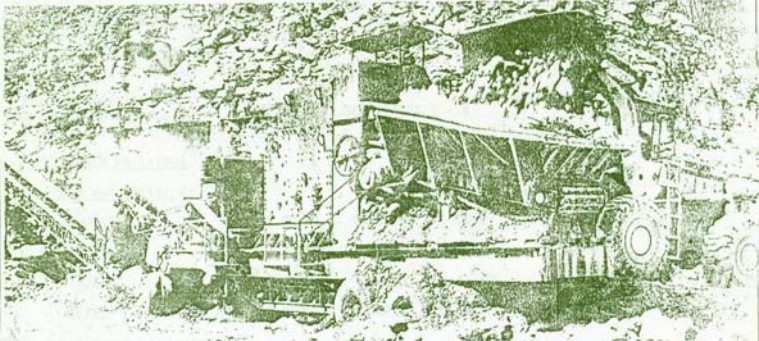
Koppers conical scrubber.

Figure: PORTABLE STONE CRUSHING PLANTS IN DEVELOPED COUNTRIES

Allis-Chalmers closed-circuit portable crushing and screening plant with Series 45 Hydrocone crusher and controls



Allis-Chalmers Model 2436 primary crushing plant has heavy duty jaw crusher with 24" x 36" feed opening.



This shows a Universal 44" x 42" Impact Master portable crushing plant feeding material onto a conveyor, producing to 600 tph.

TABLE 1
FACILITY A1
Summary of Results

Run Number	1	2	3	Average
Date	6/10/74	6/11/74	6/12/74	-
Test Time - Minutes	400	320	240	320
Production Rate - TPH ⁽¹⁾	995	1027	1010	1011
<u>Stack Effluent</u>				
Flow rate - ACFM	26430	26653	27142	26472
Flow rate - DSCFM	22351	22140	22502	22331
Temperature - °F	81.0	88.0	88.0	85.7
Water vapor - Vol. %	2.5	3.0	3.3	2.9
Visible Emissions at Collector Discharge - % Opacity	SEE TABLES 2 - 4			
<u>Particulate Emissions</u>				
<u>Probe and filter catch</u>				
gr/DSCF	0.00471	0.00504	0.00727	0.00567
gr/ACF	0.00398	0.00419	0.00602	0.00473
lb/hr	0.90	0.96	1.40	1.07
lb/ton	0.00091	0.00102	0.00139	0.00111
<u>Total catch</u>				
gr/DSCF ⁽²⁾	-	0.00597	0.00839	0.00718
gr/ACF	-	0.00495	0.00695	0.00595
lb/hr	-	1.13	1.62	1.38
lb/ton	-	0.00121	0.00160	0.00140

(1) Based on throughput through primary crusher.

(2) Back-half sample for run number 1 was lost.

Reference 1.

FACILITY A1
SUMMARY OF VISIBLE EMISSIONS (1)

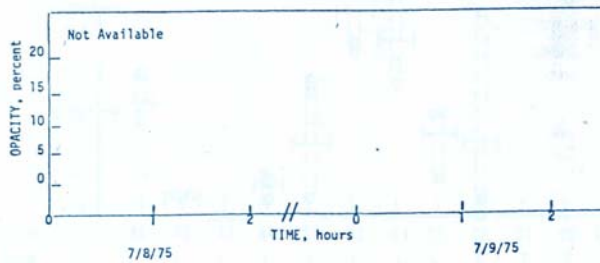
ANNEXURE 4.2

Date: 7/8/75 - 7/9/75
 Type of Plant: Crushed stone (cement rock)
 Type of Discharge: Fugitive
 Location of Discharge: Primary impact crusher (discharge conveyor or transfer point)
 Height of Point of Discharge: 6 feet Distance from Observer to Discharge Point: 15 feet
 Description of Background: Grey wall Height of Observation Point: Ground level
 Description of Sky: N.A. (indoors) Direction of Observer from Discharge Point: SE
 Wind Direction: N.A. Wind Velocity: No wind (indoors)
 Color of Plume: White Detached Plume: No
 Duration of Observation: 7/8/75 - 2 hours
 7/9/75 - 2 hours

Summary of Data:

Opacity, Percent	Total Time Equal to or Greater Than Given Opacity		Opacity, Percent	Total Time Equal to or Greater Than Given Opacity	
	Min.	Sec.		Min.	Sec.
5	3	30	55	-	-
10	0	30	60	-	-
15	0	15	65	-	-
20	0	15	70	-	-
25	0	0	75	-	-
30	-	-	80	-	-
35	-	-	85	-	-
40	-	-	90	-	-
45	-	-	95	-	-
50	-	-	100	-	-

Sketch Showing How Opacity Varied With Time:



(1) Two observers made simultaneous readings, the greater of their readings is reported.

Reference 2.

