

## DUCT SYSTEM DESIGN CONSIDERATIONS

### Part 1

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#### TYPES OF SUPPLY DUCT SYSTEMS

There are several basic types of supply and return duct systems. Any one of the system types, or a combination of different types, can be utilized to fit the needs of a particular structure. The general types of supply duct systems include:

- radial system
- extended plenum system
- reducing plenum system
- reducing trunk system
- perimeter loop system.

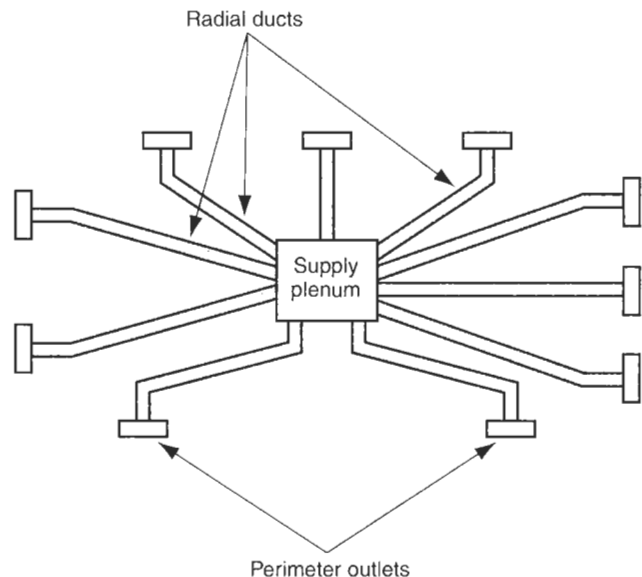
#### Radial system

The *radial* duct system in its simplest form consists of a central supply plenum that feeds a number of individual branch ducts arranged in a generally radial pattern (see Figure 1). It also can be designed and sized so that each individual run leaving the plenum can feed two or more supply outlets. This is frequently the case because of the number of supply outlets required to condition the structure successfully and the amount of space at the plenum available for takeoffs. The radial system commonly is applied in attics, crawl spaces, and in slab on grade installations (with the ducts embedded in the slab). It can be used with upflow, downflow, or horizontal air handlers and furnaces.

#### Extended plenum system

The *extended plenum* duct system (see Figure 2 on the next page) generally consists of one or two box-like pieces of ductwork extending from the main

plenum at the indoor unit. This extended plenum has the same dimensions (height and width) from the starting collar to the end of the run. Branch runs to feed the supply outlets are tapped into the extended plenum(s). The best results are achieved when the maximum length of the extended plenum is not greater than 24 ft from the air handler or furnace. If two plenums are used, this total length can be extended to 48 ft (see Figure 3 on the next page). If longer distances are required based on the physical layout of the structure, consideration should be given to using one of the other designs discussed below (such as the *reducing plenum* or the *reducing trunk* duct system). There is another area of concern with the extended plenum system—because of the higher velocities in the plenum, it is possible that the branches closest to the indoor blower may not feed the desired amount of air (cfm).



**Figure 1. Radial duct system**



A long plenum degrades the air flow through the branches that are close to the blower

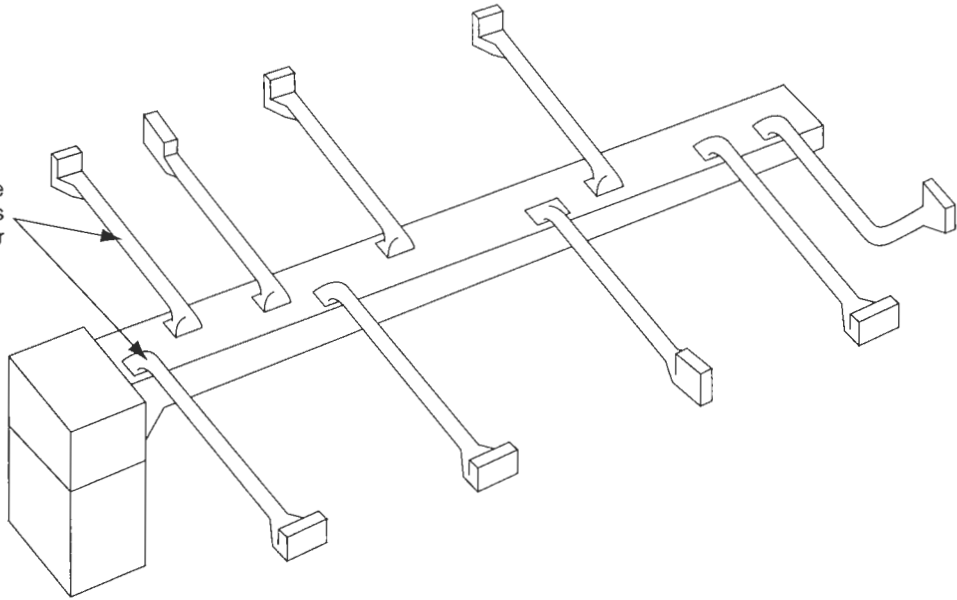


Figure 2. Extended plenum duct system (single plenum)

