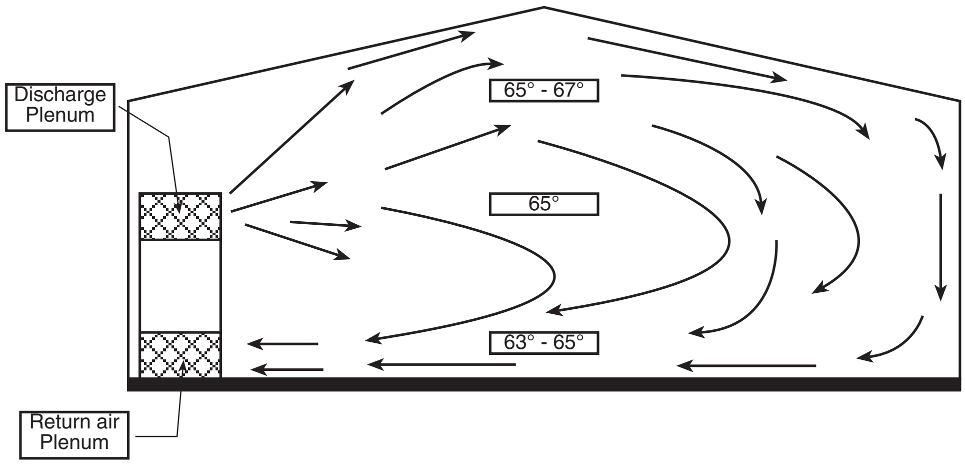
REZNOR®

APPLICATION BULLETIN
FORM NO. **RZ-T-ATO**



AIR TURNOVER
THE AIR MOVEMENT CONCEPT

THE PROBLEM: STRATIFICATION

The physical properties of air dictate that hot air is lighter than cold air and consequently hot air has a tendency to rise while cold air tends to fall. These fundamental laws, while basic, have a direct negative impact when applied to industrial heating applications.

Industrial buildings typically entail large areas of several thousand square feet with a 20 foot or greater ceiling height. As the cold air in the space migrates to the floor it forces the lighter hot air to the ceiling where it becomes trapped. Consequently stratification occurs from the floor to the ceiling and then taking into account the heat associated with the building light source and process heat operations, the problem only escalates. With this in mind, ceiling temperatures could conceivably be in excess of 125°F while the individual work areas at ground level will experience temperature swings. Conditions of this nature will waste energy and cause the facility occupants to be extremely uncomfortable.

