

Chapter 7: Heating and Cooling Systems

Design Conditions

The *Washington State Energy Code* (WSEC) sets the following conditions for heating system design and equipment sizing:

- [302.2.1] • **Indoor Design Temperature:** 70°F heating - 78°F cooling.

EXCEPTION: Other design temperatures may be used provided they result in lower energy consumption.

- [302.1] • **Outdoor Design Temperature:** Based on local weather data taken from Table 3-1 of the 2009 WSEC. If you cannot find a particular location listed in Table 3-1, use a site near your location with similar weather conditions.
- **Recommended Air Infiltration Rate for Equipment Sizing:** 0.6 air changes/hour (ACH). 0.6 ACH is a liberal air infiltration estimate for homes meeting code required infiltration rates of .00030 SLA. This infiltration rate is from the Air Conditioning Contractors of America (ACCA) *Manual J* Table 5A default infiltration rates during the heating season. .6 ACH is the assigned infiltration rate for a 1,501-2,000 sq.ft. home with average air leakage. Infiltration rates for smaller or larger houses of similar construction will vary slightly.

Design Heat Load (DHL) Calculation

- [503.2.1] Heating and cooling design loads for the purpose of sizing the heating and/or cooling equipment must be calculated in accordance with accepted engineering practice, including infiltration and ventilation.

[503.2.2]

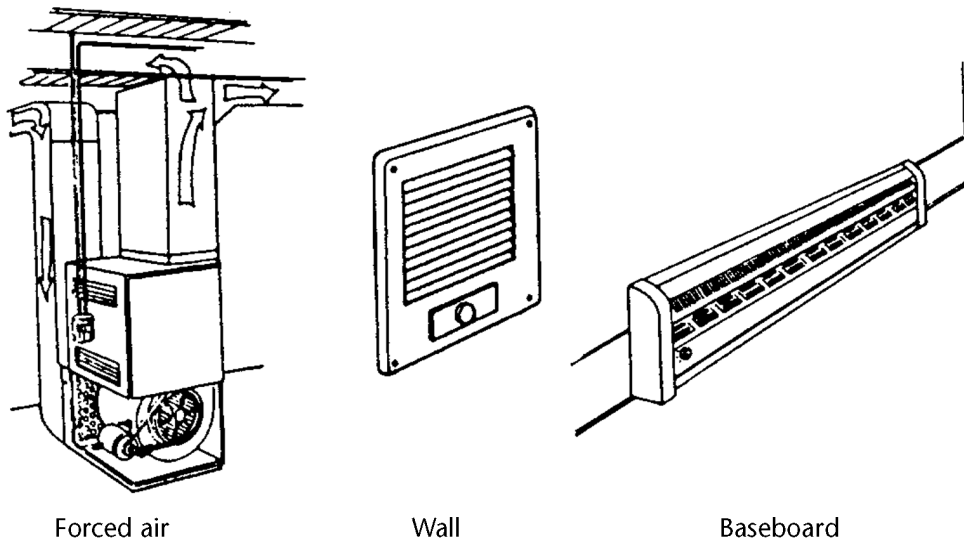
System Sizing Limit. The Code requires that systems be sized as required in *International Residential Code* (IRC) Section M1401.3. IRC M1401.3 states that systems be sized using ACCA Manual S and Manual J or other approved calculation methods. Many jurisdictions allow the use of the heating system sizing calculators that are incorporated into the *WSU Extension Energy Program Prescriptive Compliance and Component Performance worksheets*. You should check with the governing jurisdiction to see if they accept the WSU Extension Energy Program forms.

The WSEC allows some exceptions to system sizing limitations.

- Packaged equipment that provides both heating and cooling, such as a heat pump, need only show compliance for the heating or cooling sizing limit. The unit should be sized for the larger of the two loads.
- If installing a gas or oil furnace and the system size is less than 40,000 Btu/hr, it is exempt from sizing limits.
- The WSEC allows the installation of stand by equipment if controls are installed that only allow the stand by equipment to operate when the primary system is not.
- The Code also allows the installation of electric resistance heaters less than 2 kW without sizing limitations.

Figure 7-1

Electric Resistance Heating Systems



(503.4)

HVAC Equipment Performance Requirements

Electric Resistance Heating Systems

System efficiency. No requirement. Electric resistance heating is considered 100 percent fuel efficient.

