Chapter 4 – Gas Furnaces

4.1 Selection and Sizing of Gas Furnaces: Specification.

4.1.1 **Equipment Efficiency Ratings.**

(a) Gas heating equipment should comply with the required efficiency of local or utility energy codes or, as a minimum, meet ENERGY STAR efficiency levels.

(1) Furnaces: minimum 90 Annual Fuel Utilization Efficiency (AFUE).

(2) Boilers: minimum 85 Annual Fuel Utilization Efficiency (AFUE).

(b) **Verification of Furnace Efficiency.**

(1) The AFUE value of newly installed furnaces should be verified by the latest edition of the GAMA Directory (*Consumers' Directory of Certified Efficiency Ratings for Residential Heating and Water Heating Equipment* by the Gas Appliance Manufacturers Association).

4.1.2 Equipment should be selected in accordance with the most recent edition of *Residential Equipment Selection* (Manual S) by ACCA, or a comparable industry-accepted method.

4.1.3 An accurate load calculation must be performed before equipment is selected. This load should be calculated with the most recent edition of *Residential Load Calculation* (Manual J) by ACCA, or a comparable industry-accepted method. Computer software programs based on the most recent edition of Manual J are acceptable.

(a) For the purpose of load calculation, the interior design temperature used should be 70°F.

(b) The selected furnace capacity should be no less than 100 percent of the calculated Btuh heating load.

(c) Selected furnace capacity should be no more that 1.4 times the calculated Btuh required.

Condensing furnaces

Condensing furnaces achieve high efficiencies by reclaiming the thermal energy released when the water vapor in the combustion gas is condensed. Make sure this water is drained from the condensing furnace according to the manufacturer's specifications and local building codes.

Direct vent condensing furnaces vent combustion gases to the outdoors *and* take all the necessary combustion supply air from the outdoors through a dedicated pipe connected to the combustion chamber. Although not all condensing furnaces are direct-vent types, their use is recommended.

When installing condensing furnaces, carefully follow the manufacturer's specification to ensure proper and efficient operation.

Efficiency and electrical use

Annual Fuel Utilization Efficiency (AFUE) ratings do not include the cost of electricity for furnace operation. Because high-efficiency gas furnaces often use more electricity than lower efficiency units, the savings in gas cost could be partially or fully offset by the cost of increased electricity consumption. This is most likely to be a significant issue in areas with a low natural gas cost and high electricity costs.

Refer to the "GAMA Directory" (*Consumers' Directory of Certified Efficiency Ratings for Residential Heating and Water Heating Equipment*) for the estimated annual electric consumption of certified gas furnaces. This directory, published by the Gas Appliance Manufacturers Association also lists AFUE values for certified gas furnaces. Order an annual subscription (two issues) to this useful publication for $10.00 by calling 607-758-6636.

Exception: See Sections 4.1.3 (1) and 4.1.3 (2), below.

(1) If the furnace air handler is also supplying comfort cooling, make sure that the air handler blower can supply the desired cooling CFM, within 10 percent.

(2) If there are no air handlers having the correct combination of heating capacity – single- or dual-firing rates – and blower performance (for heating and cooling), ignore the 1.4 over-sizing rule and select the smallest furnace that will provide the appropriate cooling airflow.

4.1.4 Furnaces should be selected with the proper heating capacity and blower performance. Blower performance should be matched to output of furnace and ducted distribution system.

4.1.5 If the furnace air handler is also supplying comfort cooling, make sure that the air handler blower has the capacity and automatic controls to operate at the appropriate CFM for both comfort heating and cooling.

Oversized furnace operation leads to:

- Short burner-on cycle
- Long burner-off cycle
- Furnace and vent system likely to become cool
- Condensation likely to form in furnace and vent, which can lead to premature failure of system

Correctly sized furnace operation leads to:

- Longer burner-on cycle
- Smaller quantities of heat delivered at any given time
- Shorter burner-off cycle
- Furnace and vent system stay warmer
- Moisture dries up in furnace and vent system due to longer burner-on time
- Higher duct efficiency due to longer on-cycles

Common sizing mistakes

- Miscalculation of air changes per hour (ACH)
- Using summer ACH value rather than winter ACH
- Exaggeration of outdoor design temperature (too low for heating equipment sizing)
- Using a sizing multiplier that is much larger than necessary
- Sizing by the capacity of the existing equipment
- Sizing by rules of thumb

4.1.6 If the furnace air handler is also supplying comfort cooling, the capacity of the air handler blower should be adequate to overcome the external static resistance imposed by the combined heating and cooling units at the airflow required for heating or cooling, whichever is greater.

4.1.7 **Verification.** Before installation, check sizing of the furnace by comparing Manual J load calculation to the rated output of the furnace.

4.1.8 **Benefits.** Oversizing a furnace by more than 1.4 times can lead to loss in seasonal efficiency, higher equipment cost, comfort sacrifices due to short cycling, and premature degradation of the furnace and/or the vent system.

4.1.9 **Discussion.** Using a mathematical sizing procedure, such as in Manual J, requires know-how and time. If a designer performs many load calculations each week, he or she will become proficient quickly.

Improper sizing leads to customer complaints, system inefficiencies, and premature equipment degradation. Because it is very difficult to properly adjust for improper sizing once the equipment has been installed, sizing "by the book" (Manual J or a comparable method) is strongly encouraged.

Many equipment suppliers offer a free load calculation service to their installers. If such a service is used, it is vitally important that the installer make sure the method being used is based on Manual J. It is also important that the installer provide accurate job information – such as house dimensions, insulation values, window U-value, window solar transmittance, and house tightness – to the person calculating the load.

4.2 Heat Exchanger Temperature Rise/ Airflow: Specification.

4.2.1 The temperature rise or airflow across the heat exchanger should be within the range stated by the manufacturer.

(a) **Alternate Method 1.** If a manufacturer's specification for the ideal temperature rise is not available, adjust the fan flow across the heat exchanger so the temperature rise is between 40°-70°F. This temperature rise range corresponds to 18-12 CFM per 1000 Btuh, respectively, based on CFM = 1000 Btuh/(Temperature rise x 1.08). Measure with a thermometer inserted in the return plenum and the supply plenum. The thermometer inserted in the supply plenum must be "out of sight" of the hot heat exchanger so that it is not affected by radiant thermal energy.

(b) **Alternate Method 2.** Verify air handler airflow with Duct Blower Test for Ensuring Proper Airflow. Refer to Section 4.9.1.

(c) **Alternate Method 3**. Verify air handler airflow with Flow Hood Test for Ensuring Proper Airflow. Refer to Section 4.9.2.

4.2.2 **Verification.**

(a) Verify heat-exchanger temperature rise or airflow after sealing the distribution system and doing other work that might alter temperature rise/airflow.

4.2.3 **Benefits.** The proper temperature rise across the heat exchanger can save as much as 2 percent of the fuel consumption.[1] Increasing airflow lowers the temperature of the supply air, resulting in decreased conductive heat transfer from the air to the space around the ducts.

4.3 Blower Thermostat Control: Specification.

4.3.1 Set the air handler blower-on and blower-off temperatures according to the manufacturer's recommendations.

4.3.2 **Alternate Method.** On non-electronic controls, set the blower-on temperature to 115°F and the blower-off temperature to 90°F.

4.3.3 **Verification.** Verify proper settings with a radiation-shielded thermometer at installation.

Exception: New furnaces have electronic blower thermostats that may or may not be adjustable. Check these controls for adjustment options. These controls usually turn the fan on about 45 seconds after the furnace burner fires and off from 90 seconds to 5 minutes after the burner stops firing. Sometimes the timing can be

Too much airflow across the heat exchanger leads to:

- Heat exchanger staying cooler
- Corrosion of furnace and vent system is more likely to occur from moisture condensation (not a problem with condensing furnaces)

Too little airflow across the heat exchanger leads to:

- Heat exchanger getting too hot
- Furnace cycles on high limit causing inefficient operation and possible service call
- Repeated heating and cooling stresses the heat exchanger
- Deforming or cracking of heat exchanger

adjusted to increase efficiency. If the manufacturer recommends against adjustment, do not attempt to it.

4.3.4 **Benefits.** A properly adjusted blower thermostat control increases efficiency by purging the ducted distribution system and heat exchanger area of conditioned air before the air-handler blower cycles off.

4.4 Fan-Delay Relay: Specification.

If not already included as a furnace control, air handler or thermostat, a fan-delay relay must be installed to continue the operation of the air-handler blower for a minimum of one minute, or a manufacturer's preset time delay, after the burner cycles off.

4.4.1 **Verification**. Time the operation of the blower after the burner cycles off.

4.4.2 **Benefits.** The fan-delay relay control increases efficiency by purging the ducted distribution system and heat exchanger area of conditioned air before the air-handler blower cycles off.

4.5 Programmable Thermostat Control: Specification.

4.5.1 Programmable comfort thermostats should be installed for interior temperature control and should have the following features:

(a) Thermostats should be ENERGY STAR labeled.

(b) Separate weekday and weekend programs, each with up to four customized temperature settings – two for occupied periods and two for energy-saving periods when the house is unoccupied and/or when the occupants are sleeping.

(c) Thermostat must have ability to maintain room temperature within 2°F of set temperature.

(d) Thermostat must have a hold feature that allows users to temporarily override the programmed settings without altering or deleting them.

(e) The maximum recommended setback is 8-10°F.

4.5.2 If an existing electronic thermostat has settings to improve comfort and increase efficiency – such as cycles per hour or cycle times – the service technician should adjust these settings for maximum comfort and efficiency.

4.5.3 **Verification.** Check for proper placement and operation when servicing the furnace.

4.5.4 **Benefits.** Savings for temperature offset vary depending on climate, equipment, and house envelope characteristics. Studies have demonstrated savings from 1-3 percent per 1°F of eight-hour offset for heating (for temperature offsets within a range of 5-10°F). Two eight-hour setback periods per 24-hour period double the savings.

