

Standard Operating Procedure for Spray Dryers in Dyes Industries



GPCB

Gujarat Pollution Control Board

SECTOR 10A | GANDHINAGAR

**Title:**

Standard Operating Procedure for Spray Dryers in Dyes Industries.

Published:

March 2026

Under Guidance of:

Shri R. B. Barad, IAS (Retd.), Chairman, GPCB

Shri D. M. Thaker, Member Secretary, GPCB

Shri Prasoon Gargava, Sc. F & DH , CPCB

Expert Members:

Dr. Chinmay Ghoroi, Professor, Chemical Engineering Dept, IIT- Gandhinagar

Dr. G. H. Ban, Associate Professor, LD College of Engineering, Ahmedabad

Shri Naresh Khatwani, Expert member - Spray dryer manufacturer

Shri Pankaj Dadhaniya, Expert member - Industries representative

Shri Deepak Dawda, Expert member - Industries representative

Team Members:

Shri Ashok Chauhan-Unit Head, Ahmedabad (E), GPCB.

Smt J. B. Pandya-Unit Head, Vapi, GPCB.

Shri L. M. Ahir, AEE, GPCB.

Disclaimer:

The purpose of this SOP is to standardize the process and provide guidance for the Spray Dryers in Dyes Industries to improve environmental performance. This document does not entitle any entity for any sort of relaxation / exemption from anything prescribed under any law/rules. This guideline is based on general and publicly available information & practices for reference purpose. The usage of this document is suggested along with relevant applicable Acts, Rules, Notifications, Circulars, Office Orders and Policies issued and amended from time to time.

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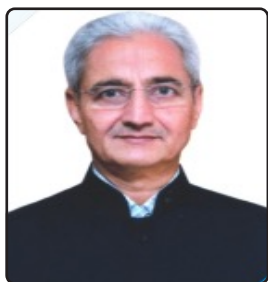


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FOREWORD



R. B. Barad, IAS (Retd.)
Chairman



Gujarat Pollution Control Board
"Paryavaran Bhavan", Sector-10A,
Gandhinagar-382 010, Gujarat

The Gujarat Pollution Control Board (GPCB) has consistently undertaken proactive environmental improvement initiatives through scientific studies, field assessments, stakeholder consultations and adoption of best available technologies to address pollution challenges across various industrial sectors.

The dyes manufacturing sector is one of the most significant contributors to Gujarat's industrial growth and plays a vital role in supporting the textile and allied industries across the country. With the progressive shift from conventional drying practices to spray drying technology, the industry has achieved improvements in process efficiency, product quality and resource optimization. However, the spray drying of dyes also poses environmental challenges, particularly in the form of emission of extremely fine particulate matter, which are long-persistent in the atmosphere and can remain suspended and travel over considerable distances if not effectively managed through high-precision air pollution control systems. This has implications for ambient air quality and public health.

This Standard Operating Procedure (SOP) has been prepared to address these concerns in a systematic manner, based on scientific assessment, particle size distribution studies, best available technologies and practical operational experience from the field. The collective implementation of this SOP is expected to contribute towards sustainable industrial development and improved air quality in and around industrial areas of Gujarat.


(R. B. Barad)

ABBREVIATIONS



APCM	:	Air Pollution Control Measures
CPCB	:	Central Pollution Control Board
FD	:	Forced Draft
GIDC	:	Gujarat Industrial Development Corporation
GPCB	:	Gujarat Pollution Control Board
HAG	:	Hot Air Generator
ID	:	Induced Draft
LPG	:	Liquefied Petroleum Gas
SOP	:	Standard Operating Procedure
TDS	:	Total Dissolved Solids
DV	:	Diameter of Volume
ESP	:	Electro Static Precipitator

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1

Introduction

Gujarat is one of the most industrialized states in India with a variety of industries, the principal ones being Textile, Engineering, Chemicals, Pharmaceuticals, Soda Ash, Dyes & Dyes Intermediate, Cement, Vegetable Oils, Pesticides, etc. Gujarat's textile industry has grown significantly over the years, and the state is known as the "Textile State of India". The two major textile manufacturing cities in Gujarat are Ahmedabad and Surat.

Dyes are a principal raw material in textile industries. Gujarat is also one of the largest producers of dyes and dye intermediates in India, both of which are widely used in the textile processing sector. In the production of dyes, dyestuff and pigments, a drying stage is required to convert liquid feedstocks into powdered products. One of the most suitable industrial methods to achieve this requirement is spray drying because of its low operating cost, process simplicity, operational ease and high encapsulation efficiency.

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Need of the SOP

The dye manufacturing industries have seen a significant shift from the conventional salting process to the modern spray drying technique due to several advantages associated with efficiency, environmental impact, and product quality. One of the major challenges of the spray drying of dyes is air pollution caused by the dispersion of fine Particulate Matter (PM) in the form of dye dust during the atomization and drying process, particularly if proper emission controls are not in place. Many times areas around the spray dryers face issue of air pollution due to functional inadequacies or inadequate air pollution control measures adopted by spray dryers used in dye manufacturing. Frequent complaints are received by the Gujarat Pollution Control Board in this regard. The air quality in the area remains a major concern and continuous monitoring and regulatory actions are necessary to ensure compliance with air quality standards.

3

Objective of the SOP

The objective of this Standard Operating Procedure (SOP) is to improvise the operation of spray dryers used in dye manufacturing and the provision of Air Pollution Control Measures (APCMs). This SOP is not only crucial for ensuring compliance with air quality standards and improved operational efficiency but also to overcome air pollution related issues arising due to spray dryers. This SOP is prepared to update and strengthen the earlier guidelines, which were based on the study conducted by the Dharmsinh Desai University, Nadiad.

This SOP outlines the procedures for safe, efficient, reliable, leak-proof automated operation and maintenance of spray dryers of dyes along with their APCMs (viz. cyclone, bag filter, and water scrubber system, etc.)