THE TRADITIONAL SOLUTION

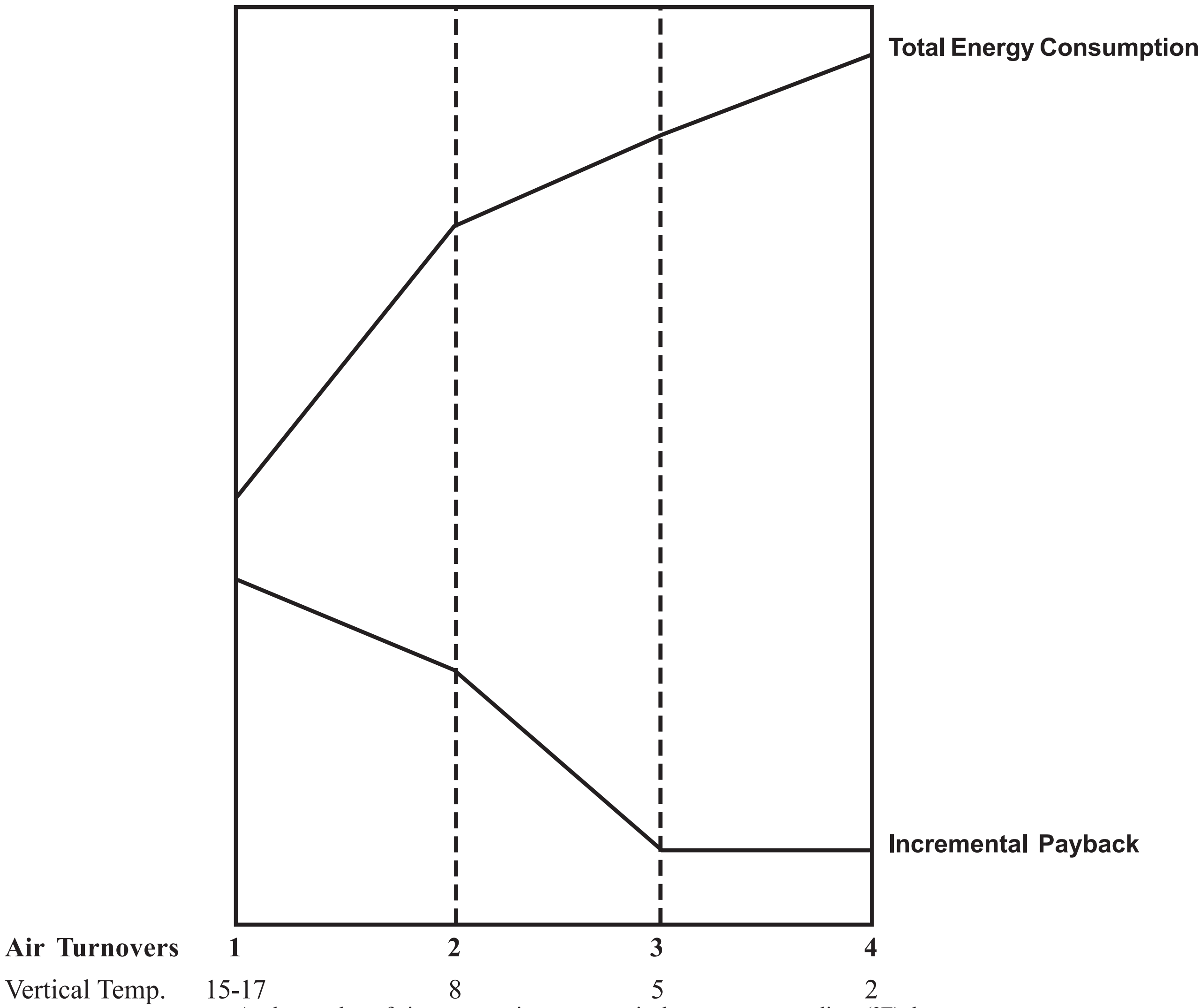
Increasing the building's heating equipment capacity would seem to be an obvious solution if applied directly at the individual work areas. However this solution does not address the energy loss issues attributed to the high temperature conditions that exist at the ceiling level due to stratification. In fact, this solution would only increase both installed cost and operating cost dramatically.

THE AIR TURNOVER SOLUTION

A better idea. By capturing and recirculating the hot air trapped at the ceiling level, and then forcing it back into the work area, additional energy use can be avoided, dramatically reducing both installed cost and operating cost.

Over 100 years of design experience have gone into making today's Reznor heating products a complete air turnover system package that addresses the problem of stratification directly. By continuously circulating a high volume of air and heating it to achieve a low temperature rise, the entire volume of air within the space can be recirculated (usually several times in a relatively short period of time). As shown in the illustration above, cool air at the floor level is drawn in through the return air plenum. Twin axial fans redirect the air upward across an indirect fired heat exchanger where the air is tempered slightly (20 to 40 degree rise). The tempered air is then discharged at a low velocity at the top of the unit through a screened discharge plenum. This air is discharged back into the space developing a gentle air flow pattern, displacing the hot air at the ceiling and returning it to the floor level, eliminating the need for costly duct systems. This reduces the stratified layer and vertical temperature gradient associated with it, as well as doing an excellent job of harnessing the energy of building light source and other heat producing operations. This can amount to a significant savings.

Figure 1: Comparative Energy Savings Chart



As the number of air turnovers increase, vertical temperature gradient (°F) decreases.
Total energy operation costs also increase as payback decreases.

HOW MANY AIR CHANGES

The number of air changes necessary for destratification of building zones is a topic which is viewed differently by many in the industry. Some manufacturers specifically suggest three air changes per hour, while others require four air changes per hour. One to two air changes per hour are recommended because within this range is where the greatest amount of operational savings exists per dollar of initial investment. Once you exceed two air changes per hour the payback ratio diminishes. Illustration of this concept is provided in Figure 1 above. The issue of air changes is usually a decision left up to the designer. In order to make an educated decision as to what the number of air changes should be, you must first ask two important questions.

1. *What are you really trying to accomplish?*

   Are you attempting to capture all of the heat being lost at the ceiling level; or are you simply trying to recover a portion of it and maintain a reasonable temperature gradient from floor to ceiling; or are you looking for some reasonable compromise?

2. *What is a reasonable temperature gradient?*

   As the number of air changes increase so does the installed cost of the equipment and the operational costs.