4.5.5 **Discussion.** Significant temperature setback in some cases can lead to moisture problems because indoor surface temperatures decrease during temperature setback, increasing the chance of the condensation of water vapor on these surfaces.

4.6 Thermostat Anticipator Control: Specification.

Space heating thermostats have anticipators as a feature. Thermostats with adjustable analog anticipators should have the anticipator set to the manufacturer's recommended setting. If no manufacturer's recommendation is available, set the anticipator within a range of 1.0-1.25 times the thermostat circuit current.

4.6.1 **Verification.** With amperage meter, check amperage at thermostat until current is stabilized. Set anticipator accordingly.

4.6.2 **Benefits.** The proper adjustment of a thermostat anticipator can save as much as 2 percent of energy consumption, increase occupant comfort, extend the life of the heating equipment and reduce the chance of corrosion occurring in the combustion vent system.[2]

4.7 Access for Maintenance: Specification.

4.7.1 When installing a furnace, adequate clearance should be provided on all sides to allow for easy access for periodic inspection and maintenance. Items requiring maintenance include filters, heat exchangers, air-handler blowers, refrigeration coils, and controls.
4.7.2 All doors leading from the mechanical room to the outdoors should be large enough to allow easy passage of equipment.
4.7.3 **Verification.** Visual inspection and measurement.
4.7.4 **Benefits.** Adequate clearance for the maintenance of important equipment components allows the equipment to be serviced properly and regularly, thereby ensuring the maintenance of maximum equipment efficiency.
4.7.5 **Discussion.** If technicians do not have easy access to equipment components that require periodic inspection and cleaning, these components will go without service and equipment efficiency will suffer. Unfortunately, technicians frequently are provided with too little space to install the equipment with adequate clearance for maintenance. If possible, it is best if the installing technician is part of the design team so that it can be ensured there is ample space for the equipment, ductwork, and proper maintenance.

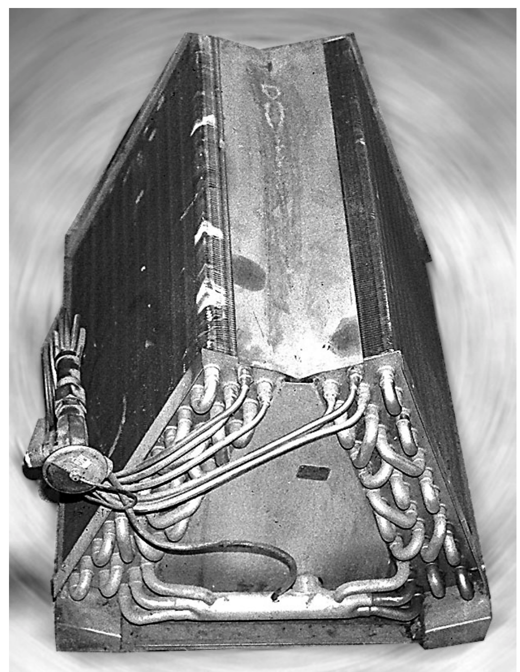
4.8 Maintenance Items: Specification.

4.8.1 Follow manufacturer's regularly scheduled maintenance program guidelines.
4.8.2 All equipment literature, including installation instructions and maintenance records, should be affixed to the equipment by means of a plastic storage pocket or other appropriate means.
4.8.3 The following items should be inspected and properly maintained at annual servicing for maintaining system efficiency.

(a) **Steady-state efficiency test.** At each servicing, a steady-state efficiency test should be performed with the proper efficiency testing equipment. This testing is not required for condensing furnaces. Steady-state efficiency should be within the range recommended by the manufacturer of the equipment.

(b) **Filters.** Verify with visual inspection whether filter requires cleaning or replacement

Access for maintenance



A-coils, mounted in plenums, can be very difficult to access for cleaning, especially with upflow furnaces. Since both duct airtightness testing and airflow testing depend on an unobstructed duct system, a plugged and neglected evaporator coil is a major energy and comfort problem. Coils may need to be removed to be cleaned, involving refrigerant recovery. Or, the furnace can be moved out from under the ductwork temporarily, after the ducts and a-coil are reinforced to hang without the furnace's support.

(1) Clean or replace filter(s) as required. Do not attempt to clean a one-time-use, throwaway filter.

(2) Make sure the filter compartment(s) are tight fitting. Make tight fitting or seal as necessary.

(3) If appropriate, educate occupants about recommended filter cleaning or changing.

(c) **Furnace gas manifold pressure.** Verify with gas pressure test.

(1) Turn the combination gas valve to the "pilot" position so that no gas flows through the control valve. Locate the pressure tap plug on the gas valve or manifold. Remove the plug and connect your manometer. The manometer must be calibrated in inches of water pressure. Check the manufacturer's specifications for normal operating manifold pressure. This is usually 3-4 inches of water for natural gas units, 10-11 inches of water for propane units.

(2) Turn the valve control knob to the "on" position. Turn up the necessary thermostat(s) so the furnace will fire. Check the pressure on your manometer. If adjustment is required, locate and remove the cap covering the pressure regulator adjustment screw on the combination gas valve. Adjust pressure upward or downward, as necessary.

(3) Make sure the movement of the adjustment screw affects the pressure reading on your manometer. If it does not, or if the pressure wavers when you are not moving the adjusting screw, replace the gas pressure regulator.

(4) Do not operate the appliance at a different gas pressure than that recommended by the manufacture.

(5) Finally, turn the control knob back to "pilot," remove your manometer from the pressure tap, replace the tap plug and return the control knob to the "on" position.

(d) **Burner orifices**. Make sure the burner orifices are properly sized for the gas type and burner input.

(e) **Heat-exchanger temperature rise**. Verify heat-exchanger temperature rise is within the recommended range. See Section 4.2 for details.

(f) **Cooling evaporator coil.** Inspect for cleanliness and clean, if necessary. See Section 3.12.3 (b) for details.

(g) **Blower thermostat control.** Verify proper operation and settings. See Section 4.3 for details.

(h) **Air-handler blower belts.**

(1) Check for wear, slippage and proper alignment.

(2) Adjust belt tension or replace belt if required.

(i) **Air handler blower motor.**

(1) Lubricate according to manufacturer's recommendations.

(2) Check the blower motor and blower bearings, whether belt-driven or direct-drive, with the power off.

[i] Hold the motor casing with one hand and grab the shaft with the other hand. Move the shaft up and down and side to side. The shaft will, under normal conditions, slide in and out of the motor case a slight amount. However, if there is excessive "play" or movement (side to side), or if there is a "sticky" spot as you spin the shaft, the bearings are bad. It is recommended that the motor be replaced rather than trying to rebuild the existing motor.

[ii] Belt-driven blower bearings can be checked by turning off the power to the blower, disconnecting the belt, and spinning the blower with your hand; the blower wheel should rotate several times on its own. If the bearings are bad, replace them.

(j) **Air-handler blower vanes**.

(1) Check for proper rotation of blower. Adjust if necessary.

(2) Check for buildup of dust, dirt and debris. Any dirt buildup on the blower vanes will greatly reduce airflow.

(3) Clean if necessary.

[i] Turn off power to blower.

[ii] Clean blower vanes using a brush, vacuum, or hot water. If water or cleansers are used, rinse the blower components and allow them to dry before proceeding. Protect the blower motor from water and chemicals.

[iii] When the blower is extremely dirty, the blower assembly should be removed, separated from the blower motor and thoroughly cleaned. Allow the blower components to dry before proceeding. Reinstall the blower assembly and motor.

[iv] Turn power to the blower unit back on.

[v] Check and adjust airflow if necessary.

(k) **Controls**. Verify the proper operation of all controls, including comfort thermostats, comfort thermostat anticipators, and furnace blower fan and limit control. See Sections 4.4, 4.5, and 4.6.

4.8.4 **Benefits.** Proper maintenance of equipment and controls will retain system efficiency, extend the life of the equipment, and ensure occupant comfort.

4.8.5 **Discussion.** The maintenance items listed here can impact system efficiency. Not all maintenance items are included here, especially those not directly influencing system efficiency.

Verification Tests

4.9 Tests for Ensuring Proper Air-Handler Airflow.

4.9.1 **Duct-Blower Test for Ensuring Proper Airflow.**

(a) **Objective of test.** The measurement of air-handler airflow. The most accurate test of the air handler airflow is to use the duct blower in conjunction with the air handler's blower. Airflow is measured after duct-leakage testing and duct sealing because measuring airflow in leaky ducts is inaccurate. During the test, the return is blocked so all return air comes through the duct blower where the airflow can be measured.

(b) **Required equipment.**

(1) Duct blower, a fan-powered flow-measuring device.

(2) A digital or analog manometer and tables for translating pressures to flows. The tables for the specific duct blower being used.

(3) A contractor using an approved aerosol applied duct sealant system may use the aerosol system manufacturer's computer-driven diagnostics program and protocol.

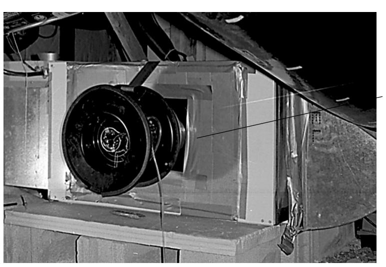
(c) **Setup.**

(1) Set up a static pressure gauge to measure the duct pressure at the supply plenum, or a few feet away from the supply plenum, in a main supply trunk with reference to the house. Once the measurement probe is located properly (select a location that gives the highest pressure), tape the static pressure probe to hold it in place. The openings in the probe must be perpendicular to the airflow in the plenum or duct.

(2) Make sure all supply registers and return grilles are open and not taped. Leave filters installed. If filters are dirty, replace or clean.

Connecting the duct blower

Connecting the duct blower to a single central return gives an accurate airflow reading as long as the ducts have been sealed to specifications listed in Chapter 5.



