RoboVent®
A Nederman Company

A Visual Guide to Combustible Dust Collection

The Dangers of Combustible Dust and How to Minimize Your Risk in Regards to Spark Arrestance, Fire Suppression and Explosion Protection

What Is Combustible Dust?

An Introduction to Combustible Dust

Combustible dust is a serious risk for many manufacturers. Designing the best combustible dust mitigation strategy depends on many factors, including your dust characteristics, hazards related to your processes, facility constraints, and more. In almost all cases, part of that strategy will include a dust collection system. At RoboVent, we understand the dangers of combustible dust and how to minimize your risks, from the Dust Hazard Analysis to dust collection system safety. This guide provides a high-level overview of some of the key questions and decisions you will need to address when designing a combustible dust solution.

Combustible dusts include (but are not limited to):

- Food dust (e.g., sugars, flours, starches, cocoa powder, milk solids)
- Woodworking and paper dust
- Textile dust
- Plastic and rubber dust
- Many metalworking dusts (e.g., aluminum, iron, titanium, magnesium)
- Weld fume dust

What Causes a Dust Explosion?

Five elements must be present to produce a combustible dust explosion (known as the "Explosion Pentagon"). A deflagration can occur when:

- a **combustible dust**
- is **suspended** in the air
- in an **enclosed** area
- where there is an **oxygen** source
- and a source of **ignition**.

Meet our Director of Engineering, Alysha Yinger

The National Fire Protection Agency (NFPA) defines combustible dust as "any finely divided solid material that is 420 microns or smaller in diameter and presents a fire or explosion hazard when dispersed and ignited in air." If such a dust is suspended in air in the right concentration, under certain conditions, it can become explosible.

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Dust Analysis Key Takeaways

Dust Analysis Key Takeaways

You need to have your dust analyzed. What's next? Learn about the different kinds of combustible dust testing and the Dust Explosion Classes. Download our guide to learn how to collect a dust sample that will be usable by a certified lab.

Key Questions:

- Is the dust combustible/explosible?
- How explosible is the dust?
- How much damage could an explosion create?

Facility Testing & Engineering

Does dust burn in a pile and/or explode in a cloud?

Conduct a go/no go test

YES:
Dust is combustible, proceed to explosibility testing & DHA

NO:
Dust is not combustible (stop)

How combustible is the dust? How severe could an explosion be?

Conduct an explosion severity test to get K_{ST} & P_{MAX} values

Proceed to full DHA & process hazard analysis

Optional: conduct additional testing (e.g., MIE, MIC, MIT)

Download How to Collect a Dust Sample

Download RoboVent's easy-to-follow guide detailing the best method for securing your dust sample.

Dust Explosion Classes Chart

KST (Bar.m/s)	Dust Explosion Class	Characteristic	Typical Examples
0	ST 0	Does not explode	Rock dust, silica
>0 and ≤200	ST 1	Weak explosion	Powdered milk, charcoal, sulfur, sugar, zinc
>200 and ≤300	ST 2	Strong explosion	Celluslose, wood flour, poly methyl acrylate
>300	ST 3	Very strong explosion	Anthraquinone, aluminum, magnesium

*(based on Kst)

Process Analysis & Mitigation Options

Process Analysis & Mitigation Breakdown

Key Questions:

- Where does combustible dust come in contact with oxygen?
- Where does dust form a cloud?
- Where are dust clouds confined?
- What are possible sources of ignition?

Understanding the Explosion Pentagon can help you identify hazards and make mitigation decisions. Learn the five elements and possible mitigation strategies for each.

Ignition

- What are possible external sources of ignition near the dust cloud? (Sparks, heat, open flame)
- Is the dust susceptible to auto-ignition?
- Possible mitigations: active or passive spark control, removal of flame or heat sources & anti-static filters. Implement proper bonding and grounding procedures.

Confinement of Dust Cloud

- Where are dust clouds contained?
- Possible mitigations: source capture & removal of containment. Install explosion protection devices onto confined spaces.

Oxygen in Air

- Is oxygen present (e.g., standard atmosphere)?