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Scope of SOP

The dye and dye intermediate manufacturing units located in the state of Gujarat may refer this SOP to improvise the operation and performance of spray dryers. The scope covers:

- I. All dye spray drying industries, including the industries engaged in dyes spray drying on job work basis as well as industries having captive dyes spray drying facility.
- II. The SOP will be applicable to the upcoming spray dryers from the date of publication. The existing units shall upgrade their facilities and air pollution control measures including bag filter as per the provisions of the SOP within one year from the date of publication.
- III. All industries shall comply with the standards/norms prescribed from time to time by CPCB and GPCB.

Gujarat is the leading hub for dye manufacturing in India, contributing significantly to the textile, chemical, and related industries. The state specializes in producing a wide range of dyes, such as Acid dyes, Reactive dyes, Direct dyes, and Pigment dyes.

Major characteristics of the dyes mainly manufactured in the state are mentioned below

Sr. No	Character-istics	Name of Dyes			
		Acid dyes	Reactive dyes	Direct dyes	Pigment dyes
1	Color Range	Offer a wide range of bright and vibrant colors.	Offer a broad spectrum of bright, vibrant, and even pastel shades.	Available in a wide range of colors, including vibrant and pastel shades.	Offer a wide range of colors, though the intensity and depth may not be as vibrant as those of reactive or acid dyes.
2	Solubility in Water	Moderate	High	Moderate	Low
3	Application	Applied in acidic conditions (pH around 4-6).	Applied under alkaline conditions (pH around 10-11).	Applied from a neutral or slightly alkaline dye bath.	Applied to fibers or materials in a dry or dispersed state and typically require a binder to adhere to the substrate.
4	Common Uses	<ul style="list-style-type: none"> Textiles: Wool, Silk, and Nylon fabrics. Cosmetics: Hair dyes and Cosmetics. Food Industry: Some are used as food colorants under strict regulations. 	<ul style="list-style-type: none"> Textiles: Cotton, Linen, Viscose, and blends of these fibers with synthetic fibers. Printing: Used in textile printing due to their excellent color fastness. 	<ul style="list-style-type: none"> Textiles: Cotton, Linen, Viscose, and their blends. Paper Industry: Used to dye paper Leather Industry: Used in leather dyeing. 	Pigments are widely used in Textiles, Inks, Coatings, Paints, Plastics, and Cosmetics. They are particularly useful in printing, dyeing synthetic fabrics, and creating vibrant colors in various industrial products.

Parameters such as solubility, pH, solid content, thermal sensitivity, and particle size are very useful while designing spray dryers and their APCMs.

6.1 Components of a Typical Spray Dryer

- a. Feed System:
 - Delivers liquid or slurry feed to the atomizer
 - Components: Feed tank, pump, and feed pipes
- b. Atomizer:
 - Converts liquid feed into fine droplets
 - Types: Rotary atomizers, pressure nozzles, pneumatic nozzles
- c. Drying Chamber:
 - The main body where drying takes place
 - Designed to provide sufficient residence time for moisture evaporation
- d. Hot Air Generator (HAG):
 - Supplies heated air for the drying process
 - Types: Direct or indirect hot air generators
- e. Product Collection System:
 - Separates and collects dried powder
 - Types: Bottom of the spray dryers, cyclone separators, bag filters

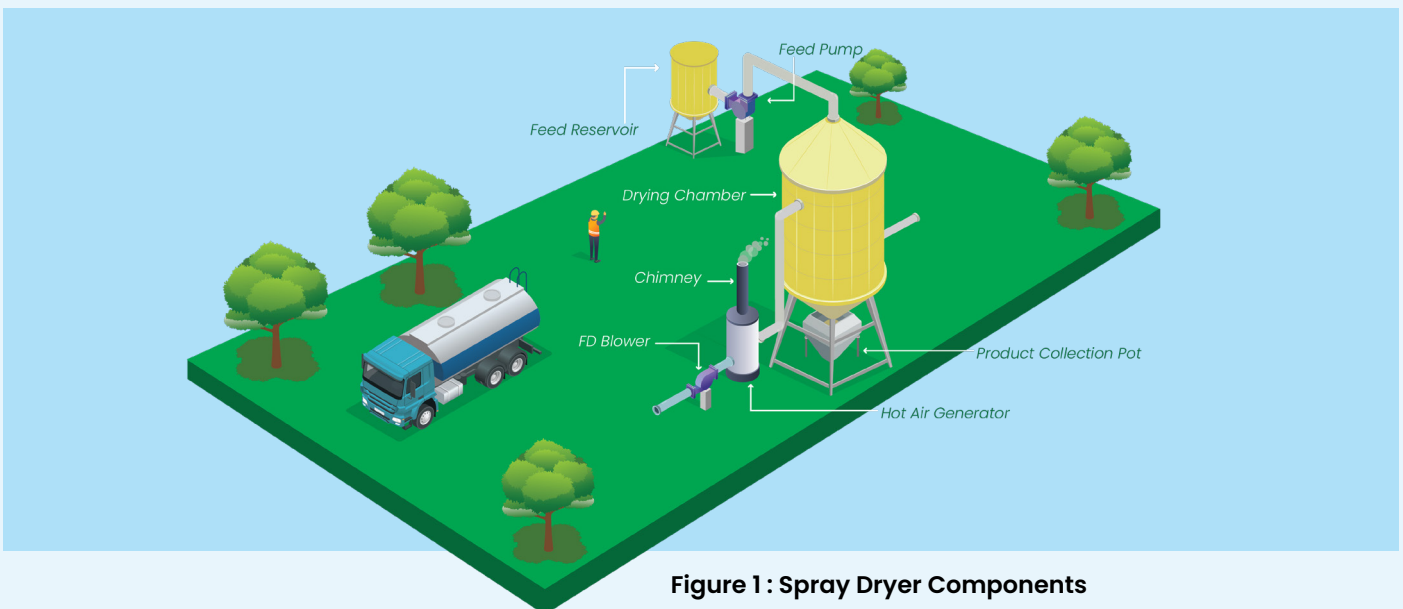


Figure 1 : Spray Dryer Components

These components work together to efficiently transform liquid feedstock into uniformly dried powder with desired characteristics, making spray dryers application versatile for various industries, including dyes, food processing, and pharmaceuticals.