A-17

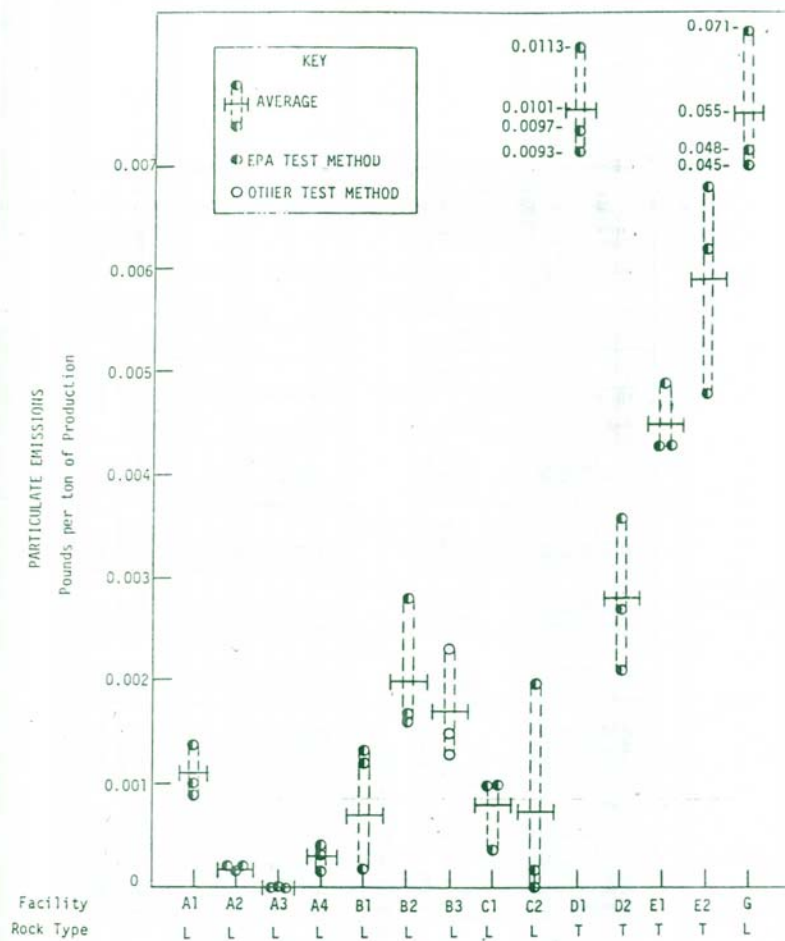


Figure 3.
Particulate emissions from crushed stone facilities.

UNIT - 1 DATE OF MONITORING: 29.3.2000

Sample No	Location	FP No.	Initial Wt Gms	Final Wt. Gms	Dust Wt. Gms	Run Time Mts.	Avg. Flow M ³ /min	Avg. Temp. °C	Wind Vel M/Sec	Distance m			Conc. µg/M ³	SPM Contribution by the unit µg/M ³
										X	Y	Z		
1.	D	102	2.7140	2.9425	0.2285	115	1.10	37	2.1	50	25	5	3222	2342
	D	103	2.7099	2.9580	0.2481	107	1.20	44	2.5					
	D	106	2.7125	3.7670	1.0545	214	1.03	41	1.3					
2.	U	101	2.7073	2.8501	0.1428	175	1.21	37	2.2	-	-	-	880	2342
	U	104	2.7113	2.7894	0.0781	101	1.05	45	2.66					
	U	105	2.7178	3.0407	0.3229	250	1.20	40	1.05					
3.	B	108	2.7217	3.1739	0.4522	266	1.13	29	0.5	-	-	-	1509	

UNIT - 2 DATE OF MONITORING: 01.4.2000

Sample No	Location	FP No.	Initial Wt Gms	Final Wt. Gms	Dust Wt. Gms	Run Time Mts.	Avg. Flow M ³ /min	Avg. Temp. °C	Wind Vel M/Sec	Distance m			Conc. µg/M ³	SPM Contribution by the unit µg/M ³
										X	Y	Z		
1.	D	110	2.7136	4.5575	1.8439	47	1.10	41	2.98	29	5	6	25224	23911
	D	111	2.7145	4.3117	1.5972	127	1.10	43	3.04					
	D	112	2.7095	6.0915	3.3820	108	1.08	45	3.95					
	D	113	2.7049	6.1688	3.4639	91	1.10	40	4.4					
2.	U	114	2.7108	3.4712	0.7604	503	1.15	44	2.39	-	-	-	1313	