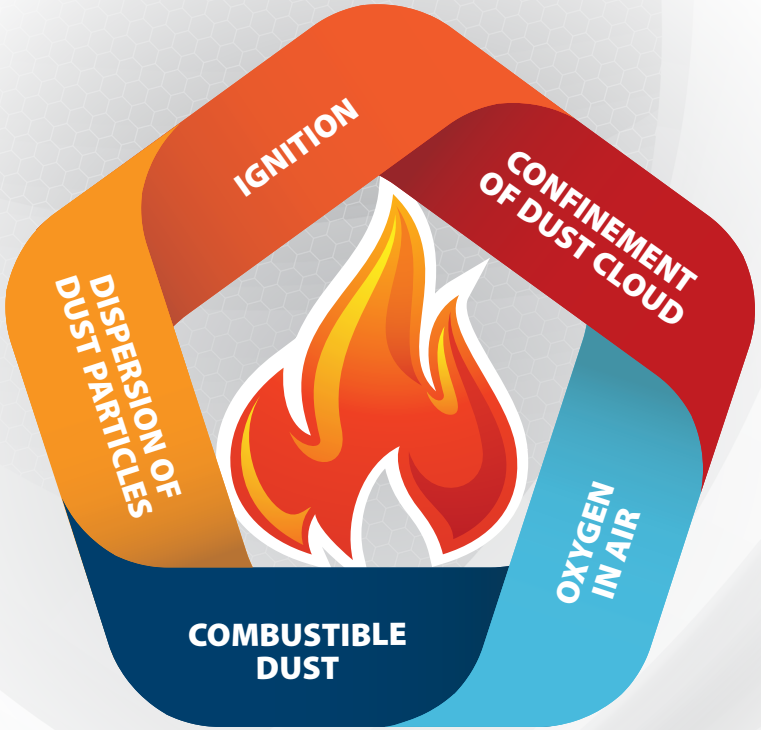
Combustible Dust

- What is the ST Class and KST value of the dust?
- Are there flamable/explosive vapors or gases present?
- Other flammable/explosive materials nearby that could sustain a reaction?
- Possible Mitigation: Eliminate or substitute combustible material in the process with non combustible alternatives. Introduce inert materials into areas containing combustible dusts (such as dust collectors).
- Remove/isolate processes and/or materials.

Dispersion of Dust Particles

- Where are dust clouds created?
- Possible mitigations: dust collection, changes to conveying/transport to reduce cloud formation & housekeeping standards.

Explosion Pentagon



Disclaimer: A Process Hazard Analysis is a complex process that must be customized for the unique characteristics and risks of the facility. It is best to conduct a PHA with a knowledgeable engineering partner. Mitigation recommendations above are not exhaustive and may or may not apply to a specific facility's situation.

Dust Collector Safety:

Spark Arrestance • Fire Prevention & Suppression • Explosion Protection

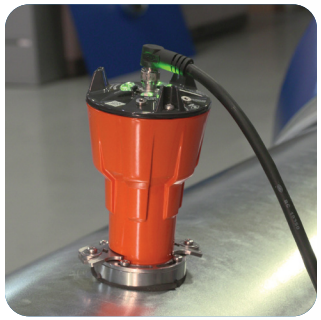
Spark Control & Mitigation Options

Delta3 Inline Video

Passive and active spark mitigation options and when to use them.

If embers are slow to extinguish, consider:

Wet Collection



Active spark control (detect-&-suppress)[1]

Abort Gates

If embers are quick to extinguish, consider:

Centrifugal (Delta3™ Inline)

Wire mesh/ baffle systems

Types of Sparks:

- Passive (mechanical) spark arrestance including centrifugal collectors, wire mesh screens, baffle systems and dropout boxes
- Active spark control systems that detect sparks and extinguish them with water or chemicals

[1] May not be adequate for explosion prevention when handling combustible dusts.

Fire Suppression

Learn more about the classes of fire produced by each dust type and best practices for suppressing and extinguishing fires in a dust collector.

Water Sprinkler System

PROS:
Cost effective, simple, extinguishes fire completely, safe for people.

CONS:
Messy if used, requires connection to water system, may cause water damage to facility or equipment.

USED FOR: A
(Do NOT use for Class D fires)

Clean Agent Gas

(e.g., CO_2, Argon, Inergen, Halocarbons, FM200)

PROS:
Little to no clean-up if deployed, residue-free, safe for electronics, some types safe to use in occupied areas.

CONS:
May be more expensive, some (like CO_2) not safe to use in occupied areas.

