Verasys® System Changeover Bypass Zoning System Design

Application Note

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Introduction

This document describes layout considerations and procedures for designing a Verasys® System Changeover Bypass (COBP) Zoning System. This document does not describe how to wire, install, set up, or troubleshoot a Verasys system. For information on these topics, see the *Related Documentation* section.

Note: The procedures in this document do not to replace local codes and regulations in place by Authorities Having Jurisdiction (AHJ).

Related Documentation

The following table lists documentation related to the Verasys System.

Table 1: Verasys Documentation

For Information On	See Document
Smart Building Hub setup procedures	*Smart Building Hub Quick Start Guide (Part No. 24-10737-00229)*
Smart Building Hub features and benefits	*Smart Building Hub Catalog Page (LIT-1901080)*
Installing Verasys Controllers	*ZEC310 Zone and BYP200 Bypass Damper Controllers Installation Instructions (Part No. 24-10143-1248)*
	Verasys Equipment Controller Installation Instructions (Part No. 24-10143-1272)
	ZEC410 VAV Controller Installation Instructions (Part No. 24-10143-1264)
	Input/Output Module (IOM) Installation Instructions (Part No. 24-10143-1256)
System Operation	*Verasys System Overview Technical Bulletin (LIT-12012370)*

Key Concepts

COBP Zoning System Overview

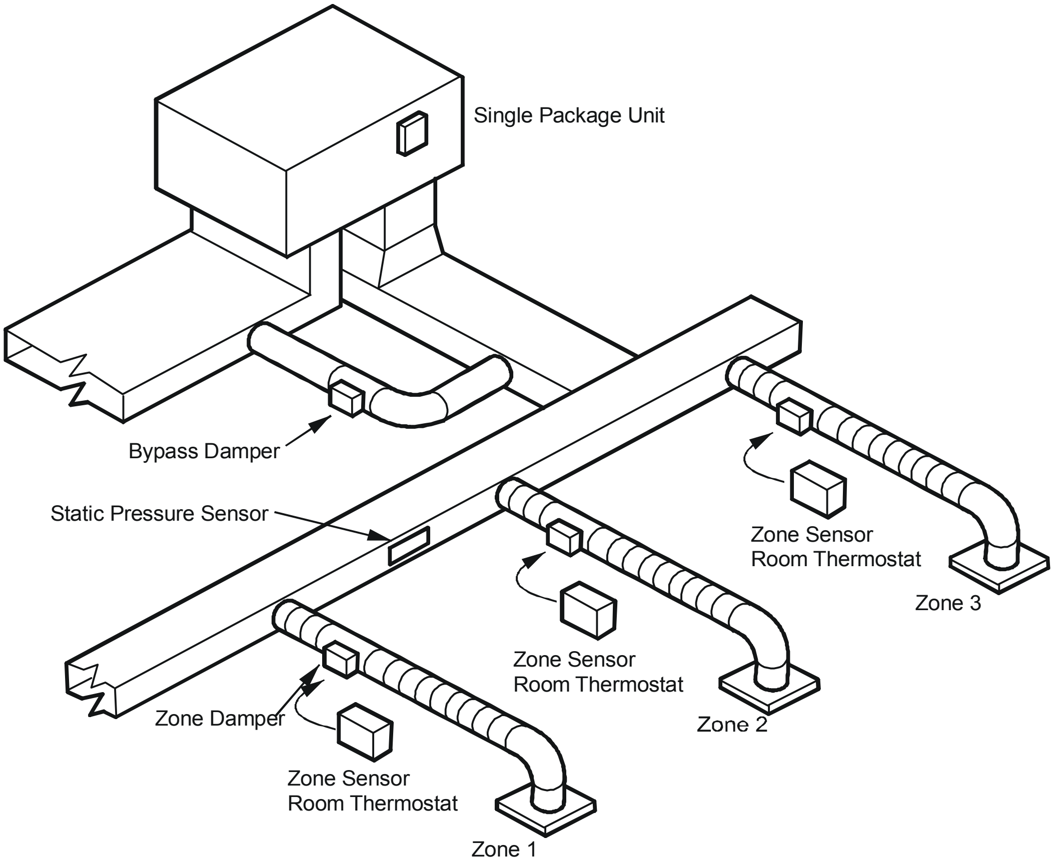
In a COBP Zoning System, the rooftop unit (RTU) uses a constant volume fan. Air bypasses from the RTU supply duct back to the RTU return to air duct to achieve air volume control. A static pressure sensor controls the bypass air. The sensor is located in the supply air duct, downstream of the unity supply air discharge.