Usually your customer wants to gain everything he can in operational payback but unfortunately the budget for the job won't allow it. Look for some reasonable compromise such that the owner can realize a significant savings in utility cost per initial dollar invested, while providing optimum comfort to all building occupants.

While some might suggest that three to four air changes per hour are necessary for optimum efficiency and human comfort, our experience tells us otherwise. Designers of Reznor products have found that one to two air changes will usually accommodate the human comfort issues, as well as allow our customers to enjoy a considerable payback in energy savings. The chart above illustrates the potential incremental payback relative to air changes per hour. While there are some incremental savings to be gained by utilizing three to four air changes per hour the greatest payback is available at one to two air changes and the incremental payback after that point diminishes. However, if installed cost is not an issue then it might be desirable to design for a greater amount of air changes.

HEAT LOSS IS HEAT LOSS

While air turnover equipment can reduce the amount of heat transmission through the ceiling by displacing it back to the floor level, a load calculation must be done in the same manner as would be done for sizing any other type of heating equipment. Keep in mind when applying Reznor air turnover equipment that the same amount of heat is being applied to the space. Air turnover equipment simply does a more efficient job of moving the air within the space, tempers that air to a low temperature rise, and then controls the ability of the air to migrate to the ceiling by circulating the entire air volume within the space several times within an hour. Pay particular attention to infiltration factors, especially the usage of shipping and receiving dock doors. Over the years it has been found that inaccurate building usage data was a significant source of error. In addition it is important to note that ventilation loads and process loads should be handled as a completely separate issue.

WHY LOW TEMPERATURE RISE

Reznor air turnover equipment is designed for a 20 to 40 degree rise across the heat exchanger (difference between inlet and discharge air temperatures). Typically, gas/oil fired units are designed for up to 75 degree rise across the heat exchanger. Simply stated, the warmer the air, the greater its ability to rise. Consequently by designing for a lower temperature rise, the tendency for air to rise is reduced, helping to eliminate stratification.

WHY AXIAL FANS

Axial fans lend a valuable dimension to the operation of Reznor air turnover equipment. Axial fans will typically generate a higher volume of air per applied horsepower than a conventional centrifugal blower system. This feature increases the operation efficiency and allows the end user to realize an even greater payback potential.

AIR TURNOVER RECAP

Experience has proven that many large industrial facilities can be heated more efficiently with indoor floor mounted air turnover equipment, provided that the equipment supplies a low temperature rise (20° to 40°) and a high volume of air relative to the cube of the space. For optimum payback and comfort, one to two air changes per hour should be considered.

APPLICATION

Consider the installation profile of a distribution center. The physical characteristics of the facility are as follows:

Building Specifications

Dimensions: 540'x 440'× 32'

Warehouse Area: 7,603,200 cu. ft.

Construction: Masonry wainscot to 15' level. Insulated metal building above.

Use: Regional warehouse and distribution center.

Structure Heat loss: 5,448.4 mbh

Outside air design temperature: 0°F

Space design temperature: 70°F

Design Temperature gradient from floor to ceiling: 12°F

Objectives:

1. Maintain uniform and comfortable temperature throughout the entire warehouse.
2. Provide rapid recovery from heavy infiltration created by indeterminate use of many large truck doors.
3. Minimize energy consumption by minimizing vertical temperature gradient.
4. Eliminate sheet metal duct work
5. Minimize horsepower requirements by using axial fans.
6. Provide maximum reliability of operation.
7. Avoid interference with material handling flow and equipment in the warehouse including racking, conveyors, etc.

EQUIPMENT SPECIFIED

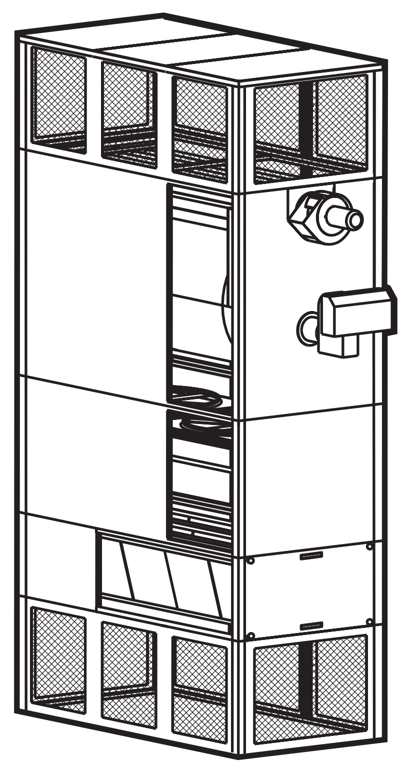
Three Model ACB indoor, indirect fired, air turnover units located as shown in Figure 2 below.