Blocking the return plenum and connecting the duct blower directly to the air-handler cabinet works well for systems with more than one return register.

(3) Perform required duct sealing to conform to standards explained in Section 5.13.1 before measuring airflow.

(d) **Conducting the test.**

(1) Turn on the system air handler by setting the thermostat fan switch to the "on" position. Systems without a fan "on" switch will need to run in cooling mode to operate at the higher of two speeds (heating usually uses a lower speed), or in heating mode for heating-only systems. If the air handler provides both heating and cooling, make sure you activate the fan speed for the appropriate application – heating or cooling. A useful verification check is to clamp an ammeter around the color wire you think corresponds to heating or cooling to determine if the wire is energized. Proceed with the test.

(2) Make sure the system air handler is on higher speed (for cooling). Measure and record the normal operating duct static pressure with reference to the house. This is the reference pressure, Psp, to be used later. Do not remove the static-pressure probe after this measurement.

(3) Shut off power to the air handler. Connect the duct blower to blow into the single return register or into the air handler at the blower compartment. All the return air should now come through the duct blower. Use the following procedures to connect the duct blower.

[i] For single-return systems: Remove the grille at the single return register. Connect the duct blower through its flexible tube or directly to the register.

[ii] For multiple-return systems: Block the return plenum's main return entry to the air handler. Filters are often located in a good location for this temporary blockage. Alternatively, the main return can be disconnected and supported temporarily, while this large duct is moved slightly to

block its opening into the air handler. If the duct blower is connected to an air handler, located outside the conditioned space, the door or access panel between the conditioned space and the air handler location must be opened.

(4) Turn on the air-handler fan. Make sure the air-handler fan is running on its normally higher speed – at the speed corresponding to your desired airflow test – heating or cooling.

(5) Turn on the duct blower to blow into the air handler, increasing airflow until the manometer measuring supply-plenum static pressure reads the same as in Section 4.9.1 (d)(2), Psp, with reference to the house.

(6) Measure and record the airflow through the duct blower. Refer to the duct-blower instruction book, if necessary. This is total system airflow in cubic feet per minute (CFM).

[i] If supply-duct pressure cannot be achieved with the duct-blower fan and the air-handler fan turned on, remove the flexible duct extension – if you have used it – from the duct blower, and connect the duct blower directly to the air-handler compartment. If high enough pressure still cannot be reached, proceed to the next step, Section 4.9.1 (d) (7) [ii].

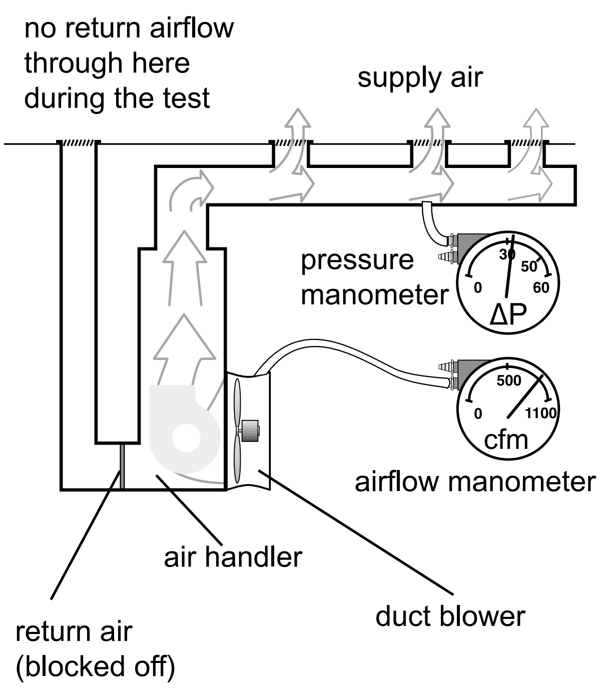
[ii] With the duct-blower and the air-handler fans turned on, measure and record the following: a) the maximum pressure (Pmax) with reference to the house, and b) the maximum duct blower-fan flow in CFM (Bmax) at the maximum pressure, Pmax. Then use the equation below in the sidebar to estimate total air-handler airflow, Q.

(e) **Interpreting the results.** This airflow measurement should yield an accuracy of ±5 percent or better.

4.9.2 **Flow Hood Test for Ensuring Proper Airflow.**

(a) **Objectives of test.** This test measures the fairly laminar airflow at return registers. Measuring supply-register airflow isn't as accurate because supply air is more turbulent and because supply registers along walls don't allow the flow hood to be centered over them. The flow-hood inlet must be larger than the return registers, although 10 percent of the register may be blocked with tape to allow the flow hood to cover the entire opening.

System airflow test using the duct blower



The duct static pressure achieved during normal operation is reproduced, using the duct blower. The return is blocked when it isn't used to connect the duct blower, so that all the system's air must travel through the duct blower where it is measured by the airflow manometer.

(b) **Limitations of test.** This test works best on systems with one to four return registers located in areas where a flow hood can cover the registers and be centered over them. Return airflows should be well within the range of the flow hood's accuracy.

(c) **Setup.** Perform required duct sealing to conform to standards explained in Section 5.13.1 before measuring airflow.

(d) **Conducting the test.**

(1) Turn on the air handler to run at the higher fan speed, normally used for cooling.

(2) Center the flow hood over the return register, covering it completely. If the register is larger that the flow hood, seal up to 10 percent of the register with tape before covering it.

(3) Read and record the airflow. Add together the airflows of the return to get the total system airflow.

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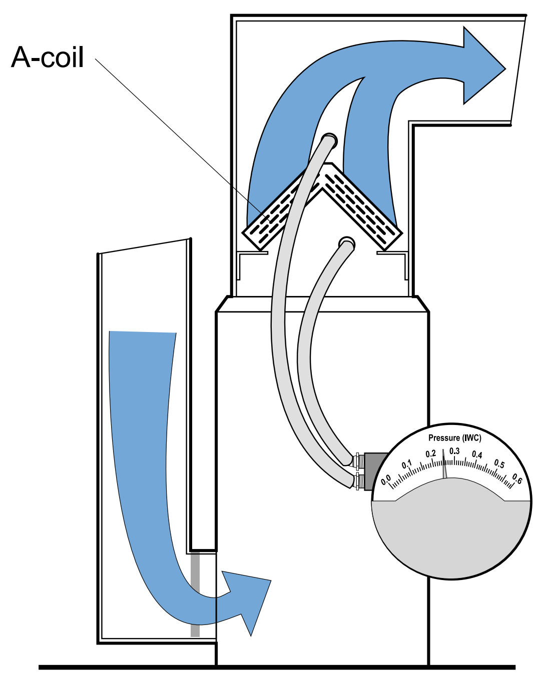
[1] J. Thorne, *Improving Residential Gas Furnace and Boiler Installation Practices: Final Report* (American Council for an Energy-Efficient Economy for the Consortium for Energy Efficiency, 1998), p. 6.

[2] J. Proctor, *Pacific Gas and Electric Appliance Doctor Pilot Project: Final Report* (Pacific Gas and Electric Company, San Francisco, 1991).

Static pressure across A-coil



Measuring this static-pressure difference can estimate airflow and detect dirt, especially if manufacturer's graphs or tables are available.

Chapter 5 – Ducts and Air Handlers

5.1 Duct Location: Specification.

5.1.1 Locate all ducts within the conditioned spaces (living areas) and semi-conditioned spaces of the building.

Exception: Ductwork may be located in unconditioned spaces, such as garages, attics or crawl spaces, if it is not possible to install it within conditioned or semi-conditioned spaces. Ductwork located in these areas will need to be heavily insulated and airtight to be efficient.

5.1.2 Ducts should not be located in exterior wall cavities.

5.1.3 All distribution-air enclosures must be hard-ducted, that is, building-framing cavities, closets, crawl spaces, and chases must not be used as distribution-air enclosures. However, ductwork may be housed by, or pass through these spaces.

5.1.4 Panned floor joists should not be used for air distribution.

5.1.5 A crawl space should not serve as a distribution plenum.

5.1.6 Existing crawl-space plenums should be abandoned and replaced with a sealed duct system.

5.1.7 **Benefits.** Duct-system efficiency depends on duct leakage, insulation levels, surface area, location and thermal conditions surrounding the ducts. Ductwork located within conditioned or semi-conditioned spaces loses less energy by conductive heat transfer and leakage than if located in unconditioned spaces, such as attics, garages or crawl spaces. Ducts located in exterior walls prevent the full insulation of the cavity within which they are located and are likely to allow a high level of heat transfer between the ducted air and the outdoors, either by conduction or air leakage. Building cavities, like floor-joist cavities and crawl spaces, are unlikely to be airtight. Avoiding their use as ducts and plenums produces tighter duct systems.

5.1.8 **Strategy.** Lay out the duct system on a floor plan, accounting for the direction of joists, hip roofs, firewalls and other possible obstructions. Determine supply register and return grille locations and types, duct lengths and connections for the installation of an efficient, cost-effective duct system given the construction limitations.

Duct sizing with rules of thumb?

Some contractors resort to using “rules of thumb” for sizing. Improper duct sizing can lead to customer discomfort and/or wasted money on ducts that are too large. However, unlike sizing cooling and heating systems that have a set output, air handler blower speeds can usually be adjusted and ducts can be throttled back with volume dampers if they are too large. Some reputable installers install ducts that are slightly oversized. They then fine-tune – balance – the distribution system with the branch volume dampers.

Duct installation warnings

- Don’t use crawl spaces as plenums
- Don’t use a dropped ceiling cavity as a plenum
- Don’t use panned floor joists for returns or supplies
- Don’t run ducts in exterior wall cavities,
- Don’t use any building cavity as a duct (may be used as duct chase)
- Don’t run a combustion appliance vent through a duct
- Don’t operate an air handler without return ductwork

Undersized return grilles

Return grilles are often sized too small. This can lead to restricted airflow, pressure imbalances, system inefficiency and occupant discomfort.

