Chapter 7

HVAC Contractor

Super Good Cents specifications that affect the HVAC contractor focus on heating system controls, forced air system installation, and ventilation systems. In some cases, the HVAC contractor is responsible for integrating the ventilation system with central forced air heating.

The HVAC contractor also may be responsible for installing ducted heat recovery ventilation systems. Super Good Cents design standards for ventilation systems specify controls, minimum airflows, and minimum equipment performance standards.

HEATING SYSTEMS

Heating System Control Requirements

1994 LTSGC 3.2

General Requirements

Super Good Cents specifications call for at least one numerically marked thermostat mounted on an interior wall for each separate heating system.

Zonal System Thermostats

Super Good Cents specifications require one heat anticipating or electronically controlled thermostat per zone.

Forced Air Furnace Thermostats

Thermostats for forced air systems must be low voltage, heat anticipating or electronically controlled. Install thermostats according to the manufacturer's instructions.

Heat Pump Thermostats

Thermostats for heat pumps must meet the following requirements:

1. Heat pump thermostats must have a manual changeover feature or a heating/cooling lockout to prevent cross-cycling between heating and cooling modes.
2. If a setback thermostat is selected, it must feature ramped/intelligent recovery to limit use of supplemental heat during recovery periods. The thermostat must have a minimum of two setback periods per day.

3. Heat pump thermostats must have a manual switch capable of energizing emergency heat when the refrigeration cycle is inoperative. The thermostat must feature an indicator light that signals when emergency heat is being used.

Duct System Installation Requirements

A recent study of forced air heating system efficiency indicates an average efficiency loss of 29 percent due to duct system heat loss. Heat produced by the furnace is lost before it arrives in living areas. To reduce duct losses, Super Good Cents program specifications for forced air systems require extensive duct sealing and high levels of duct insulation.

Duct Air Sealing and Attachment

Air sealing forced air systems in Super Good Cents homes goes well beyond standard practice. All supply and return ducts, the air handler, and plenum connections at the air handler must be sealed. Sealants must be applied at all prefabricated joints, at field joints, at corners, and at longitudinal seams. See Figures 7A, 7B, 7C, and 7D.

Recommended sealants include non-toxic mastics, foil tape with 15-mil butyl sealant, or tape meeting the test standards of UL-181. Sealants must be installed according to the manufacturer’s instructions.

Check material safety and data sheets to avoid hazardous materials. Ventilation may be poor during sealant application. Before using special tape, read manufacturer’s application instructions to see if you will be able to follow them under site conditions. If site conditions are not optimal, the tape may not form a durable seal.

Research indicates that building cavities used as ducts are very leaky. Examples are panned joist cavities and unducted plenums between crawl spaces and attics in two story construction. It is easier to seal a duct and run it through the cavity than it is to make the cavity tight. See Figure 7E.

Mechanical Fasteners

All joints in the air handler and ducts must be mechanically fastened. Flexible ducts may be mechanically fastened with nylon or plastic straps. They must be tightened with the appropriate strap tightening tool (hand tightened straps do not work) or with stainless steel worm drive clamps. Mastic and tape are not mechanical fasteners.

For assembling flex systems, it is recommended that you seal and mechanically fasten the inner liner to the adjacent metal component, pull the outer liner over everything so that no bare metal is exposed, and mechanically secure the outer liner with strapping. See Figure 7F.