Heat Capacity: 1,816,000 btuh per unit (5,448,000 btuh total).

Air Capacity: 50,688 cfm per unit with two 7.5 horsepower motors per unit (152,064 cfm. total).

Fuel / power: Natural gas / 480/3/60

Controls: Return air stats with 7-day time clocks for automatic switching of day / night temperature control.



Reznor Model ACB

APPLICATION SUMMARY

All of the objectives listed were accomplished through the selection and installation of three Reznor Model ACB heaters positioned in strategic locations as shown in Figure 2. Obstructions and highest areas of heat loss should be considered. Also discharge of air with regard to direction, (3-way or 4-way) and extensions to make sure air discharge is above obstructions like shelving.

ENGINEERING DATA

Step 1 — Calculate the total heat loss in BTUH for the entire facility to be heated including:

Transmission losses

Infiltration

Less any appreciable internal heat gains.

More information on this subject can be found in the Reznor application bulletin, Form No. RGM-T-HICB entitled, "Heating Industrial And Commercial Buildings." Also consult the ASHRAE Handbook for more detailed guidelines.

Step 2.— Determine the fill factor (F). Fill factor is an estimate of the percentage of building volume consumed by shelving or office space expressed as a percentage.

Step 3.— Determine the building air volume (V), excluding material storage, office areas, and large machinery, otherwise known as the fill factor.

$$V = L \times W \times H \times (100\% - F)$$

Step 4. — Determine a vertical temperature gradient that is acceptable to the application. Our experience indicates that an 8° to 20°F vertical temperature gradient will deliver optimum efficiency as well as comfort to all occupants. This equates to one to two air changes per hour. Figure 1 illustrates the design concept in terms of comparative energy savings potential.

Then select the corresponding air volume turnover rate (AVT) from Figure 3 (Air Volume Turnover Chart) that will support the acceptable vertical temperature gradient for use in Step 5.

Step 5. — Calculate the air flow requirement (SCFM) for the application. Reference the space volume (V) from Step 3 and air volume turn over rate (AVT) from Step 4 and apply this data to the formula listed below.

$$SCFM = \frac{V x AVT}{60}$$

Step 6.— Determine the number of units required for the application. This can be accomplished by dividing the total heat loss of the structure and the total air volume requirement calculated in Step 5, by a number who's end quotient will fit into the MBH range listed in the selection chart (Figure 4). Keep in mind that by using several units the heat will be distributed more evenly within the space providing greater comfort. However, by applying additional units the customer's installed cost can be increased. Careful consideration should be used when applying this step.

Step 7.— Select the proper unit size.

Use the selection table (Figure 4) to select a unit whose maximum output capacity (MBH) and air flow capacity meet both the SCFM requirement from Step 5 as well as the capacity for each unit selected in Step 6.

Step 8.— After you have selected a unit that appears to be adequate, check the temperature rise to insure proper application.

OUTPUT CAPACITY OF UNIT

$$\Delta T = \frac{(BTUH)}{SCFM x 1.08}$$

RULE OF THUMB

For optimum comfort and efficiency it is recommended that the temperature rise plus the building design temperature equal approximately 100°F, not to exceed 120°F.