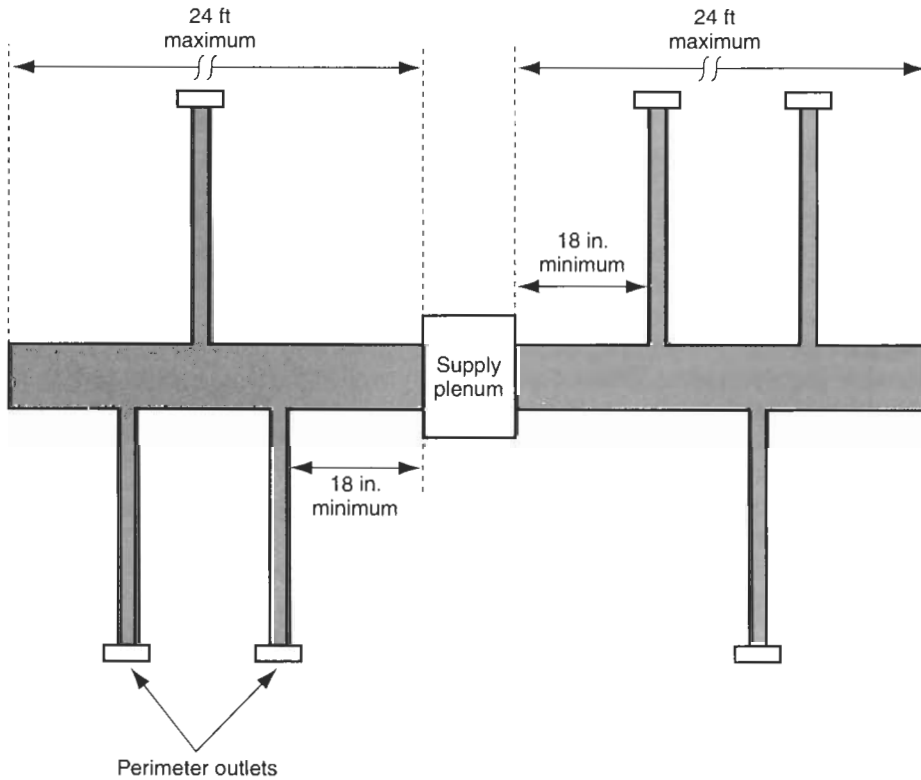


Figure 3. Extended plenum duct system (double plenum)

Never start a branch run from the end cap of an extended plenum. For best results, the starting collar of a branch run should never be any closer than 24 in. from the end cap. To sum up, observe the following general rules for the extended plenum system:

- Single plenums should not exceed 24 ft in length.
- Double plenums should not exceed 48 ft in total length.
- Keep branch run starting collars 24 in. from the end caps.
- Never locate a takeoff in the end cap.

### Reducing plenum system

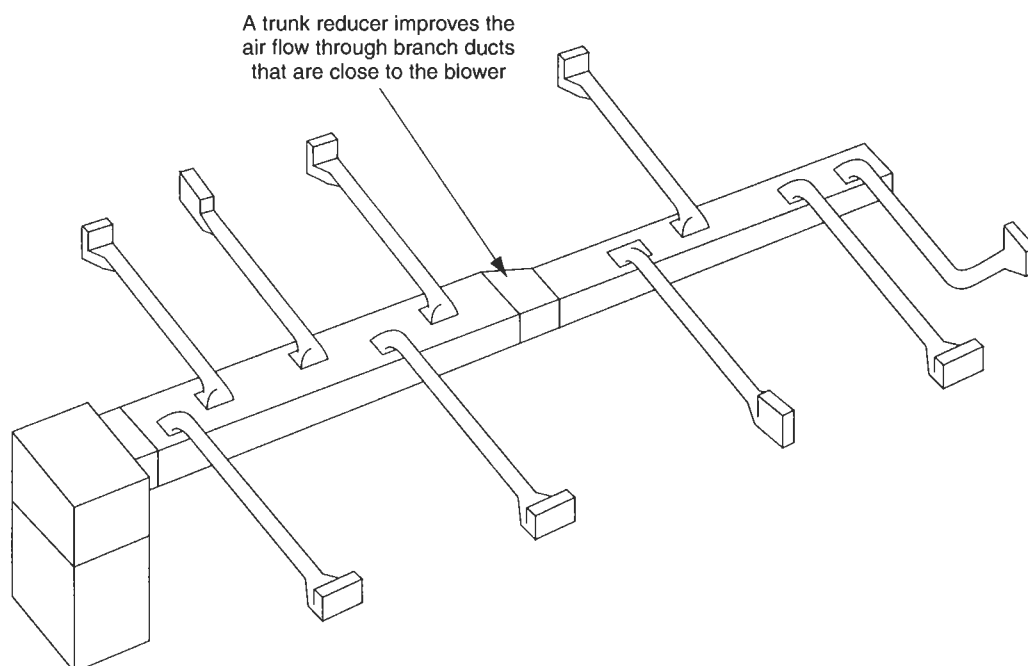
The *reducing plenum* duct system (see Figure 4) can be used when the physical size or layout of the structure calls for greater distances than the length constraints imposed on the extended plenum (24 ft). The concept of the reducing plenum system is simple—when the air velocity lost to the branch runs reaches approximately 50%, the plenum size is reduced to

regain the velocity in the remaining portion of the plenum. This reduction also improves the air flow characteristics at the branch ducts that are closest to the air-handling unit. The 50% rule is demonstrated in Figure 5 on the next page. Note that at the start of the plenum, there is an available air volume of 1,200 cfm and an available velocity of 900 ft/min. After the third branch run, a total of 600 cfm has been distributed to the branches and the velocity in the plenum has been reduced to 450 ft/min. These conditions indicate that the proper location for the reduction in the plenum is after the third branch. The outlet side of the reduction is sized to restore the velocity in the plenum to approximately 900 ft/min.