Figure 7A
SEALING AT AIR HANDLING

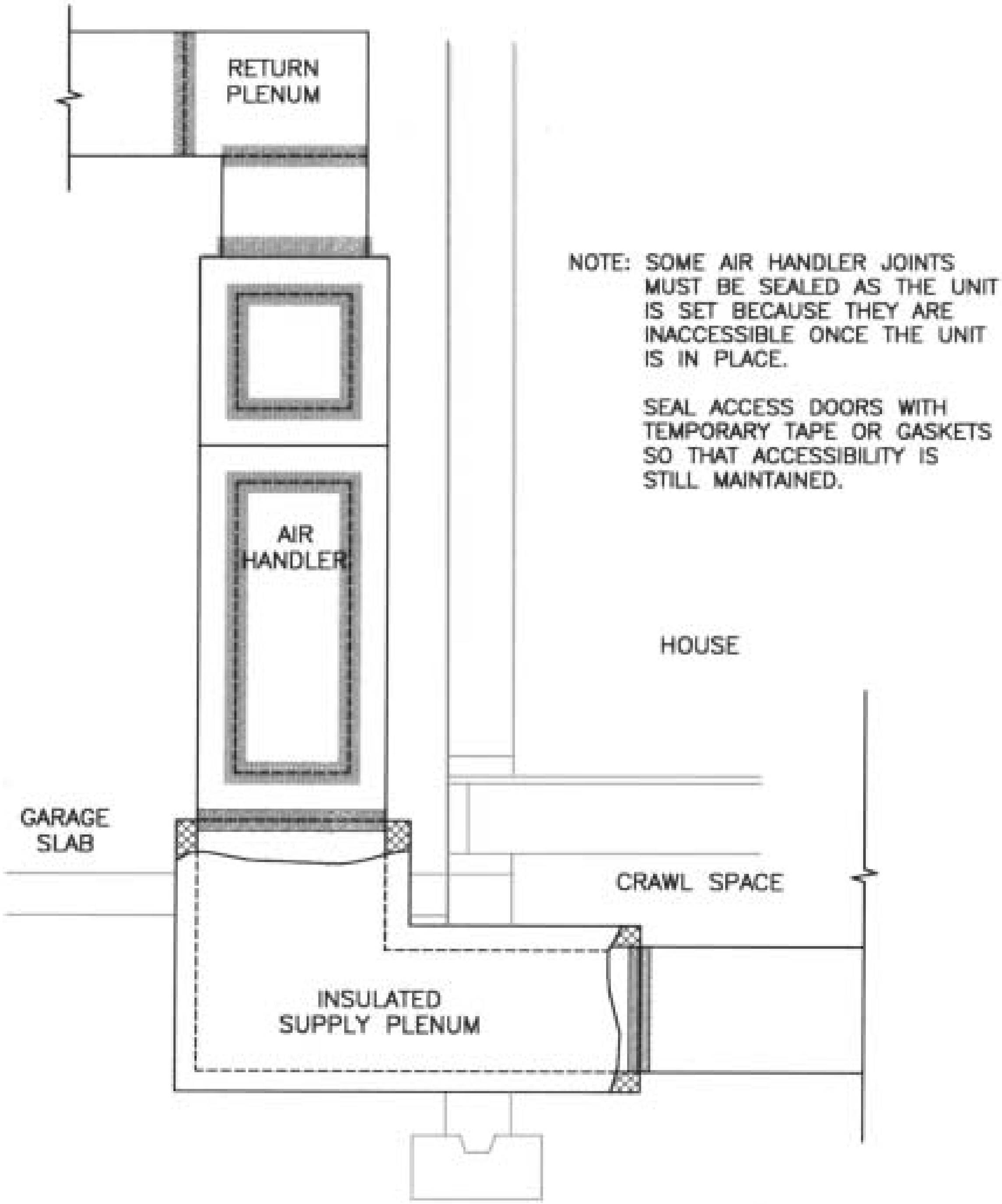


Figure 7B
SEALING AT PELNUM CONNECTIONS

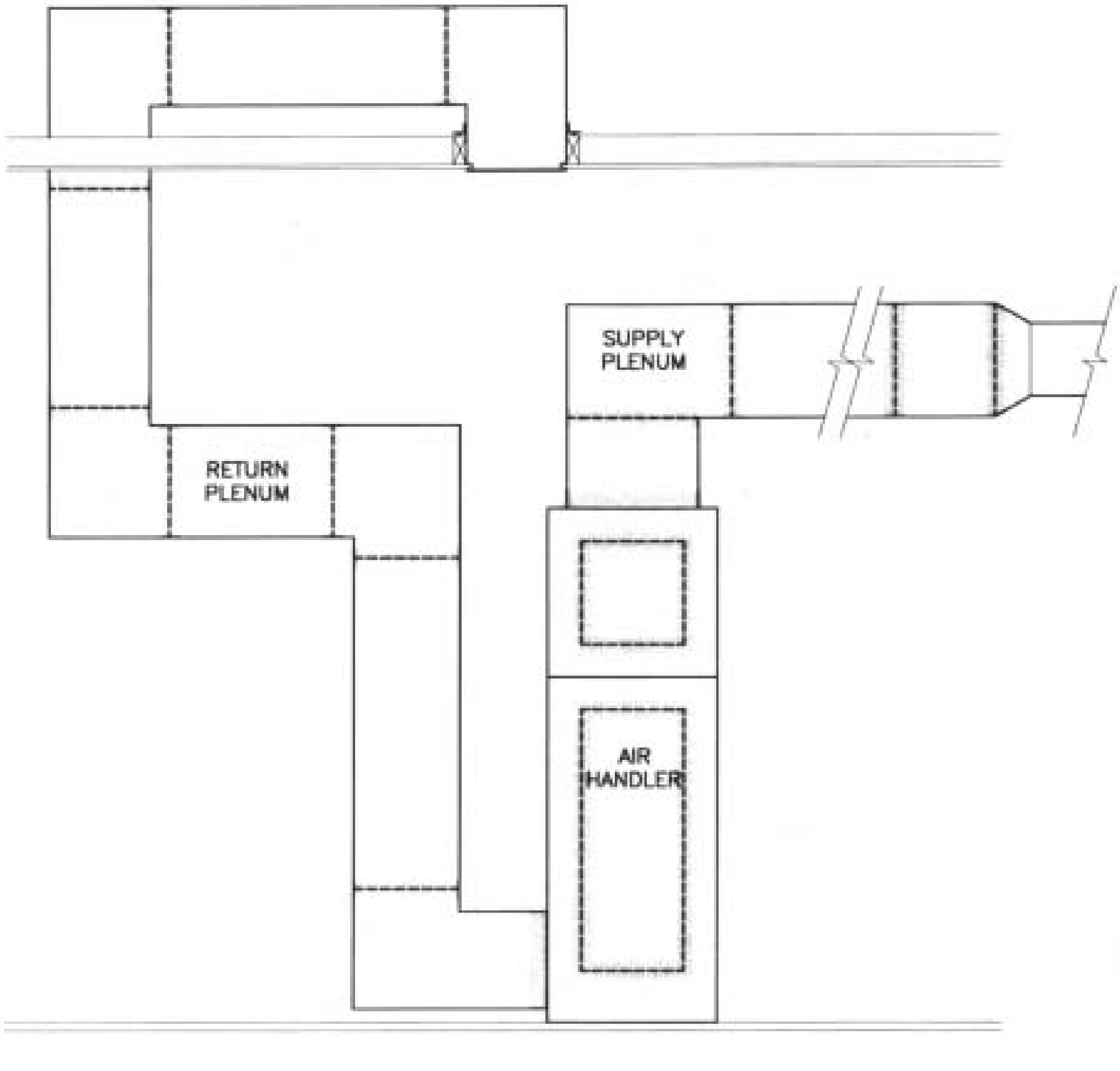


Figure 7C
SEALING AT PLENUM TAKEOFFS

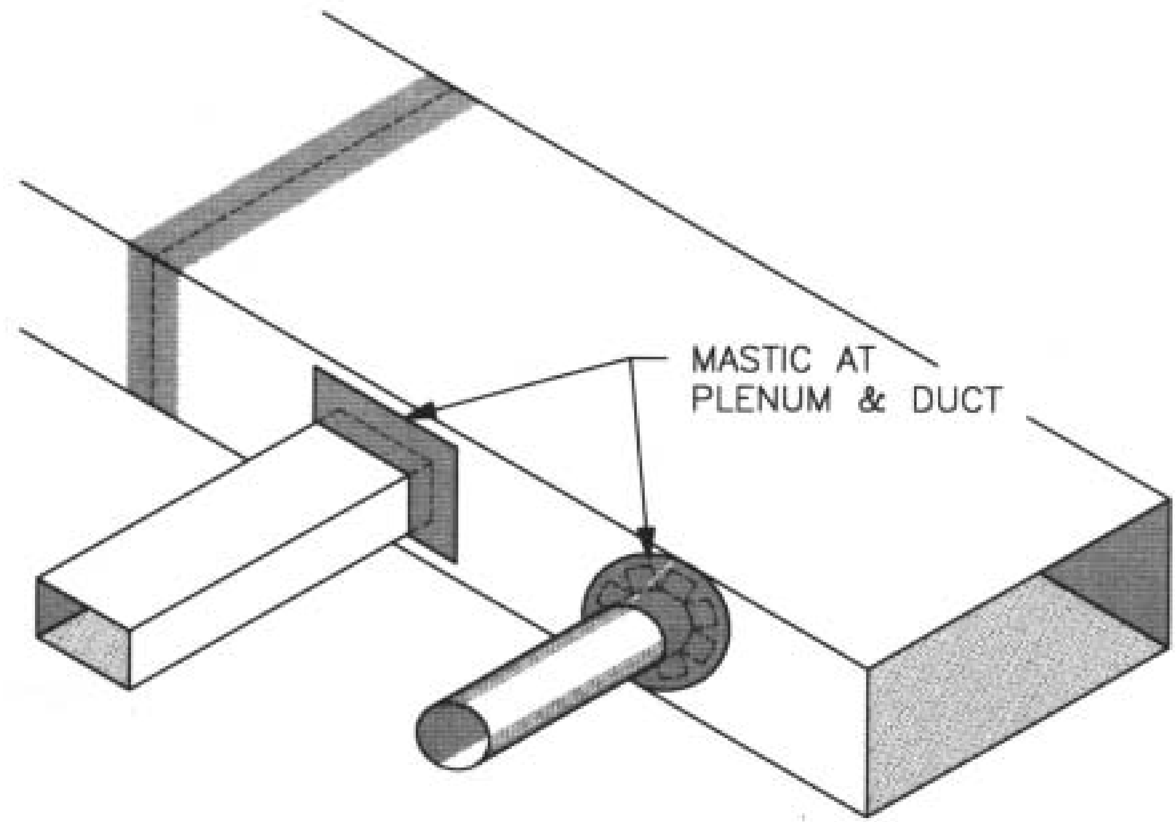


Figure 7D
SEALING AT PREFABRICATED JOINTS AND FIELD JOINTS

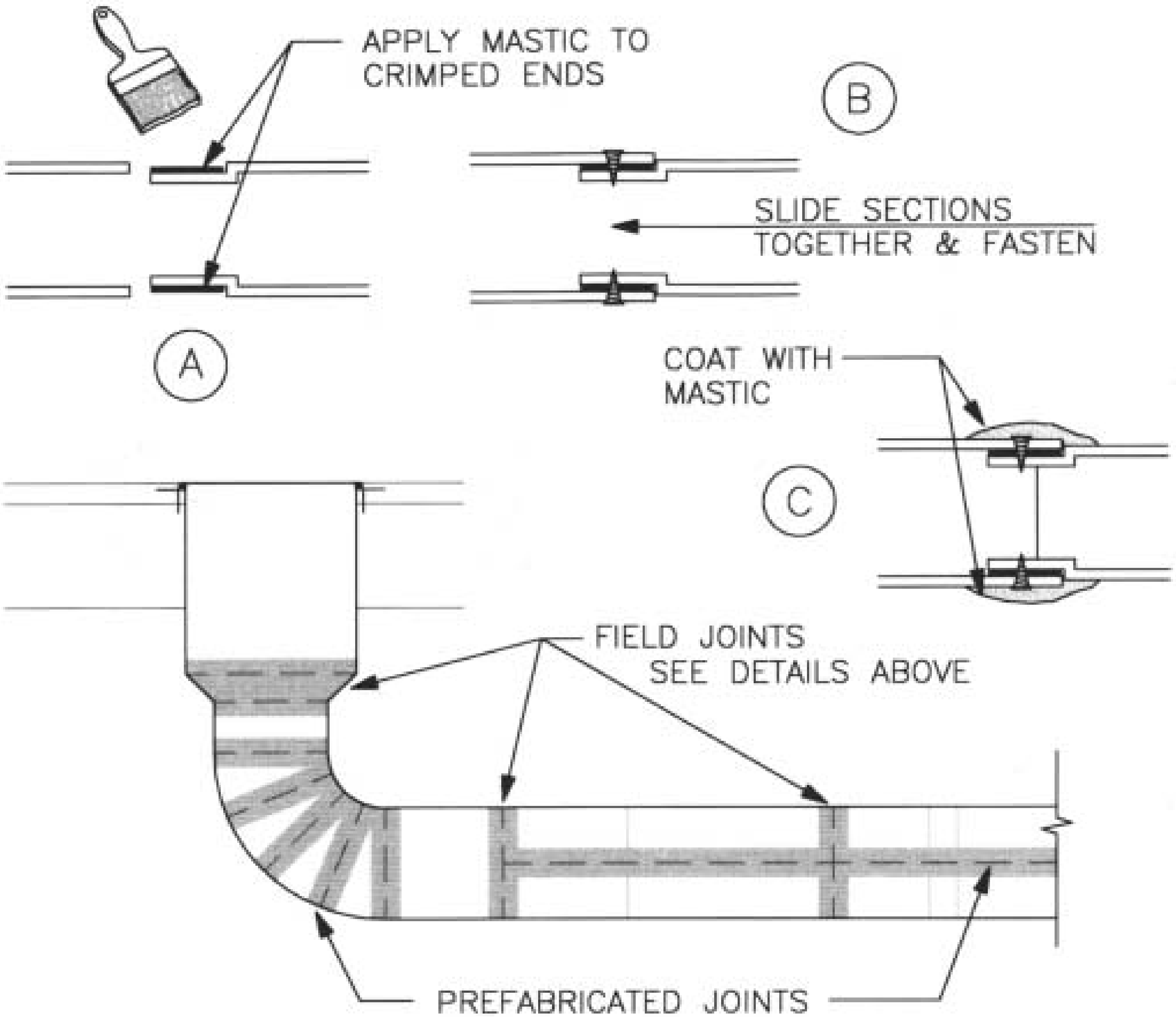
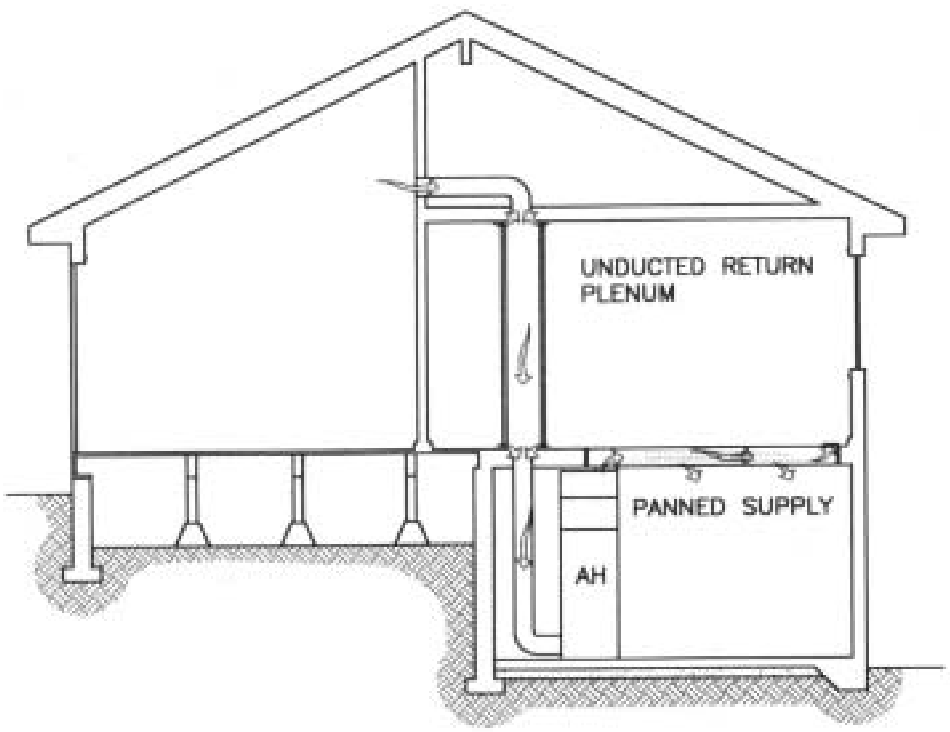


Figure 7F
DUCTED VS. UNDUCTED PLENUMS



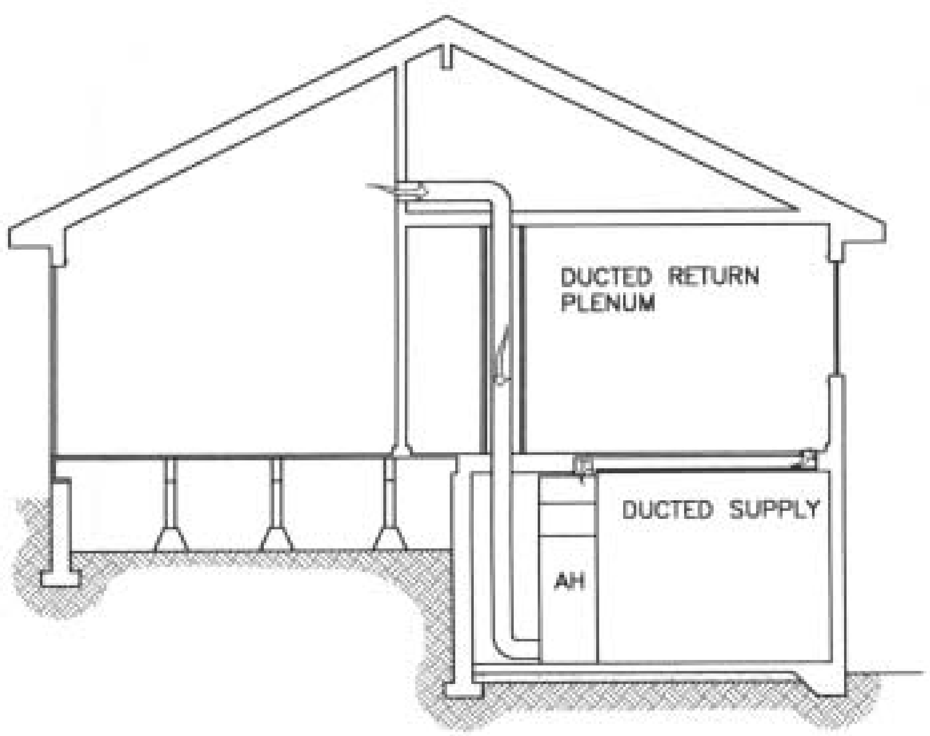
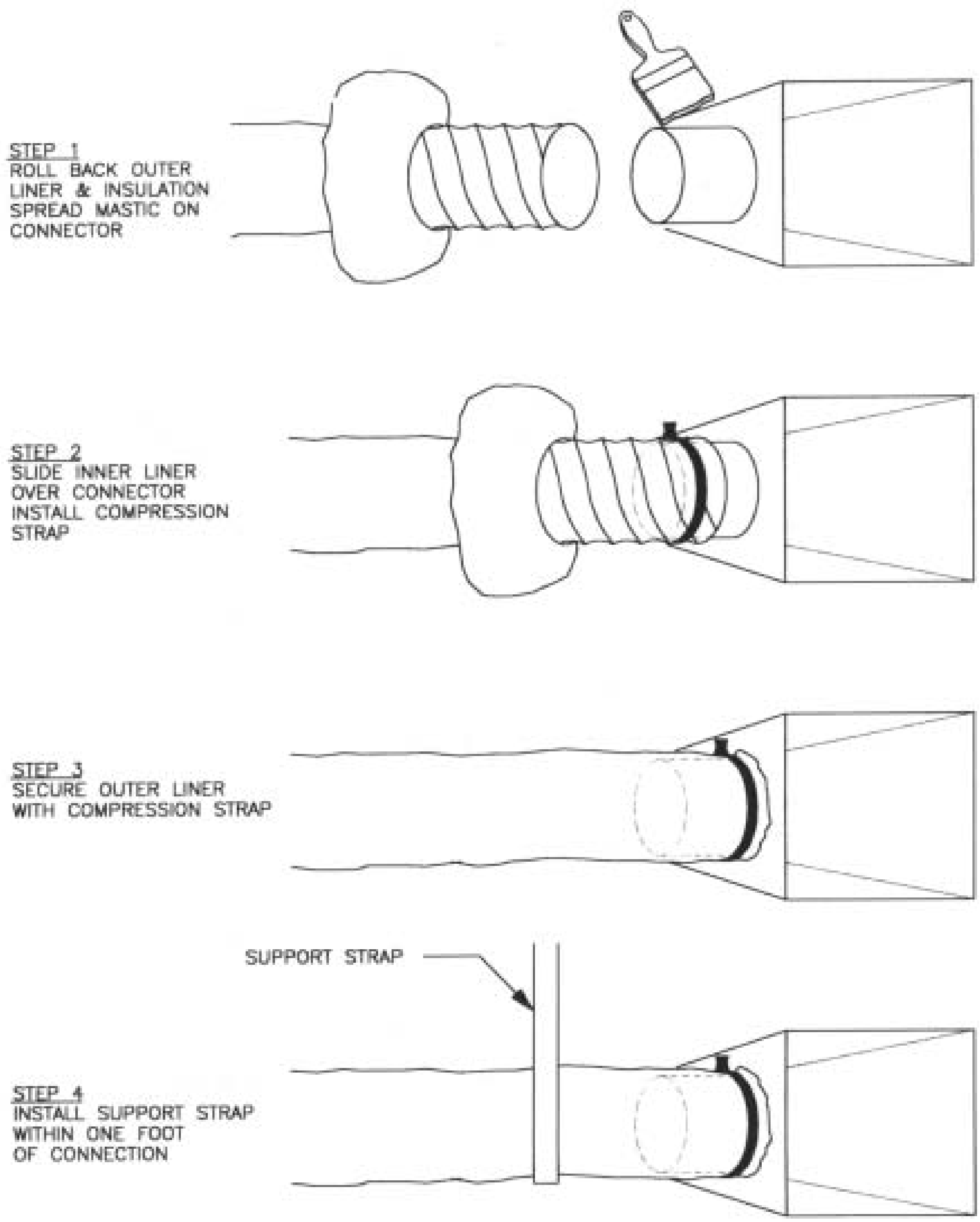


Figure 7F
SEALING AND FASTENING FLEX DUCT



Duct Insulation

Duct insulation is a Super Good Cents qualification measure, just like high efficiency windows and insulation in floors, walls, and ceilings. All components of the duct system should be insulated. See Figure 7G.

Duct insulation must meet the following minimum standards:

Flexible ducts	R-8
Metal ducts	R-11

Duct insulation levels for Super Good Cents homes vary. Higher levels of duct insulation (such as R-19) are sometimes traded for lower levels of insulation in another building component.

The HVAC contractor must install duct insulation levels specified in the Super Good Cents agreement between the builder and utility. Hopefully the builder will inform the HVAC contractor about any special agreements about duct insulation levels.

Qualification problems frequently occur in duct systems that are part metal and part flex. For example, the utility and general contractor may have agreed that the whole system will be insulated to R-11. Not knowing that, the HVAC contractor may install R-8 insulation for flex duct and R-11 insulation for metal duct. Even though these levels meet minimum program standards, the installation does not match the duct insulation level used to qualify the house.

Be sure your bid reflects the cost of the approved duct insulation level. Check with the general contractor or the Super Good Cents utility representative.

