“Guidelines for (i) Siting of rice shellers/mills; (ii) handling and storage of rice husk and (iii) handling, storage and disposal of ash generated in boiler using rice husk as fuel”

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Ministry of Environment & Forests
Government of India, New Delhi
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FOREWORD

Rice Processing mills are located in paddy producing regions spread over various States in India; like Assam, Punjab, Haryana, Tamil Nadu, West Bengal, Uttar Pradesh, Bihar, Orissa, Andhra Pradesh and Madhya Pradesh. Rice processing mills have adopted a blend of conventional methods and modern technology. Presently, two types of processing are in practice one- Raw Rice Processing (Rice Shellers) and other- Parboiled Rice Processing. Raw Rice or White Rice is the one obtained from untreated paddy, while the parboiled rice is obtained by milling the pretreated paddy. Pre-treatment is given to paddy to improve nutritional and cooking qualities of rice.

Rice Milling is a polluting industry. It discharges process waste water, particulate matter and solid waste. Rice husk is the largest by-product of rice milling industry which amounts to approximately 22-24 percent of the total paddy. The Rice Husk is used as a fuel to generate steam through boilers/furnaces resulting into Rice Husk Ash which needs to be disposed properly. For every 1000 kgs of paddy milled, about 220 -240 kgs of husk is produced, and when this husk is burnt in the boilers, about 55-60 kgs (25 %) of Rice Husk Ash is generated.

Considering the problem in handling of Rice husk and Rice husk ash, Central pollution Control Board entrusted a project on Framing the Guidelines for (i) Siting of Rice Shellers/Mills; ii) Handling and Storage of Rice Husk and (iii) Handling, Storage and Disposal of Ash Generated in Boiler using Rice Husk as Fuel' to the Federation of Indian Chambers of Commerce and Industry (FICCI).

The present document envisages production processes in Rice Mills, current practices adopted for handling & storage of rice husk and handling, storage & disposal of rice husk fired boiler ash. The present guidelines including Siting Criteria are based on the findings of the study.

I would like to thank FICCI for preparing the document and Shri U.N. Singh, Additional Director, Shri Abhey Singh Sr. Environmental Engineer and Ms. Alka Srivastava, Jr. Scientific Assistant for the sincere efforts made for bringing out this comprehensive document under the overall supervision and guidance of Sh. J.S. Kamyotra, Member Secretary,CPCB.

I hope this document will be useful for Rice Mill owners, Pollution Control Implementing Agencies and all other stakeholders concerned with the Environmental Management.

September 24, 2012

(Mira Mehrishi)

Content

<u>**LIST OF TABLES**</u>

LIST OF FIGURES

ABBREVIATIONS

CPCB	Central Pollution Control Board
TSP	Total Suspended Particulates
LPM	Liters per minute
PM	Particulate Matter
mmWc	Millimeters of Water Column
TSPM	Total Suspended Particulate Matter
RDS	Respirable Dust Sampler
ID	Induced Draft
OPC	Ordinary Portland Cement
RHA	Rice Husk Ash
APCD	Air Pollution Control Device
PCB	Pollution Control Board
BE	Bucket Elevator
BC	Belt Conveyer

EXECUTIVE SUMMARY

Typically, the rice processing units in the country are small, medium and large size mills. Most of them are situated in the paddy producing regions spread over various States in India. For study purpose units from each category - small, medium and large scale were selected. The scale of operation of selected rice mills varies from as small as 1 tonne/hr upto 50 tonne/hr or more. Typically, mills with capacity less than 3 tonne/hr can be categorized as Small Mills, 3 to 15 tonne/hr capacity as Medium and greater than 15 tonne/hr capacity as Large. Most of the large and medium units generally produce both the Parboiled and White (Raw) Rice using separate production lines. However, most of the small scale units generally produce White (Raw) rice. For the purpose of the study units producing both Parboiled and White (Raw) Rice and units producing only Raw Rice were selected, so as to cover various unit operations, such as cleaning, parboiling, drying, hulling, dehusking, polishing and sorting, etc. Some of the rice mills are located in clusters in industrial areas, away from residential areas, some in residential areas and some even in the middle of the agriculture/paddy fields. For the purpose of the study units in all the above three locations were selected. 11 units were identified for Preliminary visits based on the selection criteria. Out of 11 units, 7 units were selected for detailed field studies.

Rice husk is the largest by-product of rice milling industry which amounts to 22-24 percent of the total paddy. The units need to handle the bulk quantities of husk and store them within the unit premises till husk is used or sold. During the milling of paddy, rice husk is separated out in the de-husker machines and husk is sent to storage yard in many ways depending upon the mill scale, type and mechanism employed. In most of the small mills husk from de-husker is simply blown to storage yard with help of blowers. In most of the large mills the husk is extracted from aspirators and it is collected on the conveyor belt. From conveyor belt the husk is conveyed to the storage yard. From extraction system, the fines/dust is taken to cyclone from where the dust/fines separate out and falls from the bottom of cyclone. But major portion of the Fine Particles not collected in cyclones, escape to atmosphere from discharge of the Induced Draft Fan.

Most of the small units have a common open storage of rice husk, rice bran and also the dust collected by the Paddy Cleaner. The units have different practices for storing the rice husk like fully open storage with boundary wall, partially covered storage and completely covered storage. Most of the small and medium units store the rice husk in open area within their premises. However, most of the small and medium mills have 10 foot boundary wall surrounding the husk storage areas. Separated Rice Husk from de-husker is blown to storage yard with help of blowers without separating fines. Therefore the stored husk in these small mills has more percentage of fines which gets air-borne during windy period. Most of the large units have covered their husk storage areas partially with tall fencing, to combat with large quantity of stored husk and to reduce the fugitive emissions from the storage yard. Few medium and large units have covered storage yards for storing rice husk. The storage of rice husk in closed space eliminates the possibility of fines blowing with the wind besides reducing the fugitive emissions. Most of the medium and large mills use covered conveyor belts (mechanical system) for handling husk from storage area to boiler. Most of the parboiled units use the rice husk as boiler feed for steam generation and for electricity generation in captive power plants. After the combustion of rice husk in boiler the boiler ash is generated which needs to be handled, stored and disposed. Most of the medium and large scale units handle their boiler ash mechanically and collect it in the trucks/trolley, directly from boiler, with the help of conveyor belt and hoppers. They also spray water over the collected ash in trucks and nearby boiler section to reduce the fly ash emissions. The Small Scale Rice Mills having small size Boilers generally handle the Boiler Ash manually, during collection from Boiler Section to Temporary Storage.

A large quantity of boiler ash is generated in the parboiled rice mills which need to be stored temporarily before its disposal. Many of the small & medium rice mills store their boiler ash in partially covered storages. Most of the large units dispose their boiler ash on part of their own land, converted as landfills. After disposal of boiler ash on the land it is covered with a layer of soil and plantation developed over. Recycled wastewater is periodically sprinkled on the ash disposal site to avoid wind blowing of fly ash in the nearby areas. Most of the small and medium mills not having their own disposal facilities generally dispose their husk ash, through contractors, who dispose it to available low lying areas. Most mills give this job on contract basis where the contactors collect the boiler ash from the unit premises and dispose it on payment basis. In this case even the generator of ash is not aware of the ultimate disposal site of its boiler ash. In the areas where use of boiler ash is common in fields by farmers, the mills or contractors also sell boiler ash for use in the farms.

In rice mills fugitive emissions are generated from various sections during handling of paddy; cleaning & milling of paddy; handling and storage of husk and handling, storage and disposal of boiler ash due to various activities in the mills. Monitoring of emissions was carried out in selected 7 representative units. For monitoring purpose three parameters were considered – Fugitive Emissions Assessment, Stack Monitoring and Ambient Air Quality Monitoring. In order to evaluate and quantify the air pollution problem, measurements were carried out for selected air pollutants. Fugitive Emission Assessment was carried out at Pre-cleaning Section, Milling Section and Boiler House. In Milling Section , Stack Monitoring was done at inlet and outlet of Paddy Cleaners, De-huskers, Aspirators, Polishers, etc as well at the Inlet and Outlet of Cyclones and ID Fans. Stack Monitoring was carried out in Rice Husk fired Boiler House, at Stack.

Due to free fall, substantial fine dust is generated during unloading of paddy and its conveyance. This fine dust escapes in the mill environment due to inadequate extraction arrangement from the Unloading pit, the Bucket Elevator, the Discharge Points, etc. In the milling section during husk removal substantial quantities of fine particles of rice husk are generated due to breaking of husk in hullers and husk separation in de-huskers. During milling of paddy fine rice husk escapes in the milling section. It is generally perceived that the fine dust adhering to paddy keeps getting loosened/ separated, right from bag unloading point upto the cleaning screen and it gets accumulated and can be extracted at the final point i.e. screen. But, because, the system of conveying & storage of paddy is not air-tight hence the fine dust, as and when generated, escapes to atmosphere through the openings/leakages in the system. Even if all the leakages/openings are closed or sealed, the fine dust would escape through the vent of the storage vessel, through openings for discharging material. It is, therefore, necessary to extract / suck the fine dust particles from various locations simultaneously like transfer points, point of free fall Paddy, vents of storage bins/ silos, vibratory/rotary screens etc. Even though large volume of extraction is provided (about 15000 Nm^3/h) which may be even more than that required (as per the technical design handbook specifications), but still not able to extract the dust emissions adequately resulting in substantial fugitive emissions, because all the sucking is provided only at 1 point i.e. the vibratory screen, which is a wrong design instead of sucking dust from various required locations like belt conveyor transfer points, bucket elevators, storage silos etc,.

In nutshell, even if the industry has installed more than adequate size of dust extraction cum bag filter system and have made substantial investment on the equipment, associated with high operating costs of running the ID fan, still substantial fugitive emission occur, thereby defeating the very purpose of installing dust extraction cum control system. This is primarily because of in-appropriate design of dust extraction network and improper maintenance of the cyclone and bag filter leading to leakages in the system and high pressure drop in bag filter. Therefore, it is necessary to provide technical guidance to rice mills for the required volume of air to be extracted from various locations.

Husk contains about 75 % organic volatile matter and the balance 25% of the weight of this husk is converted into ash during the firing process, known as Rice Husk Ash (RHA). This RHA in turn contains around 80% - 90% silica. For every 1000 kgs of paddy milled, about 220 kgs (22 %) of husk is produced, and when this husk is burnt in the boilers, about 55 kgs (25 %) of RHA is generated. Presently, many rice mills blow the husk (from the de-husker) by a blower in the open area outside the factory shed wall. The husk falls to ground by gravity & forms heap. The size of heap keeps growing as more & more husk is blown. This openly stores husk leads to generation of dust due to wind blowing. To avoid this environmental air pollution problem, the blowing of husk should be done into a closed room. The room should be provided with an access door (to be kept closed during blowing) and a vent in the roof to release the air. The vent pipe should be attached to a filter-bag arrangement to arrest the fine particles. The size of the room would depend on the quantity of husk blown per hour & minimum storage quantity required.

Most rice mills do have some dust extraction arrangement but requires modifications to make the system appropriate so as to cover dust extraction from belt conveyor transfer points, bucket elevator & screens, storage silo vents etc. There are substantial fugitive emissions from area like paddy unloading section, paddy cleaning section, milling section etc. There are substantial leakages of air in the dust extraction system from cyclone bottom opening, bag-filter casing, flanges and joints etc, which reduces the useful dust extraction volumes sucked by the induced draft fan.

Thus, urgent measures need to be taken to improve the environmental performance of Rice Mills. Keeping in view the orders passed by the court and the gravity of air pollution caused by this sector, guidelines have been evolved (Chapter 10 of the report) for proper Handling and Storage of Rice Husk; Handling, Storage and Disposal of Boiler Ash and Siting Criteria for New Rice Mills.

Chapter 1: INTRODUCTION

1.1. Background

Primary milling of rice is an important activity in food grains. Rice is used in almost all parts of India. Few decades ago, rice grains were processed at family level before cooking. Today, due to Industrialization and global competitive market trend, it has emerged as one of the major industrial activity in tiny, small, medium and large scale sector to cater to the needs of increasing population. Large number of mills engaged in processing/milling of rice are spread over in almost all states across the country. Due to increasing demand the number of rice mills will continue to increase throughout the country.

The input to the Rice mill is paddy whereas the output is parboiled rice and raw /white rice depending upon whether the pretreatment is given to paddy or not. The objective of milling is to get whole grain rice and preserve most of the rice kernels in their original shape. The technologies used for rice milling in tiny and small mills are mostly conventional in nature and are not oriented towards minimizing pollution by incorporation of in plant pollution prevention cum control measures. These units generate substantial amount of pollution, especially air pollution as a result of fugitive emissions from various operations.

The pollution is particularly high in cleaning of paddy, parboiling of paddy and milling of rice. Primary and secondary cleaning of paddy gives rise to solid waste and fugitive emission in the work environment. The coal or husk fired boiler generates fly ash, suspended particulate matter, smoke, and oxides of carbon**.** Residents of nearby towns suffer due to pollution generated by rice mills. Though some of changes are being brought in production processes to improve the efficiency and lowering the cost of production etc., as regards to pollution abatement & control it remains mostly unsatisfactory. A Civil Writ came up for hearing before the Punjab and Haryana High Court recently and during hearing, the Hon'ble Court had passed an interim order-"*It be made known as to why rice husk etc. cannot mandatory be required to be stored, after expulsion by the machine, directly into an enclosed area, so that it does not in any way get out of the factory premises on to the crops/passing vehicles/any residence made in open fields/on farm workers, at all*." In compliance of the orders passed by the court, Punjab Pollution Control Board carried out a study so that some immediate action could be taken to prevent air pollution in the surrounding areas by following enclosed storage practices. The study included inspection of shellers of different capacities, measures taken by these shellers to store the Rice Husk in an environmentally sound manner, adequacy of the enclosure provided around the rice husk storage area, etc. After going through recommendations of the study, court expressed that problem of spillage of Rice Husk could not be solved without providing air tight enclosures. The court also expressed that loading/handling of Rice Husk should be inside the air tight enclosure, so as to rule out any possibility of rice husk particles becoming air borne. The handling and proper disposal of Rice Husk Ash is also a big problem. The ash deposited in the nearby areas is causing health impacts to humans as well as plants.

Keeping in view the orders passed by the court and the gravity of air pollution caused by this sector, Central Pollution Control Board entrusted a project on 'framing the guidelines for siting of rice shellers/mills; handling and storage of rice husk and handling; storage and disposal of ash generated in boiler using rice husk as fuel' to Federation of Indian Chambers for Commerce and Industry, so as to improve the environmental performance of the rice mills.

1.2. Scope of Work

The scope of work of the study is given below:

- Study of current practices in the mills for:
  - Handling of rice husk and control of dust emissions
  - Storage of rice husk and control of dust emission
  - Ash handling and Control of dust emissions from Rice Husk Fired Boilers
  - Ash Storage and its disposal from Rice Husk Fired Boiler
  - Siting issues related to locations, transportations, storages etc.

- Fugitive Emissions Assessment using samplers for estimating emissions from following sections:
  - Paddy cleaning section covering operations like unloading of paddy, pre-cleaning (Chalni), paddy cleaning in paddy cleaner/ vibrating screen etc.
  - Milling Section covering different stages of lifting and discharging of paddy /rice through bucket elevator, dehusking in rubber roll, aspirator used for husk removal, polishing & grading of rice in rice grader.
  - Storage section of rice husk & boiler ash.

- Stack Monitoring in Pre-Cleaning and Milling Section.

- Compilation of measured data & its analysis to evolve specific aspects related to fugitive dust emissions.

- To evolve practically adoptable system for proper handling and storage of rice husk and handling, storage & disposal of boiler ash.

- To frame guidelines for handling and storage of rice husk and handling, storage & disposal of boiler ash

- To evolve siting criteria for new rice shellers/ mills.

- Presentation of report recommendations to CPCB expert committee & discussions.

- Incorporating CPCB suggestions and submission of final report.

1.3. Methodology

While framing the guidelines for the rice milling sector, the following methodology was adopted:

- **Literature Survey:** A detailed literature survey was conducted for collecting information on types of technologies used, current practices on handling & storage of husk/ash etc.

- **Information Collection:** The available data from various agencies like industry associations, CPCB, SPCBs and other government agencies about rice mill technologies, practices for handling, storages etc was collected and reviewed.

- **Data Collection & Analysis:** 7 representative units were selected for detailed field studies, comprising Stack Monitoring, Fugitive Emissions Assessment and Ambient Air Monitoring. Additional number of units was also visited for dry studies & information collection.

- **Emission monitoring:** The study involved various aspects such as identification and characterization of sources of emission and emissions measurement in representative units. The particulate matter sampling was done as per method prescribed by CPCB.
    - Stack Monitoring: the measurements were carried out using stack monitoring instruments such as dry gas meter, vacuum pump assembly.
    - Air Quality Monitoring: Fugitive emissions assessment was conducted at work place in major sections of the units and ambient air quality monitoring was done using respirable/high volume samplers for measurement of TSPM & PM10.

- **Technology Assessment:** The available technologies in the rice mill sector in India for abatement, prevention and control of emissions were reviewed through discussions with Unit Management and collection of information from other sources regarding technologies used in this sector.

- **Framing of Guidelines:** The guidelines for Rice shellers/mills sector were framed keeping in view the information gathered and field study data.

CHAPTER 2: SELECTION OF REPRESENTATIVE RICE MILLS FOR THE STUDY

Typically, the rice processing units in the country are small, medium and large size mills. Most of them are situated in the paddy producing regions spread over various States in India.

For the purpose of the study a number of rice mills were identified for preliminary visits based on the following criteria:

- Scale of Operation
- Type of Rice Produced
- Age of Technology
- Siting of the unit
- Type of fugitive emission control measures practiced

2.1 Scale of Operation

The number of Rice Mills present in India is quite large, which includes small, medium and large scale mills. For study purpose units from each category - small, medium and large scale were selected. The scale of operation of selected rice mills varies from as small as 1 tonne/hr upto 50 tonne/hr or more. Typically, mills with capacity less than 3 tonne/hr can be categorized as Small Mills, 3 to 15 tonne/hr capacity as Medium and greater than 15 tonne/hr capacity as Large.

2.2 Type of Rice Produced

Rice mills in India generally produce 2 types of rice, Parboiled Rice and White (Raw) Rice. In order to improve nutritional and cooking qualities of rice, pre-treatment is given to paddy. The rice obtained from milling pretreated paddy is known as parboiled rice, whereas the rice obtained from milling untreated paddy is known as raw rice or white rice.

Most of the large and medium units generally produce both the Parboiled and White (Raw) Rice using separate production lines. However, most of the small scale units generally produce White (Raw) rice. For the purpose of the study units producing both Parboiled and White (Raw) Rice and units producing only Raw Rice were selected, so as to cover various unit operations, such as cleaning, parboiling, drying, hulling, dehusking, polishing and sorting, etc.

2.3 Age of Technology

Rice processing methods adopted in India are a blend of conventional methods and modern technology. In small rice mills, normally conventional rice processing is prevalent. In large-scale mills, modern and state-of-art technology and equipments are used. For the purpose of the study units using both modern technologies as well as units with old conventional technologies were selected.

2.4 Siting of the unit

Some of the rice mills are located in clusters in industrial areas, away from residential areas, some in residential areas and some even in the middle of the agriculture/paddy fields. For the purpose of the study units in all the above three locations were selected.

The following 11 units were identified for Preliminary visits based on the selection criteria discussed above:

Table 2.1: List of rice mills where preliminary visits were made

Unit Code No.	Milling Capacity	Scale of Operation	Type of Rice Produced	Age of Technology	Location
1	55 tonne/hr	Large	White (Raw) Rice & Parboiled	Modern	Agriculture land
2	3 tonne/hr	Small	White (Raw) Rice	Old	Agriculture land
3	1 tonne/hr	Small	White (Raw) Rice	Old	Agriculture land
4	12 tonne/hr	Medium	White (Raw) Rice & Parboiled	Modern	Residential Area
5	2 tonne/hr	Small	Parboiled	Old	Residential Area
6	5 tonne/hr	Medium	White (Raw) Rice	Modern	Agriculture land
7	2 tonne/hr	Small	White (Raw) Rice	Old	Agriculture land
8	2 tonne/hr	Small	Parboiled Rice	Old	Industrial Area
9	1.2 tonne/hr	Small	Parboiled Rice	Old	Residential Area
10	2 tonne/hr	Small	Parboiled Rice	Modern	Residential Area
11	2 tonne/hr	Small	Parboiled Rice	Old	Residential

Out of above 11 units, 7 units were selected for detailed field studies as shown in table below:

Table 2.2: List of rice mills selected for detailed field studies

Unit Code No.	Milling Capacity	Scale of Operation	Type of Rice Produced	Age of Technology	Location
1	55 tonne/hr	Large	White (Raw) Rice & Parboiled	Modern	Agriculture land
2	3 tonne/hr	Small	White (Raw) Rice	Old	Agriculture land
3	1 tonne/hr	Small	White (Raw) Rice	Old	Agriculture land
4	12 tonne/hr	Medium	White (Raw) Rice & Parboiled	Modern	Residential Area
5	2 tonne/hr	Small	Parboiled	Old + Modern	Residential Area
8	2 tonne/hr	Small	Parboiled	Old	Residential
11	2 tonne/hr	Small	Parboiled Rice	Old	Residential

Chapter 3: <u>DESCRIPTION OF PRODUCTION PROCESSES IN RICE MILLS</u>

The objective of rice milling is to get whole grain rice and preserve most of the rice kernels in their approximate original shape. In order to improve nutritional and cooking qualities of rice, a pre-treatment is given to paddy and the rice so obtained by milling the pretreated paddy is known as parboiled rice. The rice obtained from milling untreated paddy is known as raw rice or white rice. A brief overview of various stages/sections involved in parboiled rice processing is briefly discussed below:

3.1 Production Process in Parboiled Rice Mills:

3.1.1 Pre -Cleaning

Paddy which is stored in Bags is brought to the Unloading Area where bags are cut manually and Paddy is unloaded on Conveyers. It is then lifted via. Bucket Elevators to the Silos for Storage prior to Pre-Cleaning. Paddy stored in Silos is again lifted via. Bucket Elevators to the Pre-Cleaning Process. Prior to the actual milling operation, the paddy received from Silos is cleaned. Foreign matter or impurities are removed to protect the processing equipment and improve the final product. The impurities can be classified into large size impurities, small size impurities and impurities of about the same size as the paddy grains. Large impurities normally consist of rice straw, panicles, bag strings, soil stones, and sometimes iron parts. Small impurities consist of dust, sand, soil, weed seeds, insects and small stones. Impurities of about the same size as the paddy grains can be empty grains, stones and iron particles.