The bypass damper opens and closes based on the static pressure in the duct. The discharge air temperature at the RTU varies depending on the demand from the zones. Figure 1 provides an overview of the COBP Zoning System.

The COBP Zoning System RTUs have heating and cooling capabilities. The fan supplies a constant volume of cold or hot air to the duct system. Modulating zone dampers then feed the air to the individual zones. Each zone controller sends its heating or cooling needs to the Zone Coordinator. The Zone Coordinator selects the RTU mode of operation of heating, cooling, or fan only, based on what the zones need. The Zone Coordinator uses a voting system to select the correct mode of operation (see *Zone Voting Logic*).

The heating and cooling setpoints of the zone controller determine if it uses the air that the RTU supplies. For example, if one of the zones calls for cooling when the temperature in the duct is above the zone's cooling setpoint, then the zone moves to its minimum cooling position to minimize the amount of warm air that enters the space. The zone dampers within the COBP Zoning System are usually pressure dependent. However, you can also use pressure independent zone boxes.

Figure 1: COBP Zoning System



Zone Voting Logic

The COBP Zoning System uses zone voting logic. The Zone Coordinator carries out the following actions:

- Monitors the status of the individual zone: The zones vote for either heating or cooling based on how the current zone temperature deviates from the current zone temperature setpoint.
- Processes the votes and determines whether the RTU should provide heating or cooling to the zones.
- Commands the RTU to the appropriate mode of either heating or cooling.
- The Zone Coordinator continues to monitor the zones and changes the operating mode of the RTU to accommodate the zones' needs.

COBP Zoning System Guidelines

Consider the following guidelines when you design a zoning system and layout:

- Group zones with similar load profiles on the same RT.
- Keep perimeter zones separate from interior zones on the same RTU.
- Make sure that each zoned RTU has a minimum of three to four zones.
- Make sure that each zoned RTU supports a maximum of 24 voting zones.
- When all zones are at a minimum airflow, size the bypass dampers for the remaining airflow volume. Use the following equation to size bypass dampers for the correct airflow:

  Bypass Airflow (cfm) = Unit Airflow (cfm) – All Zones Minimum Airflow (cfm)

Design Considerations

Design considerations include load diversity and partial load conditions for both heating and cooling.

Load Diversity

When you create your COBP Zoning System design, do not mix interior zones that require cooling all year with exterior zones that may only require constant heating during the winter months. Group similar loads on an individual RTU, and use more than one zoning system if necessary. Use separate constant volume RTUs for special loads.

Partial Load Conditions

Cooling

Consider the following factors when you apply a COBP Zoning System for hot weather operation:

- Low Ambient Temperature Lockout - During cold weather months, mechanical systems may have low temperature lockouts that protect equipment from damage. When outside temperatures are below the safe operating limits for your equipment, the RTU services the interior zones with thermal loads that require cooling. Use an economizer or low ambient mechanical cooling provisions to prevent damage to the equipment. Economizers lower utility costs and provide comfort under conditions when it is not possible to operate the mechanical cooling system. The Verasys Control System integrates these safeguards into the zoning system operation.
- Low Supply Air Temperatures (SAT) - Under lightly loaded conditions, you can bypass much of the supply air back to the return air side of the RTU. Bypassing the supply air lowers the SAT, and increases the risk of reaching the low temperature safety limit. To protect itself from damage, the control system cuts off the mechanical cooling when you exceed the low SAT safety limit. Excessive cycling of the mechanical system can occur if this condition persists. Comfort can also suffer if the system cannot run long enough to satisfy cooling demands. To avoid excessive cycling of the mechanical system, implement the following operational and design changes:

Operational Changes:

- Increase the cooling minimum airflow or damper position settings to allow more airflow during cooling operation. Avoid minimum settings that are too high and cause overcooling.
- Increase the static pressure setpoint to reduce the amount of air being bypassed. Use of excessive static pressures can increase noise levels and operating costs. Increasing the static pressure can also cause overcooling of the spaces due to increased airflow at minimum positions.

