CSA Unit 24 - Air Handling

Chapter 1
Air Handling for Gas Technicians

Since air movement has a significant impact on building comfort and safety, the gas technician/fitter must understand air handling. Gas technicians/fitters should be familiar with the building and gas codes, provincial regulations, and industry standards that govern air handling. In addition, they should have a good understanding of the effect of the building as a system on air movement, the process of heat transfer, and the qualities and characteristics of air.

Created
by Mike Kapin

Learning Objectives

Identify Codes and Standards

Identify codes and industry standards that apply to air flow

Understand Heat Transfer

Describe the process of heat transfer and heating equipment capacity

Air Properties

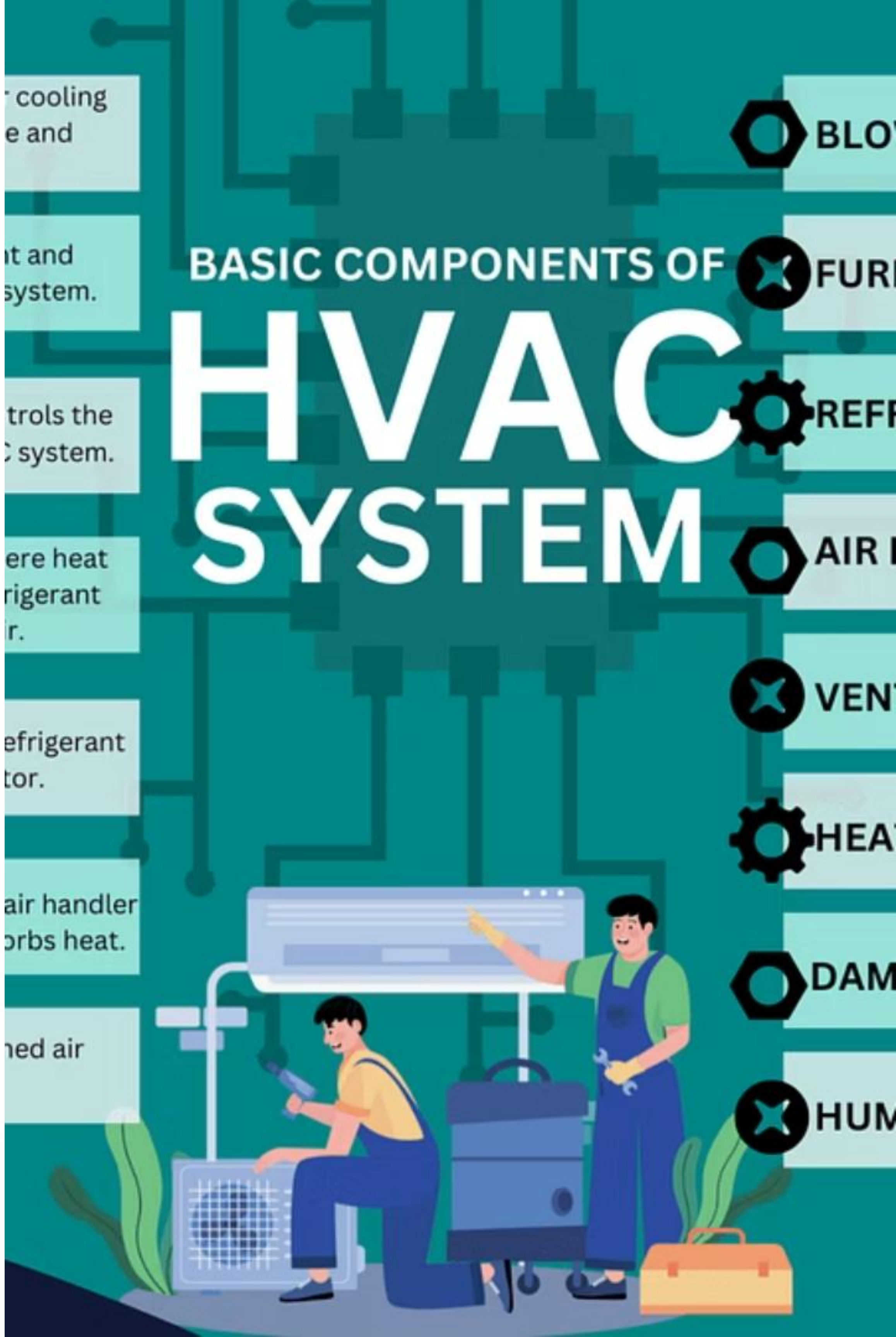
Describe the properties and characteristics of air

Service Procedures

Describe service and adjustment procedures for air handling units

Key Terminology

Abbreviation (Symbol)	Definition
H	The total heat contained in a substance, which is the sum of sensible heat and latent heat
	The process of heat moving from one source to another
	Moisture in the air that comes from water that has evaporated into the air
>	The volume of a substance per unit of the substance
	The intensity of heat, measured with a dry bulb thermometer
V	The amount of space that a three-dimensional figure occupies



Gas Trade Training and Red Seal Alignment

You can use the CSA Group Gas Trade Training materials as resources to help you prepare for the Red Seal Gasfitter – Class B exam. For more information on how these materials align with the 2014 national standard for the occupation of Gasfitter - Class B, please review an expanded reference matrix at https://store.csagroup.org/.

Codes and Industry Standards

The gas technician/fitter must be familiar with the requirements contained in CSA B149.1 as well as the appropriate provincial building codes and industry standards. CSA Group publishes two standards directly relevant to air handling equipment:

CAN/CSA F280

Standard for determining the required capacity of residential space heating and cooling appliances

CAN/CSA F326

Standard for residential mechanical ventilation systems

HRAI and Industry Support

The Heating, Refrigeration and Air Conditioning Institute of Canada (HRAI) provides certification courses and technical manuals that address the requirements of building codes and industry standards for residential and small commercial heating, ventilating, and air conditioning systems, as they apply to selection and installation of these systems.

In addition to knowing building code requirements, the gas technician/fitter must consult with municipal building departments for local bylaws pertaining to heating and ventilation.

Relevant Codes and Standards

National Building Code of Canada (NBC)

National Building Code that forms the basis for codes written in Canadian provinces

National Research Council Canada (NRC): www.nrc-cnrc.gc.ca

Ontario Building Code (OBC)

Building code used in Ontario

Contains some additional requirements beyond CAN/CSA F326

Ontario Ministry of Municipal Affairs and Housing: www.mah.gov.on.ca

British Columbia Building Code (BCBC)

Building code used in British Columbia that contains some prescriptive requirements different from those of the NBC and CAN/CSA F326 (however, CAN/CSA F326 is permitted as an alternative.)

British Columbia Codes: www.bccodes.ca

R-2000 Standard

An industry-endorsed technical performance standard for energy efficiency, indoor air tightness quality, and environmental responsibility in home construction

Technical requirements comply with CAN/CSA F326, but include additional requirements for energy performance, qualifications of the installer and designer, and record-keeping

A voluntary standard administered by Natural Resources Canada (NRCan): www.nrcan.gc.ca/home

National Building Code of Canada (NBC)

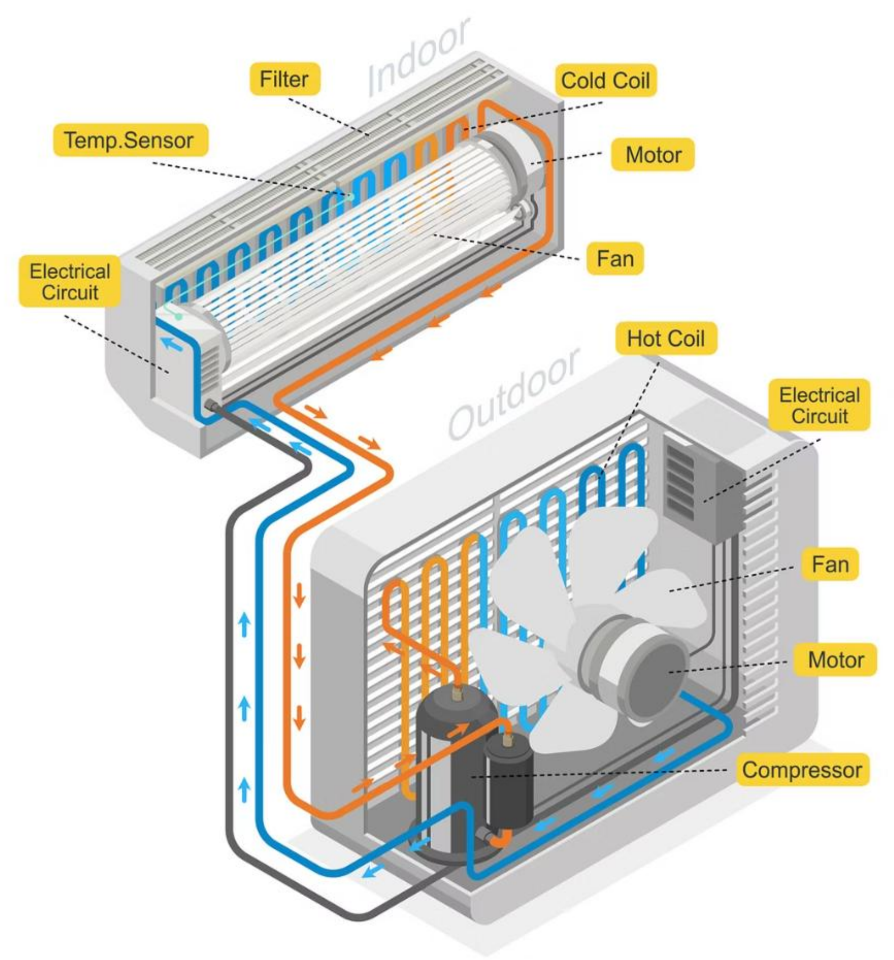
Two sections of the NBC contain clauses that apply to air handlers:

Part 6

- Heating, Ventilating and Air-Conditioning
- Covers technical requirements
- Applies to all buildings

Part 9

- Housing and Small Buildings
- Covers prescriptive requirements
- Applies to buildings of three or fewer stories and with a building area not exceeding 600 m^2



NBC Application Areas

Besides general clauses dealing with scope, application, definitions, and plans and specifications, Parts 6 and 9 apply to design and installation of:

Ventilation

Requirements for fresh air and exhaust systems

Air Duct Systems

General requirements for all ductwork

Low Capacity Systems

Specific requirements for residential and small commercial applications

Heating Appliances

Requirements for various heating equipment types

The Heating, Refrigeration and Air Conditioning Institute of Canada (HRAI)

HRAI (www.hrai.ca/) is a national non-profit trade association of heating, ventilation, air conditioning and refrigeration (HVACR) manufacturers, wholesalers, and contractors.

HRAI works with government departments at the local, provincial, and national levels to ensure that regulations reflect the expertise and concerns of those involved in the industry. The organization also provides training for the industry by conducting certification courses and publishing technical manuals.

Note: These courses do not authorize gas fitters/technicians to work on systems that exceed their local license based on the different existing trade regulations in various provinces but to offer additional avenues of training and awareness.

HRAI Ductwork Requirements

All ducting (except for bathroom fan ducts) must meet the requirements detailed in Part 6 of the NBC. HRAI refers to four practical implications of Part 6 on ductwork:

Noncombustible Materials

Ducts must be made of noncombustible materials

Flexible Duct Standards

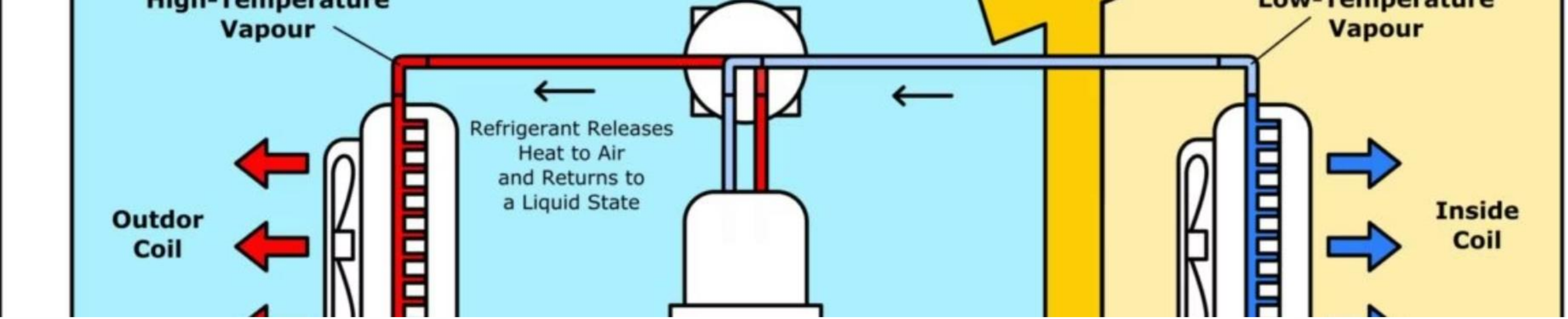
All flexible ducts must meet UL 181 Class 1 duct requirements

Proper Mounting

Ducts must be properly secured and mounted

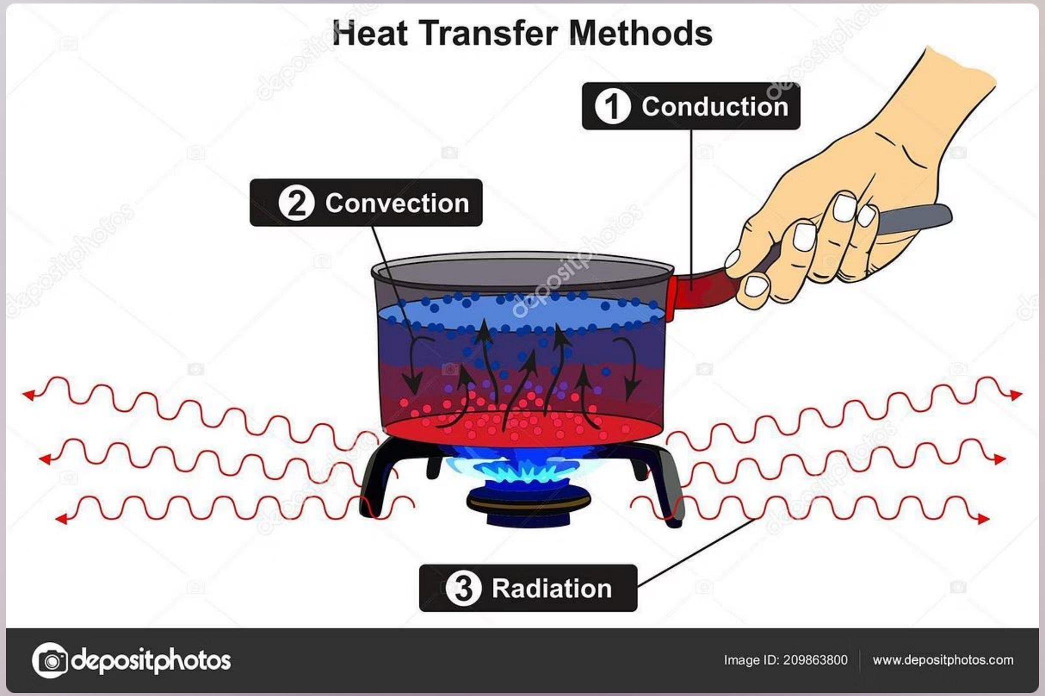
Good Engineering

The design of ducting must be in accordance with good engineering practices



Heat Transfer, Ventilation, and Air Handlers

Air handlers are a key component of heating, cooling, and ventilation systems. A review of some of the key principles of heat transfer, heat loss/gain calculations, and ventilation requirements is necessary for a full appreciation of the role of air handlers. CSA Group Gas Trade Training especially Unit 14 The building as a system - covers most of these key principles.



Heat Transfer Fundamentals

Heat transfer is the process of heat moving from one source to another. The amount of heat contained in an object or substance depends upon its:

Temperature

The measure of thermal energy intensity

Weight

The mass of the substance

Specific Heat

The amount of heat required to raise the temperature of a unit weight of a substance one degree

Heat Transfer Terminology

Sensible Heat

Heat that changes the temperature of a substance without changing its state.

Latent Heat

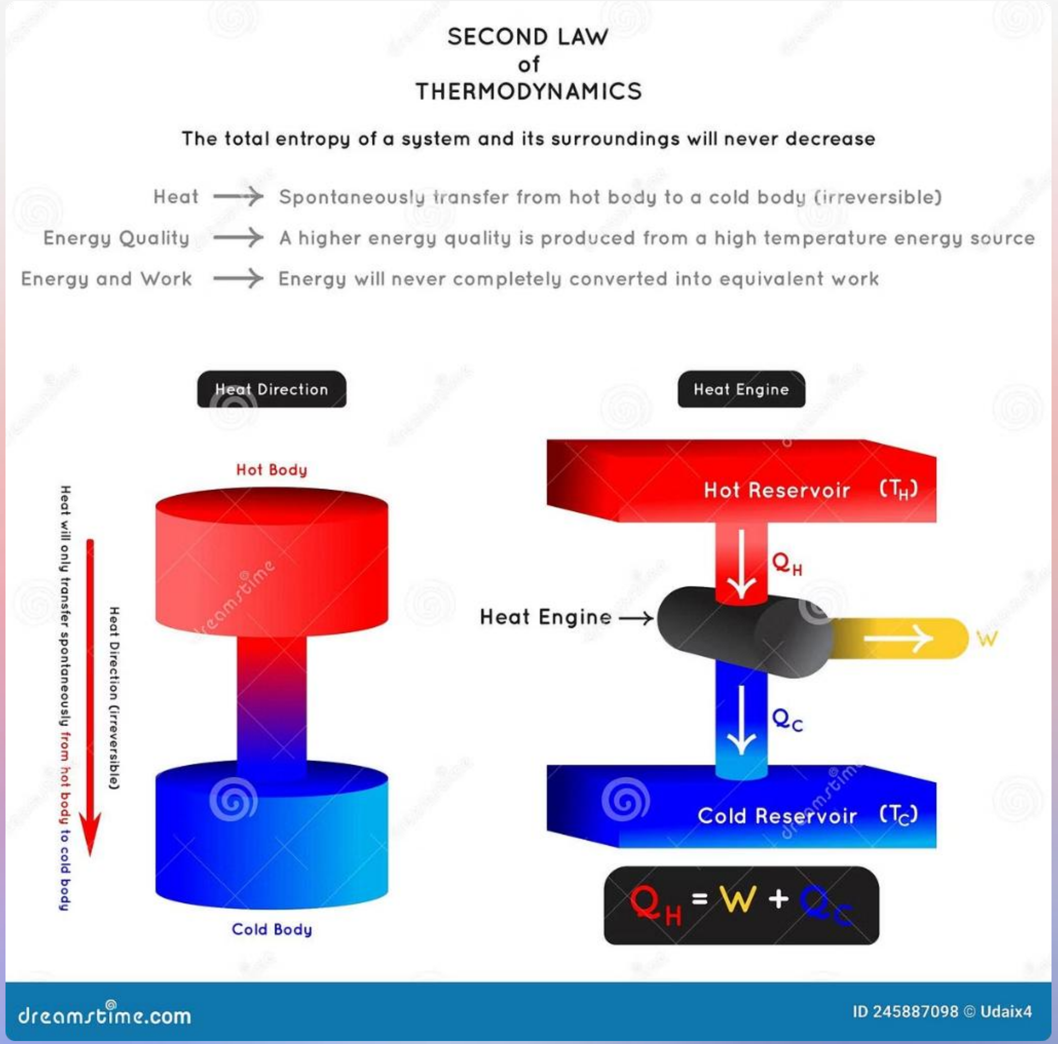
Heat required to change the state of a substance without changing its temperature.

Total Heat (Enthalpy)

Sum of all the sensible heat and latent heat contained in a substance.

Specific Heat

Amount of heat required to raise the temperature of a unit weight of a substance one degree.



Specific Heat Measurements

Imperial Units

In imperial units, the measurement is in British Thermal Units (Btu). A Btu is the amount of heat required to change the temperature of one pound of water one degree Fahrenheit (1°F).

The specific heat of water is 1 Btu in imperial units. It takes one Btu to raise one pound of water 1°F.

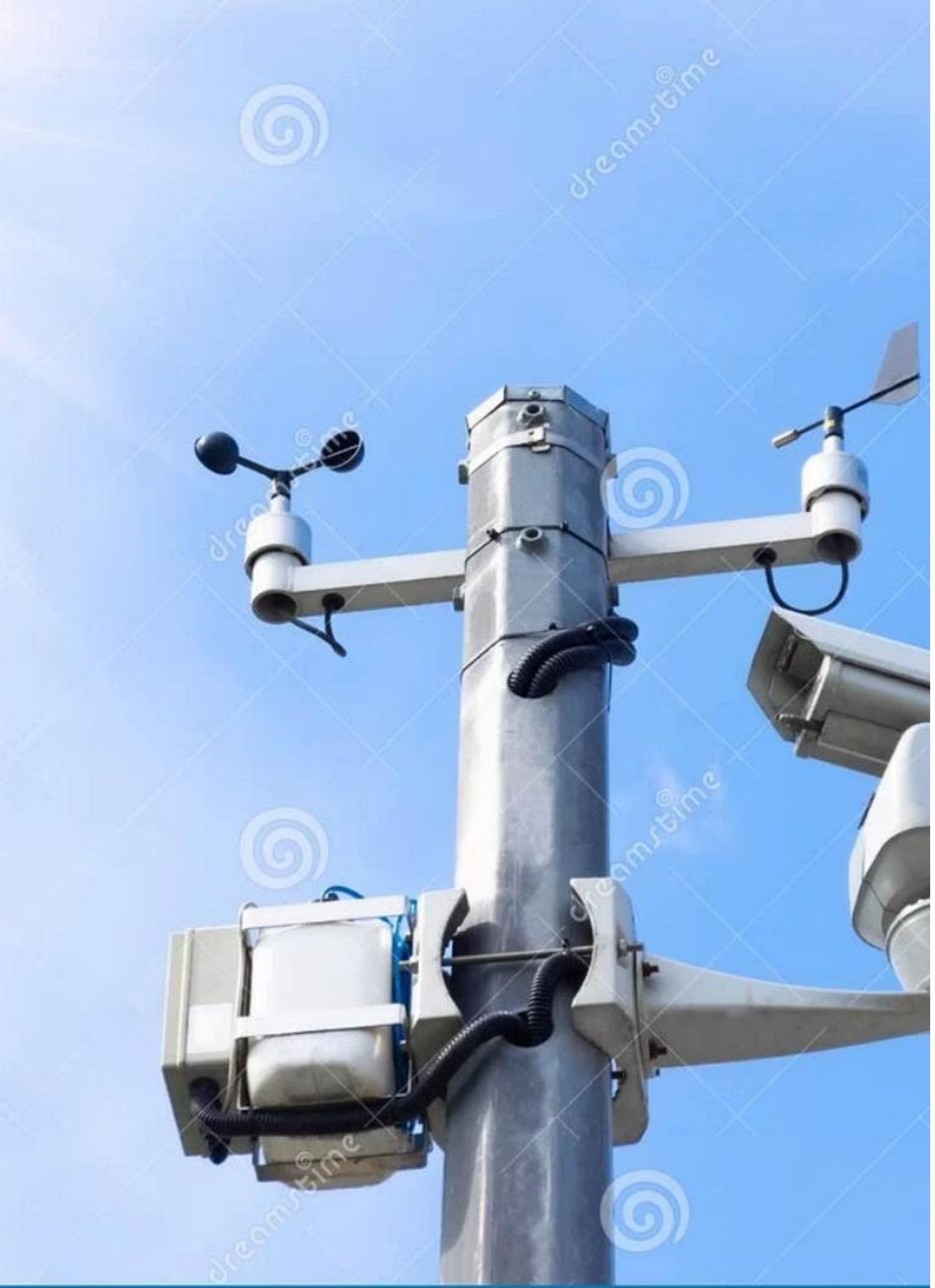
The specific heat of air varies slightly with temperature. At standard temperature, the specific heat is 0.2417 Btu/lb.

Metric Units

The calorie is the metric measurement used in the same way as the Btu. One calorie is equal to the amount of heat required to raise the temperature of one gram of water one degree Celsius.

A more commonly referenced metric unit of energy is the joule. One calorie is equal to 4.186 joules (J). Since it takes 1 kilocalorie to raise the temperature of one kilogram of water 1 °C, 4.186 kilojoules (kJ) will raise the temperature of one kilogram of water 1 °C.

In metric units, the specific heat of air is 1.01 kJ/kg.



Design Temperature Considerations

Indoor Design Temperature (IDT)

The temperature selected for the inside of the building — usually 72°F (22 °C) for buildings occupied by people.

Outdoor Design Temperature (ODT)

The expected outdoor temperature that a heating or cooling load must balance.

This temperature is based on a 10-year average for a specific location.

For heat loss calculations, it represents the lowest sustained temperature that might be expected during normal winter conditions.

For heat gain calculations, it is the highest sustained temperature that might be expected during normal summer conditions.

Heat Loss/Gain Calculation Factors

Variables

Data that relates to the location and specifications of a building.

Factors

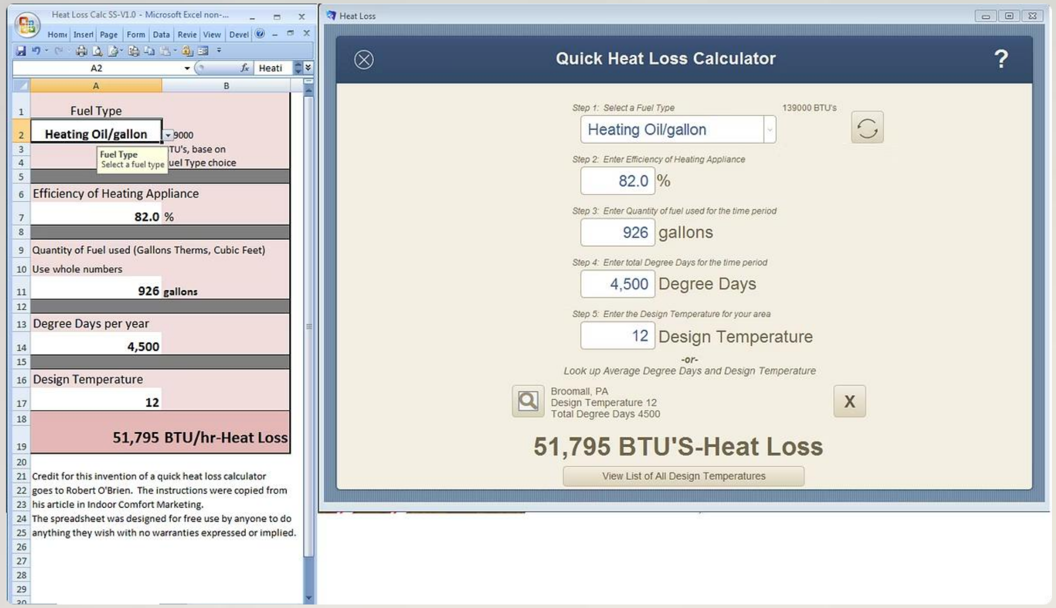
Numerical values that represent the heat produced or transferred under a specific condition.

Exposed Surfaces

Building surfaces exposed to outdoor temperatures. These are calculated using the building dimensions. The area of each wall, roof, or other exposed surface is calculated separately.

Exposure

The direction a wall faces in relation to the elements.



Solar Gain and Wall Area Calculations

Solar Gain

Building heat gain associated with radiant heat from the sun. Solar gain on a surface depends on the exposure of the exterior walls, windows, and doors. Factors for solar gain are included in calculations of heating and cooling loads, according to different exposures of each flat surface to the sun.

The area of each flat surface is found by multiplying the length of the surface by the height.

Wall Area Calculations

Gross Wall Area: Total area of a wall, including windows, doors, and other openings. Gross wall area is calculated separately for each exposed wall of a building.

Net Wall Area: Area of a wall after the areas of windows, doors, and other openings have been subtracted. The net wall area is used when calculating heating and cooling loads.

Methods of Heat Transfer

Conduction

When the temperature on two sides of a material is different, heat flows from the warmer side to the cooler side of the material. The outside surfaces of a building (walls, windows, doors, floors, and ceilings) are composed of materials across which temperature differences exist.

Convection

Transfer of heat that takes place within moving liquids or gases - as when air carries heat after it has passed over a heating coil or heat exchanger in a heating unit.

Radiation

Occurs when heat is transferred from the surface of a hot object to the surface of a cooler object by electromagnetic waves.

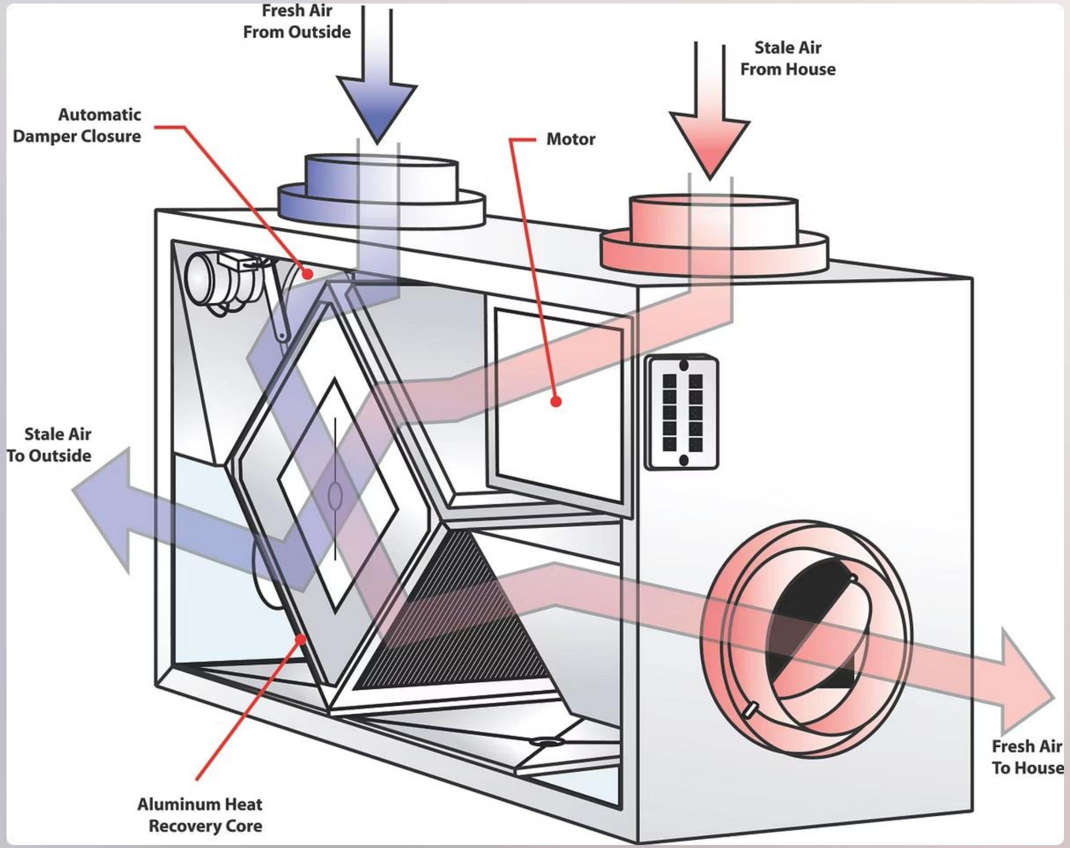
Evaporation/Condensation

Evaporation is the process by which moisture is changed into a vapour. Condensation is the reverse process, whereby vapour is changed into moisture.

Heat Transfer Calculations

As covered in Unit 14 The building as a system, the primary function of a space-heating appliance is to replace the heat lost by the building at a rate and in a manner that provides consistent comfort to the occupants. A trained individual must conduct heat loss calculations using a recognized method that meets the requirements of CAN/CSA F280.

It is the gas technician's/fitter's role to select, install, and maintain the gas-fired components of the space heating equipment to achieve the requirements of the heat loss calculation for a building.



Role of Air Handlers in Heat Transfer

Heat Generation

The combustion process and heat exchanger in forced air heating systems provide the primary heat needed to meet the designed heating needs of the building.