In the pre-cleaning process steps, different types of equipments are used depending upon size and weight of impurities. Small & large sized impurities are removed using sieving principle whereas; lighter/heavier impurities of similar size are removed using gravity separation or vibratory type screening machines as shown in Figure 3.1. Foreign material about the same weight and size as the paddy grain is difficult to remove and it is presumed to disintegrate into smaller sizes during the sub-sequent stages. The cleaned paddy is stored in bins & sent to subsequent processing.

Fig 3.1-Vibratory Screens

- **De-stoning**

Paddy after cleaning goes for de-stoning into the De-stoner machines for removal of impurities like stones as shown in figure 3.2. After De-stoning operation paddy is taken to further milling.

Fig 3.2- Destoner

3.1.2 Parboiling of Pre-Cleaned Paddy

Parboiling is one of the latest well-developed pre-milling conditioning treatment given to paddy to improve its nutritional & cooking quality. In parboiling the paddy is soaked in water and subsequently steamed and dried, before milling as shown in figure 3.3. This helps in minimizing the breakage of rice and reducing the loss of nutrients during milling.

Fig 3.3- Parboiling of Rice

There are various methods of parboiling practiced in India; some are conventional methods while some are modern technology based methods. The conventional method of parboiling includes single boiling, double boiling and CFTRI hot soaking method.

The modern technology of parboiling includes chromate-soaking method, pressure parboiling method, the modified pressure parboiling method and dry heat parboiling. The benefits of the most of modern technologies are (i) No smell problem, (ii) Reduction in time of processing and (iii) Reduction in paddy drying time due to less moisture content in the paddy**.**

3.1.3 Drying of Parboiled Paddy

Paddy, after parboiling, contains high moisture due to soaking and steaming, it may contain 35 to 40% moisture. After pressure parboiling, it may contain 20% to 30% moisture. In either case, it needs to be dried quickly to about 14% moisture for safe storage or for milling. Drying can be done either in the sun or in the hot air dryer as shown in figure 3.4 and 3.5. But whatever method of drying is employed, caution is to be exercised so that milling quality of paddy is not damaged. If drying is not proper, parboiled paddy can give very high breakage during milling. Generally, most mills employ a hot air type of drying. Hot air is passed through the paddy till it is dried to desired extent.

Fig 3.4 -Mechanical Dryers

Fig. 3.5 -Sun drying of Parboiled Paddy

3.1.4 Milling Process

The milling process broadly consists of final cleaning, de-husking/hulling, husk separation and Whitening/polishing.

- **Final Cleaning of Parboiled Paddy:**

Before De-husking, Paddy is cleaned again in Paddy Cleaners to remove impurities still present in the Paddy after Parboiling as shown in figure 3.6.

Fig 3.6- Paddy Cleaner

- **Hulling/ Dehusking:**

The objective of a hulling/dehusking operation is to remove the husk from the paddy grain with a minimum of damage to the bran layer and, if possible, without breaking the brown rice grain. Since, the structure of the paddy grain makes it necessary to apply friction to the grain surface to remove the husk; it leads to breaking of some of the rice.

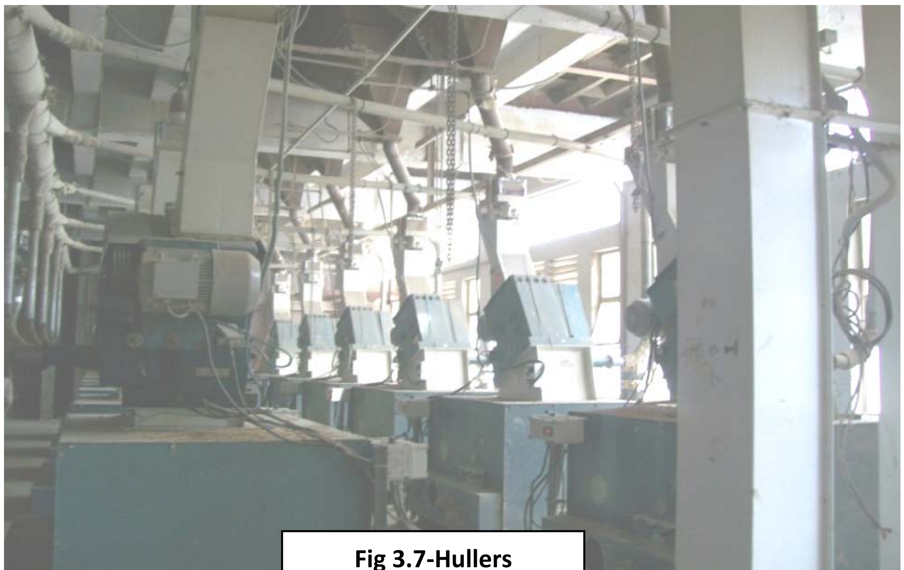


Fig 3.7-Hullers

Hulling machines are known by different names, such as shellers, hullers, dehuskers, huskers and hulling mills. Most commonly these machines are called “hullers”. The paddy is fed into the center of the machine through a small hopper as shown in figure 3.7. A vertically adjustable cylindrical sleeve regulates the capacity and equal distribution of the paddy over the entire surface of the rotating disc. By centrifugal force the, paddy is forced between the two discs and as a result of pressure and friction most of the paddy is dehusked (hulled).

- **Husk Separation:**

The discharge from a rice huller is a mixture of de-husked rice, husk and paddy. The mixture is transferred to screen for the separation of husk. A separator is used to screen the remaining paddy from the de-husked rice, generally called as “Aspirators” as shown in figure 3.8.

Fig 3.8-Aspirators (on left)

- **Whitening and polishing:**

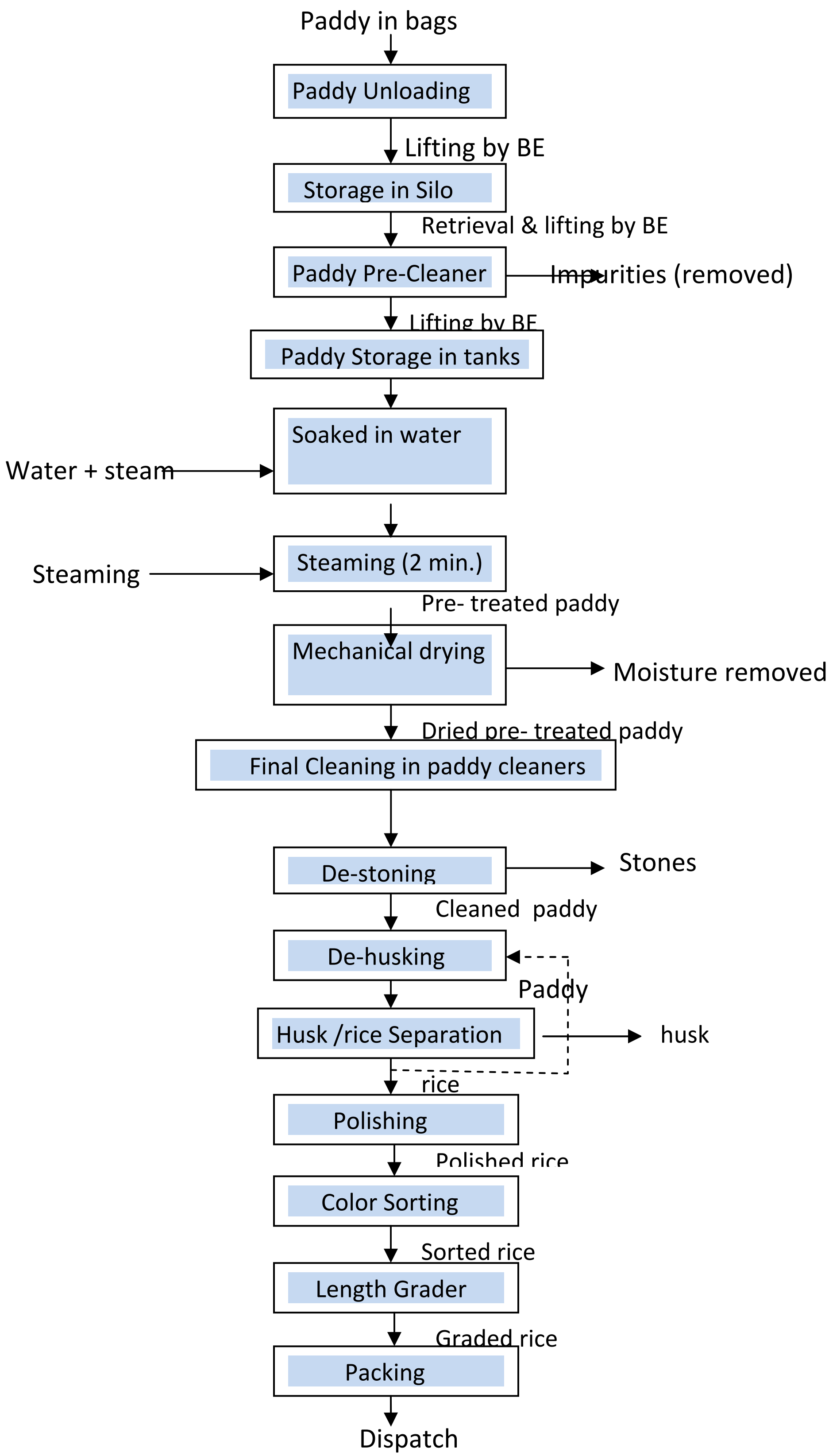
In the process of whitening, the silver skin and the bran layer of the brown rice are removed. During polishing of the whitened rice, the bran particles still sticking to the surface of the rice are removed and the surface of the rice is slightly polished to give it a glazed appearance. Three kinds of whitening machines are widely used in the rice processing industry. They are- (i) the vertical abrasive whitening cone; (ii) the horizontal abrasive whitening machine; and (iii) the horizontal jet pearler.

- **Sorting, Grading and Packing:**

The whitened and polished rice is sorted with the help of sortex machines which rejects the rice on the basis of their color. The sorted rice is graded based on their length and packed for dispatch.

A schematic process flow diagram of parboiling rice production is given in figure 3.9.

Fig: 3.9 - PROCESS FLOW DIAGRAM OF PARBOILING RICE PRODUCTION

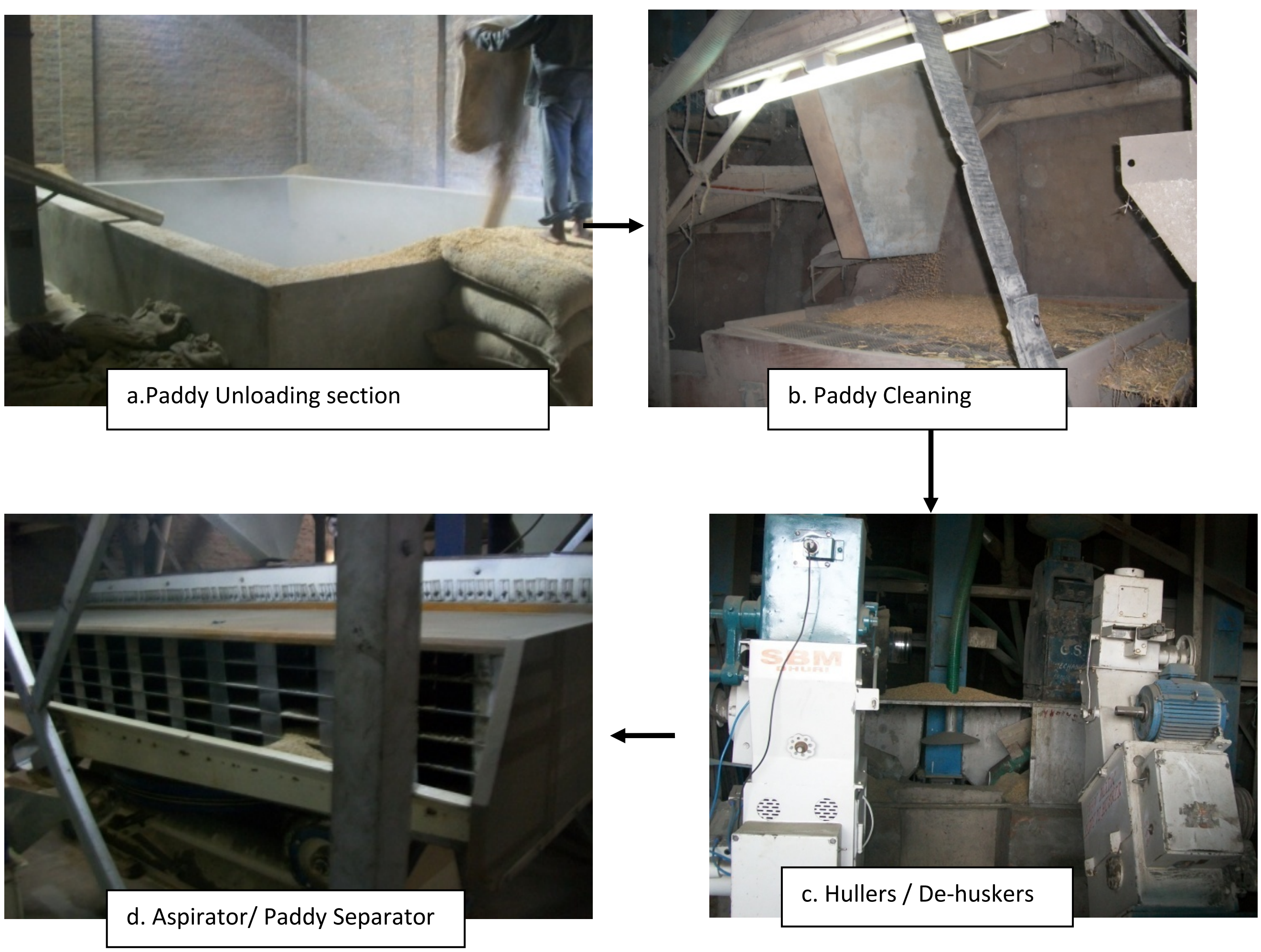


3.2 Production Process in White (Raw) Rice Mills:

The production process of white or raw rice mills generally include cleaning, de-husking, un-husked paddy separation, polishing in 3 stages to obtain rice bran and finally grading of the milled rice. A process flow diagram of white raw rice mills is shown in figure 3.10.

After unloading of paddy it is carried to the Cleaner machine through the elevator where all dust, dirt, stones present in paddy are removed. Cleaned paddy is then carried to the huller machine via. Elevators where separation of husk from rice occurs. After hulling, the paddy is taken to separator/aspirator where unhusked paddy is separated from rice. Unhusked paddy is re-circulated to the hulling machine and brown rice is carried forward to the polishing machines. There were 3 to 4 Polishers in most of the small units. Rice bran separated in the polishing machines is collected through separating beds at each polisher in few units while in some units it is collected through Cyclones into Fine and Coarse Bran. White rice goes to the Graders where separation of Rice occurs according to the length and broken rice is separated from whole rice. A pictorial presentation of main process of small white raw rice mills is given in figure 3.10:

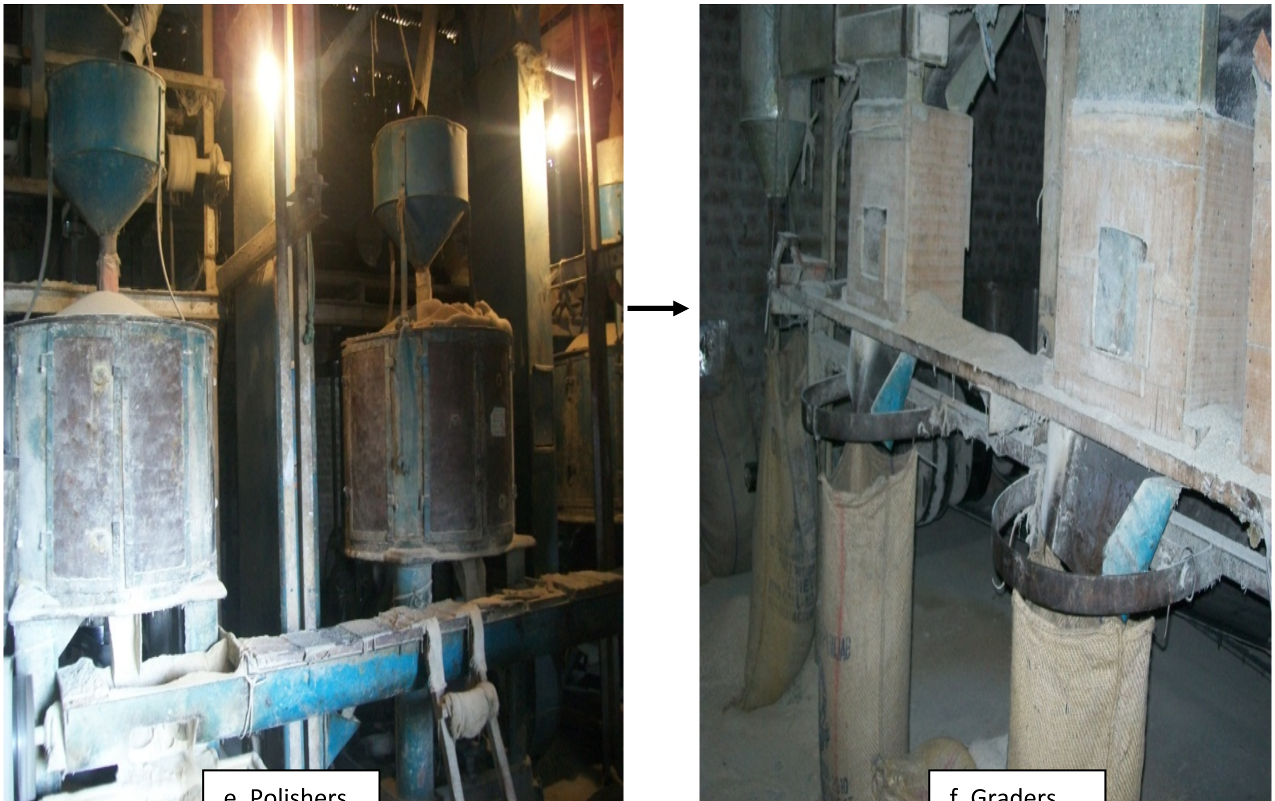
Fig. 3.10- Main sections of typical small white raw rice mills


a.Paddy Unloading section

b. Paddy Cleaning

c. Hullers / De-huskers

d. Aspirator/ Paddy Separator

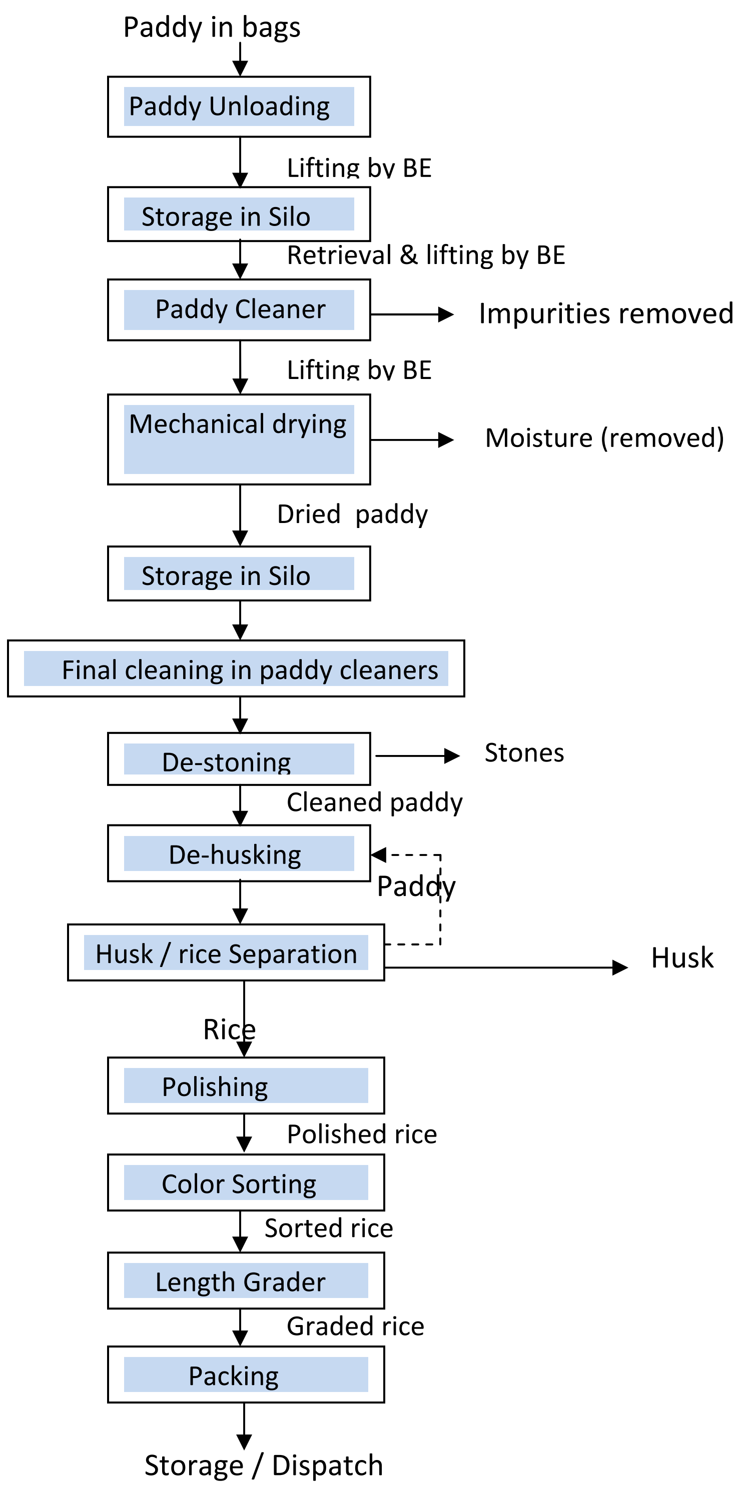


e. Polishers

f. Graders

A process flow diagram of white raw rice production is given in figure 3.11.

Fig. 3.11- PROCESS FLOW DIAGRAM OF WHITE RAW RICE PRODUCTION



Chapter 4: CURRENT PRACTICES IN THE RICE MILLS FOR HANDLING AND STORAGE OF RICE HUSK AND HANDLING, STORAGE & DISPOSAL OF BOILER ASH

Rice husk is the largest by-product of rice milling industry which amounts to 22-24 percent of the total paddy. The units need to handle the bulk quantities of husk and store them within the unit premises till husk is used or sold. The following practices are generally followed for rice husk handling and storage:

4.1 Handling of Rice Husk

i) From de-husker machine to storage

During the milling of paddy, rice husk is separated out in the de-husker machines and husk is sent to storage yard in many ways depending upon the mill scale, type and mechanism employed:

- **Using blowers**
  In most of the small mills husk from de-husker is simply blown to storage yard with help of blowers as shown in figure 4.1and 4.2.