USED FOR: A B C
(Depending on gas used)

Dry Powder Chemical Agent

(e.g., Sodium Bicarbonate, Mono-amomium Phosphate, Graphite, Sodium Chloride

PROS:
Highly effective; can be used for Class D fires; can be used in extreme temperatures.

CONS:
Very messy if deployed; extensive clean-up required.

USED FOR: B C D
(Depending on chemical agent)

Key Questions:

- What are the characteristics of the collected dust?
- What class of fire (A, B, or D) would be produced by this dust type?
- Is the collector located inside or outside?
- Will people be working in the vicinity of the dust collector?

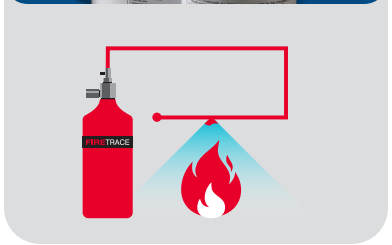
Fire Classes Legend:

- **A** **Ordinary Combustibles:** Wood, paper, cloth, etc.
- **B** **Flammable Liquids:** Grease, oil, paint, solvents
- **C** **Live Electrical Equipment:** Electrical panel, motor, wiring, etc.
- **D** **Combustible Metal:** Magnesium, aluminum, etc.
- **K** **Commercial Cooking Equipment:** Cooking oils, animal fats, vegetable oils

Fire Protection

Watch Fire Supression Video

Release Options for Fire Protection

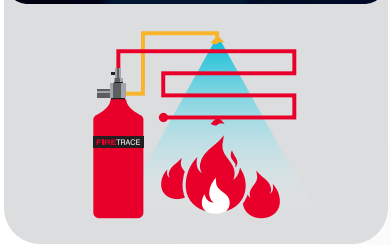


Direct Release

Uses a direct mechanism such as heat-triggered tubing to release agent.

PROS:
Failsafe, automated mechanism

CONS:
Less control in directing agent

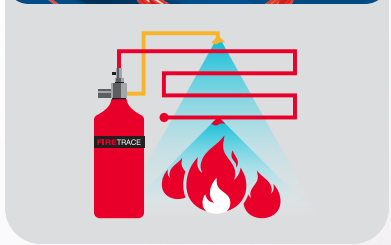


Indirect Release

Uses a sensor mechanism to trigger release through mounted nozzles.

PROS:
Can achieve more complete and effective flooding of zone

CONS:
Will not work if sensor malfunctions



Dual-Release

Uses a combination of mechanisms.

PROS:
Combines benefits of both systems for enhanced safety and efficacy

CONS:
May be more expensive

Explosion Protection & Isolation

Dust collection systems for combustible dust must be equipped with an NFPA-compliant deflagration system to reduce the potential for harm. Here are the basic elements for dust collector explosion protection.

Dust collector explosion protection must be designed in accordance with:

- NFPA 68 (Standard on Explosion Protection by Deflagration Venting)
- NFPA 69 (Standard on Explosion Prevention Systems)

Chemical Explosion Protection

Rotary Airlock

Explosion Vent

Flameless Vent

Isolation Valve

Key Questions:

- Are dust and flames safe to release?
- Is the collector located inside or outside?
- Is air returned to the facility?

Watch Explosion Video

Senturion

Powerful protection for ST1/ST2 explosive dusts

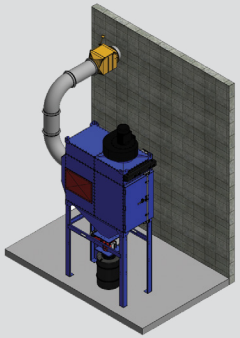
- Flexible
- Modular
- Space Saving
- Tough

Explosion Protection Strategies for Dust Collection

Dust Collector Explosion Protection

There are many ways to design a dust collection system with the given variables of a particular application. Options shown below are the most common configurations we see in the field.