Size filter grilles for 2 CFM per gross square inch and non-filter grilles for 2.5 CFM per gross square inch.

Source: *Comfort, Air Quality, and Efficiency by Design* (Manual RS), by Air Conditioning Contractors of America.

5.2 Duct System Design: Specification.

Ducts, supply registers and return grilles should be sized and selected with the use of *Residential Duct Systems*, Manual D, 1995 or later, by ACCA; Residential *Comfort System Installation Standards Manual*, 1998 or later, by SMACNA; or a comparable industry-accepted method. Before duct sizing can be calculated, individual room loads should be done with the most recent edition of *Residential Load Calculation*, Manual J, by ACCA, or a comparable industry-accepted method.

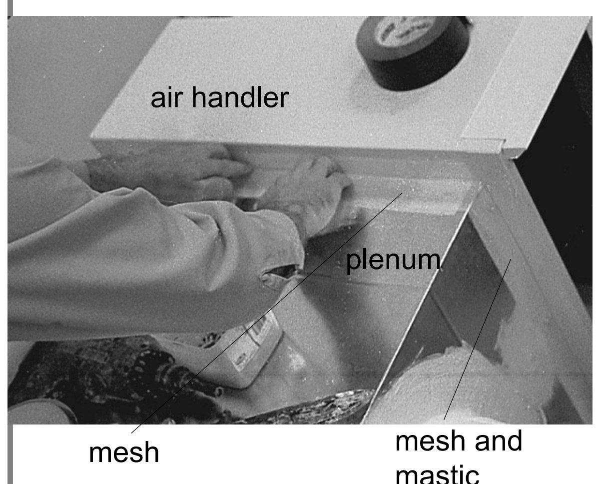
5.2.1 **Verification.** Use Manual D and Manual J procedures for verification before installation. Airflow and static pressure should be as specified by the equipment manufacturer.

5.2.2 **Benefits.** If ducts are undersized for adequate airflow, system efficiency can be adversely affected. In addition, occupant comfort may be reduced and complaints are likely to increase. Careful duct system layout and sizing can reduce static-pressure losses. As a result, the blower often can be operated at lower speeds, in turn reducing the power required to move the correct quantity of air through the heat exchanger, filter or coil.

If ducts are oversized, material installation costs are higher, putting the installer in a less competitive position. Properly sized ducts provide

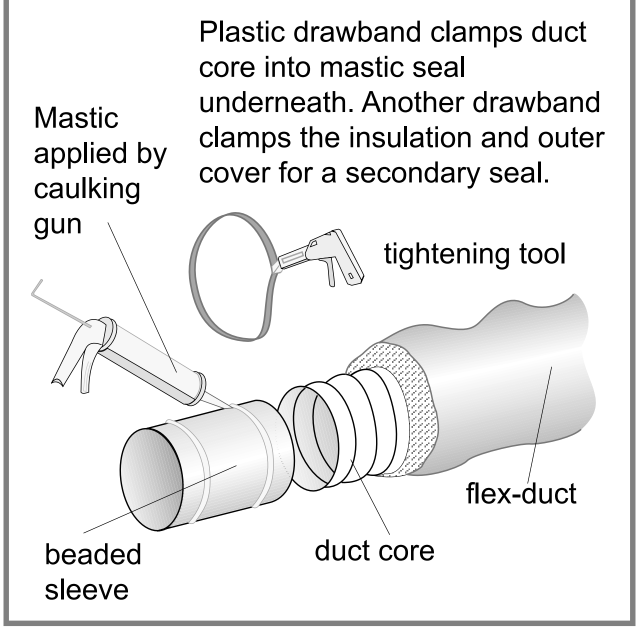
Sealing joints in metal plenums

Applying fabric mesh before spreading mastic provides this large joint with a strong and airtight seal. Airtight ducts are one of the key ingredients to a comfortable and energy-efficient home.



Sealing plenums to air handlers and sealing openings in the air handlers themselves is essential for constructing an airtight duct system.

Joining flex-duct to itself



conditioned air where it is needed quietly and efficiently.

5.2.3 **Discussion.** Using a mathematical sizing procedure, such as in Manual D, requires know-how and time. If a designer performs many duct-sizing calculations each week, he or she will become proficient quickly. However, many system designers/installers for small-to-medium-sized businesses do not find the need to do duct sizing calculations frequently, so are likely to find the process time consuming and difficult. Many equipment suppliers offer free duct-sizing service to their installers. If such a service is used, it is vitally important that the installer provide accurate job information to the person sizing the ducts.

5.3 Leakage, Ducts and Plenums: Specification.

5.3.1 **Allowable Leakage, Air Distribution Systems.**

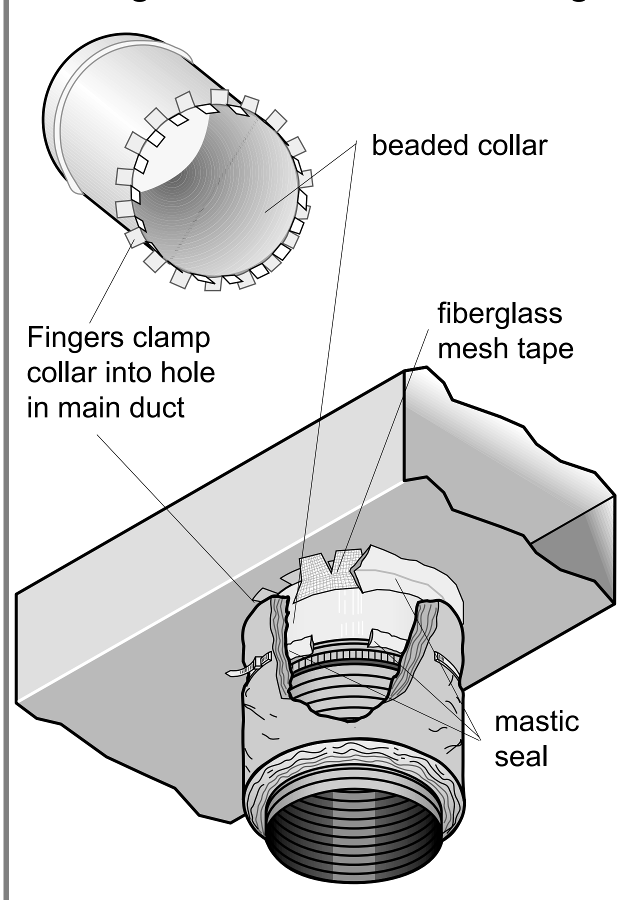
(a) **Method 1.** Duct Leakage per 400 CFM Airflow: No more than 25 CFM of leakage (the sum of supply and return leakage) for each 400 CFM of measured airflow across the indoor coil and/or heat exchanger for new ducted systems or no more than 40 CFM of leakage for each 400 CFM of measured airflow across the indoor coil and/or heat exchanger for existing ducted systems.[1]

(b) **Method 2.** Duct Leakage to Airflow Percentage: The sum of supply and return leakage divided by the measured air handler fan flow shall be no more than 6 percent for new ducted systems or no more than 10 percent for existing ducted systems.[2]

5.3.2 **Verification.** Use Total Duct Leakage and Percentage Duct Leakage Test. Refer to Section 5.13.1.

5.3.3 **Benefits.** Properly sealing ducts and plenums with traditional duct sealing techniques

Joining flex-duct with metal fittings



of hand-applying sealant to seams, among others, can save 10 percent in existing homes and 15 percent for new homes.[3] If duct leakage is reduced, cooling and heating equipment can be downsized for additional savings. Reducing leakage can also increase cooling and heating output at registers. Savings are greater for new than for existing installations because retrofitters do not have full access to duct, plenum, and boot joints.

The Electric Power Research Institute states that energy savings from duct improvement measures will save the average customer $300 per year. The US Department of Energy states that energy wasted from leaking residential ducts is equivalent to the energy used by 13 million cars each year. In addition, tighter ducts can reduce the entry of dust, excess humidity, basement and garage fumes (including car exhaust), and radon gas in affected regions.

Research results indicate an average increase in duct delivery efficiency from 64 percent to 76 percent results in a corresponding decrease in HVAC energy use of 18 percent.[4]

5.3.4 **Correction Strategy.**

(a) All joints and seams of ductwork and plenums should be sealed with approved material. Refer to the supplementary document *Duct Installation and Sealing Specification* for details.

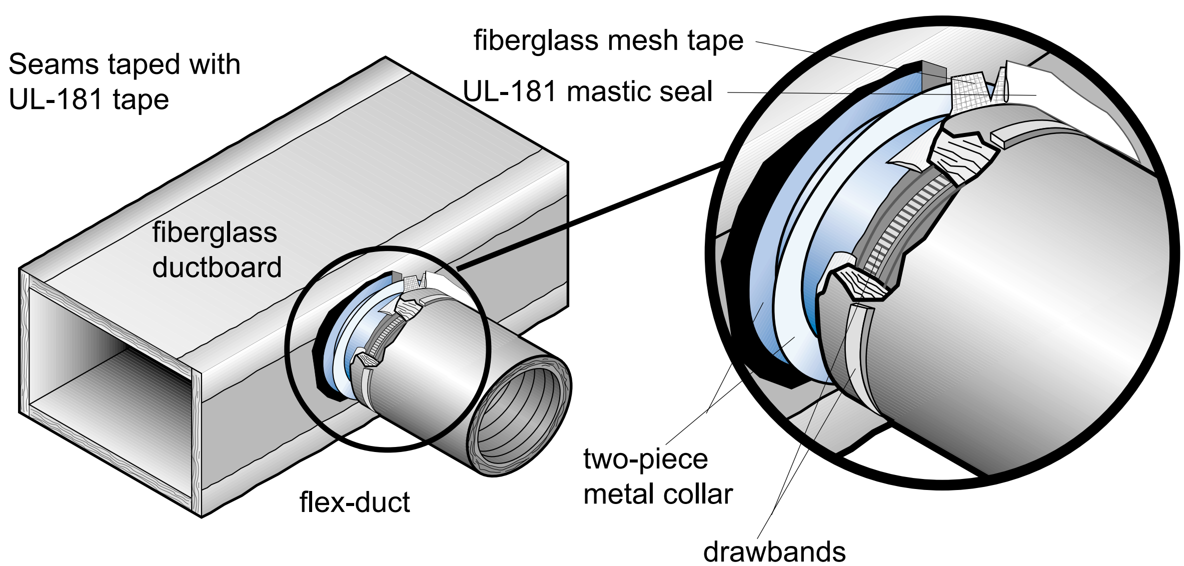
(b) Verify cooling coil airflow and/or heat exchanger temperature rise after sealing ducted distribution system.