Design Changes:

- To avoid oversizing the unit, calculate loads carefully. Oversizing the unit is a common cause of excessively low SAT cycling.
- When cooling loads are minimal, use an economizer to improve operation and ventilation during cool weather.
- Bypass the air into the ceiling plenum instead of into the return air intake.

Note: Be careful when you bypass the air into the ceiling plenum as you may get dumping of cold air from the return air grills. This method works best with plenum returns, but do not use with ducted returns.

Heating

Consider the following factors when install a COBP Zoning System for cold weather operation:

- High SAT under lightly loaded conditions - you can bypass large volumes of the supply air back into the return air side of the RTU. Bypassing the supply air raises the SAT and increases the risk of reaching the high temperature safety limit. If the supply air high temperature safety limit is exceeded, the control system cuts off the mechanical heating to protect it from damage. Excessive cycling of the mechanical system can occur if this condition persists. If the system cannot run for long enough to satisfy heating demands, occupant comfort is affected.To avoid excessive cycling of the mechanical system, implement the following operational and design changes:

Operational Changes:

- Increase the heating minimum airflow or the damper position settings to allow more airflow during heating operation. Avoid minimum settings that are too high and cause overheating.
- Increase the static pressure setpoint to reduce the amount of air being bypassed. Use of excessive static pressures may increase noise levels and operating costs. This technique may cause overcooling of the spaces due to increased airflow at minimum positions.

Design Changes:

- To avoid oversizing the unit, calculate loads carefully. Oversizing the unit is a common cause of excessive low SAT cycling.
- Bypass the air into the ceiling plenum instead of into the return air intake.

Note: Be careful when you bypass the air into the ceiling plenum as you may get dumping of cold air from the return air grills. This method works best with plenum returns, but do not use with ducted returns.

Override Conditions

After-hours overrides can produce aggravated partial load conditions in both the heating and cooling modes. Aggravated partial load conditions are caused when you override a single zone for after-hours use. This usage causes the rooftop equipment to operate for one zone only. In a Verasys system, you can use a global override to trigger a group of zones. The system uses a global override method to operate with sufficient load to reduce cycling caused by light load conditions.

Building Pressurization

When doors remain open during economizer operation, economizer effectiveness is reduced and there are building pressurization problems. To avoid these problems, use power exhaust functions. For systems with ducted returns, use power exhaust fans. The return duct pressure drop causes most barometric relief dampers to function poorly or not at all. The RTU can control the power exhaust whenever the economizer is operating.

Detailed Procedures

General Zoning Design Overview

Designing a COBP Zoning System requires seven basic steps:

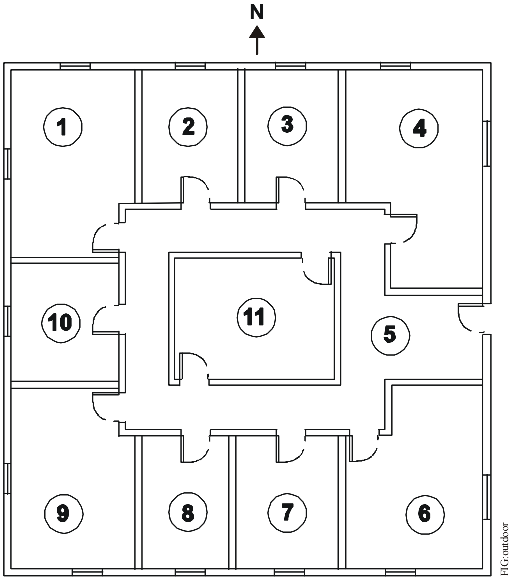
1. Determine the number and location of zones.
2. Size the zone dampers.
3. Size the central unit.
4. Plan the duct system design.
5. Select air diffusers.
6. Size the bypass dampers.
7. Locate the static pressure sensor and probe.

Determining the Number and Location of Zones

You can have a minimum of three zones and a maximum of 24 of zones within a single air handler. The primary precaution when applying the COBP Zoning System is selecting the zoning. Ensure no zone is at the maximum (design) heating or cooling load when another zone requires the opposite air temperature to satisfy its load.