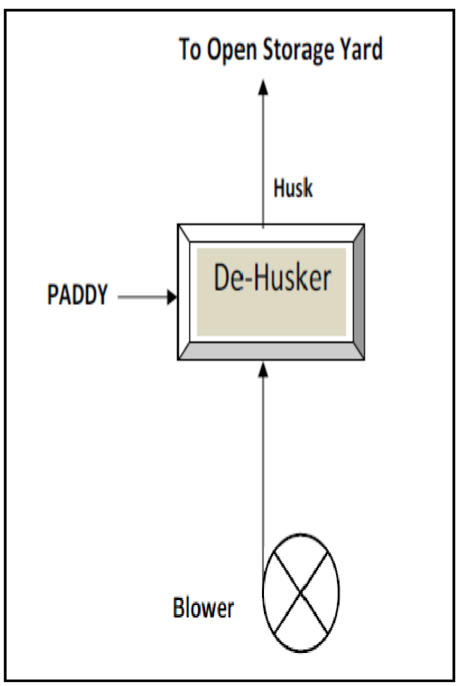


Fig 4.1-Husk Blown to Open Storage Yard Small-scale mills

Fig 4.2-Husk Handling in Small-scale mills

- **Using Conveyor-belt system & Cyclones for dust extraction**

In most of the large mills the husk is extracted from aspirators and it is collected on the conveyor belt. From conveyor belt the husk is conveyed to the storage yard (shown in figure 4.3, 4.4 and 4.5).

The units also have dust extraction system in the aspirators and other machinery of milling section connected to cyclone for fine/dust collection.

From extraction system, the fines/dust is taken to cyclone from where the dust/fines separate out and falls from the bottom of cyclone. But major portion of the Fine Particles not collected in cyclones, escape to atmosphere from discharge of the Induced Draft Fan.

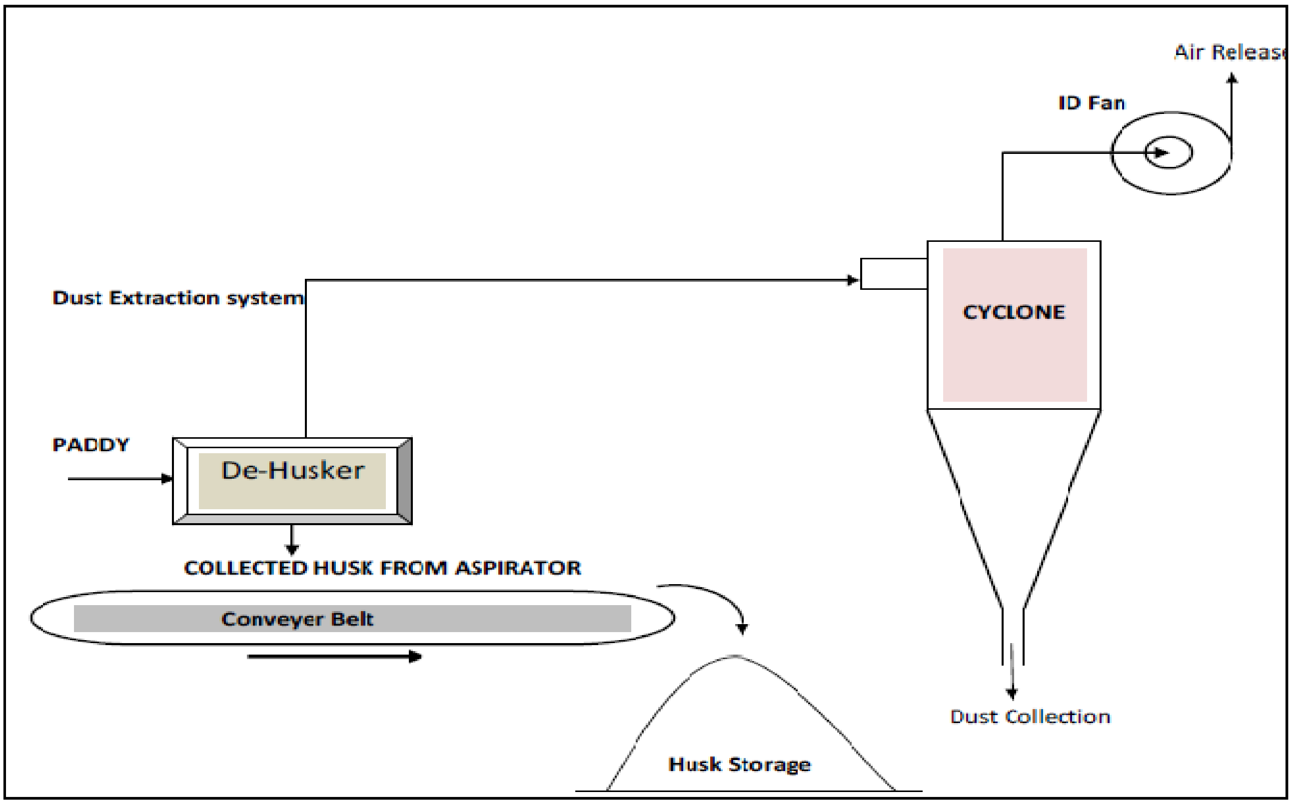


Fig 4.3-Husk Handling in Large-scale mills

Fig. 4.4- Dust extracted through Cyclone

Fig 4.5-Rice husk conveyance in storage yard using conveyor belts

ii) Storage of Rice Husk

The husk generated during milling is taken to storage yard. Most of the small units have a common open storage of rice husk, rice bran and also the dust collected by the Paddy Cleaner. The units have different practices for storing the rice husk like fully open storage with boundary wall, partially covered storage and completely covered storage as discussed below:

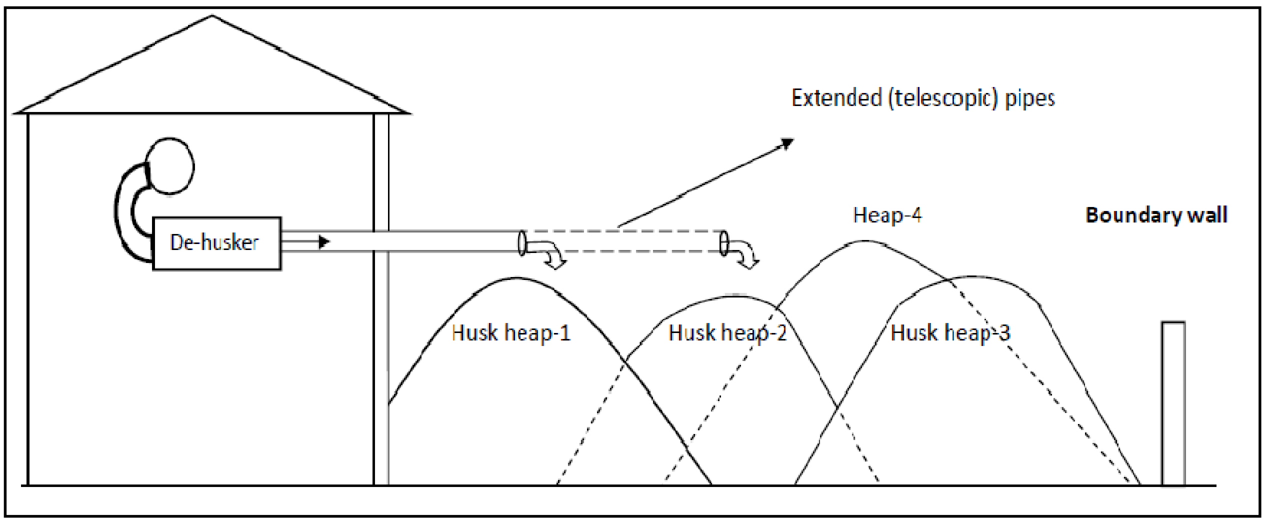
a) Fully Open Storage with boundary walls: Most of the small and medium units store the rice husk in open area within their premises. However, most of the small and medium mills have 10 foot boundary wall surrounding the husk storage areas as shown in figure 4.6., to reduce wind movement and to reduce dust carryover due to wind.

Fig 4.6-Rice husk storage in fully open area with boundary walls

Generally the storage areas available are not adequate and large heaps of rice husks could be seen rising above the boundary wall height in many of the mills. The small mills extend and divert the length of pipe which blows husk within certain distance in the storage yard, keeping in mind all the specifications of the blower so as to ensure that the pressure doesn't drop below a certain value in the pipeline & husk is blown smoothly out into the storage area, which results in formation of rice husk heaps (as shown in figure 4.7).

Periodically, as the height of a heap increases, flattening of the peak of the heap is done manually by pushing the Husk to sides. Typically, the storage is done in the area between the boundary walls and the factory shed wall.

Fig 4.7-Heaps of rice husk in the fully open storage area with extended pipes



b) Open Storage without separating fines: In most of the small mills the husk from de-husker is simply blown to storage yard with help of blowers without separating fines. Therefore the stored husk in these mills has more percentage of fines which gets air-borne during windy period.

Fig 4.8-Fully open storage of rice husk without separating fines

c) Open Storage with fines partially separated by cyclone: In most of the medium and large mills the husk from de-husker is separated with help of cyclone and fines are released to atmosphere from Cyclone discharge end. In this case the stored husk has less percentage of fines.

d) Common open storage of husk and rice bran fines: Many small mills do not separate fines & rice bran from the husk and have common storage of husk with fines and bran.

e) Partially covered storage using fencing: Most of the large units have covered their husk storage areas partially with tall fencing, to combat with large quantity of stored husk and to reduce the fugitive emissions from the storage yard. The figure 4.9 shows the storage of large quantities of rice husk with tall fencing.

Fig 4.9-Large quantities of husk storage with tall fencing

f) Covered storages: Few medium and large units have covered storage yards for storing rice husk. Figure 4.10 shows a closed room where separated husk from milling section is stored. The storage of rice husk in closed space eliminates the possibility of fines blowing with the wind besides reducing the fugitive emissions.

Fig 4.10-Rice husk storage in closed room

iii) Handling from Husk Storage to boiler

Most of the medium and large mills use covered conveyor belts (mechanical system) for handling husk from storage area to boiler as shown in figure 4.11. However, some small units also handle the husk manually for utilization in the boiler. Most of the small, medium and large mills manually level the husk heaps in storage yard.

Fig 4.11-Husk Handling from storage yard to boiler using conveyor belts in large mills

iv) Handling during loading for transportation and selling

Fig 4.12- Husk loading for transportation & selling

Rice Husk is used as a fuel in Boilers in large, medium as well as small mills. Whereas, most of the small units which are making only Raw Rice have no utilization of Rice Husk. In these units, Rice Husk is sold to the contractors for use as a Boiler Fuel of Rs. @ 3-5/kg. The husk is loaded in the trucks manually with the help of shovels and sent to the market as shown. Figure 4.1.2. In large unit, there is complete utilization of Rice Husk as Boiler Fuel whereas in Medium and Small unit some of the extra/ unutilized Rice Husk is sold.

4.2 Practices for handling, Storage and disposal of rice husk fired boiler ash

Most of the parboiled units use the rice husk as boiler feed for steam generation and for electricity generation in captive power plants. After the combustion of rice husk in boiler the boiler ash is generated which needs to be handled, stored and disposed off properly to reduce the environmental pollution in and around rice mills. The rice mills generally follow the following practices for handling, storage and disposal of ash generated from rice husk fired boiler.

4.2.1 Handling of rice husk fired boiler ash

Most of the medium and large scale units handle their boiler ash mechanically and collect it in the trucks/trolley, directly from boiler, with the help of conveyor belt and hoppers as shown in figure 4.13. They also spray water over the collected ash in trucks and nearby boiler section to reduce the fly ash emissions. The Small Scale Rice Mills having small size Boilers generally handle the Boiler Ash manually, during collection from Boiler Section to Temporary Storage.

Fig 4.13-Mechanical handling of boiler ash

4.2.2 Storage of rice husk ash

A large quantity of boiler ash is generated in the parboiled rice mills which need to be stored temporarily before its disposal. Generally the following practices are followed for boiler ash storage and disposal:

- **Open Storage**

  Most of the small & medium rice mills have open storage of boiler ash within the unit premises as shown in figure 4.14.

Fig 4.14-Open storage of husk fired boiler ash

- **Partially covered storage**

  Many of the small & medium rice mills store their boiler ash in partially covered storages. Figure 4.15. depicts the Ash generated from the Furnace on the left.

Fig 4.15-Partially covered storage of husk fired boiler

- **Limited Closed storage of APCD collection**

  Many of the large and medium units store their boiler ash (collected by APCD's, like Cyclones, Multicyclones, etc) in closed rooms where it is stored temporarily before their disposal as shown in figure 4.16.

Fig 4.16-A Closed storage of husk fired boiler ash

4.2.3 Disposal of rice husk fired boiler ash

- **Disposed in own land-fill sites, by Large Mills.**

  Most of the large units dispose their boiler ash on part of their own land, converted as landfills (Figure 4.17). After disposal of boiler ash on the land it is covered with a layer of soil and plantation developed over. Recycled wastewater is periodically sprinkled on the ash disposal site to avoid wind blowing of fly ash in the nearby areas.

Fig 4.17-Boiler ash Disposal land-fill site

Fig 4.18-Layer of soil after disposal of boiler ash

Fig 4.19-Plantation in the boiler ash disposal

- **Disposal through Ash Contractors for disposal in low –lying areas**

Most of the small and medium mills not having their own disposal facilities generally dispose their husk ash, through contractors, who dispose it to available low lying areas. Most mills give this job on contract basis where the contactors collect the boiler ash from the unit premises and dispose it on payment basis. In this case even the generator of ash is not aware of the ultimate disposal site of its boiler ash.

In the areas where use of boiler ash is common in fields by farmers, the mills or contractors also sell boiler ash for use in the farms. Limited amount of ash is required for conditioning and stabilization of poor soils in fields. As only a small quantity is required, therefore, farmers buy only some percentage of the boiler ash as per their requirement.

CHAPTER 5: FUGITIVE EMISSIONS AND ENVIRONMENTAL ASPECTS IN RICE MILLS

5.1 Sources of Fugitive Emissions in Rice Mills

In rice mills fugitive emissions are generated from various sections during handling of paddy; cleaning & milling of paddy; handling and storage of husk and handling, storage and disposal of boiler ash due to various activities in the mills. Brief description of sources of fugitive emissions are given below and also discussed in table 5.1.

1. **Fugitive Emission during handling of Paddy from Unloading to Silo.**
    - During Unloading of paddy (cutting open the Gunny bags and releasing Paddy)
    - At different stages of lifting and discharging of paddy rice through bucket elevator
    - Transfer points (belt to belt; belt to elevator; elevator to silo)
    - Storage Bins (emissions from top of Silo, as Paddy is discharged by Bucket Elevator)
    - Locations of free fall of paddy (fine dust getting airborne due to free fall)

2. **Fugitive Emission during Cleaning of paddy:**
    - During pre-cleaning (mostly in Rotary Drums- fines separated due to movement and free fall of Paddy)
    - During paddy cleaning in paddy cleaner/ vibrating screen (due to rigorous movement of paddy, fines are generated)
    - De-stoner machines (fines get extracted)
    - Final cleaning in Paddy cleaners (fines are extracted out).

Fig 5.1-Paddy Unloading

Fig 5.2(a)-Bucket Elevator

Fig 5.2(b) Conveyer

Fig 5.3-Silo

Fig 5.4-Paddy Cleaner

Fig 5.5-Vibratory Screens

3. Fugitive Emissions during Milling of paddy

- At different stages of lifting and discharging of paddy /rice through bucket elevator (fines get airborne due to movement, fall of Paddy/ Rice)
- During dehusking of paddy in Hullers (fines are generated due to breaking of Paddy)
- At Aspirators used for husk removal (fines are extracted)
- During polishing of rice (fines are generated due to polishing)
- During grading of rice in rice grader (fines carried along with rice)


Fig 5.6-Conveyer & BE


Fig 5.7-De-huskers


Fig 5.8-Polishers & Graders


Fig 5.9-Aspirators

4. Fugitive Emissions from Handling & Storage of Rice Husk:

- During conveying of Rice Husk from milling section to husk storage area (Unseparated fines are blown along with Husk)
- At Rice Husk Storage area (fines get airborne due to wind currents)
- During Conveying and Handling of Rice Husk to Boiler Section (fines contained in the dry husk, get airborne during transport/ conveying & free fall of Husk)

Fig 5.10-Rice Husk Storage Areas and conveyance systems

5. Fugitive Emissions of Fly Ash in the Boiler Section:

- Through leakages in the ducts/flanges from boiler to stack (fines escape to atmosphere
- Fall of coarser Boiler Fly Ash from Stack (coarser Fly Ash particles fall on ground in the vicinity of Stack)
- From temporary Ash Storage (fugitive emissions due to wind blowing of Fly Ash temporarily stored at site)

Fig 5.11-Boiler section and ash generation

Fig 5.12-Fly ash deposited on ground near boiler section due to Fugitive Emissions

6. Fugitive Emissions from temporary Ash Storage and Disposal areas:

- Boiler ash conveyance from boiler to trolley (carryover of Fines during conveyance, free fall of Ash)
- From open temporary ash storage area (fines get airborne due to wind currents)
- From uncovered and unprotected disposal sites (as the moisture dries away, or top soil layer gets removed, fines in the dry Ash get airborne due to wind currents)

Fig 5.13-Fugitive Emissions from Boiler Ash temporary storage area

Fig 5.14- Re-entrainment of boiler ash particles from unprotected dry disposal sites

Fig 5.15-Typical Fugitive Emission Sources in Rice Mills

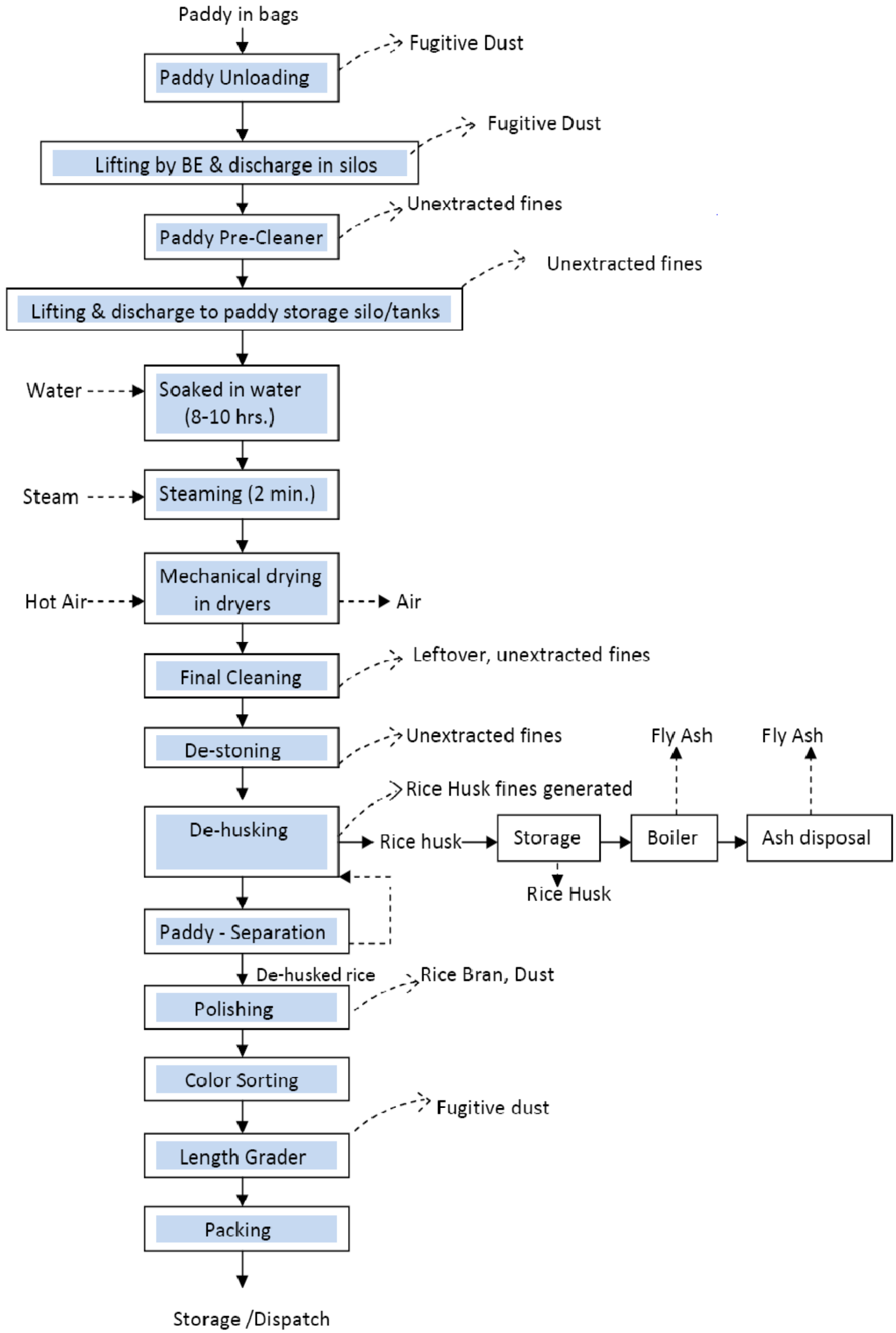


Table 5.1: Typical Sources of Fugitive emissions in Rice Mills

S.NO.	SECTIONS	SOURCES OF FUGITIVE DUST EMISSIONS	TYPE OF FUGITIVE EMISSIONS
1.	**UNLOADING SECTIONS**	a) Paddy Unloading	Fugitive Dust
		b) Bucket Elevator	Fugitive Dust
		c) Transfer points • Belt to belt • Belt to elevator • Elevator to silo	Fugitive Dust
		d) Paddy storage Bins	Fine Dust
		e) Locations of free fall of Paddy	Fine Dust
2. 2.	**CLEANING SECTION**	f) Pre- Cleaner machine	Unextracted Fines
		g) Vibratory screen	Fine Dust
		h) De-stoner	Unextracted fines
		i) Paddy cleaner	Fine Dust
3.	**MILLING SECTION**	j) Bucket Elevator	Fine Dust
		k) Hullers/ De-huskers	Rice husk fines generated
		l) Paddy Separator/ Aspirator	Fine Dust
		m) Polishers	Rice Bran Dust
		n) Grader	Fugitive Dust
4.	**RICE HUSK HANDLING & STORAGE**	o) Conveyers	Fine Dust, Rice Husk
		p) Rice Husk Storage Area	Fine Dust, Rice Husk
5.	**BOILER SECTION**	q) Leakages from ducts and flanges from boiler to stack	Fly ash
		r) Ash Conveyers	Fly Ash
6.	**ASH STORAGE AND DISPOSAL SITE**	s) Open Ash Storage	Fly Ash
		t) Ash loading and unloading	Fly Ash
		u) Unprotected Ash disposal site	Fly Ash

5.2 Fugitive Emission Control Systems Adopted by Rice Mills

The raw paddy received by the mills commonly contains fine dust and long fibers shaped particles carried from Paddy fields. This Fine dust includes partly the soil contents in which the paddy was grown and other fine particles. During rice milling fine dust is generated, like Rice Husk fines, Rice Bran fines, etc. In order to improve the work environment and control the fugitive emissions from various sections (i.e. Unloading, Pre-Cleaning, milling, Boiler etc.) most of the rice mills have employed various dust extraction cum control systems as discussed below.