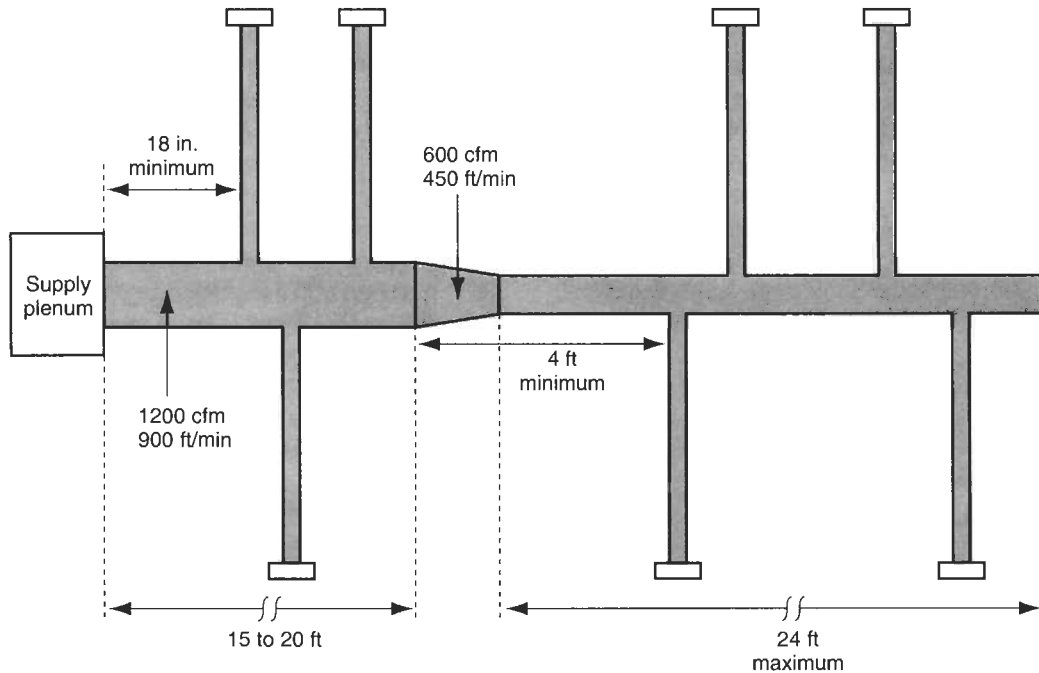
This system is relatively easy to fabricate and install. Additional sheet metal sometimes is required to build the system, but if done correctly it can deliver good results. It may be necessary to balance the system branch dampers properly.

### Reducing trunk system

The *reducing trunk* duct system (see Figure 6 on the next page) is very similar to the reducing plenum



**Figure 4. Reducing plenum duct system**

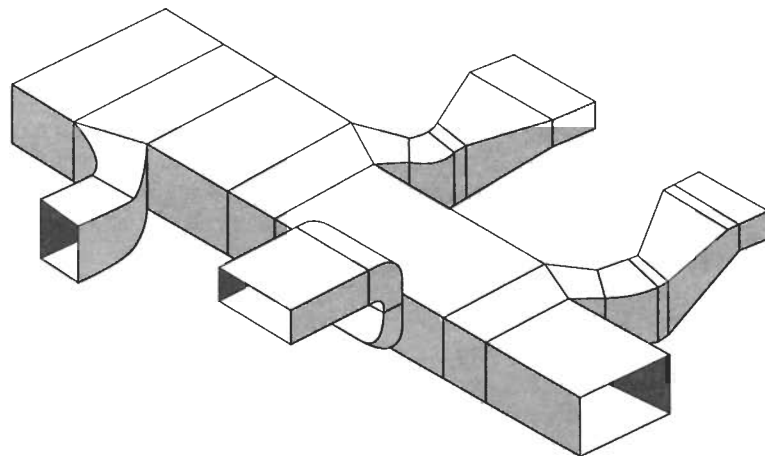


**Figure 5. Reducing plenum “50% rule”**

system, with the exception that the trunk run is reduced in size after each branch takeoff. These multiple reductions make it possible to maintain a constant velocity (ft/min) in the trunk even though the total air volume is reduced as each branch is supplied. This type of system generally takes more sheet metal to build and requires more labor to fabricate and install. Another major concern is that there are more joints to seal (to prevent air leakage). The reducing trunk system also can be applied using lengths of round duct and manufactured fittings. Round duct systems can significantly reduce the cost of labor for fabrication and installation, and produce very satisfactory results if properly applied.

Another configuration that may be used in some cases is known as the *primary-secondary trunk* system (see Figure 7). This type of system has a primary trunk and two or more secondary trunks. The “tee” fitting located at the end of the primary trunk in this system performs the same function as the reduction in the

reducing trunk system. Each secondary trunk has a cross-sectional area that is smaller than that of the primary trunk. The secondary trunks are sized to deliver the proper air volume to each branch at the proper velocity. This type of system can be used very successfully in a structure that spreads out in two or more directions.