5.3.5 **Discussion.** Repairing duct leaks should proceed in a cost-effective manner, that is, the largest and easiest-to-fix leaks should be treated first. An example of this type of leak is a joint disconnection. Secondly, leaks experiencing the greatest pressure differentials during air-handler operation should be sealed. These include leaks close to the air-handler blower, such as those at the supply and return plenum. Next, move on to less significant leaks.

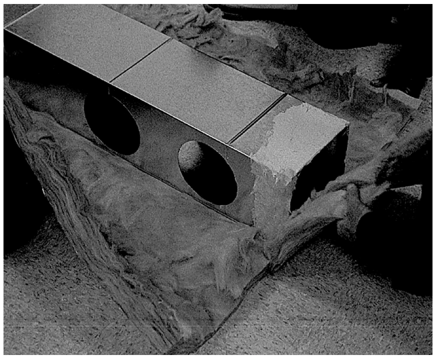
5.4 Duct-Sealing Materials and Methods: Specification.

Please refer to *Duct Installation and Sealing Specification*, a supplement to this Specification.

Joining flex-duct to fiberglass ductboard

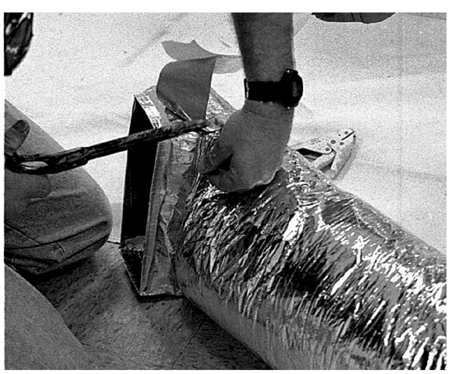


Insulating new ducts



Duct trunks are easier to insulate before they're installed. After ducts are installed, hangers and other obstacles can make installing insulation difficult.

Insulating boots and fastening them to flex-duct is another effective prefabrication that is easier to perform outside an attic or crawl space.



Making a tight seal between the flex-duct's insulation and the boot's insulation is important for preventing condensation from damaging the insulation during the cooling season.

5.5 Duct and Plenum Insulation: Specification.

5.5.1 Insulation, New and Existing Installations: Specification.

(a) Duct and plenum insulation should be installed according to the supplementary document *Duct Installation and Sealing Specification.*

(b) All duct insulation R-values should be based on insulation only, excluding air films, vapor barriers or other duct components.

(c) All thermal insulation should be installed without voids, gaps or tears.

(d) All insulation should be installed according to the manufacturer's recommendations, ensuring durability and rated insulation R-value. Existing ductwork should be insulated in accordance with the ENERGY STAR *Specification for Existing Ductwork* and *Duct Installation and Sealing Specification.* If any elements of this Specification and the two listed just above conflict, the most stringent element shall be followed.

(e) Any insulation installed on the exterior of a building exposed to the weather must be protected from degradation by the weather.

(f) **Verification.** Visual inspection.

(h) **Benefits.** Duct-system efficiency depends on duct leakage, insulation levels, surface area, location and thermal conditions surrounding the ducts. Ductwork located where significant temperature differences exist between the air in the duct and the air surrounding the duct – such as attics, garages or crawl spaces – experiences significant conductive heat transfer unless insulated properly. The R-value levels selected for this specification are cost effective.

5.5.2 Insulation, New Installations: Specification.

(a) Supply and return ducts and plenums in conditioned spaces do not require thermal insulation.

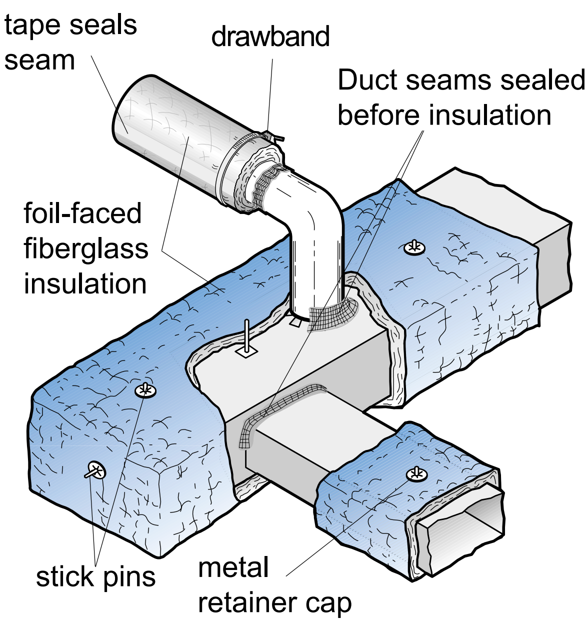
Exception: Where needed, ducts should be insulated to prevent condensation on duct surfaces. Insulation used for this purpose should have a vapor barrier on its surface closest to the outside.

(b) Supply and return ducts, plenums and distribution boxes in unconditioned spaces should be insulated with a minimum R-value of 6.

(c) Supply and return ducts, plenums and distribution boxes located on the exterior of the building (such as a packaged system having some ductwork outdoors) should be insulated to at least an R-8 value.

(d) **Verification.** Visual inspection of insulation to ensure that the actual R-values meet these requirements. Check for excessive compression of insulation and insulation voids, both of which decrease overall insulation effectiveness.

Insulating existing ducts



Exterior foil-skrim-kraft (FEK) duct insulation is attached to existing metal ducts with stick pins or drawbands. FSK tape is used to seal seams in the insulation.

5.5.3 Insulation, Existing Installations: Specification.

(a) Supply and return ducts and plenums in conditioned spaces do not require thermal insulation.

Exception: Where needed, ducts should be insulated to prevent condensation on duct surfaces. Insulation used for this purpose should have a vapor barrier on its most external surface.

(b) Supply and return ducts, plenums and distribution boxes in unconditioned spaces should be insulated with a minimum R-value of 6.

Exception 1: Inaccessible parts of the distribution system do not require thermal insulation. Inaccessible means nearly impossible to insulate because of location or obstructions.

Exception 2: If ducts are already thermally insulated to a level of R-4 or greater, no additional insulation is required.

(c) Supply and return ducts, plenums and distribution boxes located on the exterior of the building (such as a packaged system having some ductwork outdoors) should be insulated to at least an R-8 value.

(d) **Verification.** Visual inspection of insulation to ensure that the actual R-values meet these requirements. Check for excessive compression of insulation and insulation voids, both of which decrease overall insulation effectiveness.

5.6 Room-Pressure Imbalances: Specification.

Pressure differences during air-handler operation between 1) closed rooms and the outdoors, and 2) between the main body of the house and outdoors with all interior doors closed should be no more than 0.01 inches water gauge (3 Pascals), positive or negative.

5.6.1 **Verification.** Check pressure difference from each room to the outdoors using Room Pressure Imbalances Test. Refer to Section 5.14. This test should always be done after the ductwork is sealed.

5.6.2 **Correction Strategy.** If the pressure difference is more than 0.01 inches water gauge (3 Pascals), provide for pressure relief (bring the pressure difference down to a magnitude of 0.01 inches water gauge, or less) by one of the following methods:

(a) Undercut door by appropriate amount or add a transfer grille to the door.

(b) Install pass-over or pass-under transfer ducts in attics, basements, crawl spaces, or tuck-under garages.

(c) Design and install a wall transfer grille between the room and the main body of the house. (Note: Grilles with sound-dampening capabilities are prefered.)

(d) Add a return-air grille or supply-air register to the room.

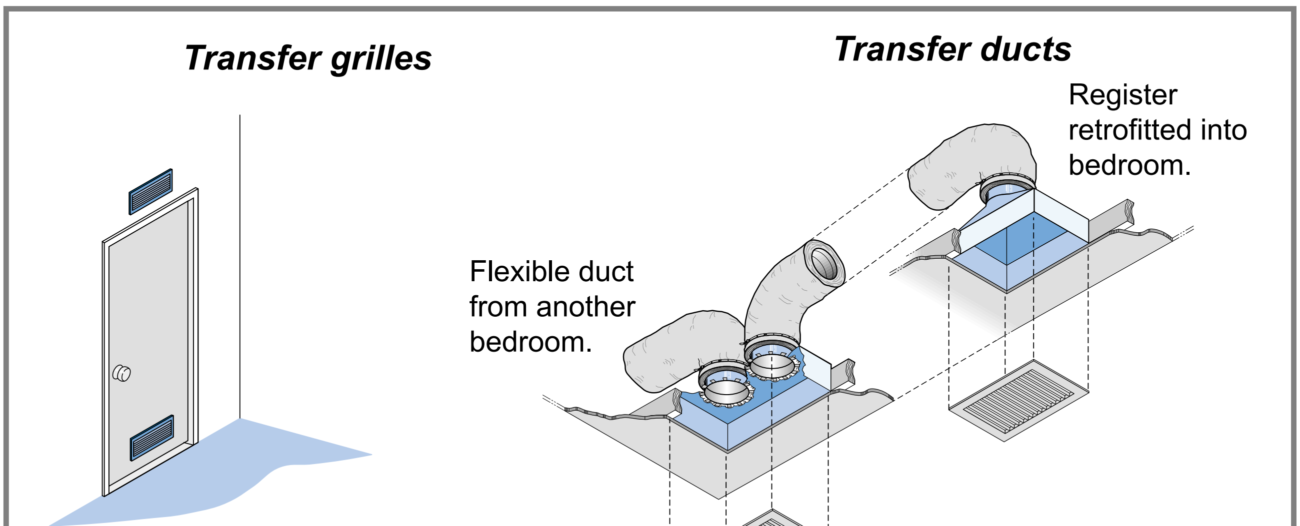
(e) Install a jumper duct.

