

SMART AND SUSTAINABLE ROOFTOP EXHAUST SYSTEMS: A COMPREHENSIVE INDUSTRIAL REVIEW

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Article Received on 21/04/2025

Article Revised on 12/05/2025

Article Accepted on 01/06/2025

ABSTRACT

An industrial exhaust fan is a heavy-duty mechanical device that provides ventilation and air circulation in industrial settings. These fans are typically more extensive and powerful than residential or commercial exhaust fans. HVAC is an acronym that stands for Heating, Ventilation, and Air Conditioning. A residential HVAC system is a complete home comfort system that can heat and cool your home, as well as provide improved indoor air quality and humidity control. Industrial ventilation systems are designed to move out (exhaust) and bring in (intake) a specific amount of air at a specific speed (velocity), which results in the removal of undesirable contaminants in a specific area or space.

KEYWORDS: HVAC, Exhaust fan, Ventilation.

INTRODUCTION

Roof exhaust fans RF are designed for ventilation systems of buildings with low levels of air pollution. They are used in exhaust systems of residential buildings, supermarkets, industrial halls, workshops, warehouses, toilets, garages, parking lots, outhouses and others. Commercial roof exhaust fans optimize airflow by removing stale air, heat, and moisture. This process improves overall air quality and eliminates pollutants, odors, and excess humidity in commercial buildings. Roof ventilation allows air to flow through the attic

space, escaping through the roof vents. Properly installed roof vents will prevent the roof from overheating. They also prevent condensation of moisture. When the roof overheats or moisture builds up, this can lead to substantial damage or health risks. An exhaust fan is typically installed on a wall and consists of a propeller fan. When switched on, the fan blades start spinning, drawing air from the room into the fan housing. This creates a pressure difference, forcing the collected air to move outside through a duct or vent.



Figure 1: Roof top exhaust fan.

Purpose: Removing airborne contaminants such as dust, smoke and fumes. Reducing excess heat from equipment, processes and high-temperature work areas. Controlling humidity and moisture to prevent mold growth and corrosion. An exhaust system collects the hot gases produced by the engine and directs them through a series of pipes, mufflers, and catalytic converters before releasing them into the atmosphere. The system also helps to reduce engine noise and improve fuel efficiency.

Industrial air pollution is when factories, mines, and transportation release harmful substances into the air. These pollutants can cause health problems such as respiratory diseases, cancers, decreased lung function, and asthma. The creator of the exhaust system, particularly in the automotive industry, is considered to be **Milton Othello Reeves** (August 25, 1864 – June 4, 1925).

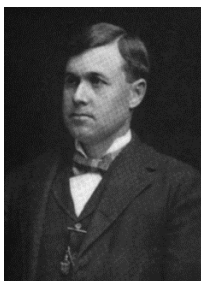


Figure 2: Exhaust fan inventor.

In 1896, he aimed to create a device to address engine noise and fumes. Industrial exhaust fans, on the other hand, are heavy-duty mechanical devices used for ventilation and air circulation in industrial settings. In industrial settings, the two basic types of ventilation systems are **Dilution Ventilation** and **Local Exhaust Ventilation**.

1. Dilution Ventilation is designed to reduce the concentration of pollutants in a work area by mixing outside air with the contaminated air. Dilution ventilation, also known as general ventilation, is a method for controlling air contaminants by introducing fresh, clean air into a space, diluting the concentration of pollutants. This process effectively reduces the concentration of airborne contaminants like vapors, gases, and particles to safe levels, typically below occupational exposure limits.

Industrial air ventilation systems must have industrial exhaust fans. They aid in purging the workplace of dangerous gases, smoke, dust, and other impurities. Industrial exhaust fans come in a variety of designs, such as industrial exhaust fans, greenhouse exhaust fans, heavy-duty exhaust fans, and wall-mounted exhaust fans. Each one has unique qualities and capabilities that make it suitable for diverse industrial environments. When it comes to ventilation solutions, types of commercial exhaust fans offer tailored options for various businesses, ensuring efficient air circulation and maintaining air quality. Whether it's a bustling restaurant kitchen or a large warehouse, exhaust fan industrial type units are designed to meet the rigorous demands of industrial settings, effectively removing contaminants and preventing the buildup of heat and humidity.

Trustworthy and robust, these types of commercial exhaust fans are indispensable for promoting a healthy and comfortable environment in diverse workspaces.

Types of Industrial Exhaust Fans

1. Greenhouse Exhaust fans: The greenhouse ventilation exhaust fan is made to run continuously at barns, workshops, Poultry farms, and greenhouses.