6.2 Hot Air Generator in Spray Dryers

A Hot Air Generator (HAG) is a crucial component of a spray drying system. It provides the necessary hot air for efficiently and uniformly drying liquid feedstock to convert it into dry/powder/salt form.

6.2.1 Types of Hot Air Generators

- a. Direct-Fired HAG:
 - Uses fuels such as natural gas, liquid fuel, solid fuels, etc.
 - Combustion gases directly mix with the drying air.
 - Suitable for non-sensitive applications.
- b. Indirect-Fired HAG:
 - Uses fuels like natural gas, liquid fuel, solid fuels, etc.
 - Heat exchange occurs without direct contact between combustion gases and drying air.
 - Ensures cleaner, contaminant-free air.
 - Ideal for food, pharmaceuticals, and sensitive dyes.

6.2.2 Components of a Hot Air Generator

- a. Fuel System: Supplies fuel to the burner.
- b. Combustion Chamber: Burns fuel to generate heat.
- c. Heat Exchanger: Transfers heat to process air.
- d. Blower/Fan: Ensures adequate airflow to the drying chamber.
- e. Temperature Control System: Maintains desired outlet air temperature.

6.3 Various Types of Spray Dryers

There are several types of spray dryers, each with its own advantages and specific applications.

- a. **Rotary Atomizer Spray Dryer:** Uses a rotating disk to atomize the liquid feed into fine droplets. Suitable for large-scale production and can handle a wide range of feed materials.
- b. **Pressure Nozzle Spray Dryer:** Uses high-pressure nozzles to atomize the liquid. It is often used for products requiring a fine powder with a uniform particle size.
- c. **Two-Fluid Nozzle Spray Dryer:** Employs two fluids, typically air and the liquid feed, to create fine droplets. Commonly used for heat-sensitive and sticky products, as well as for low-capacity spray dryers.
- d. **Closed-Loop Cycle Spray Dryer:** Operates in a closed-loop system with inert gas, preventing oxidation and allowing the recovery of solvents. Ideal for drying products sensitive to oxygen or volatile solvents.
- e. **Multi-Stage Spray Dryer:** Combines spray drying with additional drying stages, such as fluid bed drying, to achieve a specific moisture content and improve powder properties.
- f. **Spray Dryer with Brooms:** Incorporates mechanical agitation to improve drying efficiency and prevent agglomeration. Suitable for viscous and sticky feed materials.

Each type of spray dryer has its unique features and is selected based on the specific requirements of the product and process. Rotatory Atomizer and Pressure Nozzle type spray dryers are mainly used in spray drying of dyes.

6.4 Working Principle of Spray dryer

The working principle of a spray dryer involves converting a liquid mixture into a dry powder by rapidly drying it with hot air.

- a. **Atomization:** The liquid feed is atomized into micro-droplets using an atomizer. This can be done using various methods like rotary, pressure, or centrifugal atomizers.
- b. **Hot Air Introduction:** Hot air (which acts as the drying medium) is introduced into the drying chamber. This air can be heated by using different energy sources such as gas, steam, electricity etc.
- c. **Contact:** The fine droplets of the liquid feed come into contact with the hot air in the drying chamber.
- d. **Evaporation:** As the droplets travel through the drying chamber, the moisture content of the droplets quickly evaporates due to the heat, leaving behind solid particles.
- e. **Separation:** The dried particles are then separated from the air using a collection system, cyclones, or bag filters.
- f. **Recovery:** The air, now cooled and laden with evaporated moisture, is exhausted from the chamber, often passing through a heat recovery system to improve energy efficiency.

6.5 Operation Procedures of Spray Dryer

6.5.1 Pre-Operation Inspection:

- a. Inspect the spray dryer for any signs of wear or damage.
- b. Check for any leakages, damage, or obstructions in the system (Based on previous day records and observations).
- c. Ensure that all valves and controls are in the correct position and in working conditions.
- d. Ensure that sufficient quantity of fuel & feed supply is available.

6.5.2 Startup:

- a. Start water scrubber pump.
- b. Start ID Fan and set chamber vacuum as per design.
- c. Start auto Lubrication. Pump.
- d. Start atomizer.
- e. Start HAG system and set temperature as per product requirement.
- f. Start feed pump on water mode once temperature reaches above 100°C.
- g. Start hummer.
- h. Rise temperature slowly and stabilize system. Set inlet temperature and outlet temperature as per product requirement.
- i. Note all parameters in log sheet every 60 minutes.

6.5.3 Operation:

- a. Monitor the system for any signs of abnormal operation, such as increased pressure drop, excessive noise, or unusual vibrations.
- b. Regular inspection of the cyclone, bag filter, and water scrubber during the operation. Regular inspection frequency must be pre-decided for each & every spray dryer along with records to be maintained and should be specified in SOP .
- c. Ensure that the spray dryer is operating at the correct temperature and feed rate.

6.5.4 Shutdown:

- a. Change system dyes mode to water mode.
- b. Stop firing in HAG.
- c. Step wise reduce inlet temperature.
- d. Stop feed pump.
- e. Stop atomizer.
- f. Stop auto lubrication pump.
- g. Stop scrubber pump.
- h. Stop ID blower.
- i. Stop hummers.

6.6 Temperature Profile in Spray Dryer for Dyes Industries

In the dye industry, a spray dryer is commonly used to dry the liquid dyes. The temperature profile in a spray dryer plays a crucial role in achieving the desired product quality (e.g. color, particle size, moisture content).