5.6.3 **Benefits.** Restricted airflow between spaces in a house during air handler operation pressurizes some spaces and depressurizes others. These pressure differentials can increase space-conditioning energy use by increasing exfiltration and infiltration and by causing the air handler to run longer. Field studies have demonstrated as much as a tenfold increase in house air leakage when interior doors are closed and the air handler is operating. Appropriate pressure relief not only decreases the space conditioning energy use, it also increases occupant comfort by increasing conditioned airflow to the room in question.

5.6.4 **Discussion.** If a room with a closing interior door has a supply register, but not a return grille, the closed interior door can block the pathway of supply air back to the return grille. The door acts as a damper to the proper airflow within the conditioned space, resulting in too-hot or too-cold temperatures and "stuffy" air quality.

5.7 Selection and Location of Supply Registers: Specification.

5.7.1 At least one supply-air register should be installed in each habitable room that can be



A transfer grille is installed through an interior door or wall to relieve the pressure, produced by the room's supply register.

closed off from the main body of the dwelling with a door. Each register should be of sufficient size and correct type to properly handle the required CFM and air velocity to meet the design heating/cooling requirements.

5.7.2 Supply registers should be selected to optimize room air distribution and duct static pressure while keeping air velocity below 700 feet per minute to control noise.

5.7.3 Supply registers should be selected for proper throw, drop and spread to maximize comfort and efficiency. Floor supplies should be located under windows. In cooling-dominated regions, ceiling and high side-wall supplies should be located some distance away from the exterior wall and designed for a throw that reaches the exterior wall.

5.7.4 **Benefits.** Reducing duct surface area – shorter length and reduced diameter – reduces duct leakage and conductive heat transfer, making the duct system more efficient. As building envelopes and windows have improved, the need to install supply registers under windows on exterior walls may no longer exist. If supply registers are installed on or near interior walls, duct runs can be reduced and system efficiency can be increased.

5.8 Selection and Location of Return Grilles: Specification.

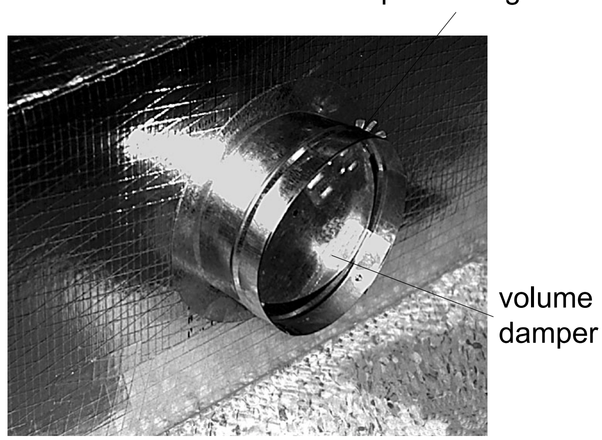
5.8.1 Return-air grilles shall be located to provide pressure-balanced air circulation during air handler operation.

5.8.2 Return grilles should be selected to optimize airflow within the occupied space and grille face velocity should be kept to 500 feet per minute or less.

5.8.3 It is preferred to place a return-air grille in every room having a supply-air register and an operable interior door, except for bathrooms and kitchens.

5.8.4 **Benefits.** The proper placement of return grilles reduces the occurrence of pressure imbalances between closed rooms during air handler operation. These pressure imbalances can increase space-conditioning energy use by increasing air leakage and causing the air-handler blower to run for longer periods. In addition, they can affect occupant comfort by adversely impacting indoor air quality.

Volume damper



Volume dampers allow final adjustment of measured room airflow, to match design room airflow.

5.9 Duct Support: Specification.

Please refer to the supplementary document *Duct Installation and Sealing Specification* for details.

5.10 Volume Dampers: Specification.

5.10.1 Supply branch ducts should be equipped with volume dampers to allow for manual balancing of the distribution airflow. The balancing dampers should be located at the takeoff end of the branch duct rather than at the supply-air register.

5.10.2 After installation, the distribution system should be balanced to ensure the maximum comfort for the occupants.

5.10.3 Volume dampers should have a means of fixing the position of the damper after the air distribution system is balanced.

5.10.4 **Servicing.** Check distribution balance at servicing. Interview occupants to determine if their thermal comfort is suffering from improper balancing.

5.10.5 **Correction Strategy.** If volume (balancing) dampers have not been installed, put one in each supply branch. After installation, balance the distribution system.

5.10.6 **Benefits.** Volume dampers allow the balancing of the air distribution after installation. This can significantly increase occupant comfort and increase the energy efficiency of the comfort-conditioning system by ensuring that the proper amount of conditioned air flows to each conditioned room.

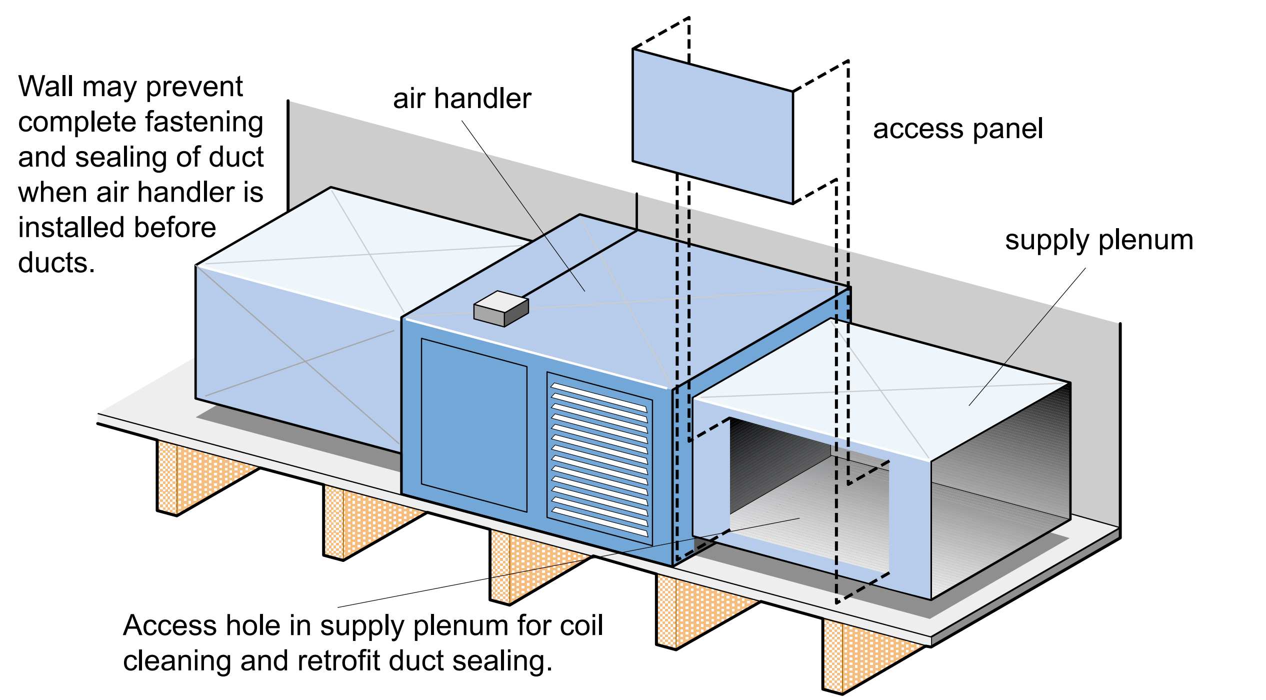
5.10.7 **Discussion.** When a conditioning system supplies both space heating and cooling, different air-handler blower speeds are used (usually a higher speed for cooling). Since few systems are re-balanced seasonally to adjust for the different air-handler airflow, a compromise must be made in the design and the balancing of the air distribution system. It is common to select the greater of the two airflow rates for the design of duct branches and registers serving each room. For the purpose of balancing, it is recommended that the higher of the fan speeds be used.

In houses where manual dampers need to be changed seasonally, an automatic zoning system with motorized dampers is the best way to achieve comfort. Two-story homes, homes with occupied basements, and homes with rooms that get intense sun, will need zoning. Zoning can also be done using multiple systems.

5.11 Access for Installation and Maintenance: Specification.

5.11.1 When installing the air handler and ductwork, adequate clearance should be provided on all sides to allow easy access for periodic maintenance. Items requiring maintenance include filters, heat exchangers, volume dampers, air handler blowers, refrigeration coils and controls.

Access for maintenance or retrofit duct sealing



5.11.2 All doors leading from the mechanical room to the outdoors should be large enough to allow easy passage of equipment.
5.11.3 **Verification.** Visual inspection at installation.
5.11.4 **Benefits.** Adequate clearance for the maintenance of important equipment components allows the equipment to be serviced properly and regularly, thereby ensuring the maintenance of maximum equipment efficiency.
5.11.5 **Discussion.** If technicians do not have easy access to equipment components requiring periodic inspection and cleaning, these components will go without service and equipment efficiency will suffer. Unfortunately, technicians frequently are provided with too little space to install the equipment with adequate clearance for maintenance. If possible, it is best if the installing technician is part of the design team so ample space for the equipment and ductwork is ensured. During construction, personnel installing the ductwork should have the first opportunity to work in tight spaces, such as framing cavities and chases, because ducts are larger and less flexible than plumbing pipes and electrical wires.