Figure 2: Example Project Building Layout

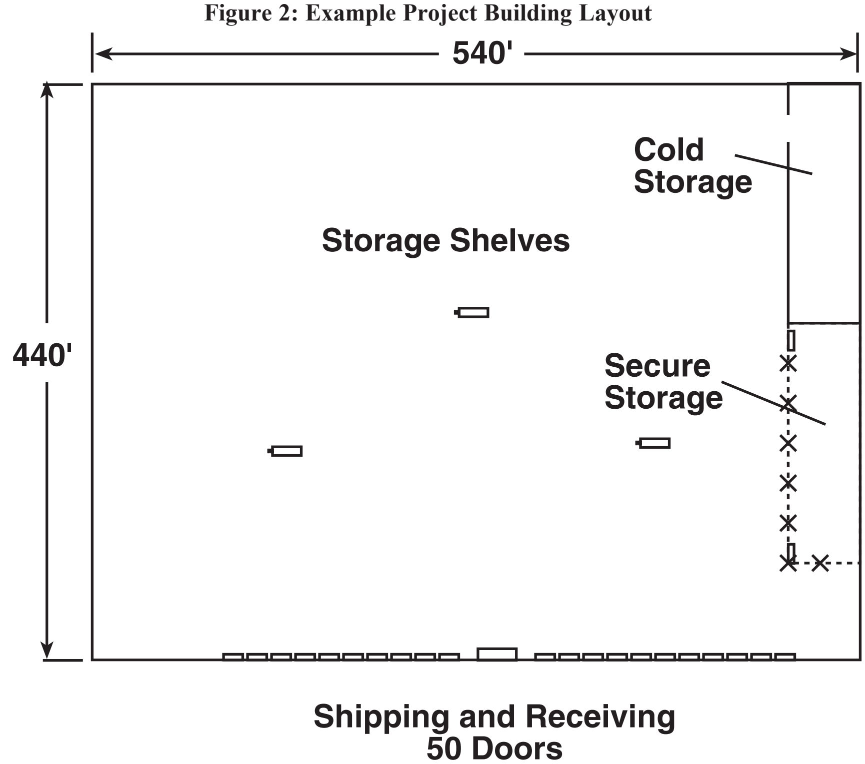
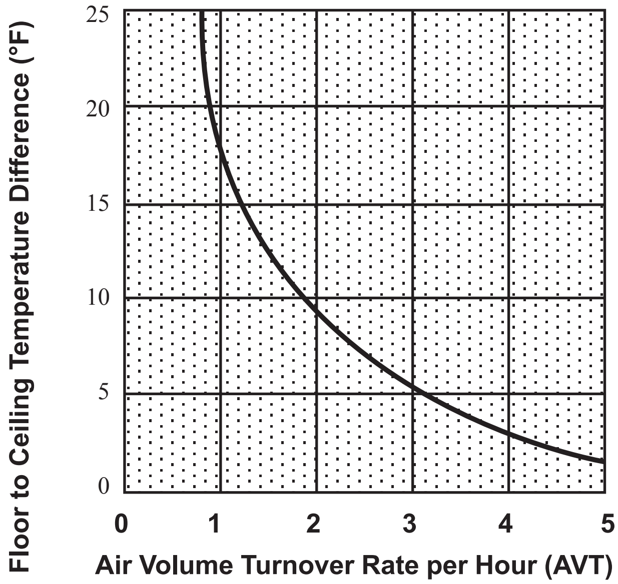


Figure 3: Air Volume Turnover Chart



APPLYING EQUIPMENT SIZING PROCEDURES

APPLIED TO APPLICATION EXAMPLE

Step 1.— The Total BTU loss was determined to be 5,448.4 MBH.

Step 2.— Our fill factor has been determined to be 20%, F = **20%**

Step 3.— Determine the building air volume:

V=LxWxHx(100%-F)

540 × 440 × 32 × .80 = 6,082,560 cu. ft.

Step 4.— Determine the vertical temperature gradient: A 12° gradient was selected because between 8° to 20° is where the largest payback exists. As you can see from Figure 1, the incremental payback is diminishing after an 8° vertical temperature gradient. Using the air turnover chart, Figure 3, to achieve a 12° vertical temperature gradient it will require 1.5 air changes per hour.

Step 5. — Calculate the total air flow requirement:

6,082,560 × 1.5 ÷ 60 = 152, 064

Step 6.— Determine the number of units:

5,448.4 MBH ÷ 3 units = 1,816.1 MBH per unit

152,064 CFM ÷ 3 units = 50,688 CFM per unit

Step 7. — Select the proper unit:

Referring to Figure 4, it can be determined that three Model ACB 248-200 units would be ideal for our application.

Step 8. — Double check using rules of thumb:

A. Heat rise should be 20 to 40 degrees F.

1816.1 MBH ÷ (50,688 × 1.08) = 33º rise

B. Total of heat rise plus desired space temperature should be around 100°F and not over 120°F.

33° rise + 70° space design Temperature = 103º

Our temperatures check out so the application is finished.

Note: Models and sizes have been pre-engineered with certain heat and air capacities. Some applications will require different combinations of heat and air. Please contact your Reznor Representative for more information.