**Figure 6. Reducing trunk duct system**

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## Perimeter loop system

The *perimeter loop* duct system (see Figure 8 on the next page) is well-suited for buildings that are constructed using concrete slab on grade. It generally performs better than the radial system in such applications, especially in cold climates. However, the perimeter loop system does have the disadvantage of being a little more difficult to design and more expensive to install. It is basically laid out around the perimeter of the structure next to the edge of the slab. The entire perimeter loop is the same size duct. The loop is fed by four or more ducts radiating out from the central plenum. They are usually the same size as the loop duct. The boot boxes are sized to deliver the proper cfm to each room of the structure.

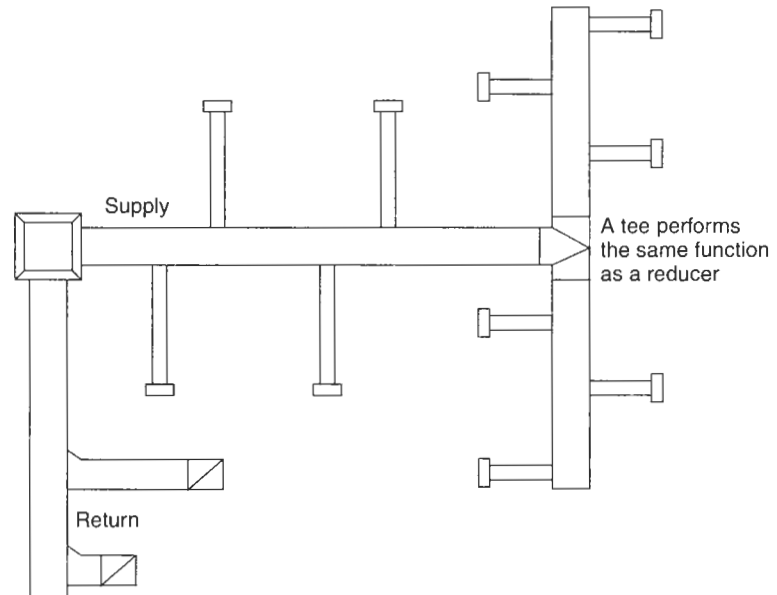


Figure 7. Primary-secondary trunk system

## SUPPLY DUCT SYSTEM LOCATIONS

Decisions regarding the location of a supply air distribution system should be made based on the winter design temperature for the structure's geographic location. Table 1 in ACCA's *Manual J* lists design conditions for locations in the U.S. and Canada. This information should be consulted to ensure that the proper type and location of duct system is selected for the structure in question. The ASHRAE *Fundamentals Handbook* contains HVAC design criteria for most countries around the world.

The general guidelines state that if the winter design temperature for the location of the structure is *above* 35°F, then both perimeter floor and ceiling distribution systems will provide satisfactory results. If the winter design temperature for the location of the structure is *below* 35°F, the ceiling distribution system is *not* recommended and the floor distribution system should be considered. A modified type of ceiling distribution system can be used if the registers are moved closer to the outside walls and the primary air is directed out of the occupied zone and toward the window and door openings.

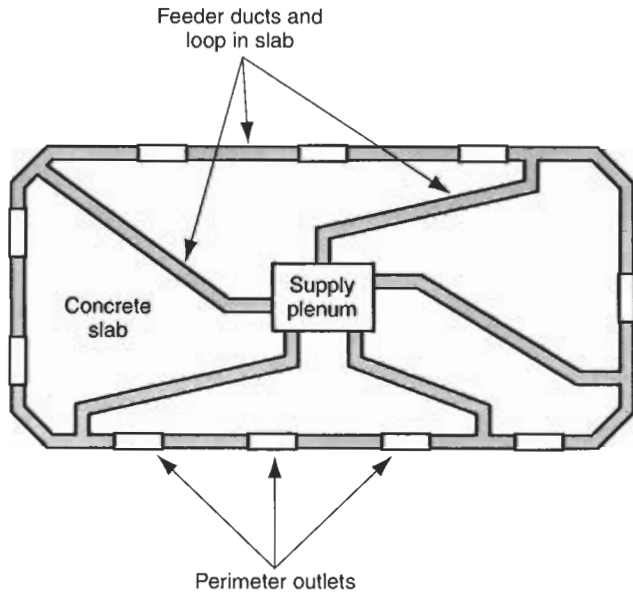
There are six basic locations for supply duct systems in residential structures. Most residential structures

can accommodate one or more of these configurations. One of the most important jobs of the designer is to select the type of installation that best suits the air distribution requirements of the structure and the needs and desires of the customer. This must be balanced with the cost of the installation and the comfort conditions within the structure. The six basic locations for supply duct systems are as follows:

- attic installations
- basement installations
- between floors of multistory structures
- crawl space installations
- conditioned space installations
- embedded in concrete slab.

### Attic installations

Attic installations lend themselves readily to all of the duct system types. A duct system located in an attic must be insulated and must have a vapor barrier installed to prevent condensation on the exterior of



**Figure 8. Perimeter loop duct system**

the ductwork. Condensation can cause corrosion and rusting of the duct system and possible structural damage to the ceilings. All joints and side seams must be sealed to prevent duct leakage. Some local codes do not permit the use of duct tape as a sealant. In these cases, waterproof mastic must be used. Depending on the type of equipment being used, the air handler or furnace may be installed in the attic space, in the garage area, or in an alcove or closet in the interior of the structure. A packaged unit located outside the structure can be installed on the roof, on the ground, or on a stand raised above ground level. Special insulation and waterproofing must be applied to all ductwork that is exposed to outdoor weather conditions.