5.12 Maintenance Items: Specification.

The following items should be inspected and properly maintained and adjusted at annual servicing for the purpose of maintaining system efficiency.
5.12.1 **Filters.** Verify with visual inspection whether filter requires cleaning or replacement.
(a) Clean or replace filter(s) as required. Do not attempt to clean a one-time-use, throw-away filter.
(b) Make sure the filter compartment(s) are as tight as possible.
(c) If appropriate, educate occupants regarding recommended filter cleaning or changing.
5.12.2 **Duct obstructions and debris.**
(a) Check registers and grilles for blockage by carpeting, rugs, furniture or other obstructions.
(b) Check register and grille boots for clothing, toys or other obstructions.
(c) Clear ducts of any obstruction.
(d) Educate occupants, if necessary, about obstructing the flow of distribution air out of supply registers and into return grilles.
5.12.3 **Duct leaks and duct disconnections.**
(a) Check by visual inspection and repair, if required.
(b) Other tests may indicate significant duct leaks. These include static-pressure changes, indoor-coil airflow rate or temperature rise across the furnace heat exchanger. If any of these tests indicate significant leakage or disconnection, find and repair them.
5.12.4 **Volume dampers.** Check for proper placement, operation, and position.
(a) If volume dampers have not been installed in supply branches, install if proper balancing is not possible without them.
5.12.5 **Balancing.** Check for proper system balance, room by room, for heating and cooling. Balance with volume dampers if required.
5.12.6 **Duct sealing materials.**
(a) Check the integrity of duct-sealing materials wherever you are able to visually inspect.
(b) Other tests may indicate significant duct leakage resulting from failed duct-sealing materials. These tests include static pressure changes, indoor-coil airflow rate or temperature rise across furnace heat exchanger.
(c) Replace or repair duct-sealing materials, if necessary.
5.12.7 **Duct Insulation.**
(a) Check the integrity of duct insulation and vapor barrier wherever you are able to visually inspect.
(b) Replace or repair if necessary. See

Section 5.5 for details.

5.12.8 Check room-pressure differences after installation and at servicing. See Section 5.6 for details.

5.12.9 **Benefits.** Proper maintenance of the forced-air distribution system will help retain system efficiency, extend the life of the equipment and ensure occupant comfort.

Verification Tests

5.13 Tests for Ensuring a Tight Ducts.

5.13.1 **Duct Leakage per 400 CFM Airflow and Duct Leakage to Airflow Percentage Tests.**

(a) **Objectives of tests.**

(1) **Method 1.** Duct Leakage per 400 CFM Airflow: To determine total sum of supply and return leakage from ducted distribution system to surrounding areas and the amount of this leakage per 400 CFM of measured air-handler airflow.

(2) **Method 2.** Duct Leakage to Airflow Percentage: To determine total sum of supply and return leakage from ducted distribution system to surrounding areas and the percentage of this leakage to the total air handler airflow. The leakage test shall be performed at a pressure difference of 0.1 inch water gauge (25 Pascals).

(b) **Required equipment.**

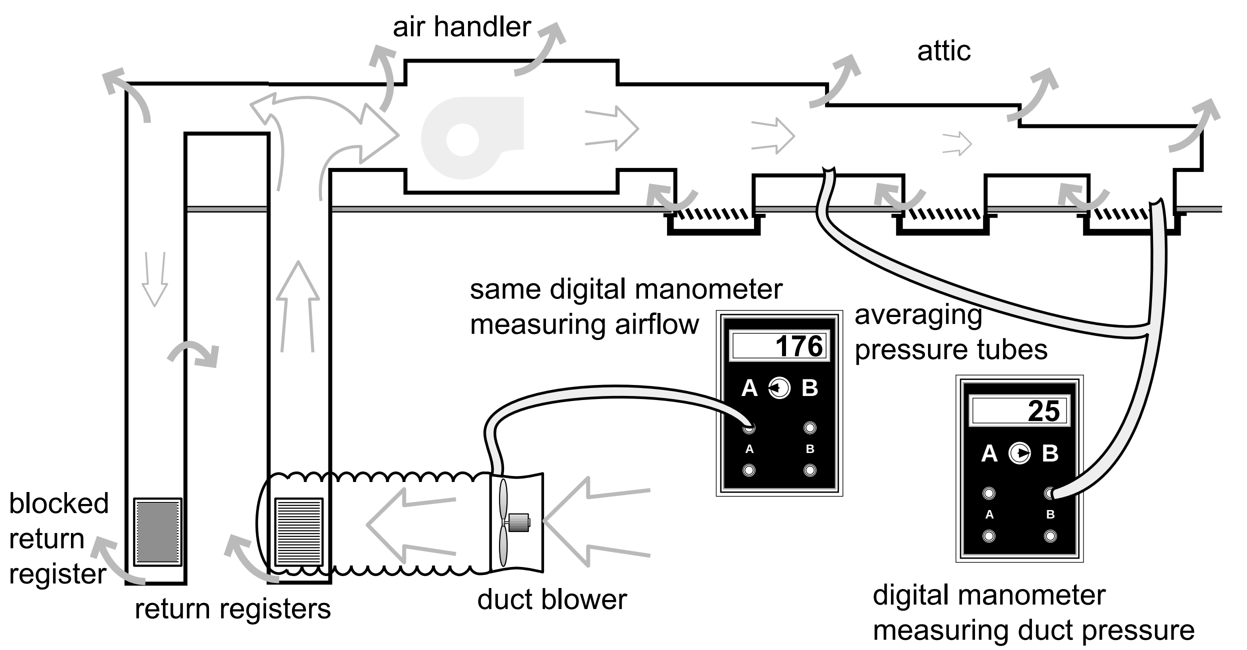
(1) Duct blower.

(2) Digital manometer with hoses.

(c) **Setup.**

(1) Any door or access between the conditioned space and locations containing ducts shall be closed if the ducts are in unconditioned space (example: attic access panels must be closed). If the duct location is conditioned (example: conditioned basements) the door or access shall be opened during the test.

Measuring total duct air leakage



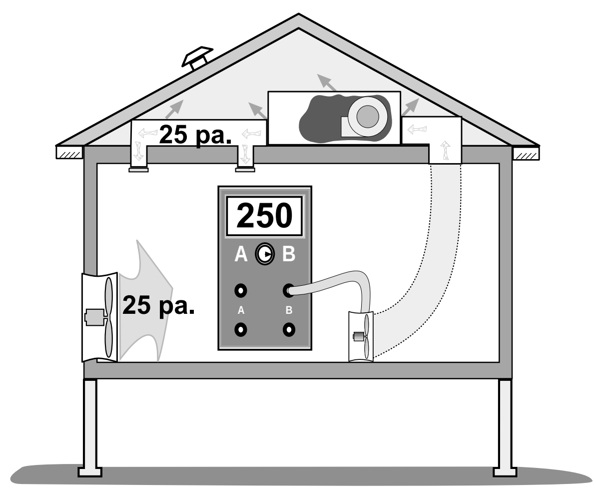
The duct blower pressurizes the sealed duct system through one of two return registers. At 25 Pascals of duct pressure, these ducts have 176 CFM_{25} of duct air leakage.

(2) Seal all the supply registers and return grilles, being careful not to damage floor, wall and ceiling finishes.
(3) Open a window or door to outside. If the duct blower is attached to the duct system in a garage, then the garage door to outside shall be opened. If ducts are in an unconditioned basement, then the basement door or windows to outside shall be opened. If ducts are in the attic, air must be able to flow freely from the attic space to the outdoors.

(d) **Conducting the test.**
(1) Attach the duct blower to the duct system at the air handler blower access so as to pressurize the duct system. If the system fan access is unsuitable for connecting the duct-pressurization device, then make the connection at the return grille nearest to the return plenum.
(2) Install a duct pressure probe at both a supply and a return grille or supply and return plenums. Then connect the probes to a manifold using equal lengths of hose to average the pressures in supply and return.
(3) Adjust the duct-blower airflow until the pressure between the ducts and the surrounding area is 0.1 inch water (25 Pa).
(4) Record duct-blower airflow: This airflow is the sum of supply and return duct air leakage at 0.1 inch water (25 Pa).
(5) Method 1. Duct Leakage per 400 CFM Airflow: The maximum leakage allowed is found by dividing the measured air handler airflow (see Sections 3.13 or 4.9, Tests for Ensuring Proper Air-Handler Airflow) by 400 CFM. This quotient is then multiplied by 40 for existing duct systems or 25 for new duct systems. The duct-blower airflow (duct leakage CFM) from Section 5.13.1 (d)(4) must be equal to or less than this value. For example, if the measured air handler airflow is 1200 CFM, divide this by 400 CFM to get the answer of 3. For new ducted systems, 75 CFM or less of duct leakage is allowed (3 x 25 CFM) and for existing ducted systems, 120 CFM of duct leakage is allowed (3 x 40 CFM).
(6) Method 2. Duct Leakage to Airflow Percentage: The duct-blower airflow from Section 5.13.1 (d)(4) is then divided by the result from the selected test procedure listed in Sections 3.13 or 4.9, Tests for Ensuring Proper Air Handler Airflow. The resulting quotient is then multiplied by 100 to convert the answer to a percentage. This is the percentage duct leakage. For example if the measured air handler airflow is 1200 CFM and the duct leakage CFM from Section 5.13.1 (d)(4) is 70 CFM for a new system,

Measuring duct leakage to outdoors

Same manometer measures both airflow and pressure differences, required in this test.



The house and its ducts are both pressurized to 25 Pascals. When there is no pressure difference between the house and ducts, there should be no airflow between them. All the airflow going through the duct blower is going outdoors.

divide 70 CFM by 1200 CFM and multiply the answer by 100. This yields 5.8 percent leakage, and complies with the specification for new duct systems.

(e) **Tolerances.**

(1) All pressure measurements shall be plus or minus 0.008 inches of water gauge (0.2 Pascals) or 1 percent of reading.