Heat Extraction

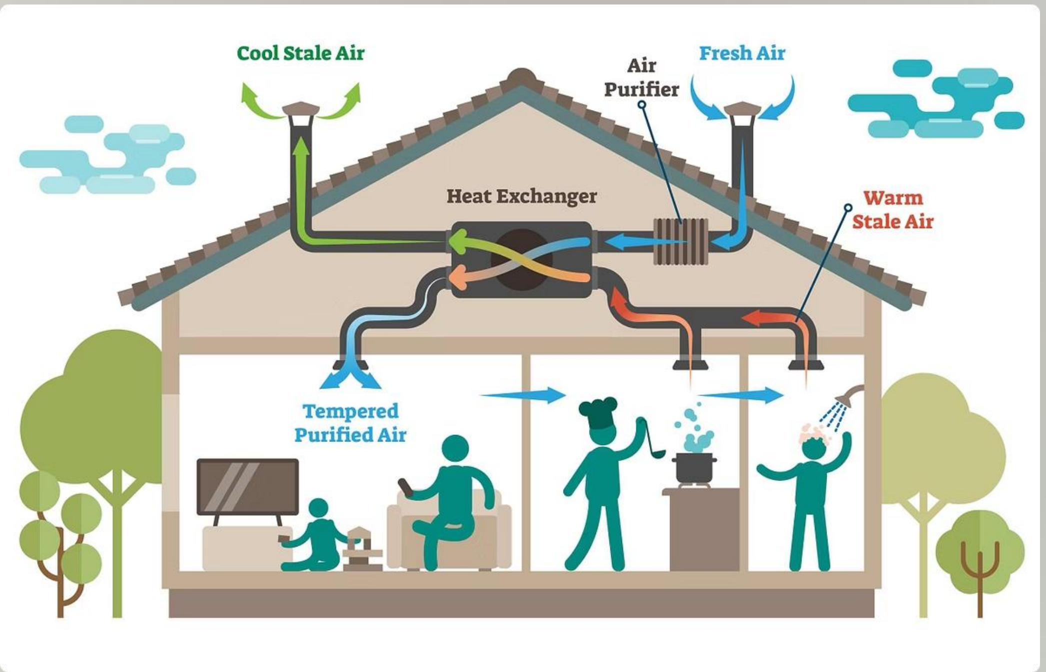
Air handling equipment removes the heat from the heat exchanger at a rate that matches the heat transfer capability and design of the heat exchanger.

Heat Distribution

Together with the attached supply and return ductwork, delivers that heat to the proper areas in the building to replace heat being lost.

Dual Function

Air handling equipment attached to gas-fired appliances often serve the dual function of distributing heated air during the winter and cooling air during the summer.



Building Ventilation Requirements

As detailed in Unit 14 The building as a system, the NBC and province-specific codes, such as the OBC or BCBC, establish requirements for the ventilation of rooms and spaces in residential occupancies by natural ventilation and by mechanical ventilation systems serving only one dwelling unit.

HRAI defines three basic concerns related to the mechanical ventilation of a house:

1. **Proper Air Volume**

   Bringing in the proper amount of ventilation air

2. **Effective Distribution**

   Distributing the air to the required locations

3. **Pressure Balance**

   Avoiding excessive pressurization or depressurization

Exhaust Fan Ventilation Systems

Exhaust fan systems are easy to install and have been in use for years. Their operation creates a suction force in the house. The tighter the building envelope, the higher the suction force for the same amount of exhaust flow.

This negative pressure can create problems, such as accentuating drafts through the remaining holes in the envelope. If the suction forces are high enough (for example, if the exhaust fans are strong enough or the building envelope is tight), it can cause problems with the venting action of fuel-fired appliances, creating combustion product spillage or back-drafting.

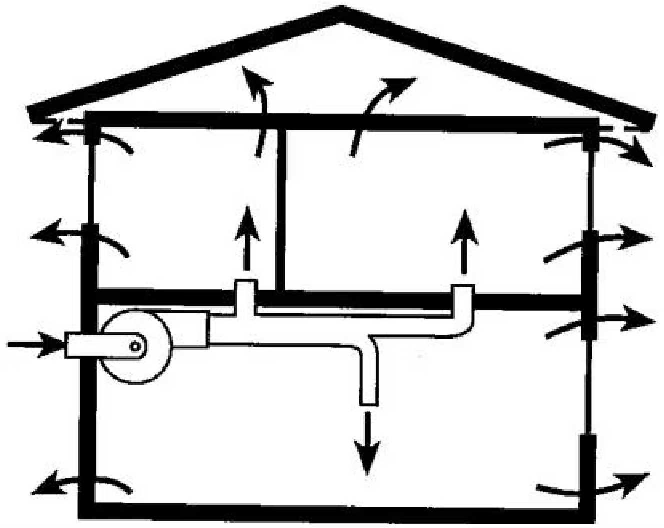
Figure 1-1
Exhaust fan system

Supply Fan Ventilation Systems

Supply fan systems draw fresh air into the house and create a positive pressure in the building. This eliminates some of the concerns found with exhaust fan systems, but the positive pressure can force warm, moist indoor air through holes in the building envelope and increase the risk of problems due to condensation in walls and attics. Use supply fan systems only in buildings with good air barriers.

Another problem with supply systems is that, in the winter, relatively large quantities of cold outdoor air enter the house at one or two locations. The outdoor air should be preheated, mixed with the indoor air, and distributed in a manner whereby cool air does not blow on the occupants of the house. This can increase installation costs.

Figure 1-2
Supply fan system



Balanced Ventilation Systems

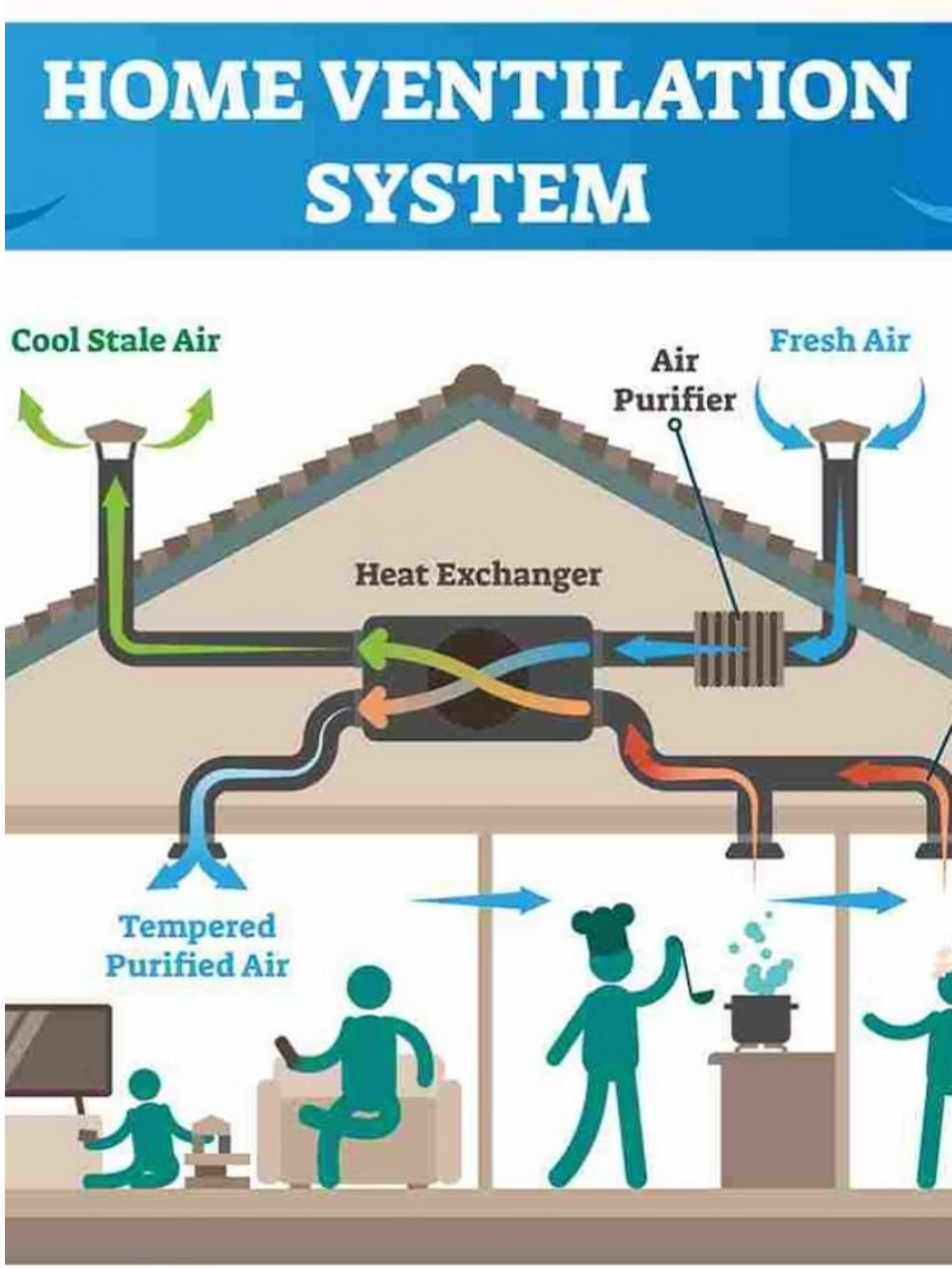
Balanced systems are designed to have no impact (either negative or positive) on the pressure balance of the house. This eliminates the problems that result from both positive and negative pressures, but at some additional cost. In most cases, two fans work in tandem to provide ventilation. These fans must be interconnected electrically and may be connected physically. As with supply systems, the incoming air requires warming before distribution.

Figure 1-3
Balanced fan system

Distribution Systems Overview

The ventilation air distribution system distributes the ventilation air to the appropriate locations in the house. Three types are described below. In all cases, exhaust air is exhausted from bathrooms, kitchens, and utility rooms, through dedicated exhaust ductwork.

The terms dedicated (or independent), integrated (or combined), and through-the-wall distribution systems refer specifically to the method of distributing supply air throughout the house.



Dedicated Distribution Systems

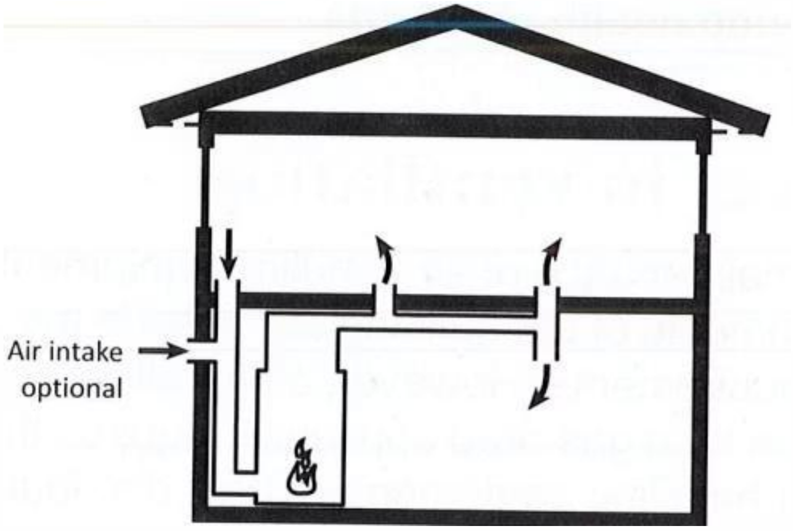
Dedicated, independent, or separately ducted systems distribute ventilation air using an independent or dedicated set of ductwork. Each habitable room in the house should have its own ventilation air supply outlet or exhaust air inlet. These systems are commonly used in houses with baseboard or radiant heating systems.

Figure 1-4
Separately ducted system

Integrated Distribution Systems

Integrated or combined systems utilize the forced-air heating and/or cooling system to distribute ventilation air throughout the house. The ventilation air supply is connected to the forced-air return duct, and the forced-air recirculation fan—which must be capable of operating continuously—distributes the ventilation air throughout the house while mixing it with return air.

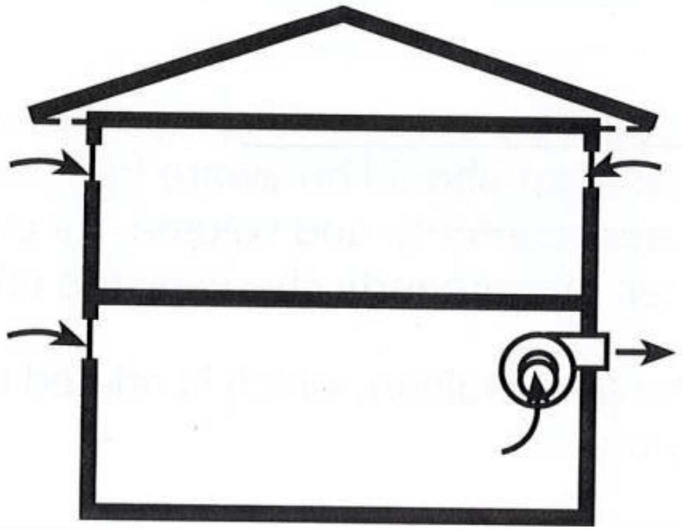
These systems also rely upon an appropriately sized exhaust fan that runs continuously to create the building suction needed to draw in outside air. Proper sizing of the return air system and location of the outdoor air inlet connection are critical to ensure the furnace air circulating fan does not influence the amount of ventilation air being drawn into the furnace.



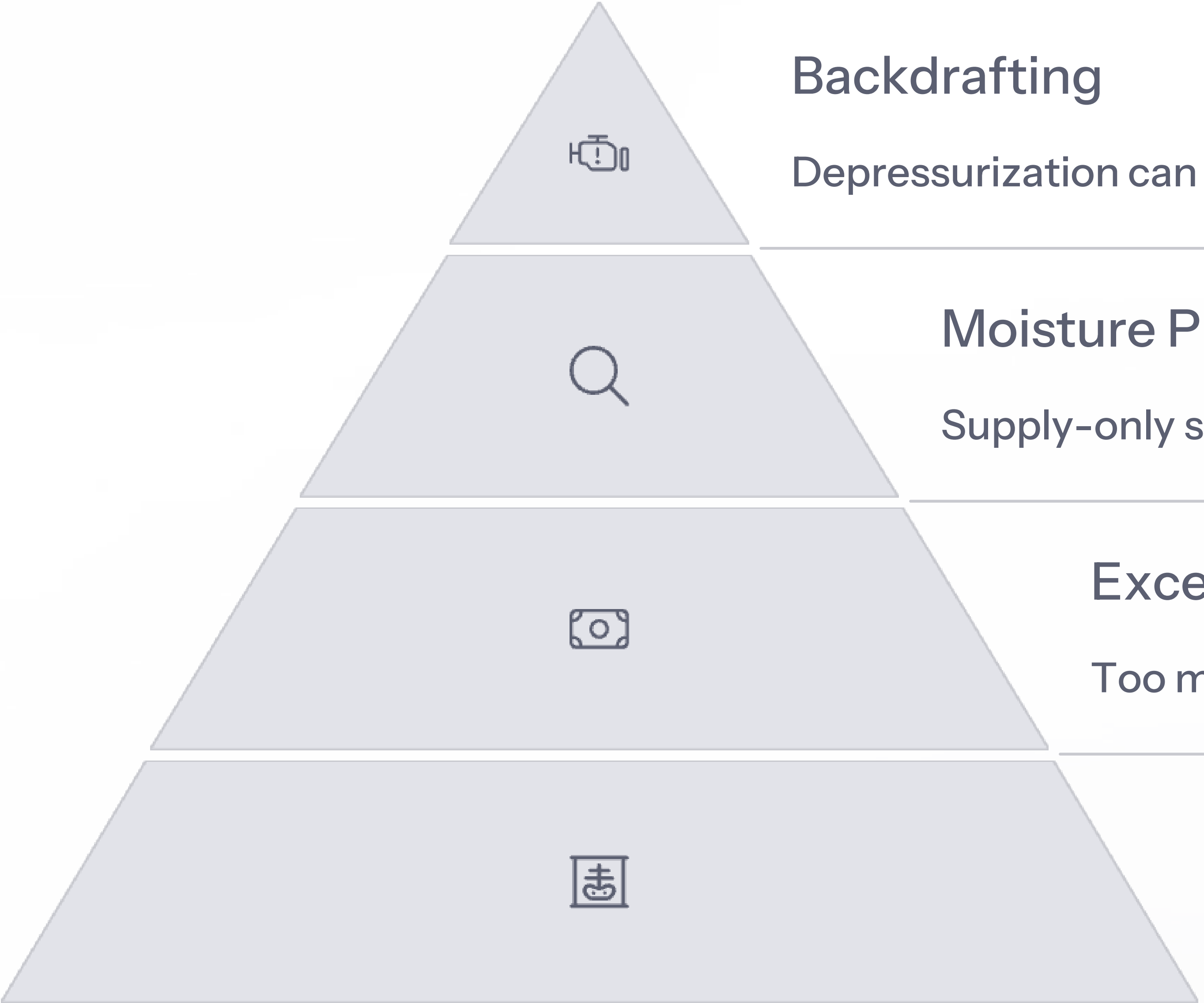
Through-the-Wall Distribution Systems

Through-the-wall distribution systems utilize exhaust fans to induce infiltration into the house. Through-the-wall diffusers introduce outside air directly to each room in a controlled fashion.

Figure 1-6
Through-the-wall system



Ventilation System Hazards



Backdrafting

Depressurization can cause furnaces or fireplaces to backdraft poisonous gases

Moisture Problems

Supply-only systems in leaky houses can drive moisture into wall cavities

Excessive Costs

Too much ventilation increases energy costs unnecessarily

Health Concerns

Inadequate ventilation can lead to pollutant buildup

Role of Air Handlers in Ventilation

The design, installation, and maintenance of air handling equipment that is used exclusively for ventilation is generally outside the scope of the gas technician/fitter certificate and training requirements. However, air handling equipment employed for both heat distribution and ventilation for a gas-fired appliance requires that the gas technician/fitter understand the dual role of air handling equipment for heat distribution and ventilation.

In all cases, the ventilation system — whether separate or part of the gas appliance — can have a significant effect on the safe and efficient operation of a gas appliance installed in the building, as indicated in the Caution Note above.

Understanding Ventilation Effects

To understand the effects that a ventilation system may have on a gas-fired appliance and on any attached air handling equipment, a gas technician/fitter must have a sound understanding of ventilation principles. Additional courses, such as HRAI's Residential Mechanical Ventilation courses, are highly recommended.

Building Envelope

Air tightness affects pressure dynamics

Ventilation System

Creates pressure differentials

Gas Appliance

Requires proper venting conditions

Balanced Operation

Safe and efficient performance

Properties and Characteristics of Air

The properties of air and the relationships between its properties are described in physics as psychrometrics. The gas technician/fitter should be aware that the properties of air are temperature, humidity, enthalpy (heat content), and volume. As air is conditioned, one or more of the properties of air changes. When one property changes, the others are affected.

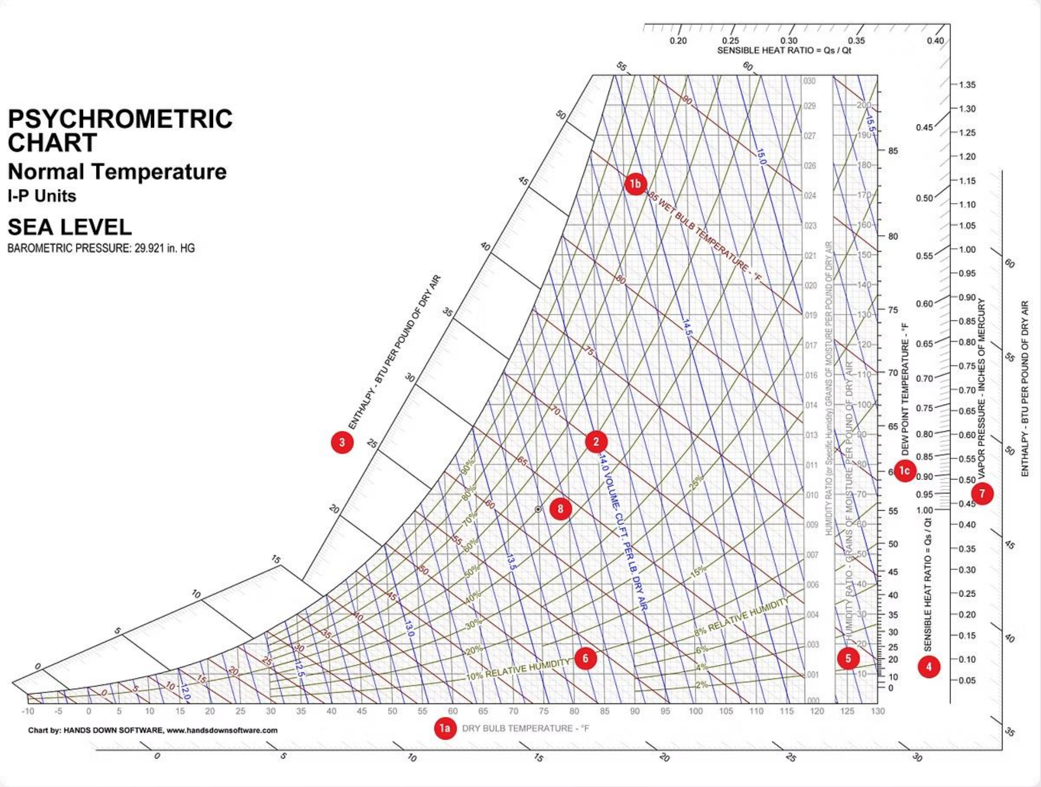
The properties of air determine the air condition, which is related to comfort and health. The condition of air depends primarily on:

Temperature

The intensity of sensible heat

Humidity

The moisture content in the air

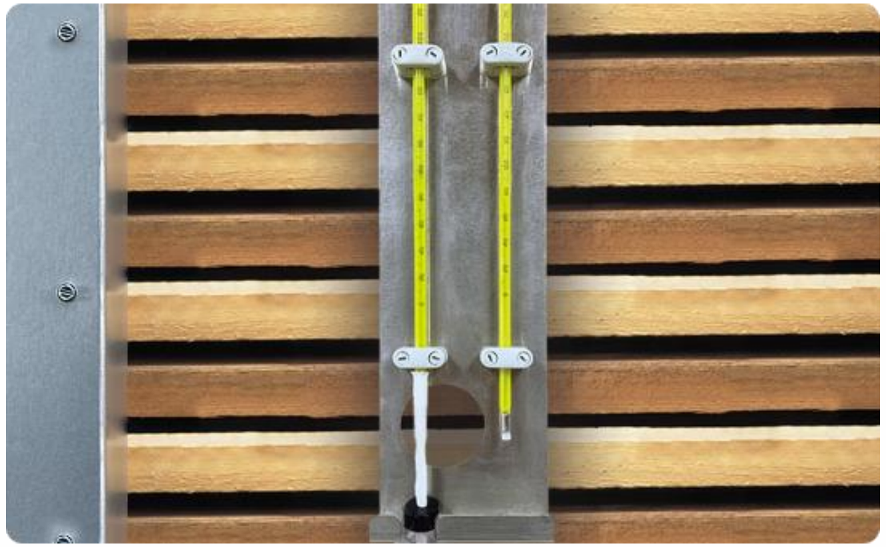


Temperature

Temperature is the intensity of sensible heat, measured with a dry bulb thermometer. Thermostats in HVAC systems turn equipment off and on in response to sensible heat.

Digital Thermostat

Modern thermostats measure temperature and control HVAC equipment based on programmed setpoints



Dry Bulb Thermometer

Traditional instrument for measuring air temperature without the influence of humidity

Infrared Sensor

Non-contact temperature measurement tool used by technicians for diagnostics

Humidity

Humidity is moisture in the air that comes from water that has evaporated into the air. The amount of moisture that air can hold depends on its temperature. When air is warm, it can hold more moisture than when it is cool. When the total volume of air is small, the amount of moisture in the air is also small. Humidity is expressed as either relative humidity or humidity ratio.

Humidity Measurements

Relative Humidity (RH)

The amount of moisture in the air compared to the amount it would hold if the air were saturated at the same temperature.

Relative humidity is always expressed as a percentage. For example, air that has a relative humidity of 55% holds 55% of the moisture it can hold at the same temperature when it is saturated.

Humidity Ratio (W)

The ratio of the mass (weight) of the moisture in a quantity of air to the mass of the air and moisture together.

Humidity ratio (also referred to as the Absolute Humidity) indicates the actual amount of moisture found in the air.

Humidity ratio is expressed in grains (gr) of moisture per pound of dry air (gr/lb) or pounds of moisture per pound of dry air (lb/lb). In metric, it is usually measured in grams per kilogram (g/kg).

Dew Point and Measuring Latent Heat

Dew Point (DP)

The temperature below which moisture in the air begins to condense.

Dew point varies with the dry bulb temperature and the amount of humidity in the air. At dew point, air is saturated with moisture and the dry bulb and wet bulb temperatures are the same.

This is also known as saturation temperature. On a psychrometric chart, the dew point values are the same as the saturation temperature values.

Measuring Latent Heat (Water Vapour)

A wet bulb thermometer helps measure latent heat, which is the amount of water vapour in the air. A wet bulb thermometer is a mercury thermometer with a small cotton sock placed over the bulb. The end of the sock is placed in a reservoir of distilled water, so both sock and bulb remain wet.

The bulb is cooled as water evaporates from it. The thermometer registers a lower temperature than it would if the bulb were dry. The drier the air, the quicker the evaporation.

Once dry and wet bulb temperatures are known, consult psychrometric tables to determine the relative humidity. If relative humidity is 100%, indicating that the air can absorb no more water, the wet bulb temperature will be the same as the dry bulb temperature.

Enthalpy (H)

Any material that has a dry bulb temperature above absolute zero contains heat. Enthalpy (H) is the total heat contained in a substance, which is the sum of sensible heat and latent heat. Enthalpy is expressed in Btu per pound of moist air or in metric units joules per kilogram of moist air.

You can find the enthalpy of air at different conditions on a psychrometric chart.

Volume (V) and Specific Volume (v)

Volume (V)

Volume (V) is the amount of space occupied by a three-dimensional figure.

It is expressed in cubic units, such as cubic inches (cu inches), cubic feet (cu ft or ft^3), or cubic metres (m^3).

Specific Volume (v)

Specific volume (v) is the volume of a substance per unit of the substance. Air, like most substances, expands when heated and contracts when cooled.

The specific volume of air is expressed in cubic feet per pound (cu ft/lb) or (m^3/kg) at a given temperature.

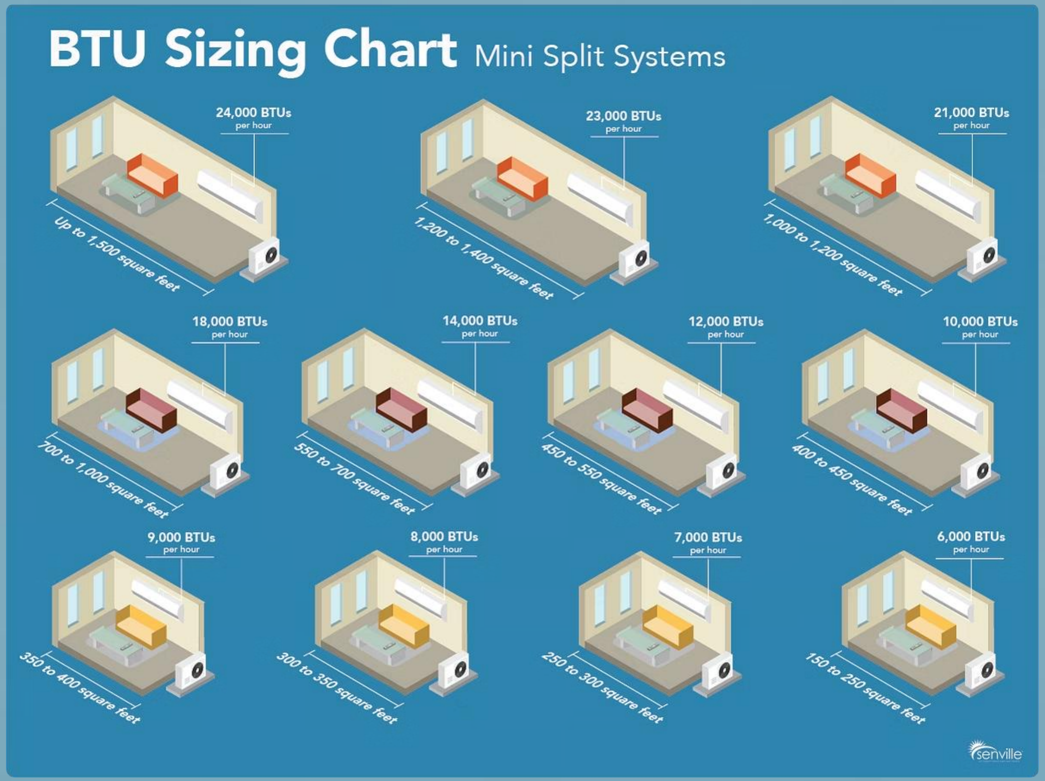
Because air expands and contracts with temperature change, air volume varies as temperature varies.

Standard Conditions

Properties of air are compared at standard conditions. Standard conditions are values used as a reference point in comparing properties of air at different elevations and pressures.

One pound of dry air and its associated moisture at standard conditions has a pressure of 14.7 psia, temperature of 68°F (20 °C), volume of 13.33 ft^3 (0.377 m^3), and density of 0.0753 lb/ft^3 (1.21 kg/m^3).

Use standard conditions when comparing the relationships between the different properties of air, such as on a psychrometric chart.



Calculating Volumetric Flow Rate of Ventilation Air

Ventilation air is brought into a building to keep indoor air fresh. The air must undergo:

Heating

If it is cooler than the indoor air.

Cooling

If it is warmer than the indoor air.

The occupancy and function of the structure determine the volumetric flow rate of ventilation air required. For residential and small commercial applications, the number of people occupying the space and the function of the facility may affect the degree and amount of air, as specified in the applicable building code. The design and installation of residential ventilation systems should be in accordance with the applicable provincial building code, CAN/CSA F326, and/or HRAI's manual (www.hrai.ca).

Volumetric Flow Rate Calculations

You may calculate volumetric flow rate required either in cfm (imperial: cubic feet per minute) or L/s (metric: litres per second).