The air handler should be located where the shortest duct runs possible are attained. The shorter the duct runs are, the lower the resistance to air flow and the lower the heat gains and heat losses will be. One disadvantage to locating the air handler in the attic space is serviceability. Provisions for service access must be provided. Most local codes require a floored walkway from the attic entry to the unit. A floored area must extend at least 3 ft on all sides of the unit to provide a platform for service work. Another consideration to take into account when the furnace or air handler is

installed in an attic is the requirement for an auxiliary drain pan, along with a condensate line and/or emergency float switch to shut down the system in case of a condensate overflow. Locating the return air filter grilles in the conditioned space is recommended with attic installations. This allows the homeowner to change the filters without having to enter the attic.

The duct system types that lend themselves to attic installations include the extended plenum, the reducing trunk, and the radial arrangements. A wide variety of duct materials can be used with attic installations. However, great care must be taken when installing a flexible duct system. Improper installation that allows sagging, sharp bends, kinks, and crimping of flexible duct will increase the friction loss of the system and increase the total amount of static pressure that the indoor blower must overcome. This can result in service problems and possible equipment failure. It is always necessary to follow the recommendations of the manufacturer when installing a system utilizing flexible duct products.

### **Basement installations**

Basement installations also lend themselves to all of the duct system types. A basement system must be insulated and must have a vapor barrier installed to prevent condensation on the exterior of the ductwork if the basement is to be unconditioned. If the basement is to be conditioned, then the ductwork is considered to be in a conditioned space and insulation may not be required. However, it is recommended that a duct liner be installed for sound attenuation. All joints and side seams must be sealed to prevent duct leakage. Again, be aware that some local codes do not permit the use of duct tape as a sealant. In these cases, waterproof mastic must be used. The air handler or furnace may be installed in the basement, or outside the structure if a packaged unit is to be installed. Any ductwork exposed to outdoor weather conditions must be specially treated with insulation and waterproofing.

As in an attic installation, the air handler should be located where the shortest duct runs possible are attained. One advantage to locating the air handler in the basement is serviceability. Return air filters may be located at the unit in a basement installation, or filter grilles in the conditioned space may be used.



The duct system types best-suited to basement installations are the extended plenum and the reducing trunk arrangements. Due to headroom and appearance considerations, the radial duct system does not always lend itself to basement installations, although it can be used in some cases.

All types of duct materials can be used with basement installations. However, flexible duct materials are discouraged, largely because of the appearance and the problem of providing proper support. Sagging ductwork will increase the friction loss of the system and increase the total amount of static pressure that the indoor blower must overcome, resulting in service problems and even equipment failure.

### **Between floors of multistory structures**

Between-floor installations usually are installed in fir-down areas, with branch ducts running between the combination ceiling/floor joists. These systems generally are constructed of lined sheet metal. Sometimes duct board is used for sound and noise control. Between-floor ductwork normally does not require insulation, since it is located within the conditioned space. Ductwork that passes through an unconditioned space must be insulated and must have a vapor barrier installed to prevent condensation from accumulating on the exterior of the ductwork. All joints and side seams must be sealed to prevent duct leakage. If local codes do not permit the use of duct tape as a sealant, waterproof mastic must be used. The air handler or furnace may be installed in a garage, in an interior alcove or closet as permitted by local codes, or, if a packaged unit is to be installed, outside the structure. Any ductwork located outside the structure must be specially treated with insulation and waterproofing if exposed to outdoor weather conditions.

The air handler should be located where the shortest duct runs possible are attained. One of the major advantages of a between-floor installation is that the heat gains and losses often associated with ductwork are negated because the ductwork is in the conditioned space. With this type of installation, return air filters may be located at the unit, or filter grilles in the conditioned space may be used.

The reducing trunk and the extended plenum configurations are the most common types of duct systems

installed between the floors of the multistory structures. Many types of duct materials can be used with between-floor installations. However, flexible duct materials generally are discouraged because they are not as durable as metal ductwork. Once the duct system is installed, it is a major project to make repairs if needed.

### **Crawl space installations**

Crawl space installations are adaptable to all of the duct system types. A crawl space system must be insulated and must have a vapor barrier installed to prevent condensation on the exterior of the ductwork. All joints and side seams must be sealed to prevent duct leakage. If local codes do not permit the use of duct tape as a sealant, waterproof mastic must be used. The air handler or furnace may be installed in the crawl space, in the garage area, in the interior of the structure as permitted by local codes, or, if a packaged unit is to be installed, outside the structure.

The air handler should be located where the shortest duct runs possible are attained. The main disadvantage to locating the air handler or furnace in the crawl space is serviceability. Provisions for service access must be made. With crawl space installations, return air filter grilles in the conditioned space should be used.

The duct system types that lend themselves to crawl space installations include the extended plenum, the reducing trunk, the radial, and the perimeter loop arrangements. Although many types of duct materials can be used in crawl space installations, flexible duct materials are discouraged due to the problem of providing proper support for the ductwork.