Strong housing made of galvanized sheet steel:

Manually operated drop hammer shutters can be closed tightly or widely.

Accompanied by motorized shutters to keep out dust, pests, and rain.

Streamlined, through-wall mounting design.

Durable stainless steel or zinc-coated blades.

2. Wall Mounted Exhaust Fan: The type of exhaust fan that is usually used in residences, especially those with walls that are directly in front of open spaces, is a wall-mounted exhaust fan. This type of exhaust fan is simple to install and is easily placed. The exhaust fan is effective at removing stale and contaminated air from your home. Wall-mounted exhaust fans are frequently perfect for use in small and medium-scale industries and in domestic use.

3. Industrial Exhaust Fans: An exhaust fan removes stale air from a space and replaces it with clean air. When there are excessive amounts of hot air, moisture, carbon dioxide, vaporized chemicals, dust, fungus spores, and unpleasant scents in the air, such air is said to be polluted. By venting dirty indoor air outside and drawing in pure air from the outside, exhaust fans reduce interior air pollution. Exhaust fans are required because they guard against mildew, chemical buildup, and overheating damage to goods and property. Also, they are essential for the health of those who live and work in areas with high levels of indoor smog.

4. Heavy-Duty Exhaust Fans: An industrial exhaust fan should be heavy-duty. These exhaust fans have a bigger sweep size than other types of exhaust fans. These fans include a powerful motor and an epoxy powder coating

for stiffer resistance to the potent gases common in factories.

- **Industrial Exhaust Fan Applications:** Industrial exhaust fans are versatile and can be used for a number of things, including:
 - They can be found as parts of industrial systems or are used to transport large volumes of air. The air quality within the building and around the equipment is improved by exhaust fans.
 - **Dust Loading:** The amount of dust is minimal because exhaust fan exhausts effectively move and collect dust, keeping it from building up in machinery or across the entire facility.
 - **Material handling:** In industrial settings, a lot of particles are frequently accumulated. Larger particles, such as wood chips, sawdust, grain, wood chips, plastic pellets, and a variety of other materials, can be handled by exhaust fan exhausts.
 - **Fans for saturated air:** The term “saturated air” refers to air that contains a substantial amount of humidity or moisture. Exhaust fans are frequently employed to evacuate the air, preventing the buildup of moisture that could lead to corrosion or the growth of mould.
 - **High temperatures:** In some industrial processes, such as heat treatment, extremely high temperatures can occur, necessitating the use of specialized equipment. In these severe circumstances, exhaust fans may safely circulate hot air.

Key Concepts

- **Mixing:** Dilution ventilation works by mixing the contaminated air with a large volume of fresh, clean air.
- **Airflow:** It relies on airflow to ensure proper mixing and dilution of contaminants.
- **Contaminant Reduction:** The goal is to reduce the concentration of airborne contaminants to acceptable levels.

How it Works

1. **Fresh Air Supply:** Fresh air is introduced into the work area, often through vents, fans, or natural drafts.
2. **Mixing:** The fresh air mixes with the existing contaminated air, reducing the concentration of pollutants.
3. **Exhaust:** The now diluted air, along with any remaining contaminants, is exhausted from the work area.

Advantages of Dilution Ventilation

- **Simplicity:** Relatively simple to implement and maintain.
- **Cost-effective:** Can be a cost-effective solution for controlling a wide range of contaminants.
- **Broad Applicability:** Suitable for various industries and workplaces where contaminants are released over a wide area.

Disadvantages of Dilution Ventilation

- **Not ideal for high toxicity:** May not be suitable for controlling extremely toxic substances, as it can spread the contaminants throughout the workspace.
- **May require significant air volume:** Can require large amounts of air, potentially increasing energy costs.
- **Less effective for localized sources:** May not be as effective in controlling contaminants from localized sources.
- ✓ **When to Use Dilution Ventilation:** Low to moderate hazard contaminants. When contaminants pose a relatively low health or safety hazard.
- ✓ **Wide area release:** When contaminants are released over a wide area in the workplace.
- ✓ **Contaminants unlikely to settle:** When gases, vapors, or fumes are unlikely to settle to the ground. In essence, dilution ventilation is a method of controlling air contaminants by diluting them with fresh air, reducing their concentration to safe levels throughout the workspace.^[1]