6.6.1 Inlet Temperature:

- a. Range: 120°C to 300°C (or as specified in design consideration)
- b. The inlet temperature is the temperature of the hot air entering the dryer. In the case of the dye industry, it must be high enough to ensure rapid evaporation of moisture from the liquid feed but not so high that it degrades the dye or causes unwanted chemical reactions.

6.6.2 Drying Chamber Temperature:

- a. Range: 60°C to 100°C (or as specified in design consideration)
- b. Inside the drying chamber, the temperature drops as the hot air mixes with the liquid feed. The drying process is faster at higher temperatures, but the product must not reach a temperature that cause damage or degradation of sensitive dye compounds.

6.6.3 Outlet Temperature:

- a. Range: 60°C to 100°C
- b. The outlet temperature refers to the temperature of the air and the dried powder exiting the spray dryer. The outlet temperature should be low enough to prevent overheating or degradation of the product, while ensuring that the moisture content is minimized to desired level.

6.6.5 Key Considerations:

- a. **Product Sensitivity:** Dyes can be sensitive to high temperatures, discoloration, or degradation of dyes. The temperature profile should be carefully controlled to prevent this.
- b. **Particle Size Control:** The temperature profile can also influence the size of the final powder particles. Lower inlet temperatures may produce larger particles, while higher temperatures produce finer particles.
- c. **Flow Rate of Feed:** The feed rate and droplet size also play a key role in the temperature requirements, which affect drying efficiency.
- d. Different types of dyes (e.g., acid dyes, direct dyes, and reactive dyes) may require slightly different temperature profiles due to their chemical properties.
- e. **Moisture Content:** Final product moisture content requirement typically ranges from 0.5% to 3%, depending on the specific dye formulation and desired product characteristics.

7

Sampling and Particles Size Analysis

In order to finalize the SOP for spray dryer of dyes, the exercise of particle size distribution and microscopic analysis was carried out through Sophisticated Instrumentation Centre for Applied Research and Testing (SICART), Anand, which is also a GPCB recognized Schedule-I Environment Auditor. Brief details of the particle size distribution analysis and microscopic analysis are provided herewith:

7.1 Method Adopted for Sample Collection:

Isokinetic sampling techniques were adopted for collection of particulate matter from the inlet of cyclone separator, outlet of cyclone separator and from chimney.

7.2 Particle Size Analysis by Particle Size distribution:

The Particle size distribution helps to describe the overall spread of particle sizes in a sample from fine particles at $D_v(10)$ to coarse particles at $D_v(90)$ with $D_v(50)$ giving a sense of the typical size.

- a. **Instrument Details:** Malvern Panalytical, Mastersizer-3000
- b. **Measurement Technique:** Laser Diffraction
- c. **Operational Condition:** Temperature: 24 °C & Humidity: 35%.
- d. **Interpretation of results:** The particle size distribution analysis of dyes particles was carried out by wet method as well as dry method. The particle size distribution analysis of samples collected from final outlet i.e chimney of spray dryer indicates that $D_v(90)$ is 5 μm i.e the 90% of the particles in the sample are smaller than the particle size 5 μm and only 10% particles are coarser than the particle size 5 μm .

7.3 Microscopic Analysis of Particles:

The microscopic analysis of samples collected from final outlet i.e chimney of spray dryer also confirms that contribution of particles of less than 5 μm is very high.

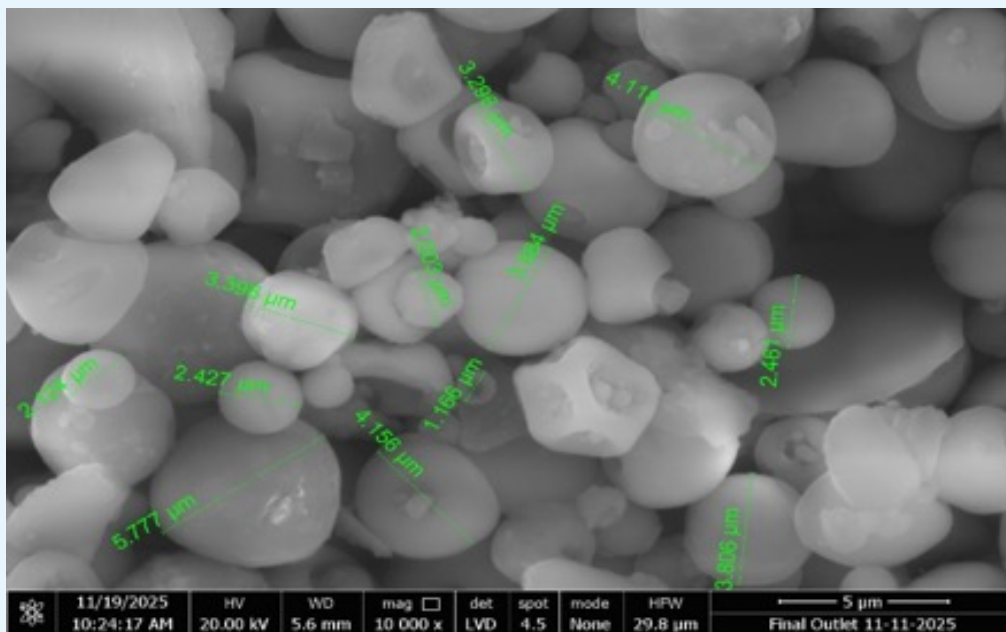


Figure 2 : Size of dyes particle

7.4 Need for Strengthening of Air Pollution Control Measures (APCMs):

In present condition cyclone separator and water scrubber are provided as APCM with spray dryers. However, cyclone separator works more as product recovery unit than the APCM. Literature study and practical experiences reveal that Cyclone Separators are not efficient for removal of particles of less than 5 μm size. As per the particle size distribution analysis and microscopic analysis carried out shows contribution of particles of less than 5 μm size is very high. In such situation Cyclone Separator cannot work as a sole Air Pollution Control Measures for control of extremely fine dye particle emission. Further the existing water scrubber performance is solely dependent on solubility of dyes particles and temperature of scrubber water. Considering this limitation, strengthening of the APCM is required. The bag filters are more efficient air pollution control measure for particulate matter than the cyclone separator. The bag filter is required for air pollution control because it effectively captures particles across the entire distribution, particularly smaller or fine particles, which are otherwise difficult to remove/capture by other means and pose greater health risks. ESP is also another option similar to APCM, which is having efficiency higher than 99%. But looking to its higher installation and operational cost, it may or may not be viable for use. However, selection of Bag Filters, ESP, Scrubber or combination of APCMs, Hybrid APCM should be decided with due consideration of effective control, product recovery, regulatory compliance requirement and local environmental conditions .