### **Conditioned space installations**

Some basement installations, installations between floors, and fir-down duct systems can be considered "conditioned space" installations. Each of these types of systems has its own considerations, previously discussed. Generally speaking, duct systems that are installed within a conditioned space do not require thermal insulation to prevent heat loss and heat gain. It is desirable, however, to use duct materials such as duct liners or duct board systems constructed properly for sound attenuation. In warm, moist climates,



duct systems installed in conditioned spaces may need to be insulated to prevent condensation from forming on the exterior surfaces of the ductwork and causing mold, mildew, and structural damage. The most common types of duct systems applied to conditioned space installations are the extended plenum and the reducing trunk arrangements. Both the extended plenum and the reducing trunk systems frequently are installed in fir-down areas above hallways, cabinets, and closets. They typically are associated with the high inside wall type of supply outlets.

### **Embedded in concrete slab**

Different types of construction present different problems for system designers and installers. In climates where the average winter temperature is below 35°F, slab on grade construction is used. The floor distribution duct system must be embedded in the slab, which can create several challenges for the designer/installer. Most codes require that the duct system in such cases be installed above the final lot grade. If metal duct material is to be used, it must be treated to prevent rust and corrosion and completely encased in a minimum of 2 in. of concrete grout. Failure to treat the metal duct properly can lead to the failure of the duct system due to rust and corrosion. In areas where the ground water table is high or proper drainage is not ensured, the collapse of the duct system can occur in as little as five years.

When this happens, the system usually must be abandoned and the supply duct system must be installed in some other location (e.g., in the ceiling). It also means filling the outlet boots with concrete and most likely replacing the flooring materials in the structure. Needless to say, this is a very expensive and time-consuming undertaking—one that is not possible in some multistory structures without major remodeling work. Sometimes the floor must be removed completely so that repairs can be made. The duct system must be graded back toward the supply air plenum for drainage and removal of any ground water that may enter the duct system. The best way to avoid such problems is to make sure that the design and installation are right the first time.

PVC duct materials offer a large advantage over metal in this type of system installation. PVC duct systems do not need to be encased in concrete grout

or treated for corrosion, but they still must be graded back toward the plenum for ground water removal and installed above the final lot grade. A wide selection of fittings, boots, and plenums constructed from PVC materials is available today. When PVC duct materials are used, all joints are glued, thus creating a water-resistant duct system. (Some codes do not allow for the use of screws in the assembly of PVC duct systems.)

Another factor that is sometimes a detractor to the embedded slab system is the code requirement stipulating that the duct system must be installed above the final grade. The builder may be required to increase the foundation stem wall height from the normal 16 in. to 20 to 24 in. to accommodate the duct system installation. In some areas, builders may resist this additional expense in the cost of the structure.

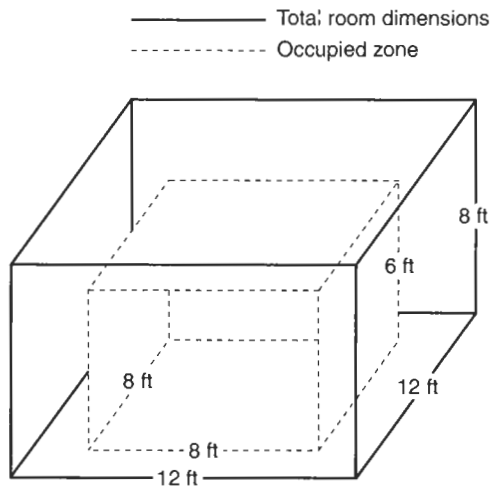
The boot boxes and terminal devices used with an embedded concrete slab system should be located under or near doors and windows. They must discharge into the unoccupied space of the room to prevent the primary airstream from coming in contact with the room's occupants. The number of outlets for each room depends on the room's usage, its physical layout, cfm requirements, and the heating and cooling loads as determined by a room-by-room load calculation.

When a floor distribution system is used, it is always a good idea to be mindful of furniture placement in the room. The main goal of good system design is to have the outlets discharging into the unoccupied zone of the room. The "occupied zone" of a room is generally defined as the volume of space that exists between the floor and 6 ft above the floor in the vertical direction, and is 2 ft or more from the walls in the horizontal direction (see Figure 9). Outlets should not be placed where room furnishings will cover them. This may require having multiple outlets in some rooms to ensure that the distribution air being delivered matches the load.

### **SUPPLY AIR OUTLET LOCATIONS**

One of the most critical tasks in the design of an air distribution system is the selection of the proper type and proper placement of the supply outlets. The designer must select locations that will deliver the





**Figure 9. “Occupied zone” of a room**

conditioned air into the space to be conditioned in such a way that the high heat gain/heat loss load areas (doors and windows) are covered by the primary airstream. In addition, the secondary air (room air) must mix with the primary airstream to ensure even temperatures throughout the room. The design should accomplish these objectives while keeping the primary airstream from entering the occupied zone within the room.

By delivering the primary air into the unoccupied zone of the room and mixing it with the secondary air, the designer ensures that the primary airstream does not come in direct contact with the room occupants. If the primary airstream is allowed to come in contact with the room occupants, the result will be complaints of drafts and the overall comfort of the occupants will suffer. In most cases (depending on the location of the duct system and the location of the outlet), this problem is next to impossible to solve without the investment of major time and expense. The best time to *prevent* this potential problem is when the system is being designed and installed.