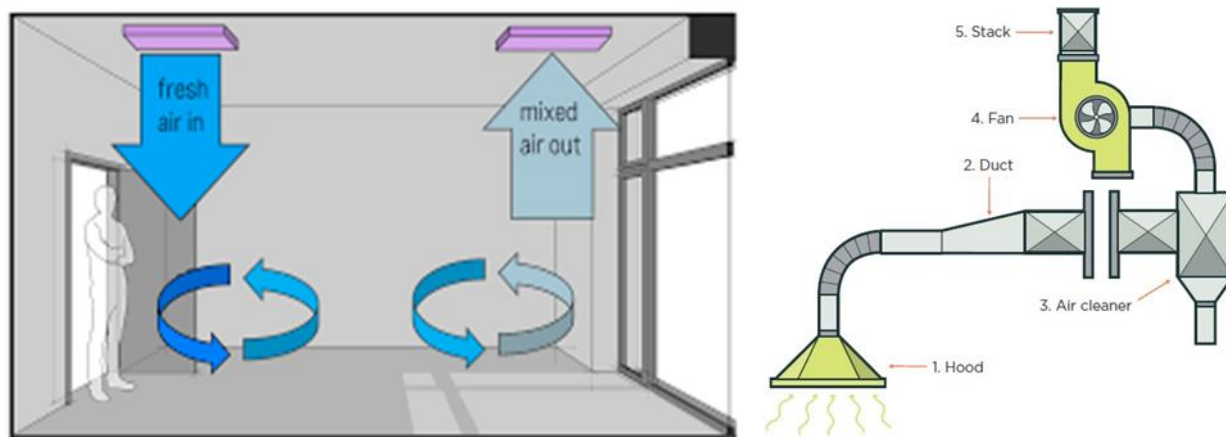


Figure 3: Dilution Ventilation and Local Exhaust Ventilation.

2. Local Exhaust Ventilation (LEV) in industry refers to a system designed to capture and remove airborne

contaminants at their source, preventing them from spreading into the workplace. It's a crucial safety

measure for protecting workers from hazardous substances like dust, fumes, gases, and mists. LEV systems typically consist of a hood or enclosure to capture the contaminant, ducting to transport it, an air cleaner (like a filter or scrubber), and a fan to move the air. Local Exhaust Ventilation (LEV) is an engineering control system designed to capture airborne contaminants at or near their source and remove them from the workplace, preventing exposure to workers. It's a crucial part of managing occupational health and safety, especially in industries where dust, fumes, gases, or other airborne contaminants are generated.

Key aspects of LEV in industry

Contaminant Capture: LEV systems are designed to capture contaminants at or near their source, preventing them from dispersing into the broader workspace.

Protection for Workers

- LEV is primarily used to protect workers from exposure to hazardous substances that could pose a health risk.

Compliance with Regulations

- LEV systems help ensure compliance with occupational health and safety regulations.
- Different Types of LEV:
- LEV systems can vary in size and complexity, from small portable units to extensive, permanent installations in large industrial facilities.

Applications

- LEV is used in various industries, including food production, chemicals, pharmaceuticals, and plastics.

Components

- LEV systems typically include a hood, ducting, an air cleaner, and a fan.

Benefits of LEV

Improved Worker Safety: LEV minimizes exposure to hazardous substances, protecting workers from respiratory and other health issues.

Enhanced Workplace Air Quality: By capturing contaminants at the source, LEV helps create a cleaner and healthier work environment.

Regulatory Compliance: LEV systems help industries meet occupational health and safety regulations.

Improved Operational Efficiency: By reducing exposure to hazardous substances, LEV can improve worker productivity and reduce downtime due to health issues.

In summary, LEV is a critical engineering control measure in industrial settings, providing a targeted and effective way to protect workers from airborne contaminants and ensure a safer and healthier work environment. According to ASHRAE standards, a rate of 35 or 3 CFM (cubic feet per minute) per each 100 square feet in a space is an adequate rate of airflow. Along with sizing, ventilation exhaust should be designed and fitted with pollution control in mind.



Figure 4: Roof exhaust.

American Society of Heating, Refrigerating, and Air-Conditioning Engineers. It's a professional organization that develops and publishes standards and guidelines for HVAC&R systems, indoor air quality, and building energy efficiency. Industrial fans are a major asset for businesses within a wide range of industries as they help with their heating and cooling needs, including transportation, manufacturing, and construction. Exhaust fans are essential for maintaining the air quality and temperature of homes and commercial spaces. They

work by pulling out hot, humid, and stale air and making it relatively cool. Industrial exhaust fans are typically made of durable, corrosion-resistant metals like stainless steel, aluminum, and galvanized steel. Stainless steel is a common choice for durability and resistance to rust and corrosion, while galvanized steel is a more affordable option. Aluminum is also used, particularly for its lightweight and strong properties. Some fans may also have cast iron components. Exhaust gas treatment refers to the process of reducing harmful emissions from