One part of the duct system that is frequently overlooked is the section of the supply plenum that runs from the furnace to the crawl space through a hole in the garage slab. See Figure 7H. Super Good Cents utilities are looking for a minimum of R-8 rigid insulation on ducts that are to be enclosed in concrete, but the general contractor may have agreed with the utility to install a higher insulation level. If the plenum is placed before the slab is poured, do not forget the insulation! Or talk to the concrete contractor and specify that the hole in the slab be large enough for the duct plus R-11 insulation. Two-inch foam board is recommended.

R-8 duct board products are acceptable, but are traded with R-11 rigid ducts in the house qualification process. If R-8 duct board is installed, some other component in the house is beefed up to maintain the overall energy performance of the building.

Figure 7G
INSULATED DUCT SYSTEM

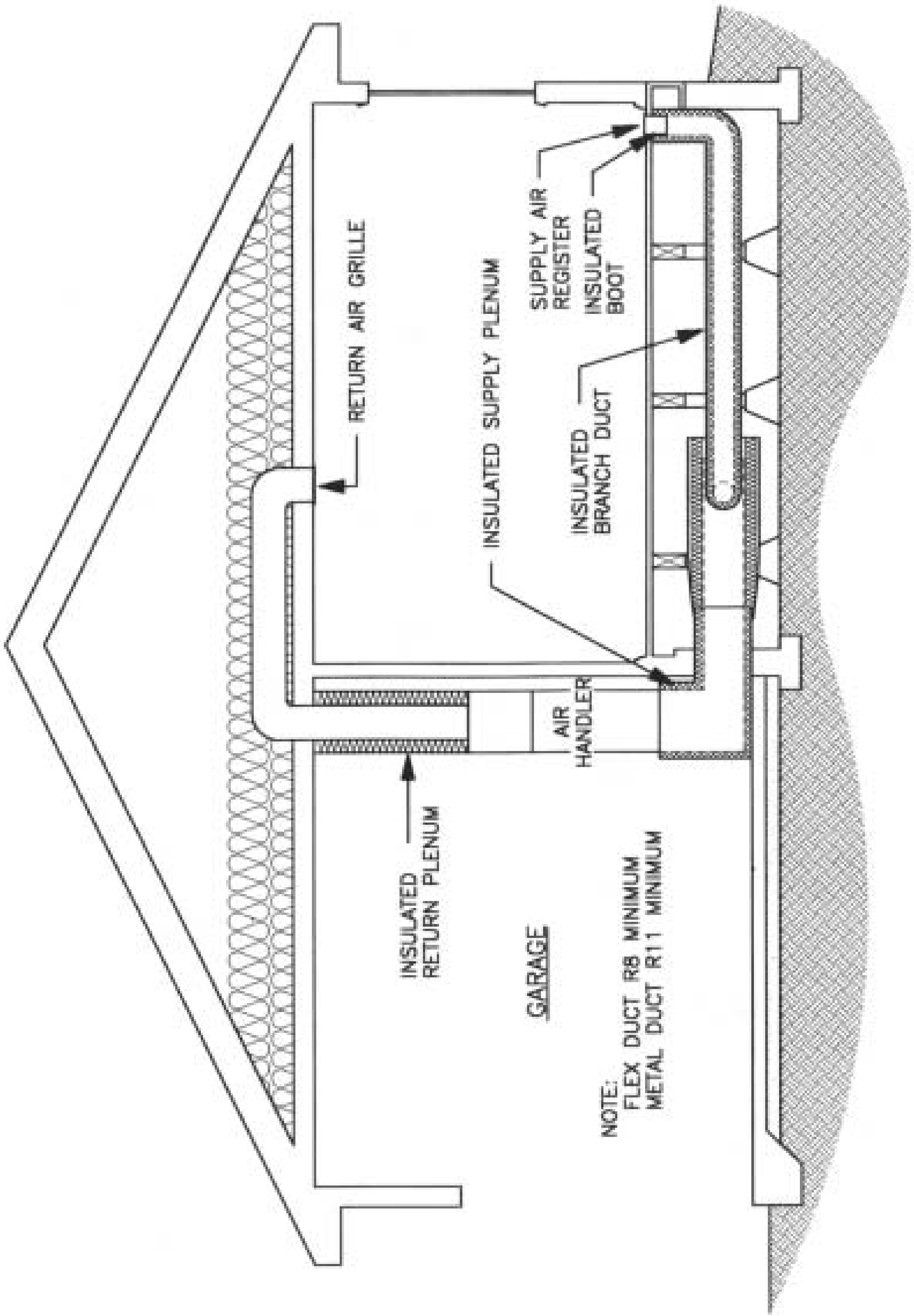
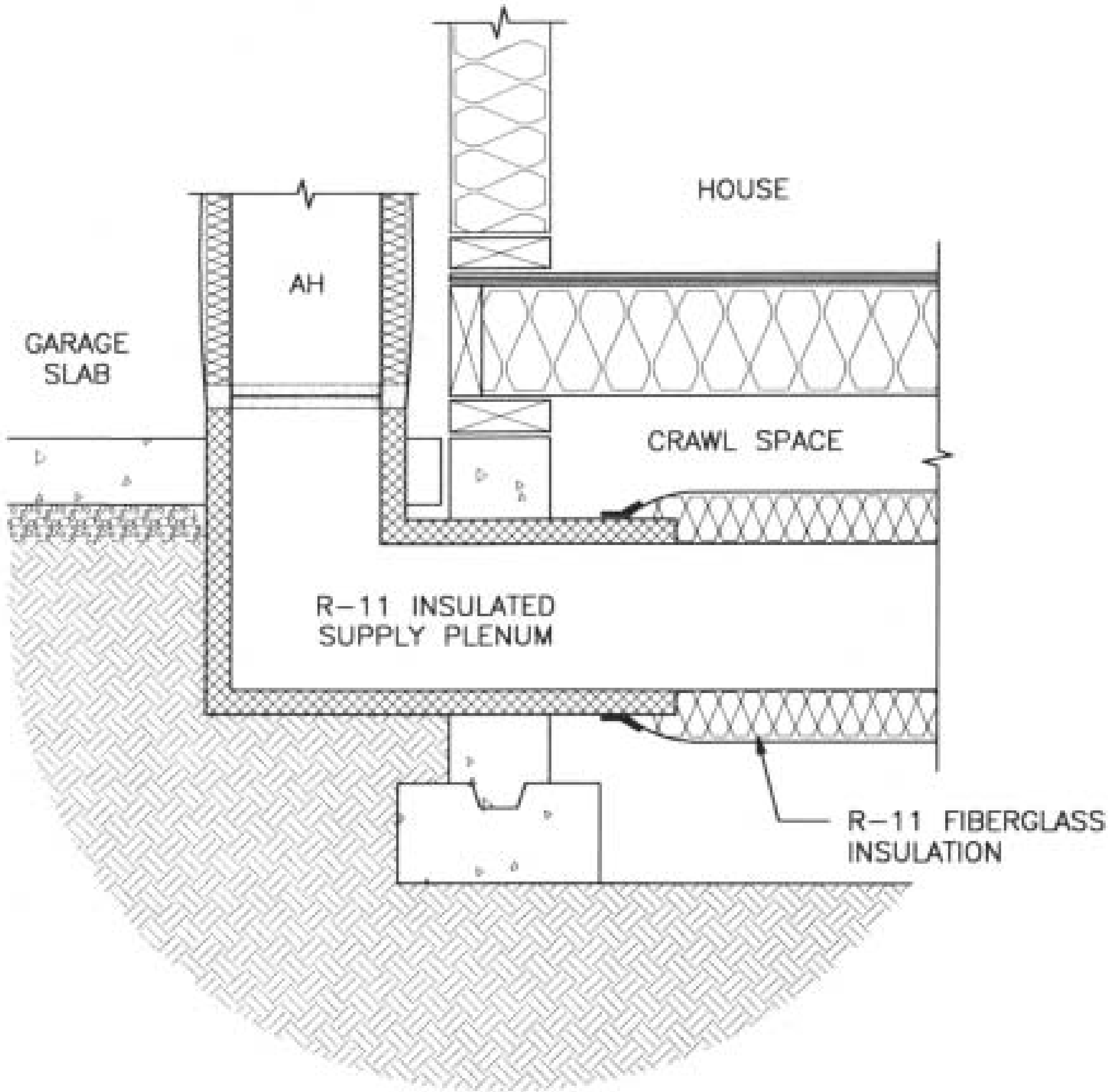


Figure 7H
INSULATED SUPPLY PLENUM IN GARAGE SLAB



Duct Leakage, Duct Design, and Heating System Safety Issues

Recent research demonstrates that forced air system operation can change air pressures inside a home. Air pressure differences created by forced air system operation can have unintended adverse effects on indoor air quality, health and safety, and building durability.

Negative Pressure

Supply leakage to a space outside the building envelope creates negative pressure inside the main living area. See Figure 7I. A home is under negative pressure if air pressure inside is lower than outside. Air will flow into the building (infiltration) through any hole it can find to reestablish neutral conditions. Combustion appliance flues are particularly convenient air paths.

Potential Effects of Negative Pressure on Combustion Appliances

Negative pressure may cause “spillage” of a combustion appliance—temporary venting of combustion gasses into the living space. Spillage is common at startup, before the appliance has a chance to establish a strong draft. Negative pressure prolongs spillage of combustion gasses into the home.

Negative pressure also may pose a fire danger from flame rollout. If negative pressure is strong enough, combustion appliance flames can be pulled out of the combustion chamber at startup and ignite nearby combustibles.

Negative pressure in a combustion appliance zone also may cause “backdrafting,” a complete flow reversal of flue gasses into the living space.

In addition to health and safety effects, supply leakage wastes energy. Heated or cooled air that should be going to the living space is lost to the outdoors. Heat is lost directly through duct leaks, and air pressure changes created by duct leakage induce higher levels of air infiltration through the building envelope.

Positive Pressure

A home is under positive pressure if air pressure inside is higher than outdoors. Air will flow from the home outdoors (exfiltration) any way it can to reestablish neutral conditions.

Concerns about positive pressure focus on where the air is coming from—the source of the air that is pressurizing the home—and potential for pressure driven moisture problems in structural cavities.

In homes with forced air systems, positive pressure in a main living area may indicate leakage in return ducts. See Figure 7J. If a leaky return is in the attic, attic air can be drawn into the house. If return plenums or furnace cabinetry in a garage are leaky, garage air can be drawn into the home.

Under positive pressure conditions, air that flows out of the house carries with it moisture present in indoor air. Moisture can condense in cooler building cavities and cause mold growth, structural decay, siding problems and many other moisture related problems.

Goals of Duct Sealing: Improved Safety, Indoor Air Quality, Building Durability, and Thermal Efficiency

By sealing supply and return ducts carefully as they are installed, the HVAC contractor ensures that heating system operation:

- will have a neutral effect on house air pressures;
- will not create negative or positive air pressure conditions;
- will not draw air from combustion appliance flues, attics, and garages into living spaces;
- will not drive moisture into structural cavities; and
- will avoid energy losses associated with duct leakage.

Central Returns: Door Closure

Many forced air systems are designed so that one or two central return grills serve all supply registers. Central returns often are located in the same zone as a fireplace or wood stove. In homes with forced air systems, central returns, and combustion appliances, closing interior doors can create negative pressure in the return/combustion appliance zone. Air delivered in the zone with the closed door cannot get back to the return, and the return becomes “starved” for air. The return/ combustion appliance zone is depressurized (under negative pressure), and the return may pull air from the combustion appliance flue for house makeup air. See Figure 7K.

Combustion appliances are not designed to operate in negative pressure environments. Spillage or backdrafting can result.

To avoid door closure effects in homes with combustion appliances, provide an air path from each supply register back to the return through passive pressure relief grills or distributed returns. See Figures 7L and 7M. Size distributed return grills and ducts using standard duct design procedures. Passive grills probably provide sufficient pressure relief if they provide 1 square inch of net free grill area for each CFM delivered to the room.