There are several specifications listed in the engineering tables for outlet devices that are very important to the designer. They include:

- *face velocity*—the velocity of the air leaving the outlet, measured in ft/min

- *cfm*—the volume of air that the outlet device delivers as a result of the face velocity (“cfm” stands for cubic feet per minute)
- *noise criteria (NC)*—a measure of the air noise associated with the outlet device
- *pressure loss*—the amount of pressure loss associated with the outlet device, measured in in. w.g.)
- *spread*—the width of the primary air envelope measured at the point of terminal velocity
- *terminal velocity*—the velocity of an airstream at the end of its throw, measured in ft/min
- *throw*—the distance from the face of the outlet that the air travels before reaching terminal velocity
- *AK factor (effective area)*—the calculated area of the outlet device based on the average measured velocity between the fins
- *drop*—the vertical distance between the base of the outlet and the bottom of the airstream at the end of the horizontal throw.

In addition, you should be familiar with the following terms:

- *diffuser*—an outlet that discharges supply air in a spreading pattern
- *grille*—a louvered covering for an opening through which air passes
- *register*—a grille equipped with a damper or a control valve that directs air in a nonspreading jet.

### Floor locations

Grilles and registers installed in the floor should be located in the unoccupied zone of the room. They should be positioned to cover high load areas, such as door and window locations. As mentioned previously, consideration also must be given to the placement of furniture within the room. The selection of the



proper grille or diffuser (outlet device) is one of the designer's more critical tasks. The outlet device must be selected to deliver the required air volume (cfm) at the correct velocity (ft/min) to condition the space.

### **Ceiling location (center of room)**

There are basically two different types of ceiling outlet locations. The first is in the center of the room, with the directional pattern of the device being essentially circular. This type of installation may work well for cooling-only applications—however, it is one of the poorest selections for heating systems. In the heating season, higher velocities of the conditioned air must be attained in order to force the heated air down into the conditioned space. Higher noise levels will accompany the higher discharge velocities required from the outlet. If the winter design temperature is below 35°F, this type of delivery outlet device is not recommended for systems that will be used in the heating season.

### **Ceiling location (modified)**

The second type of ceiling outlet is one that is moved away from the center of the room and out toward the exterior wall. The discharge is directed toward the high load areas of the room (doors and windows). The location of the outlet must be determined by studying the manufacturer's engineering data supplied for the selected outlet device.

The outlet device should be selected to deliver the required amount of air (cfm) at the proper velocity (ft/min), with an acceptable throw to match the room heat loss/heat gain. It is recommended that the primary air envelope (air moving faster than 35 ft/min for heating and faster than 50 ft/min for cooling) from the outlet not be allowed to come in contact with the room occupants.

For example, let's assume that the room cfm requirement is 200 cfm. Due to the physical characteristics of the room, it is determined that the best solution is to install two outlets to cover the high load areas (there is a large amount of glass in the room). The designer selects two outlet devices, each of which will deliver 100 cfm at a face velocity that meets the noise criteria (for residential structures, normally NC35 or below). Depending on the outlet device selected, a

face velocity of 500 to 750 ft/min generally is acceptable for residential structures. The outlet devices selected will deliver 100 cfm at 600 ft/min, with a noise level of NC30. The throw at these conditions is shown in engineering data to be 6.5 ft at a terminal velocity of 35 ft/min for heating and 8.5 ft at 50 ft/min for cooling. The terminal velocity listed for heating is the most critical. Most people are more sensitive to drafts during the heating season, and more tolerant of air movement during the cooling season.

To locate the position of the outlet so that the primary airstream does not come in contact with the room occupants, the designer's first task is to make sure that the primary airstream is directed toward the unoccupied zone of the room. Chairs and other room furnishings sometimes can be placed in the unoccupied zone. The primary air envelope, therefore, should not move down the wall past the 4 to 5-ft level. For example, assume that the ceiling height is 8 ft. The terminal velocity for the selected outlet device is 6.5 ft for heating. If you start at the 5-ft level on the exterior wall and measure up the wall and across the ceiling 6.5 ft, the location of the outlet will be 3.5 ft from the wall to the center of the outlet. The primary air envelope (air moving faster than 35 ft/min) will terminate at the 5-ft level on the exterior wall.

A ceiling supply system designed and installed in this manner can be used successfully in areas where the winter design temperatures are below 35°F. This outlet design approach can be utilized with all of the duct system types used in ceiling distribution systems.

### **High inside wall locations**

A high inside wall outlet system delivers air into the conditioned space from the interior walls. The selection of the outlet device, which is very similar to the procedure described above for modified ceiling locations, is critical to a successful system. This type of delivery normally is associated with fir-down duct systems.

Again, the designer must select the outlet device that will deliver the required volume of air (cfm) at the proper velocity (ft/min) to condition the space. The velocity becomes even more critical with this type of delivery system, because the airstream must be directed across the ceiling all the way to the exterior



wall and part way down the wall to provide coverage of the high load areas in the room. If the room is 20 ft wide, the outlet device must be selected with a throw of more than 20 ft in order to guarantee that the primary airstream will remain in the unoccupied portion of the room. If the selected device does not have sufficient throw, the primary airstream will drop into the occupied zone of the room and comfort conditions will suffer. The throw and drop characteristics are very important to the successful application of this type of supply outlet.

Unless a high-quality outlet device is used, noise problems with this type of delivery system can be very common. The outlet device selected should have adjustable deflection vanes and should be equipped with a damper for volume control and balancing (a register). The noise criteria specifications for the register should be in the range of NC30 to 35.