OPTIONS AND CONTROLS

- Industrial high volume axial fans
- NEMA design B high efficiency open drip proof motors
- V-belt drive rated at 150% of motor horsepower
- Industrial construction for long life and serviceability
- 409 stainless steel primary, carbon steel secondary, four-pass heat exchanger
- Gas burner control panel with manual-auto fan and burner switch
- Internal air-cooled metal radiation shield
- Expanded metal return and discharge air plenums
- Power burner with single stage, two stage or electronic modulation gas control.
- Main and pilot gas pressure regulator
- Power venter with stainless steel housing
- Electronic flame safety system
- Combustion air flow switch, and fan and high limit switch
- Control panel with deadfront disconnect switch
- FM and IRI gas trains
- Stainless steel secondary heat exchanger
- Discharge extensions
- Rubber in shear fan isolation

Figure 4: Equipment Selection Chart

MODEL	AIR VOLUME	CFM	MBH OUTPUT
224-050	LOW	6,000	300
	STD	10,000	500
	HIGH	14,000	
230-075	LOW	12,000	750
	STD	17,000	
	HIGH	21,000	
236-100	LOW	18,000	1,000
	STD	24,000	
	HIGH	30,000	
242-150	LOW	28,000	1,500
	STD	35,000	
	HIGH	42,000	
248-200	LOW	38,000	2,000
	STD	48,000	
	HIGH	58,000	
254-250	LOW	48,000	2,500
	STD	60,000	
	HIGH	72,000	

OPERATIONS FOR REZNOR MODEL ACB AIR TURNOVER UNITS

1. Sequence Of Operation:

Refer to Figure 5 - Wiring Diagram

a. Close disconnect switch (1DS).

b. Turn blower switch (1S) to the "Auto" position.

c. Turn burner cabinet "ON - OFF" control switch (2S) to "ON" and burner "OFF-AUTO" switch (3S) on unit panel to "AUTO".

d. Turn " MANUAL-AUTO" selector switch (MA) on burner cabinet to "AUTO".

When the space temperature falls past the set point of the thermostat (1TH) the burner fires (after prepurge period).

When heater plenum temperature rises to the set point temperature of the fan limit control (FL), main blower motor is energized.

When temperature rises past the set point of the room thermostat (1TH) the burner flame is extinguished.

When heater plenum temperature drops below set point of fan limit control, it shuts off the main blower.

The heater will cycle on and off under the control of the space thermostat.

2. CONTINUOUS BLOWER:

a. The heater may be operated with the blower operating continuously by turning the unit panel blower switch (1S) to "ON" to start the main blower motor.

3. AIR CIRCULATION WITHOUT HEAT:

a. For constant air without heat, turn the unit panel blower switch (1S) to "ON" and the burner control switch (2S) or the unit panel burner switch (3S) to "OFF".

4. SAFETY SHUTDOWN:

a. If the temperature at the fan high limit control (FL-2) exceeds its temperature setting, it will shut down the heater. When temperature falls and limit control closes, the heater will continue to operate normally.

b. When flame safeguard causes a safety shutdown it must be manually reset before heater operation can be resumed.

See manual for detailed operational sequences.

REZNOR PRODUCT SCOPE

Reznor products include an extensive line of heating, cooling and ventilating systems, using gas, oil, hot water/steam or electric heat sources. Reznor equipment is designed for the commercial/industrial market. A national network of sales representatives and distributors are trained in Reznor products and possess technical tools to help you determine the best equipment for your particular application. Please feel free to contact these specialists when industrial heating and cooling is being considered.

NOTICE:

This bulletin is intended for general information only. In all cases, local and national mechanical and electrical codes must be followed. Also refer to and abide by the manufacturer's specific installation, operation and maintenance instructions for all equipment. Installation and service of equipment should be by licensed, qualified professionals only.

IMPORTANT:

Read manufacturer's installation, operation and maintenance manuals thoroughly regarding all INSTRUCTIONS, CAUTIONS, WARNINGS AND NOTICE STATEMENTS before specifying, installing, operating or servicing equipment.

WARNING

Improper specification, installation, operation or maintenance of equipment may cause:

- severe personal injury or death and/or
- conditions that may result in property damage.