5.2.1 Unloading and Conveying Section

In most of the large, medium and small rice mills substantial amount of dust is generated during unloading to storage section. Dust sources include Conveyers, Transfer Points, Silos and Bucket Elevators. However various mills have adopted different fugitive emission control system in the unloading and conveying section as discussed below.

CONTROL SYSTEMS ADOPTED	
Large & Medium Scale Mills	Small Mills
Suction Ducts and Hoods at Bucket Elevators and Conveyers, Suction Hood at unloading area, etc as shown in figure below	No such dust extraction systems are present in many small mills.

Fig 5.16-Extraction Hood near Bucket Elevator in large mills

5.2.2 Paddy cleaning Section

Typically the emissions from the cleaning section comprise of dirt, dust, fibers etc. in huge quantity. This dirt is generated in the Vibratory Screen/ Paddy Pre-Cleaner. Various extractions cum control systems adopted in large medium and small mills are discussed below.

CONTROL SYSTEMS ADOPTED	
Large & Medium Scale Mills	Small Mills
Few of the Large Mills employ Cyclone cum Bag-filter type arrangement in the Pre-cleaning section for collection of Coarse and Fine Dust respectively as shown in figure 5.17. Whereas most of the medium scale mills employ only Cyclones for collection of Dust.	Generally employ an ID Fan for extraction of Dust from various equipments. Typically, several flexible pipe connections are taken from the main pipe entering the ID Fan (shown in Fig. 5.18 below). The extracted air is passed through a Cyclone, where coarse particles are collected and the fines are discharged through a Stack placed above Cyclone.

Fig 5.17-Cyclone followed by Bag Filter at Pre-Cleaner in large mills

Fig 5.18-Various flexible suction pipes sucking from various equipments and passed through a common cyclone in small rice mills

5.2.3 Milling Section:

Emissions from milling section comprise of Fine Dust, Rice Husk fines and Rice Bran generated at distinct stages of milling and their control systems are discussed below:

CONTROL SYSTEMS ADOPTED	
Large & Medium Scale Mills	Small Mills
Nearly all Large mills possess proper extraction systems with ID Fan arrangement as shown in figure 5.19. Most of the mills employ only Cyclones for control of Dust extracted from Hullers, Paddy Separator and Polishers.	Most of the Small Mills have flexible Suction Ducts for extraction of Dust, Rice Husk fines and Rice Bran as shown in figure 5.20. For separation and collection of fines generally Cyclones are installed (shown in figure 5.21).

Fig 5.19-Proper dust extraction system with cyclone and ID fan in Large mills

Fig 5.20-Various suction ducts from milling section to a common cyclone in small rice mills

Fig 5.21-Suction ducts from polisher to cyclone for bran separation in small rice mills

5.2.4 Boiler Section

In boiler section fugitive emissions mainly occur through leakages in the ducts/flanges from boiler to stack. The dust control systems adopted by mills in the boiler section are as follows:

CONTROL SYSTEMS ADOPTED	
Large & Medium Scale Mills	Small Mills
Most of the Large and Medium scale Mills employ Cyclones and Multi-cyclones for collection of Bottom Ash in the Boiler Section. Generally partial enclosure is provided.	Ash generated in Furnace is manually taken out in pits.

Fig 5.22- Cyclone for collection of boiler ash in large and medium rice mills

5.2.5 Rice Husk Handling and Storage Section:

In most of the mills Rice Husk is stored openly surrounded by walls in order to control the fugitive emissions. Closed rooms are also provided by units for storage of Rice Husk to control the emission of rice husk fines.

5.2.6 Ash Handling and Disposal Site

Many medium and large mills spray water in the boiler ash handling sections to suppress the fly ash. Ash is loaded and conveyed to open Landfills in wet form in order to control fugitive emissions and is also covered with a fine layer of soil at the disposal site for the same purpose.

A schematic diagram highlighting various types and locations of fugitive emission control system in small and large/medium mills are shown below in figure 5.23 and 5.24:

Fig.: 5.23 Dust Extraction cum Control Systems Adopted in Small White (Raw) Rice Mills

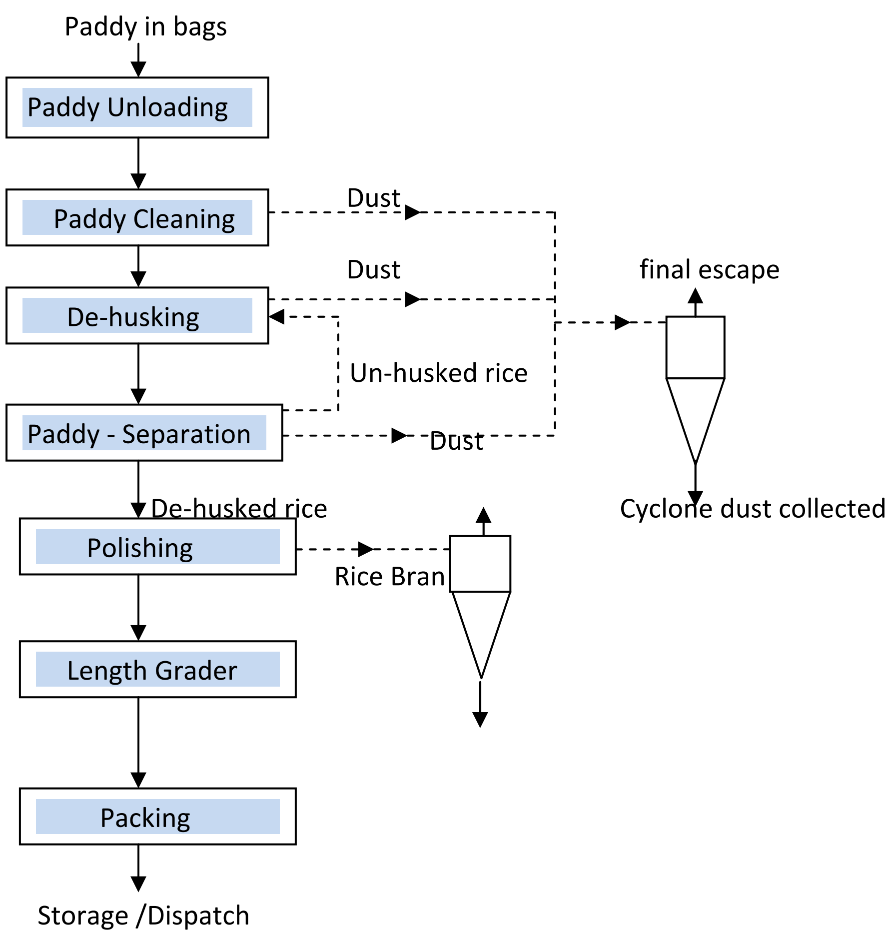
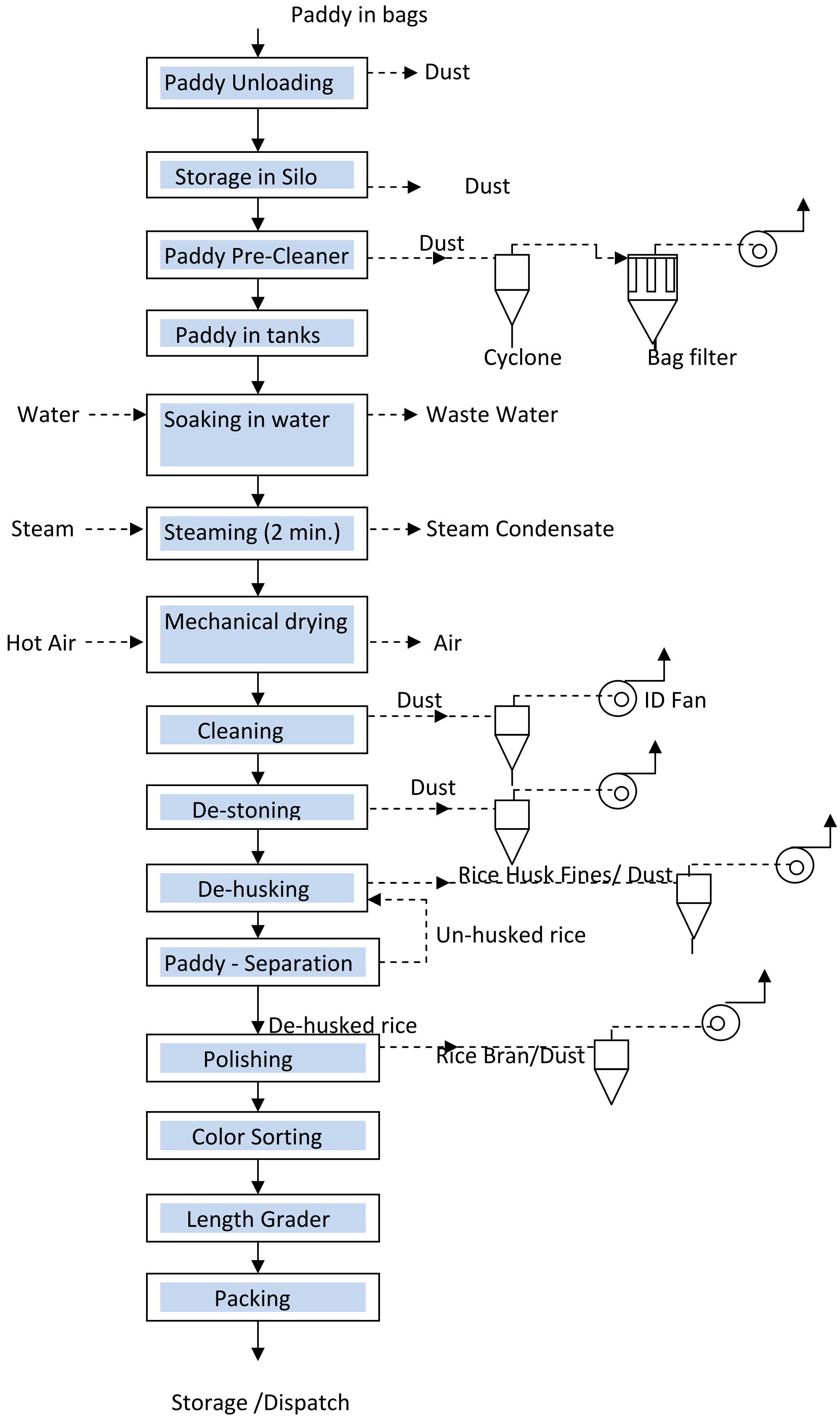


Fig. 5.24 EXTRACTION CUM CONTROL SYSTEMS ADOPTED IN LARGE & MEDIUM SCALE MILLS



5.3. Overall Observations on Fugitive Emissions:

In regard to fugitive emission controls following observations were made:

5.3.1 Unloading and conveying area

- Substantial amount of dust is generated at the unloading section. Dust sources include conveyers and bucket elevators.
- There are no effective control devices to capture the dust at transfer points. Dust escapes during free fall of Paddy and various conveying points.
- Some mills practice unloading of Paddy in closed rooms whereas some it in open.

5.3.2 Cleaning section

- Typically the emissions from the cleaning section comprised of dirt, dust, etc. carried from agriculture field along with the raw material.
- The Pre- cleaning section had Cyclone cum Bag-filter type arrangement in few of the Large Mills and others had only Cyclone. Still there was high level of fugitive emissions observed at the pre-cleaning section. This shows that the dust extraction systems employed in most of the mills are poorly designed and working inefficiently, due to lack of maintenance, choking of ducts, inappropriate quantities of air extracted, etc.
- Dust generated at the pre-cleaning section could be seen deposited on the floors, walls and control devices.
- However, most of the small mills do not possess proper extraction systems at Paddy cleaner. They possess a common cyclone for all the Milling operations. It was observed that the fines generated at the Paddy Cleaner were spreading in the environment.

5.3.3 Milling Section

- It was observed that fugitive emissions arise at various stages of lifting and discharging of Paddy as well as in the Milling Section at Huller, Paddy separator, Polishers, etc.
- It was seen that nearly all Large and Medium scale mills employ individual Cyclones for control of Emissions at Hullers, Paddy Separator and Polishers. Most of the mills possess extraction systems having Cyclone cum ID Fan arrangement.

- However, most of the Small Mills possess only Blowers or Flexible Suction Ducts for extraction of Dust, Rice Husk fines and Rice Bran. But for collection of fines most of the small units have Cyclones.
- Many of the small mills possess common cyclone for cleaner, de-husker and paddy separator. Ducts from all these machines combine at the inlet of ID Fan.

5.3.4 Rice Husk Storage and Handling site

- It was observed that Fugitive emissions occur at various stages of lifting and handling of husk as well as during its conveying to the Boiler section.
- Most of the small mills had Common area for Open Storage of Rice Husk, Rice Bran and Fines generated in the Milling Section. The fines generated are blown away by the wind leading to Fugitive Emissions in the surrounding environment.
- In most of the small mills the husk from de-husker is simply blown to storage yard with help of blowers. Moreover, huge heaps of Rice Husk could be seen in these small mills rising beyond the boundary wall height indicating excessive storage.
- The Large and Medium Mills possess semi-closed Storage system for Rice Husk. Storage is either closed or surrounded by Fine Mesh Walls.

5.3.5 Ash Handling and Disposal site

- It was observed that fugitive emissions occur at the Ash Handling and Discharge point near the Boiler Section.
- Few of the Mills store the Ash generated in open area.

CHAPTER 6: CHARACTERIZATION AND QUANTIFICATION OF POLLUTANTS AND FUGITIVE EMISSIONS IN RICE MILLS:

6.1. Field Measurements Conducted:

Monitoring of emissions was carried out in selected 7 representative units as shown in Table 6.1. For monitoring purpose three parameters were considered – Fugitive Emissions Assessment, Stack Monitoring and Ambient Air Quality Monitoring. In order to evaluate and quantify the air pollution problem, measurements were carried out for selected air pollutants.

Fugitive Emission Assessment was carried out at Pre-cleaning Section, Milling Section and Boiler House. In Milling Section , Stack Monitoring was done at inlet and outlet of Paddy Cleaners, De-huskers, Aspirators, Polishers, etc as well at the Inlet and Outlet of Cyclones and ID Fans. Stack Monitoring was carried out in Rice Husk fired Boiler House, at Stack.

Table 6.1 Type of Monitoring carried out in 7 representative units.

Unit Code	Milling Capacity	Scale of Operation	Type of Process Employed	Type of Monitoring carried out
1	55 tonne/hr	Large	White (Raw) Rice & Parboiling both	Fugitive Emissions Assessment, Stack Monitoring, Ambient Air Quality Monitoring
2	3 tonne/hr	Small	White (Raw) Rice Mill	Fugitive Emissions Assessment, Stack Monitoring, Ambient Air Quality Monitoring
3	1tonne/hr	Small	White (Raw) Rice Mill	Fugitive Emissions Assessment, Stack Monitoring
4	12 tonne/hr	Medium	White (Raw) Rice & Parboiling both.	Fugitive Emissions Assessment, Stack Monitoring
5	2 tonne/hr	Small	Parboiled mill	Fugitive Emissions Assessment, Stack Monitoring
8	2 tonne/hr	Small	Parboiled Rice	Stack monitoring, Fugitive Emissions Assessment
11	2 tonne/hr	Small	Parboiled Rice	Stack Monitoring, Fugitive Emissions Assessment

6.1.1 Equipments used for Emission Monitoring:

- Equipments used during Stack Monitoring comprised of Digital Thermometer, Inclined Manometer, U-tube Manometer and Stack Monitoring Kit.
- Digital Thermometer was used to measure ambient temperature and Stack Gas Temperature.
- Velocity measurement was done using Inclined Manometer (as shown in fig. 6.1)
- Static Pressure and Pressure Drop were measured using U-tube Manometer.
- Particulate Matter Sampling was done using Stack Monitoring Kit (as shown in Fig. 6.2.)
- Ambient Air Quality Monitoring and Fugitive Emissions Assessment were done using High Volume Samplers (as shown in Fig. 6.3.)

Fig. 6.1 Inclined Manometer used for Velocity Measurement

Fig. 6.2 Stack Monitoring Kit

Fig. 6.3 Respirable High Volume Sampler

6.1.2 Procedure for carrying out Emissions Monitoring:

1. **Ambient Air Quality Monitoring:**
24 hours Sampling was done for Ambient Air Quality Monitoring. Selection of monitoring locations, monitoring and analysis of various parameters of interest was conducted according to the CPCB guidelines.

i. **Identification of Monitoring Stations:** After a preliminary reconnaissance of the study region and taking into account the meteorological conditions, sites were identified for Air Quality Monitoring.

The criteria followed for selecting the monitoring sites as per CPCB regulations were as follows:

- The sampling station had free exposure so that it did not collect air from stagnant pockets.
- It was not obstructed by large structures.
- The sampling point was not directly influenced by any local sources of emissions.
- It was located at a minimum height of 3 m from the ground level.

ii. **High Volume Sampler:**

- The high volume filtration method is popular for measurement of the mass conc. of suspended particulate matter smaller than 50 µm. A known volume of air is sucked by high speed blower through a fine filter and the increase in weight due to trapped particles is measured.
- **Respirable Dust Sampling -** Ambient air laden with suspended particulates enters the system through the inlet pipe. As the air passes through the cyclone, coarse, non respirable dust is separated from the air stream by centrifugal forces acting on the solid particles. These separated particulates fall through the cyclone's conical hopper and are collected in the sampling bottle placed at its bottom. The fine dust forming the respirable fraction of the Total Suspended Particulates (TSP) passes through the cyclone and is carried by the air stream to the filter paper clamped between the top cover and filter adaptor assembly. The Respirable Dust is retained by the filter and the carrier air exhausted from the system through the blower.

iii. Gaseous Pollutants Sampling:

- Absorption of gaseous pollutants into a liquid medium is probably the most commonly employed method of collection of gaseous matter. The basic properties of various gaseous pollutants are used to absorb them in suitable chemical reagents.

- Absorption separates the desired pollutant from air through direct solubility in the absorbing medium.

- In the impinger, the gas stream is impinged at high velocity onto a flat surface thus providing good contact between the gas and the liquid.

- A filtered sample of flue gas is bubbled through an impinger train at a metered flow rate. The impingers filled with appropriate reagents absorb the gases of interest from the process being monitored.

- The system allows two gases to be sampled simultaneously.

- While the volume of gas sampled is determined from the knowledge of the sampling time and flow rate, concentration of individual pollutants is determined through an analysis of the absorbers.

2. Stack Monitoring:

i. In Stack Sampler simultaneous sampling for Particulate Matter (PM) and gaseous pollutants can be carried out.

ii. Flue gases enter the system through the nozzle at the tip of the sampling probe, pass through the FILTER THIMBLE, where particulate matter is removed and carrier air reaches the sampling train/condenser assembly in the instrument panel. Here the gas stream is split into two sections. One section passes at low flow rate (0.5-3 LPM) through a train of impingers loaded with suitable reagents to absorb gaseous pollutants, relevant to the emission source while the remaining gas stream bubbles through a distilled water impinger followed by silica gel. Relatively clean gases then pass through the flow meter and dry gas meter so that the volume of flue gas sampled is measured and are subsequently exhausted into the atmosphere through the vacuum pump.

iii. Change in weight of the thimble is used to determine the quantity of dust contained in the flue gas sample while a product of the sampling rate and time is used to measure the sample volume. Since particles in motion have inertia, if the PM concentration in the sample drawn from the stack is to truly represent the PM concentration in the stack, ISOKINETIC conditions must be maintained at the tip of the sampling probe. Apparently non- isokinetic conditions tend to cause a separation of particles and gas molecules so that both the concentration and size distribution are altered by non-isokinetic sampling. A standard S- type pitot tube is used to sense the velocity in the stack and the differential pressure produced is measured on a digital/ inclined manometer. A Digital thermometer is used to measure the stack gas temperature. Aerodynamic drag along the stack wall, damper vanes, right angle bends, and side entry ducts etc. cause the flow rate across the cross-section of the duct/chimney to vary. Hence air velocity measurements are averaged out by determining the velocity at different points across the cross-section.

iv. Since the flow of stack gases varies across the cross-section of the duct/chimney, the particulate concentration too is likely to vary and must be sampled at different traverse points with corresponding change in sampling rate to maintain isokinetic conditions. Therefore, appropriate traverse point need to be fixed where the tip of the sampling probe can be located for obtaining a representative sample. Traverse points are selected based on Standard Protocol (given in Table in Annexure 3).