### RETURN AIR DUCT SYSTEMS

The return air duct system is just as important as the supply system, and too often it is largely ignored. In many cases, the return system consists of one or two improperly sized openings connected back to the air handler through improperly sized return ducts or through wall, floor, and ceiling framing cavities. Although panned framing members can be used for return systems, they generally should be avoided. These types of installations are next to impossible to seal. Air leaking into the system can cause additional sensible and latent loads on the HVAC system and lead to comfort complaints from the occupants of the structure.

#### Duct leakage

If duct leakage occurs in the attic space during the cooling season, warm, moist air can be pulled into the return, resulting in an increase in both the latent load and the sensible load on the HVAC system. This infiltration into the return system will be aggravated if the return system is undersized. For example, consider a 3-ton system that requires 450 cfm per ton for cooling (1,350 cfm). Assume that the return is improperly sized and can handle only 1,000 cfm. Due to the undersizing of the return and the available static pressure of the blower, the blower will try to pull air from the attic space if leaks are present in the duct

system. If the leaks are large enough in the return system, the 350-cfm shortfall will be drawn from the high-temperature air in the attic. In some areas, attic temperatures can reach 140 to 150°F db (dry bulb) even if the attic is vented properly. Under these conditions, the mixed air temperature entering the evaporator coil will be 91.9 to 96.9°F db, instead of the normal 75 to 80°F db. For most systems, the  $\Delta T$  across the evaporator is 18 to 20°F db, which means that in this case the air leaving the evaporator will be 73.9 to 76.9°F db instead of the normal 55 to 60°F db. If the relative humidity of the air in the attic is high, it also will increase the latent load on the evaporator and degrade the system's capacity to maintain the desired comfort conditions in the structure.

As a general rule, when framing members are used as part of the return air duct system, the following approximate cfm values are recommended:

2 × 4s on 16-in. centers =	150 cfm
2 × 4s on 24-in. centers =	200 cfm
2 × 6s on 16-in. centers =	210 cfm
2 × 6s on 24-in. centers =	340 cfm
2 × 8s on 16-in. centers =	340 cfm
2 × 8s on 24-in. centers =	560 cfm
2 × 10s on 16-in. centers =	500 cfm
2 × 10s on 24-in. centers =	800 cfm
2 × 12s on 16-in. centers =	700 cfm
2 × 12s on 24-in. centers =	1,020 cfm

The approximate cfm values listed here are based on the true net free areas. They do not take into account the complications encountered with sealing cavities against air infiltration and other problems discussed above.

If the return air duct system is located in the crawl space of the structure and panned joists are used for the return system, duct leakage can add a large latent load on the HVAC system, resulting in reduced sensible heat removal capacity and increased operating costs for the homeowner. Complaints about the comfort conditions within the structure are also likely.

As you can see, a properly sized, sealed return duct system is just as important as a properly sized, sealed supply duct system in ensuring that the comfort conditions within the structure are maintained in an economical manner.

## CENTRAL RETURN SYSTEMS

Central return systems can be applied in smaller structures with success. These systems consist of one or more return inlets, strategically located within the structure and sized to return the total amount of the supplied air volume to the indoor blower. Both the inlet box and the return connecting ductwork should be sized where the room air will flow back to the blower at a relatively low velocity. As emphasized above, the return duct system must be free of leaks. It is sometimes desirable to have some turns or other fittings in the duct run in order to prevent blower noise from being transmitted down the duct and exiting the return air grille. The return air box should be lined with sound attenuation insulation and insulated on the outside to prevent or retard heat gain and heat loss.

Air delivered to all rooms of the structure should have an unrestricted path back to the return grille. This means that closed doors must not isolate a room. The most common method seen in construction today is to undercut the doors, thus allowing air to pass under a door if it is closed. The amount of the undercut is determined by using the same methods as those used to size the return grille or the connecting return duct—that is, when the door is closed, there must be adequate free area to ensure that the room does not become pressurized. If a room is allowed to become pressurized, the delivery of the supply air will be impeded, comfort conditions in the room will suffer, and the exfiltration of room air will occur. Assume, for example, that the room in question has a cfm requirement of 200 cfm and a 32-in. entry door. Based on a design friction loss factor for the return system of 0.05 in. w.g., the opening at the bottom of the door would need to be approximately 3 in. of “free” space (excluding any floor coverings) in

order to ensure a proper return air flow from the room. A better solution would be to install a boot sleeve above the door and nonvision (non-see-through) transfer grilles on either side, or install non-vision transfer grilles in the door itself (a 12-in. × 8-in. transfer grille would be required in this case).

Larger structures require multiple returns in order to achieve satisfactory results. Each of the returns must be sized to return the amount of air delivered to the rooms or zones where the return grille is located. It is worth repeating that the return system must be capable of handling the same amount of air as that delivered by the supply side of the system.

## INDIVIDUAL ROOM RETURN SYSTEMS

In some structures it may be desirable to install individual room returns. Of course, this means that the return system is just as elaborate as the supply system. Each individual room return is sized to return the same amount of air that is delivered to the room by the supply system. The results are excellent if the layout and sizing are done properly—in fact, there is no other return system that performs as well as the individual room return system. The major drawback to this approach is the initial cost.

## SUMMARY

It is the goal of this document to offer an overview of the general principles of duct system design and to call attention to some of the special considerations that need to be given to the process to ensure a satisfactory result. The ultimate objective is to provide a dependable system that not only serves the needs of the consumer, but also increases profits for the installing contractor by reducing callbacks.