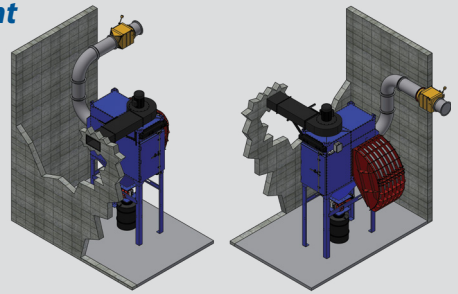
Collector Outside – Clear Safety Zone



Standards
- NFPA 652
- NFPA 68 (Venting)
- NFPA 69 12.2.4.4.1 (Rotary Airlock)

Protection
- Isolation on inlet line to collector
- Discharge directed to a safe unoccupied location (or outfitted with isolation to return back to the building or a process)
- Explosion venting on unit (Explosion relief panels directed towards an unoccupied area)
- Rotary airlock with close clearance as a form of isolation on discharge

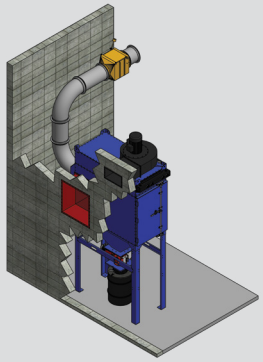
Collector Inside – Flameless Vent



Standards
- NFPA 652
- NFPA 68 6.9 (Venting with Flame Arresting & Particulate Retention)
- NFPA 69 12.2.4.4.1 (Rotary Airlock)

Protection
- Isolation on inlet line to collector
- Discharge directed to a safe unoccupied location (or outfitted with isolation to return back to the building or a process)
- Explosion venting into a Flameless vent (flame arresting device)
- Rotary airlock with close clearance as a form of isolation on discharge

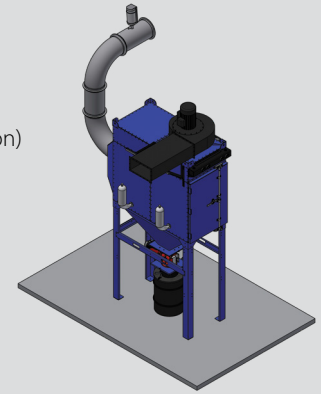
Collector Inside – Vented Outside to Clear Safety Zone



Standards
- NFPA 652
- NFPA 68 6.8 (Venting Through Discharge Ducts)
- NFPA 69 12.2.4.4.1 (Rotary Airlock)

Protection
- Isolation on inlet line to collector
- Discharge directed to a safe unoccupied location (or outfitted with isolation to return back to the building or a process)
- Explosion venting on unit near exterior wall. Relief vent directed through the wall with properly sized discharge duct (Explosion relief panels directed towards an unoccupied area)
- Rotary airlock with close clearance as a form of isolation on discharge

Collector Inside – Suppression

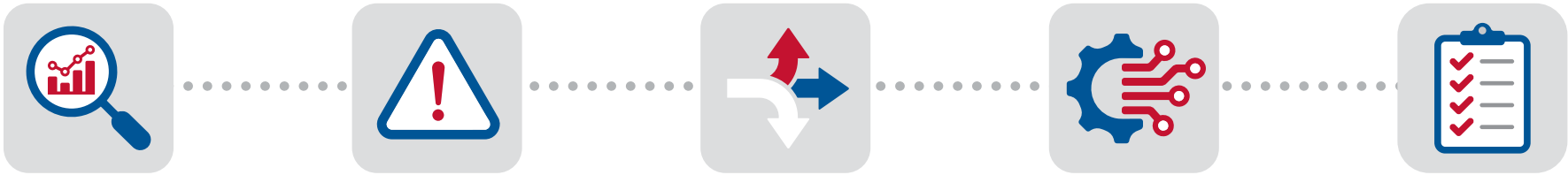


Standards
- NFPA 652
- NFPA 69 Chapter 10 (Deflagration Control by Suppression)
- NFPA 69 12.2.4.4.1 (Rotary Airlock)

Protection
- Isolation on inlet line to collector
- Discharge directed to a safe unoccupied location (or outfitted with isolation to return back to the building or a process)
- Chemical Suppression system designed to withstand a deflagration inside of the unit
- Rotary airlock with close clearance as a form of isolation on discharge

Summary of the Combustible Dust Collection and Mitigation Process

Do you need a Dust Hazard Analysis (DHA)? If you are working with known combustible dust, or are not sure whether your dust is combustible, the answer is probably yes. This is an overview of what you can expect during the process.