Figure 7I

NEGATIVE PRESSURE CREATED BY SUPPLY DUCT LEAKAGE

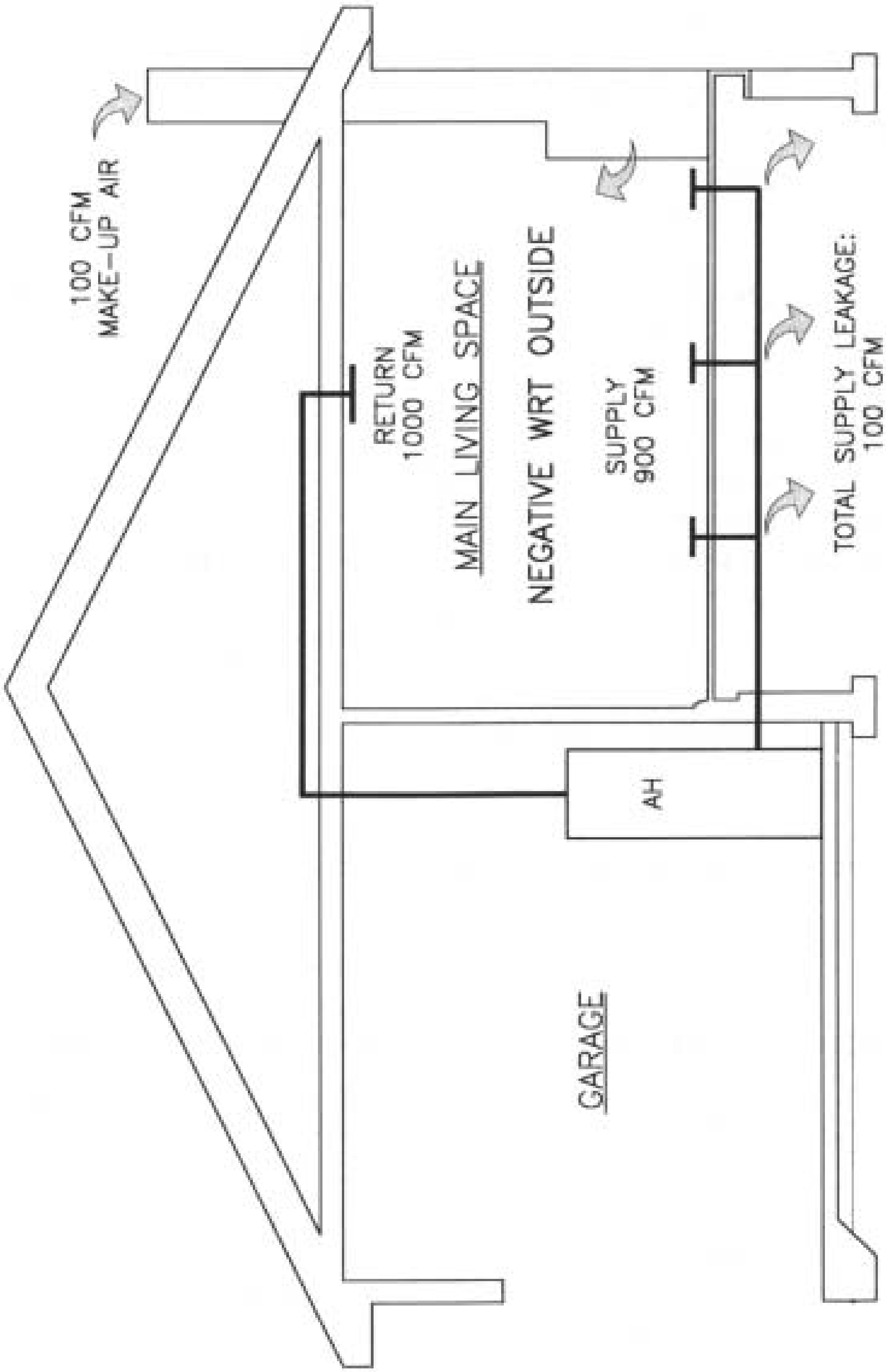


Figure 7J
POSITIVE PRESSURE CREATED BY SUPPLY DUCT LEAKAGE

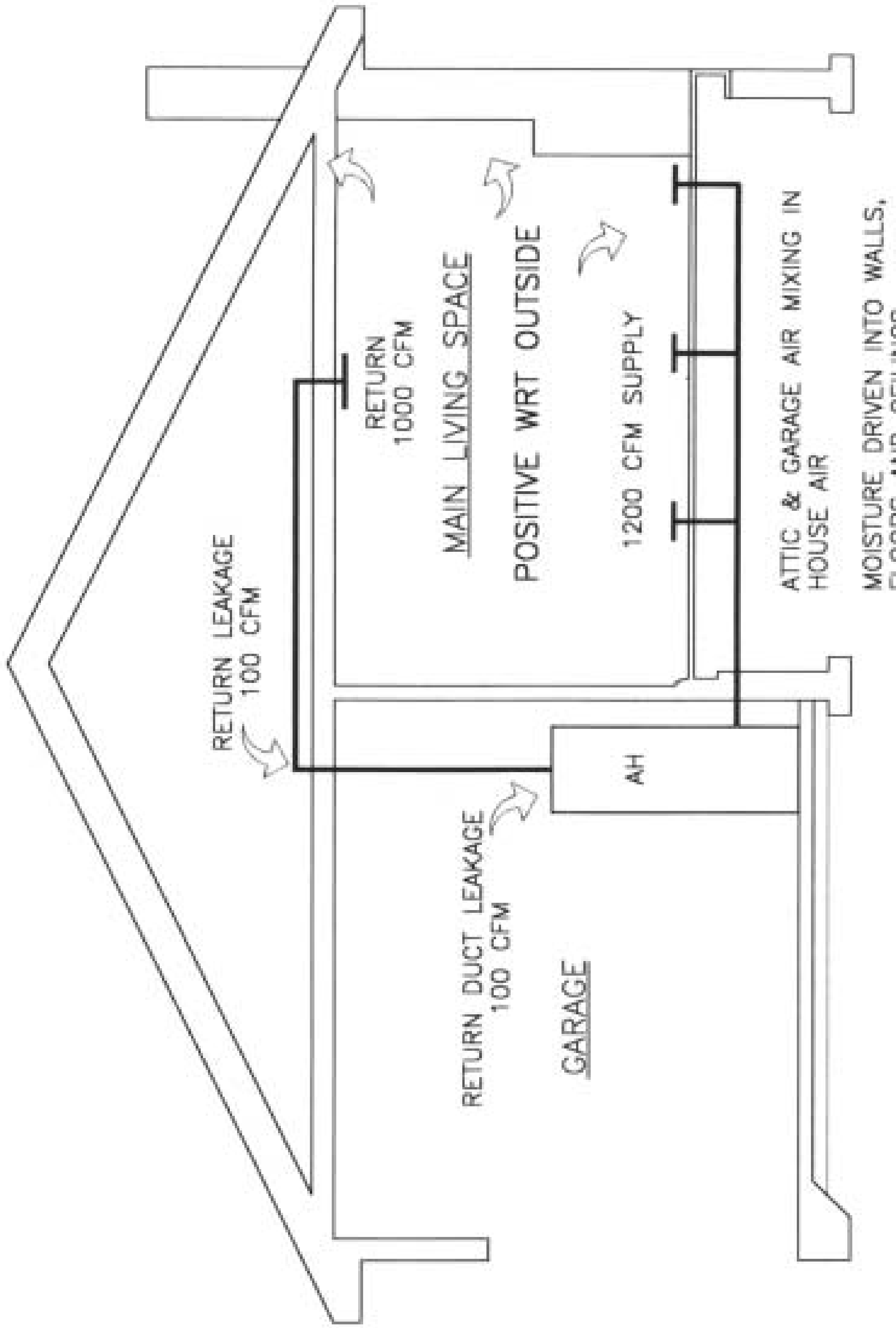


Figure 7K
DOOR CLOSURE EFFECT

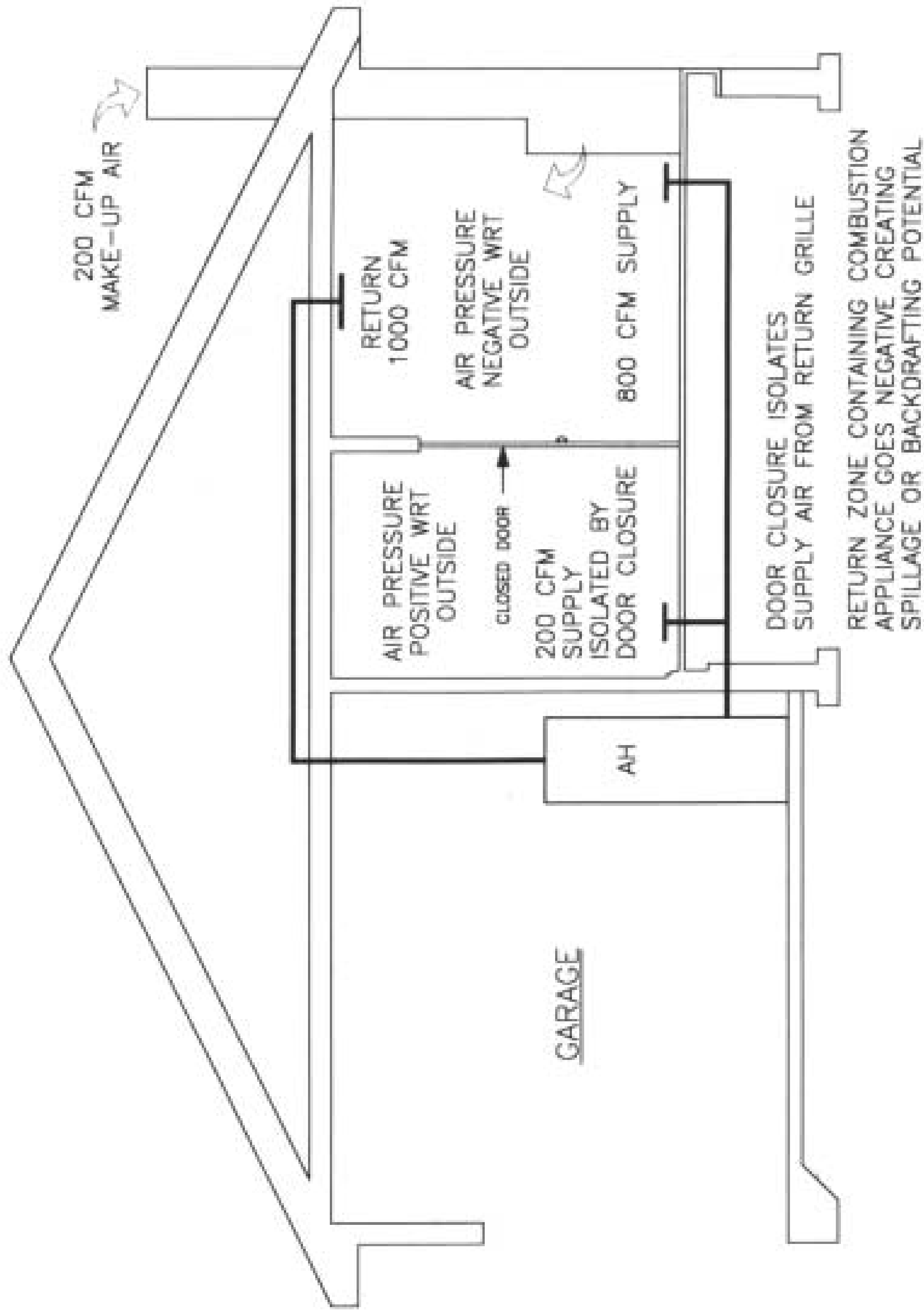
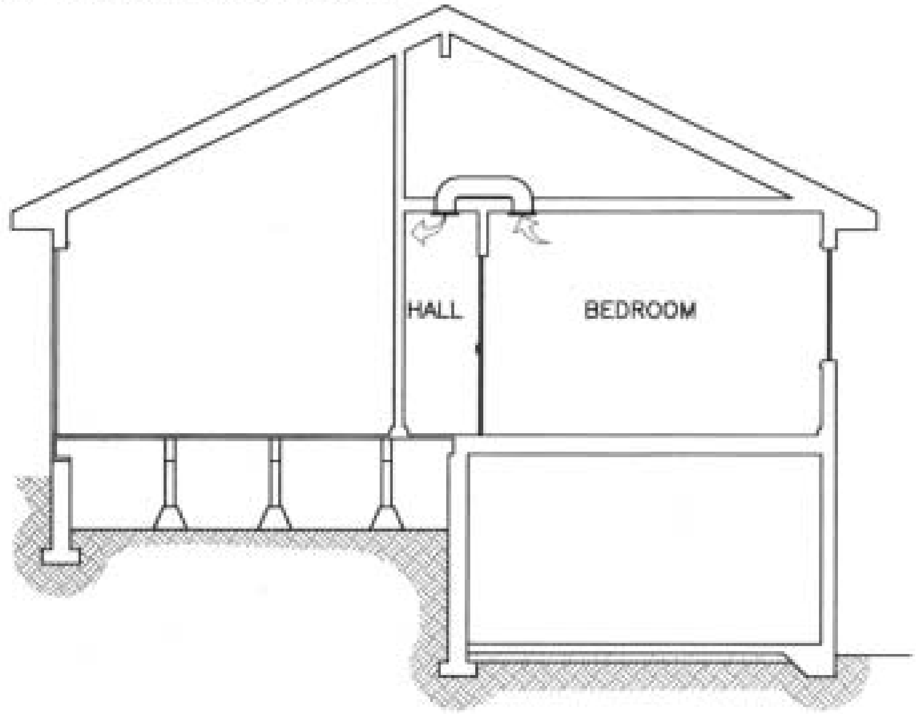