5.13.2 **Test for Determining Duct Leakage to and from Outdoors.** Please Note: This test procedure is not required for compliance with this Specification. It is included here for the information of the Specification user.

(a) **Objective of test.**

To determine leakage from ducted distribution system to the exterior of the building envelope. This is accomplished by first pressurizing the house with a blower door to 0.1 inch water gauge (25 Pascals) and then pressurizing the duct system with a duct blower fan until a zero pressure difference exists between the duct system and the inside of the house. Measuring duct leakage to and from the outdoors is often used with whole-house diagnostic procedures for troubleshooting both ducts and the building shell. In this test, the conditioned zones and the ducts are pressurized to the same pressure with reference to outdoors. Since the ducts are sealed and no pressure difference exists between the ducts and the house, all the leakage measured by the duct blower is to the outdoors. This is directly related to potential energy savings from duct sealing.

(b) **Required equipment.**

(1) Blower door.

(2) Duct blower.

(3) Digital manometer with hoses.

(4) Materials for temporarily blocking supply registers and return grilles.

(c) **Setup**.

(1) Take all appropriate safety precautions to prevent damage of weak structure or ductwork.

(2) Remove the air filter(s) from the duct system.

(3) Seal all supply and return registers.

(4) If ductwork is installed in attics, crawl spaces, or garages, open these spaces to the outdoors so that leaking ducts will not pressurize these spaces.

(d) **Conducting the test.**

(1) In a centrally located exterior doorframe, install the blower door to pressurize the home. The blower-door fan should be blowing air into the dwelling.

(2) Connect the duct blower to the air handler or to a large return register, oriented to pressurize the ducts.

(3) Connect an airflow manometer to measure the fan with reference to the outdoors.

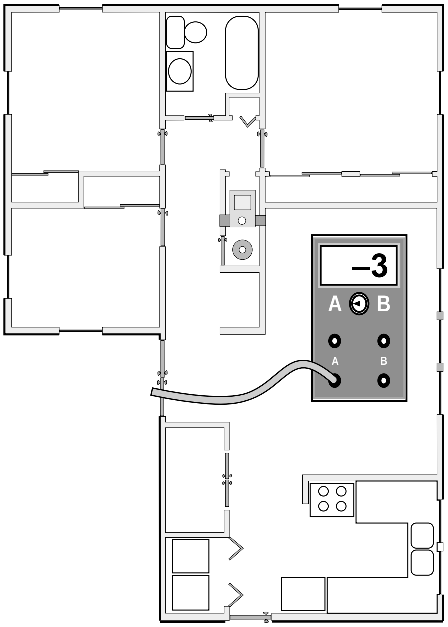
(4) Check manometer(s) for proper settings. Dial-and-needle manometers may need warm-up and calibration. Digital manometers require selection of the correct-mode, range, and fan-type settings.

(5) Turn on the blower door and pressurize the house to 0.1 inch water gauge (25 Pascals).

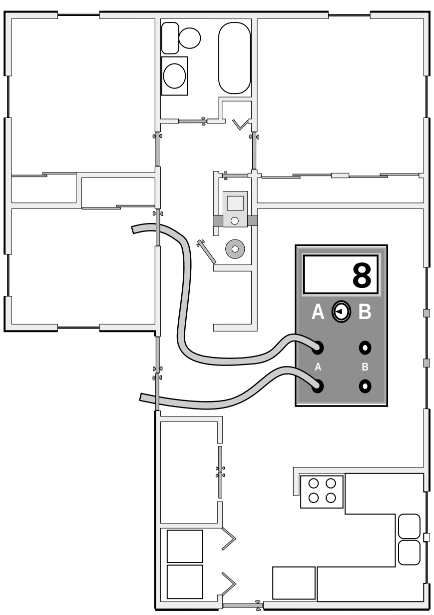
(6) Connect a manometer to measure pressure differential between the house and ducts. Turn on the duct blower and pressurize the ducts to obtain a house-to-duct pressure difference of zero pressure difference. Make sure the blower door is still pressurizing the house to 0.1 inch water gauge (25 Pascals). Adjust house pressure and zero house-to-duct pressure again with the duct blower, if necessary.

[i] The best location for measuring duct pressure is often in or near the supply or return plenum. Select a location on the opposite side of the duct system as the duct blower fan. For example, if the duct blower fan is connected to a return register, the supply plenum is a good

Room-pressure imbalance tests



The main body of the home, where the single return is located, is depressurized with reference to outdoors. The main return and closed interior doors cause this unwanted pressure difference.



The bedroom, with reference to outdoors, measures 8 Pascals, indicating a pressurized bedroom, due to imbalanced airflow. Unbalanced airflow in a single-return system separates the home into pressurized zones, promoting air leakage through the building shell.

reference pressure location.

(7) Record duct-blower airflow. This airflow is duct leakage to the outdoors at the test pressure.

(8) After testing and associated air sealing are complete, restore filter(s), remove seals from registers, and check air handler.

(9) Separating supply-duct leakage from return-duct leakage is desirable in many cases because supply leakage is a more serious energy problem than return leakage. Sometimes, however, return leakage is a very important energy and durability factor – in hot, humid climates or in very cold climates, for example. An option for distinguishing supply leakage from return leakage is outlined below.

(i) Option. Physically separate supply ducts from return ducts. Install a barrier of cardboard or another suitable material between supply and return ducts at the air handler. Often the filter slot will work well for this purpose. Installing a barrier at the return inlet to the air handler allows the supply ducts to be tested with the duct blower attached to the air handler. The return ducts can then be tested with the duct blower attached to a return register. Disconnecting supply or return plenums, and temporarily blocking their inlet to the air handler, is another option for separating the duct leakage measurement.

5.14 Room-Pressure Imbalances Testing.

5.14.1 **Room-Pressure Imbalances Test.**

(a) **Objective of test.** This test identifies restricted airflow in the duct system and dwelling resulting from closed interior doors.

(b) **Required equipment.**

(1) Manometer. A digital unit that records pressure in units of Pascals is preferred because of its greater accuracy.

(2) One length of plastic hose that will fit on one of the pressure taps of the manometer. The pressure hose must be long enough to extend from the tested room to the outdoors. Another length of hose can be used to extend under the door and into the room being tested or the manometer may simply be located in that room.

(c) **Setup.**

(1) Duct sealing should be completed before this test is done.

(2) Air distribution filters should be clean.

(3) Air handler should be operating.

(4) All interior doors should be closed.

(5) House exterior envelope closed (windows and exterior doors closed tightly).

(d) **Conducting the test.**

(1) While standing in the room to be tested, attach one end of the pressure hose to one of the pressure taps on the manometer. Place the other end of the hose outdoors. You are reading the pressure differential between the room in which you are standing with the manometer and the outdoors.

(2) Close the door of the room, taking care not to completely close off the hose if it runs under the door (compressing the hose will not affect the test, but completely closing it off will yield invalid results).

(3) Measure the pressure difference between the closed room and the outdoors with differential manometer. Read and record the pressure differential.

(4) Stand in the main body of the house with the manometer, with all the interior doors closed. Read and record the pressure differential between the main body of the house and the outdoors.

(e) **Interpreting the results.**

(1) If the pressure difference between the 1) closed room and the outdoors or, 2) the main body of the house and the outdoors is more than ±0.01 inches water gauge (±3 Pascals), pressure relief is recommended. Refer to Section 5.6.2 for options.

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[1] For existing ducted systems, based on *Specification for Existing Ductwork*, an ENERGY STAR specification, 2000.

[2] For existing ducted systems, based on *Specification for Existing Ductwork*, an ENERGY STAR specification, 2000.

[3] C. Neme, J. Proctor, and S. Nadel, *National Energy Savings Potential from Addressing Residential HVAC Installation Problems* (U.S. Environmental Protection Agency ENERGY STAR Program, 1999), p. 11.

[4] D. Jump, I. Walker, and M. Modera, *Field Measurements of Efficiency and Duct Retrofit Effectiveness in Residential Forced Air Distribution Systems* (American Council for an Energy-Efficient Economy, 1996 Summer Study, August 1996).

[5] The full title of this document is: *Duct Installation and Sealing Specification: 1999 Residential Contractor Program Installation Standards*. See page 62 for ordering information

Key References and Organizations.

Consumers' Directory of Certified Efficiency Ratings for Residential Heating and Water Heating Equipment – commonly called the GAMA Directory – by the Gas Appliance Manufacturers Association. This directory is published each April and October. The cost is $5.00 per issue. It is available from:

GAMA Efficiency Certification Program
Intertek Testing Services
3933 U.S. Route 11
Cortland, NY 13045-0950
Telephone: 607-758-6636

Residential Comfort System Installation Standards Manual by the Sheet Metal and Air Conditioning Contractors' National Association (SMACNA). This manual is available from:

SMACNA
4201 Lafayette Center Drive
Chantilly, VA 20151-1209
Telephone: 703-803-2989

Directory of Certified Unitary Equipment Standards by the Air-Conditioning & Refrigeration Institute (ARI). This directory is available from:

ARI
4301 North Fairfax Drive, Suite 425
Arlington, VA 22203
Fax: 703-528-3816

Residential Duct Systems: Manual D by ACCA
Residential Load Calculation: Manual J by ACCA
Residential Equipment Selection: Manual S by ACCA
These manuals are available from:

Air Conditioning Contractors of America
1712 New Hampshire Avenue, NW
Washington, DC 20009
Telephone – 202-483-9370

Duct Installation and Sealing Specification: 1999 Residential Contractor Program Installation Standards, Chapter 3, by Pacific Gas & Electric
Available from:

Consortium for Energy Efficiency
One State Street, Suite 1400
Boston, MA 02109

ENERGY STAR - *Specification for Existing Ductwork*

For information about this ENERGY STAR® Specification, call 888-STAR-YES or visit the ENERGY STAR® web site at www.energystar.gov.