dioxide sensors, as a proxy for the adequacy of ventilation, that measure the change in carbon dioxide levels in a zone relative to the levels in the outdoor air. A controller will operate the outdoor air, return air, and relief air dampers to maintain proper ventilation. See HV22 for more discussion on demand ventilation control and HV14 for methods of operating the system efficiently.

HV8 Exhaust Air (Climate Zones: all)

Central exhaust systems for restrooms, janitorial closets, etc., should be interlocked to operate with the air-conditioning or heat pump unit except during unoccupied periods. These exhaust systems should have a motorized damper that opens and closes with the operation of the fan. The damper should be located as close as possible to the duct penetration of the building envelope to minimize conductive heat transfer through the duct wall and avoid having to insulate the duct. During unoccupied periods, the damper should remain closed and the exhaust fan turned off, even while the air-conditioning or heat pump unit is operating, to maintain setback or setup temperatures.

HV9 Ductwork Distribution (Climate Zones: all)

Many retail stores use unitary rooftop systems with no ductwork or minimal ductwork. This is a less desirable design option that should be avoided because nonducted systems have more difficulty achieving proper airflow and ventilation, often resulting in poor air quality.

Air should be ducted through low-pressure ductwork with a system pressure classification of less than 2 in. Where practical, rigid ductwork is preferred. Supply air should be ducted to supply diffusers in each individual space. Return air should be ducted from return registers provided in appropriate locations for proper airflow but not necessarily in every space. The ductwork should be as direct as possible, minimizing the number of elbows, abrupt contractions and expansions, and transitions. Long-radius elbows and 45° lateral take-offs should be used wherever possible. Where variable air volume systems are used, they should have single-duct air terminal units to control the volume of air to the zone based on the space temperature sensor.

In general, the following sizing criteria should be used for the duct system components:

a. Diffusers and registers should be sized with a static pressure drop no greater than 0.08 in.
b. Supply and return ductwork should be sized with a pressure drop no greater than 0.08 in. per 100 linear feet of duct run.
c. Flexible ductwork should be of the insulated type and should be

1. limited to connections between duct branch and diffusers,
2. limited to connections between duct branch and variable air volume terminal units,
3. limited to 5 ft (fully stretched length) or less,
4. installed without any kinks,
5. installed with a durable elbow support when used as an elbow, and
6. installed with no more that 15% compression from fully stretched length, and
7. hanging straps, if used, need to use a saddle to avoid crimping the inside cross-sectional area. For ducts with 12 in. or less diameter use a 3 saddle; for larger than 12 in. use a 5 in. saddle.

Ductwork should not be installed outside the building envelope in order to minimize heat gain to or heat loss from the ductwork due to outdoor air temperatures and solar heat gain. Ductwork on rooftop units should enter or leave the air-conditioning or heat pump unit through an insulated roof curb around the perimeter of the air-conditioning or heat pump unit's footprint.

Duct board should be airtight (duct seal level B, from ASHRAE Standard 90.1) and should be taped and sealed with products that maintain adhesion. Duct static pressures should be designed and equipment and diffuser selections should be selected to not exceed the noise criteria for the space. See HV19 for additional information.

HV10 *Duct Insulation* (Climate Zones: all)

All supply air ductwork should be insulated. All return air ductwork located above the ceiling and below the roof should be insulated. Any outdoor air ductwork should be insulated. All exhaust and relief air ductwork between the motor-operated damper and penetration of the building exterior should be insulated.

Include a vapor barrier on the outside of the insulation where condensation is possible.

Exception: In conditioned spaces without a finished ceiling, only the supply air duct mains and major branches should be insulated. Individual branches and run-outs to diffusers in the space being served do not need to be insulated, except where it may be necessary to prevent condensation.

HV11 *Duct Sealing and Leakage* (Climate Zones: all)

The ductwork should be sealed for Seal Class B from ASHRAE Standard 90.1 and leak-tested at the rated pressure. The leakage should not exceed the allowable cfm/100 ft^2 of duct area for the seal and leakage class of the system's air quantity apportioned to each section tested. See HV15 for guidance on ensuring the air system performance.

HV12 *Fan Motors* (Climate Zones: all)

Motors for fans 1 hp or greater should meet National Electrical Manufacturers Association (NEMA) premium efficiency motor guidelines when available.

HV13 *Thermal Zones* (Climate Zones: all)

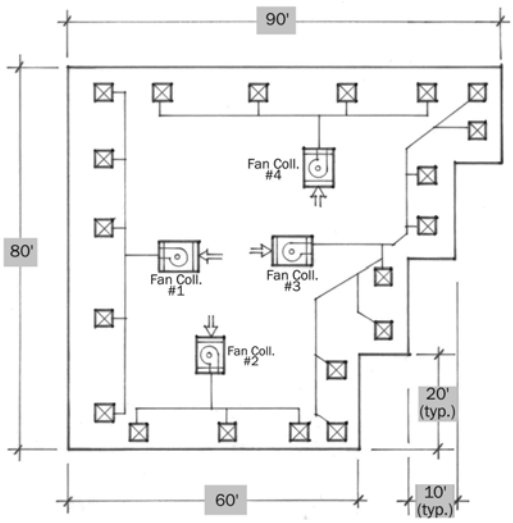

Figure 5-28. (HV13) Perimeter system zoning.

Retail buildings should be divided into thermal zones based on building size, part-load performance requirements, space layout and function, number of tenants, and the needs of the user. In a retail building with similar internal loads throughout, a minimum of one zone for the interior and one for the front exposure is recommended. If side exposures have significant glass area, additional zones may be needed. (See Figure 5-28 for an example of perimeter system zoning.)

Zoning can also be accomplished using multiple air-handling units or by having multiple-zone control with a single air-handling unit. The temperature sensor for a zone should be installed in a location representative of that entire zone.