Figure 7L
PASSIVE PRESSURE RELIEF

DUCT THROUGH CEILINGS INTO HALL



THROUGH–WALL TRANSFER GRILLE
TO HALLWAY

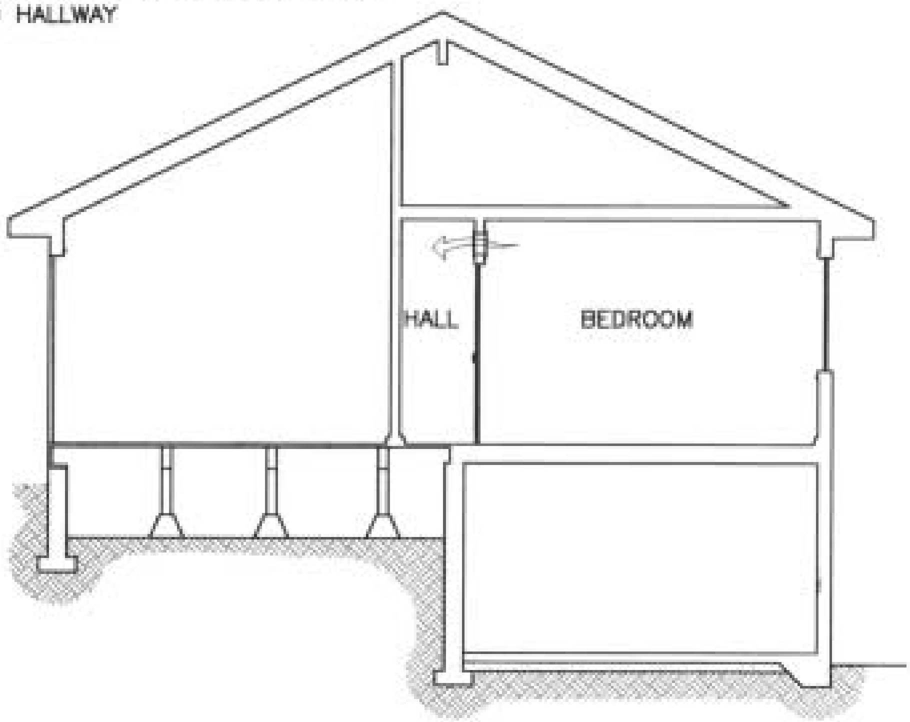
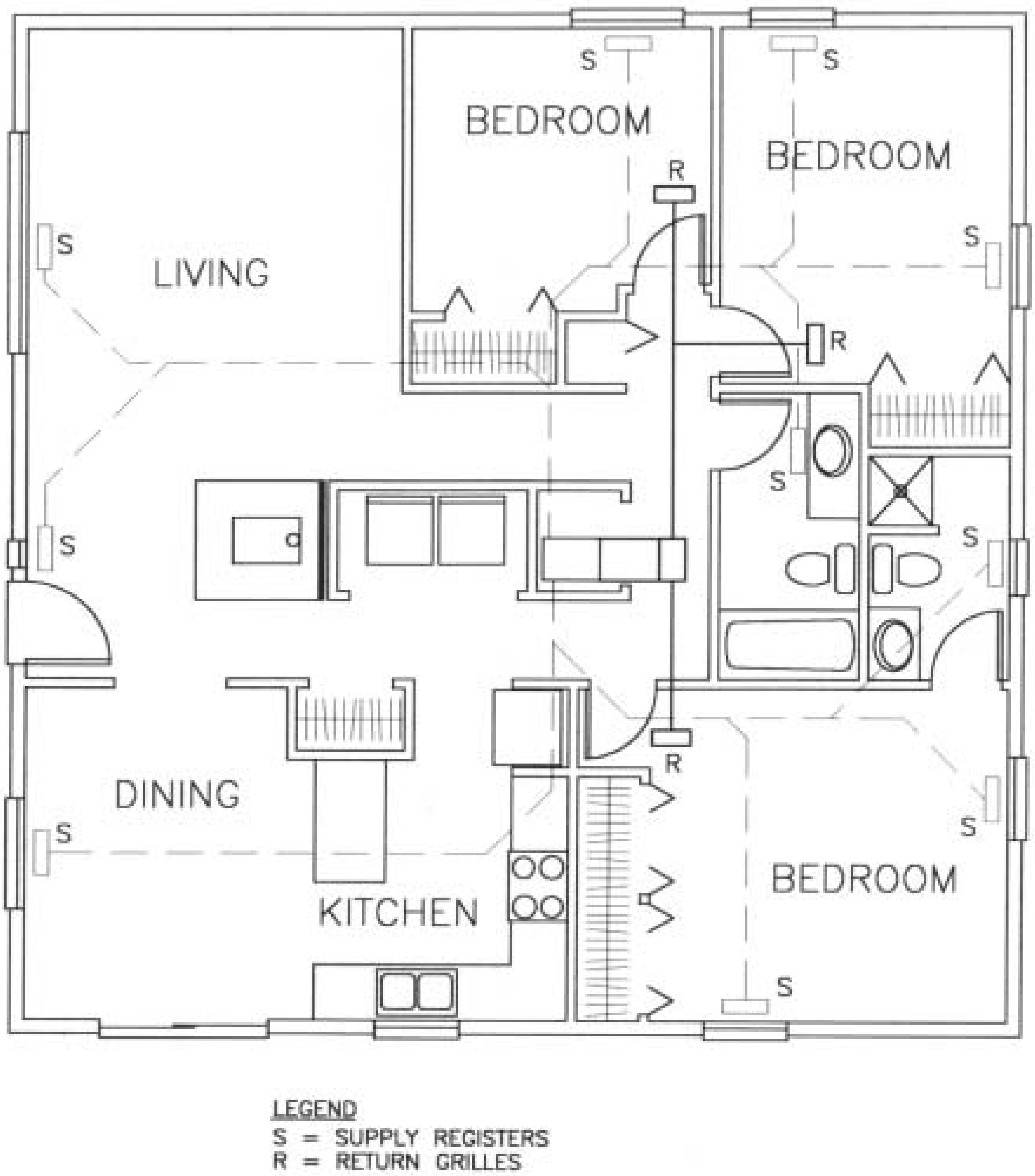


Figure 7M
DISTRIBUTED RETURN



VENTILATION SYSTEMS INSTALLED BY THE HVAC CONTRACTOR

1994 LTSGC 4.3

Ventilation Approaches for Multifamily Units (Six or more units)

Any of the following whole house ventilation systems are approved for use in multifamily housing: 1) Multifamily Continuous Ventilation; 2) Multifamily Intermittent Ventilation; and 3) Multifamily Intermittent Ventilation Integrated With Ducted Forced Air System.

Multifamily Continuous Ventilation and Multifamily Intermittent Ventilation are usually installed by the electrical contractor. Chapter 5 of this guide describes these systems. Multifamily Intermittent Ventilation Integrated With Ducted Forced Air System usually is installed by the HVAC contractor and is described below.

Table 7.1 shows minimum (and maximum) fan CFM ratings for continuous ventilation systems in multifamily buildings. The flow rates also are the basis for required intermittent flow rates when ventilation is provided by the forced air system. Table 7.1 CFM minimums apply when only the whole house fan provides whole house ventilation and separate spot ventilators serve the kitchen and baths.

Table 7.1
CONTINUOUS VENTILATION RATES FOR MULTIFAMILY CONSTRUCTION - WHEN SPOT FANS ARE SEPARATE

LTSGC 4.3, Table A

Number of Bedrooms	Min. Certified Fan Flow @ 0.25" w.g.	Max. Certified Fan Flow 0.25" w.g.
1	30 CFM	60 CFM
2	50 CFM	75 CFM
3	60 CFM	90 CFM
4	80 CFM	120 CFM

INTERMITTENT VENTILATION RATES FOR MULTIFAMILY CONSTRUCTION

Intermittent ventilation rates for multifamily construction require CFM ratings 1.5 times the minimum prescriptive flows specified in Table 7.1.

Multifamily Intermittent Ventilation Integrated With Ducted Forced Air System

The ventilation system may be integrated with the heating/cooling system only if each multifamily unit has a separate forced air system. The HVAC contractor usually takes the lead in installing these systems, but may have the electrical contractor provide a 24-hour timer, an exhaust fan, and a 24-volt control circuit for the furnace fan and motorized damper. The HVAC contractor may provide the final furnace and damper hookups.

A whole house exhaust fan must be installed that meets multifamily CFM requirements (for intermittent systems), is controlled by a 24-hour timer with a manual override switch, and is set to provide a minimum ventilation period of 8 hours per day. The 24-hour timer also controls the furnace fan and a motorized damper on a duct that delivers fresh air to the furnace return plenum. When the timer calls for ventilation, the exhaust fan comes on, the motorized damper opens, and the furnace fan comes on. Stale air is exhausted from the residence and fresh air is distributed throughout the home. See Figures 7N-1, 7N-2, and 7N-3.

To avoid creating negative pressure environments in multifamily units with combustion appliances, the amount of air coming in through the furnace must match the amount of air exhausted by the whole house fan. You may need to call the electrical contractor, general contractor, or Super Good Cents representative to determine the correct ventilation CFM and, therefore, the correct amount of fresh air to bring in through the heating system, and how to provide it.

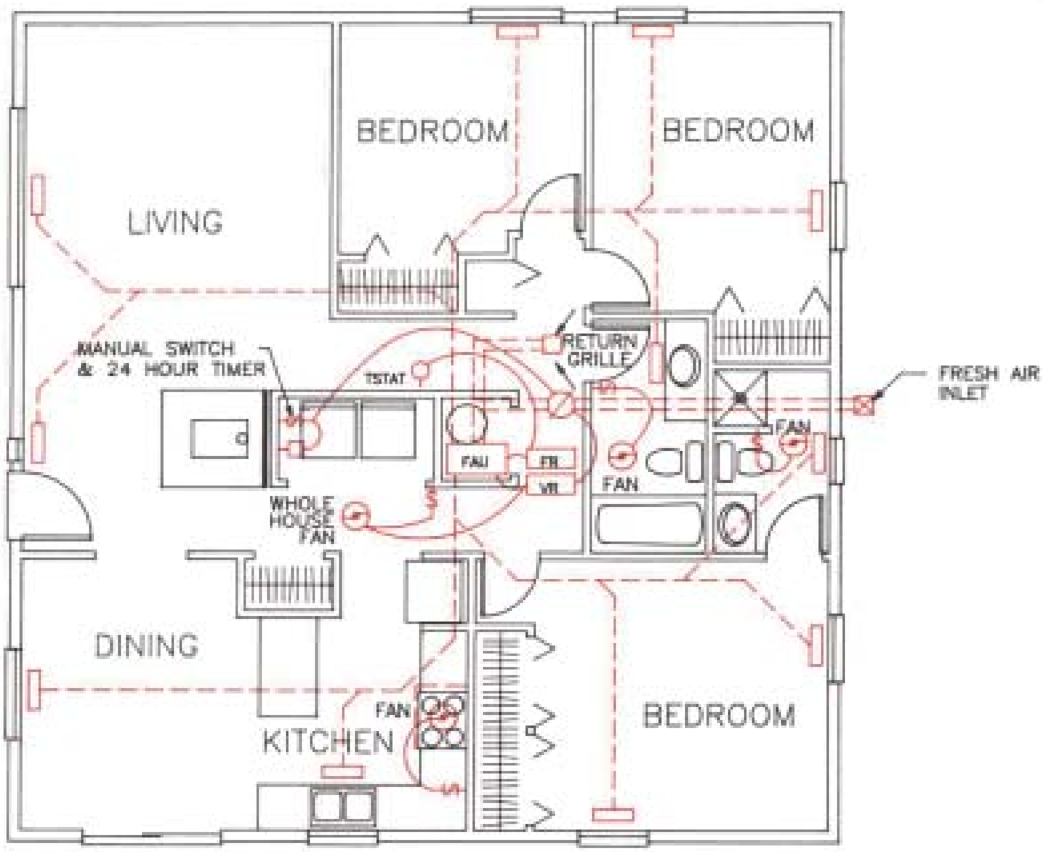
Table 7.2
AIR INLET DUCT LENGTH VS. DIAMETER

LTSGC 4.3.7.1, Table E

Number of Bedrooms	Min. Smooth Duct	Min. Flex Duct Diameter	Max. Duct Length[1]	Max. Number of Elbows[2]
2 or less	6"	7"	20 ft	3
3	7"	8"	20 ft	3
4 or more	8"	9"	20 ft	3

Notes:
[1] For lengths over 20 ft, increase duct diameter by 1 inch.
[2] For more than three elbows, increase duct diameter by 1 inch.