For example, depending on the wall, ceiling, and floor material and location within the building (top or middle floor), a typical floor of a building usually has several distinct temperature or control zones uniquely affected by the outdoor load. These zones are shown in the following figure:

Figure 2: Outdoor Load Locations and Zones



Depending on the size of the building and partition layout, some of the zones may overlap or may not require zoning.

For example, in Figure 2, if Zone 11 consists of multiple conference or computer rooms, additional zoning is required. If Zone 5 is a corridor, no zoning is required. Similarly, Zones 7 and 8 may comprise of a single zone if no external windows and partitions exist between them. Some zones may be divided into multiple offices with full partitions between them, therefore requiring separate damper assemblies because of different internal loads, but the same external load.

Generally, the greater the number of individual zones, the greater the comfort. The designer has to evaluate the specific building, balancing the costs of multiple zones to match the building requirements.

It is important to recognize purely internal zones, such as Zone 11 in Figure 2, which may contain separate offices, conference, and computer rooms. If the internal zones have high cooling requirements and the external zones (1,2,3) are on or near the design heating load, applying a single zoning system to this arrangement of zones may result in poor zoning system performance. It can also result in problems meeting the preferred comfort levels of the occupants.

Serve the interior zones with cooling only loads with a separate RTU that can zone between multiple rooms with a similar profile. System performance may be compromised. Frequent change-over from the heating to the cooling mode occurs during the heating season if internal zones combine on the same air conditioning unit serving perimeter zones. The exposure to the sun has a large effect on the loading of the building. With the building zoned as shown in the following section, for best control, put Zones 6, 7, 8, 9, and 10 on one RTU and Zones 1, 2, 3, 4, and 5 on another RTU. Put Zone 11 on a separate single zone constant volume RTU.

See *Appendix: Example Zoning Designs* for multiple building layout scenarios and zoning recommendations.

Sizing the Zone Dampers

Sizing the zone dampers depends upon multiple factors within your zone. Refer to guidelines found in the American National Standards Institute (ANSI)/American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) Standard 62.1-2010, *Ventilation for Acceptable Indoor Air Quality,* for information on properly sizing zone dampers.

See the following tables for zone damper sizes based on airflow.

Table 2: Round Zone Damper Assemblies

Air Velocity through Damper (FPM)	Damper Size, in. (Area - Sq. Ft)					
	6 (0.188)	8 (0.338)	10 (0.532)	12 (0.769)	14 (1.050)	16 (1.375)
	Airflow (cfm)					
750 FPM - Zone	141	254	399	577	788	1,031
1000 FPM - Zone	188	338	532	769	1,050	1,375
1250 FPM - Zone	235	423	665	961	1,313	1,718

Table 3: Rectangular Zone Damper Assemblies

Air Velocity through Damper (FPM)	Damper Size, W x H in. (Area - Sq. Ft)					
	8 x 12 (0.42)	8 x 14 (0.5)	8 x 16 (0.58)	10 x 16 (0.77)	10 x 20 (1.00)	14 x 18 (1.33)
	Airflow (cfm)					
750 FPM - Zone	315	375	435	578	750	998
1000 FPM - Zone	420	500	580	770	1,000	1,330
1250 FPM - Zone	525	625	725	963	1,250	1,663

Sizing the Central Unit

When sizing the central unit, use a dependable load estimating program to calculate the individual zone loads. Select the central unit for the instantaneous peak load instead of the sum of the peak loads to ensure load diversity. A constant volume single zone system also uses this method. Consider the following guidelines when you size the central unit:

- Size the peak cooling load based on the month, day, and hour of the greatest total building system load.
- Size the heating load for the lowest design temperature with an additional margin for morning pickup. This margin is generally 20% to 25% of base design.

Note: In addition to unit size, consider that RTUs with multiple heating stages tend to provide better temperature control than single-stage RTUs.

Planning the Duct System Design

The Verasys system uses a low pressure duct design. To reduce noise problems, duct pressures must not exceed 1 in. (25.4 mm) Water Column (W.C.).