The following precautions MUST be observed:

- Proper venting, gas and electrical supply according to national and local codes.
- Proper application, setup and operation of all direct-fired heating equipment to eliminate buildup of CO or other combustion gases in the conditioned space.
- Proper venting of indirect-fired heating equipment to exhaust all flue products to the outside atmosphere.
- Proper installation to prevent harmful gases in the discharged air caused by entrained liquid vapors (such as chlorinated or halogenated hydrocarbons) drawn across burner flames or hot surfaces.
- Proper environment/atmosphere or application to avoid fire or explosion from hazardous atmospheres containing flammable vapors or combustible dust.
- Avoiding the use, storage, containment and handling of gasoline or other flammable vapors and liquids in the vicinity of heating equipment.
- Specification of the proper equipment for the particular application.

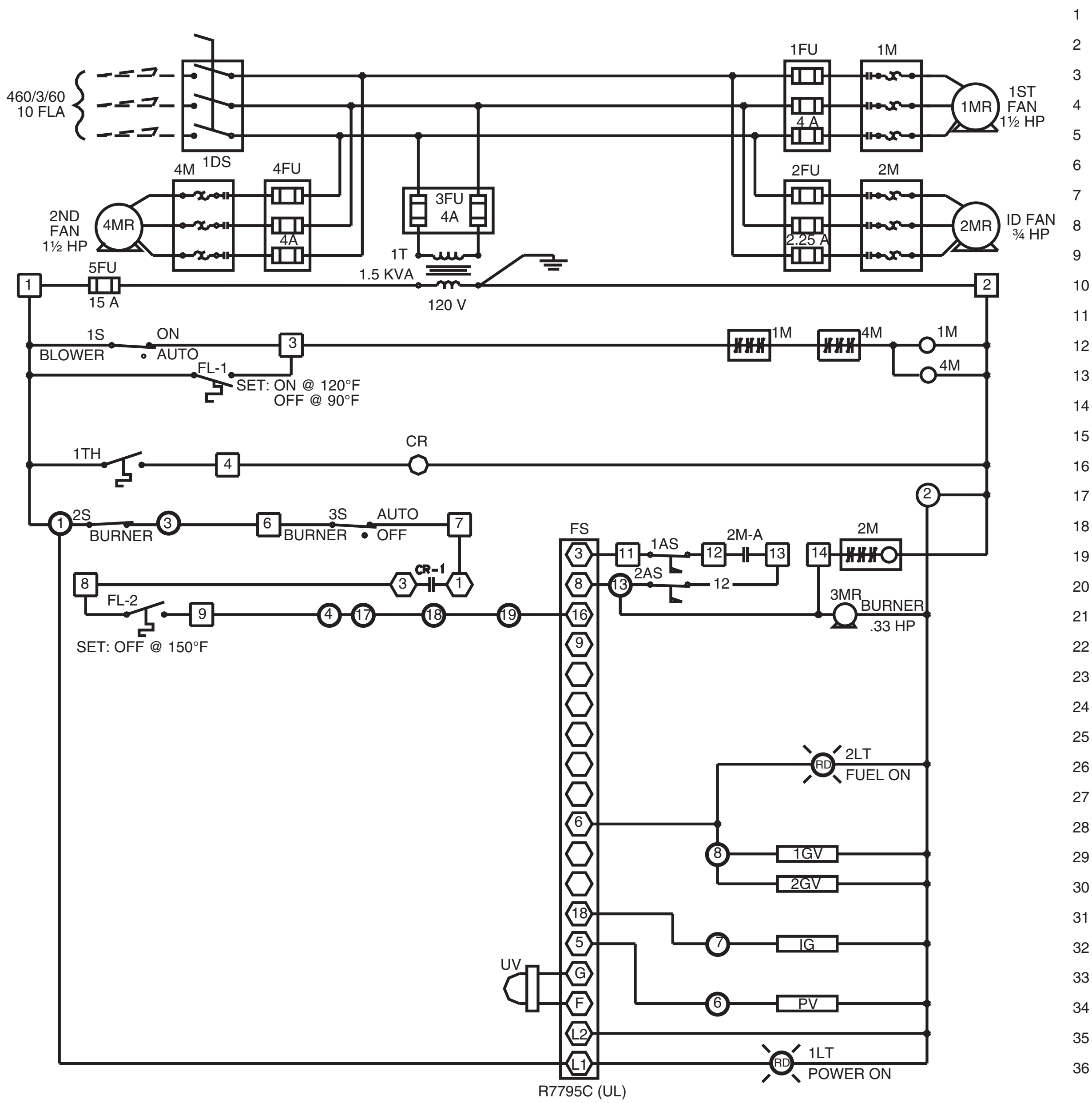


Figure 5 Basic Wiring Diagram

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