Imperial Calculation

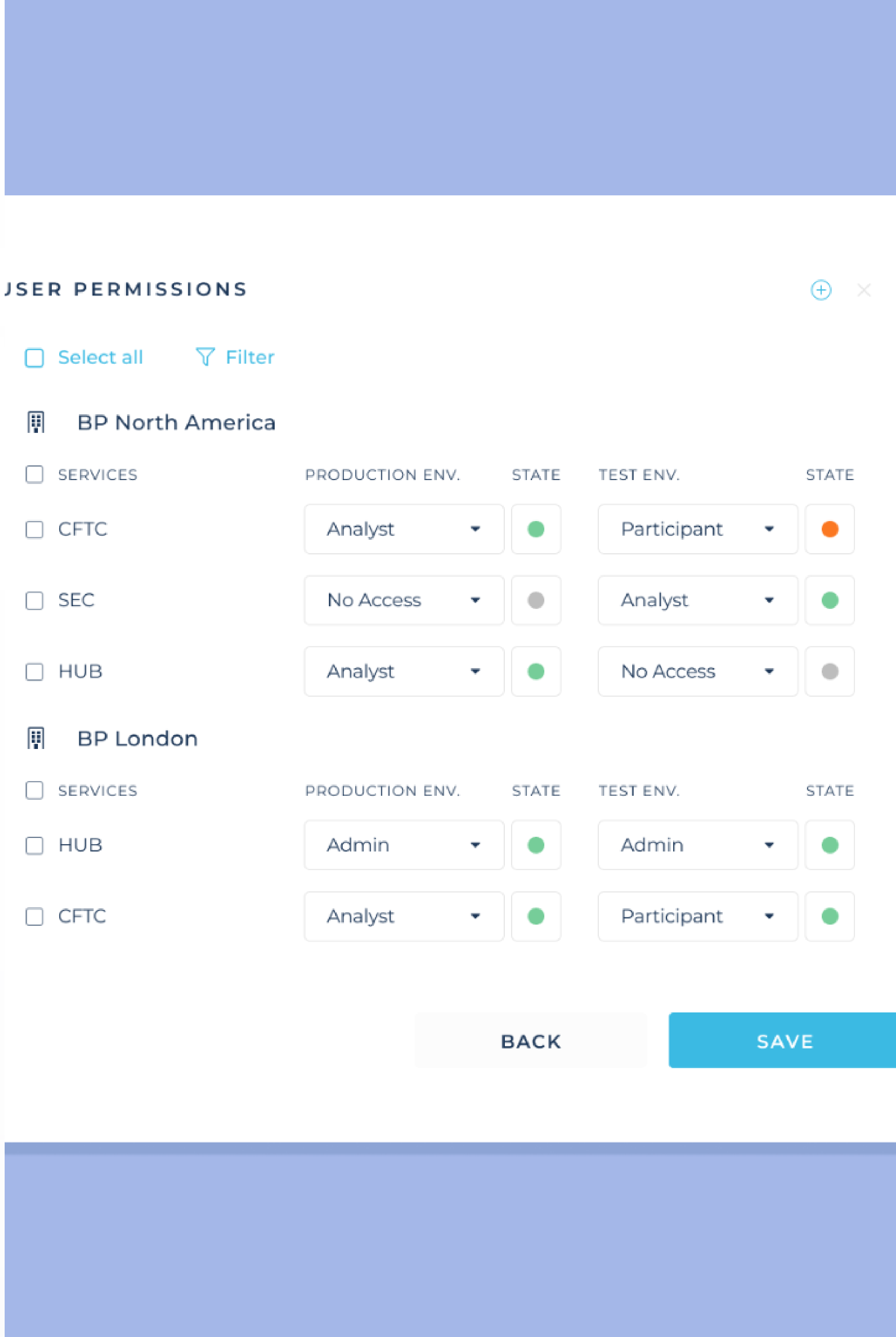
Air flow required for 1.5 air changes per hour:

cfm = Volume of heated space in cu ft × 1.5 / 60

Metric Calculation

Air flow required for 1.5 air changes per hour:

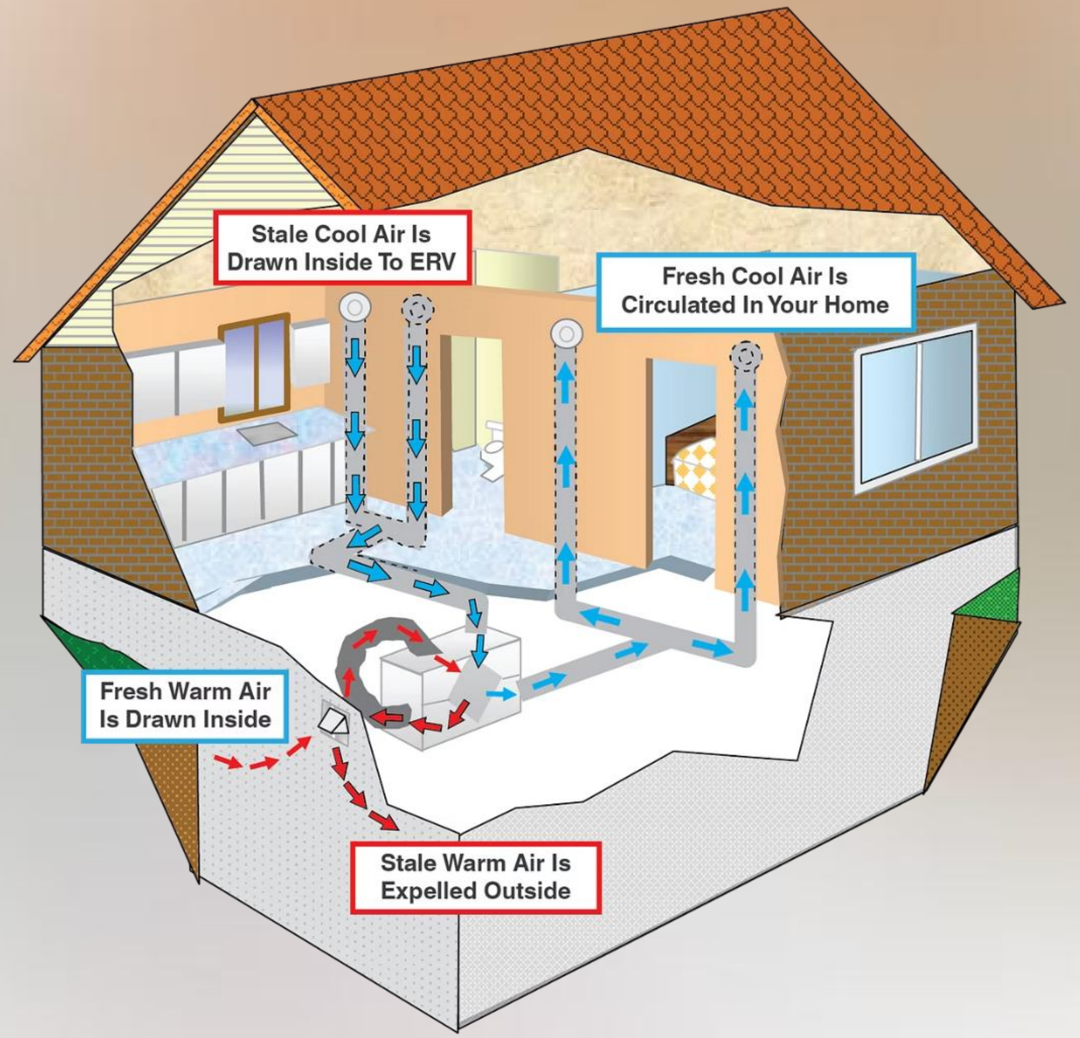
L/s = Volume of heated space in m^3 × 1000 × 1.5 / 3600

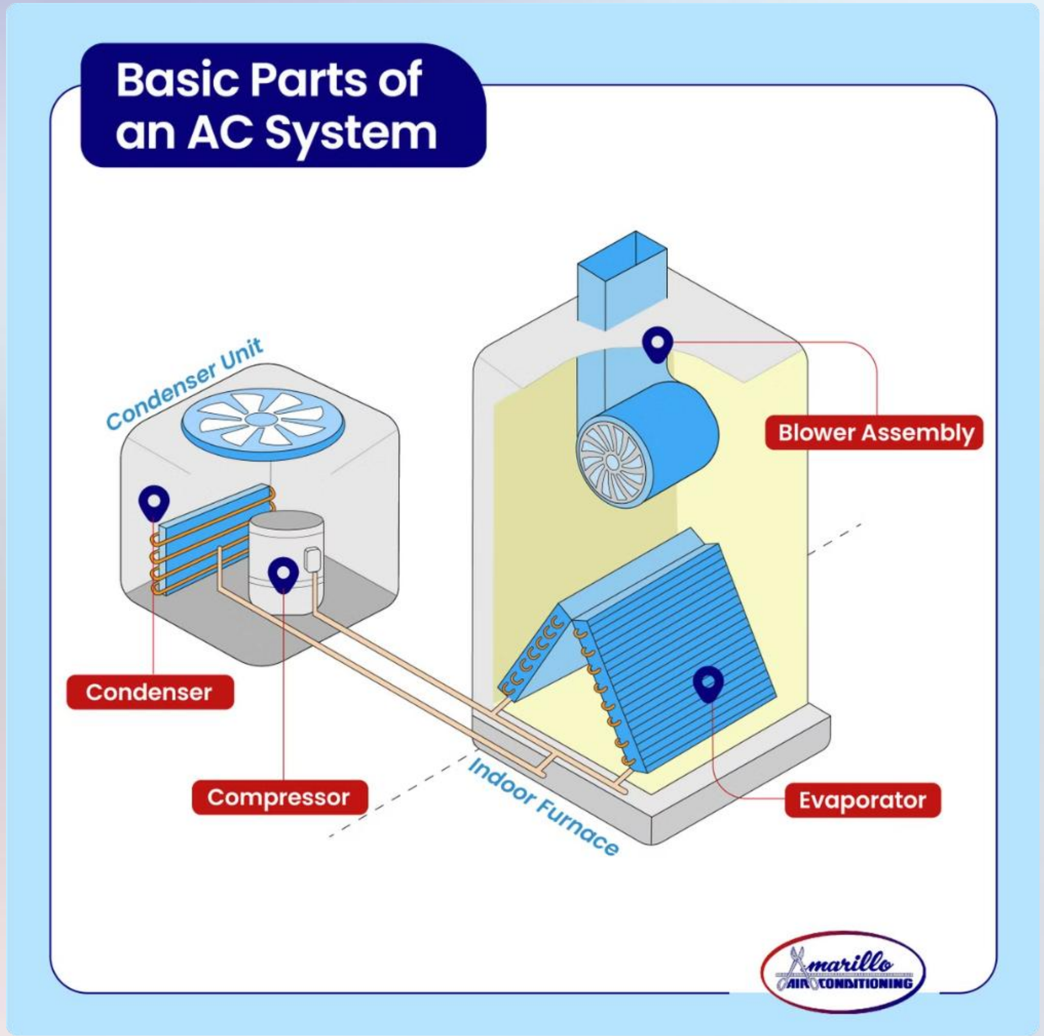


Ventilation Requirements Based on Bedrooms and Floor Area

This example of a building code table uses the number of bedrooms and the floor area to determine the ventilation fan air flow rate.

Floor Area, m^2	Minimum Air-flow rate, L/s Number of bedrooms				
	1	2	3	4	5
<140	14	21	28	35	42
140-280	21	28	35	42	49
281-420	28	35	42	49	56
421-560	35	42	49	56	64
561-700	42	49	56	64	71
>700	49	56	64	71	78





Air Handler Components

Blower

Moves air through the system

Filter Section

Removes particulates from air

Heating/Cooling Coils

Transfer thermal energy to/from air

Controls

Regulate system operation

Air Handler Blower Types

Forward Curved

Most common in residential systems. Provides high airflow at relatively low static pressures. Economical but less efficient than other designs.

Backward Curved

More efficient than forward curved. Better for higher static pressure applications. Self-limiting power characteristic prevents motor overload.

ECM Motors

Electronically Commutated Motors provide variable speed capability with high efficiency. Becoming standard in high-efficiency systems.

Air Handler Filtration

Basic Filters

Disposable fiberglass or washable aluminum mesh

Pleated Filters

Higher surface area and better filtration

HEPA Filters

High-Efficiency Particulate Air filtration

Electronic Air Cleaners

Electrically charged plates capture particles

Air Handler Maintenance

Filter Replacement

Replace filters regularly according to manufacturer specifications and system usage

Coil Cleaning

Clean heating and cooling coils to maintain heat transfer efficiency

Blower Service

Check blower wheel cleanliness, motor operation, and belt tension (if applicable)

Lubrication

Lubricate bearings and moving parts as recommended by manufacturer

Control Verification

Test all control functions and safety devices

Air Flow Measurement

Anemometer

Measures air velocity at supply registers or return grilles

Flow Hood

Captures and measures total air flow from registers or grilles

Manometer

Measures static pressure in ductwork to help determine system performance

Air Balance Procedures

System Inspection

Verify all components are properly installed and functioning

Blower Setup

Set blower speed to match system requirements

Flow Measurement

Measure air flow at all supply and return registers

Damper Adjustment

Adjust dampers to achieve proper air distribution

Documentation

Record all measurements and settings for future reference

Troubleshooting Air Flow Issues

Insufficient Air Flow

- Dirty filters
- Blocked registers or grilles
- Duct leakage or restrictions
- Improper blower speed setting
- Undersized ductwork

Excessive Air Flow

- Blower speed too high
- Missing filters
- Oversized ductwork
- Improper system design

Uneven Air Distribution

- Improperly balanced system
- Closed or partially closed dampers
- Duct design issues
- Zoning system problems

Noise Issues

- Loose components
- Blower wheel imbalance
- Air velocity too high
- Duct vibration

Air Handler Control Systems

Temperature Sensing

Thermostats monitor room conditions

Control Logic

Determines required system response

Equipment Operation

Activates heating, cooling, and fan components

Feedback Monitoring

Verifies proper system operation

Variable Air Volume (VAV) Systems

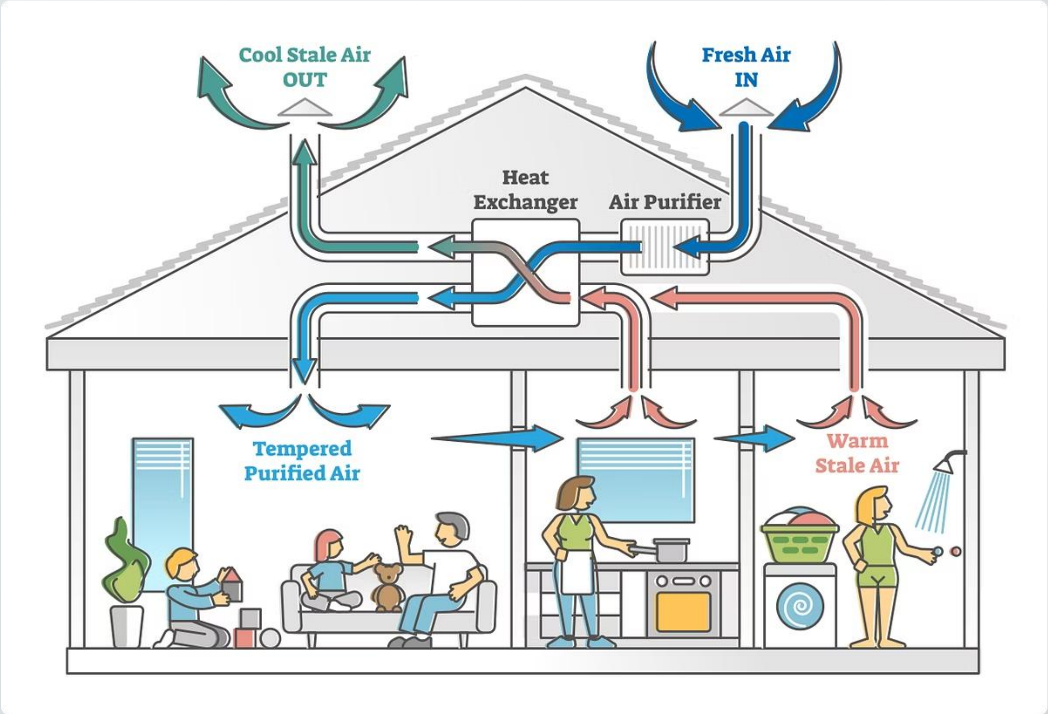
Variable Air Volume systems adjust the amount of air delivered to different zones based on heating or cooling demand, rather than varying the temperature of a constant air volume.

Components

- Central air handler with variable speed capability
- VAV terminal units (boxes) for each zone
- Zone thermostats
- Damper actuators
- Pressure sensors
- Control system

Advantages

- Energy efficient operation
- Individual zone control
- Reduced fan energy consumption
- Better humidity control
- Quieter operation at partial loads



Energy Recovery Ventilators (ERVs)

Energy Recovery Ventilators transfer heat and moisture between outgoing exhaust air and incoming fresh air, reducing the energy required to condition ventilation air.

Heat Exchange

Transfers thermal energy between airstreams

Moisture Transfer

Balances humidity between indoor and outdoor air

Energy Savings

Reduces heating and cooling costs

Fresh Air

Provides continuous ventilation

Heat Recovery Ventilators (HRVs)

Heat Recovery Ventilators transfer heat between outgoing exhaust air and incoming fresh air, but unlike ERVs, they do not transfer moisture.

Operation

HRVs use a heat exchanger core where exhaust air and fresh air pass through adjacent channels. Heat transfers through the separating material without the air streams mixing. In winter, heat from outgoing warm air preheats incoming cold air. In summer, incoming hot air is pre-cooled by the outgoing conditioned air.

Applications

HRVs are ideal for colder, drier climates where moisture recovery is not as critical. They provide excellent ventilation while minimizing heat loss, making them particularly valuable in energy-efficient, tightly sealed buildings where natural air infiltration is limited.

Duct Design Considerations

Load Calculation

Determine heating and cooling requirements

Duct Sizing

Calculate proper dimensions for air flow

Layout Planning

Design efficient duct routes

Register Selection

Choose appropriate supply and return grilles

Duct Sealing and Insulation

Duct Sealing

Properly sealed ducts prevent air leakage, which can account for up to 30% of energy loss in some systems. All joints, seams, and connections should be sealed with:

- Mastic sealant (preferred method)
- Metal tape (not cloth duct tape)
- Aerosol-based sealants (for existing systems)

Duct Insulation

Insulation is critical for ducts running through unconditioned spaces like attics, crawlspaces, and garages. Benefits include:

- Reduced energy loss
- Prevention of condensation
- Noise reduction
- Improved system efficiency

Typical R-values range from R-6 to R-8 depending on climate zone.

Air Handler Safety Considerations

Electrical Safety

Always disconnect power before servicing. Use proper lockout/tagout procedures. Verify proper grounding of all components.

Fire Safety

Maintain proper clearances around equipment. Ensure fire dampers are properly installed and functional. Keep combustible materials away from heat sources.

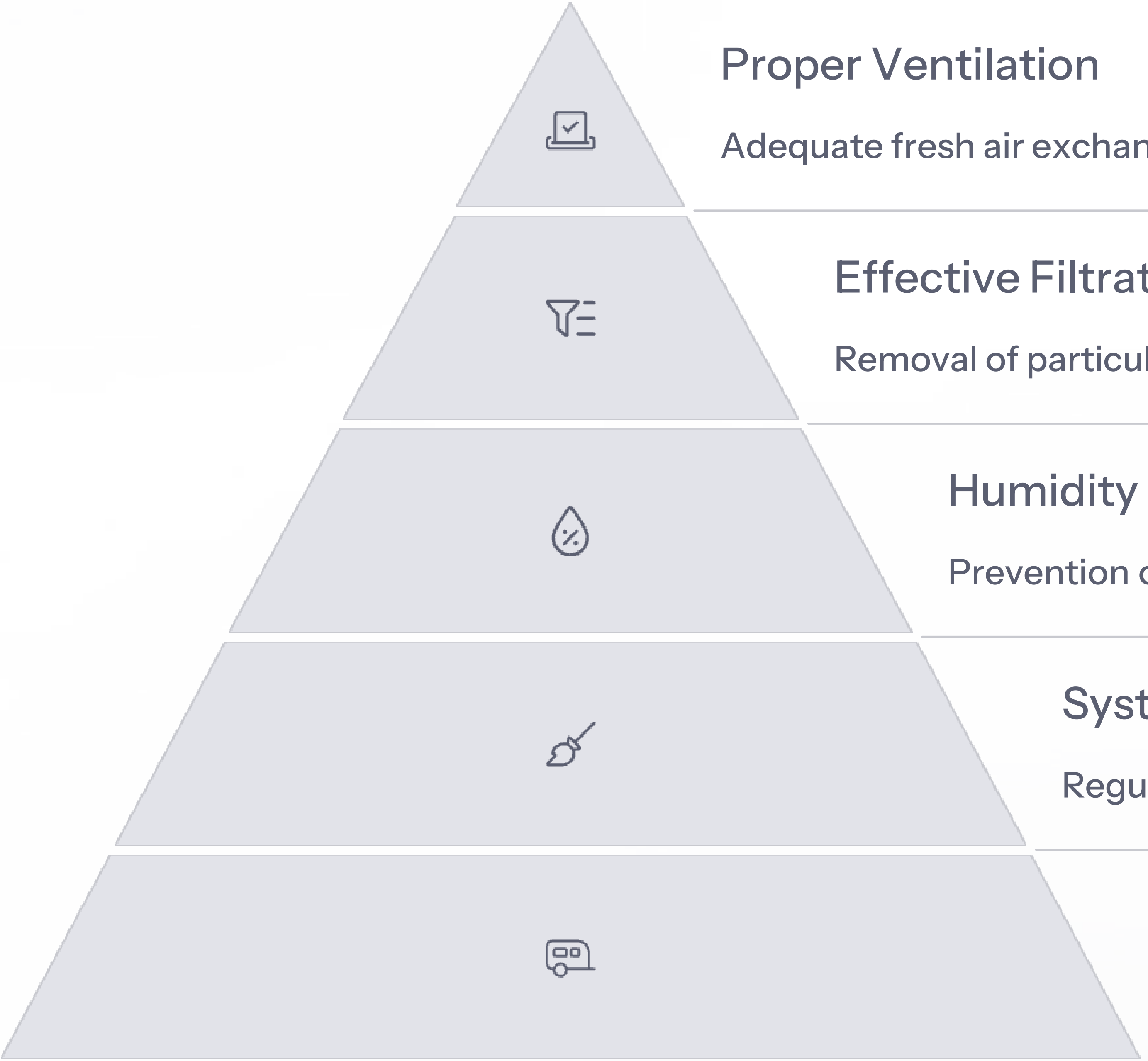
Respiratory Protection

Use appropriate PPE when working with insulation, sealants, or in dusty environments. Ensure proper ventilation during service work.

Mechanical Safety

Be aware of sharp edges on ductwork and equipment. Secure access panels properly. Use caution around moving parts like blower wheels.

Air Quality Considerations



Proper Ventilation

Adequate fresh air exchange

Effective Filtration

Removal of particulates and allergens

Humidity Control

Prevention of mold and bacteria growth

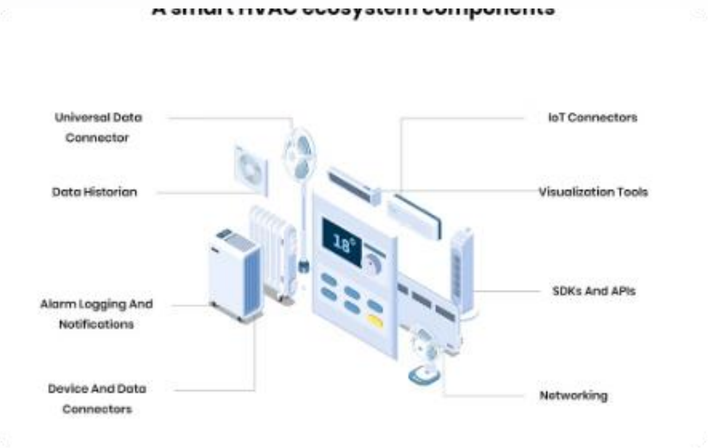
System Cleanliness

Regular maintenance of all components

Source Control

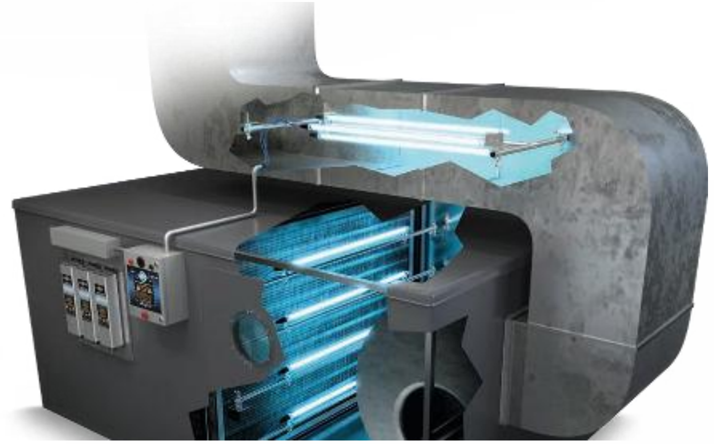
Elimination of pollutant sources

Advanced Air Handling Technologies



Smart Controls

Intelligent systems that learn occupancy patterns and preferences to optimize comfort and efficiency. These systems can integrate with home automation and provide remote access via smartphone apps.



UV Air Treatment

Ultraviolet germicidal irradiation (UVGI) systems that kill or inactivate microorganisms like bacteria, viruses, and mold. These systems are installed in air handlers to improve indoor air quality.

Variable Refrigerant Flow

Advanced systems that vary the refrigerant flow to multiple indoor units from a single outdoor unit. These systems provide exceptional zoning capabilities and energy efficiency.

Summary of Air Handling Principles

3

Ventilation Types

Exhaust, supply, and balanced systems

4

Heat Transfer Methods

Conduction, convection, radiation, and evaporation

2

Key Air Properties

Temperature and humidity

1.5

Air Changes Per Hour

Typical residential ventilation requirement

Understanding air handling principles is essential for gas technicians/fitters to ensure safe, efficient, and effective operation of gas-fired heating and ventilation systems. Proper application of these principles helps maintain indoor air quality, occupant comfort, and equipment longevity while meeting all applicable codes and standards.

CSA Unit 24

Chapter 2
Air Handling Units

Air movement in a building comes about because of the relationship between the properties of the air itself and the building, the blower moving the air, and the duct system. In this presentation, we'll explore air handling devices and the duct system in detail. Understanding the electrical and mechanical components of blowers and their service and adjustment is essential for gas technicians and fitters.

Purpose of Air Handling Units

Building Comfort

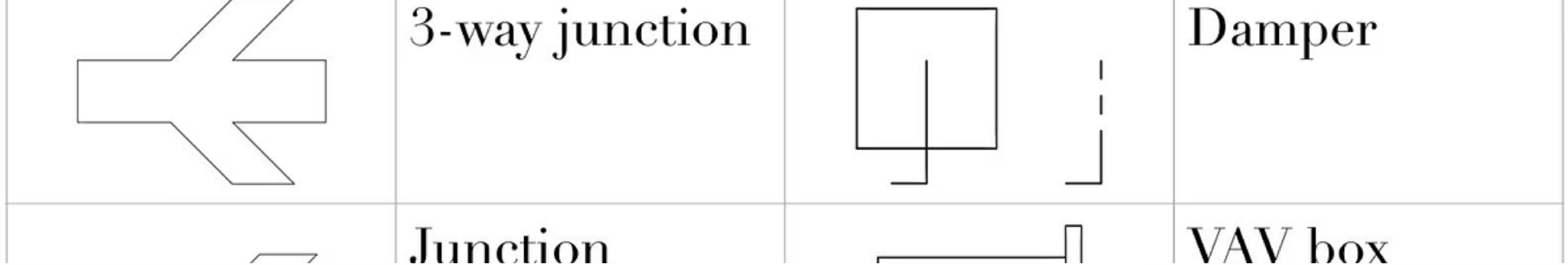
Air handling units ensure proper air movement throughout a building to maintain comfort levels for occupants.

Temperature Control

They work with heating and cooling systems to distribute conditioned air to maintain desired temperatures.

Air Quality

Air handling units help filter and circulate fresh air, improving indoor air quality.



Key Terminology

Air handling device	Any device that moves air in a ducted system
Dampers	Used in duct systems to control the flow of air
Electronically commutated motor (ECM)	A brushless dc, variable speed motor that uses less energy but delivers more torque than the standard PSC motor
Permanent split capacitor (PSC)	A capacitor motor that uses its start winding and capacitor continuously without change in capacitance
Total external static pressure (TESP)	The measurement of all the resistance in the duct system that the fan has to work against

Gas-Fired Duct Furnaces

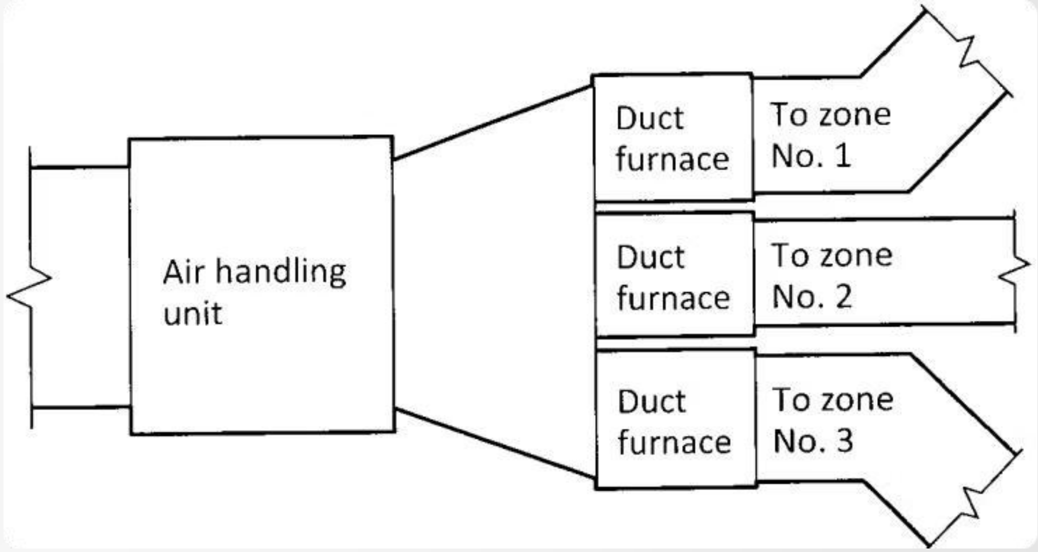
Definition

Gas-fired duct furnaces are designed for use in ducted applications with a separate air handling device. They can be installed inside or outside a building and are most frequently used in commercial and industrial settings.

Flexibility

Because duct furnaces use a separate air source, they allow for considerable flexibility in air flow delivery. For example, multiple duct furnaces can be used with an air handling unit to provide zone heating.

Figure 2-1
Zone heating with multiple duct furnaces
Courtesy of The Trane Company



Duct Furnace Configurations

Typically, duct furnaces are used in conjunction with filters, cooling coils, and an air handler to provide a complete heating, cooling, and air handling system for a building. Configurations vary depending on building structure and heating and cooling requirements.

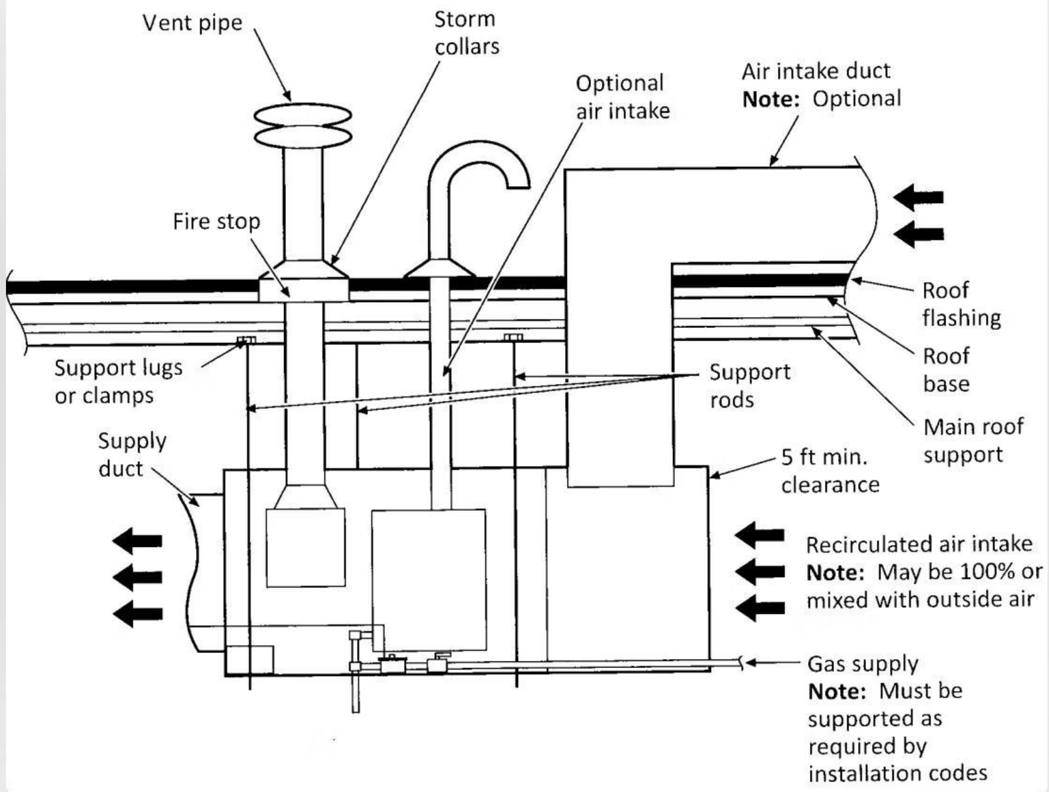
Indoor Duct Furnaces

Designed for installation in buildings, usually suspended from the main roof beams.

Outdoor Duct Furnaces

Weatherproof and designed for outdoor installation, working with HVAC and makeup air systems.

Figure 2-3
Indoor duct furnace
Courtesy of Gasmaster Industries Inc.



Indoor Duct Furnaces

Safe Venting

Use only vent materials approved for use with the indoor duct furnace.

Clearances

Pay attention to clearances required from combustible material and clearances to fresh air intakes and other vents.

Accessibility

Vents must not block access to the furnace and must be accessible for cleaning.