Avoid undersizing primary trunk ducts, especially for pressure dependent systems. Pressure dependent systems are zone damper assemblies without the airflow sensor. You can maintain relatively constant pressure to each zone when you have larger truck ducts. Keep duct runs as short as possible, and the trunk duct system as symmetrical as possible to facilitate system balancing. Wherever possible, run the trunk ducts above corridors and locate the zone dampers above corridors to reduce noise and facilitate unit service. Size trunk ducts no more than 0.1 in. (2.54 mm) W.C. drop per 100 feet, and a maximum duct velocity of 2,000 feet per minute (FPM).

Selecting Air Diffusers

Air motion directly contributes to occupant comfort. Selecting air diffusers for a COBP Zoning System requires more care than a constant volume system due to varying airflow into the zones. It is best practice to use slot diffusers due to their superior performance at low airflows. Zone airflow is a variable volume. Lower-cost round or rectangular diffusers may not provide a satisfactory airflow in a COBP Zoning System. These diffusers may dump cold air at low flows in the cooling mode, resulting in insufficient room air motion at low airflows in the heating mode. Although high air motion in the heating mode is usually unwanted, a slot diffuser with a high induction ratio reduces room air stratification when the heating comes from a ceiling diffuser. Select linear slot diffusers for the airflow and throw suited to the specific installation or zone.

Sound level and throw at design flow are additional factors to consider in diffuser selection. Generally, multiple diffusers result in lower sound levels in the space, but you can balance this with the additional hardware and installation costs. It is best practice to locate slot diffusers near the perimeter or the outside wall, and direct the airflow into the room. Consult your diffuser supplier for proper diffuser sizing and location.

Sizing the Bypass Dampers

Bypass dampers modulate on a signal from a duct static pressure sensor to bypass air from the supply duct back into the return air duct. If the duct static pressure exceeds the adjustable setpoint, then the damper opens to bypass more air. If the static pressure drops below the setpoint, the damper closes to bypass less air.

Size the bypass dampers for the remaining airflow volume when all zones are at minimum airflow. Use the following equation to help size bypass dampers for the correct airflow:

Bypass Airflow (cfm) = Unit Airflow (cfm) – All Zones Minimum Airflow (cfm).

To size the damper, select a damper based on calculated bypass cfm and a maximum velocity between 1,750 and 2,250 FPM. When determining the bypass duct size, make sure to consider any transition fittings and associated pressure drops. See Table 4 and Table 5 for bypass damper selections.

Use a single bypass damper and round duct for the bypass. Use a rectangular damper if there are space limitations or total airflow requires it.

Locating the Static Pressure Sensor and Probe

Locate the static pressure sensor in the correct position to ensure you can control the bypass damper properly. Figure 3 shows the correct sensor location.

In addition, you must locate the duct static pressure probe in an area where supply plenum pressure is stable. Follow these guidelines when locating the probe:

- Locate the probe at least 10 ft (3.05 m) downstream from the Air Handling Unit (AHU).
- Locate the probe at least 5 ft (1.52 m) downstream from the first turn off of the supply plenum trunk.
- Avoid locating the probe excessively far from the supply plenum trunk or past multiple zone taps.

For a supply plenum tee, locate two probes at least 5 ft (3.05 m) downstream from the main supply trunk on opposing supply plenum branches. Connect the probes with a tee fitting to average the duct static pressure readings from the two supply plenum branches, as shown in the following figure.