Figure 7N-1
WHOLE HOUSE VENTILATION INTEGRATED WITH FORCED AIR HEATING/COOLING



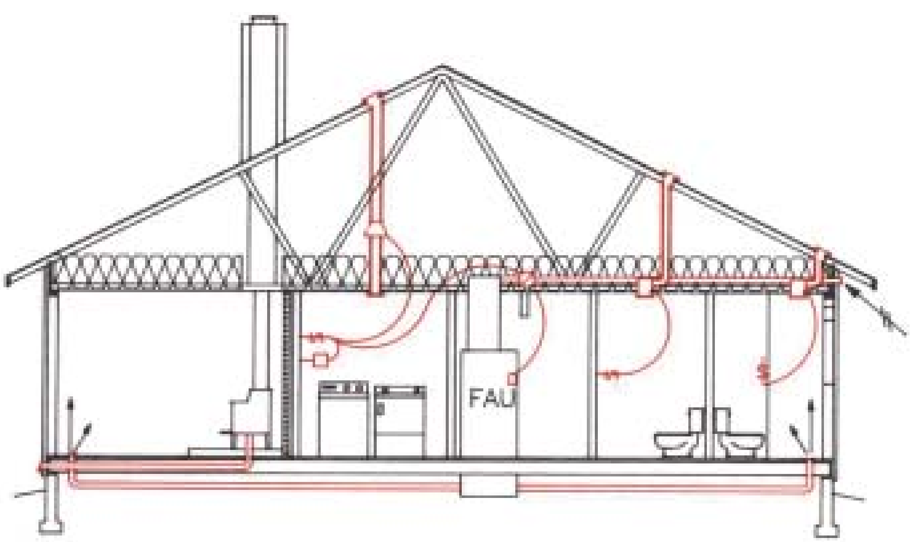


Figure 7N-2
EXAMPLE 1 CONTROL WIRING SCHEMATIC:
WHOLE HOUSE VENTILATION INTEGRATED WITH FORCED AIR HEATING/COOLING

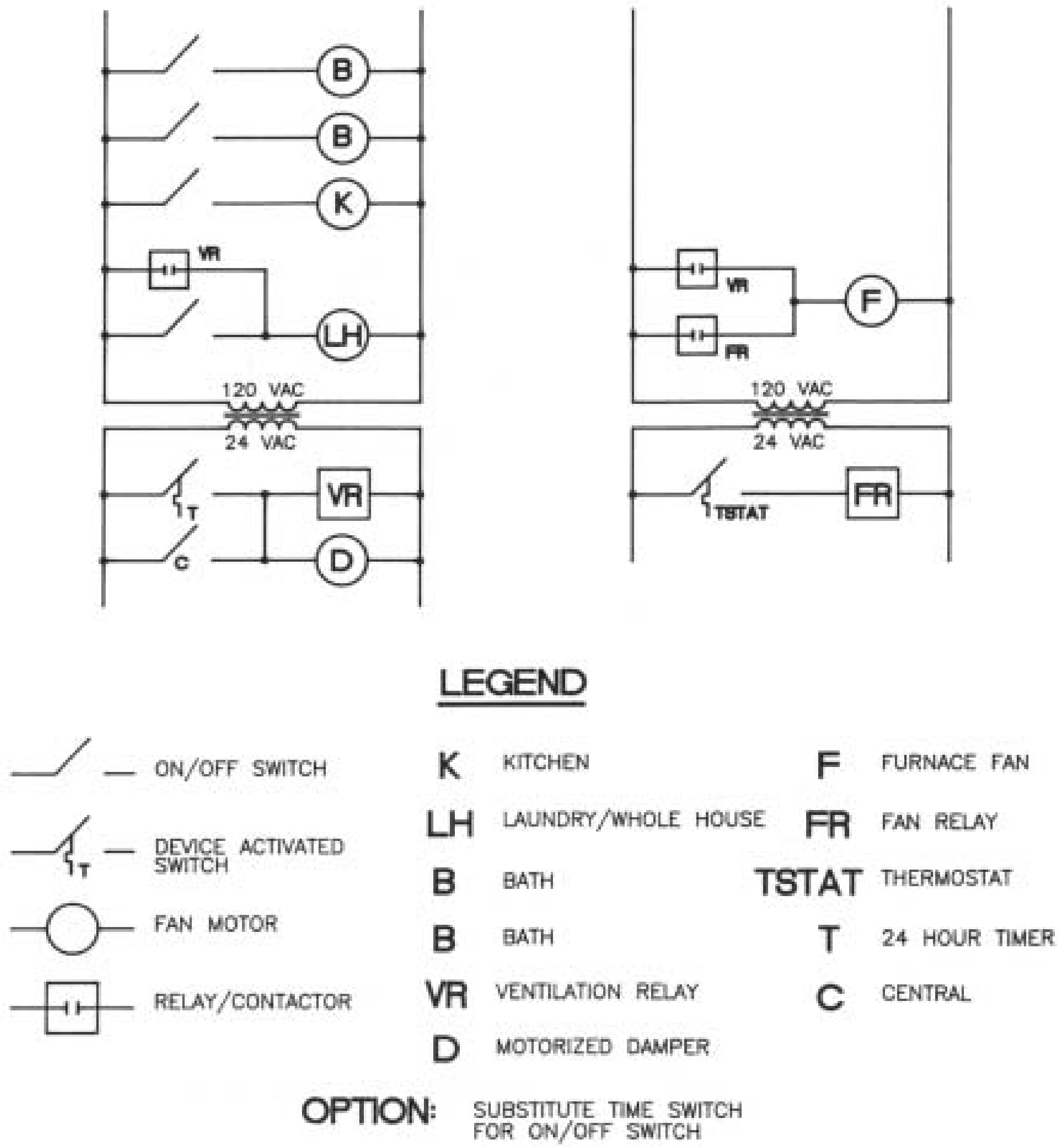
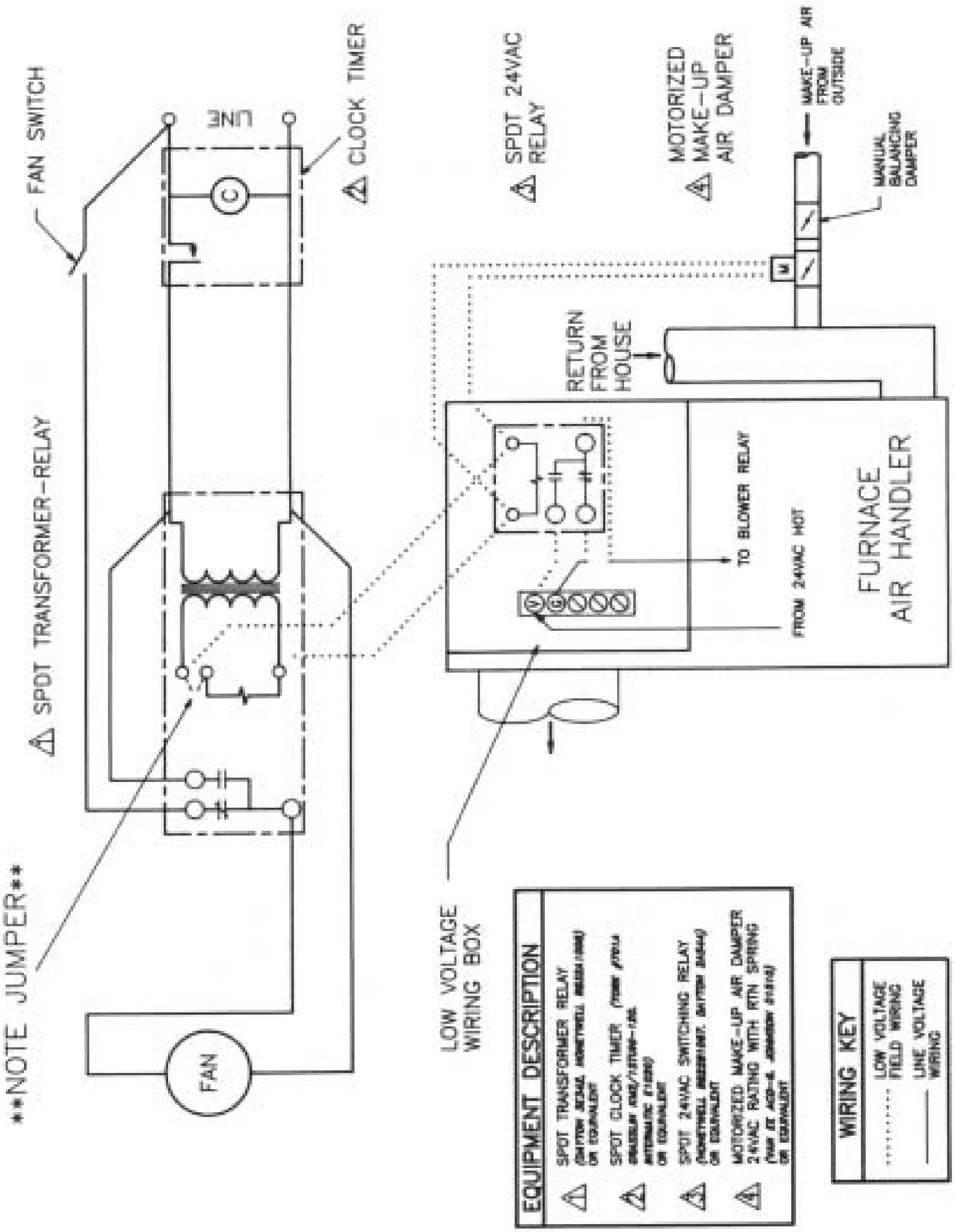


Figure 7N-3

EXAMPLE 2 CONTROL WIRING SCHEMATIC:
WHOLE HOUSE VENTILATOIN INTEGRATED WITH FORCED AIR HEATING/COOLING



Install the pickup point for the fresh air intake duct in a location where it will not pick up pollutants or odors. Places to avoid are close to grade level, areas where cars park, and roofs where asphalt or other petroleum products are used. Protect the pickup from rain, insects, leaves, and other objects. Keep the duct length as short and straight as practical.

Dampers

Unless the ventilation system is continuous, the intake duct must have a mechanical damper that opens only when ventilation is called for. The intake duct also must have a fixed damper or other air volume control set to provide the required airflow through the duct.

Simple pressure tests can determine whether the system is balanced as intended. Contact your Super Good Cents utility or state technical assistance provider.

Whole House Ventilation Approaches for Single Family Construction (Five units or less)

Four different approaches are approved for whole house ventilation in single family construction: 1) Single Family Integrated Spot and Whole House Ventilation, 2) Single Family Continuous Ventilation, 3) Single Family Discrete Spot and Whole House Ventilation, and 4) Single Family Intermittent Ventilation Integrated With Ducted Forced Air System.

Single Family Integrated Spot and Whole House Ventilation, Single Family Continuous Ventilation, and Single Family Discrete Spot and Whole House Ventilation usually are installed by the electrical contractor. Chapter 5 describes these systems. Single Family Intermittent Ventilation Integrated With Ducted Forced Air System usually is installed by the HVAC contractor and is described below.

Ventilation Rates for Single Family Construction

Table 7.3 specifies minimum flow rates for intermittent systems. Minimum flow for continuous systems is 20 CFM per bathroom plus 25 CFM for the kitchen.

Table 7.3
SINGLE FAMILY INTERMITTENT VENTILATION

LTSGC 4.3.1, Table B

Number of Bedrooms	Min. Certified Fan Flow @ 0.25" w.g.	Max. Certified Fan Flow @ 0.25" w.g.
2 or less	50 CFM	75 CFM
3	80 CFM	120 CFM
4	100 CFM	150 CFM
5	120 CFM	180 CFM

Single Family Intermittent Ventilation Integrated With Ducted Forced Air System

The ventilation system may be integrated with the heating/cooling system if the home has a forced air system. The HVAC contractor usually takes the lead in installing these systems, but may have the electrical contractor provide a 24-hour timer, the whole house exhaust fan, and a 24-volt control circuit for the furnace fan and motorized damper. The HVAC contractor may provide the final furnace and damper hookups.

A whole house exhaust fan must be installed that meets CFM requirements (for intermittent systems), is controlled by a 24-hour timer with a manual override switch, and is set to provide a minimum ventilation period of 8 hours per day. The 24-hour timer also controls the furnace fan and a motorized damper on a duct that delivers fresh air to the furnace return plenum. When the timer calls for ventilation, the exhaust fan comes on, the motorized damper opens, and the furnace fan comes on. Stale air is exhausted from the residence and fresh air is distributed throughout the home. See Figures 7N-1, 7N-2, and 7N-3.

To avoid creating negative pressure environments in single family homes with combustion appliances, the amount of air that comes in through the furnace must match the amount of air that is exhausted by the whole house fan. You may need to call the electrical contractor, general contractor, or Super Good Cents representative to determine the correct ventilation CFM and, therefore, the correct amount of air to bring in through the heating system.

Table 7.4
AIR INLET DUCT LENGTH VS. DIAMETER

LTSGC 4.3.7.1, Table E

Number of Bedrooms	Min. Smooth Duct	Min. Flex Duct Diameter	Max. Duct Length[1]	Max. Number of Elbows[2]
2 or less	6"	7"	20 ft	3
3	7"	8"	20 ft	3
4 or more	8"	9"	20 ft	3

Notes:
[1] For lengths over 20 ft, increase duct diameter by 1 inch.
[2] For more than three elbows, increase duct diameter by 1 inch.

Install the pickup point for the fresh air intake duct in a location where it will not pick up pollutants or odors. Places to avoid are close to grade level, areas where cars park, and roofs where asphalt or other petroleum products are used. Protect the pickup from rain, insects, leaves, and other objects. Keep the duct length as short end straight as practical.

Dampers

Unless the ventilation system is continuous, the intake duct must have a mechanical damper that opens only when ventilation is called for. The intake duct also must have a fixed damper or other air volume control set to provide the required airflow through the duct.

Simple pressure tests can determine whether the system is balanced as intended. Contact your Super Good Cents utility or state technical assistance provider.

Heat Recovery Ventilation Systems

The HVAC contractor may be responsible for installing a central heat recovery ventilation system.

Air-to-Air Heat Exchangers

Air-to-air heat exchangers (AAHXs) are central ducted ventilation systems that bring fresh air into a building and pull stale air out. Airflows to and from the building are routed through a heat exchanger core that transfers heat from the outgoing stale air to incoming fresh air. Because the systems are balanced, they are a good choice for ventilation in homes with combustion devices. Balanced systems do not create negative pressure environments, avoiding potentially unsafe interactions with combustion appliances.

AAHXs are not designed to handle range hood exhaust. Kitchen spot ventilation can be achieved through the AAHX by providing a recirculating hood over the stove and a separate exhaust pickup at the kitchen ceiling. Provide an 8-ft horizontal separation between the range top and the kitchen exhaust pickup location.

Minimum AAHX airflow rates and equipment performance standards. Super Good Cents specifications require minimum airflows as described above in Tables 7.1 and 7.3. Do not over ventilate.

If the air-to-air heat exchanger is being installed as a Super Good Cents program option, it must meet certain minimum performance standards. In homes larger than 1,300 square feet, equipment must have a sensible heat recovery efficiency of 65 percent at 117 CFM and 32°F. For houses smaller than 1,300 square feet, the unit must have a sensible heat recovery efficiency of 55 percent at 64 CFM and 32°F, as certified by the Home Ventilating Institute. Include manufacturer's product information with the plans. That way the plan reviewer can verify that the equipment provides required minimum flows and meets performance specifications.

AAHX installation. Locate the AAHX where it is readily accessible for changing air filters and any other maintenance required by the manufacturer. Locating the unit indoors improves heat recovery efficiency. Indoor locations also make access for maintenance easier.

Make the general contractor or electrical contractor aware that a dedicated circuit is recommended.

Since most AAHXs generate condensate, you will probably need to have the plumbing contractor provide a connection to a drain.

AAHXs work most efficiently when exhaust and supply airflows are balanced. This requires a warm side balancing damper in both the main supply and exhaust ducts. Flow hoods or flow grids can be used to verify balanced flow.

Install adjustable grills or registers on each fresh air delivery and exhaust air pickup point. They allow airflow adjustment in each room. Measuring is the only way to ensure that the system is balanced and delivering the design airflow to each space.

AAHX design assistance. Correct design of duct systems and selection of the right terminal devices are critical to successful installations. Many manufacturers have excellent design and installation manuals. Following are other sources of help with AAHX ventilation system design:

Installer's Manual of Heat Recovery Ventilators, available from Home Ventilating Institute, 30 West University Drive, Arlington Heights, IL 60004; 708-394-0150.

"Air-to-Air Heat Exchanger Systems: Marketing, Design and Installation" - Video training tape and study guide available from Super Good Cents utilities or Oregon State University Extension Energy Program, Batcheller Hall 344, Corvallis, OR 97331-2405, 503-737-3004.

Figures 7O-1 and 7O-2 show a typical ventilation system design using an AAHX.