Based on the particle size distribution and microscopic analysis, the needs for a bag filter in air pollution control can be summarized as below:

- a. **Capture Fine Particles:** If the particle size distribution contains a significant fraction of fine particles, these particles are difficult to capture using other methods like cyclone separator. Bag filters are effective in removing the fine particles because they have a high surface area and can trap even very small particles from the air.
- b. **Filter Efficiency:** Bag filters operate by forcing polluted air through a fabric material that physically captures particles. Since these filters can efficiently capture particles down to a very small size, they are especially useful for industrial processes that generate fine particulate matter.
- c. **Regulatory Compliance:** The control of particulate emissions is the requirement of all the air pollution regulations, particularly for fine particles, which are more harmful to human health and the environment. A bag filter helps meet these standards by effectively capturing particles within the range indicated by the particle size distribution.
- d. **Preventing Health Hazards:** Fine Particulate Matter (PM_{2.5}) is known to pose significant health risks, including respiratory and cardiovascular issues. A bag filter helps in effective removal of such harmful particles from the emission, reducing the risk to human health in and around industrial settings.

8

APCMs to Spray Dryer

1. Cyclone Separator
2. Bag Filter
3. Water Scrubber
4. Dipping Tank before venting through stack (Chimney)

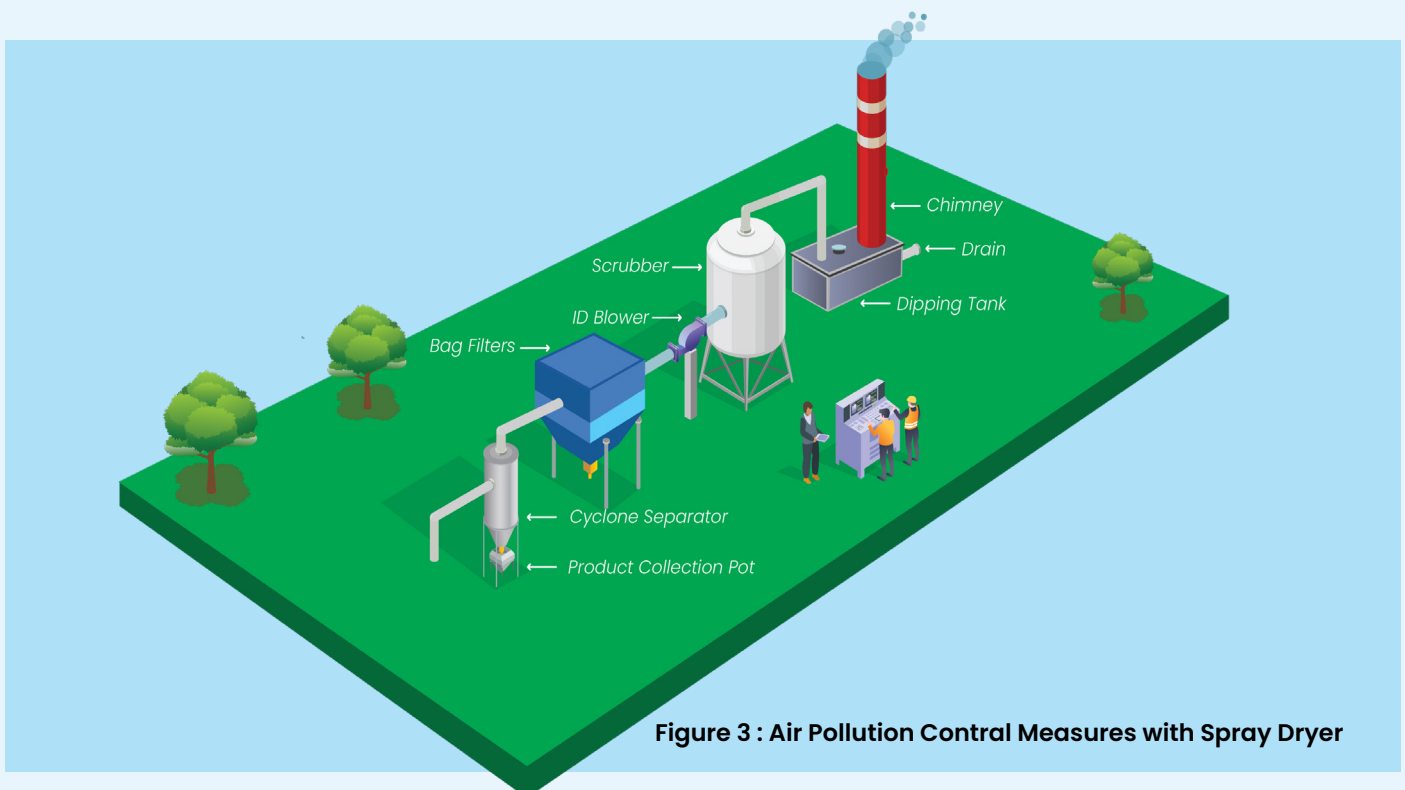
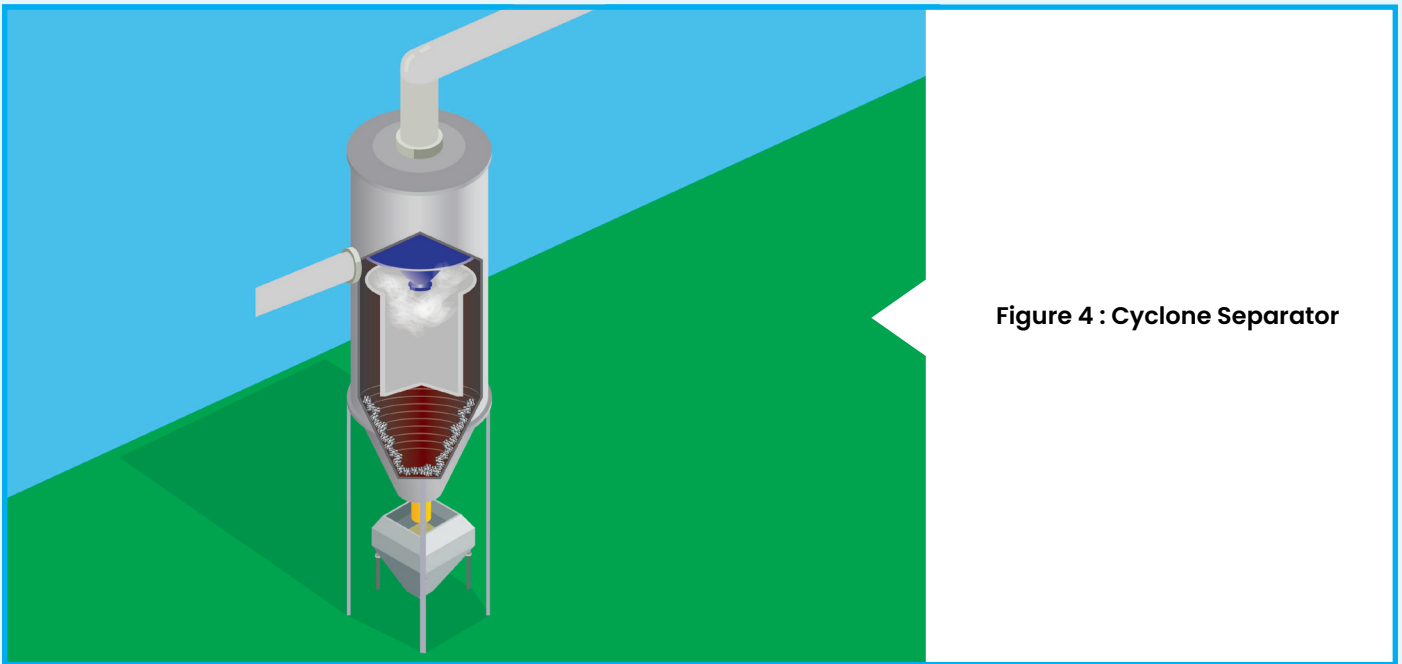