UNIT - 3 DATE OF MONITORING: 08.4.2000

Without Sprinkler

Sam- ple No	Locat- ion	FP No.	Initial Wt Gms	Final Wt. Gms	Dust Wt. Gms	Run Time Mts.	Avg. Flow M ³ /min	Avg. Temp. ° C	Wind Vel M/Sec	Distance m			Conc. µg/M ³	SPM Contri- bution by the unit µg/M ³
										X	Y	Z		
1.	D	159	2.7027	5.9654	3.2627	116	1.16	36	1.2	33	0	-2	36826	36406
	D	142	2.7192	5.5663	2.8471	149	1.03	41	2.4					
	D	141	2.7162	6.7090	3.9928	110	0.95	39	2.1					
	D	143	2.7255	6.3750	3.6495	41	1.0	44	2.9					
2.	U	158	2.7098	2.8249	0.1151	236	1.16	39	1.0	-	-	-	420	
3.	B	146	2.7243	2.8430	0.1187	241	1.17	43	2.1	-	-	-	880	
	B	147	2.7290	3.1068	0.3778	235	1.20	35	0.8					

With Sprinkler

Sam- ple No	Locat- ion	FP No.	Initial Wt Gms	Final Wt. Gms	Dust Wt. Gms	Run Time Mts.	Avg. Flow M ³ /min	Avg. Temp. ° C	Wind Vel M/Sec	Distance m			Conc. µg/M ³	SPM Contri- bution by the unit µg/M ³
										X	Y	Z		
1	D	145	2.7173	3.5420	0.8247	255	1.23	45	3.1	33	0	-2	12523	11844
	D	144	2.7050	7.8300	5.1250	236	0.97	45	2.5					
2	U	148	2.7298	2.9170	0.1872	228	1.21	45	2.8				679	

Unit 4

Date of Monitoring : 13/05/01

Sample No	Location	Filter Paper No	Initial Weight, g	Final Weight, g	Dust weight, g	Run time, min	Average flow, m ³ /min	Average Temp, °C	Wind velocity, m/sec	Distance, m			Concentration, ug/m ³	SPM contribution by unit
										x	y	z		
1	Downwind	401	2.541	3.493	0.952	220	1.2	39	3.2	35	20	0	10118	9413
2	Downwind	402	2.321	3.962	1.641	280	0.9	39	4.1	35	20	0		
3	Upwind	400	2.2382	2.595	0.3568	460	1.1	39	3.1					

Unit 5

Date of Monitoring : 25/05/01

Sample No	Location	Filter Paper No	Initial Weight, g	Final Weight, g	Dust weight, g	Run time, min	Average flow, m ³ /min	Average Temp, °C	Wind velocity, m/sec	Distance, m			Concentration, ug/m ³	SPM contribution by unit
										x	y	z		
1	Downwind	501	2.223	3.382	1.159	240	1.1	38	2.5	20	5	0	10975	10117
2	Downwind	502	2.435	4.265	1.83	247	1.125	38	3.6	20	5	0		
3	Upwind	500	2.356	2.757	0.401	467	1	38	2.2					

Unit 6

Date of Monitoring : 26/02/01

Sample No	Location	Filter Paper No	Initial Weight, g	Final Weight, g	Dust weight, g	Run time, min	Average flow, m ³ /min	Average Temp, °C	Wind velocity, m/sec	Distance, m			Concentration, ug/m ³	SPM contribution by unit
										x	y	z		
1	Downwind	601	2.126	5.156	3.030	245	1.3	27	3.4	50	10	0	21166	19152
2	Downwind	602	2.234	5.584	3.35	230	1.25	27	4.2	50	10	0		
3	Upwind	600	2.467	3.515	1.048	473	1.1	27	2.8					

Unit 7

Date of Monitoring : 10/01/02

Sample No	Location	Filter Paper No	Initial Weight, g	Final Weight, g	Dust weight, g	Run time, min	Average flow, m ³ /min	Average Temp, °C	Wind velocity, m/sec	Distance, m			SPM value, ug/m ³	PM ₁₀ , ug/m ³	Total SPM contribution by unit, ug/m ³
										x	y	z			
1	Downwind	701	2.045	3.135	1.090	172	0.9	22	3.6	10	3	5	63372	7041	113168
2	Downwind	702	2.254	4.704	2.45	166	1	22	3.8	15	7	5	57771	14759	
3	Upwind	700	2.468	4.874	2.41	345	1.1	22	2.2				23425	6350	

* Note: Ambient air quality monitoring (AAQM) was carried out using respirable dust sampler

Date of Monitoring : 11/01/02 **Unit 8**

Sample No	Location	Filter Paper	Initial Weight,	Final Weight,	Dust weight,	Run time,	Average flow,	Average Temp, °C	Wind velocity,	Distance, m			SPM value,	PM ₁₀ , ug/m ³	Total SPM contribution
										x	y	z			
1	Downwind	801	2.165	4.215	2.050	165	1.2	22	4.8	6	3	4	40832	10353	81840
2	Downwind	802	2.293	4.593	2.3	172	1.125	22	5.2	8	7	4	51710	11886	
3	Upwind	800	2.321	5.251	2.93	350	1	22	3.8				24570	8371	

* Note: Ambient air quality monitoring (AAQM) was carried out using respirable dust sampler