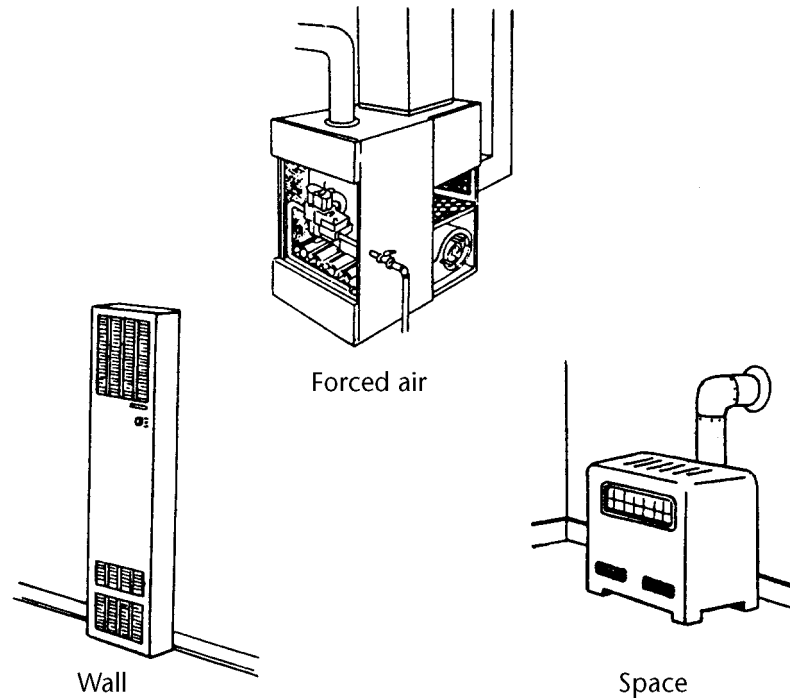
Combustion Heating Systems

System efficiency. A minimum 78 percent AFUE is required.

- Oil, gas, or propane space heaters require an intermittent ignition device and must meet 1987 NAECA efficiency requirements.
- Chapter 9 of the 2009 WSEC gives 1.0 credit for systems installed with a 92 percent AFUE or greater.

Figure 7-2

Combustion Heating Systems



Heat Pumps

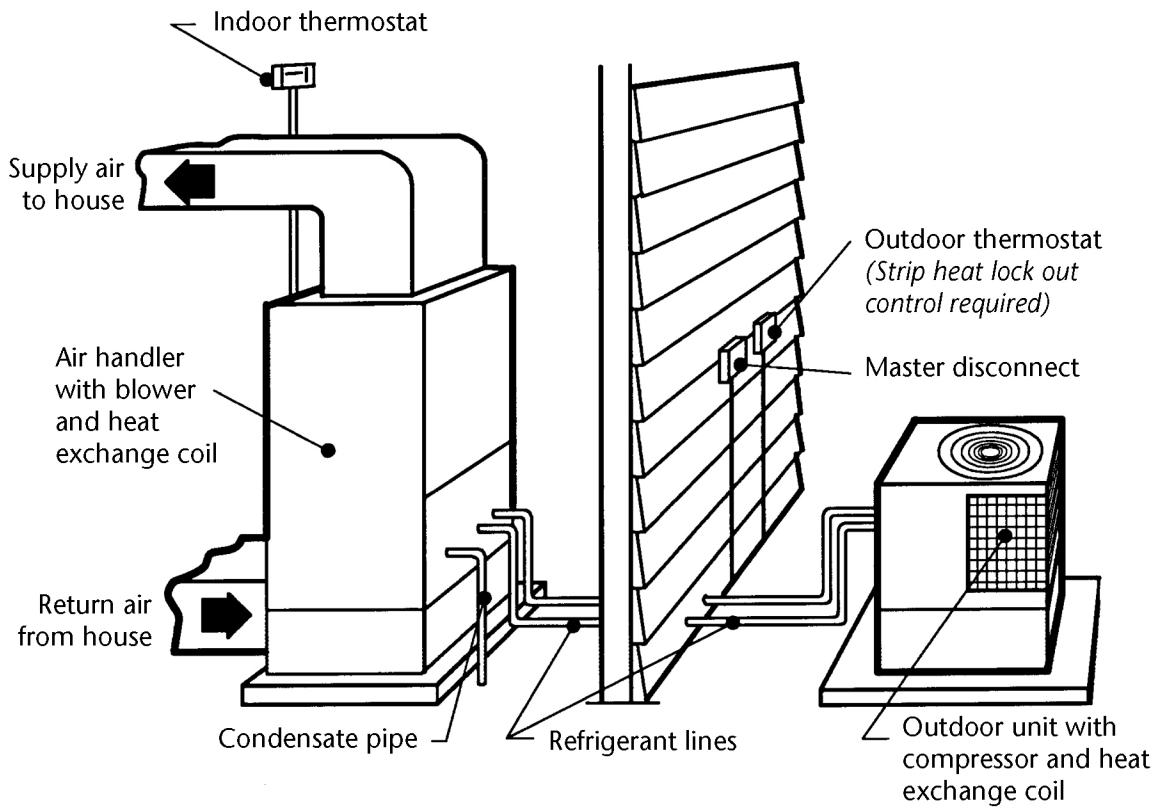
System efficiency.