vehicle exhaust by using catalytic converters and selective heating strategies to meet stringent regulations and minimize fuel consumption. Industrial waste is treated by treatment technologies used include advanced biological treatment (e.g. activated sludge with nitrification), multimedia filtration, cyanide destruction (e.g. hydrolysis), steam stripping and wastewater recycling. An exhaust fan is typically installed on a wall and consists of a propeller fan. When switched on, the fan blades start spinning, drawing air from the room into the fan housing. This creates a pressure difference, forcing the collected air to move outside through a duct or vent. Exhaust ventilation systems work by depressurizing your home. The system exhausts air from the house while make-up air infiltrates through leaks in the building shell and through intentional, passive vents. Exhaust ventilation systems are most appropriate for cold climates. Your vehicle's exhaust system is made up of a complex system of pipes and devices that serve four essential functions: collect gases from the engine, remove harmful toxins from those gases, reduce engine noise and discharge the gases away from the car's occupants. Exhaust fans offer numerous benefits, including: Improved ventilation: By removing stale air, pollutants and moisture, exhaust fans can improve the ventilation inside a room. This can prevent the buildup of harmful substances like mould, mildew, and bacteria, which can cause respiratory problems. Removing airborne contaminants such as dust, smoke and fumes. Reducing excess heat from equipment, processes and high-temperature work areas. Controlling humidity and moisture to prevent mold growth and corrosion. Industrial exhaust fans are designed to remove air and contaminants from industrial spaces, with capacities ranging from 1000 to 44,000 CFM (Cubic Feet per Minute) or CMH (Cubic Meters per Hour). The specific capacity needed depends on the size of the area, the type of contaminants, and the desired air changes per hour (ACH). An industrial exhaust fan is a powerful ventilation device used in industrial settings to move large volumes of air or gas. They are typically more robust and capable than residential or commercial exhaust fans, often used to control dust, fumes, and odors in industrial processes. These fans are crucial for maintaining air quality and worker safety in factories, warehouses, and other industrial environments.^[2]

Mechanism: Roof exhaust fans work by using a motorized fan to draw out hot, stale air from a building's upper levels, such as the attic or roof area, and expel it outside. An attic is a room at the top of a house just below the roof. This process helps to regulate temperature, reduce strain on air conditioning systems, and improve air quality within the building. Preparing a roof for exhaust involves several steps to ensure proper ventilation and a clean, efficient installation. This includes cleaning the roof surface, removing debris, choosing the right vent type and location, and properly installing and sealing the vent.

Here's a more detailed explanation

1. Creates a Negative Pressure

The fan blades rotate, creating a negative pressure inside the building, which draws in air from surrounding areas.

2. Draws Out Hot Air

The fan extracts hot air from the roof or attic, often where it accumulates.

3. Expels Air Outside

The air is then forced out of the fan and through a duct or vent, typically leading to the exterior.

4. Improves Air Circulation

As the hot air is expelled, it creates space for fresh air to enter, improving overall air circulation.

In essence, roof exhaust fans work by creating a continuous flow of air that extracts unwanted heat and stale air, promoting a more comfortable and energy-efficient environment.

Key Features and Functions

High Capacity: Industrial exhaust fans are designed to move large quantities of air, often from 200 to 2,000,000 cubic feet per minute, making them suitable for industrial applications.

Local Exhaust Ventilation: They are frequently part of local exhaust ventilation systems, where a hood captures contaminants at their source, ducts transport them, and a fan moves the air through the system.

Contaminant Removal: These fans help remove dust, particles, fumes, and other hazardous components from the air in industrial settings.

Ventilation: They provide ventilation by drawing air from a specific area and exhausting it outside or to a treatment system.

HVLS Fans: In some cases, industrial exhaust fans can also be high-volume, low-speed (HVLS) fans, which move large amounts of air at low speeds, often used for comfort in large spaces like warehouses or factories.

Types: Industrial exhaust fans can be axial fans (propeller fans), centrifugal fans, or other types, depending on the specific application.

Applications

Dust and Fume Removal: Industrial exhaust fans are used in manufacturing, mining, and other industries to remove dust, fumes, and other pollutants from the work environment.

Local Exhaust Ventilation Systems: They are a key component of local exhaust ventilation systems, which are designed to capture contaminants at their source and prevent them from spreading.

HVLS Fans for Comfort: In some industrial settings, HVLS fans are used to circulate air and improve worker comfort in large, open spaces.

Ventilation in Underground Spaces: Industrial exhaust fans are used to ventilate underground spaces, such as mines and car parks, by removing exhaust fumes and other contaminants.