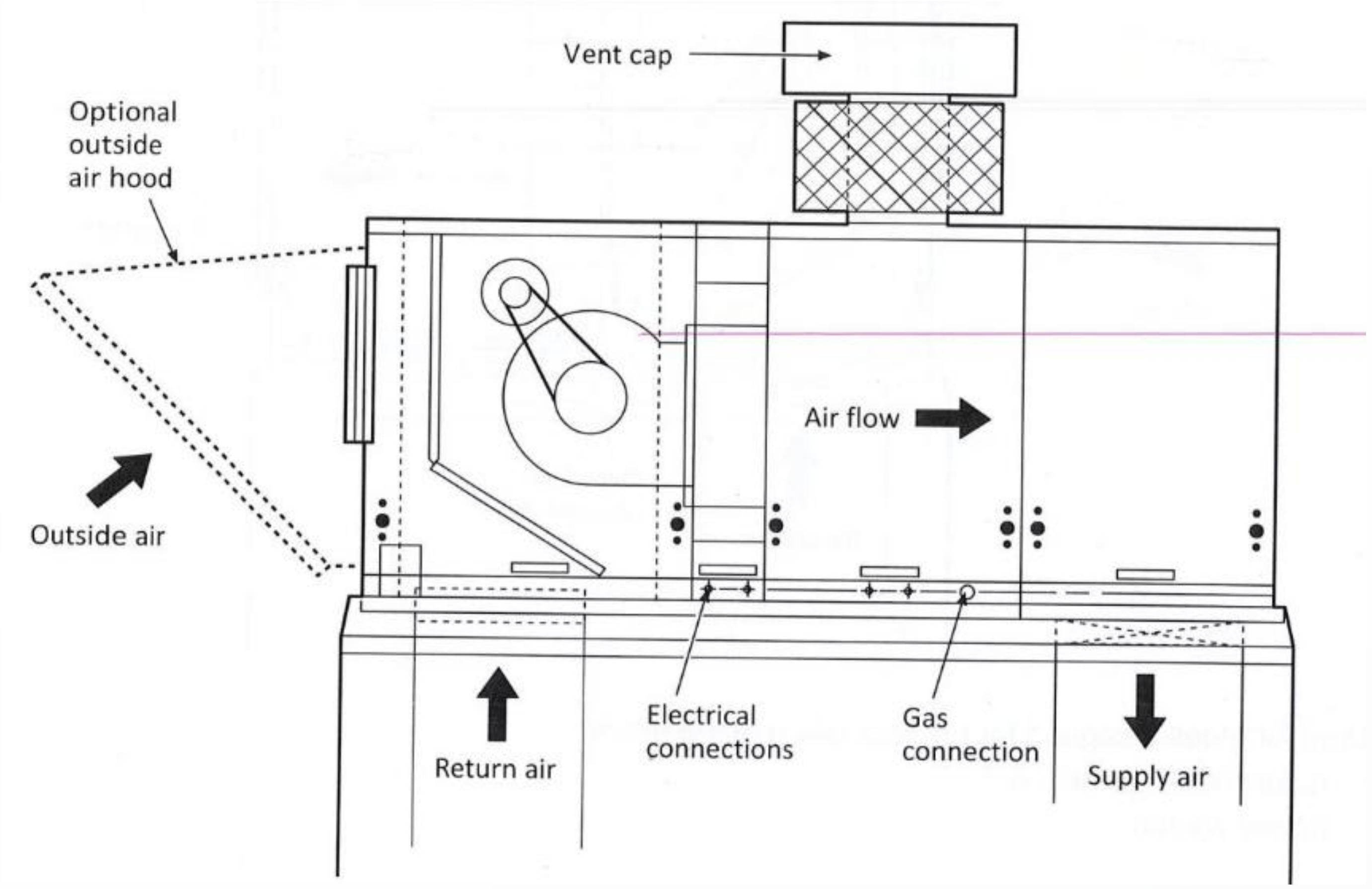
No Restrictions

Never install dampers or any other device that cause vent restriction.

Outside Duct Furnaces

Down-flow Plenum

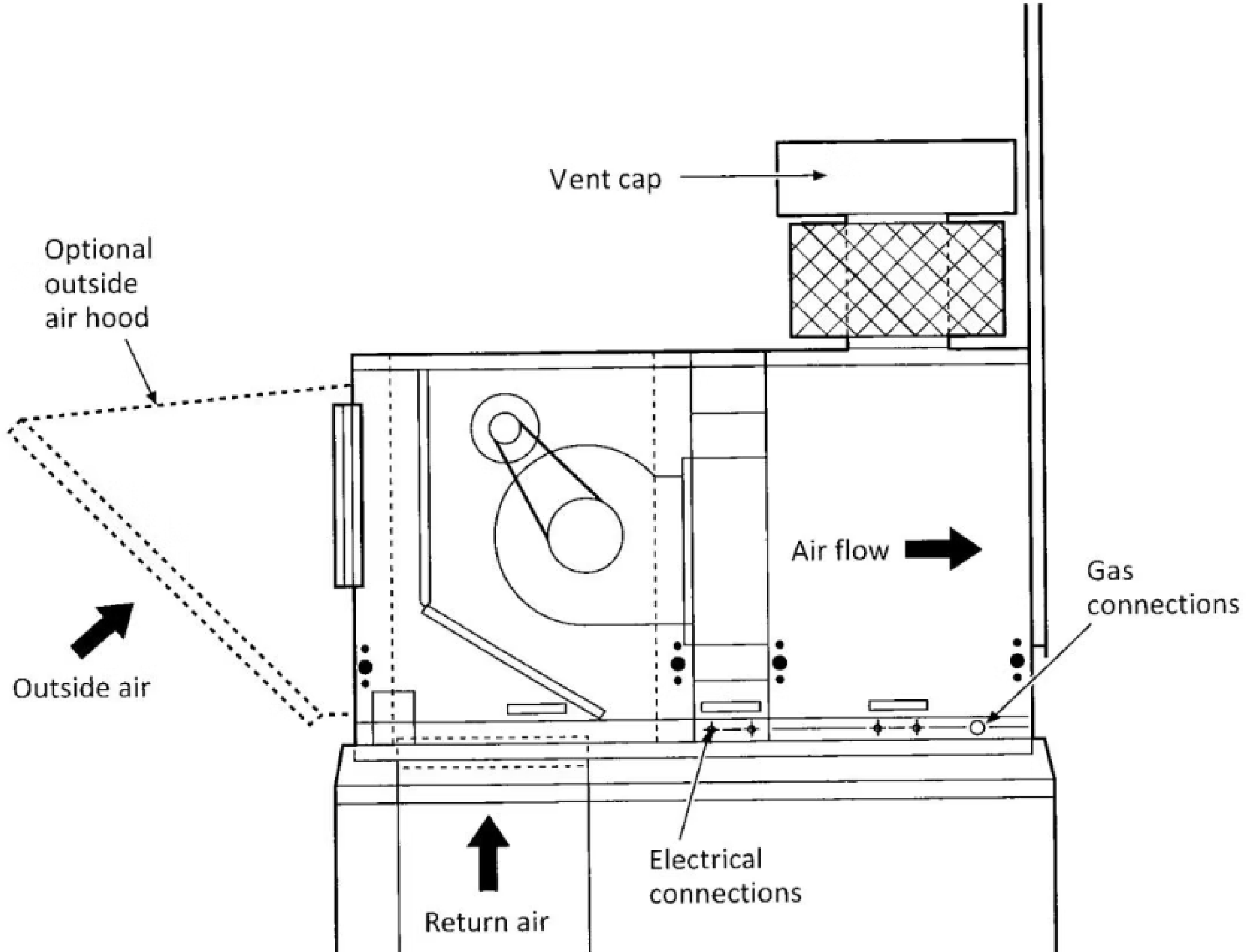
In duct furnaces with a down-flow plenum, the blower fan forces supply air down into the plenum as it leaves the heat exchanger, for subsequent dispersion through the ducts.



Horizontal Plenum

In duct furnaces with a horizontal plenum, the supply air is blown through the heat exchanger in a straight line, into the plenum, for subsequent dispersion through the ducts.

Outside duct furnace with horizontal plenum
Courtesy of The Trane Company



Outdoor Duct Furnace Venting

Natural Draft Vented

Uses natural convection to remove combustion gases, relying on the tendency of hot gases to rise.

Power Vented

Uses a fan or blower to force combustion gases out of the furnace and through the venting system.

Installation and Mounting Options

Roof Curbs

Constructed of heavy gauge steel. The duct furnace unit has sealing to the roof curb using a neoprene gasket.

Base Frames

An iron base frame running the length and width of the unit supports the frame. Base rails must be sealed to the roofing material and be the same width apart as the unit's main frame rails.

Suspension Mountings

Mounting points are provided on the unit for easy installation using threaded rods.

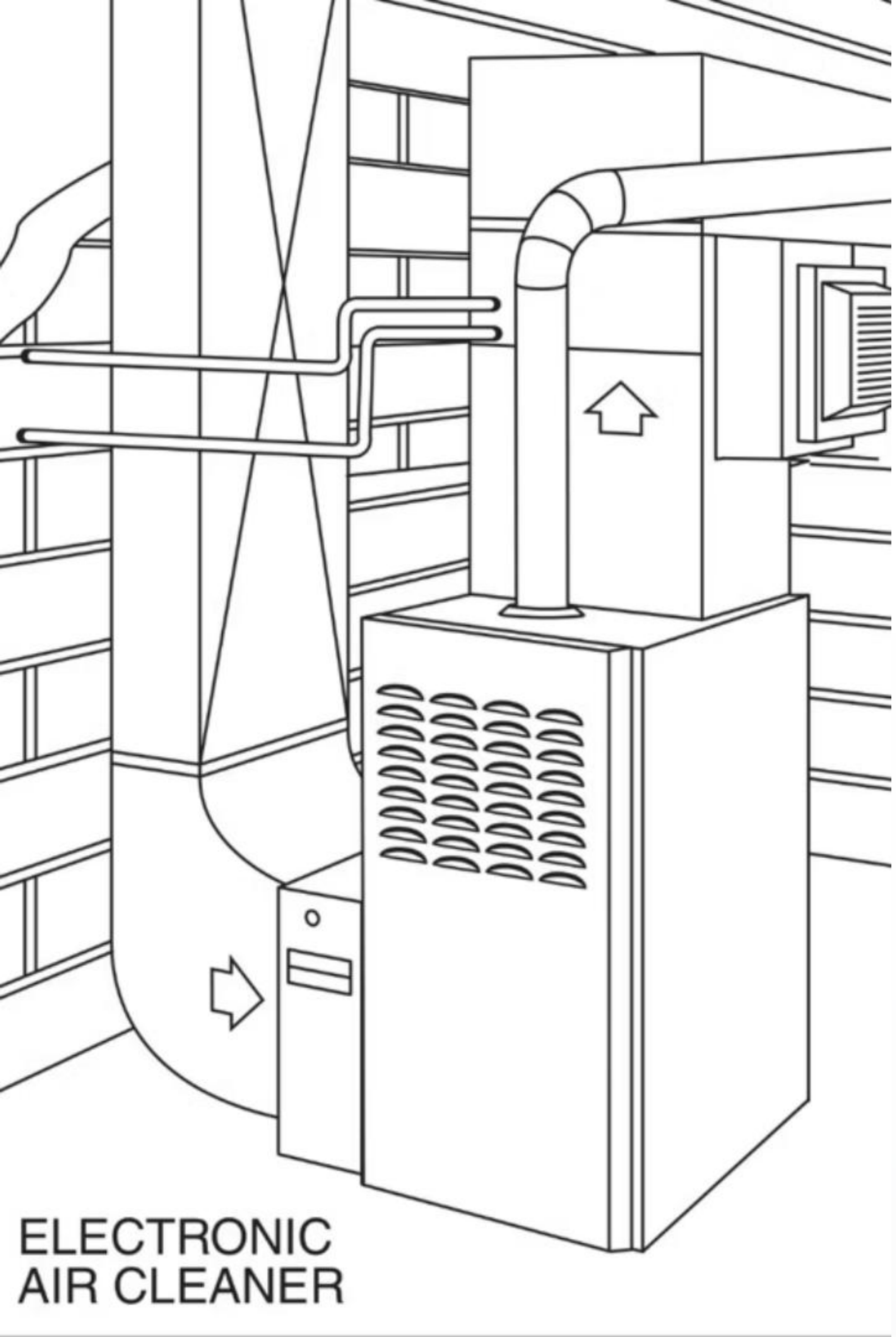
Installation Requirements

Must

- Be well supported
- Be installed with appropriate clearances on all sides
- Provide access for required service
- Be installed upstream from air conditioning coils

Must Not

- Be installed inside if intended for outside
- Be located under an overhang
- Have the heat exchanger subject to negative pressure
- Have downstream duct furnaces operate before upstream ones



Combustion Air Requirements

It is important that air used in the combustion process not contain materials that can harm the heat exchanger.

Harmful Chemicals

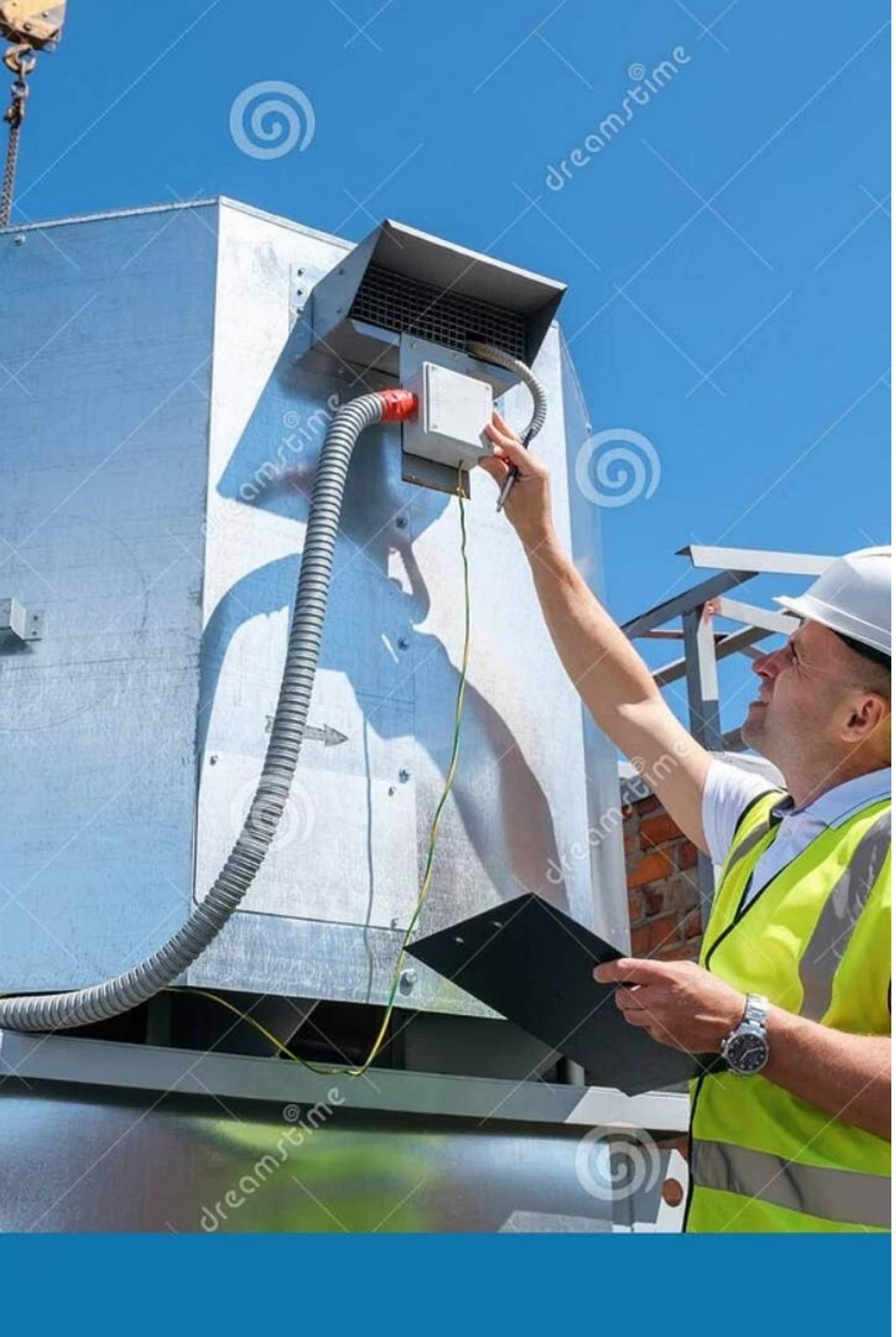
Many chemicals used in industrial processes can damage heat exchangers, including halogen-type refrigerants, cleaning solvents, and printing inks.

Chlorine Products

Chlorine-based products including waxes, cleaners, and pool chemicals should be kept away from combustion air.

Laundry Products

Laundry products can contain chemicals that may damage heat exchangers if present in combustion air.



Supply Air Fan Checks

Check Motor Starter Overloads

Ensure they are correctly adjusted to the full load current shown on the motor nameplate, and all thermal resets are made.

Set Fan Switch

If the unit has a remote fan switch, set it to the ON position.

Check Fan Rotation

Verify the correct rotation of the supply fan. If necessary, reverse any two leads on a three-phase motor or follow manufacturer's wiring diagram.

Verify Amperes Draw

Make sure amperes draw of supply motor does not exceed amperes on rating plate of motor.

Monthly Maintenance Tasks

Check Valves and Piping

Check all valves, piping, and connections for leaks.

Inspect Flame

Check flame signal and flame characteristics.

Check Pressures

Check gas supply line pressure and burner manifold pressure at each firing rate.

Inspect Filters

Clean or replace filters as necessary.

Quarterly Maintenance Tasks

Complete Monthly Tasks

Perform all monthly maintenance tasks first.

Check Belt Tension

Check and adjust belt tension on main fans.

Check Alignment

Check alignment of sheaves.

Inspect Bearings

Inspect bearings and lubricate if necessary.

Check Pilot Assembly

Clean and adjust if necessary.

Annual Maintenance Tasks

Complete Previous Tasks

Perform all monthly and quarterly maintenance procedures.

Inspect Fan Assemblies

Clean and check that all fan assemblies are secure.

Inspect Heat Exchanger

Check the secondary heat exchanger surface and clean as necessary.

Flush Condensate Drains

Ensure they are free flowing.

Other Air Handling Components

Manufacturers typically custom-design air handling equipment for commercial and industrial applications as required for specific installations. A typical duct furnace can be installed in conjunction with many different blowers, in different sizes, and with different duct configurations.

Custom Design

Except for the simplest air handling installations, the equipment is custom designed and built.

Discharge Options

Equipment may be designed for top discharge, bottom discharge, or side discharge, depending on the configuration required.

Air Conditioning Coils

These may become dirty and reduce air flow through the duct system. Always inspect and clean these additional components as necessary.

The Duct System

The proper design of an air handling system — whether for residential, commercial, or industrial use — is not just a matter of selecting the individual components. The blower, heating and cooling units, add-on devices, and duct systems must all work together to make the space comfortable and safe for building occupants.

Purpose

The duct system distributes heated or cooled air to the conditioned space. It must let the air move freely, but at the same time, it must not be oversized.

Considerations

- New construction
- Renovations or retrofits
- Troubleshooting existing systems

Function of Duct Systems

Blower Push

The blower pushes air into the supply side duct system.

Air Diffusion

Air is diffused into the conditioned building space.

Return Air

Air moves from the space into the return air ducts and returns to the blower.

Supply Air Side: Extended Plenum

In an extended plenum system, a trunk duct — the same size as the furnace plenum — carries air to small ducts called branches to circulate air to the building's rooms. Branch ducts are usually round and typically five or six inches in diameter.

Trunk Duct

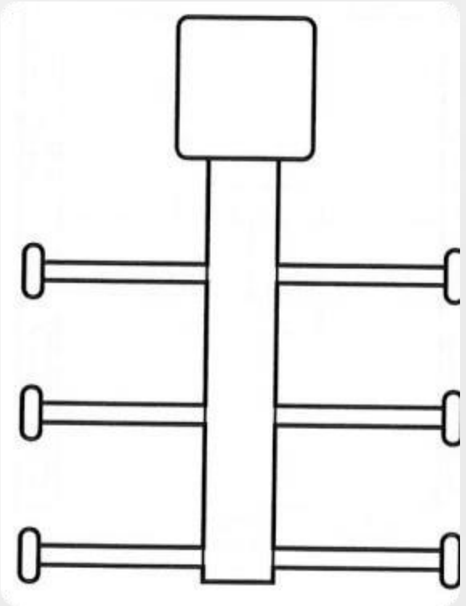
Same size as the furnace plenum throughout its length.

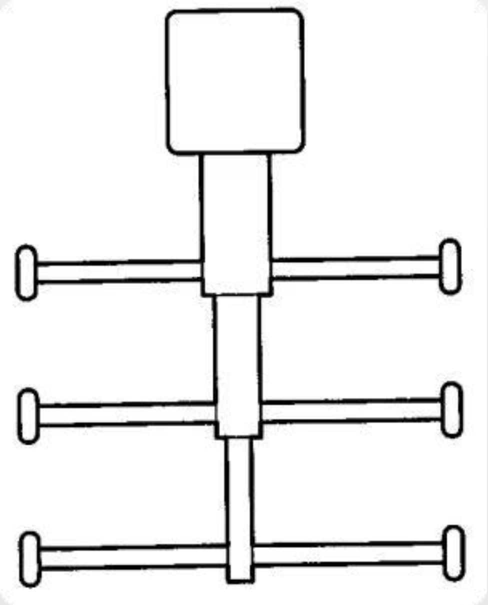
Branch Ducts

Small round ducts that deliver air to individual rooms.

Positioning

Takes the plenum closer to the branch connections farthest from the blower.





Supply Air Side: Reducing Plenum

The reducing plenum system is also called a graduated trunk system. Like the extended plenum system, the reducing plenum system uses branches to deliver air to rooms. The size of the trunk duct is reduced as branch ducts are added.

Graduated Sizing

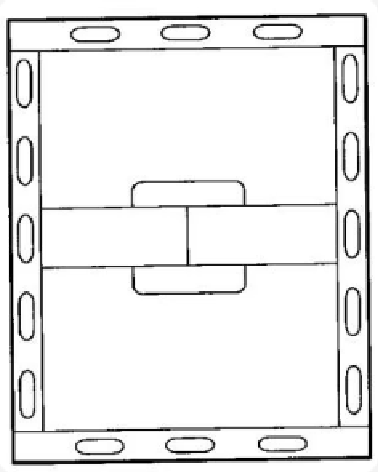
The trunk duct gets smaller as branch ducts are added along its length.

Pressure Maintenance

When properly sized, the same pressure is maintained along the trunk's length and in the branches.

Efficiency

This design helps ensure even air distribution throughout the system.



Supply Air Side: Perimeter Loop

A perimeter loop system is particularly suited for installation in a concrete floor. The loop can run around the perimeter to the outer walls, with the outlets next to the wall. When the furnace fan is running, there is warm air in the whole loop.

Concrete Floor Installation

Ideal for installation in concrete slab construction.

Even Temperature

Keeps the slab at an even temperature throughout.

Constant Pressure

Since the loop is at a constant pressure, air pressure is the same to all outlets.

Figure 2-9
Radial duct system

Supply Air Side: Radial System

In a radial system, supply air is delivered from a central plenum to a separate duct for each register. Since warm air ducts are normally located below joist level, a radial system will reduce head room in the basement.

Central Plenum

Air is distributed from a central point to individual ducts.

Individual Ducts

Each register has its own dedicated duct running from the central plenum.

Best Applications

More suitable for crawl space or slab construction due to headroom requirements.

Return Air Side

Central Return

In a central return system, one return air grille is installed on each floor of the building in a central location. Pressure differences draw air from all rooms to the return air grille.

For the system to function, there must be a clear path for the air: open doorways, doors with grillwork openings, or undercut doors may be used.

Individual Return

Individual return air systems have a return air grille in every room, except kitchens, bathrooms, or rooms without supply air.

This system is more expensive than a central return system, but will give the most positive return air system. Return air ducts are usually slightly larger than the supply duct, so there is less resistance to air flow in the return system.

Components of Duct Systems: Take-offs

Take-offs are fittings that draw some or all of the air from a plenum or duct into another duct.

Plenum Take-offs

Typically the same width as the plenum and serve as the transition between the plenum and the supply-side duct.

Top Take-offs

Draw air from major duct sections and direct it into smaller sections for diffusion into the conditioned space.

Side Take-offs

Similar to top take-offs but positioned on the side of the duct.

Universal Take-offs

Can be used either on the side or on the top of ductwork, performing the same function.

Components of Duct Systems: Transition Fittings

To ensure even air circulation and prevent excessive pressures on ductwork, changes in duct volume must be gradual. This is accomplished by installing transition fittings.

Transition Piece

A fitting used to connect ducts that have different-shaped mating surfaces.

Right-angle Boot

A fitting going from rectangular to round on a 90° angle. Sometimes used when going from an interior wall space containing rectangular ducts to a round duct.

Universal Boot

A fitting used to make a transition from a rectangular to a round duct without changing direction.

End Boot

A fitting going from rectangular to round, with the length of the rectangle in line with the round duct.

Components of Duct Systems: Dampers

Dampers are used in duct systems to control the flow of air. They may be installed in the duct system to control air flow to the building space.

Operation

When the damper is closed, the plates overlap and air flow is stopped. When the damper is open, the plates allow air passage between them.

Typically, dampers are made of metal plates. Dampers for supply registers are made of a single metal piece and are available in all supply duct shapes and sizes.

Control Methods

- Manually (for example, dampers on supply registers in residential applications)
- Automatically by a temperature-activated device or end switch

Components of Duct Systems: Outlets and Connectors

Grille

Perforation or louvred cover installed at the outlet or intake of a duct.

Diffusers

Outlets in the duct system supply side, through which warmed or cooled air enters the heated or cooled space of the building.

Block Ends

End cap of a duct.

Drive Cleat

A clip hammered on to the preformed edges of duct to hold two pieces of duct together.

Components of Duct Systems: Structural Elements

Joist Liner

Sheet metal covering the space between two joists, allowing the space to be used as a duct.

Riser

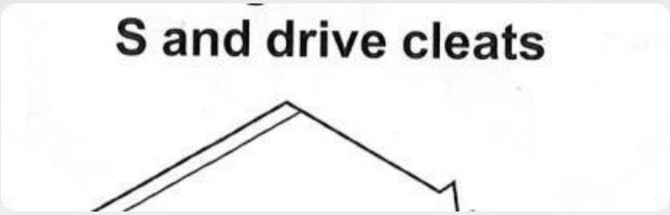
A vertical duct or fitting that connects two ducts that are parallel but at different elevations.

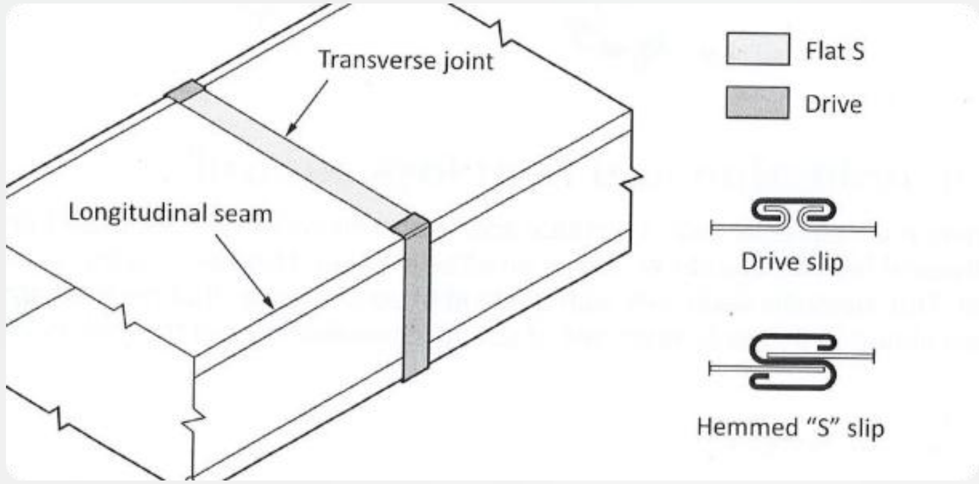
Offset

A fitting that connects two ducts that are parallel without changing elevation.

S Cleat

An S-shaped clip used along the long sides of ducts to join them. The cleat prevents air loss at points where ducts connect.





Duct System Diagram

This diagram shows the interrelationships between the various components of a duct system, including the supply and return sides, as well as the various fittings and transitions used throughout.

Supply Side

Distributes conditioned air from the furnace to the living spaces.

Return Side

Brings air back to the furnace to be reconditioned.

Connections

Various fittings and transitions ensure proper air flow throughout the system.

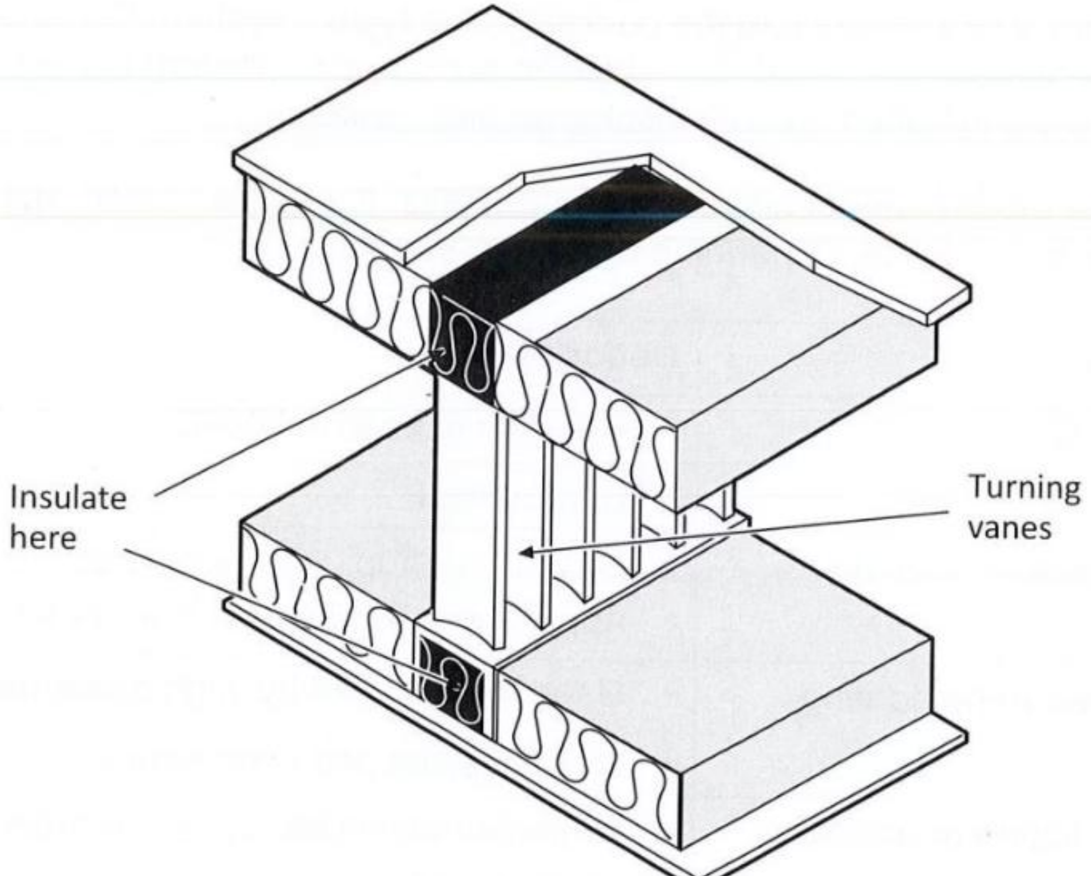
Noise Reduction and Heat Loss Control

Duct liners are frequently used to reduce sound and minimize heat transfer. Fibreglass — since it can withstand high temperatures and is an effective sound barrier — is the most frequently used material. The materials used vary with the levels of sound. Specifications for the installation must be followed.

Acoustical Liners

An effective acoustical or thermal liner must be continuous, without gaps. Build-outs help anchor the material. The build-outs must also have insulation.

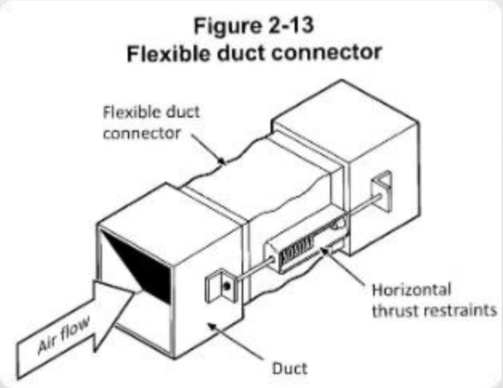
Figure 2-12
Insulated build-out



Types of Liners

- Flexible liners (blankets)
- Exterior insulation
- Semi-rigid boards

Always install the black side of the duct liner toward the air stream. High-velocity ducts may have an internal perforated metal liner to further protect the fibreglass.



Flexible Duct Connectors

Flexible duct connectors are used in HVAC systems to reduce noise. Noise is transmitted from fans and blowers into the ductwork of a typical system. Flexible connectors — typically made of fabric — absorb the vibration to reduce or prevent noise transmission.

Connector Fabric	Description
Polyester with PVC	Commonly used in HVAC, Economical
Fibreglass with hypalon coating	Used in rooftop units and outdoor air handling applications where weatherproofing is a must
Fibreglass with neoprene coating	Used in high velocity, high pressure duct systems, Resists acids and toxic fumes
Fibreglass with silicone or urethane coating	Replaces asbestos for high-temperature applications

Add-on Devices

Add-on devices such as humidifiers, cooling coils, and air cleaners can affect the flow of air in the return or supply system.

Humidifier

Add-on devices that introduce water vapour into the air, increasing the relative humidity in the building. Operation may be based on evaporation, vaporization, or atomization.

Cooling Coil

Devices used in conjunction with blowers to air condition a home. In residential applications, often an add-on device, installed into the supply-side plenum and using the air moving potential of the blower.

Air Filtration Devices

Normally located upstream from humidifiers to prevent them from becoming wet (especially important for electronic air cleaners). May be placed in the outside air intake, or in the return plenum or duct.

Air Flow in the Duct System

Building comfort depends on air flow. Several factors influence operation of the air flow system. These include the building itself and its heating or cooling load, the duct system, and the air handling unit moving the air through the ducts.

Building Factors

The structure, insulation, and heating/cooling requirements of the building affect air flow needs.

Duct System

The size, layout, and components of the duct system determine how efficiently air can move.