Dust Analysis

- Industry data
- Literature data (eg., NFPA Standards, DustEx datatbase)
- Combustion Screening (Can dust burn in a pile?)
- Go/No Go Test (Is dust explosible in a cloud?)
- Explosibility Testing (Kst, PMAX, Minimum Ignition Energy (MIE), Minimum Ignition Temperature (MIT))

Process Analysis

- Presence of dust + oxygen/airflow
- Identification and likelihood of ignition sources
- Likelihood of a hazardous atmosphere
- Airborne clouds of dust
- Containment
- A PHA/DHA will result in the identification of potential fire and explosion hazards
- A DHA is required according to NFPA 652 (and NFPA 61 for agriculture and food dust).

Mitigation Options

- Inerting with dust additives[1]
- Dust collection
- Removal of ignition sources
- Housekeeping and mainenance (eg., bag cutting and damping techniques, increased PMS and inspections
- Administrative safeguards

System Design (NFPA Compliance)

- Collector choice (dry media, cyclone, wet collector)
- Collector placement (inside vs. outside)
- Air return vs. exhaust
- Fire & explosion protection (water, chemical, CO_2)
- Deflagration system
- Spark control (active or passive)

Documentation & Verification

- Pre/post mitigation data
- Documentation of hazards & mitigation actions
- DHA revalidation required every 5 years in accordance with NFPA 652 7.1.4

Resources

Combustible Dust Resources

NFPA Compliance for Dust Collection Systems

Dust collection systems for combustible dust must be designed according to standards set by the National Fire Prevention Association (NFPA). RoboVent designs our systems to be fully compliant with relevant NFPA standards, including:

- **NFPA 652 –** Standard on the Fundamentals of Combustible Dust
- **NFPA 654 –** Standard on the Prevention of Fire and Dust Explosions from the Manufacturing, Processing, and Handling of Combustible Particulate Solids
- **NFPA 68 –** Standard on Explosion Protection by Deflagration Venting
- **NFPA 69 –** Standard on Explosion Prevention Systems
- **NFPA 484 –** Standard for Combustible Metals
- **NFPA 664 –** Standard for the Prevention of Fires and Explosions in Wood Processing and Woodworking Facilities

Labs in North America (Source: DustSafetyProfessionals.com)

- Fauske & Associates, LLC
  Chicago, Illinois
- Stonehouse Process Safety, Inc.
  (Princeton, New Jersey)
- Jensen Hughes
  (Halifax, Nova Scotia)
- Fike Corporation
  (Blue Springs, Missouri)
- Combustion Research Center, IEP Technologies
  (Spencer, Massachusetts)

Want More Resources?

At RoboVent our combustible dust experts have you covered...

Follow this link to on-demand videos, blog posts, our Filter That podcast, case studies, white papers, FAQs and so much more!