Figure 3 : Air Pollution Control Measures with Spray Dryer

Regular maintenance is crucial for ensuring the optimal performance and longevity of APCMs i.e. Cyclone separator, Bag filter and Water scrubber. Cyclone separator, Bag filter and Water scrubbers are used to remove particulate matter and gaseous pollutants from gas emission streams as described below.

9.1 Maintenance and Operation of Cyclone Separators:



A. Regular Inspections:

- a. **Visual Inspections:** Conduct visual inspections to identify any signs of wear, corrosion, or damage; such as cracks, leaks, or excessive erosion.
- b. **Component Checks:** Inspect the cyclone's components, including the body, cone, vortex finder, and chamber outlet pipe for any abnormalities.

B. Cleaning:

- a. **Dust Removal:** Clean the APCMs weekly to remove accumulated dust and to prevent clogging. Use appropriate cleaning methods, such as compressed air or water flushing, depending on the nature of the particles collected. Maintenance schedule along with its method should be prepared, displayed, and recorded as & when done.
- b. **Fouling Prevention:** Implement measures to prevent fouling, such as using anti-fouling coatings or adjusting operating conditions.

- c. **Surface Cleaning:** Depending on the application, periodic cleaning of the internal surfaces may be necessary to maintain efficiency. Maintenance schedule for dust removal through internal surface cleaning and methods thereof should be prepared, displayed & recorded as and when done.

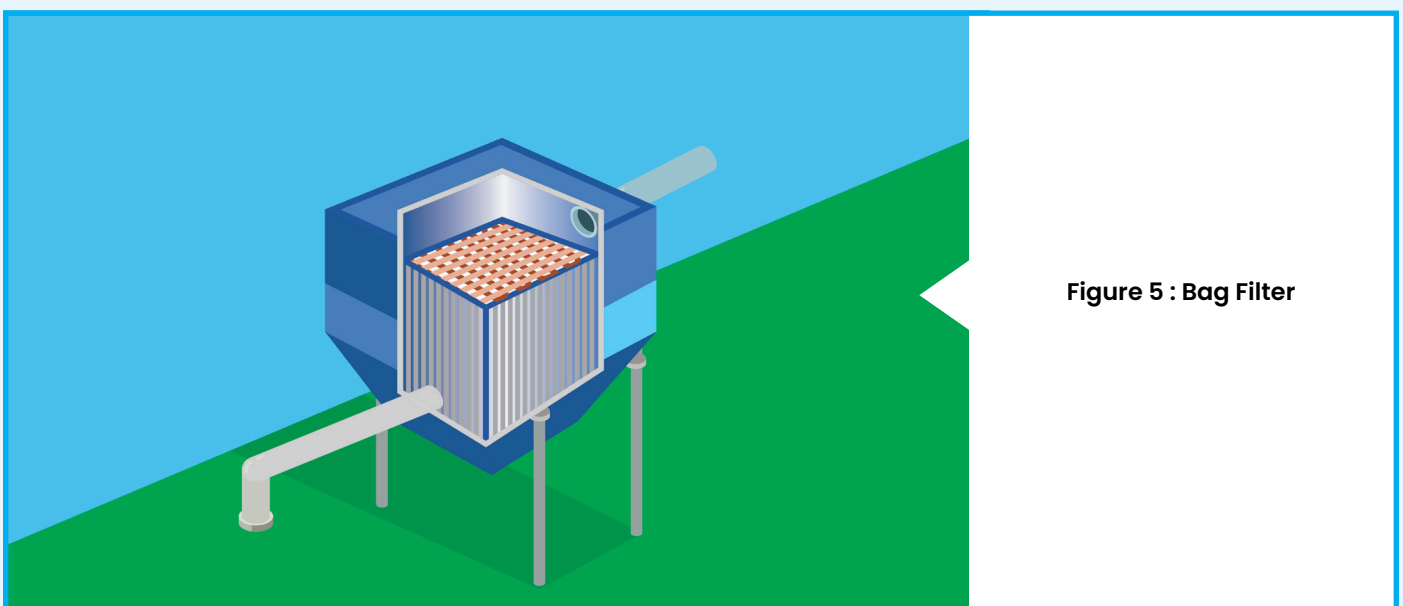
C. Maintenance:

- a. **Worn Parts:** Replace worn or damaged components, such as the vortex finder or outlet pipe, to maintain optimal performance and prevent failures. Follow the manufacturer's recommendations for component replacement intervals and specifications.
- b. **Seals and Gaskets:** Inspect seals and gaskets for wear or damage and replace them. It is necessary to prevent leaks.
- c. **Inlet and Outlet Ducts:** Check ducts for any signs of erosion or buildup that could affect airflow.
- d. **Moving Parts:** Lubricate any moving parts, such as bearings or seals, according to the manufacturer's instructions. Proper lubrication helps prevent premature wear and prolongs the cyclone's lifespan.
- e. **Inventory of Critical Parts:** Keep readily available stock of critical operational parts to avoid delay in replacement of parts during fault or emergency.

D. Performance Monitoring:

- a. **Efficiency Checks:** Regularly assess the cyclone's separation efficiency using appropriate methods, such as particle size analysis or pressure drop measurements. Efficiency assessment method of the cyclone must be displayed & recorded as and when done.
- b. **Performance Optimization:** Adjust operating conditions or maintenance practices as needed to maintain optimal performance.

9.2 Maintenance and Operation of Bag Filter.



A. **Operational Parameters**

- a. **Monitor Pressure Drop:** Regularly check pressure gauges to monitor the pressure drop across the filter.
- b. **Maintain Air Flow Rates:** Adjust air flow rates as necessary to maintain optimal performance.
- c. **Record Data:** Keep detailed records of pressure trends, bag life, and maintenance tasks.

B. **Startup Inspection:**

- a. Visually inspect the bag filter system for any damage or obstructions.
- b. Check the integrity of all electrical connections and control systems.
- c. Verify the availability of compressed air for cleaning the filter bags.

C. **Maintenance Tasks**

- a. **Visual Inspection:** Perform a daily visual inspection of the filter bags and housing for any signs of wear or damage.
- b. **Clean Housing:** Clean the filter housing and surrounding area daily to prevent buildup of solids.
- c. **Check Seals:** Inspect seals on daily basis for any signs of wear or leaks and replace if necessary.
- d. **Replace Filter Bags:** Replace filter bags according to the manufacturer's recommended schedule or when the pressure drop indicates replacement is needed.
- e. **Maintenance of Solenoid & Rotary Valves:**
 - Solenoid valves: Regularly check air pressure, diaphragm condition, coil functioning & clean ports to ensure proper pulse cleaning
 - Rotary valve: Inspect for wear, bearing condition shaft seal leakages to avoid jamming and air leak.
- f. **Lubricate Moving Parts:** Lubricate moving parts to ensure smooth operation.
- g. **Check Safety Equipment:** Ensure all safety equipment (e.g., gloves, masks) is available and in good condition.
- h. **Identify Issues:** Identify any operational issues (e.g., high pressure drop, leaks) and address them promptly.
- i. **Inventory of Critical Parts:** Keep readily available stock of critical operation parts/spares to avoid delay in replacement of parts.

D. **Performance Monitoring:**

- a. **Pressure transmitter:** Provide a pressure transmitter with the bag filter. When the pressure drop reaches a certain threshold, indicating that the bags are clogged, the control system triggers an alert.
- b. **Performance Optimization:** Adjust operating conditions or maintenance practices as needed to maintain optimal performance.

9.3 Maintenance and Operation of Water Scrubbers



A. Capacity of the Scrubber Water Tank:

Capacity of the scrubber tank should align with the capacity of the spray dryer. In no case the scrubber water tank should be less than 500 lit. capacity.

B. Regular Inspections:

- a. **Visual Inspections:** Conduct visual inspections to identify any signs of wear, corrosion or damage, such as cracks, leaks, or excessive erosion.
- b. **Component Checks:** Inspect the scrubber's components, including the packing, nozzles, sprays, pumps and the water distribution system, for any abnormalities

C. Maintenance & Cleaning:

- a. **Packing Cleaning:** Clean the packing material to remove accumulated particulate matter and prevent clogging. Use appropriate cleaning methods, such as water flushing or chemical cleaning, depending on the nature of the contaminants.
- b. **Nozzle and Spray Maintenance:** Clean the nozzles and sprays. Replace if they are clogged or damaged.
- c. **Water Distribution System:** Inspect and clean the water distribution system to ensure even water flow.
- d. **Settling Tanks:** Clean the settling tanks to remove sludge and contaminants.
- e. **Surface Cleaning:** Weekly cleaning of the internal surfaces are necessary to maintain efficiency of scrubber.
- f. **Worn Parts:** Replace worn or damaged components, such as the packing, nozzles, sprays, glands, flanges, gaskets/seals etc., to maintain optimal performance and prevent failures. Follow the manufacturer's recommendations for component servicing/replacement intervals and specifications.
- g. **Inventory of Critical Parts:** Keep readily available stock of critical operation parts to avoid delay in replacement of parts.