Figure 3: Locating Pressure Sensor and Probe in a Supply Plenum Tee

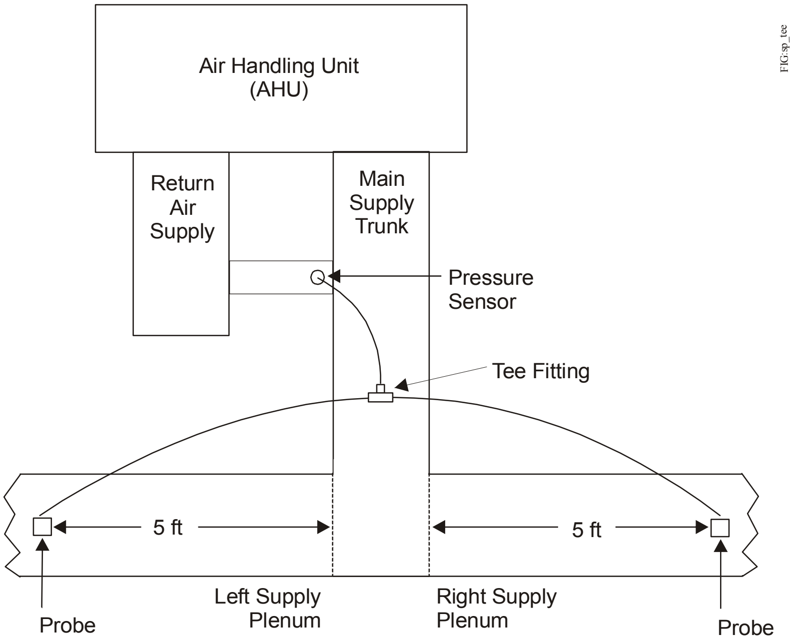


Table 4: Round Bypass Damper Assemblies

Air Velocity through Damper (FPM)	Damper Size, in. (Area - Sq. Ft)					
	6 **(0.188)**	**8** **(0.338)**	**10** **(0.532)**	**12** **(0.769)**	**14** **(1.050)**	**16** **(1.375)**
	Airflow (cfm)					
1500 FPM - Bypass only	282	507	798	1,154	1,575	2,062
1750 FPM - Bypass only	329	592	931	1,346	1,838	2,405
2000 FPM - Bypass only	376	676	1,064	1,538	2,100	2,749
2250 FPM - Bypass only	423	761	1,197	1,730	2,363	3,094

Table 5: Rectangular Bypass Damper Assemblies

Air Velocity through Damper (FPM)	Damper Size, W x H in. (Area - Sq. Ft)			
	14 x 12 (0.83 sq ft)	16 x 16 (1.36 sq ft)	20 x 20 (2.25 sq ft)	30 x 30 (5.44 sq ft)
	Airflow (cfm)			
1500 FPM - Bypass only	1,245	2,040	3,375	8,160
1750 FPM - Bypass only	1,453	2,380	3,938	9,520
2000 FPM - Bypass only	1,660	2,720	4,500	10,880
2250 FPM - Bypass only	1,868	3,060	5,063	12,240

Special Considerations for Large Units (30 Tons and Over)

Due to the large airflow capacities of larger units, careful consideration is essential when designing an effective zoning system. Consider the following factors when designing a COBP Zoning System with a larger RTU:

- Use constant volume units in your zoning system design.
- Size the bypass dampers for the remaining airflow volume when all zones are at minimum airflow:

  Bypass Airflow (cfm) = Unit Airflow (cfm) – All Zones Minimum Airflow (cfm)
- Use rectangular dampers that have a larger air volume capacity than the round dampers. See Table 3 for rectangular damper sizes and cfm ratings.
- To prevent bypassing large amounts of conditioned air, locate bypass dampers towards the end of the main supply duct run.
- Always have a minimum of six zones on large units due to the high airflow capacities.
- Set the zone damper total minimum airflow settings equal to, or preferably greater than, 30% of the unit's rated cfm to prevent excessive noise in the system.
- To prevent over-pressurization of the duct work, install a high duct static safety switch such as Johnson Controls® P32 Series Sensitive Pressure Switch or similar.

Appendix: Example Zoning Designs

Figure 4 shows a building layout with seven zones. Three zones have an eastern exposure (5, 6, 7), four zones have a western exposure (1, 2, 3, 4), two zones have a northern exposure (4, 5) and two zones have a southern exposure (1, 7). You can control this building from a single constant volume air handler because all the zones have the same exterior exposure. The layout lacks entirely internal zones making similar load requirements for each zone.