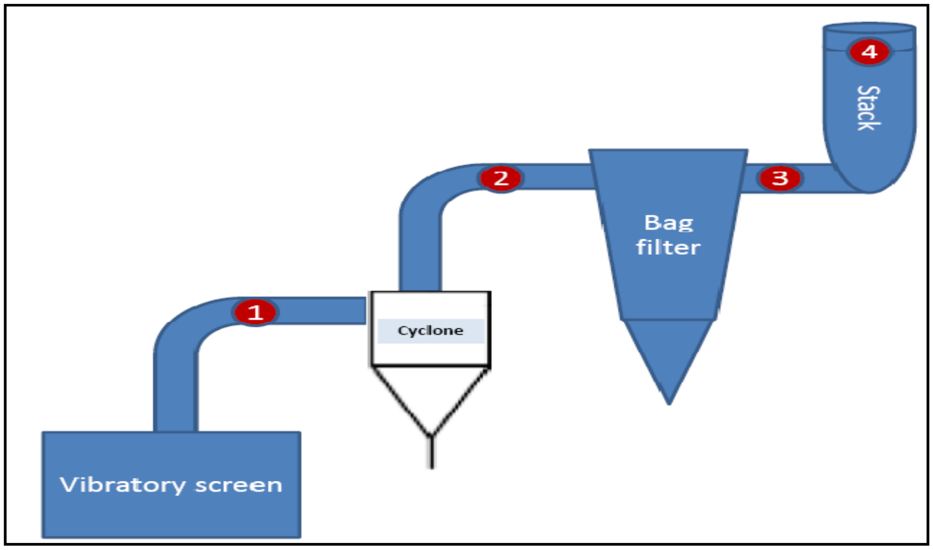
Data Sheet used for Point Source Emission Monitoring is given in Annexure 4

6.1.3 <u>Monitoring Locations :</u>

<u>UNIT 1 (Code 1):</u>

1. Monitoring at Pre cleaning section:

a) Stack Monitoring at various locations



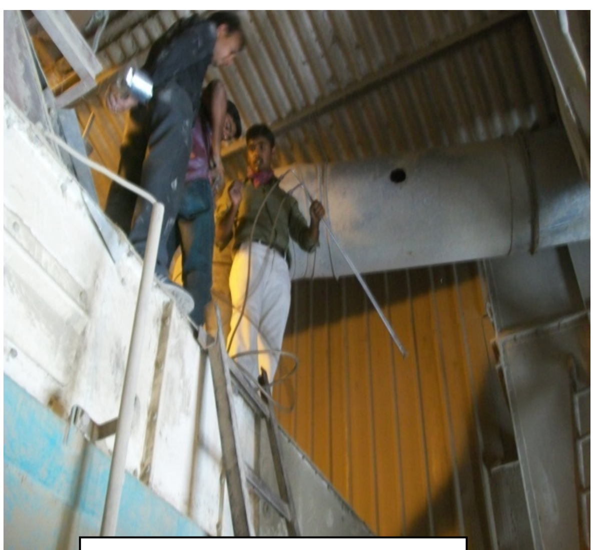


Fig.6.4 Port Hole at Cyclone

Fig.6.5 Cyclone followed by Bag Filter

MONITORING LOCATIONS in PRE-CLEANING SECTION		PARAMETERS						
		Diameter (m)	Cross Sectional Area (m^2)	Stack Temp. (◦C)	velocity(m/s)	Flow Rate (Nm^3/hr)	Static Pressure (mmwc)	PM (mg/Nm^3)
Location 1	Cyclone Inlet	0.65	0.33	30	12.4	14495	-15	126.4
Location 2	Bag Filter Inlet	0.65	0.33	30	14.6	17488	-68	-
Location 3	ID Fan Inlet	0.8	0.51	30	12.2	22123	-290	-
Location 4	Stack outlet	0.8	0.51	30	12.2	22123	+14	35.7

The flow measurements indicate leakages at Cyclone & Bag-filter, as below:

- Leakage volume sucked from cyclone bottom = (17488-14495) = 2993 m^3/hr
- Leakage volume sucked through Bag-filter Casing = (22123-17488) = 4635 m^3/hr
- **Total Leakage Volume = 7628 m^3/hr**

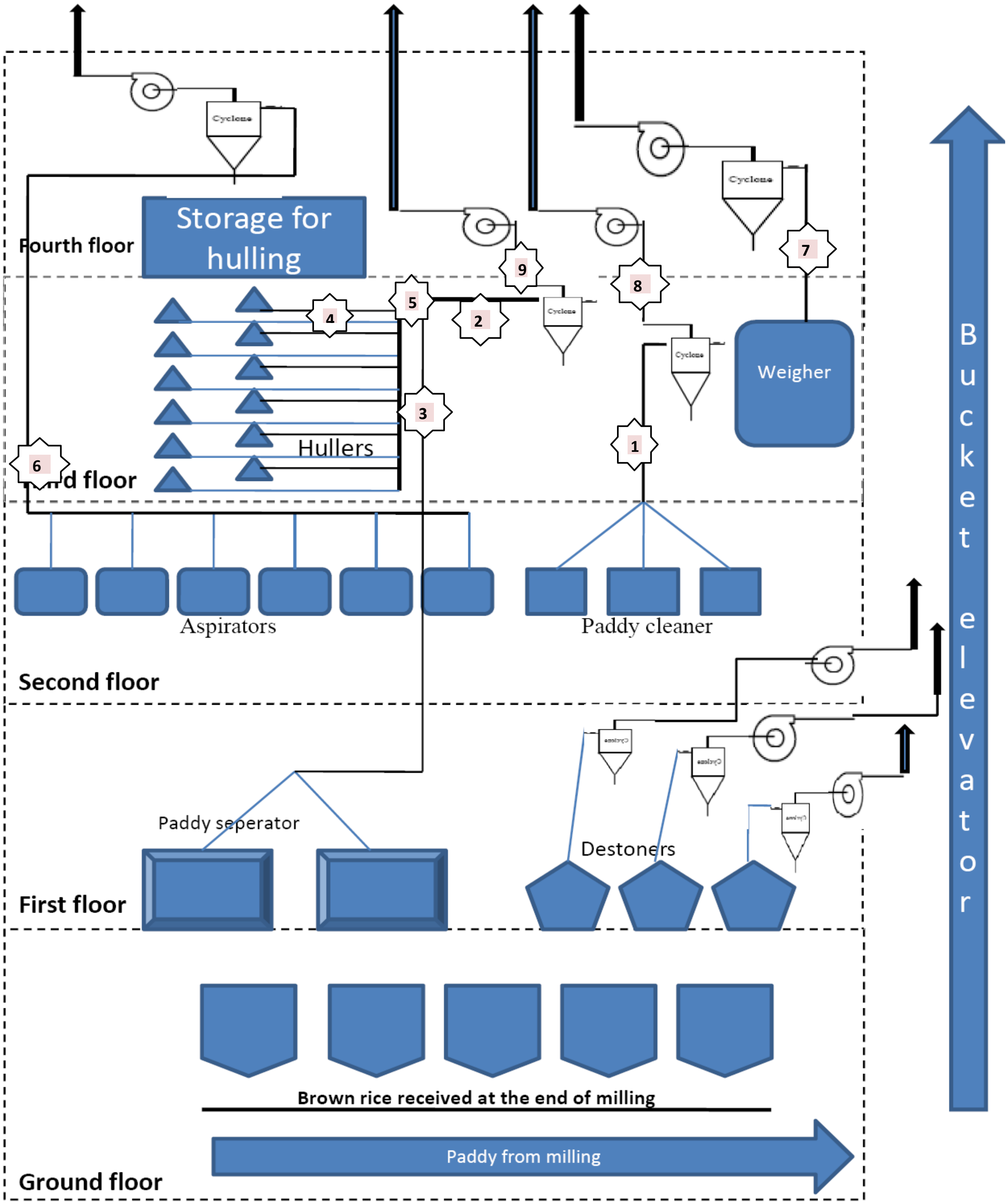
b) Fugitive Emissions Assessment

MONITORING LOCATIONS		PARAMETERS		
		TSPM (µg/m^3)	PM 10	
			(µg/m^3)	% fines
Location 1	Within cleaning section shed at Ground Floor(5m distance away from screen)	3699	3677	99

Fig.6.6. Pre- Cleaning

Observations: There were substantial fugitive emissions observed which is indicated by the high TSPM measurements. This would be because the dust extraction from some locations was not adequate and therefore only partial dust is sucked by the system, hence, lower dust concentrations in the extracted air.

2. Monitoring at Milling Section: A Schematic of Milling Section in Unit 1 comprised of following lay out plan, showing various equipments on various floors along with dust extraction arrangement & ID Fan, Cyclone and Final Discharges:



Schematic of the Milling Section showing Locations of Sampling Portholes (1 to 9)

Equipment Extracted	System Component	Port Holes
Hullers	Extraction ducts-cyclones- ID fan- stack	2,3,4,5,9
Paddy cleaner	Extraction ducts-cyclones- ID fan- stack	1,8
Aspirators	Extraction ducts-cyclones- ID fan- stack	6
Weigher	Extraction ducts-cyclones- ID fan- stack	7
Destoners	Extraction ducts-cyclones- ID fan- stack	-

a) Stack Monitoring:

In the Milling Section, the assessment of volume of air extracted from various equipments and the flow distribution in various branch ducts was done by measurement of velocity, static pressure etc. in various ducts. The measured data is given in the table below.

Extraction System	Port Hole	Location of Ducts	D(m)	Cross Sec. area (m^2)	TS (^0C)	v (m/s)	Flow Rate (Nm^3/hr)	Ps (mmWc)
Hullers	2	Common duct of all Hullers & Paddy Seperator	0.5	0.20	30	15.5	10756	42
	3	From Paddy Separator	0.4	0.13	20	10.4	4614	32
	4	Outlet from Single Huller	0.08	0.005	30	19.7	348	55
	5	Common Outlet from Hulling Section	0.3	0.07	30	11.7	2922	45
	9	ID Fan Inlet (coming from Hulling Section)	0.6	0.29	30	11.4	11434	80
Paddy Cleaners	8	ID Fan Inlet (coming from Paddy Cleaning section)	0.75	0.44	30	12	18712	27
Aspirators	6	Common Outlet from Paddy Separators/ Aspirators	0.55	0.24	30	7.6	6361	7
Weigher	7	Cyclone Inlet from Weigher	0.45	0.16	30	8.3	4663	35

Fig.6.7. Common Duct from Paddy Separators (2^{nd} floor)

Fig. 6.8. ID Fan Inlet (Port Hole 8) on 4^{TH} Floor

Fig.6.9. Outlet from Single Huller (Port Hole 4) on 3^{rd} floor

Fig.6.10. Cyclone Inlet (Port Hole 7) on 4^{th} floor

Photographs showing various Sampling Locations

b) Fugitive Emission Assessment

To assess the quantum of Fugitive Emissions generated due to inadequate extraction at some locations, measurement of Total Suspended Particulate Matter and PM 10 was done using samplers.

MONITORING LOCATIONS		PARAMETERS		
		TSPM (µg/m³)	PM 10	
			(µg/m³)	% fines
Location 1	Ground Floor of Milling Section	1570	596	38
Location 2	4th Floor of Milling Section	4365	1261	29

Fig.6.11. Ground Floor (Milling Section)

Fig.6.12. 4th Floor of Milling Section

Observation: Apart from extraction systems provided for various sections, the fugitive emission leads to high values of TSPM and PM 10, which could be due to inadequate extraction at some locations.

3. Monitoring at Boiler House

Fugitive emission at Boiler House

MONITORING LOCATIONS		PARAMETERS		
		TSPM (µg/m³)	PM 10	
			(µg/m³)	% fines
Location 1	Near Boiler House (at ash discharge point)	661	433	66

4. Ambient Monitoring at Unit 1

MONITORING LOCATIONS		PARAMETERS				
		TSPM (µg/m³)	PM 10		SO_2	NOx
			(µg/m³)	% fines		
Location 1	Near Factory Gate (North East Corner)	293	117	40	24	34
Location 2	Near Civil Block (South East Corner)	496	178	36	-	-
Location 3	Near ETP Plant (North West Corner)	446	145	33	-	-
Location 4	Near Plant Colony (South West Corner)	273	171	63	11	23

Fig.6.13 Near Factory Gate

Fig.6.14 Near ETP

Fig. 6.15 Near Plant Colony

Observation: The TSPM concentration in Ambient Air is found to be higher at some locations.

<u>Unit 2 (Code 2):</u>

1. *Ambient Air Monitoring:*

Ambient Air Monitoring was conducted at and beyond the unit boundary at 3 locations.

a) Location 1 (Downwind side) : South West Corner of the plant

b) Location 2 (Upwind side) : North West Corner of the plant (100 m away from the plant)

c) Location 3 (Upwind side) : South Side of plant

MONITORING LOCATIONS		PARAMETERS		
		TSPM (µg/m³)	PM 10	
			(µg/m³)	% fines
Location 1 (Downwind side)	South West Corner of the plant	974	306	32
Location 2 (Upwind side)	North West Corner of the plant	404	129	32
Location 3 (Upwind side)	South Side of plant	270	161	60

Fig.6.16. Downwind Side

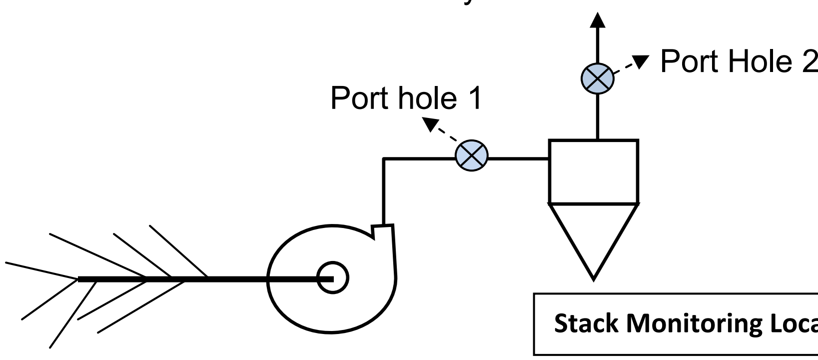
Fig.6.17. Upwind Side

Observation: The Ambient Air Concentration was found to be higher at 2 locations.

2. *Monitoring at Milling Section:*

a) Stack monitoring:

Location 1 : b/w ID Fan and Cyclone
Location 2 : After Cyclone in Stack



Stack Monitoring Locations in Unit

Port Hole Location	**Port Hole 1**	**Port Hole 2**
	b/w ID Fan and Cyclone	After Cyclone in Stack
Parameters		
Diameter (m)	0.25	0.25
Cross Sec. Area (m^2)	0.05	0.05
Stack Temp. (◦C)	31	31
velocity(m/sec)	15.1	16.5
Flow Rate (Nm^3/hr)	2642	2829
Static Pressure (mmwc)	+39	+3.3
Particulate Matter (mg/Nm^3)	92.3	45.8

b)Fugitive Emission Assessment

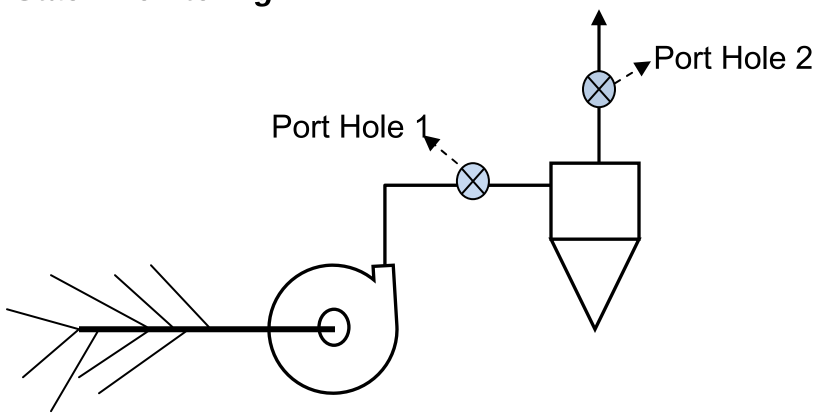
MONITORING	**LOCATIONS**	**PARAMETERS**		
		TSPM ($\mu g/m^3$)	**PM 10**	
			($\mu g/m^3$)	**% fines**
Location 1	Near the door of Milling Section	2524	1882	75

Observations: There were substantial fugitive emissions observed which is indicated by the high TSPM measurements. This could be because the dust extraction from some locations was not adequate and therefore only partial dust is sucked by the system, hence, lower dust concentrations in the extracted air.

Unit 3 (Code 3):

1. ***Monitoring at Milling Section:***

a. Stack Monitoring:



Port Hole Location	Port Hole 1	Port Hole 2
	b/w ID Fan and Cyclone	After Cyclone in Stack
Parameters		
Diameter (m)	0.25	0.25
Cross Sec. Area (m^2)	0.05	0.05
Stack Temp. (◦C)	31	31
velocity(m/sec)	13.5	11.4
Flow Rate (Nm^3/hr)	2330	1964
Static Pressure (mmwc)	+38	+1.8
Particulate Matter (mg/Nm^3)	96.4	43.8

b) Fugitive Emission Assessment

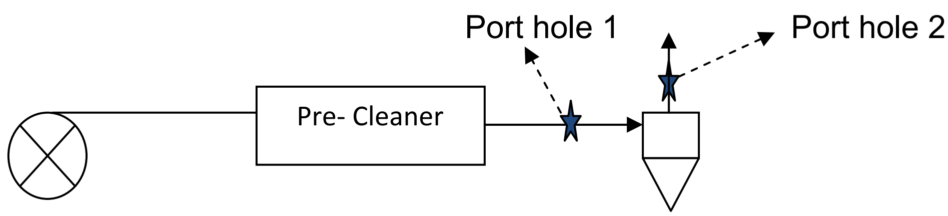
MONITORING	LOCATIONS	PARAMETERS		
		TSPM ($\mu g/m^3$)	PM 10	
			($\mu g/m^3$)	% fines
Location 1	Near the door of Milling Section	4482	3406	76

Observations: There were substantial fugitive emissions observed which is indicated by the high TSPM measurements. This could be because the dust extraction from some locations was not adequate and therefore only partial dust is sucked by the system, hence, lower dust concentrations in the extracted air.

Unit 4 (Code 4):

1. Monitoring in Pre-cleaning Section:

a) Stack Monitoring



Parameters	Pre-Cleaning Section	
	Cyclone Inlet (Port hole 1)	**Cyclone Outlet (Port hole 2)**
Diameter (m)	0.3	0.3
Cross Sec. Area (m^2)	0.07	0.07
Stack Temp. (◦C)	31	31
velocity(m/sec)	10.7	11.1
Flow Rate (Nm^3/hr)	2677	2758
Static Pressure (mmwc)	+96	+2.5
Particulate Matter (mg/Nm^3)	45.6	41.7

b) Fugitive Emission Assessment

MONITORING	LOCATIONS	PARAMETERS		
		TSPM (µg/m^3)	**PM 10**	
			(µg/m^3)	**% fines**
Location 1	Pre-cleaning room of Raw Rice Mill	906	461	51

2. Monitoring in Milling Section

a) Fugitive Emission Assessment

MONITORING LOCATIONS		PARAMETERS		
		TSPM ($\mu g/m^3$)	PM 10 ($\mu g/m^3$)	% fines
Location 2	Milling Section extraction cyclones outlet area	3293	1966	60

2. Monitoring at Polishing Section:

Parameters	Measured values at Polishing Section Stack
Diameter (m)	0.3
Cross Sec. Area (m^2)	0.07
Stack Temp. (∘C)	31
velocity(m/sec)	10.8
Flow Rate (Nm^3/hr)	2549
Static Pressure (mmwc)	54
Particulate Matter (mg/Nm^3)	32.7

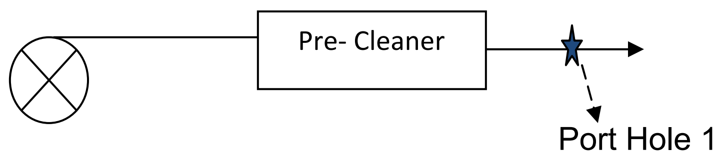
Observations: There were substantial fugitive emissions observed which is indicated by the high TSPM measurements. This could be because the dust extraction from some locations was not adequate and therefore only partial dust is sucked by the system, hence, lower dust concentrations in the extracted air.

Unit 5 (Code 5):

1. Monitoring at Pre-cleaning Section:

a) Stack Monitoring:

➢ At the outlet of Pre-cleaner.



Parameters	Measured values at Outlet of Pre-Cleaner
Diameter (m)	0.3
Cross Sec. Area (m^2)	0.07
Stack Temp. (◦C)	31
velocity(m/sec)	6
Flow Rate (Nm^3/hr)	1488
Static Pressure (mmwc)	+12
Particulate Matter (mg/Nm^3)	86.9

2. Monitoring at Milling Section

MONITORING	LOCATIONS	PARAMETERS		
		TSPM (µg/m^3)	PM 10 (µg/m^3)	% fines
Location 1	Near the door of Milling Section	926	335	32

Observations: There were substantial fugitive emissions observed which is indicated by the high TSPM measurements. This could be because the dust extraction from some locations was not adequate and therefore only partial dust is sucked by the system, hence, lower dust concentrations in the extracted air.

Unit 6 (Code 8):

1. Monitoring at Pre-cleaning Section:

a) Stack Monitoring

MONITORING LOCATION	PARAMETERS					
	Diameter (m)	Stack Temp. (◦C)	velocity(m/s)	Static Pressure (mmwc)	Flow Nm^3/hr	Particulate Matter (mg/Nm^3)
Pre cleaning Outlet	0.33	34	9.3	+14	2765	32.6

b) Fugitive Emission Assessment

MONITORING LOCATION	PARAMETERS		
	TSPM	PM 10	
	(µg/m³)	(µg/m³)	% fines
Near Pre-Cleaning Section	1753	561	32

2. Monitoring at Milling Section:

a) Stack Monitoring

MONITORING LOCATION	PARAMETERS					
	Diameter (m)	Stack Temp. (◦C)	velocity (m/s)	Static Pressure (mmwc)	Flow Nm^3/hr	Particulate Matter (mg/Nm^3)
Milling Section Stack	0.33	34	19.9	4.8	5935	52.3

Observations: There were substantial fugitive emissions observed which is indicated by the high TSPM measurements. This could be because the dust extraction from some locations was not adequate and therefore only partial dust is sucked by the system, hence, lower dust concentrations in the extracted air.

Unit 7 (Code 11):

1. Monitoring at pre cleaning section:

a) Stack Monitoring

MONITORING LOCATIONS		PARAMETERS					
		Diameter (m)	Stack Temp. (◦C)	velocity(m/s)	Static Pressure (mmwc)	Flow Nm^3/hr	Particulate Matter (mg/Nm^3)
Location 1	Pre cleaning outlet	0.15	32	12.6	+19	777	39.1

b) Fugitive Emissions Assessment

MONITORING LOCATION	PARAMETERS		
	TSPM ($\mu g/m^3$)	PM 10	
		($\mu g/m^3$)	% fines
Near Pre-Cleaning Section	16110	9115	56

Observations: There were substantial fugitive emissions observed which is indicated by the high TSPM measurements. This could be because the dust extraction from some locations was not adequate and therefore only partial dust is sucked by the system, hence, lower dust concentrations in the extracted air.

6.1.4 Monitored SO_2 and NOx Values in Various Rice Mills

Unit Code	Location	SO_2 Concentration		Avg. SO_2 Conc.
		Sample 1	Sample 2	
1.	Near Factory Gate	23.8	24.2	24
1.	Near Plant Colony	10.9	11.1	11
8.	Near Main Gate	7.5	7.8	7.6
11.	Near Main Gate	9.5	10.1	9.8

Unit Code	Location	NOx Concentration		Avg. NOx Conc.
		Sample 1	Sample 2	
1.	Near Factory Gate	33.8	34.1	34
1.	Near Plant Colony	22	24.5	23
8.	Near Main Gate	13	13.7	13.4
11.	Near Main Gate	16.3	16.5	16.4

CHAPTER 7: FUGITIVE EMISSIONS IN RICE MILLS

7.1 Escape of unextracted fine dust from Paddy Unloading Area and its Conveyance System:

In the unloading section, the paddy bags are cut open and paddy emptied out in the pit, from where it is conveyed to bucket elevators for conveying to the pre-cleaning section. Due to free fall, substantial fine dust is generated during unloading of paddy and its conveyance. This fine dust escapes in the mill environment due to inadequate extraction arrangement from the Unloading pit, the Bucket Elevator, the Discharge Points, etc.