Air Handling Unit

The capacity and settings of the blower determine how much air can be moved through the system.

System Balance

Each of these factors is dependent on the others. It is not possible to alter one aspect of the system without causing changes in the overall operation.

Air Pressure Readings

Gauge Pressure	Amount by which pressure of air, or of a fluid, exceeds the ambient atmospheric pressure. Used to express pressures inside a closed system. Expressed in pounds per square inch gauge (psig) or Pascals (Pa).
Absolute Pressure	The level of pressure above a perfect vacuum. Equal to gauge pressure plus atmospheric pressure. Expressed in pounds per square inch absolute (psia) or kilopascals (kPa).
Atmospheric Pressure	Used to measure atmospheric pressure. A test tube is placed opening down in an open dish of mercury. With a perfect vacuum in the tube, atmospheric pressure on the surface of the mercury forces it up the tube.
Water Column	Very small pressure changes are expressed in inches of water column (w.c.) or Pascals (Pa), rather than mercury. Since the pressure in forced-air systems is very low, most measurements use these units.

Calculating Air Flow

You must consider a number of factors to calculate air flow in a building. These factors include the velocity of the air, the volume of air moving through the ducts, and the effect of friction from ducts and fittings on the air flow.

Velocity

The speed at which air moves from one point to another, typically measured in feet per minute (ft/min) or meters per minute (m/min).

Volume

The amount of air moving through the system, typically measured in cubic feet per minute (cfm) or cubic meters per hour (m^3/h).

Friction

The resistance to air flow caused by the duct system and its components, which affects how much air can be moved by the blower.

Volumetric Air Flow

You must know the volume of air flow in order to ensure the system moves enough air to provide the required air changes per hour. Air flow is ordinarily measured in cubic feet per minute (cfm). It may also be measured in cubic meters per hour (m^3/h).

400

CFM per Ton

Typical air flow needed per ton of cooling

12-15

Air Changes

Recommended air changes per hour for most spaces

1.08

Constant

Used in air flow calculations for heating systems

Air Velocity

Air velocity is the speed at which air moves from one point to another. Air velocity is an important part of air circulation. Proper air circulation is important since it prevents temperature stratification and drafts.

Calculation Formula

To find the velocity, divide the air flow rate (in cfm) by the area of duct (in ft^2), or the air flow rate (in m^3/min) by the area of the duct (in m^2).

$V = Q/A$

Where:

V = air velocity (ft/min or m/min)

Q = air flow rate (cfm or m^3/min)

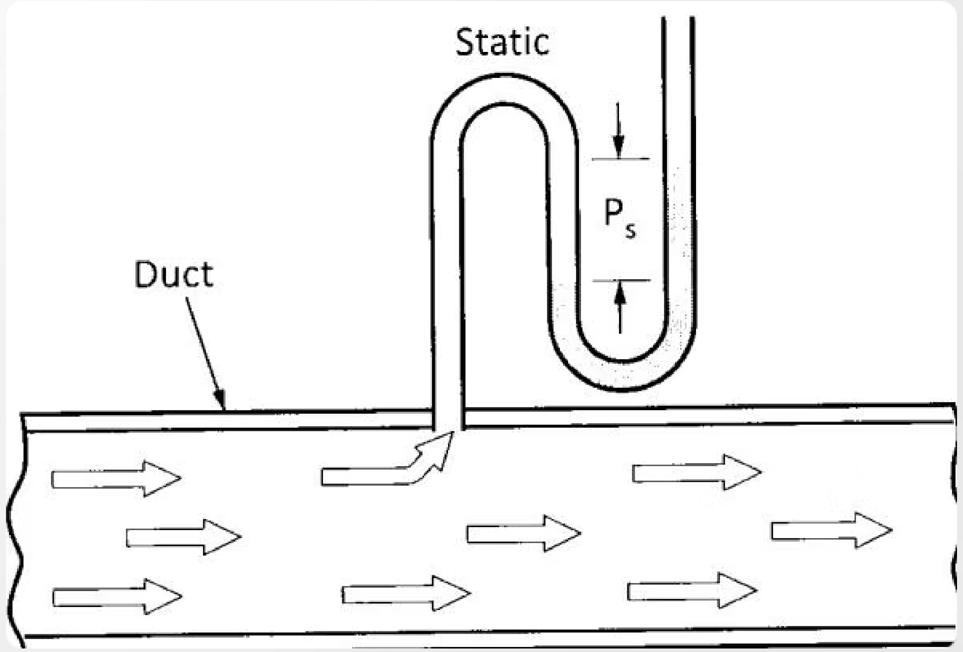
A = area of duct (ft^2 or m^2)

Example

If the blower in a forced-air distribution system moves 1200 cfm of air through a 24 × 12 inch duct:

$A = (24 \times 12) \div 144 = 2\ ft^2$

$V = 1200 \div 2 = 600\ ft/min$



Duct System Pressures: Static Pressure

Static pressure is air pressure in a duct, at right angles to the direction of air flow. In the diagram, a manometer connection is positioned perpendicular to the walls of the duct and, therefore, senses only the outward or static pressure.

Measurement

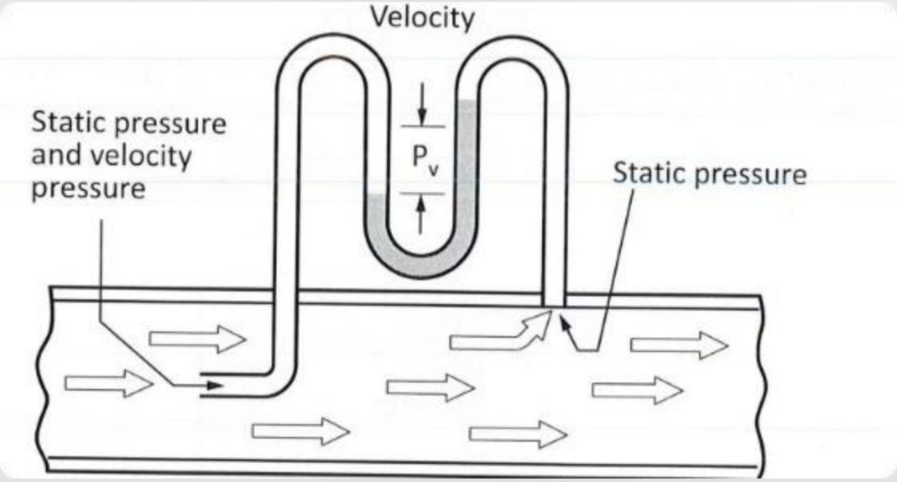
Measured using a manometer with a connection perpendicular to the duct wall.

Importance

Static pressure is a key factor in determining the resistance that the blower must overcome.

Units

Typically measured in inches of water column (w.c.) or Pascals (Pa).



Duct System Pressures: Velocity Pressure

Velocity pressure is the air pressure in a duct that parallels the direction of air flow. The weight and velocity of the air creates it. However, measuring velocity pressure without also measuring static pressure is difficult; therefore, calculate velocity pressure by subtracting the static pressure from the total pressure.

Direction

Velocity pressure acts in the direction of air flow.

Calculation

Velocity pressure = Total pressure - Static pressure

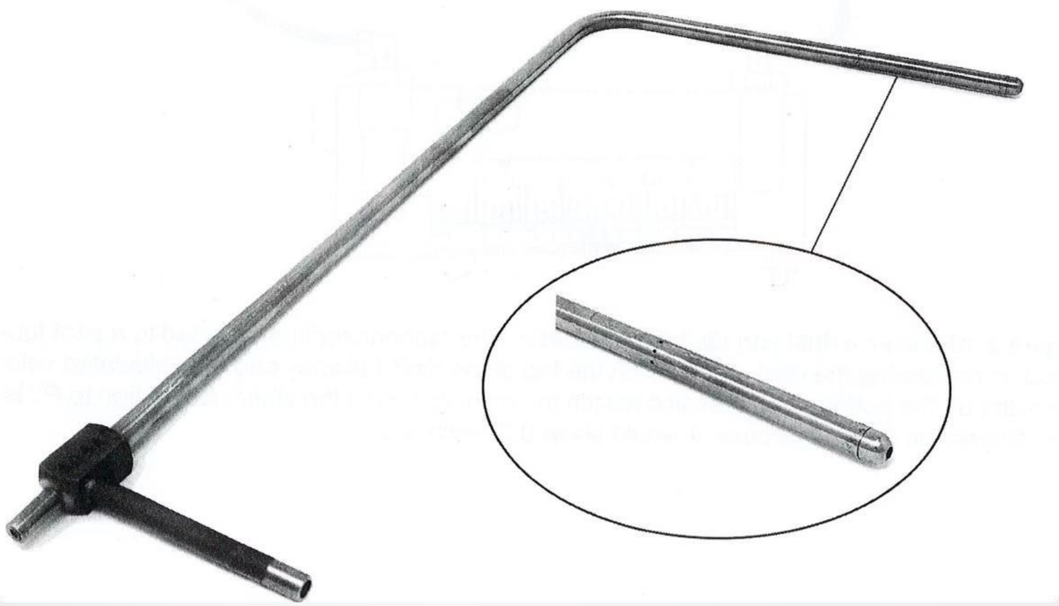
Measurement

Requires special equipment to measure accurately.

Pitot Tube for Pressure Measurement

The use of a special device called a pitot tube, which has two concentric tubes, can make velocity pressure measurement easier. The hole in the center tube senses total pressure, and holes on the outer tube sense static pressure.

Figure 2-16
Pitot tube
Courtesy of Camosun College, Rodney Lidstone, licenced under CC BY



Construction

Two concentric tubes with specific openings to measure different pressures.

Center Tube

The hole in the center tube senses total pressure (static + velocity).

Outer Tube

Holes on the outer tube sense only static pressure.

Connection

The pitot tube outlets are connected to an incline manometer or other pressure measuring instrument.

Using a Pitot Tube in Duct Systems

The pitot tube tip must point directly into the air stream. To obtain accurate results, the reading must be taken at least ten duct diameters downstream from elbows and five duct diameters upstream from other obstructions that might cause swirls or eddies.

Position the Pitot Tube

Insert the pitot tube into the duct with the tip pointing directly into the air stream.

Connect to Measuring Device

Connect the pitot tube to an inclined manometer or digital manometer.

Take Readings

Record the pressure readings, ensuring you're far enough from obstructions for accurate measurements.

Calculate Results

Use the readings to calculate velocity pressure and air velocity.

Figure 2-17
Measure velocity pressure with a pitot tube and inclined manometer

Digital Manometer for Pressure Measurement

A dual port digital manometer can be connected to a pitot tube for pressure measurements. The digital display shows the measured pressure and can calculate velocity directly.

Digital Display

Shows pressure readings directly in digital format.

Dual Ports

Allows for simultaneous connection to both the total and static pressure ports of a pitot tube.

Automatic Calculation

Many digital manometers can automatically calculate velocity from pressure readings.

Precision

Provides more accurate readings than analog devices, typically to 0.01 inch w.c.

Air Velocity Calculation

You can determine air velocity by measuring the velocity pressure and by using the following formula to derive the velocity: $V = 4005 \times \sqrt{Pv}$

Formula Components

V = Air velocity (in ft/min)

Pv = Velocity pressure (in inches w.c.)

4005 = Constant

Example Calculation

To determine the air velocity wherein the measured velocity pressure is 0.02 inch w.c.:

$V = 4005 \times \sqrt{0.02}$

$V = 4005 \times 0.1414$

V = 566 ft/min

$$\rho = \frac{\left(98\,kPa \times \frac{10^3\,N/m^2}{1\,kPa}\right)}{(287)(45)}$$

$$= 1.0737\ kg/m^3$$

$$V = \sqrt{\frac{2(P_2 - P_1)}{\rho}} \qquad P_2 - P_1 = \rho_w g h$$

$$V = \sqrt{\frac{2(\rho_w g h)}{\rho}} \qquad \rho_w = 1000$$

External Static Pressure

External static pressure is any resistance to air flow from outside the furnace casing, caused by ductwork or even from the factory-supplied filter in an air handling device.

Definition

The resistance to air flow that the blower must overcome, excluding the internal components of the furnace itself.

Sources

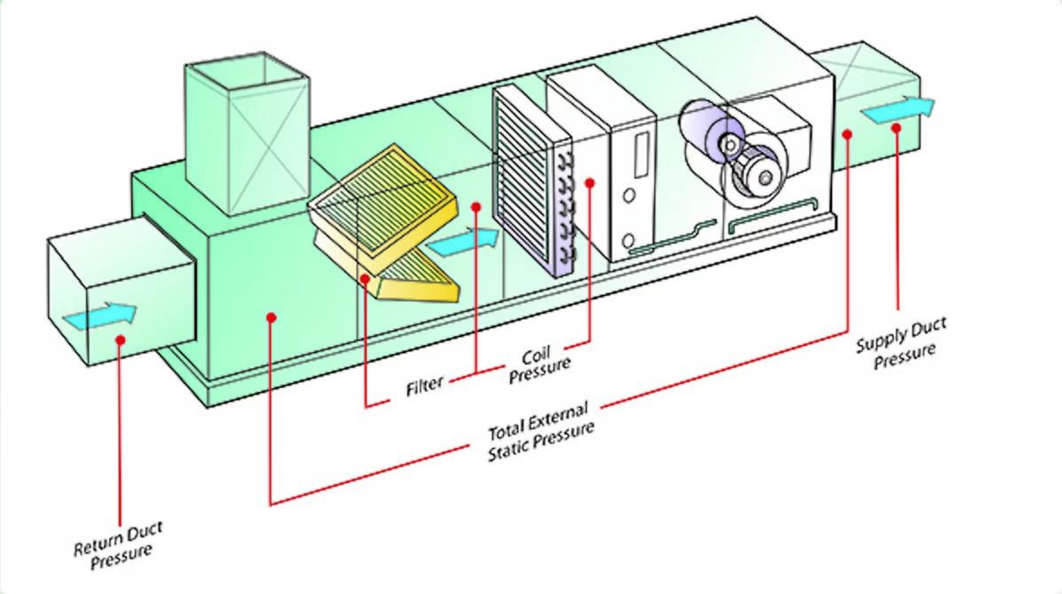
Ductwork, filters, dampers, grilles, registers, and other components outside the furnace casing.

Importance

Manufacturers design air flow in furnaces, fan coils, and air handlers based on total external static pressure (TESP).

Typical Limits

A typical furnace is designed to operate at a maximum of 0.50 inch w.c. of external static pressure as stated on the rating plate.



Static Pressure Drop (Friction Loss)

Static pressure drop is the decrease in air pressure as a result of friction between the air moving through a duct and the internal surfaces of the duct. The difference between static pressure at two points in a duct is the friction loss that has occurred in that duct section.

Calculation Formula

To calculate the total static pressure drop, use the following formula:

TPD = (L/100) × DPD

Where:

L = Length of the duct section (in ft)

DPD = Design static pressure drop, in inches w.c.

TPD = Total static pressure drop for the duct section, in inches w.c.

Example

If a duct is 140 ft long and the duct section has a design static pressure drop of 0.08 inch w.c.:

TPD = (140/100) × 0.08

TPD = 1.4 × 0.08

TPD = 0.112 inch w.c.

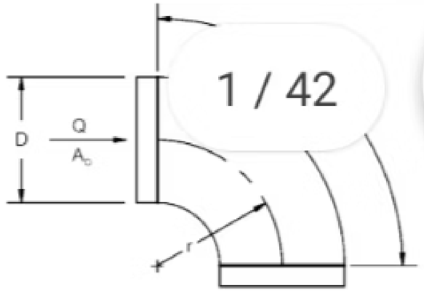
FITTING LOSS COEFFICIENTS

Fittings to support Examples 6 and 7 and some of the more common fittings are reprinted here.
For the complete fitting database see the *ASHRAE Duct Fitting Database* (ASHRAE 2009).

ROUND FITTINGS

CD3-1 Elbow, Die Stamped, 90 Degree, *r*/*D* = 1.5

D, in.	3	4	5	6	7	8	9	10
C_o	0.30	0.21	0.16	0.14	0.12	0.11	0.11	0.11



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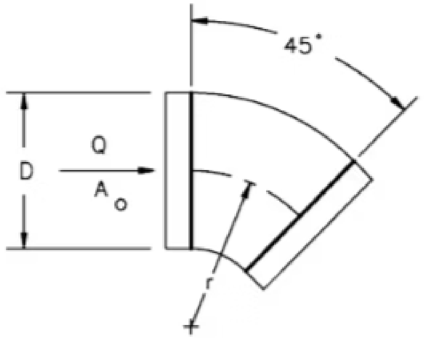
CD3-3 Elbow, Die Stamped, 45 Degree, *r*/*D* = 1.5

D, in.	3	4	5	6	7	8	9	10
C_o	0.18	0.13	0.10	0.08	0.07	0.07	0.07	0.07



CD3-5 Elbow, Pleated, 90 Degree, *r*/*D* = 1.5

Static Pressure Drop in Duct Fittings

Static pressure drop is greater through fittings and transitions than it is through a piece of straight duct of the same size. To correctly determine static drop in a system, consult a table of equivalent lengths.

Equivalent Length

The length of straight duct that would create the same pressure drop as a particular fitting.

Example

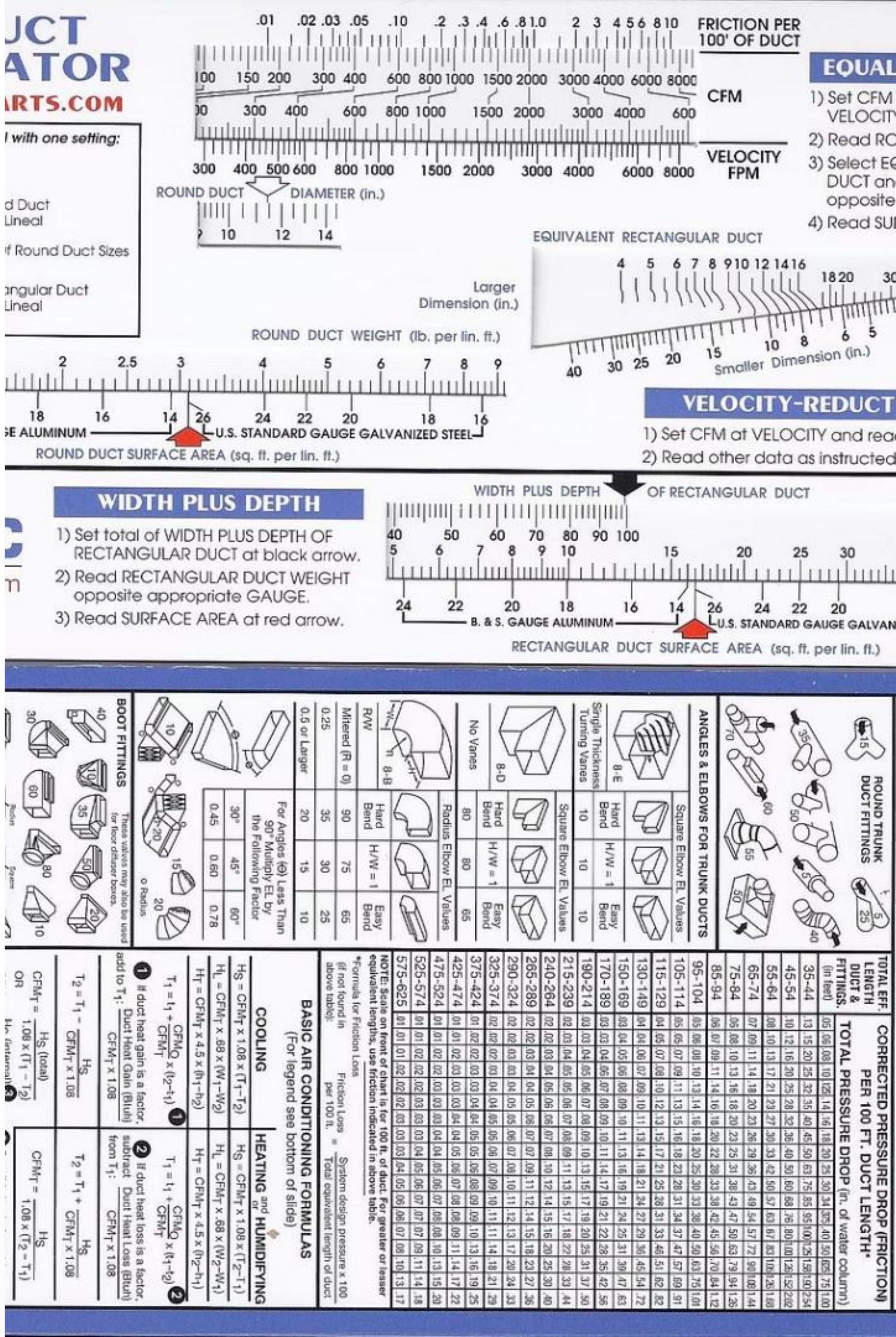
A universal boot 10 inches wide generates a static drop equivalent to a 10-foot straight section of 10 inch duct.

Importance

Accounting for fittings is crucial for accurate system design and troubleshooting.

Reference Tables

HVAC professionals use tables of equivalent lengths to calculate the total pressure drop in a system.



System Pressure Drop

The system pressure drop refers to the total static pressure drop over an entire system, including the drop through all duct sections, fittings, transitions, and accessories such as filter or coils.

Total System

Includes everything that adds resistance to the air flow.

Parallel Sections

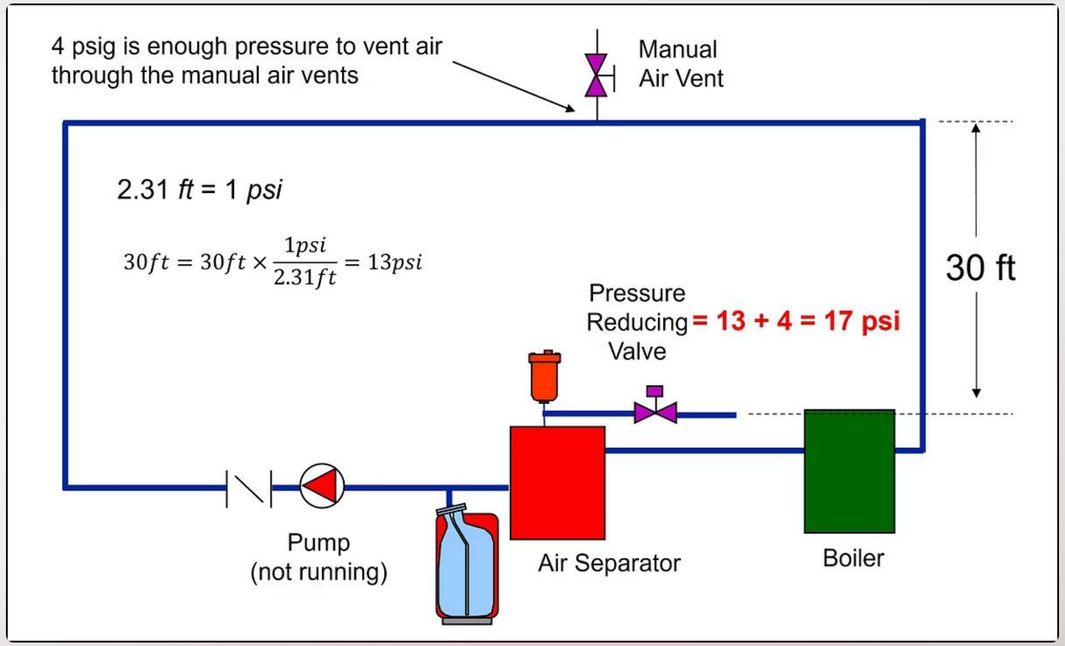
Not used to size the blower as there are often parallel sections of duct, and these parallel runs would not create accumulated (series) resistance.

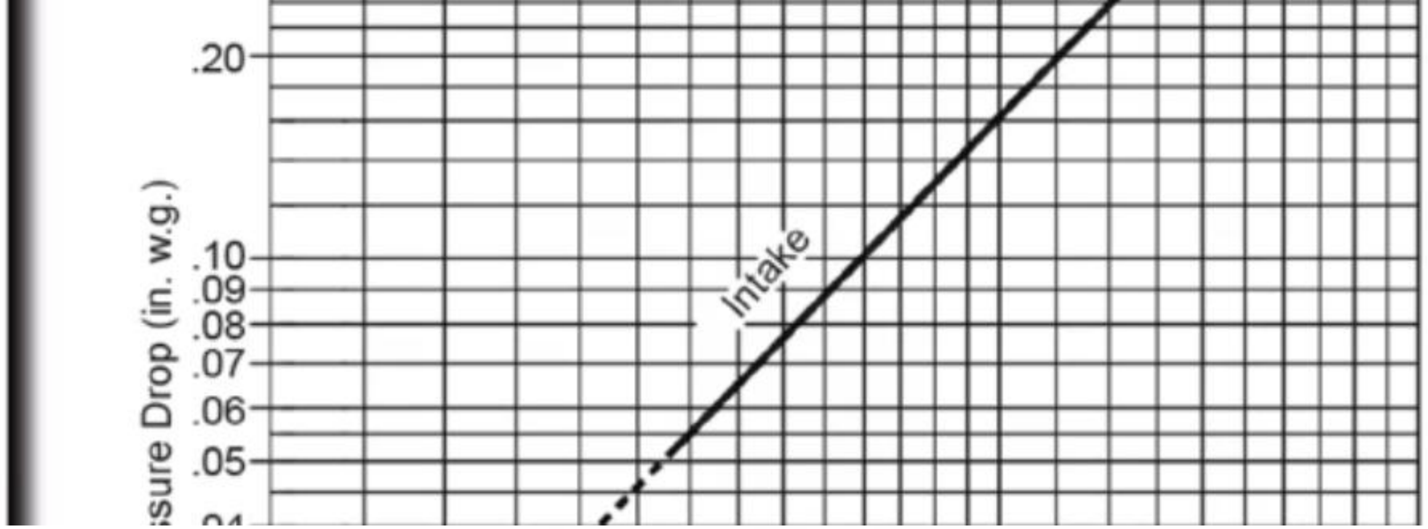
Design Considerations

When designing a system, you must account for the pressure drop to ensure the blower can overcome it.

Measurement

Can be measured directly or calculated from individual component pressure drops.





Total Pressure Drop

When sizing a blower for a forced-air distribution system, it is necessary to find the supply duct section with the highest static pressure drop and the return duct section with the highest static pressure drop.

Identify Critical Path

Find the supply duct section with the highest static pressure drop.

Identify Return Path

Find the return duct section with the highest static pressure drop.

Calculate Total

Add the two static pressure drop values together to find the total static pressure drop against which the blower has to work.

Select Blower

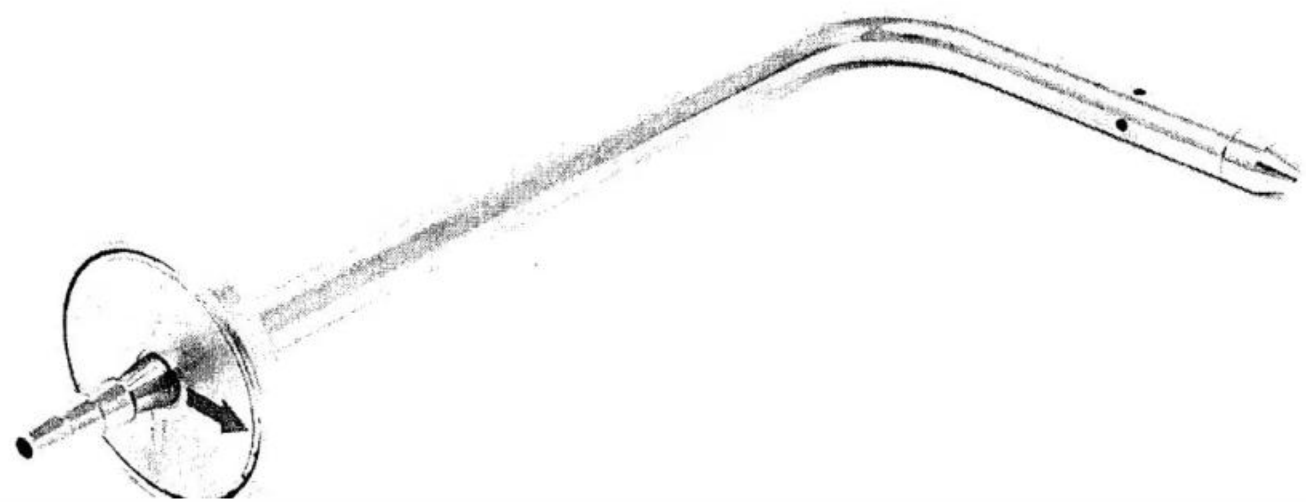
Choose a blower that can overcome this total pressure drop while delivering the required air flow.

Static Pressure Test

Testing the static pressure of the entire ductwork can provide valuable information about the "health" of the system. The test is similar to a blood pressure test to determine the health of a person's veins and arteries.

Required Equipment

- A sensitive pressure measuring device such as an incline manometer, magnehelic gauge, or digital manometer
- A static pressure tip or probe
- A 3 feet (1 m) length of 3/16 inch (5 mm) plastic tubing
- A 3/8 inch (9 mm) metal piercing drill bit



Static Pressure Tip

These tips are angled and have a 4 inch insertion depth with four radially drilled 0.040 inch sensing holes. The magnetic flange and painted arrow ensure proper orientation and allow hands-free use.

Conducting a Static Pressure Test

Locate Test Points

Find appropriate places to drill test holes on the supply side (+) between the furnace and the coil, and on the return side (-) between the filter and the furnace.

Drill Test Holes

Use a 3/8 inch drill bit, being careful to avoid coils, tubes, condensate pans, or circuit boards. Never drill into the furnace cabinet!

Connect Equipment

Connect the static pressure tip to the manometer using the tubing.

Measure Supply Pressure

Insert the tip into the supply side test hole facing the air flow and record the reading.

Measure Return Pressure

Move the connection to the LOW port and insert the tip into the return side test hole.

Calculating Total External Static Pressure

Calculate the system's Total External Static Pressure (TESP) by adding the absolute values of the supply and return static pressure readings.

0.26

Supply Pressure

Example supply static pressure reading in inches w.c.

0.21

Return Pressure

Example return static pressure reading in inches w.c.

0.47

Total Pressure

Total system static pressure in inches w.c.

High Pressure Issues

If static pressure is higher than the design pressure stated on the appliance rating plate, check for problems with the ductwork causing low air flow, such as blockage in ducts, closed dampers, improper transitions, offsets, or kinked flex duct.

Low Pressure Issues

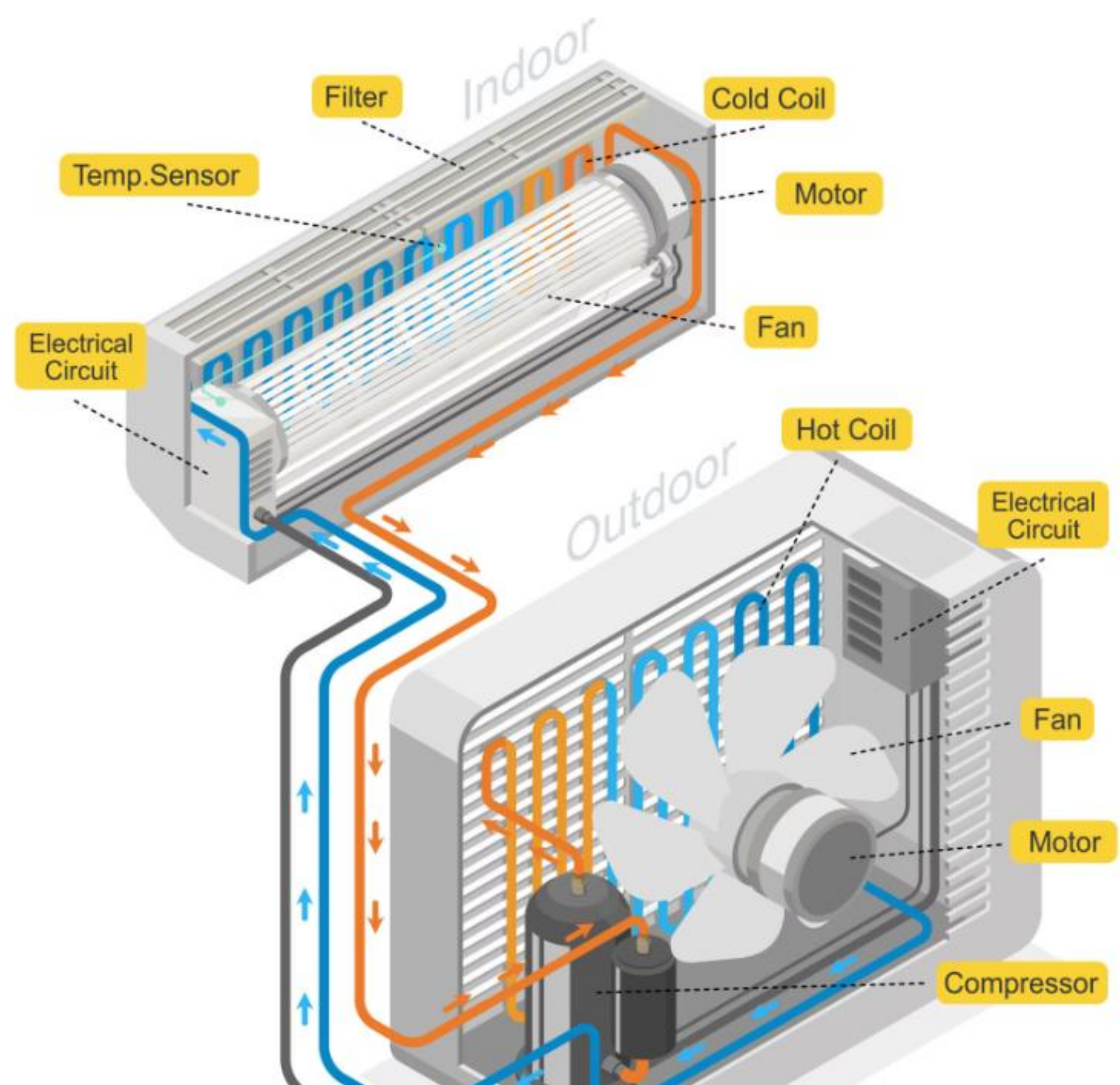
If static pressure is lower than the design pressure stated on the appliance rating plate, this may indicate leaking ductwork or plenums, missing filters, low fan speed, or separated ductwork.