Figure 4: Zone Layout with External Zones Only

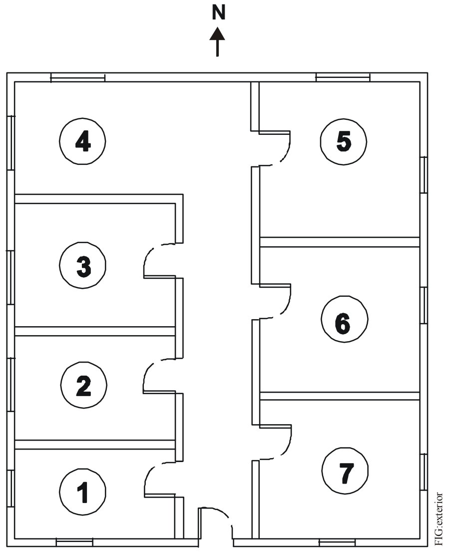


Figure 5 shows a building with seven zones. Four of the zones have a northern exposure (1, 2, 3, 4) and the other three zones have a southern exposure (5, 6, 7). It is best practice to install two separate zoned RTUs because northern and southern exposures have different effects on a building. The solar load is larger on the southern exposure than the northern exposure.

Figure 5: Zones with Northern and Southern Exposures

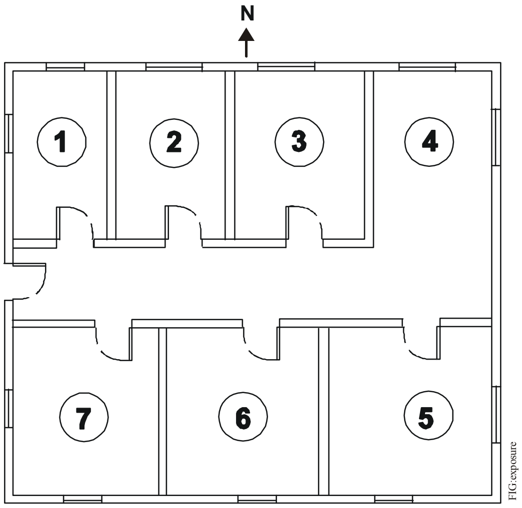
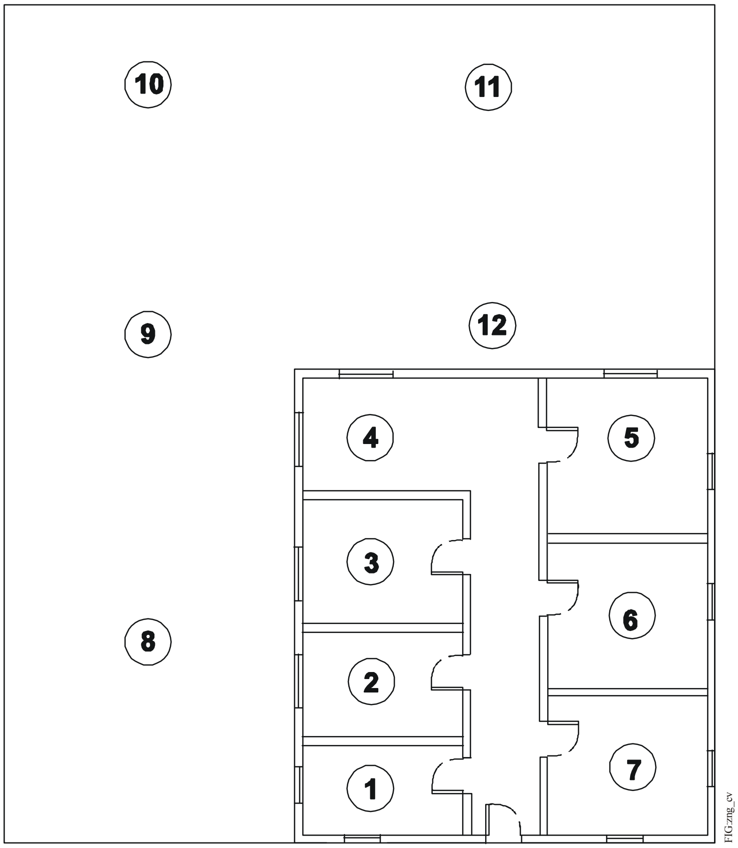


Figure 6 shows a combination manufacturing facility and office area. Two RTUs control the space temperature in the individual zones, numbered 1 through 7. One RTU controls the interior Zones 2, 3, and 4. Another RTU controls exterior Zones 1, 5, 6, and 7. A single constant volume RTU is used for each of the Zones 8 through 12.

Figure 6: Zoning and Constant Volume Units



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