Exhaust Air Heat Pumps

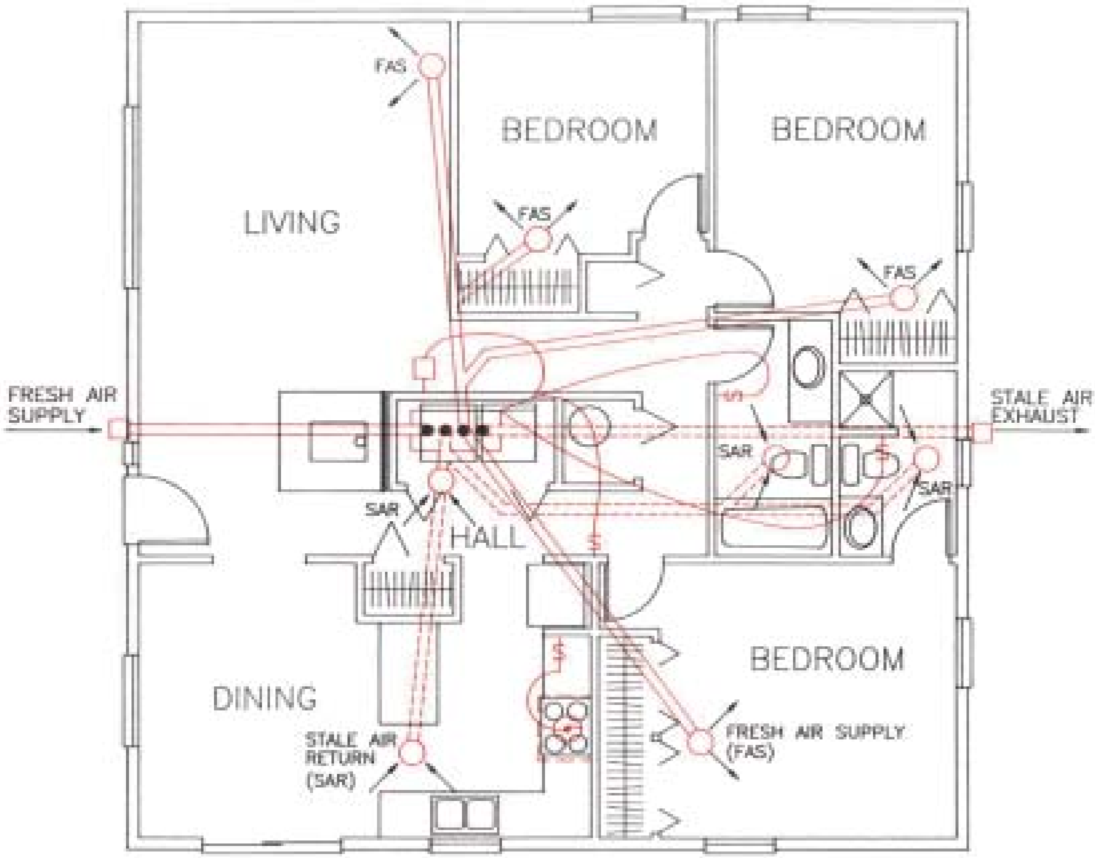
Exhaust air heat pumps (EAHPs)—sometimes called "ventilating heat pump water heaters"—are exhaust ventilation systems that use a small heat pump to recover heat from outgoing stale air. The heat is pumped into the home's hot water system. HVAC contractors typically install them because the system involves refrigeration equipment and oftentimes ducts. The heat recovery efficiency of an EAHP is better than an air-to-air heat exchanger, but the ventilation it provides is not balanced unless you provide makeup air equivalent to exhaust flow. Figure 7P-1 shows layout of a typical EAHP system.

EAHPs: Water heating only. Most EAHPs heat water only. Exhaust air flows over an evaporation coil on top of the water heater tank (usually supplied with the EAHP). Exhaust air can be ducted from a central location in the house (most economical installation) or from bathrooms, utility rooms, and even kitchens.

Ducting from bathrooms is more expensive, but it is a good way to provide high quality spot ventilation. If you use an EAHP to ventilate kitchens, make sure stale air is not picked up right above the stove top. That could cause problems with grease accumulation. Instead, use a range hood to pick up stale air from the range. Use the EAHP pickup for general kitchen stale air and moisture.

EAHPs: Space conditioning option. Some EAHPs offer an option to provide supplemental space heating and cooling. This increases their heat recovery efficiency. The systems require additional ductwork to and from the space(s) being cooled or heated and a heating/cooling thermostat in each space. Generally, they provide space conditioning at about 7,000 Btu/hr. That is adequate for supplemental conditioning of a fairly large zone in the house, such as a family room, living room, or great room.

Figure 7O-1
AIR-TO-AIR HEAT EXCHANGER VENTILATION SYSTEM



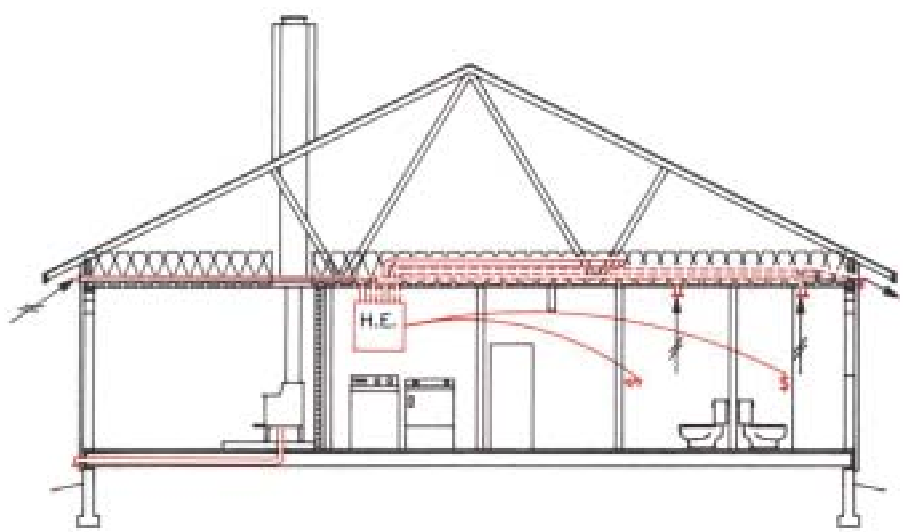
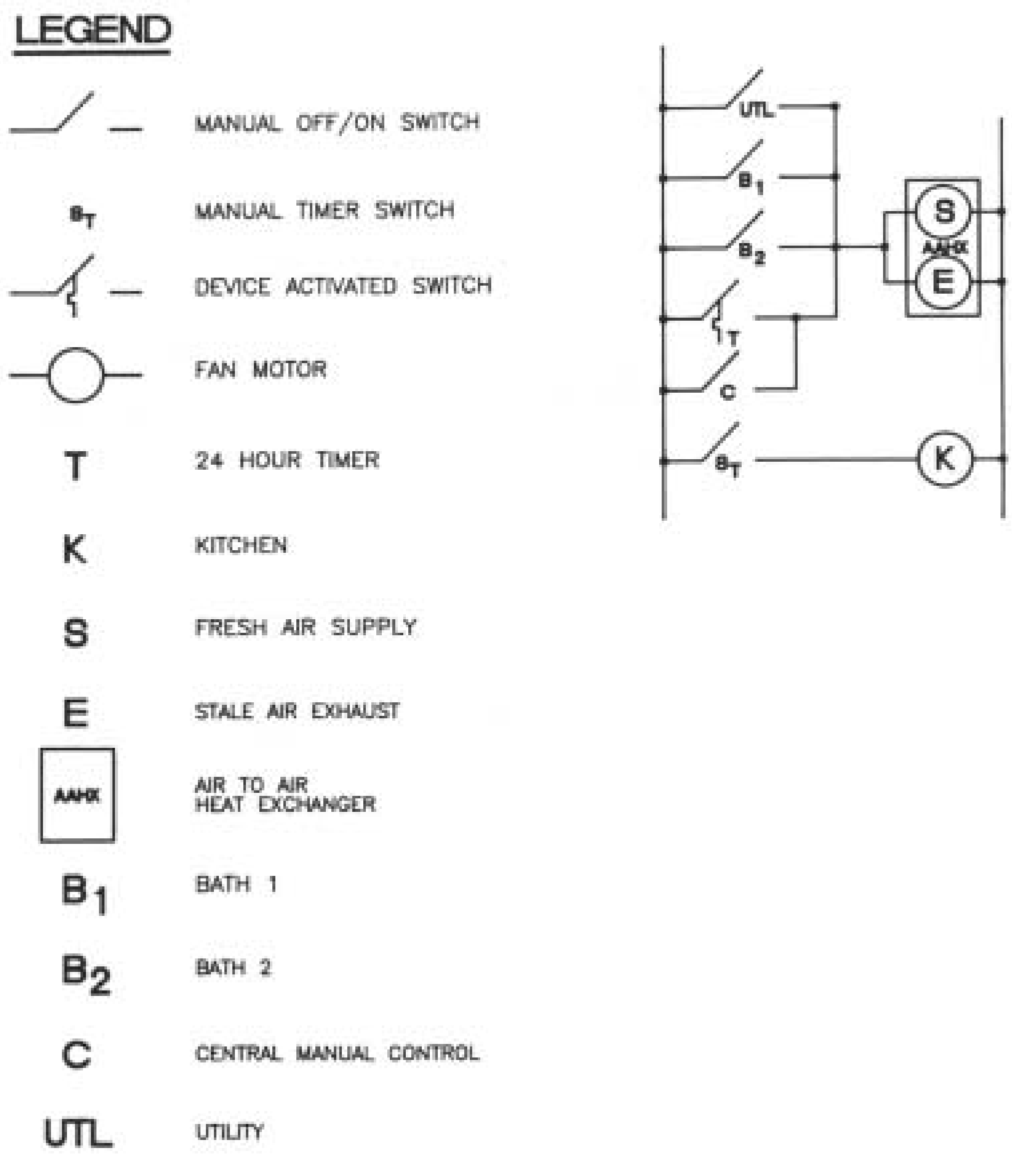


Figure 7O-2
CONTROL WIRING SCHEMATIC:
AIR-TO-AIR HEAT EXCHANGER VENTILATION SYSTEM



EAHP installation. EAHPs can be installed most places you would install a regular water heater. It is a good idea to locate the unit where duct runs can be kept inside the heated space as much as possible, and where duct runs can be kept short and simple. Installation in a utility room often works well.

One difference from installing a conventional water heater is that the plumber must install a condensate drain line to a vented drain. It disposes of water condensed out of the cooled exhaust air.

Requirements for wiring, refrigerant lines, and supply water locations vary from unit to unit. Make sure you have the manufacturer's instructions and templates in hand when you make the bid.

Sizing EAHP airffows. The exhaust air minimum flows for EAHPs are the same as for any Super Good Cents ventilation system. See Tables 7.1 and 7.3 for requirements.

EAHP controls. EAHPs have two main controls:

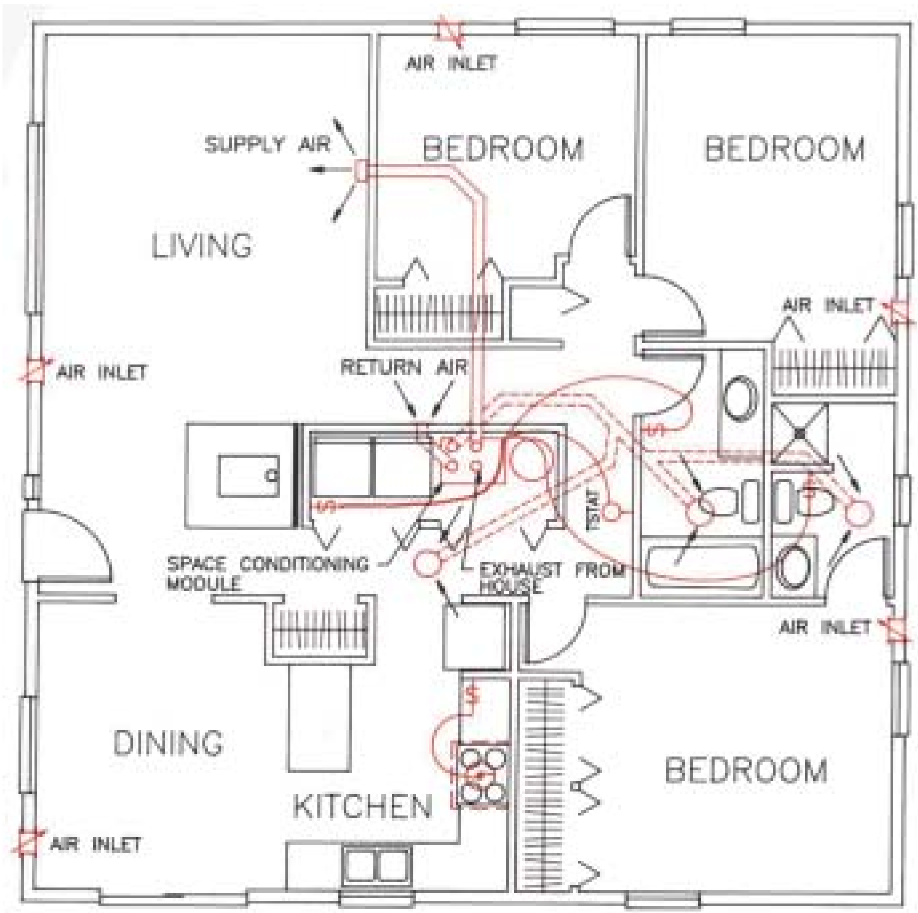
One controls hot water use. When water is drawn from the tank, the tank thermostat calls for heat and turns on the exhaust fan. The heat pump moves heat into the tank. This is effective control since hot water use usually indicates someone is in the house and ventilation is needed.

The second control is a 24-hour clock timer. It is set to turn on the ventilation system at preset times during the day. Super Good Cents specifications require that the timer be set to provide ventilation at least twice a day, for a minimum total ON time of 8 hours. Ventilation is more effective when ON intervals are distributed throughout occupied daylight hours and during sleeping periods. Timing some of the daily ventilation intervals to precede hot water use periods is a good idea.