Air Flow and System Efficiency

Air flow has a major influence on the efficiency of heating and cooling systems.

Cooling Systems

The rule of thumb for cooling systems is that every ton of cooling requires 400 cfm of air flow. For example, a two-ton cooling system requires 800 cfm of air flow.



Heating Systems

The relationship between air flow and temperature rise can be expressed as follows:

$AF = OR / (1.08 \times TR)$

Where:

AF = Air flow (cfm)

OR = Output rate (Btu/h)

TR = Temperature rise (°F)

1.08 = Constant

Measuring Heat Rise

Prepare the System

Replace the air filter and ensure all registers are in the open position.

Operate the Furnace

Run the furnace until it reaches steady-state efficiency, usually 10 minutes. If the furnace has multi-stage firing rates, operate it at the highest firing rate first.

Measure Return Air Temperature

Record the temperature of air entering the furnace.

Measure Supply Air Temperature

Measure the temperature in the supply air duct at a location close to the supply plenum downstream of any air conditioning coils.

Calculate Temperature Rise

Subtract the return air temperature from the supply air temperature.

Adjusting for Proper Temperature Rise

Compare to Specifications

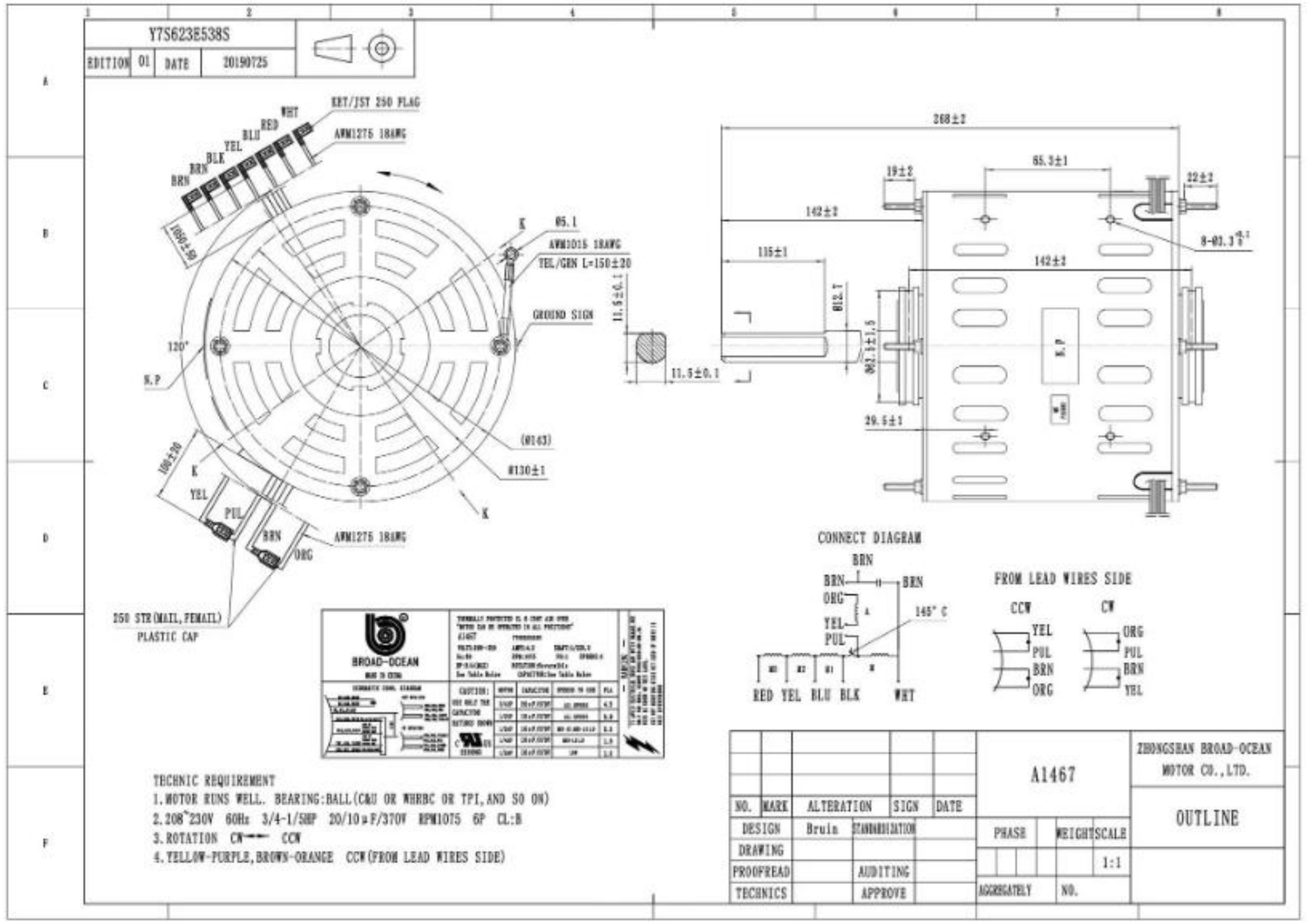
Compare the measured temperature rise with the design temperature rise range specified on the rating plate for the furnace.

The temperature difference should not exceed the range specified by the manufacturer.

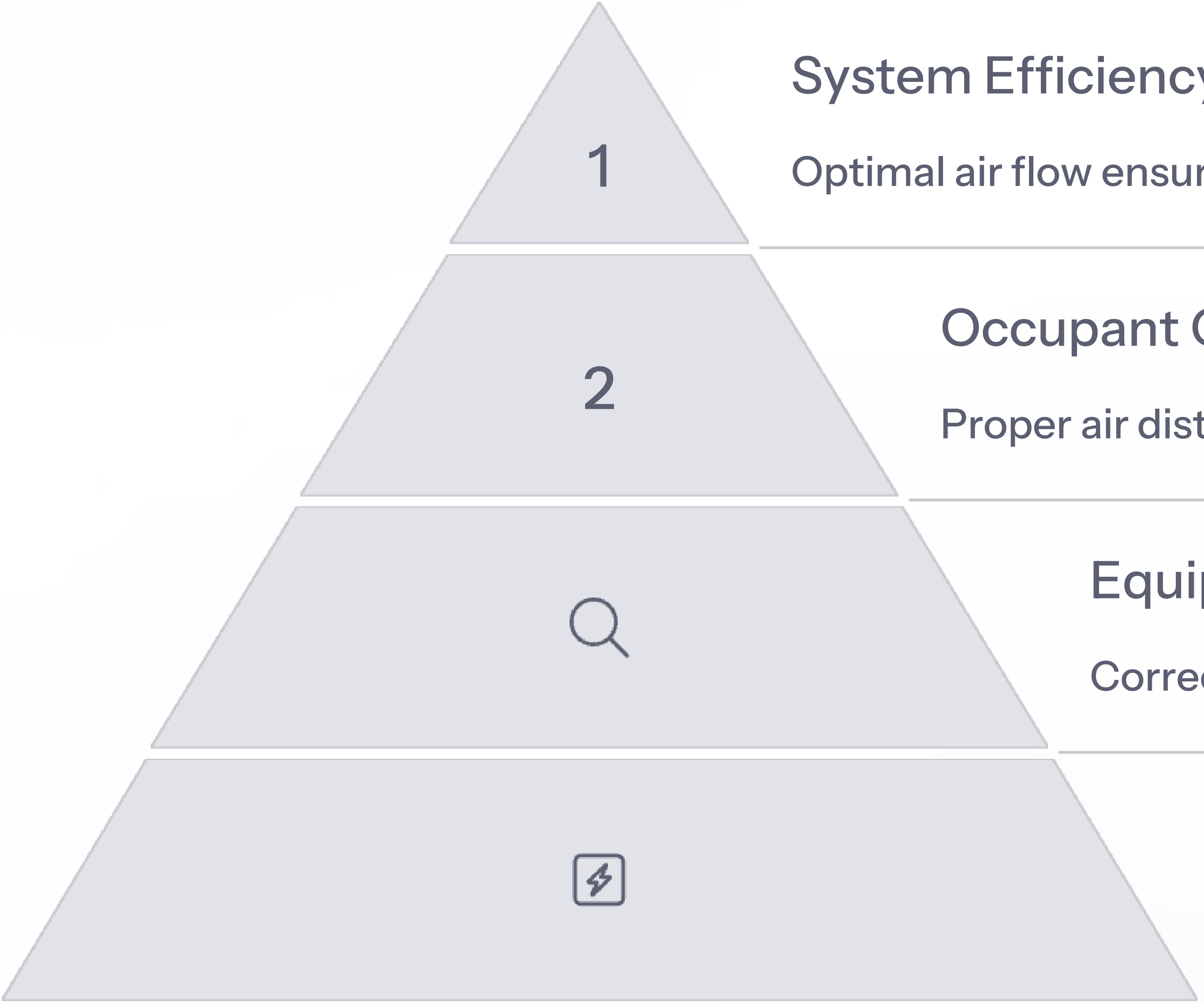
Make Adjustments

- If the temperature rise is higher than specified, increase the blower speed to increase air flow.
- If the temperature rise is too low, decrease the blower speed.

Note: Failure to properly set the air temperature rise may result in damage to the furnace. If the temperature rise is higher than what the manufacturer specified, the efficiency of the appliance will drop.



Importance of Proper Air Flow



System Efficiency

Optimal air flow ensures the system operates at peak efficiency

Occupant Comfort

Proper air distribution prevents hot and cold spots

Equipment Longevity

Correct air flow prevents stress on system components

Energy Consumption

Balanced air flow minimizes energy use

Factors Affecting Fan Capacity

Voltage

The voltage at which a fan is operating can significantly impact its performance. Low voltage can reduce fan speed and air flow.

Cleanliness

Dirt and debris on fan blades can reduce efficiency and air flow. Regular cleaning is essential for optimal performance.

Motor Condition

The condition of a blower motor affects its ability to move air. Worn bearings or other issues can reduce capacity.

Duct Configuration

The layout and design of ductwork near the fan can create turbulence or restrictions that affect air flow.

Common Air Flow Problems

Blockages

Debris, closed dampers, or collapsed flexible ducts can restrict air flow.

Duct Leakage

Gaps in ductwork can allow conditioned air to escape before reaching its destination.

Improper Sizing

Ducts that are too small create excessive resistance, while oversized ducts can cause air velocity issues.

Dirty Filters

Clogged filters restrict air flow and force the system to work harder.

Poor Design

Too many bends, long runs, or improper transitions can create excessive pressure drop.

Troubleshooting Air Flow Issues

Visual Inspection

Check for obvious blockages, damage, or disconnected ducts

Pressure Testing

Measure static pressure to identify restrictions

Temperature Testing

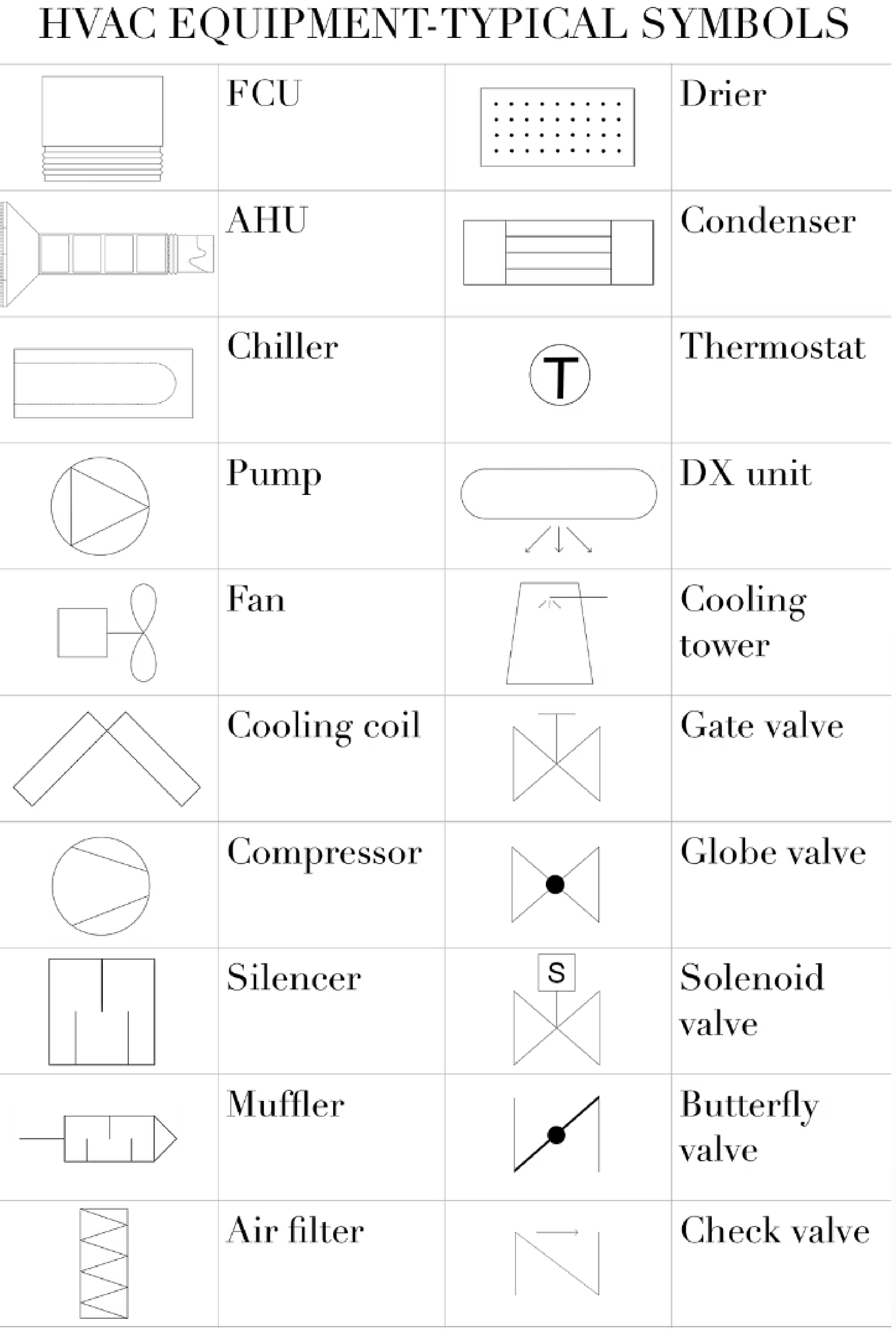
Check temperature rise across the heat exchanger

Flow Measurement

Use an anemometer to measure actual air flow at registers

System Adjustment

Make necessary repairs and adjustments to optimize performance



Best Practices for Air Handling Systems

Proper Design

Ensure system is correctly sized for the building's needs

Quality Installation

Follow manufacturer specifications and industry standards

Regular Maintenance

Perform scheduled inspections and service

Performance Testing

Verify system operation meets specifications

Summary: Air Handling Units

Gas-Fired Duct Furnaces

Provide flexible heating solutions for commercial and industrial applications with separate air handling.

Duct Systems

Various configurations distribute air throughout buildings, with supply and return sides working together in a continuous loop.

Air Flow Principles

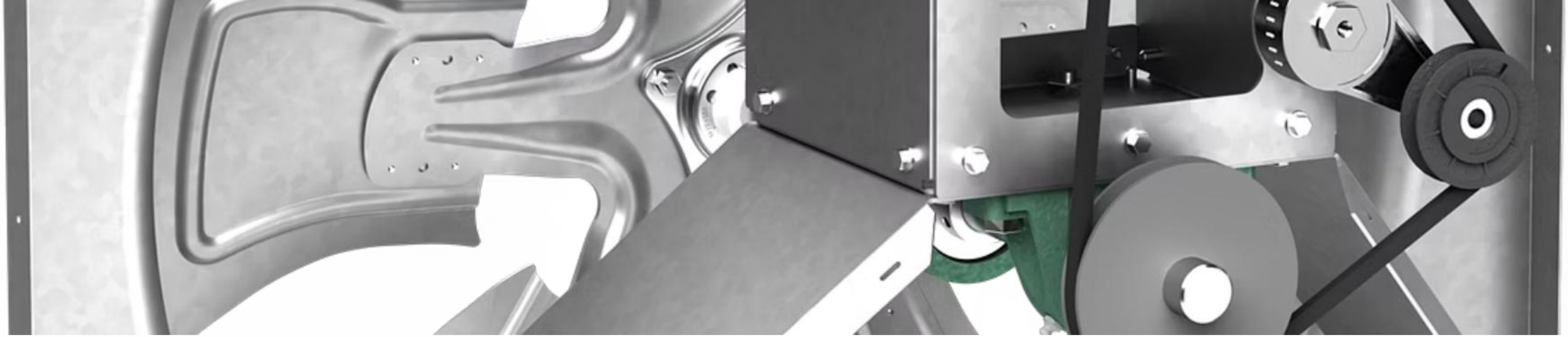
Understanding static pressure, velocity pressure, and friction loss is essential for proper system design and troubleshooting.

Maintenance Requirements

Regular monthly, quarterly, and annual maintenance ensures efficient operation and extends equipment life.

Electrical and Mechanical Components

The fan, or blower, is a crucial component of the air handling system. Let's explore the various types of electrical and mechanical components used in HVAC systems, with a focus on blowers, motors, and their operation.



Types of Fans and Blowers

Direct or belt drive

Different connection methods between motor and blower

Draw-through or blow-through

Determines how air moves through the system

Single outlet or double outlet

Affects air distribution patterns

Terminology

Blower

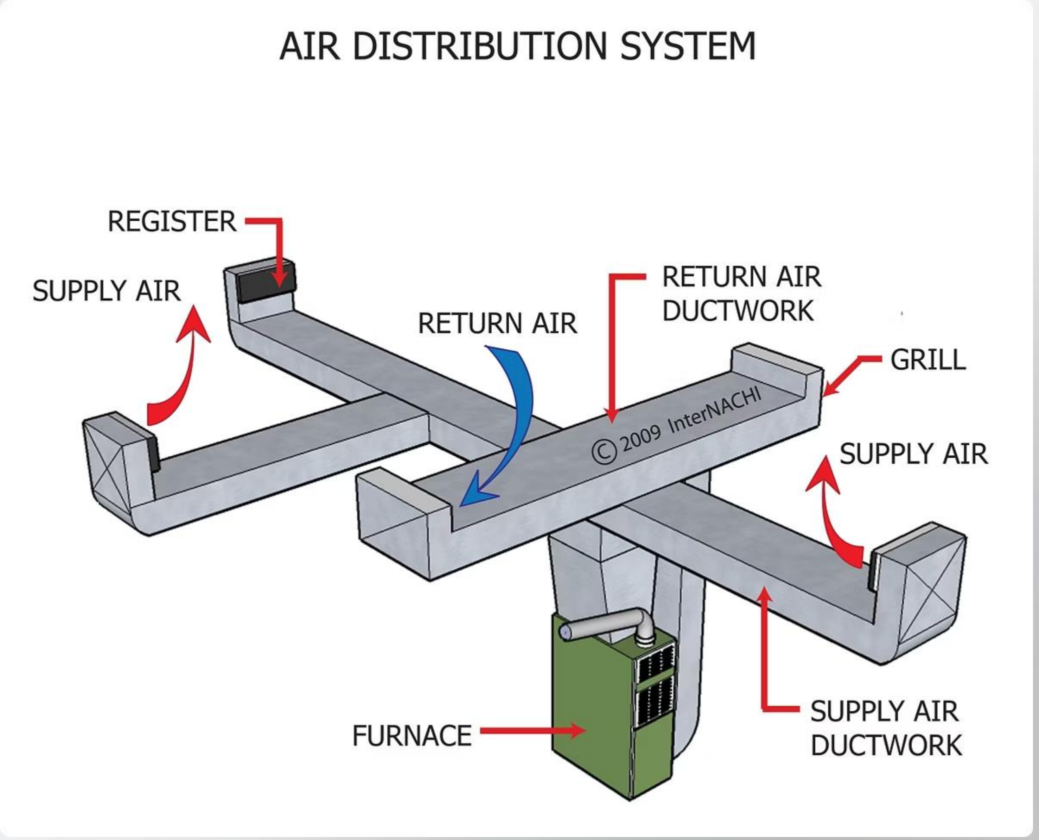
Generally used to describe all devices or device components designed to move air through a ducted system

Fan

Used only when it identifies a type of blower that is invariably described as a fan (e.g., axial fan)

Air Moving Device (AMD)

Alternative term used by some manufacturers



Duct Furnace Configuration

Because duct furnaces are typically blow-through, this presentation does not discuss draw-through units (typical of direct-fired makeup air units) in detail.

Blow-Through Configuration

Common in duct furnaces, where air is pushed through the heat exchanger

Draw-Through Configuration

Typical of direct-fired makeup air units, where air is pulled through the system

Choosing and Sizing Blowers

The blower must be large enough to move the required amount of air through the system. To choose a blower, the gas technician/fitter must know:

Required air flow rate

The volume of air needed for the building

Total static pressure drop

The resistance the system presents to air flow

Calculating Static Pressure

1. **Identify Critical Sections**

   Find supply duct section with highest static pressure drop

2. **Calculate Return Pressure**

   Find return duct section with highest static pressure drop

3. **Add Pressure Drops**

   Combine the two calculations to find total static pressure

4. **Select Appropriate Blower**

   Use blower performance tables to choose correct model

Figure 2-21
Example

Blower Performance Tables

Blower performance tables indicate the blower wheel velocity and horsepower required to generate the necessary air flow, given the total static pressure drop.

SP = 249 = KPA

Using Blower Performance Tables

Find Required CFM

Look in the left-hand column to find the value for your required cubic feet per minute

Locate Static Pressure Column

Move across to the column matching your calculated static pressure (e.g., 0.5 inch w.c.)

Determine Power Requirements

Read the power rating (BHP) required from the table (e.g., 0.17)

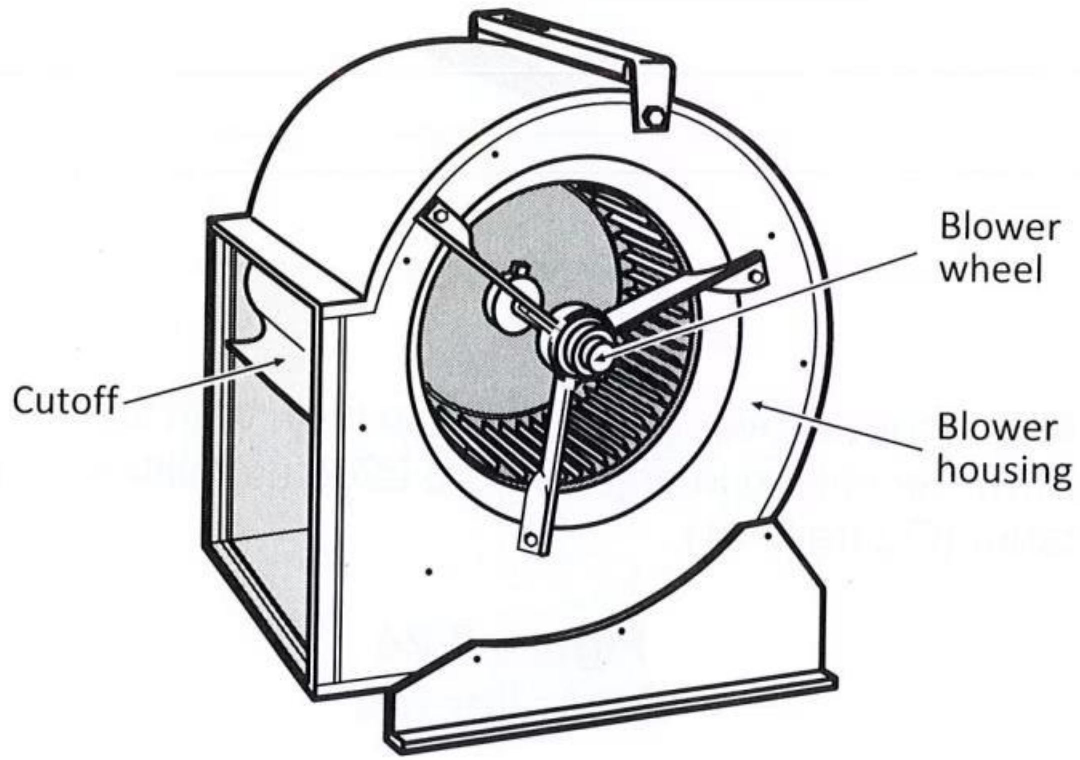
Select Motor and Pulleys

Choose a slightly more powerful motor to account for drive losses and select motor pulleys according to the required RPM

Figure 2-21 Example

Example of Blower Selection

Figure 2-22
Typical blower in housing
Courtesy of Delhi Industries Inc.



1. **Find 1000 CFM in left column**
   Locate your required air flow rate

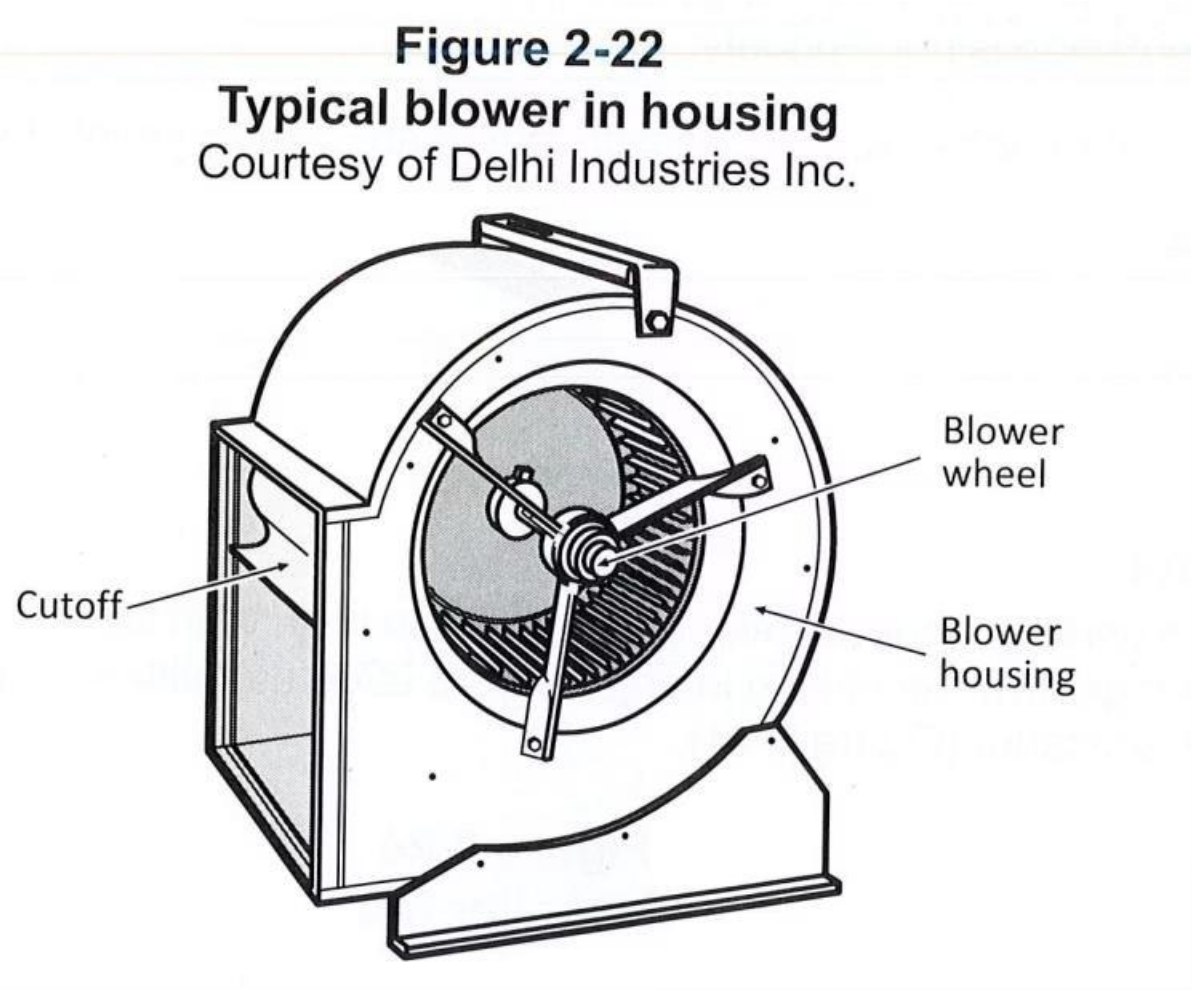
2. **Find 0.5 inch w.c. static pressure column**
   Move across to match your system's resistance

3. **Read power rating of 0.17 BHP**
   Note that this doesn't include drive losses

4. **Select 0.25 hp motor**
   Choose slightly more powerful motor to account for losses

5. **Note required RPM of 802**
   Select motor pulleys according to this requirement

Belt Drive Blower



The cut-off device provides back pressure to the blower wheel to keep it from freewheeling.

Key Characteristics

Belt drive blowers are connected to the blower motor via a belt. They are more frequently used on older air handling systems.

They have four bearings:

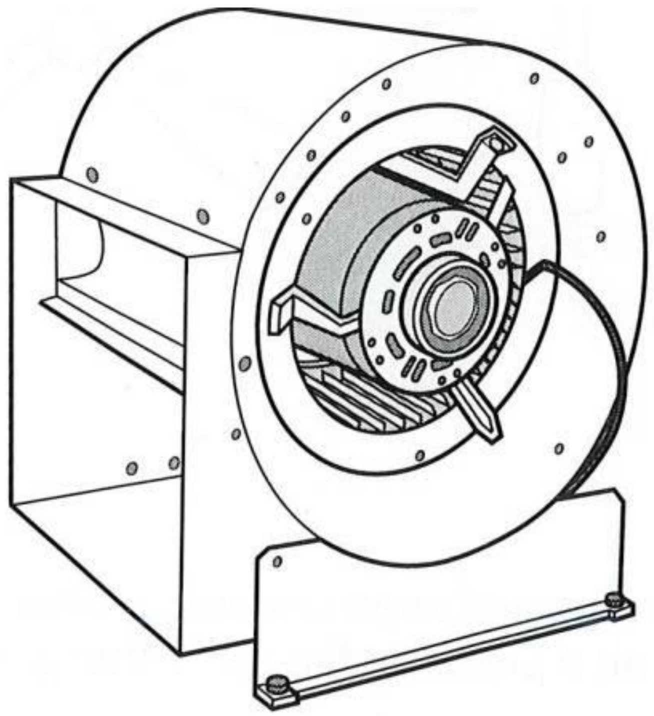
- Two on the fan shaft
- Two on the motor

Direct Drive Blower

Key Characteristics

Direct drive blower motors are mounted inside the blower and linked directly to the blower wheel.

- No belt required
- More compact design
- Less maintenance
- Common in modern systems



Blower Types and Uses

Blowers are divided into two groups, depending on the way air flows through the impeller.

Axial Fans

Air flow is parallel to the fan shaft. These can move large quantities of air and are often used in situations where noise suppression is not a priority.