Air Source:

- For split and single package systems, a minimum of 7.7 Heating Seasonal Performance Factor (HSPF) for heating and 13.0 Seasonal Energy Efficiency Ratio (SEER) is required for cooling for systems under 65,000 Btu/h (see WSEC Table 14-1B).
- Chapter 9 of the 2009 WSEC gives 1.0 credit for systems installed with an HSPF of 8.5 or greater.

Figure 7-3

Split Package Heat Pump Options Ducted



Ductless



Air handler with blower and heat exchange coil



Outdoor unit with compressor and heat exchange coil

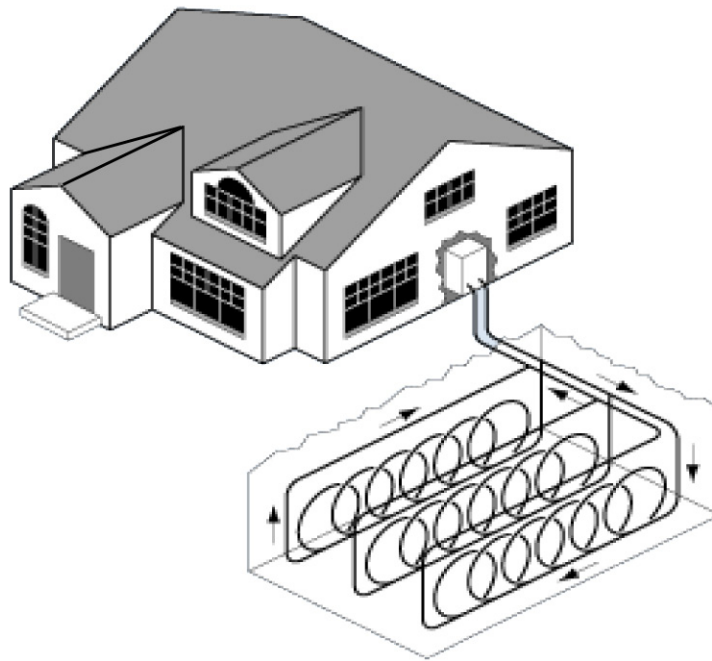
Ground Source

- Minimum Coefficient of Performance (COP) = 3.1
Chapter 9 of the 2009 WSEC gives 2.0 credits for systems installed with a COP of 3.3 or greater.

Figure 7-4

Ground Source Closed Loop System

From EERE.ENERGY.GOV



[503.8]

Controls. Applicable to all system types

A primary space conditioning system must have a programmable thermostat as its control. At a minimum, the programmable thermostat must have the capability to program temperature settings for five weekdays and two weekend days. In addition, the thermostat must be able to be programmed for two setback periods per day.

The Code also states that each additional space conditioning system within a dwelling unit shall be provided with at least one adjustable thermostat for the regulation of temperature. An example of this may be a house with electric resistance wall heaters for its heating system. The main living area could be controlled by a programmable thermostat while the bedrooms and bathrooms would have their heaters controlled by individual and adjustable thermostats.

The WSEC allows two exceptions for space conditioning control requirements. An occupant sensor may be used instead of a programmable thermostat. The occupant sensor must shut off the system when no occupants are detected for a period of up to 30 minutes.

A timer control may be installed if the timer limits the operation of the system to two hours.

The WSEC requires that each thermostat shall be capable of being set by adjustment or selection of sensors as follows:

- When used to control heating only: 55°F to 75°F
- When used to control cooling only: 70°F to 85°F.
- When used to control both heating and cooling, the thermostat shall be capable of being set from 55°F to 85°F and shall have an adjustable deadband of not less than 10°F between hot and cold.
- If the heat pump has an electric resistance backup heating system, a control that locks out the strip heat needs to be installed. The control must prevent the backup system from operating when the heating load can be met by the heat pump alone.
- Have the capability to lock out supplementary heating based on outdoor temperature. The Code requires that the control has a maximum setting of

40°F and is set to 32°F at final inspection. If the heat pump will not meet the heating load at the 32°, the lockout can be set higher but not above 40°

- Lockout capacity may be met by external or internal components. Programmable thermostats with lockout capability or aftermarket devices that meet the temperature requirements noted above are examples of externally applied lockout mechanisms. Some heat pumps may have lockout capability built into the system.