Figures 7P-2, 7P-3, 7P-4, and 7P-5 show typical operating sequences for EAHPs.

EAHP fresh air supply. The EAHP provides only exhaust and control elements of a ventilation system. Framers or finish carpenters need to be sure there is a fresh air supply. Most common are fresh air inlets in bedrooms and other locations in the house. Chapter 2 has more information on fresh air inlets.

Figure 7P-1
EXHAUST AIR HEAT PUMP VENTILATION SYSTEM



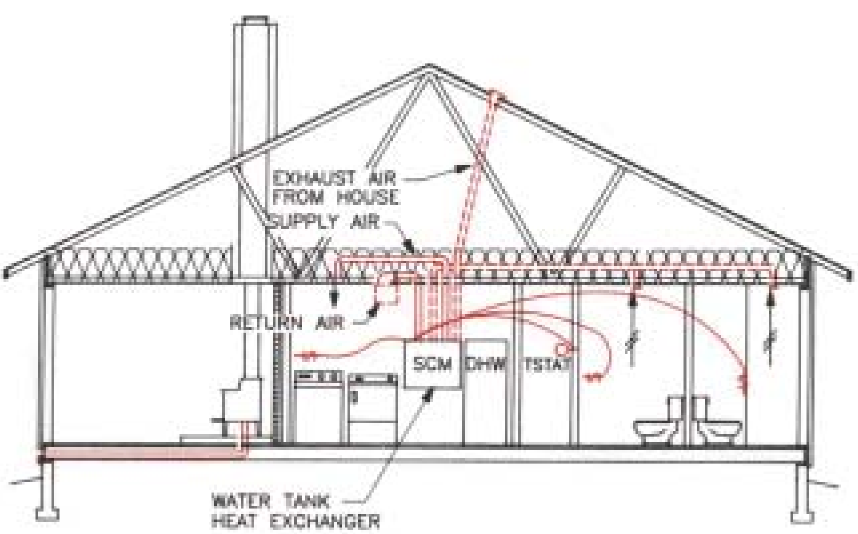


Figure 7P-2
EXHAUST AIR HEAT PUMP: WATER HEATING MODE

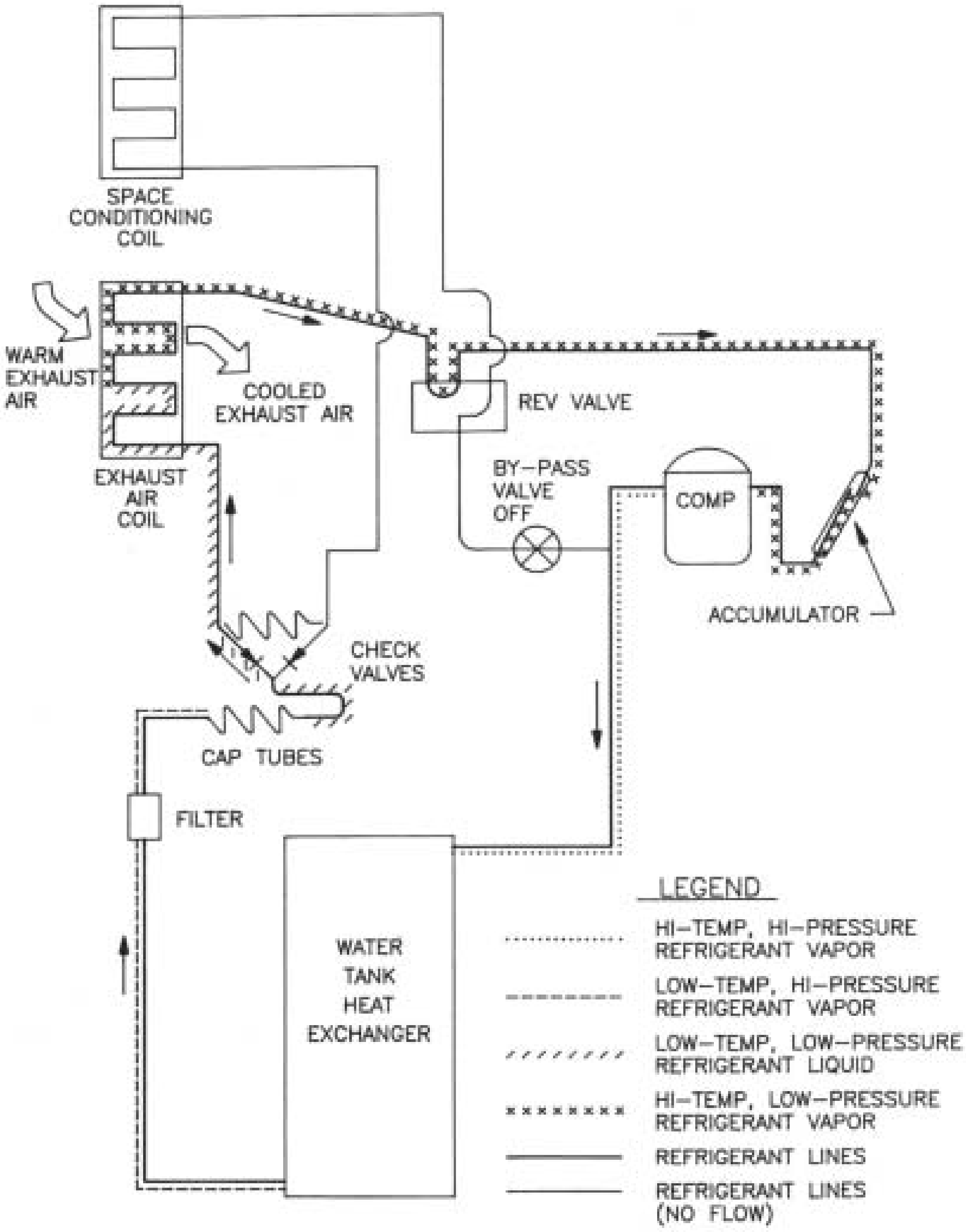


Figure 7P-3
EXHAUST AIR HEAT PUMP: SPACE HEATING MODE

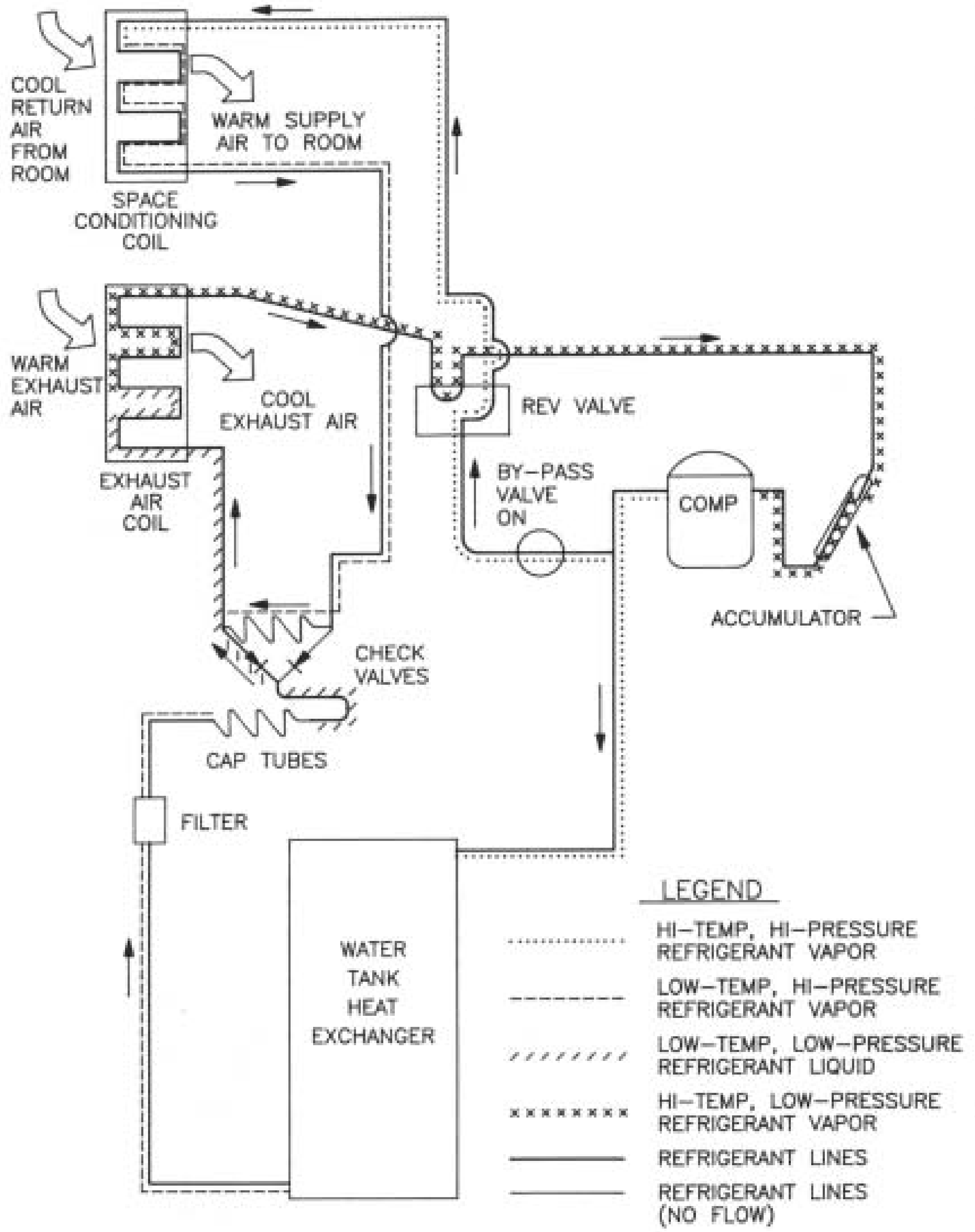


Figure 7P-4
EXHAUST AIR HEAT PUMP: STAGE 1 COOLING

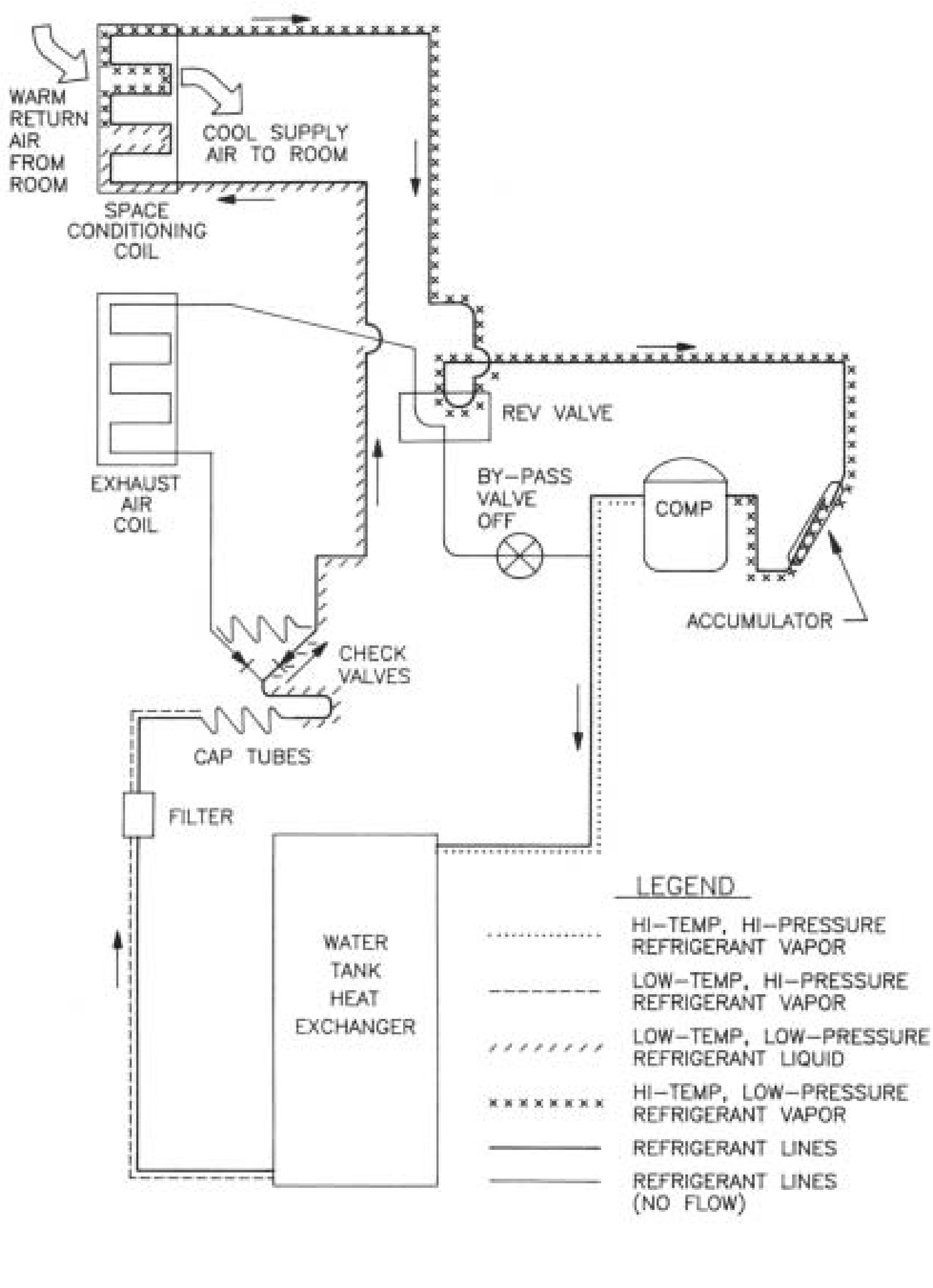


Figure 7P-5
EXHAUST AIR HEAT PUMP: STAGE 2 COOLING