Types include:

- Propeller
- Tube-axial
- Vane-axial

Centrifugal Blowers

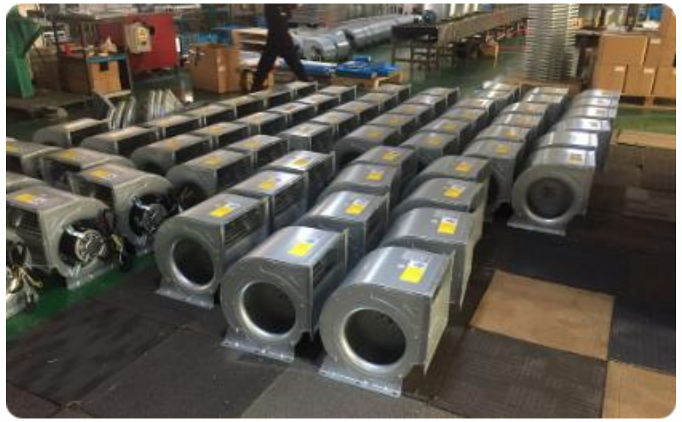
Air moves perpendicularly to the shaft. The blower is usually enclosed in a scroll-shaped casing rather than a straight casing like the axial fans.

Blade types include:

- Straight
- Curved forward
- Curved backward
- Airfoil shape

Duct Furnace Blower Types

Blower types for duct furnaces are typically single outlet, double inlet. Air can be drawn in from both sides of the blower and discharged through a single outlet.



Single Outlet, Double Inlet

Common configuration for duct furnaces, allowing air to be drawn from both sides

Typical Installation

Shows how the blower is positioned within the duct furnace system

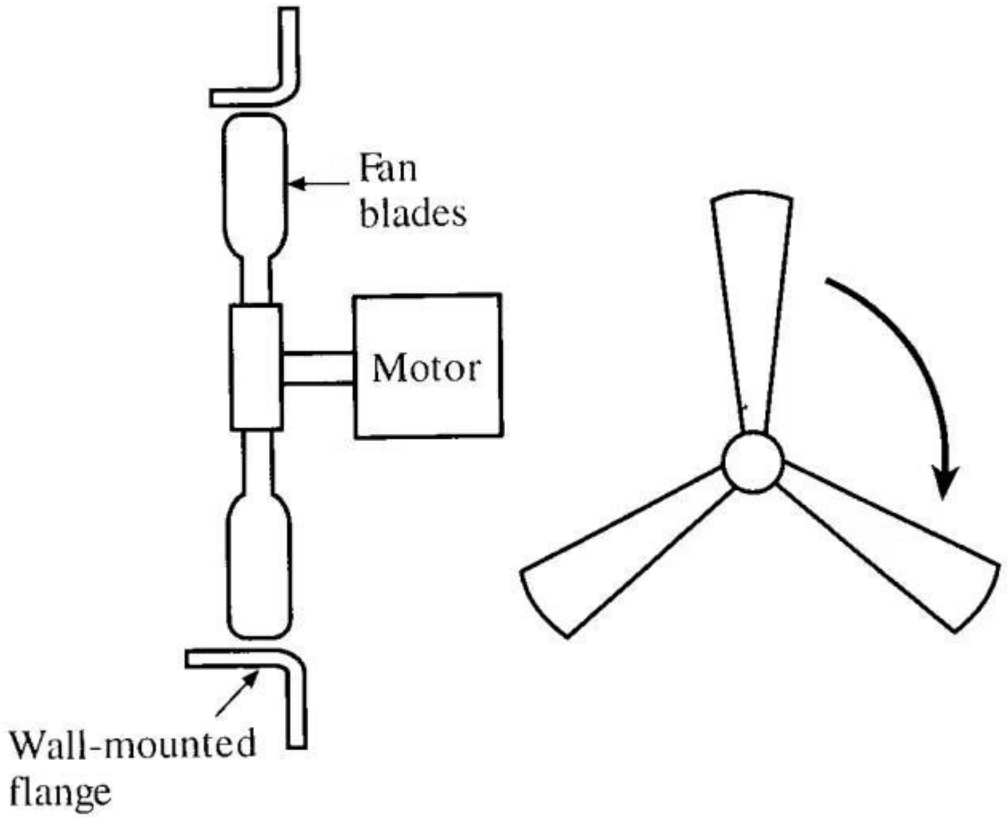
Axial Fans: Propeller Type

Characteristics

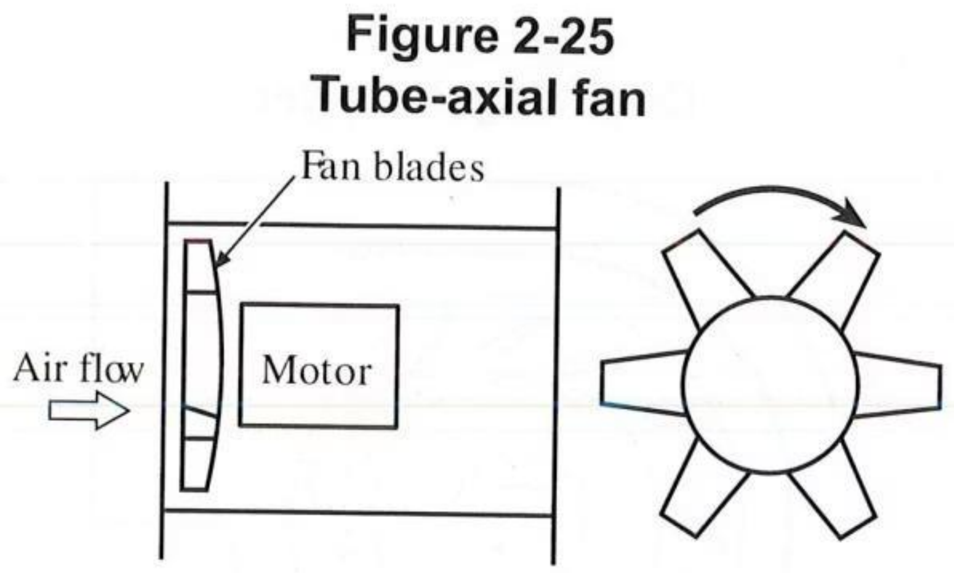
Propeller fans are usually mounted over an outlet in the wall. With little or no ducting attached, they are typically mounted in areas where large quantities of air need to be moved against low static pressure.

- Simple design
- Low static pressure applications
- High volume air movement
- Minimal ducting required

Propeller fan



Axial Fans: Tube-Axial Type



Characteristics

Tube-axial fans are mounted in a tube just large enough to clear the blades. They are more efficient than a propeller fan since they produce a more useful static pressure range.

- Higher efficiency than propeller fans
- Better static pressure capabilities
- Suitable for ducted applications
- More focused airflow

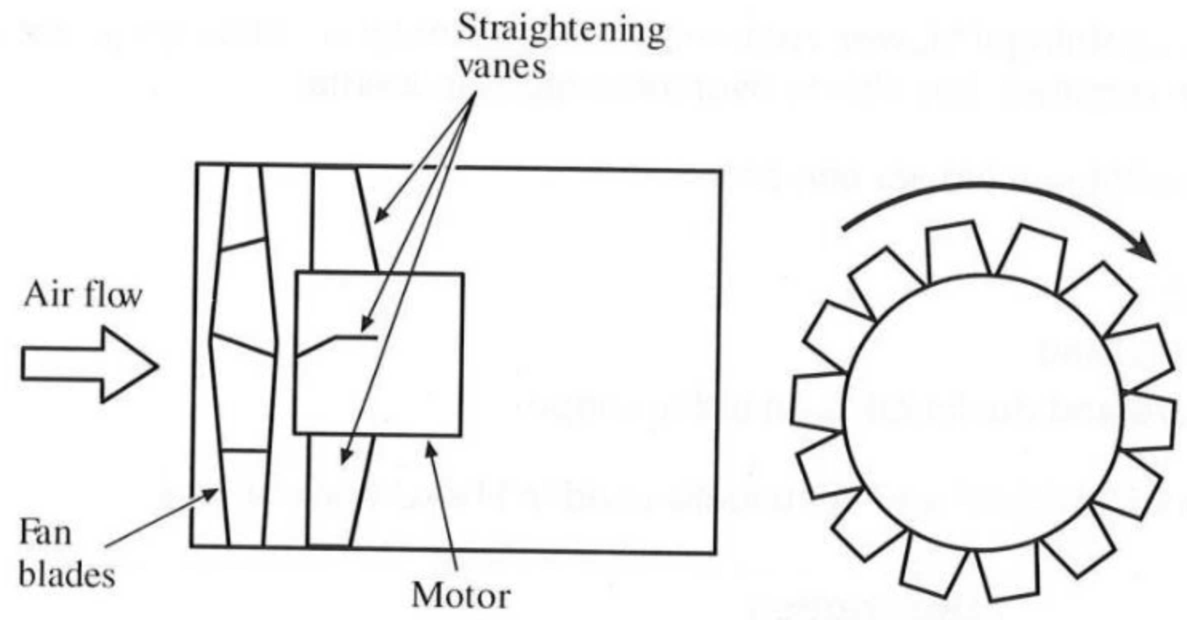
Axial Fans: Vane-Axial Type

Characteristics

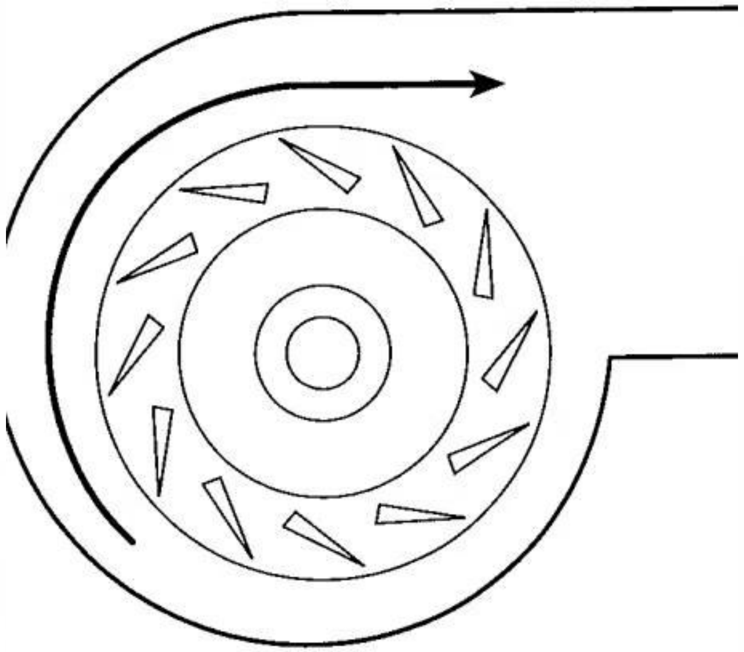
All axial fans output air in a spiral pattern. The vane-axial fan outputs air into a set of vanes, thus straightening the air flow and increasing the efficiency of the fan.

- Highest efficiency among axial fans
- Straightened airflow pattern
- Better for applications requiring directed air
- More suitable for complex duct systems

Vane-axial fan



Centrifugal Blowers



Key Characteristics

In centrifugal blowers, the air moves perpendicularly to the shaft. The blower is usually enclosed in a scroll-shaped casing rather than a straight casing like the axial fans.

- Air enters through a side inlet
- Leaves through a rectangular or square outlet
- Can move large quantities of air at high static pressure
- Requires greater horsepower as static pressure increases
- Motor must overcome start-up inertia

Centrifugal Blower Blade Types

Forward-Curved Blades

Most common in residential applications for both heating and air conditioning. Less efficient but inexpensive and operate at a wide range of static pressures.

Backward-Curved Blades

Slightly less efficient than airfoil blowers but move about twice as quickly as forward-curved ones, requiring larger shaft and bearings.

Airfoil Blades

Most efficient centrifugal blowers, consisting of 10-16 blades of airfoil contour. Usually only used in large systems where efficiency helps reduce costs.

Tubular Centrifugal

Installed in straight-line ducts where centrifugal efficiency is required but duct configuration suggests an axial fan.

Forward-Curved Blades

Characteristics

- Can overload the motor if static pressure increases
- Inexpensive
- Slow-moving, so bearings and shafts are small
- Can operate at a wide range of static pressures

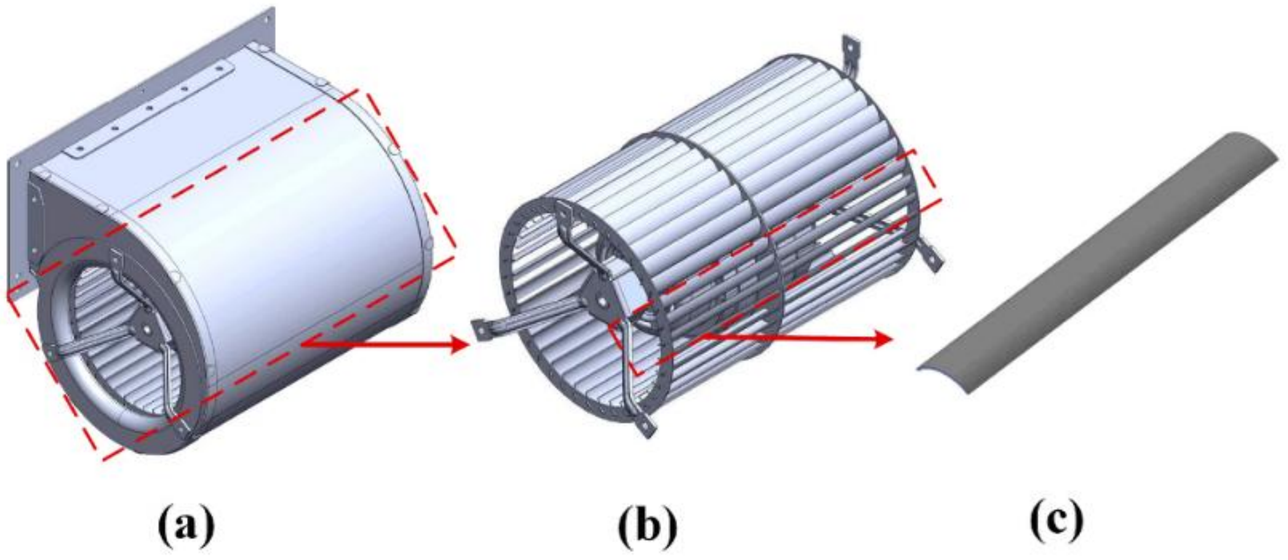
These are the blowers used most commonly in residential applications, for both heating and air conditioning.

Backward-Curved Blades

Characteristics

- Slightly less efficient than airfoil blowers
- Move about twice as quickly as forward-curved ones
- Require larger shaft and bearings due to higher speeds
- Better efficiency than forward-curved designs
- More suitable for commercial applications

Airfoil Blades



Characteristics

Airfoil centrifugal blowers are the most efficient of the centrifugal blowers. They consist of ten to sixteen blades of airfoil contour, curved away from the direction of rotation.

- Air leaves the impeller at a velocity less than the tip speed
- Usually only used in large systems
- Greater efficiency helps reduce costs in large industrial operations
- Highest initial cost but best long-term efficiency

Tubular Centrifugal Blowers

Applications

You can install these blowers in straight-line ducts. They are sometimes installed where the efficiency of a centrifugal blower is required, but duct configuration would suggest an axial fan.

- Combines benefits of centrifugal and axial designs
- Works well in straight duct configurations
- Provides higher pressure capabilities than standard axial fans
- Specialized application in commercial and industrial settings

COOK

CIC/UCIC

Tubular Centrifugal Blowers

INSTALLATION, OPERATION, AND MAINTENANCE MANUAL

This publication contains the installation, operation and maintenance instructions for standard units of the *CIC/UCIC-Tubular Centrifugal Blowers*. Carefully read this publication prior to any installation or maintenance procedure.

Loren Cook catalog, *CIC*, provides additional information describing the equipment, fan performance, available accessories, and specification data.

For additional safety information, refer to AMCA publication 410-96, *Safety Practices for Users and Installers of Industrial and Commercial Fans.*

All of the publications listed above can be obtained from Loren Cook Company by phoning 417/869-6474, extension 166; by FAX at 417/832-9431; or by e-mail at info@lorencook.com.

For information on special equipment, contact Loren Cook Company Customer Service Department at 417/869-6474.

Receiving and Inspection

Carefully inspect the fan and accessories for any damage and shortage immediately upon receipt of the fan.

- Turn the wheel by hand to ensure it turns freely and does not bind.
- Inspect dampers for free operation of all moving parts.
- Record on the *Delivery Receipt* any visible sign of damage.

WARNING
This unit has rotating parts. Safety precautions should be exercised at all times during installation, operation, and maintenance.
ALWAYS disconnect power prior to working on fan.

Handling

Lift the fan by the base or lifting eyes. ***Never lift by the shaft, motor, windband, or housing.***

Storage

If the fan is stored for any length of time prior to installation, completely fill the bearings with grease or moisture-inhibiting oil. Refer to *Lubricants* on page 6. Also, store the fan in its original crate and protect it from dust, debris and the weather.

CIC Storage

To maintain good working condition of a CIC when it is stored outdoors, or on a construction site, follow the additional steps below.

- Cover the inlet and outlet, and belt tunnel opening to prevent the accumulation of dirt and moisture in the housing.
- Periodically rotate the wheel and operate dampers (if supplied) to keep a coating of grease on all internal bearing parts.
- Periodically inspect the unit to prevent damaging conditions.

UCIC Storage

To maintain good working condition of a UCIC fan when it is stored outdoors or on a construction site, always store in upright position. Also, if the dampers are not mounted, cover discharge.

Personal Safety
Disconnect switches are recommended. Place the disconnect switch near the fan in order that the power can be swiftly cut off in case of an emergency, and in order that maintenance personnel are provided complete control of the power source.

Installation

Most motors are shipped mounted on the fans with belts and drives installed. However, extremely heavy motors and drives are shipped separately, and some motors are shipped separately due to height limitations. These motors and drives will require field installation. Please refer to page 3.

CIC Installation

Arrangements 1 and 9 (FM) are floor-mounted fans. They require a strong, level foundation of reinforced poured concrete.

The foundation's size is determined by fan size, motor size and position, and the specific location of the installation.

Use the following guidelines to calculate foundation size:

- The overall dimensions of the foundation should extend at least 6 inches beyond the outline of the fan and its motor.

CIC

Blower Speed and Air Volume

Direct Relationship

The speed of the blower and the volume of air that it moves have a direct relationship

Adjustment Methods

Adjusting blower speed is one way to remedy insufficient air delivery

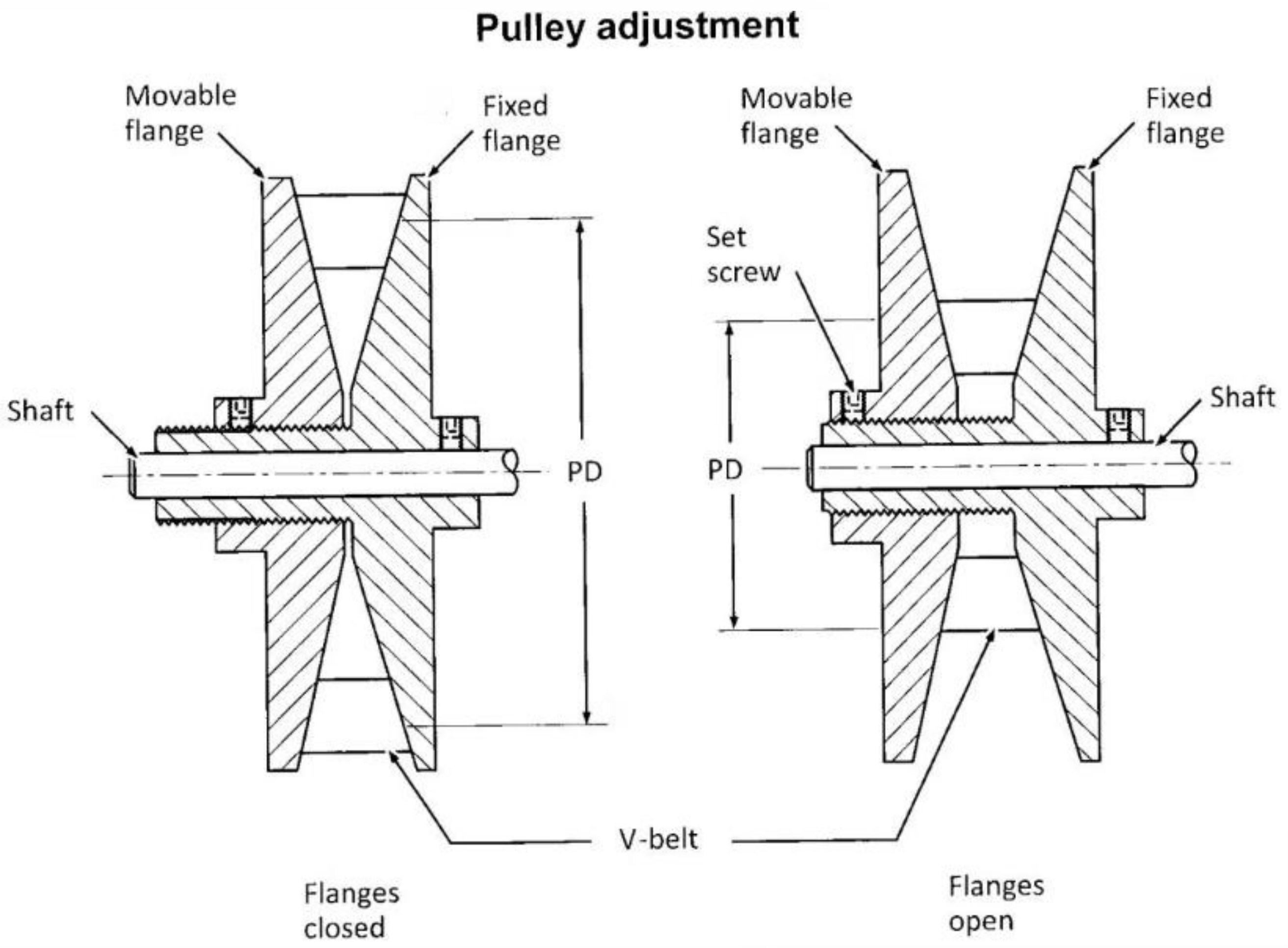
Pulley Replacement

Replacing the motor pulley can help adjust blower speed on older belt drive appliances

Temperature Effects

Changes in air movement correspond to changes in temperature rise across the heat exchanger

Pulley Adjustments



Adjustable Pulleys

Some motors come with adjustable pulleys. Adjusting the pulleys will change the blower speed and, therefore, the volume of air that is moved and the temperature rise across the heat exchanger.

- Moving the adjustable pulley in and out raises and lowers the belt
- Smaller motor pulley = lower rpm, less air, increased temperature rise
- Larger motor pulley = higher rpm, more air, lower temperature rise

Do not adjust beyond design specifications as this could damage the motor or system.

Current Draw Effects

Condition	Effect on current draw
Blocked cooling coil	Decreases
Blocked filter	Decreases
Decrease in cfm	Decreases
Increase in blower speed	Increases
Increase in motor horsepower rating	Increases
Increase in static pressure	Decreases
Open blower cabinet door	Increases

Motor Speed and Rotation

Determining Motor Speed

To determine the speed of a motor in rpm, you need to know the number of poles of the motor and its frequency.

The greater the number of poles, the slower the rpm.

Formula: $S\ (rpm) = (hertz \times 120) \div \text{number of poles}$

Examples

Two-pole, split-phase motor:

$S = (60 \times 120) \div 2 = 3600$ rpm

Four-pole, split-phase motor:

$S = (60 \times 120) \div 4 = 1800$ rpm

Blower Speed Laws

CFM and RPM

The cfm varies directly with the blower revolutions per minute (rpm)

Pressure and RPM

Static pressure and total pressure vary with the square of the blower rpm

Horsepower and RPM

Horsepower varies directly with the cube of the blower rpm

Practical Application

These relationships help technicians calculate the effects of speed changes

Example: Speed Increase Effects

50%

Speed Increase

Blower rpm increases from 500 to 750 rpm

50%

CFM Increase

Air volume increases from 5000 to 7500 cfm

125%

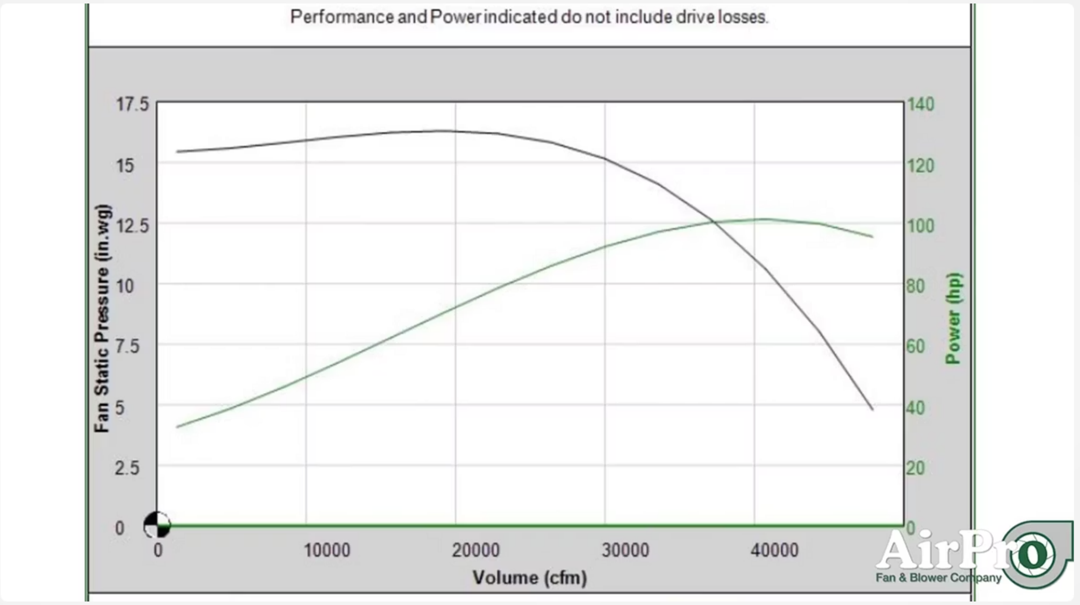
Pressure Increase

Static pressure increases from 1 to 2.25 inches w.c.

238%

Horsepower Increase

Power requirement increases from 2 to 6.75 hp

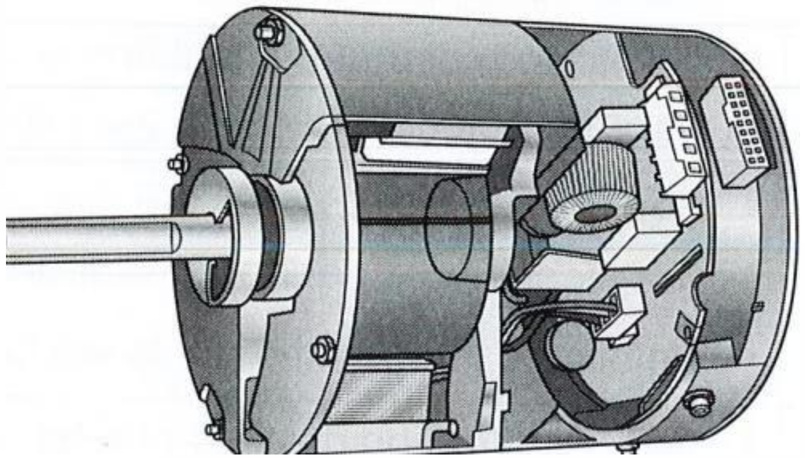


Drive Ratio

In belt-driven blowers, the drive ratio is the relationship between the motor pulley size and blower pulley size. The drive ratio multiplied by the rpm of the motor equals the rpm of the blower.

Motor pulley size	Blower pulley size	Blower speed
3.5 inches	8 inches	(3.5÷8)×1725 = 755 rpm
4 inches	8 inches	(4÷8)×1725 = 863 rpm
3.5 inches	7 inches	(3.5÷7)×1725 = 863 rpm

Electronically Commutated Motors (ECM)



Modern Motor Technology

Most modern appliances are now equipped with a variable speed electronically commutated motor (ECM).

The ECM is a brushless DC motor that offers several advantages:

- Uses less energy
- Delivers more torque than PSC motors
- Offers more control over air flow and velocity
- Requires a microprocessor control board

ECM Control Programs

Soft Start

Motor ramps to 50% initially, then after a set period increases to 100%

Responsive Operation

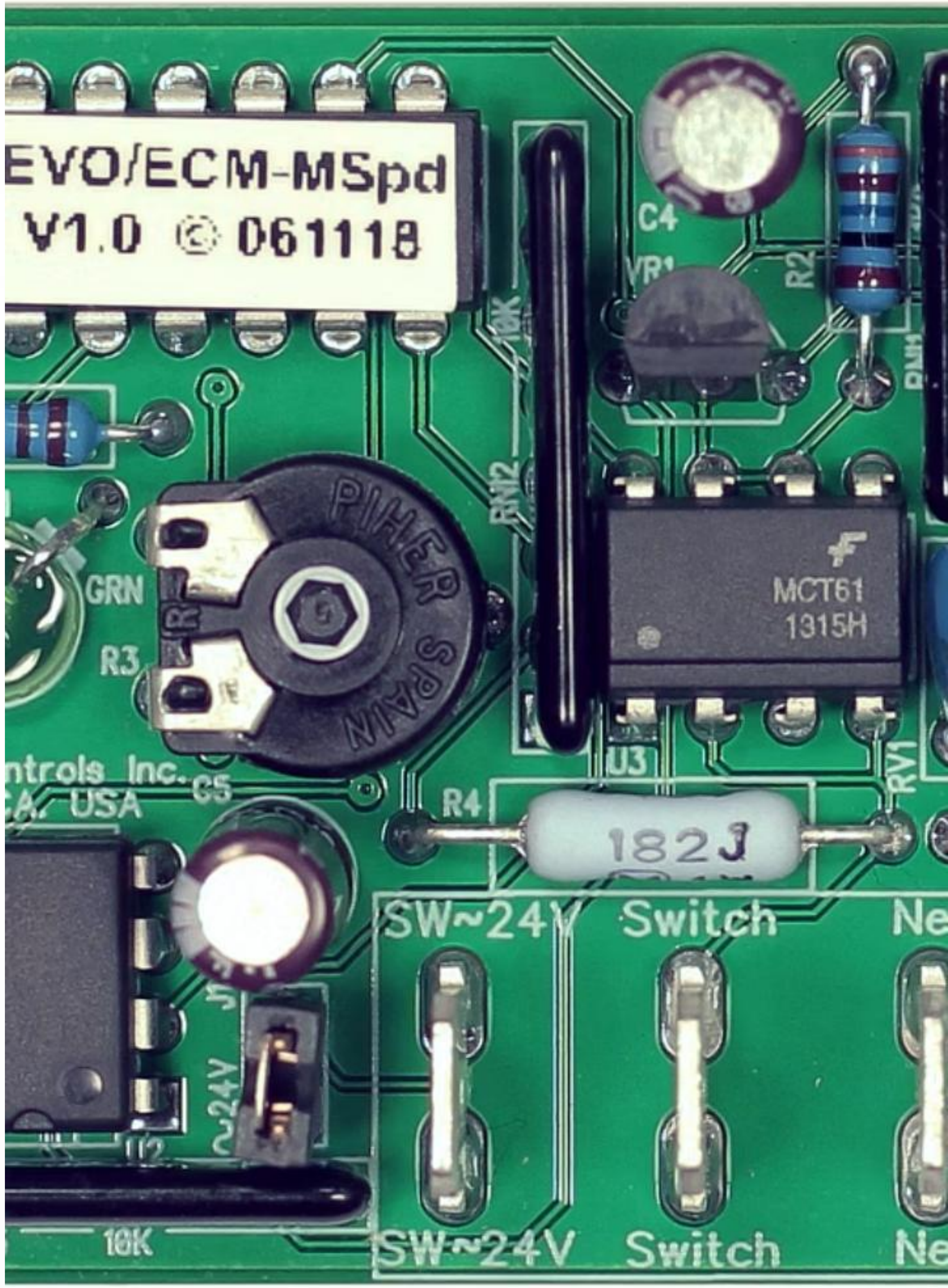
Automatically changes air volume in response to firing rates, back pressure, or temperature rise

Soft Stop

Motor slowly ramps down when thermostat is satisfied, then stops after a set time period

Customization

Technicians can change the program using dip switches to adjust air flow capacities



ECM vs. PSC Motors

PSC Motor Characteristics

- Starts immediately at 100%
- Stops immediately when thermostat is satisfied
- "Hard start and hard stop" can cause heat stress to heat exchanger
- Delivers high humidity air at cooling start-up
- 10-50% efficiency depending on speed

ECM Advantages

- Soft start and stop reduces heat exchanger stress
- Increases fuel efficiency during heating
- Better humidity control during cooling
- Maintains 60-80% efficiency across all speeds
- Generates significantly less heat

Service and Adjustments

Numerous problems can cause improper air flow in a building and reduce the comfort of occupants. One way to reduce problems with air handling is to ensure that equipment undergoes proper servicing on a regular basis.

Regular Maintenance

Proper servicing helps prevent air flow problems and ensures system efficiency

System Inspection

Identifying issues early can prevent more serious problems and maintain occupant comfort

Common Air Flow Restrictions

Return Air Blockage

Openings throughout the building must not have blockages. Building occupants should not position furniture or other objects directly in front of return-air registers.