D. Scrubbing Media Quality:

- a. **Water Treatment:** Ensure that the water used in the scrubber is of the appropriate quality to prevent scaling, corrosion or fouling.
- b. **Water Treatment Chemicals:** Use appropriate water treatment chemicals, such as pH adjusters or corrosion inhibitors, to maintain water quality.
- c. Check the density of the scrubbing water using a hydrometer and replace the scrubbing water periodically.
- d. If using packing media, inspect it regularly for wear and tear, replacing it as necessary to maintain efficiency.

E. Corrosion Prevention:

- a. **Protective Coatings:** Corrosion-resistant materials are recommended for scrubber construction. Apply protective coatings or linings to the scrubber's internal surfaces to prevent corrosion.

F. Performance Monitoring:

- a. **Efficiency Checks:** Regularly assess the scrubber's removal efficiency.

G. Pump Maintenance

- a. **Regular Checks:** Inspect and maintain pumps, ensuring they are operating efficiently and without leaks.
- b. **Seal and Bearing Inspection:** Check seals and bearings regularly and replace them if there are signs of wear.

9.4 Maintenance of Enclosure Room

- a. Check leakages in enclosure room and rectify if any leakages observed.
- b. **Cleaning:** Make periodic cleaning schedule of enclosure room and make record of cleaning.

9.5 Maintenance of Dipping tank

- a. Provide water level indicator and maintain adequate water in dipping tank.
- b. **Cleaning:** Make periodic cleaning schedule of dipping tank and make record of cleaning.

9.6 Monitoring of Stack

- a. **Stack and Sampling Point:** Provide adequate stack with minimum height of 15 meters, along with ladder, platform, and pothole for stack monitoring of emission from the stack. The publication "Emission Regulation Part-III" published by CPCB may be referred to make proper provision.
- b. **Emission Monitoring:** Carry out emission monitoring of stack using standard methods at regular interval also with and record details in logbook.

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Minimum Automation and Interlinking System Requirement

Advance technology-based operation system should be provided with spray dryer and air pollution control measures as under:

- a. Interlinking between startup temperatures and feeding of the solution with operational status of air pollution control measures should be provided.
- b. Automated system of water level sensors with dosing system and automated water quality indicators with display should be provided in scrubbers.
- c. Automated water level indicator in dipping tank should be provided.
- d. Hooter indication should be interlinked in case of adverse temperature & feed rate as well as abnormal pressure in cyclone & bag filter.
- e. Interlinking of scrubber pump with operation of spray dryer should be provided in such a way that spray dryer will not start if scrubber pump is tripped.
- f. Interlinking of ID blower & FD blower with feed pump & burner should be provided in such a way that tripping of the blowers results in automatic tripping of feed pump & burner.
- g. Tripping of feed pump to be interlinked to tripping of burner.
- h. Hooter indication in case of abnormal inlet & outlet temperature
- i. Any other necessary measure without compromising the safety aspect and overall efficient operation and maintenance of the system.

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Record Keeping

Records of the following desired to be maintained in the logbook or electronically.

- a. Record of regular & periodic inspection of APCMs.
- b. Record of cleaning of APCMs.
- c. Record of maintenance of APCMs, pumps, and spray dryer.
- d. Record of replacement of parts.
- e. Daily records of pressure data of cyclone & bag filter.
- f. Daily records of scrubber media quality in terms of pH, density, and quantity.
- g. Record data of scrubber media change data.
- h. Records of spot test carried out along with filter papers of last 3 months.
- i. Record of preventive maintenance schedule and checklist to be made available at site.

12.1 Do's for Spray Dryer

- a. Keep all the facilities ready. Feed tank, water tank, and scrubber tank should be filled sufficiently before starting the plant.
- b. Lubricate ID blower bearings every week.
- c. Clean oil filter of atomizer lubrication pump every week.
- d. Change the atomizer lubrication oil when its color becomes dark.
- e. Clean the dryer chamber every week.
- f. Keep ID blower running for at least 20 to 30 minutes after the plant is shut down.
- g. Open the dryer chamber door in case of power cut or emergency shutdown.
- h. Keep all spare parts ready to avoid production loss.
- i. Turn on feed supply valve and water supply valve manually before starting the plant.
- j. Refer the operation manual provided by the equipment supplier for precise and timely actions.
- k. Use, store, treat and dispose waste/waste water generated in the process such as Used Oil, Exhausted Scrubbing Media, Residues, Sludge etc. in environmentally sound manner with compliance of prescribed regulatory conditions/norms.

12.2 Don'ts for Spray Dryer

- a. Don't use excessive heat.
 - b. Don't ignore feed homogeneity.
 - c. Don't neglect maintenance.
 - d. Don't overlook safety measures.
 - e. Don't allow powder build-up.
 - f. Do not run the atomizer lubrication oil without oil.
 - g. Do not run the feed pump dry during operation.
 - h. Do not run the atomizer oil alone for a long time.
 - i. Do not concentrate scrubber water more than 10% TDS.
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1. <https://www.spray.com/en-in/-/media/dam/industrial/usa/sales-material/technical-manual/tm402-spraydry-manual.pdf>
2. Handbook of Industrial Drying by Arun S. Mujumdar (editor) Third Edition.
3. Handbook on Spray Drying Applications for Food and Chemical Industries edited by M. Selvamuthukumar.
4. AIR POLLUTION CONTROL TECHNOLOGY HANDBOOK, Authored by Karl B. Schnelle, Jr., Ph.D., P.E. Vanderbilt University Nashville, Tennessee Charles A. Brown, P.E. VECO Pacific, Inc. Bellingham, Washington.
5. <https://gcwgandhinagar.com/econtent/document/1588318895ClassificationOfDyes.pdf>
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GPCB

Gujarat Pollution Control Board

**Paryavaran Bhavan, Sector-10A,
Gandhinagar-382010.**

Phone : (079) 2323 2152

Website: <https://gpcb.gujarat.gov.in/>