7.2 Fugitive Emissions of Unextracted and Uncaptured fines from Paddy Cleaning Section:

The objective of the pre-cleaning section is to remove the fine dust and dirt from the unloaded paddy before it goes to parboiling/milling section. During pre-cleaning activity the separated fine dust from paddy escapes in and around the pre-cleaning section due to following main reasons:

- Lack of extraction systems in the pre-cleaning section mainly in small rice mills (instead, only blowing of Dirt/ Dust is done with the help of a Blower).
- Inefficient extraction systems in the pre-cleaning section, mainly in small rice mills where number of flexible pipes are taken from main duct. The duct connections are not appropriate; hence sucking capacity from various equipments varies and does not match the requirement.
- Poor design, operation and maintenance to existing extraction cum control systems. Mills employing cyclone followed by bag-filter are observed to be having substantial dust and fugitive emissions, may be due to choking of filter bags, inappropriate cleaning of bags, inappropriate extraction locations, etc.
- Limitation of employed control system.
  The fine dust ≤10 micron can only be effectively controlled using bag-filters and most of the small and medium mills have adopted cyclone as APCD.

7.3 Unextracted and Uncaptured Fines from Milling Section:

In the milling section during husk removal substantial quantities of fine particles of rice husk are generated due to breaking of husk in hullers and husk separation in de-huskers. During milling of paddy fine rice husk escapes in the milling section due to following main reasons:

- Lack of extraction systems in the milling section mainly in small rice mills.
- Inefficient extraction systems in the milling section, mainly in small rice mills where number of flexible extraction ducts from various operations enter a common header duct.
- Poor design, operation and maintenance to existing extraction cum control systems. Mills employing cyclones with blowers/ID fans are observed to be having substantial dust and fugitive emissions.

- Limitation of employed fugitive emission control system. The fine dust ≤10 micron can only be effectively controlled using bag-filters and most of the small and medium mills have adopted cyclones in the milling section which are not suitable for controlling fine dust emission.

7.4 Unextracted fine dust particles in Husk stored in Open Areas:

In rice mills the rice husk is handled using different systems and stored in husk storage yard in open/partially covered or in closed storage. The fugitive dust emission during rice husk handling and storage happens due to following main reasons:

- Non-removal of fines from the husk before storage. In many small mills husk is blown to storage area without extracting fines from it.
- Inefficient removal of fines from the husk before storage. Many mills have blower with cyclone which remove only coarser dust particles.
- Common open storage of rice husk and rice bran fines.
- Inefficient extraction systems in the milling section. Poor design, operation and maintenance of existing extraction cum control systems.
- Limitation of employed fugitive emission control system. The fine dust≤10 micron can only be effectively controlled using bag-filters and most of the small and medium mills have adopted cyclones for husk separation which are not suitable for controlling fine dust emission.

7.5 Fine dust Emissions from the Ash Disposal:

In rice mills ash is generated in the boiler section. This ash escapes from the boiler section due to following main reasons:

- Open temporary storage of boiler ash in the mills- fines get airborne due to wind currents.
- Disposal of boiler ash in the unprotected landfill site- dust gets re-entrained due to wind.

CHAPTER 8: ANALYSIS OF EXISTING DUST CONTROL ARRANGEMENTS & POSSIBLE MODIFICATIONS FOR IMPROVEMENT

8.1 Dust extraction system for paddy cleaning section –

Such systems are typically employed in most rice mills. The most predominant problem identified is:

- That there are substantial fugitive emissions from various locations like belt conveyor, bucket elevator discharge locations, from the vent of storage silo and the cleaning screen area.

It is generally perceived that the fine dust adhering to paddy keeps getting loosened/ separated, right from bag unloading point upto the cleaning screen and it gets accumulated and can be extracted at the final point i.e. screen.

But, because, the system of conveying & storage of paddy is not air-tight hence the fine dust, as and when generated, escapes to atmosphere through the openings/leakages in the system. Even if all the leakages/openings are closed or sealed, the fine dust would escape through the vent of the storage vessel, through openings for discharging material.

It is, therefore, necessary to extract / suck the fine dust particles from various locations simultaneously like transfer points, point of free fall Paddy, vents of storage bins/ silos, vibratory/rotary screens etc.

Minimum air volume to be extracted

The most authentic design handbook, namely “Industrial Ventilation” (a manual of recommended practices, 23rd edition, 1998, by American Conference of Governmental Industrial hygienists, USA), gives the “basic minimum” extraction volumes to be extracted from belt conveyors, bucket elevators and screens, which shall be followed while designing an appropriate dust extraction system.

In the large unit studied (Unit-1), employing above type of systems, the measured parameters are as below:

(i) System for Paddy-cleaning section at Unit 1:

System comprises of a single point dust extraction from vibratory screen, a cyclone followed by bag filter, ID fan and stack

Measurements were conducted at cyclone inlet, between cyclone & bag filter, between bag filter & ID fan and at the outlet of ID fan in the stack. The measurement shows the following problems in the dust extraction system.

- The actual flow extracted by the ID fan was 22123 Nm^3/hr, out of which the useful volume actually extracted from the vibratory screen was only 14495 Nm^3/hr (which is about 65% only). The balance 35% flow are leakages, 2993 Nm^3/hr from cyclone bottom (14%) and 4635 Nm^3/hr from bagfilter casing leakages (21%). These leakages of about 35% in the system adversely affect the performance of the dust extraction system.
- The pressure drop across the bagfilter was measured to be 222 mmWC which is quite high and could be due to improper cleaning of the filter bags resulting in formation of thick dust layer on the filter cloth.
- Substantial fugitive emission were observed from the vibratory screen through front side opening as well as leakages from the screen sides which indicate inadequate extraction of dust from the cleaning screen.
- The fugitive emission assessment done using respirable type high volume sampler (RDS) placed at ground floor (at about 5 meter distance from the vibratory screen) indicated TSPM in the range of 3699 and PM 10 in the range of 3677 ug/m^3. This high value of emissions indicate substantial fugitive emissions from the cleaning section.
- The respirable particulate matter (PM 10, less than 10 micron size) is about 99% in the total suspended particulate matter (TSPM), which indicates that almost all the fugitive emissions from the cleaning sections are very fine in size which can only be captured by bag filters.

Even though large volume of extraction is provided (about 15000 Nm^3/h) which may be even more than that required (as per the technical design handbook specifications), but still not able to extract the dust emissions adequately resulting in substantial fugitive emissions, because all the sucking is provided only at 1 point i.e. the vibratory screen, which is a wrong design instead of sucking dust from various required locations like belt conveyor transfer points, bucket elevators, storage silos etc,.

In nutshell, even if the industry has installed more than adequate size of dust extraction cum bag filter system and have made substantial investment on the equipment, associated with high operating costs of running the ID fan, still substantial fugitive emission occur, thereby defeating the very purpose of installing dust extraction cum control system.

This is primarily because of in-appropriate design of dust extraction network and improper maintenance of the cyclone and bag filter leading to leakages in the system and high pressure drop in bag filter.

Therefore, it is necessary to provide technical guidance to rice mills for the required volume of air to be extracted from various locations.

(ii) System for cleaning section of Unit 2 -

Substantial fugitive emissions were observed from the cleaning section which indicate inadequate extraction of dust from the cleaning screen.
The fugitive emission assessment done using respirable type high volume sampler (RDS) placed at ground floor (at about 5 meter distance from the screen) indicated TSPM in the range of 2524 and PM 10 in the range of 1882 ug/m³. The high emission values indicate substantial fugitive emissions from the cleaning section.

The respirable particulate matter (PM 10), less than 10 micron size, is about 75% in the total suspended particulate matter (TSPM), which indicates that majority of the fugitive emissions from the cleaning section are very fine in size and can only be captured by bag filter.

The Unit has dust extraction cum cyclone type system. From the main pipe at the ID fan inlet, there are many flexible pipes branching out to various locations for sucking dust. Uniform distribution of flow is not maintained and the branching of the ducts from the main header unscientifically done, a design fault and hence cannot ensure optimal dust extraction from various locations.

Though the industry has installed a dust extraction system sucking about 2800 Nm³/h volume, due to improper design of the branch ducts and its connections with the main header, the system cannot ensure appropriate extraction of fine dust from required locations and hence appropriate technical guidance need to be provided to the rice mill to help them design and adopt proper dust extraction system.

(iii) System for cleaning section of Unit 3 -

Substantial fugitive emissions were observed from the cleaning section which indicate inadequate extraction of dust from the cleaning screen.

The fugitive emission assessment done using respirable type high volume sampler (RDS) placed at ground floor (at about 5 meter distance from the screen) indicated TSPM in the range of 4482 and PM 10 in the range of 3406 µg/m³. The high emission value indicate substantial fugitive emissions from the cleaning section.

The respirable particulate matter (PM 10), less than 10 micron size, is about 76% in the total suspended particulate matter (TSPM), which indicates that mostly of the fugitive emissions from the cleaning section are very fine in size which can only be captured by bag filter.

The Unit has dust extraction cum cyclone type system. From the main pipe at the ID fan inlet, many flexible pipes branches are taken out to various locations for sucking dust. Uniform distribution of flow is not maintained rather branching of the ducts from the main header unscientifically done, a design fault and hence cannot ensure appropriate dust extraction from different locations.

Though the industry has installed a dust extraction system sucking about 2330 Nm^3/h volume, due to improper design of the branch ducts and its connections with the main header, the system cannot ensure appropriate extraction of fine dust from required locations and hence appropriate technical guidance need to be provided to the rice mill to help them design and adopt proper dust extraction system.

8.2 Dust extraction system for Milling section –

(i) System for Milling Section at Unit 1:

Different extraction systems are installed to extract dust from various sections :

- Dust extraction system for paddy final cleaner
- Dust extraction system for d-stoners
- Dust extraction system for paddy weigher machine
- Dust extraction system for Paddy separator / huller
- Dust extraction system for aspirators

All the above extraction systems have dust extraction pipes for one or more points with a cyclone and an ID fan followed by a pipe exhausting the air outside the milling shed. There are no provisions of portholes in the system and therefore stack monitoring could not be done. However, the volumes extracted where measured which are as below :

- Dust extraction system for paddy final cleaner (18712 Nm^3/h)
- Dust extraction system for paddy weigher machine (4663 Nm^3/h)
- Dust extraction system for Paddy separator / huller (11434 Nm^3/h)
- Dust extraction system for aspirators (6361 Nm^3/h)

The fugitive emission assessment done using respirable type high volume sampler (RDS) placed at ground floor indicated TSPM in the range of 1570 and PM 10 in the range of 596 $\mu g/m^3$ and 4365 and PM 10 in the range of 1261 $\mu g/m^3$ at fourth floor level. The high emission values indicate substantial fugitive emissions in the milling section.

(ii) System for Milling Section at Unit 2:

The extraction system has dust extraction pipes for one or more points with a cyclone and an ID fan followed by a pipe exhausting the air outside the milling shed. There are no provisions of portholes in the system and therefore stack monitoring could not be done.

The fugitive emission assessment done using respirable type high volume sampler (RDS) placed at ground floor indicated TSPM in the range of 2524 and PM 10 in the range of 1882 μg/m³. The high emission values indicate substantial fugitive emissions in the milling section. These fine particles get carried away with the husk and can get airborne due to wind carry over.

(iii) System for Milling Section at Unit 3:

The extraction system has dust extraction pipes for one or more points with a cyclone and an ID fan followed by a pipe exhausting the air outside the milling shed. There are no provisions of portholes in the system and therefore stack monitoring could not be done.

The fugitive emission assessment done using respirable type high volume sampler (RDS) placed at ground floor indicated TSPM in the range of 4482 and PM 10 in the range of 3406 μg/m³. The high emission values indicate substantial fugitive emissions in the milling section. These fine particles get carried away with the husk and can get airborne due to wind carry over. It is, therefore, important to install appropriate dust extraction cum bag filter type dust control system.

(iv) System for Milling Section at Unit 4:

The extraction system has dust extraction pipes for one or more points with a cyclone and an ID fan followed by a pipe exhausting the air outside the milling shed. There are no provisions of portholes in the system and therefore stack monitoring could not be done.

The dust extracted from the milling section is passed through cyclones kept inside a room, without any outlet stack but only a short pipe for outlet above the cyclone which ends within the shop floor roof and all the air exhausted from cyclone along with fine dust is exhausted from the room door. The fugitive emission assessment done using respirable type high volume sampler (RDS) placed near the door indicated TSPM in the range of 3293 and PM 10 in the range of 1966 ug/m³. The high emission values indicate substantial escaping of fine dust as fugitive emissions from the milling section. These fine particles can get airborne due to wind carry over. It is, therefore, important to install appropriate dust extraction cum bag filter type dust control system.

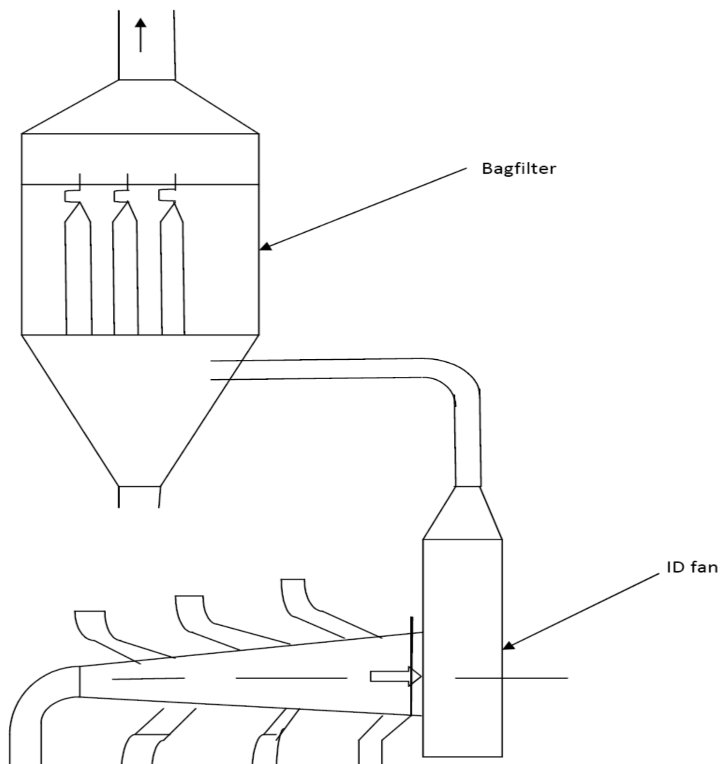
8.3 Dust Extraction system for small capacity (< 4 tonne/hr) rice mills:

The Unit has dust extraction cum cyclone type system. From the main pipe at the ID fan inlet, many flexible pipes branch out to various locations for sucking dust. There is no uniform distribution of flow and the branching of the ducts unscientifically done, which is a design fault and hence cannot ensure appropriate dust extraction from various locations.

Though the industry has installed a dust extraction arrangement sucking about 2800 Nm^3/h volume, due to improper design of the branch ducts and its connections with the main header, the system cannot ensure appropriate extraction of fine dust from required locations and hence appropriate technical guidance needs to be provided to the rice mill to help them design and adopt proper dust extraction system.

Proper duct branching at proper angle from the main pipe (30 deg) should be provided for optimal extraction of dust. A comparison of existing arrangement Vs required arrangement is shown below.

Existing Dust Extraction cum Control System



Proper Branch Ducts connected at 30^0 angle, equally spaced, properly sized Preferred/ Required dust Extraction cum Control System

Fig 8.1: Comparison of Existing Vs Required Dust Extraction cum Control System for Rice Mills (For paddy cleaning section)

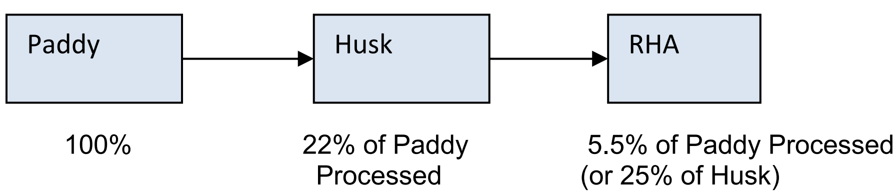
8.4 Rice Husk Handling & Storage Practices:

(i) Characteristics of Rice Husk*

- Rice husk is difficult to ignite and it does not burn easily with open flame unless air is blown through the husk. One concern in rice husk firing is the behavior of the ash, i.e., its slagging and fouling tendency caused by a low melting point of the rice husk ash.
- When burned the ash content is about 25%, a lot higher than wood (0.2-2%). This means when used for steam generation large amounts of ash need to be handled.
- Rice husk has a average calorific value of 3410 kcal/kg and therefore is a good, renewable energy source.
- It is highly resistant to moisture penetration and fungal decomposition. Husk therefore makes a good insulation material.
- Because of the high silica content rice husk is very abrasive and wears conveying elements quickly.
- Rice husk has low bulk density of only 70-110 kg/m³, 145 kg/m³ when vibrated or 180kg/m³ in form of brickets or pellets. It thus requires large volumes for storage and transport, which makes transport over long distances un-economical
- Handling of rice husk is difficult because it is bulky and dusty. It has angle of repose of about 40-45° which means that it's flow ability, e.g. in feed hoppers is very poor.
- Rice husk has a high silica (SiO_2) content which means that it decomposes slowly when brought back to the field. It also makes it a poor fodder.

**Source: International Rice Research Institute, Philippines (www.knowledgebank.irri.org)*

(ii) Quantity of Husk & Ash generation from Paddy: Husk contains about 75 % organic volatile matter and the balance 25% of the weight of this husk is converted into ash during the firing process, known as Rice Husk Ash (RHA). This RHA in turn contains around 80% - 90% silica. For every 1000 kgs of paddy milled, about 220 kgs (22 %) of husk is produced, and when this husk is burnt in the boilers, about 55 kgs (25 %) of RHA is generated.



Based on the above, typical ash quantities generated per day by various sites of Rice Mills is shown below:

Table 8.4.1: Typical Ash Balance for various size Rice Mills

Paddy Milling Capacity (tonne/hr)	Amount of Ash generated per hour (kg/hr)
1	55
2	110
5	275
25	1375

(iii) Typical Composition of Rice Husk Boiler Ash

Typical composition of Boiler Ash from Rice Husk fired Boiler is as below:

Table 8.4.2: Composition of Rice Husk Ash on Dry Basis*

Constituent	Mass Fraction %
Silica (SiO_2)	80-90
Alumina	1-2.5
Ferric oxide	0.5
Calcium oxide	1-2
Magnesium oxide	0.5-2.0
Sodium oxide	0.2-0.5
Potash	0.2
Loss on ignition	10-20

**Source: D.N. Subbukrishna, K.C. Suresh, P.J.Paul, S. Dasappa and N.K.S. Rajan – "Precipitated Silica from Rice Husk Ash by IPSIT Process" (Combustion,Gasification & Propulsion Laboratory, IISc, Bengaluru).15th European Biomass Conference and Exhibition, May 2007.*

Unburnt Carbon in the Ash may vary from unit to unit and depends on type of combustion in respective boilers. Following Table shows Typical Unburnt Carbon % in Boiler Ash, from 3 rice mills studied.

Table 8.4.3: % Carbon in Rice Husk Ash Samples from various Rice Mills

S.No.	Unit Code No.	Milling Capacity	Type of Combustion	Appearance of Ash	% of Unburnt Carbon
1.	1	55 tonne/hr	Travelling & Pulsating Grate	Grey	6.98
2.	4	12 tonne/hr	Extended Combustion	Blackish	8.83
3.	5	2 tonne/hr	Fluidized Bed	White	0.24

(iv) Minimum area requirement for storage of rice husk

The rice husk requires large storage area as its bulk density is low (average about 90 Kg/m³). A natural heap of husk, maximum height of 4 meter & angle of repose 45^0 will occupy 8 meter diameter; area (50 m^2 floor area) & can hold 6 tonne of husk (8.3 m² Area/Tonne of husk).

Assuming that a minimum of 10 hour operations/day of a 1 tonne/hr capacity Rice Mill, will generate about 220 kg/hr x 10 hrs = 2.2 tonne/day of husk.

Table 8.4.4: Typical storage Volume required for various capacity mills

Paddy Processing Capacity (tonne/hr)	Quantity of husk generated		Storage Volume required for storing 1 week husk quantity (m^3)
	Kg/hr	tonne/Week	
1	220	15.4	171
2	440	30.8	343
5	1100	77	856
10	2200	154	1712
25	5500	385	4278

8.5 Blowing of husk in storage area

Presently, many rice mills blow the husk (from the de-husker) by a blower in the open area outside the factory shed wall. The husk falls to ground by gravity & forms heap. The size of heap keeps growing as more & more husk is blown. This openly stores husk leads to generation of dust due to wind blowing.

To avoid this environmental air pollution problem, the blowing of husk should be done into a closed room. The room should be provided with an access door (to be kept closed during blowing) and a vent in the roof to release the air. The vent pipe should be attached to a filter-bag arrangement to arrest the fine particles. The size of the room would depend on the quantity of husk blown per hour & minimum storage quantity required.