Undersized Ducting

If ducting is undersized, the system will not be able to deliver the air changes per hour required by the building. Velocities through the ducts will be high if ducts are too small.

Dirty Air Filtration Device

Dirty air filtration devices are the chief cause of inefficient operation of heating and cooling systems. Forced-air systems require filtration to operate safely.

More Air Flow Restrictions

Blocked Cooling Coil

If the cooling coil is blocked, the air conditioning system cannot function properly. Regular cleaning is essential for efficient operation.

Improperly Positioned Dampers

When a damper is not closing or opening as required, it affects the air flow throughout the system, creating imbalances.

Dirty/Clogged Blower

If filtration is maintained properly, the blower should not become dirty. If it does, you must clean it, and clean and replace the filters as well.

Servicing Mechanical Components

The components of the blower, including the motor, shaft, and fan, must undergo servicing to ensure efficient functioning of the air handling system.

Follow Manufacturer Guidelines

Consult the manufacturer's manuals for the specific type and model of blower being serviced

Safety First

Turn the power to the furnace off at the breaker before servicing the motor

Prevent Accidents

Lock out and tag the breaker so it is not turned on accidentally

Servicing Direct Drive Blowers

1. **Check Blower Motor Bearings**

   Test for excessive movement that indicates bearing wear

2. **Lubricate Bearings**

   Follow manufacturer's instructions, being careful not to over-lubricate

3. **Clean Blower and Compartment**

   Remove dust and dirt from vanes and housing

4. **Check Wheel Balance**

   Ensure the wheel rotates freely and is properly balanced

5. **Inspect Housing**

   Verify all mounts and screws are tight and secure

Adjusting Direct Drive Blowers

Speed Adjustment Methods

Adjust the air volume by varying the speed of the motor. Most modern PSC and ECM motors can be adjusted electrically through:

- Speed controllers with multiple settings
- Different wire leads (speed taps) from the motors
- Control boards with dip switches or jumpers

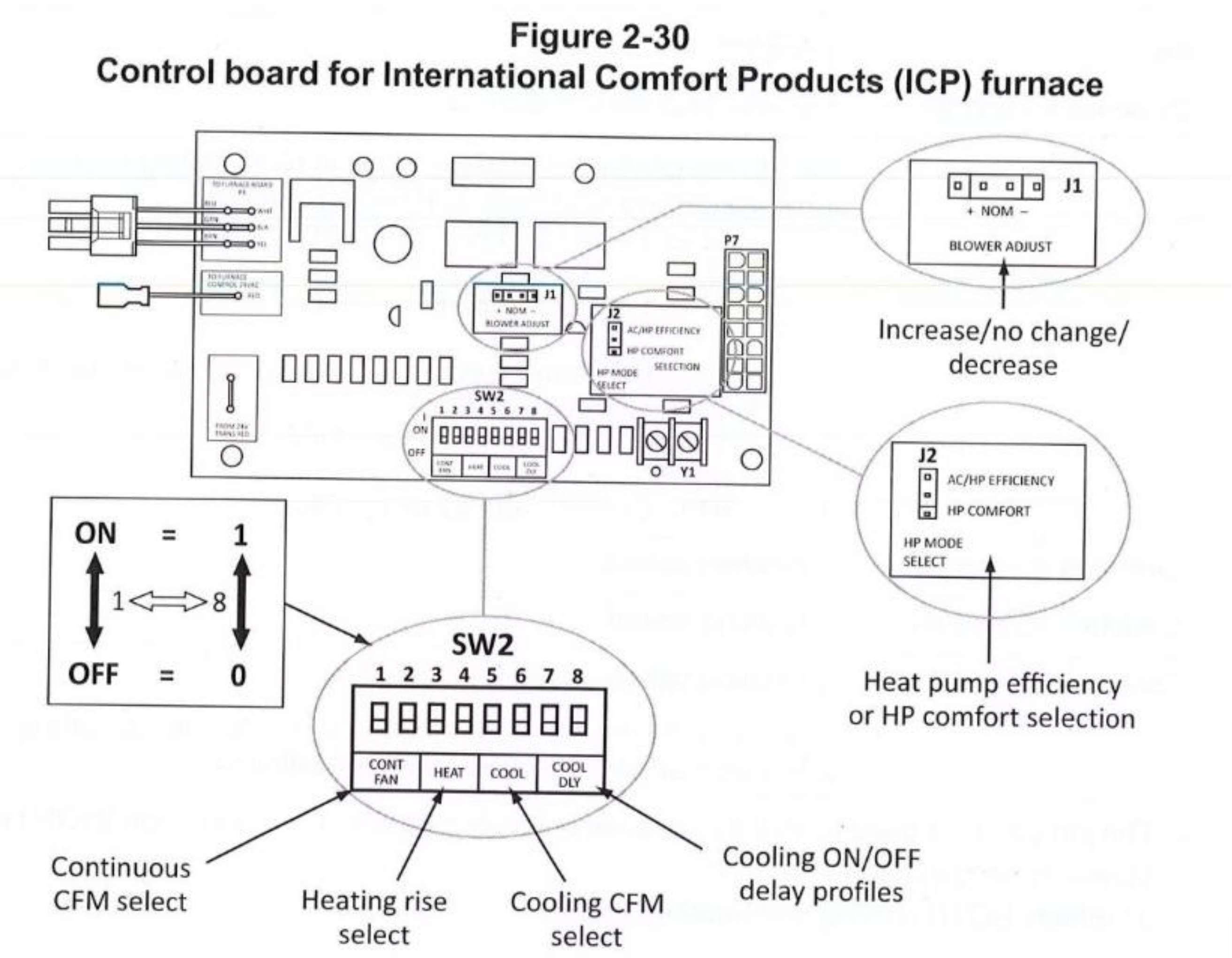
Standard Wiring Colors

Typical color coding for motor speed connections:

- White = Common
- Black = High
- Yellow = Medium
- Blue = Medium low
- Red = Low

Always refer to manufacturer's instructions when wiring.

Control Board Adjustments



Using Dip Switches

Some appliances come with blower control units as either part of the furnace control board or separate Tap Select Interface Boards with select switches or jumpers to change the speed and/or operation sequence of the blower motor.

Always turn off power before making adjustments and wait at least 1 minute before restoring power after changes.

Control Board Switch Settings

1. ## Switches #1 and #2

   Control continuous blower speeds and determine how the blower responds to cooling calls

2. ## Switches #3 and #4

   Adjust heating speed to match the requirements of the installation

3. ## Switches #5 and #6

   Set cooling speed for optimal performance and comfort

4. ## Switches #7 and #8

   Configure cooling speed on/off delay profiles

5. ## Jumper J1

   Used to slightly increase (+), decrease (-), or not change (NOM) the blower speed selected from SW2

Servicing Belt Drive Blowers

Check Belt Condition

Remove the belt and inspect for wear, cracks, and splits in the rubber

Inspect Motor Bearings

Test for excessive movement that indicates bearing wear

Examine Blower Wheel Bearings

Check for movement that could indicate worn bearings or loose collars

Lubricate Components

Follow manufacturer specifications for proper lubrication

Belt Identification and Replacement

Belt Sizing System

The size of belts used in belt drive motors is indicated in the belt's model number:

- First number equals the width in 1/8 inch increments
- Letter describes belt strength
- Final number is the diameter

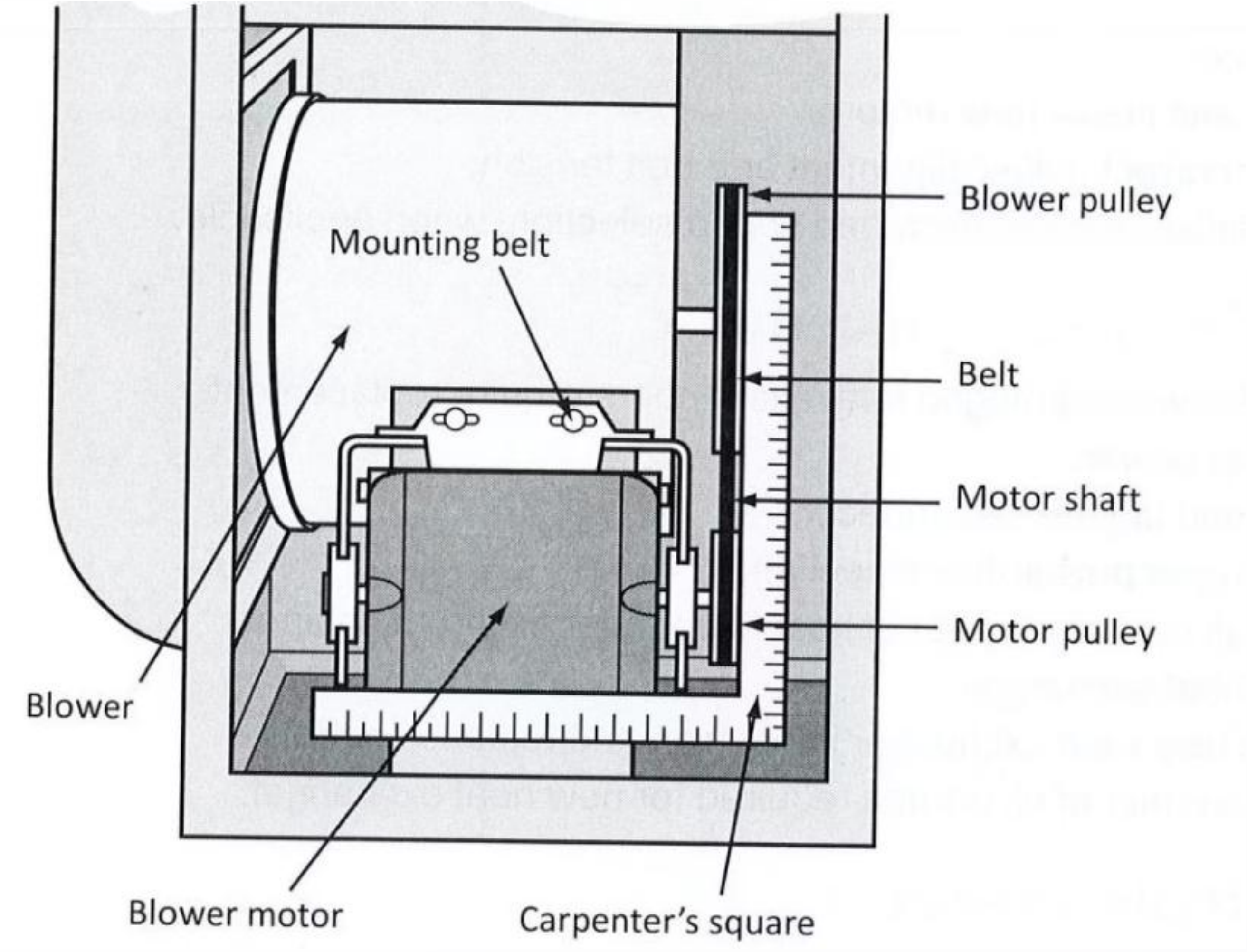
Example: Belt numbered 4L-35 is:

- 4 = 1/2 inch wide (4 × 1/8 inch)
- L = light duty (for fractional horsepower motors)
- 35 = 35 inches in diameter

Replacement Tips

- If the blower uses two belts, replace both
- If only one belt is replaced, the new belt will take more load and wear out quickly
- Ensure proper tension after installation
- Check pulley alignment when installing new belts

Pulley Alignment



Checking Alignment

If pulleys are not correctly aligned, the sides of the belt will wear more quickly than usual.

1. Place a straight rod across the grooves of the motor and blower pulleys
2. If grooves do not line up, loosen shaft set screw
3. Move motor pulley until it is aligned with blower pulley
4. Tighten motor pulley set screw and recheck alignment

If the set screw is jammed or rusted, loosen the mounting bolts on the motor and slide it backward or forward until the pulleys are properly aligned.

Belt Tension

Proper Tension

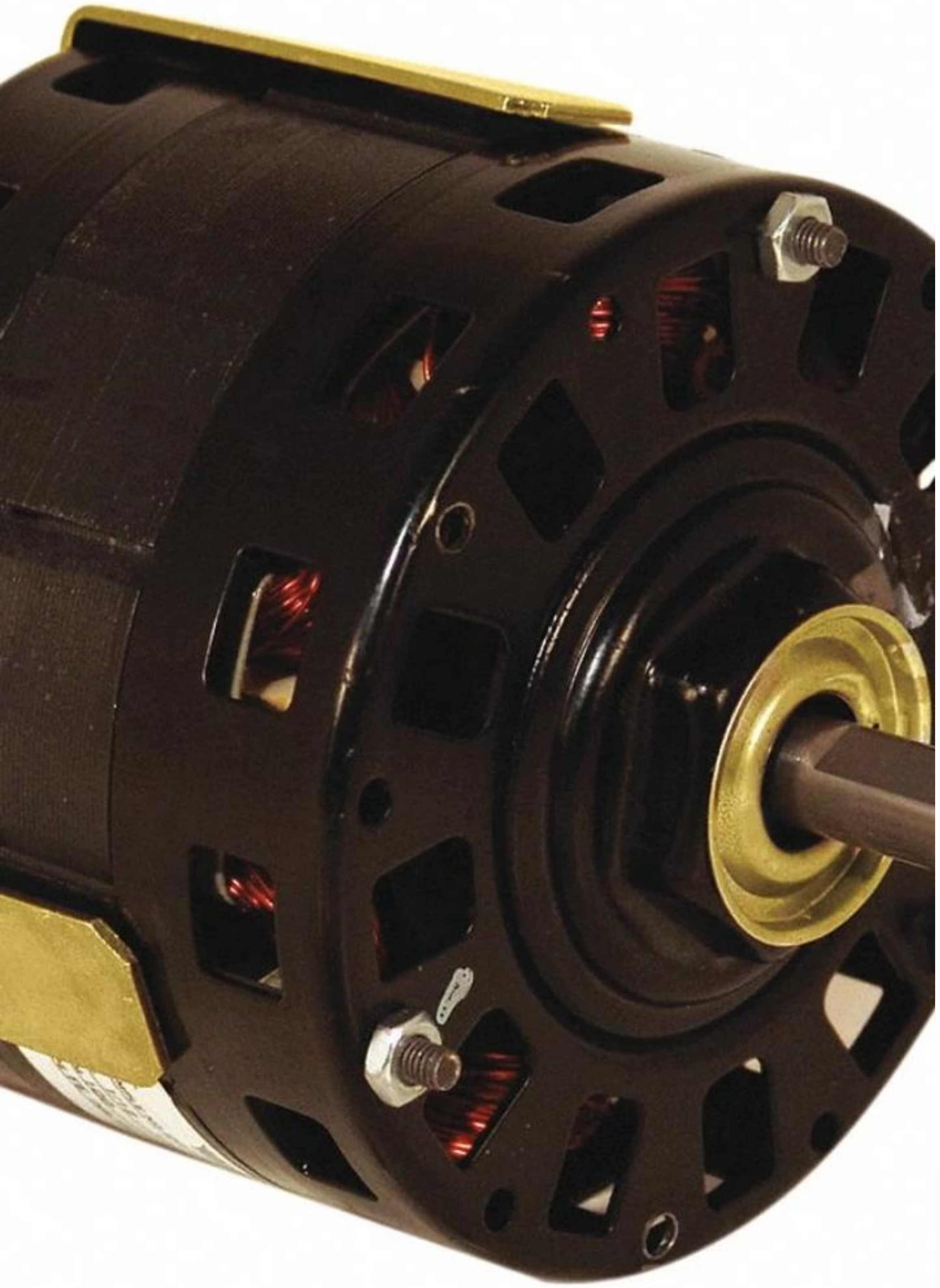
Push down on the belt halfway between pulleys. The belt should move approximately 3/4 inch.

The belt tension required varies depending on the type of bearings used:

- Sleeve bearings or combination: 3/4 to 1 inch deflection with moderate force
- Roller bearings: Belt may be as tight as can be adjusted by hand

Final Checks

- When tension is correct, tighten motor mount
- Check all blower housing and motor mounts for tightness
- Tighten any loose parts
- Verify proper operation after adjustment



Motor Replacement: Direct Drive

Preparation

Disconnect power, lock out and tag the disconnect, test for proper power disconnection

Disassembly

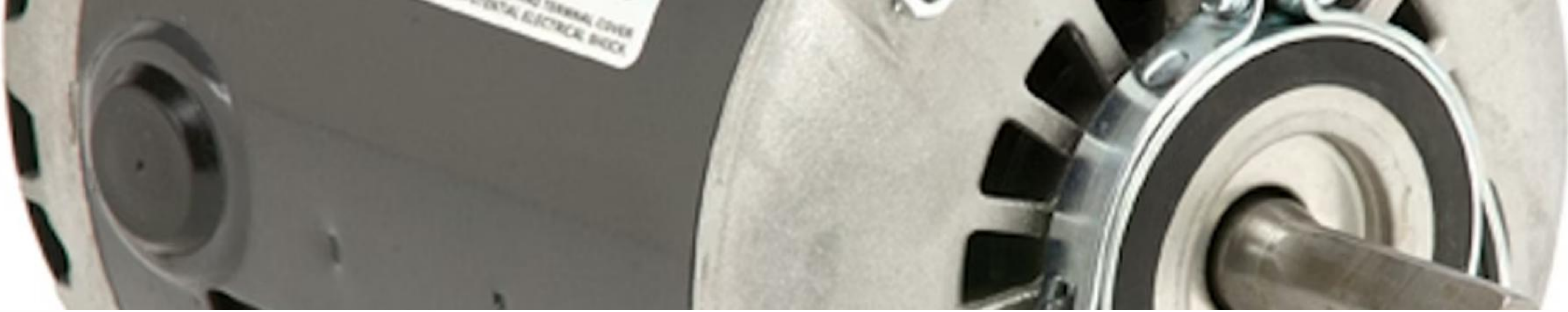
Remove blower assembly, prepare shaft, loosen set screws, remove motor bracket

Selection

Check motor specifications: size, horsepower, rotation, voltage, and speeds

Installation

Select new motor with capacitor, lubricate and install, check rotation, current draw, and speed selections



Motor Replacement: Belt Drive

Preparation

Disconnect power, lock out and tag the disconnect, test for proper power disconnection

Removal

Remove motor and bracket from the system

Selection

Check for voltage, horsepower rating, size, shaft size and length, number of speeds, and rotation

Installation

Lubricate and install new motor, check for correct pulley alignment and belt tension, verify rotation, current draw and speed selection

Heat Exchanger Replacement

1

Preparation

Disconnect power, lock out and tag the disconnect, test for proper disconnection

2

Removal

Remove all controls in path of heat exchanger exit from cabinet

3

Extraction

Carefully remove the damaged heat exchanger

4

Installation

Place the new heat exchanger in position and replace controls

5

Customer Notification

Advise customer of oil burnoff required for new heat exchanger

Bearing Replacement

Preparation

Disconnect power, lock out and tag, test for proper disconnection

Disassembly

Remove blower assembly, shaft retainer, and impeller set screws

Shaft Removal

Lubricate shaft, reinstall pulley to use as a handle, pull and twist shaft out

Bearing Replacement

Remove old bearings, install new ones, reinstall shaft by reversing steps

Final Checks

Verify pulley alignment, belt tension, lubricate motor and test operation

Motor Capacitor Replacement

Disconnect Power

Turn off power, lock out and tag the disconnect

Test for Stored Charge

Use a DC voltmeter to check for voltage, discharge through meter if present

Replace Capacitor

Use one with equal or greater voltage and the same capacitance

Reconnect and Test

Restore connections and verify proper operation

Note: Do not substitute a capacitor with higher or lower capacitance, as motor burnout may occur.

Troubleshooting Duct Furnaces

General Approach

Troubleshooting the duct furnace involves solving problems related to ignition and flame quality. The procedures are similar to those for forced warm-air heating systems.

- Always refer to manufacturer's manuals for the specific unit
- Power-vented units may require adjustments to the power vents themselves
- If you detect a gas odor, shut off the gas supply immediately

Common Issues

- Ignition problems
- Flame quality issues
- Venting malfunctions
- Control system failures
- Air flow restrictions

Troubleshooting Excessive Noise

Blower Wheel Issues

- Hitting scroll side
- Hitting cut-off
- Loose on shaft
- Unbalanced
- Worn from abrasive materials

Drive Problems

- Loose pulleys
- Improper belt tension
- Wrong belt cross-section
- Mismatched belts
- Misaligned pulleys
- Worn belts

Bearing Issues

- Defective or worn
- Needs lubrication
- Loose mounting
- Misaligned seals
- Foreign material

More Noise Troubleshooting

Housing Problems

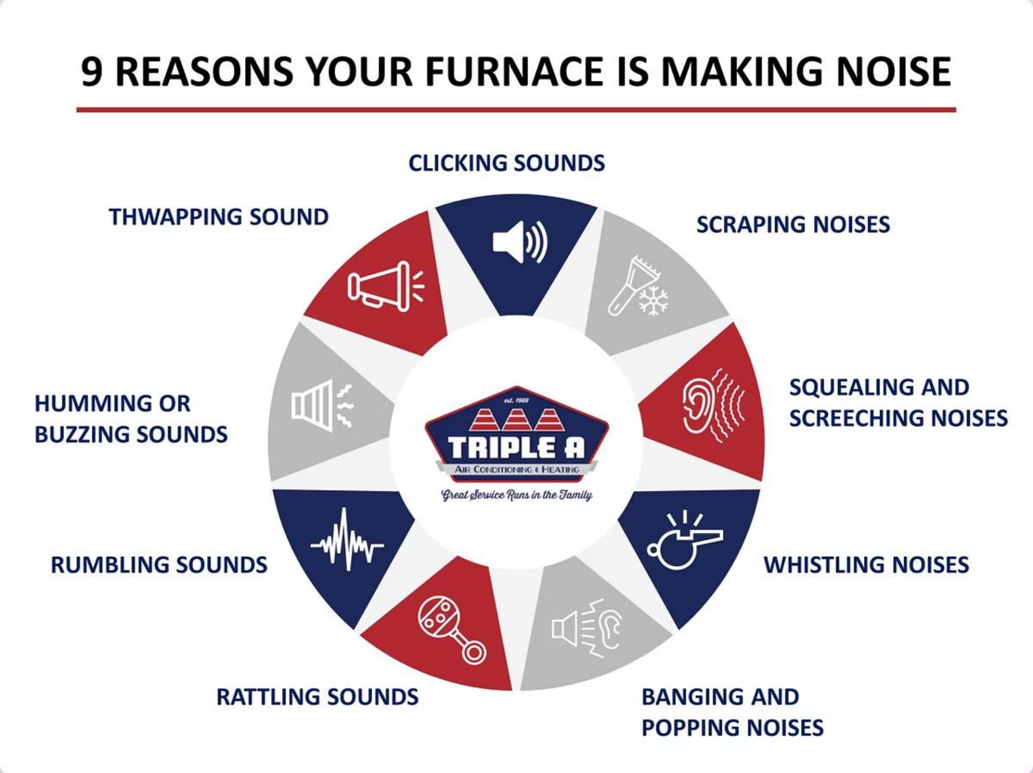
- Foreign material in housing
- Loose parts rattling

Electrical Issues

- Loose lead-in cable
- AC hum in motor or relay
- Starting relay chatter
- Noisy motor bearings
- Single-phasing a three-phase motor

Shaft Problems

- Bent shaft
- Undersized shaft
- Misaligned bearings



Air Flow Noise Issues

High Air Velocity

- Ductwork too small for application
- Blower too small
- Registers or grilles too small
- Cooling coil has insufficient face area

Specific Noise Types

- Pure tone whistle or rattle caused by obstruction in high-velocity air stream
- Sharp elbows
- Sudden expansion or contraction in ductwork
- Turning vanes
- Pulsation or surge from oversized blower
- Rattles or rumbles from vibrating ductwork

Troubleshooting Insufficient Air Flow

Blower Issues

Forward-curved blower wheel installed backwards, operating backwards, missing cut-off, or RPM too low

Damper and Register Problems

Closed dampers or registers restricting air flow through the system

Duct System Problems

Leaks in supply duct, dirty or clogged components, obstructions, sharp elbows, or improper design

System Resistance

Actual system more restrictive than expected in the design calculations

Troubleshooting Excess Air Flow

Blower Issues

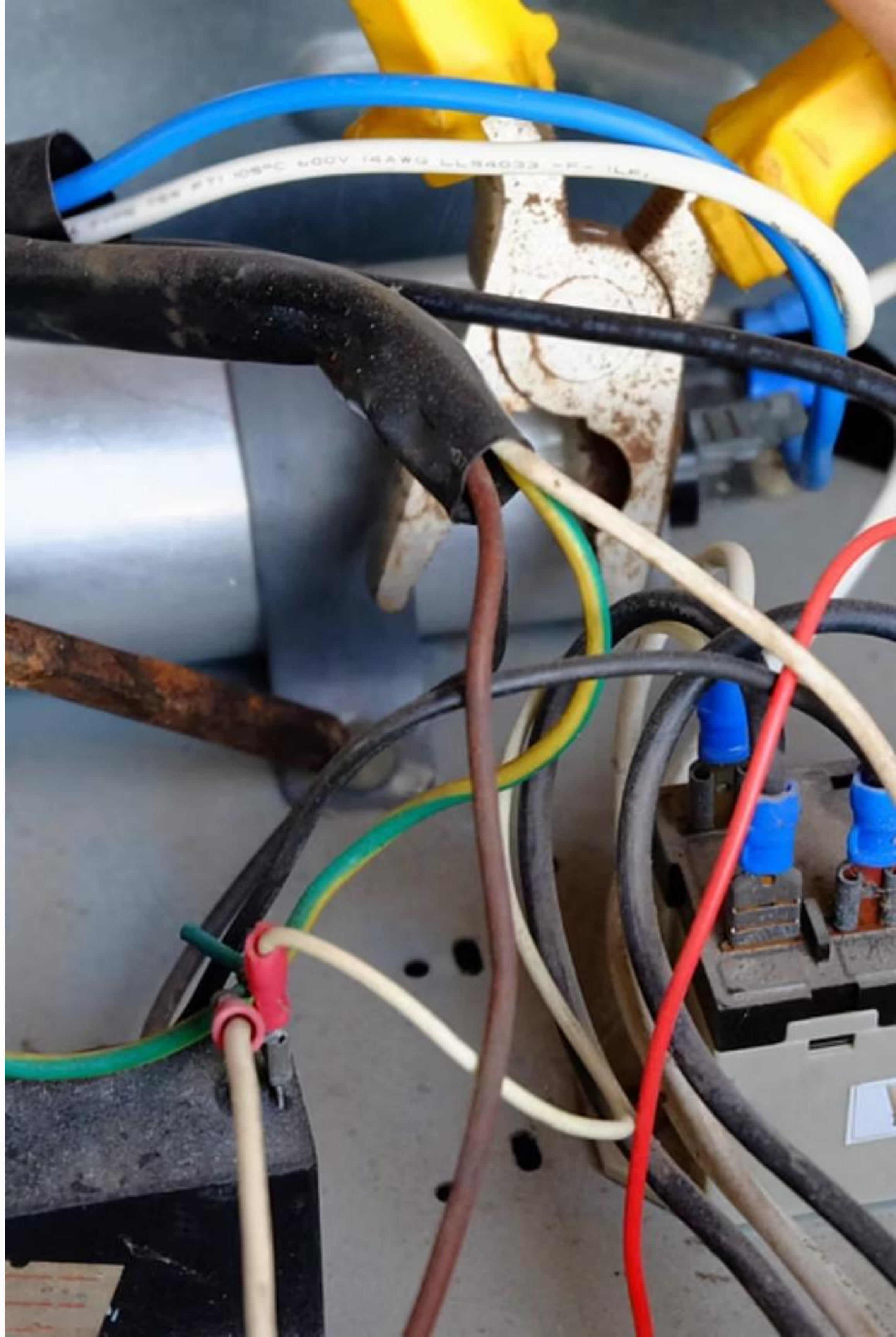
Blower RPM too high for the application requirements

System Problems

- Oversized ductwork
- Access door open
- Registers or grilles not installed
- Filters not in place
- System resistance lower than anticipated

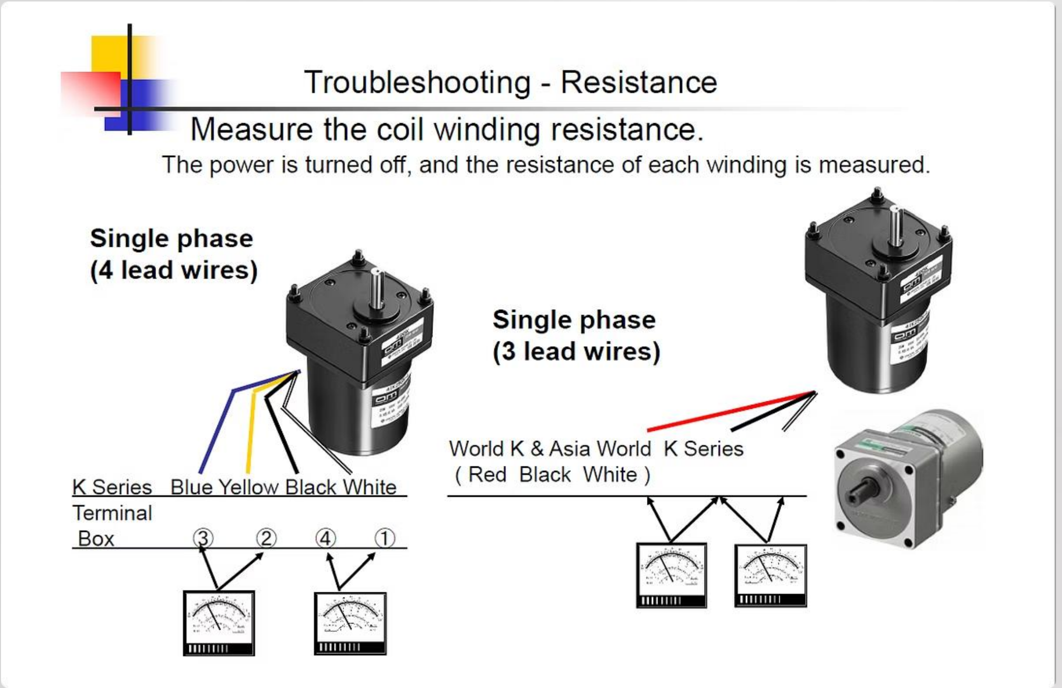
Troubleshooting Blower Motor Problems

Problem	Probable Cause	Solution
Blown fuse or open circuit breaker	Short circuit, excessive current	Check for short circuit, ensure proper size, replace fuse or reset breaker
Overload trip	Motor overloaded	Check and reset manual switch
Improper line connections	Vibration, corrosion	Check connections to unit wiring diagram
Improper current supply	Electrical supply or wiring problem	Check power supply against motor specifications
Mechanical failure	Age and operating conditions	Check that motor and drive turn freely, inspect bearings



More Motor Troubleshooting

Problem	Probable Cause	Solution
Motor stalls	Wrong application, overloaded motor, low voltage	Consult manufacturer, reduce load, check voltage
Motor runs and then dies down	Partial loss of line voltage	Check for loose connections, verify power supply
Motor doesn't reach speed	Undersized motor, low voltage, small wiring	Replace with larger motor, check voltage, install larger wiring
Slow acceleration	Excessive load, loose connection	Replace with larger motor, check connections
Wrong rotation (3-phase)	Improper wiring sequence	Reverse any two line voltage connections



Troubleshooting Fan Assembly

Short Belt Life

- Spin burns from slippage
- High ambient temperature
- Grease or oil on belts
- Worn pulleys
- Belt misalignment

Belt Breakage

- Foreign material in drive
- Belts damaged during installation
- Extreme overload
- Excessive vibration
- Damaged cord section
- Loose belts

Heat Exchanger and System Issues

Heat Exchanger Overheating

Overheating of the heat exchanger may cause it to warp and crack. This is a serious problem since damaged heat exchangers cannot be repaired but must be replaced.

Causes may include:

- Insufficient air flow
- Blocked filters
- Improper gas pressure
- Oversized burners

Cycling on Limit Devices

If limit and control devices cycle off and on too frequently, they may wear out from overuse. Constant cycling will result in methods that are uncomfortable for building occupants; in addition, it is an inefficient use of the equipment.

Check for:

- Improper thermostat location
- Incorrect limit settings
- Undersized ductwork

System Efficiency and Maintenance

Since care and maintenance related to system efficiency and general comfort levels are a priority, consult the following for detailed descriptions:

Heat Exchanger Assemblies

Primary and secondary heat exchangers should be cleaned according to procedures in Unit 19 Forced warm-air heating systems, Chapter 2. Servicing of mechanical components.

Condensate Systems

Proper drainage is essential for system efficiency and to prevent water damage. Regular inspection and cleaning is required.

Cooling Coil and Drain

Refer to Unit 23 Forced-air add-on devices, Chapter 3. Cooling coils for proper maintenance procedures.