In summary, industrial exhaust fans are essential for maintaining air quality and worker safety in industrial settings by removing contaminants and providing ventilation. An industrial exhaust fan is a heavy-duty mechanical device that provides ventilation and air circulation in industrial settings. These fans are typically more extensive and powerful than residential or commercial exhaust fans. Industrial fans and blowers are machines whose primary function is to provide and accommodate a large flow of air or gas to various parts of a building or other structures. This is achieved by rotating a number of blades, connected to a hub and shaft, and driven by a motor or turbine. An exhaust fan is typically installed on a wall and consists of a propeller fan. When switched on, the fan blades start spinning, drawing air from the room into the fan housing. This creates a pressure difference, forcing the collected air to move outside through a duct or vent. Commercial and industrial exhaust fans are designed to enhance air quality by removing stale air, odors, and excess moisture while replacing them with fresh air. There are many uses for the continuous flow of air or gas that industrial fans generate, including combustion, ventilation, aeration, particulate transport, exhaust, cooling, air-cleaning, and drying, to name a few. The industries served include electrical power production, pollution control, metal manufacturing and processing, cement production, mining, petrochemical, food processing, cryogenics, and clean rooms. This equipment is known as an eco-ventilator or a turbo ventilator, which is a self-driven ventilation system that is powered entirely by wind energy. Turbo ventilators expel hot and stale air from inside the building outside through the roof, and also increase the supply of fresh air back inside. The turbofan was invented to improve the fuel consumption of the turbojet. It achieves this by pushing more air, thus increasing the mass and lowering the speed of the propelling jet compared to that of the turbojet. This is done mechanically by adding a ducted fan rather than using viscous forces. Roof ventilation provides a means for hot air and moisture to escape your roof cavity, and replaces it with cooler, drier air. A ridge vent is a type of vent installed at the peak of a sloped roof which allows warm, humid air to escape a building's attic. Ridge vents are most common on shingled residential buildings.

CONCLUSION

An industrial exhaust system removes air pollutants and excess heat from industrial processes. It typically involves a combination of fans, ducts, and filtration systems to capture and vent contaminated air. The

system's components work together to improve air quality, protect workers, and ensure compliance with environmental regulations.

Here's a more detailed look at the mechanism

1. Capture and Containment

Hoods and Collection Systems: Industrial exhaust systems often use hoods or other collection systems to capture pollutants at the source. These might be located near welding machines, dust generation points, or other areas where contaminants are produced.

Ducts: Ducts are a network of pipes that connect the collection systems to the exhaust fans and other components of the system. They transport the collected air and contaminants.

2. Air Movement

Fans: Industrial exhaust fans are powerful devices that draw air into the system and move it through the ductwork. These fans can be designed to handle various types of contaminants, including dust, fumes, and vapors.

Dampers: Dampers are valves that regulate airflow within the duct system, allowing for precise control of ventilation and energy efficiency.

3. Filtration and Treatment (Optional)

Filters: Some exhaust systems include filters to remove specific pollutants from the air before it's vented outdoors. Common types of filters include HEPA filters for particulate matter and activated carbon filters for gases and odors.

Other Treatment Systems: In certain cases, additional treatment systems like scrubbers or incinerators might be used to further reduce or eliminate pollutants before they are discharged.

4. Venting

Exhaust Stack or Chimney: The contaminated air is typically vented to the outside through an exhaust stack or chimney. This ensures that pollutants are released away from occupied areas and into the atmosphere.

5. Control and Monitoring

Control Systems: Many industrial exhaust systems are equipped with control systems that monitor airflow, pressure, and other parameters. These systems can be used to adjust fan speed, damper position, and other settings to optimize system performance.

Monitoring Equipment: Monitoring equipment, such as pressure sensors and flow meters, can be used to track the performance of the exhaust system and identify any potential issues.

Key Considerations

Type of Contaminant: The specific design and components of an industrial exhaust system will depend on the type of pollutants it's designed to handle.

Airflow and Ventilation Rates: Proper design ensures that the system can effectively remove pollutants and maintain acceptable air quality.

Material Selection: The materials used in the exhaust system (e.g., ducts, fans, filters) should be compatible with the contaminants being handled.

Safety: Industrial exhaust systems are designed to protect workers from hazards, and proper installation and maintenance are essential for safety.

Environmental Compliance: Industrial exhaust systems must meet regulatory requirements for air emissions.

Industrial Ventilation Systems | Fans | Noise and Explosion.

In essence, the industrial exhaust mechanism is a carefully designed and integrated system that removes contaminants from the air, improves air quality, and protects workers and the environment.

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