Duct Systems

Insulation Requirements

[503.9]

Ducts, plenums, and enclosures outside conditioned space such as crawl spaces, attics or garages must be insulated to R-8. Ducts and plenums on roofs and/or the exterior of buildings must have an approved weatherproof barrier. These ducts need to be insulated to R-8 in Climate Zone 1 and R-10 in Climate Zone 2. Ducts and plenums in slabs or in the ground shall be insulated to R-5 with material approved for below grade application for both climate zones. Extruded polystyrene is typically used for this requirement.

Exceptions:

Ducts do not have to be insulated when:

- 1. The heat gain or loss of the ducts, without insulation, will not increase the energy requirements of the building.*
- 2. Ducts are within HVAC equipment.*
- 3. Exhaust air ducts. Some exhaust air ducts are required to be insulated by the Washington State Amendments to the IRC.*
- 4. Supply or return air ducts installed in basements or cellars in one and two-family dwellings.*

5. *The insulation required on supply air ducts may be reduced to R-4 when the ducts are located in buffer spaces not intended for human occupancy such as insulated crawl spaces and enclosed attic spaces. To use this exception, the buffer space must be air sealed and insulated to the full value of the conditioned spaces.*

Duct Fasteners

Ducts must be fastened in accordance with the *International Mechanical Code* (IMC). For small sheet metal ducts, a minimum of three screws per connection equally distributed around the duct, or equivalent is required. For flex duct, and duct board, you must follow instructions developed by the SMACNA, noted in the IMC. More information can be found at: www.smacna.org/

[503.10]

Building cavities may not be used as ducts. You may run a duct through a building cavity but installation of these ducts in exterior walls, floors or ceilings shall not displace required envelope insulation.

Leakage Testing

Ducts shall be leak tested in accordance with RS-33 (available at www.energy.wsu.edu/code), using one of the maximum duct leakage rates specified below:

- Post construction test. This test is typically done at or near completion of construction.
 - Leakage rate to outdoors shall be less than or equal to 6 percent of the conditioned floor area tested at 25 pascals pressure. This test measures duct leaks that are outside of the conditioned space. To perform this test you need a duct tester and a blower door.

Or

- Total leakage rate shall be less than or equal to 8 percent of the conditioned floor area tested at 25 pascals pressure.
 - Rough-in test. This test is done immediately after the HVAC system is installed. This is the preferred time to test so the ducts are still exposed and any leakage areas are accessible.
 - Total leakage rate shall be less than or equal to 6 percent of the conditioned floor area tested at 25 pascals pressure.
- Or**
- Total leakage shall be less than or equal to 4 percent of the conditioned floor area tested at 25 pascals pressure if the air handler is not present. To accomplish this test you need to test the supply ducts and the return ducts and add the leakage rates together.

EXCEPTIONS:

1. Duct testing is not required if the air handler and all ducts are located within the conditioned space.
2. Duct testing is not required if the furnace is a nondirect vent type combustion appliance installed in an unconditioned space. This is an atmospherically vented furnace installed outside the conditioned space, usually in a garage. This exception allows a maximum of six feet of connected ductwork in the unconditioned space. All additional supply and return ducts need to be inside the conditioned space.

Duct Sealing

All duct, air handler and filter box seams and joints shall be sealed.

Primary sealants approved for ducts include welds, gaskets, mastic or mastics with embedded fabric systems. Tapes may be used if specific installation procedures provided by the manufacturer are followed.