Glossary of Terms

- **Combustible dust:** A solid particulate material that is capable of producing a fire or explosion when suspended in a cloud in the presence of oxygen.
- **Combustion:** An exothermic chemical reaction, usually between oxygen and a reactive material, that generates heat and light. Combustion reactions include fires, deflagrations and detonations.
- **Deflagration:** A exothermic combustion reaction which propagates at subsonic speeds through a combustible material dispersed in an oxidizing atmosphere (e.g., air). Contrasted with a detonation, which propagates at supersonic speeds.
- **Dust collector:** A machine used to filter airborne contaminants out of the air in an industrial environment. A blower is used to draw air into the filter chamber, where air is filtered before being exhausted or returned to the facility.
- **Dust Hazard Analysis (DHA):** A systematic review of materials and processes in a facility, conducted according to NFPA 652, to identify, evaluate and quantify the risks associated with combustible solid particulates and provide recommendations for mitigating these hazards. May include both material characterization and process analysis and may be part of a broader PHA.
- **Explosion indices:** Parameters that are used to quantify the potential severity of an explosion. Includes KST and PMAX.
- **Explosion pentagon:** A representation of the five elements that must be present for a combustible dust explosion to take place, including fuel (combustible dust), dispersion of dust particles in a cloud, confinement of the dust cloud, oxygen and an ignition source.
- **Explosion vent:** A non-reusable safety device designed to burst at a set pressure to safely relieve rising pressures and direct explosive energy in a safe direction. Required by NFPA 69 and 69 for dust collection systems, HVAC systems, conveyance systems and many other types of equipment when handling combustible dusts.
- **Explosion:** A general term for a rapid combustion reaction. Includes both deflagrations (subsonic speed reactions) and detonations (supersonic speed reactions).
- **Fire triangle:** A representation of the three elements that must be present for a fire to take place, including fuel (a combustible/flammable material), oxygen and an ignition source.
- **Isolation valve:** A one-way valve designed to contain the pressure wave caused by a deflagration. May be required by NFPA 69 for dust collection systems and other equipment when handling combustible dusts.
- **KST:** Maximum rate of pressure rise in a confined space; one of the explosion indices for combustible dust. Known as the dust explosibility constant.
- **MEC:** Minimum explosible concentration.
- **MIE:** Minimum ignition energy is the energy required to start a combustible reaction.
- **MIT: Minimum (auto)ignition temperature:** The minimum ignition temperature (MIT) is the lowest temperature of the furnace at which flame is observed minus 20 o C for furnace.
- **NFPA:** The National Fire Prevention Association. A global non-profit organization that creates international recognized standards for fire and explosion safety. These standards are not directly enforceable by NFPA, but are used as the basis for many legally enforceable regulations created by governing bodies such as OSHA.
- **PMAX:** Maximum explosion pressure in a confined space; one of the explosion indices for combustible dust.
- **Process Hazard Analysis (PHA):** A comprehensive and systematic review of fire, explosion and toxic material risks required for certain types of facilities under OSHA's Process Safety Management (PSM) Standard 29 CFR 1910.119. While similar to a DHA, the PHA is broader in scope.
- **ST Class:** An OSHA rating system that classifies dust into four classes based on explosive potential (KST value), from ST 0 (no explosion potential) to ST 3 (highest explosive potential).
- **The Explosion Pentagon:** a useful framework for considering combustible dust explosion hazards. All five elements of the pentagon must be present to create and sustain a dust explosion.
- **A reactive material:** is one that can generate a chemical or combustion reaction when exposed to heat, pressure, shock, friction, air, water or another material (e.g., aluminum + metal oxides produces a thermite reaction).

RoboVent®
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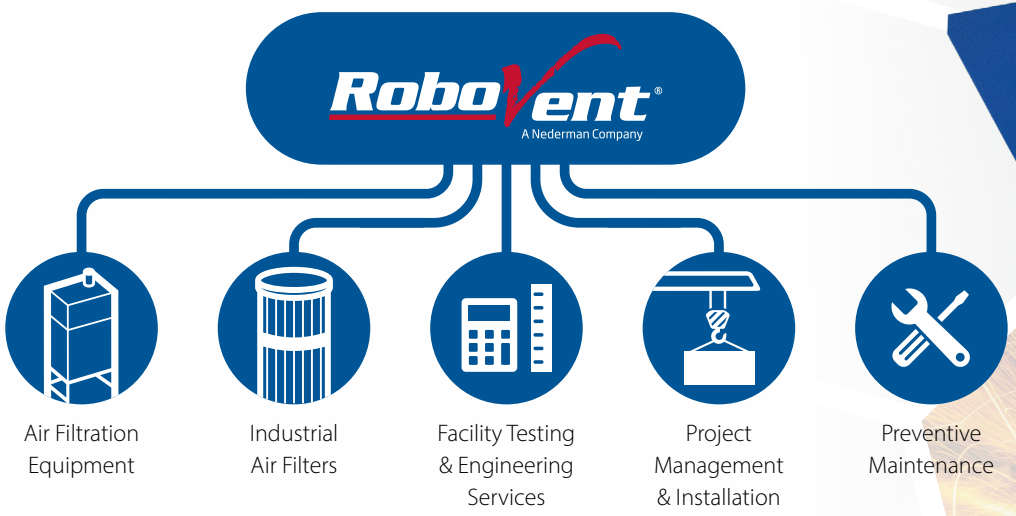
Your Total Air Filtration Partner for Combustible Dust Collection

RoboVent engineers and manufactures industry-leading NFPA compliant dust collection equipment at our manufacturing facilities. We also manufacture high-quality filters for practically any make and model of dust collector as well as other filtration applications. We guarantee a solution that delivers superior performance and safety while minimizing maintenance and operating costs. We can help you at every stage of the process to keep your people and facility safe from combustible, toxic or hazardous dust.



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