8.6 Technical specification of volume to be extracted from various material handling equipment:

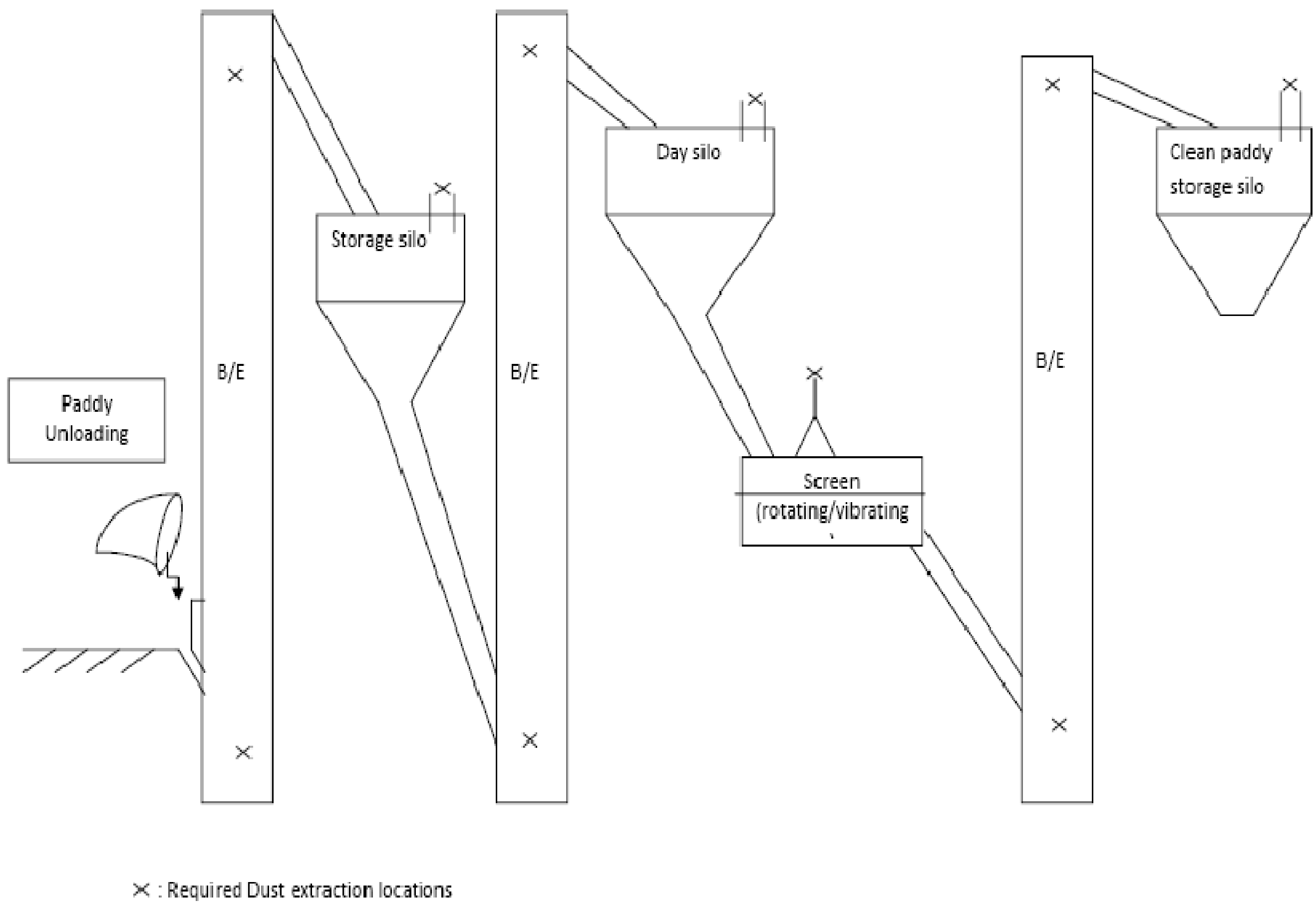
Table 8.6: Technical Specifications for Dust Extraction*

Mode of material handling/equipment	Volume to be extracted	Referred page of handbook
Belt conveyor(<1m/sec) **(>1m/sec)**	**1950 m^3/metre belt width** **2790 m^3/metre belt width**	**VS-50-01**
Bucket elevator	**1830 m^3/m^2 Cross section Area**	**VS-50-01**
Screens(vibratory/ rotary)	**915 m^3/m^2 Cross section Area**	**VS-99-01**
Storage bins	**3660 m^3/m^2) of all open area**	**VS-50-10**

***Source**: *"Handbook on Industrial Ventilation" (a manual of recommended practices, 23rd edition, 1998, by American Conference of Governmental Industrial hygienists, USA)*

As per the above specifications, a sample calculation of volume to be extracted from various locations from paddy unloading upto the cleaning screen section is shown in the diagram below (figure 8.1) and subsequent calculated values in the table below.

A sketch comparing the existing extraction system and a technically appropriate extraction system is shown below, to provide guidance to the rice mils.



Typical Set of Paddy unloading to Cleaning Section showing "Required Dust Extraction locations"

Figure 8.2

8.7 Typical volume to be extracted from various locations: Typical Volume to be extracted from various locations for a large size Rice mill (unit 1, 30 tonne/hr paddy processing) (from paddy unloading to cleaning screen)

Table: 8.7: Typical Volume to be Extracted from Various Locations

Location No	Items	Width (m)	Breadth (m)	From	To	Processing area	Specific volume to be extracted	Total volume to be extracted	Actual Volume extracted in unit 1
1	Belt conveyor 1	0.45	-	Unloading	Bucket elevator 1	1.5	1983 m³/m	892	-
2	Bucket Elevator 1	0.75	0.45	BC 1	Next	3.75(top)	1890 m³/m²	640	-
3	Bucket Elevator 1	0.75	0.45	BC 1	BE 2	3.75 (bottom)	1890 m³/m²	640	-
4	Bucket Elevator 2	0.75	0.45	BE 1	Storage silo	3.75 (top)	1890 m³/m²	640	-
5	Bucket Elevator 2	0.75	0.45	BE 1	Storage silo	3.75 (bottom)	1890 m³/m²	640	-
6	Silo(opening)	0.45	0.45	Front end	Rear end	2.25	3777 m³/m² opening	1105	-
7	Bucket Elevator 3	0.75	0.45	Storage silo	Day silo	3.75 (top)	1890 m³/m² (top)	640	-
8	Bucket Elevator 3	0.75	0.45	Storage silo	Day silo	3.75 (bottom)	1890 m³/m² (top)	640	-
9	Vibratory screen	2.4	1.2	Front end	Rear end	32	944 m³/m²	2720	14495
10	Bucket Elevator 4		VS	Clean silo	3.75(top)			640	-
11	Bucket Elevator 4				3.75 (bottom)			640	-
Total								9837	-
		Total Volume to be extracted (with 10% safety margin) (m³/hr) =						10820	14495

The above table indicates that for Rice Mills like unit no. 1 (30 TPH paddy capacity), the dust shall be extracted from about 11 locations & total volume to be extracted is about 10820 m³/hr.

Against this requirement, in unit 1, actually the dust is extracted from only one location (instead of 11 locations) and that too 14495 m³/hr (against 2720 m³/hr required for that point), which is technically a wrong design issue & hence there are un-sucked fugitive emissions from various locations.

8.8 Typical Efficiencies of Various Control Systems for Various Particle Sizes: Typical efficiency of various control devices for various size particles is given below:

Table: 8.8: Typical Collection Efficiencies of APCDs*

Type of APCD	% Efficiency for fine particle size range in µ			% Efficiency for coarse particle size range in µ		
	0 to 2.5 µ	2.5 to 6 µ	6 to10 µ	10 to20 µ	20 to 30 µ	>30 µ
Gravity Collector (Settling Chamber)	2.9 %	4.0 %	4.8 %	7.4%	15%	>40%
Single Cyclone	10.0 %	35.0 %	50.0 %	65%	90%	>98%
Fabric Filter (Bag filter)	99.0 %	99.5 %	99.5 %	> 99.5%		

**Source: Environmental Pollution Control Engineering Book by C.S. Rao*

8.9 Conclusions

- Most rice mills do have some dust extraction arrangement but requires modifications to make the system appropriate so as to cover dust extraction from belt conveyor transfer points, bucket elevator & screens, storage silo vents etc.
- There are substantial fugitive emissions from area like paddy unloading section, paddy cleaning section, milling section etc.
- There are substantial leakages of air in the dust extraction system from cyclone bottom opening, bag-filter casing, flanges and joints etc, which reduces the useful dust extraction volumes sucked by the induced draft fan.

CHAPTER 9: UTILIZATION OF RICE HUSK ASH

9.1 A number of possible uses of Rice Husk Ash:

Typical possibilities of utilization of Rice Husk Boiler Ash that are being investigated are as shown below:

Table 9.1: Typical uses of rice husk ash and carbonize rice husk*

	Rice husk ash (RHA)	Carbonized rice husk (CRH)
Description	➢ White, fine structure ➢ Contains around 80-90% silica around 25% of the weight of husk	➢ Black, often still in the shape of the husk ➢ Depending on the combustion still contains 8-15% carbon
Use	• Partial cement replacement material for high-strength concrete • Steel additive for quality steel or tundish powder in steel production. • Used in manufacturing of refractory bricks • Insulators	➢ Activated carbon ➢ Soil conditioner for poor soils ➢ Carbon sequestration, bio char ➢ Charcoal as fuel

Source: International Rice Research Institute, Philippines (www.knowledgebank.irri.org)

Some of the Ash utilization Areas are elaborated below:

a) Use of Rice Husk Ash in Cement Concrete Mix as SILPOZZ*

The particle size of the cement is about 35 microns. There may be formation of void in the concrete mixes, if curing is not done properly. This reduces the strength and quality of the concrete. A product – Silpozz – which is made out of this RHA is finer than cement having particle size of 25 microns, so much so that it fills the interstices in between the cement in the aggregate, and that is why it can reduce the amount of cement in the concrete mix.

RHA is a good super-pozzolan. **Silpozz** can be used in a big way to make special concrete mixes. There is a growing demand for fine amorphous silica in the production of special cement and concrete mixes, high performance concrete, high strength, low permeability concrete, for use in bridges, marine environments, nuclear power plants etc. This market is currently filled by silica fume or micro silica, being imported from Norway, China and also from Burma. Due to limited supply of silica fumes in India and the demand being high the price of silica fume has risen.

- **Uses OF SILPOZZ:** Typical uses of SILPOZZ made from Rice Husk Boiler Ash are described below:

1) For Strength:
Silpozz has the potential to be used as a substitute silica fumes or micro silica at a much lower cost, without compromising on the quality aspect. Adding Silpozz to the concrete mix even in low replacement will enhance the workability, strength and impermeability of concrete mixes, while making the concrete durable to chemical attacks, abrasion and reinforcement corrosion.

2) For water proofing :
Silpozz has excellent water resistance (impermeability) properties and is used in waterproofing compounds to give better results. It reduces the water penetration by as much as 60%.

3) For Better Concrete in Marine environment:
Adding Silpozz to concrete and paints helps to reduce the chloride ion penetration by as much as 50 % into the structure, thus improving life of the building.

4) For Lower Heat of Hydration:
Adding Silpozz to concrete lowers the heat of hydration by as much as 30 % and prevents formation of cracks during casting.

TABLE 9.2: TECHNICAL SPECIFICATIONS OF SILPOZZ*	
SiO2 – Silica	85 % minimum
Humidity	2 % maximum
Particle size	25 microns
Colour	Grey
Loss on ignition at 800°C	4 % maximum
pH value	8

**Source: www.ricehuskash.com/details.htm - N. Singhania, NK Enterprises, Orissa*

9.2 Use of Rice Husk Ash in manufacturing Pozzolana Cement*

Pozzolanas are materials containing reactive silica and/or alumina which on their own have little or no binding property but, when mixed with lime in the presence of water, will set and harden like cement. Pozzolanas are an important ingredient in the production of alternative cementing materials to Portland cement (OPC). Alternative cements provide an excellent technical option to OPC at a much lower cost and have the potential to make a significant contribution towards the provision of low-cost building materials.

Pozzolanas can be used in combination with lime and/or OPC. When mixed with lime, pozzolanas will greatly improve the properties of lime-based mortars, concretes rendering it suitable for use in a wide range of building applications. They can be blended with OPC to improve the durability of concrete and its workability, and considerably reduce its cost.

RHA has been successfully used as a pozzolana in commercial production in a number of countries including Columbia, Thailand and India.

To produce the best pozzolanas, the burning of the husk must be carefully controlled to keep the temperature below 700°C and to ensure that the creation of carbon is kept to a minimum by supplying an adequate quantity of air. At burning temperatures below 700°C an ash rich in amorphous silica is formed which is highly reactive. Temperatures above 700°C produce a crystalline silica which is far less reactive. Ashes composed of crystalline silica will require a considerable amount of grinding to produce an acceptable reactivity. Even then they are unlikely to match the quality of amorphous ash.

The presence of large quantities of carbon in the ash will adversely affect the strength of any concrete or mortar produced using RHA cements. Where possible, the carbon content of the ash should be limited to a maximum of 10%, although some studies have suggested higher percentages can be tolerated with only a relatively small decrease in strength.

Rice husks which have been burnt in large open heaps to dispose of waste husks, or burnt as a fuel in an industrial furnace, are unlikely to produce ashes with the specification described above. In particular, they are likely to be crystalline due to high combustion temperatures. Although this does not rule out their use as a pozzolana, ashes composed of crystalline silica will require a considerable amount of grinding to produce an acceptable reactivity. Even then they are unlikely to match the quality of amorphous ash.

9.3 Grinding of Rice Husk Ash for use in Cement Production*

The second step in processing is grinding the RHA to a fine powder, and ball or hammer mills are usually used for this purpose. Crystalline ash is harder and will require more grinding in order to achieve the desired fineness. Fineness similar to or slightly greater than that of OPC is usually recommended for pozzolanas although some have been ground considerably finer. The minimum fineness recommended by the Indian Standards for pozzolana (1344) is 320 and 250m^2/kg for grade 1 and 2 pozzolanas respectively, measured by the Blaine air permeability test. Although this standard is for calcined clay, the fineness requirements are also suitable for RHA.

Sources:* 1. *"Corrosion Performance of Rice Husk Ash Blended Concrete"- An article from 'Construction and Building Materials' August 1,* ***2007*
2. *"Mortar Incorporating Rice Husk Ash- Strength and Porosity" – European Journal of Scientific Research ISSN 1450-216X Vol.40 No.3* ***(2010)***
3. *www.ricehuskash.com*

9.4 Utilization of Rice Husk Ash in Lime Stabilization of Poor Soils*

Many procedures have been developed to improve the physical behaviour of soil by incorporating a wide range of stabilizing agents, additives and conditioners. Undoubtedly the most widely applied methods involve the use of inorganic cementing agents. The effectiveness of such agents relies on the formation of cementing bonds between the particles in the soil system.

Soil stabilization has been widely recommended for developing countries for the construction of various elements of the pavements. The reasons usually put forward are that the use of locally available materials will lead to lower costs. An understanding of local conditions is of paramount importance while developing any soil stabilizing technique for a given country. Climatic conditions can affect the behaviour of stabilized soil materials as well as construction procedures.

Stabilization of soil by lime is achieved through cation exchange, flocculation and agglomeration, lime carbonation and pozzolanic reaction. These reactions involve interaction between soil silica and (or) alumina and lime to form various types of cementing agents thus enhancing the strength. The chemical processes modify the soil structure whereby larger grain aggregates are formed, leading to several advantage in the suitability of soil in road construction.

The characteristics of compacted soil, if improved, resulting from residue utilization like flyash, blast furnace slag, rice husk ash etc mostly brings environmental and economic benefits. However on a comparative scale the use of rice husk ash has found limited application.

Cumulative generation of ash requires a large space for disposal. Utilization of rice husk ash by exploiting its inherent properties is the only way to solve the environmental and disposal problem of the ash. A number of researchers have studied the physical and chemical properties of rice husk ash. Rice husk ash cannot be used alone for stabilization of soil because of the lack of cementitious properties. The high percentage of siliceous material in rice husk ash indicates that it has potential pozzolonic properties.

The properties of rice husk depend whether the husks have undergone complete destructive combustion or have been partially burnt. The rice husk ash has been classified into high carbon char, low carbon ash and carbon free ash.

Since RHA is much cheaper than lime, addition of rice husk ash in lime-soil mix can result in cost reduction of construction. In tropical countries where rice husks are abundant and considered as waste material, use of RHA in the construction of roads and other earthworks may particularly become attractive, because of reduced construction costs, reduced disposal costs and environmental damage and conservation of high grade construction materials.

Source: "Effect of Rice Husk Ash on Lime Stabilization" – Published in Journal of the Institute of Engineers (India), Volume 87, November 28,* ***2006*

9.5 Other Uses of Rice Husk Ash:

RHA acts as a very good insulator. RHA is also used for insulation of molten metal in tundish and ladle in slab caster. The temperature of molten metal in the ladle is around 1400 ^{0} C and above. When this metal flows from ladle to tundish, the temperature drops to around 1250 ^{0} C. This reduction in temperature leads to choking and causes breakdown in the slab caster. When this RHA is spread as a coating over the molten metal in the tundish and in ladle, it acts as a very good insulator and the temperature is maintained, hence reducing the breakdown time of the casting.

As regards to the utilization aspects of Rice Husk Ash as discussed above, time tested examples of proven technologies could not be identified.

9.6 Some Definitions related to Rice Husk/Ash Utilization:

Amorphous Silica: Rice Husk is burnt in controlled temperature which is below 700 ^{0} C. and the ash generated is amorphous in nature. The transformation of this amorphous state to crystalline state takes place if the ash is exposed to high temperatures above 850 ^{0} C.

Green Concrete : Green Concrete as the name suggests is eco friendly and saves the environment by using waste products generated by industries in various forms like rice husk ash ,micro silica ,etc. to make resource-saving concrete structures .Use of green concrete helps in saving energy, emissions, waste water. Green concrete is often cheap to produce as it uses waste products directly as a partial substitute for cement, thus saving energy consumption in production of cement. Over and above green concrete has greater strength and durability than the normal concrete.

Silica Fumes: Silica Fumes (very fine non crystalline silicon dioxide) or Micro silica is a waste product of induction arc furnace in the ferro silicon industry.

9.7 Possible Alternate Uses of Rice Husk than as Boiler Fuel:-

Rice Husk can be put to use as building material, fertilizer, insulation material, or fuel. Some of the current and potential applications are listed below apart from being utilized as a fuel:

1) **Chemistry:**
   Rice husk can be used to produce mesoporous molecular sieves , which are applied as catalysts for various chemical reactions, as a support for drug delivery system and as adsorbent in waste water treatment.

2) **Building material:**
   Rice husks are a class A insulating material because they are difficult to burn and less likely to allow moisture to propagate mold or fungi. Rice husk when burned produces silica which provides excellent thermal insulation.

3) **Fertilizer:**
Rice husks are organic material and can be composted. However, their high lignin content can make the process slow . Sometimes earthworms are used to accelerate the process. Using vermicomposting techniques, the husks can be converted to fertilizer in about four months.

4) **SiC Production:** Rice husks are a low-cost material from which silicon carbide "whiskers" can be manufactured. The SiC whiskers are then used to reinforce ceramic cutting tools, increasing their strength tenfold.

5) **Juice extraction:** Rice hulls are used as a "press aid" to improve extraction efficiency of apple pressing.

6) **Pillow stuffing:** Rice hulls are used as pillow stuffing. The pillows are loosely stuffed and considered therapeutic as they retain the shape of the head. Since 2009, in China, these pillows have become popular, and are considered a luxury item.

7) **Animal Fodder:** Rice husk is an inexpensive byproduct of human food processing, serving as a source of fiber that is considered a filler ingredient in cheap pet foods.

Chapter 10: PROPOSED GUIDELINES & SITING CRITERIA FOR RICE MILLS

10.1 Guidelines for Handling, Storage & Transport of Rice Husk

i Prevention of Fine Dust from various operations of paddy processing

a) The industry shall ensure the adequate dust extraction form various points of dust generation starting from unloading section up to paddy cleaning section as mentioned below.

   - At the point of discharge from the belt conveyor (from paddy unloading area) to bucket elevator.
   - Extraction from the bucket elevator from two locations, one at the bottom end (above the bottom roller), and the other at the top side of the elevator (just below the top roller)
   - Extraction from the silo top vent, near the point of fall of paddy into the silo.
   - Extraction from the top of the cleaning screen (vibratory or rotary screen)
   - As the dust particles extracted from the paddy are very fine in size (majority of the particles being less than 10 micron size), the extracted dust should be filtered through a bag filter type control device. A low cost bag filter made from cotton bags with a manual shaker type cleaning arrangement could be installed. The fine dust filtered should be collected in bags and sealed and then disposed along with the bag, so that the fine dust does not get airborne again due to secondary wind blowing etc.

The unit may refer the Foot Note for designing of dust extraction systems for them.

Foot Note: Reference Design Criteria for Dust Extraction Volumes

- *For extraction of dust from the transfer point of a belt conveyor, about 1968 m^3/hr/m (600 m^3/hr/ft) of belt width (for belt speed of less than 1 m /Sec.) Or 2789 m^3/hr/m (850 m^3/hr/ft) of belt width for belt speed more than 1 m/sec shall be extracted.*
- *For bucket elevator extraction, 1830 m^3/m^2 (170 m^3/ sq. ft) of casing cross section each shall be extracted from two locations, one at the bottom end and other at the top end of the elevator.*
- *For cylindrical or vibratory cleaning screens, 1830 m^3/m^2 (170 m^3/ sq. ft) of cross section of screen shall be extracted.*

b) Prevention of dust during blowing, storage and handling of husk:

- The units shall provide a closed room type enclosure for blowing & storage of rice husk. This room type enclosure shall be closed from all sides and have an access door for loading/handling of rice husk. A vent above roof level shall be provided on this enclosure connected to a bag-filter to arrest/filter the fine particles. No activity regarding blowing & storage of rice husk shall be carried out outside the said enclosure.

- The units should have a minimum area for closed storage of rice husk in the plant premises. The units may decide the size of the enclosure based on their milling capacity, operating hours and utilization of husk. Typically one ton of paddy processing generates about 220 kg of husk, which would occupy 2 to 2.5 m^3 storage volume, as the bulk density of husk is in the range of 70-110 kg/m^3.

c) Prevention of dust form rice polishing section:

- The rice bran generated during polishing of raw rice, is fine in size and can get airborne with wind, and should be stored in “closed sheds only”. The fine particles escaping from the air vent shall be connected to a filter bag arrangement to ensure that only clean air is released to the atmosphere.

ii. Prevention of Fine Dust emissions during conveyance/Transportation of husk

- All the belt/chain conveyors conveying husk from de-husking section to storage and from storage to boiler section, shall be covered from all sides to prevent wind blowing of the husk.

- During transporting husk through vehicles, it should be covered from all sides with tarpoline to prevent wind blowing of husk.

- All the rice mills shall provide paved/brick roads inside their premises for movement of vehicles so as to prevent dust generation.

10.2 Guidelines for Handling, Transportation, Storage and Disposal of Ash from Husk Fired Boiler

A

1. The ash collected from APCD from husk fired boiler shall be temporarily stored in a shed / chamber closed from at least three sides and a roof, with access only from the front side for ash removal purpose.

2. During loading/unloading of ash, water shall be spread periodically to keep the ash heap in wet condition so that the top layer remains wet thereby prevent blowing of ash particles due to wind.

3. All the conveyors/vehicles conveying ash within or outside the plant premises shall be covered from all sides to prevent blowing of ash particles due to wind.

4. The boiler ash shall be disposed in such a way that secondary emissions of the ash do not occur due to wind blowing effect. The following disposal practices may be followed:

   (a) For units disposing ash outside their own premises:

   - The rice mills disposing their boiler ash outside their premises through contractors shall ensure that the ash has been disposed to a designated landfill site facility as approved by State Pollution Control Board.

   (b) For units disposing ash within their own premises:

   - The units disposing ash at the ground level should cover the ash with soil and periodically spray water on the disposed ash so as to keep it in wet condition. Piling up of another batch of ash over the earlier disposed ash could be done, but the ash heap needs to be covered each time by soil and kept wet by spraying water. A wind breaking wall of a height equal to the height of the ash heap disposed shall be erected around the ash disposal site, leaving the opening only for access road.

   - The industry may develop underground ditch for disposal of boiler ash within plant premises.

B

The industry should explore possibilities of ash utilization in making bricks or use in cement plants instead of disposal. To enable possibility of use of ash in cement plants, controlled burning of rice husk in the boiler shall be adopted through use of preferably fluidized bed boiler such that unburnt carbon in ash is below 8 percent. The feasibility to be explored by concerned agencies.

10.3 Siting Criteria for Rice Mills:

- The Siting of the Rice Mills shall not be less than 1 Km from the Census village and notified Authorized area.

- The minimum distance between the boundary of the new rice mill site and right of way of the
  - i) National Highway shall be -100 m
  - ii) State Highway shall be - 50 m
  - iii) Village roads shall be - 25 m

- The industry should plant thick plantation of spreading crown trees all along the boundary wall of the plant. For large rice mills (processing more than 20 ton/hr paddy), a Green belt of 3 m width shall be developed. For other rice mills, at least 2 rows of trees shall be developed along the boundary wall of plants.

ANNEXURE - 1

List of Rice Mills visited for the Study

S.No.	Name of the Unit	Address	Scale of Operation	Milling Capacity	Type of Rice produced
1.	KRBL Limited	Village Bhasaur, Dhuri, Sangrur, Punjab.	Large	55 tonne/hr	Parboiled Rice &White (Raw) Rice
2.	J.S. Rice Mills	Memasa Village, Dhuri, Punjab	Small	3 tonne/hr	White (Raw) Rice Mill
3.	J.P. Rice Traders	Village Bhasaur, Dhuri, Punjab	Small	1 tonne/hr	White (Raw) Rice Mill
4.	D.D. International	Village Takhana, Taraori Distt., Karnal	Medium	12 tonne/hr	Parboiled Rice & White (Raw) Rice
5.	Garg Enterprises	Village Takhana, Taraori Distt., Karnal	Small	2 tonne/hr	Parboiled Rice
6.	Bombay Agro Tech.	Bhullerheri, Dhuri, Sangrur, Punjab	Small	5 tonne/hr	White (Raw) Rice
7.	BCB Agro Tech.	Bhullerheri, Dhuri, Sangrur, Punjab	Small	2 tonne/ hr	White (Raw) Rice
8.	Veejay Rice Mills	Kerala	Small	1.16 tonne/hr	Parboiled Rice
9.	KKR Rice Mills	Kerala	Small	2 tonne/hr	Parboiled
10	Edathala Modern	Kerala	Small	1.16 tonne/hr	Parboiled
11	K &T	Kerala	Small	2 tonne/hr	Parboiled

Annexure-2

Copy of Rice Mills Questionnaire for Preliminary visits

1. Name of the Unit :
2. Contact Details of the Unit Head:

Name:	Designation:
Address:	
City:	State:
Telephone:	E-mail:
Fax:	Website:

3. Scale of Operation: Large ☐ Medium ☐ Small ☐ Tiny ☐
4. Location of plant: Residential/ Industrial/Other *Approximate distance from residential area: ☐
5. Milling capacity in metric tonne *:
6. a) Year of commission: b) No. of months of operation: Please specify all the months:

7. Type of mill: Dry Rice grinding mill / Parboiled mill / White (Raw) rice mill
8. Raw material : (tick the appropriate one)

Paddy		Milled rice	
Brown rice		Parboiled rice	
Any other , please specify*			

9. Storage & Capacity: Silo ☐ Godown/bulk ☐ Godown/bags ☐

---

10. Quality of raw material:
    - Average Moisture Content (%):
    - Field dried ☐ Mechanically dried ☐

---

11. Brief Process Description & Process Flow Chart.

12. Please specify type of technologies used in your plant for the following operations: (whichever applicable)

    Cleaning of paddy/Parboiling section/Hulling / Dehusking operation/Husk separation /Whitening and polishing operation

13. Particulars of by- products:

    a) Rice Bran for: (tick the appropriate one)

Feed stuff	Extraction plants	Exports	Any other

b) Rice Husk for: (tick the appropriate one)

Boiler	Waste	Milling Plant	Cattle feed	Any other use

- Storage facilities: Required ☐ Available ☐

- Type of Storage:
- Holding Capacity: ☐ Tonne ☐ sq.m / sq.ft

c) Boiler Ash:

- Storage facilities: Required ☐ Available ☐
- Type of Storage:
- Mode of Disposal:

14. Boiler section details: Efficiency/No. of chimney/Chimney height & diameter

15. Details of Fuel Consumption: (if applicable)

Types of Fuel used	Average Quantity consumed per day
Rice husk	
Coal	
Others (please specify)	

16. APCD's at Sources of Dust Emissions: (whichever applicable)

S.No.	Sources of emission	Type of APCD employed	ID Fan Capacity
1.	Paddy pre-cleaner		
2.	Paddy cleaner/ Vibratory screen		
3.	De-stoner machine		
4.	De-husker		
5.	Paddy separator		
6.	Boiler House		

17. Characterization and Quantification of pollutants:

Milling section	Average Dust concentration Before APCD* mg/Nm^3	Average Dust concentration After APCD* mg/Nm^3	Type of APCD	Gas flow Nm^3/hr	Average Dust load before APCD (kg/hr)	Specific Dust load before APCD (kg/T)
a. Cleaning section						
b. Milling section						
c. Boiler House section						

Annexure -3

Data Sheet of Traverse Points Standard Protocol

TRAVERSE POINTS STANDARD PROTOCOL:

Traverse Point	Traverse points in Circular Stack or Ducts						
1	**4**	**6**	**8**	**10**	**12**	**14**	**16**
2	6.7	4.4	3.2	2.6	2.1	1.8	1.6
3	25	14.6	10.5	8.2	6.7	5.7	4.9
4	75	29.6	19.4	14.6	11.8	9.9	8.5
5	73.3	70.4	32.3	22.6	17.7	14.6	12.5
6		85.4	67.7	34.2	25.0	20.1	16.9
7		95.6	80.6	65.8	35.6	26.9	22
8			89.5	77.4	64.4	36.6	28.3
9			96.8	85.4	75.0	63.4	37.5
10				91.8	82.3	73.1	62.5
11				97.4	88.2	74.9	71.7
12					93.3	85.4	78
13					97.9	90.1	83.1
14						94.3	87.5
15						98.2	91.5
16							95.1
17							98.4

Annexure- 4

Data sheet for point source emission monitoring

Location:	Fuel Used:
Fuel Consumption:	Plant Load:

Physical Details of Stack:

- Height:
- Diameter (m):
- Cross Sectional Area (m^2):
- Flue Gas temperature, ºK (Ts): =
- Ambient Temperature, ºK (Ta): =
- Atmospheric Pressure, mm Hg (Pa):
- Static Pressure, mm Hg (Pst):
- Absolute Stack Pressure, mm Hg (Ps): Pa + Pst =

Traverse Points	T1	T2	T3	T4	T5
Distance from the inside wall of the Stack Duct (cms)					
Pressure Drop (mm)					
Velocity (m/sec)					

- Average Velocity , m/s =
- Flow (m^3/sec) =
- Flow (Nm^3/ sec) =

Annexure - 5

Literature Data on % of fines in Dust in Grain Mills

Literature Survey on percentage of particles in various size ranges in the dust from grain handling and processing mills is reproduced below. In developed countries, all the food grains like wheat, paddy, pea etc are classified as "grains". The typical particle size distribution of grain handling/processing operations is given in table 8.1, which can be considered representation for either of the grains handled.

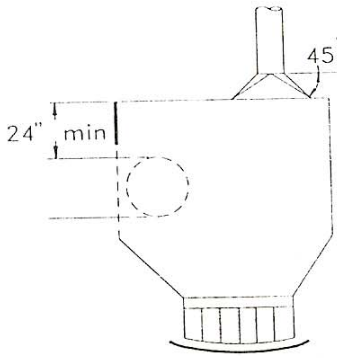
Typical PSD for Grain Handling/Processing Operations

Operation	Sub-section	Emissiong enerated due to	Typical equipments	Percentage of Particle Size Range (microns)			Overall % < 10 micron
				0–2.5	2.5 – 6	6 - 10	
Handling	Material Transfer, Misc. handling	Mechanical agitation of materials	Bucket elevators, unloading etc.	1%	6%	8%	15 %
Processing	Screening, Grinding	Separation size reduction	Rotary / Vibratory screens, Grinding machines	23%	20%	18%	61 %

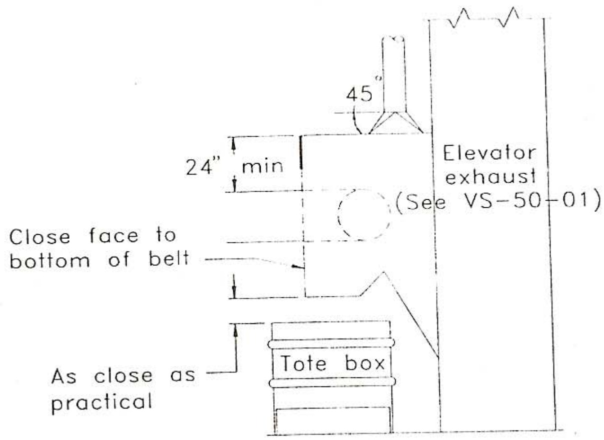
Ref: Air Pollution Engineering Manual, USA.

Annexure - 6

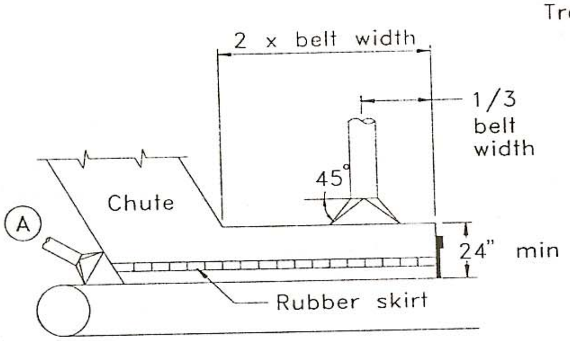
Reference Papers from Handbook



1. Conveyor transfer less than 3' fall. For greater fall, provide additional exhaust at lower belt. See 3 below.
$h_e = 0.25\ VP_d$



2. Conveyor to elevator with magnetic separator.
$h_e = 0.25\ VP_d$



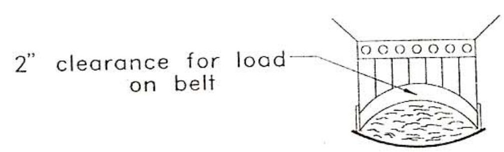
3. Chute to belt transfer and conveyor transfer, greater than 3' fall. Use additional exhaust at (A) for dusty material as follows:
Belt width 12"–36", Q=700 cfm
Belt width above 36", Q=1000 cfm
$h_e = 0.25\ VP_d$

Note: Dry, very dusty materials may require exhaust flowrates 1.5 to 2.0 times stated values.

DESIGN DATA

Transfer points:

Enclose to provide 150 – 200 fpm indraft at all openings. (Underground mining tunnel ventilation will interfere with conveyor exhaust systems.)

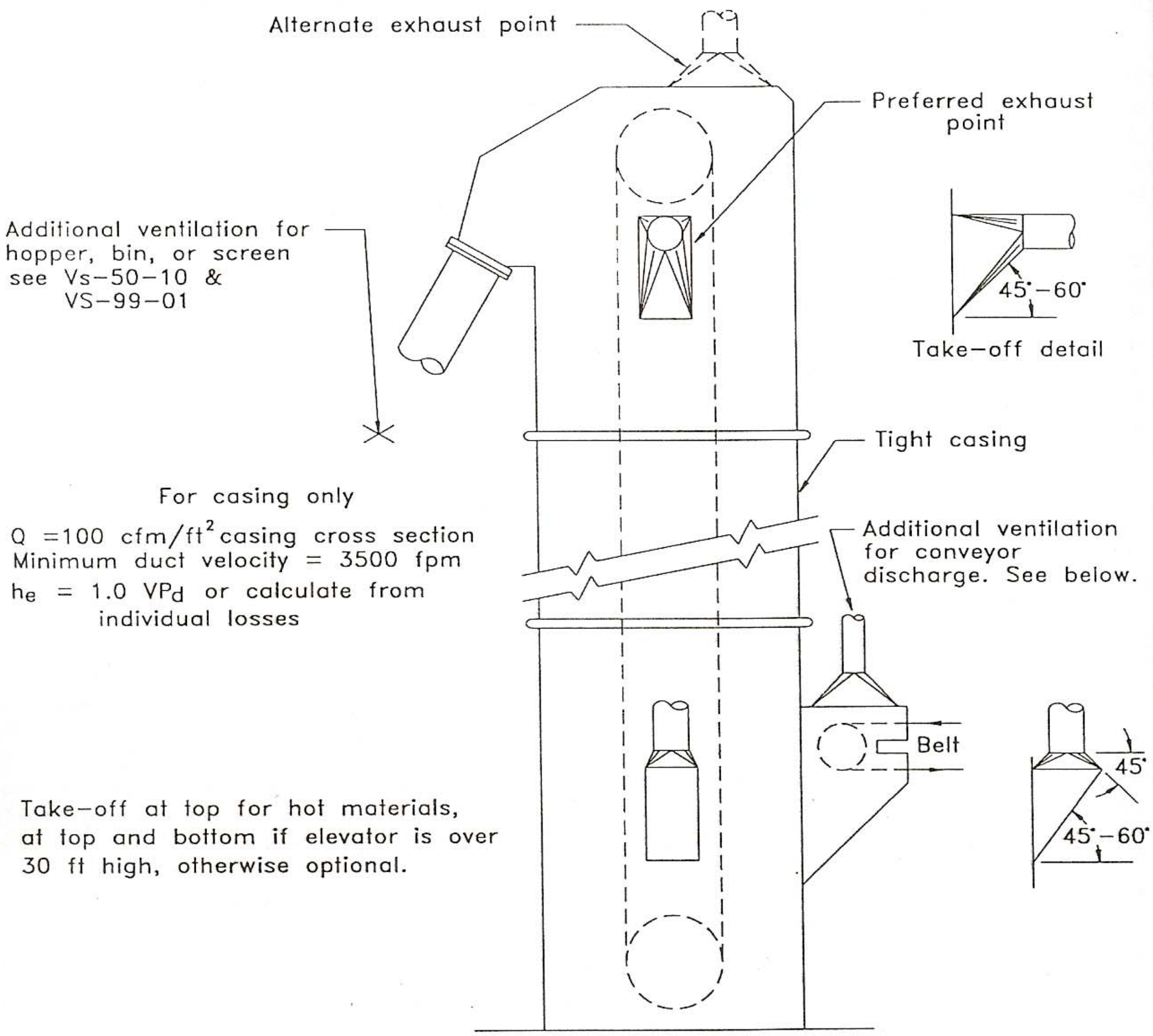


DETAIL OF BELT OPENING

Q = 350 cfm/ft belt width for belt speeds under 200 fpm. (minimum)
= 500 cfm/ft belt width for belt speeds over 200 fpm and for magnetic separators. (minimum)
Minimum duct velocity = 3500 fpm
$h_e = 0.25\ VP_d$

Conveyor belts:
Cover belt between transfer points
Exhaust at transfer points
Exhaust additional 350 cfm/ft. of belt width at 30' intervals. Use 45° tapered connections.

AMERICAN CONFERENCE OF GOVERNMENTAL INDUSTRIAL HYGIENISTS	CONVEYOR BELT VENTILATION	
	DATE 1–91	FIGURE VS–50–20



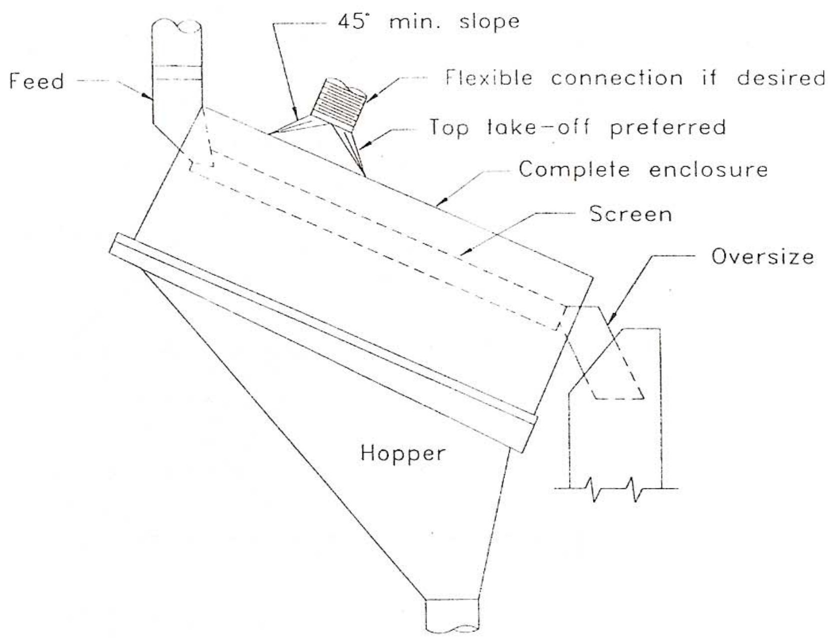
CONVEYOR BELT DISCHARGE VENTILATION

BELT SPEED	FLOWRATE
Less than 200 fpm	350 cfm/ft of belt width. Not less than 150 cfm/ft^2 of opening.
Over 200 fpm	500 cfm/ft of belt width. Not less than 200 cfm/ft^2 of opening.

AMERICAN CONFERENCE OF GOVERNMENTAL INDUSTRIAL HYGIENISTS

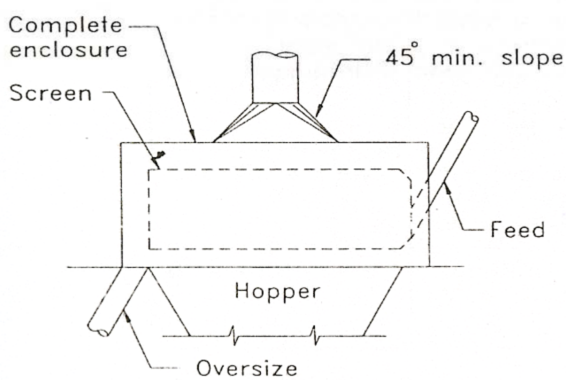
BUCKET ELEVATOR VENTILATION

DATE *1-91* FIGURE *VS-50-01*



FLAT DECK SCREEN

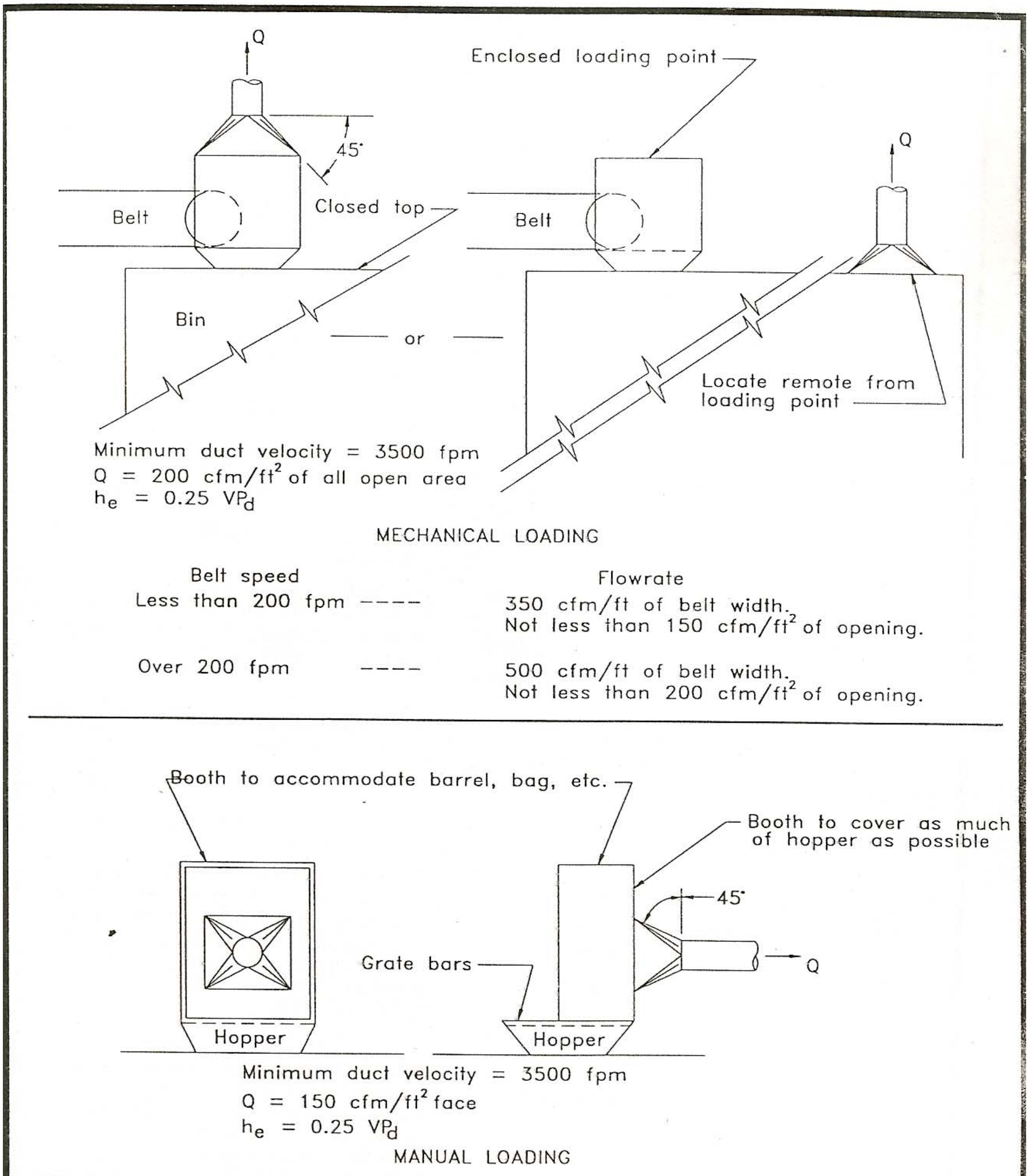
Q =200 cfm/ft^2 through hood openings, but not less than 50 cfm/ft^2 screen area. No increase for multiple decks
Minimum duct velocity = 3500 fpm
h_e = 0.50 VP_d



CYLINDRICAL SCREEN

Q = 100 cfm/ft^2 circular cross section of screen; at least 400 cfm/ft^2 of enclosure opening
Minimum duct velocity = 3500 fpm
h_e = 0.50 VP_d

AMERICAN CONFERENCE OF GOVERNMENTAL INDUSTRIAL HYGIENISTS	*SCREENS*	
	DATE *12–90*	FIGURE *VS–99–01*



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BIN & HOPPER VENTILATION

DATE *1-91* FIGURE *VS-50-10*

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