Figure 7-5

Duct Insulation and Sealing

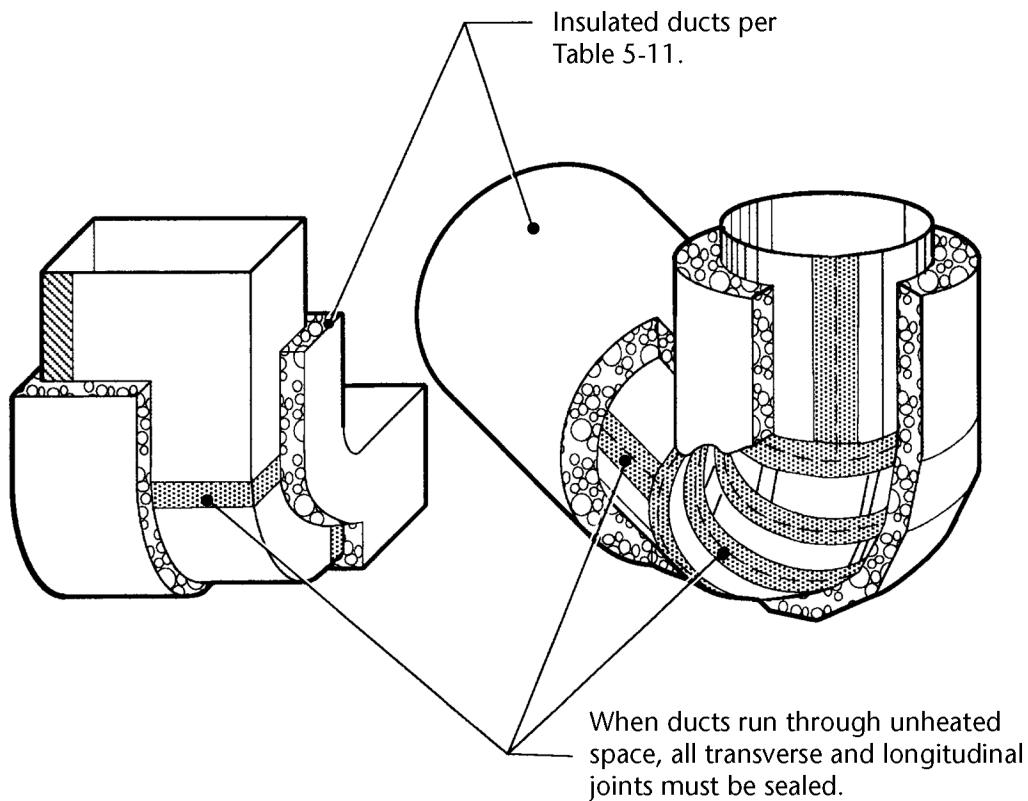
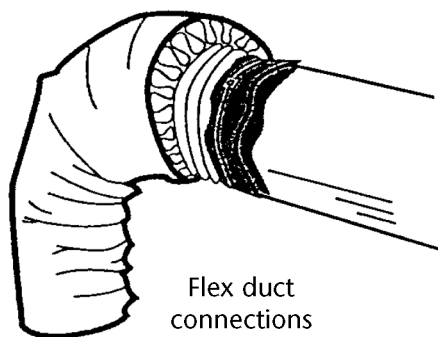
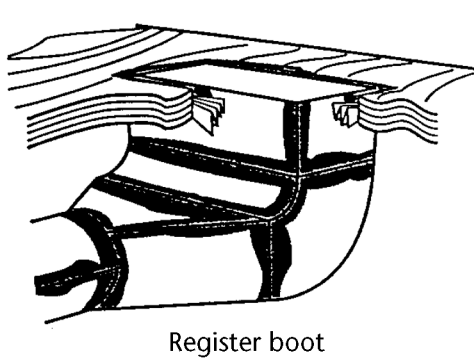
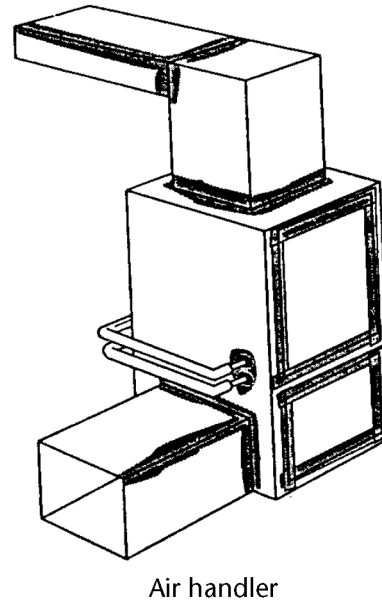
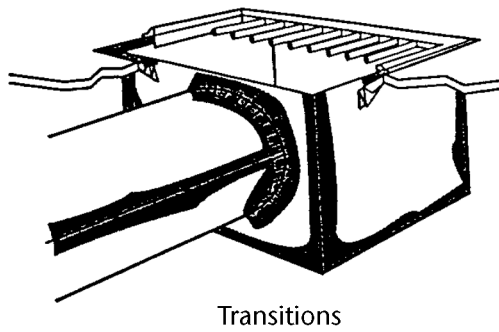


Figure 7-6
Sealing Ducts



Tapes must be installed in accordance with the manufacturer's instructions, or in the case of UL 181 sealants, in accordance with the product listing. If the product does not have instructions specific to the material or application it is being applied to, it does not meet the intent of the Code. For example, if tape is used to seal sheet metal, instructions published by the manufacturer must include notes on application to sheet metal. If the sheet metal needs to be cleaned, the manufacturer's instructions must provide specific instructions on cleaning. These instructions must be followed by the installer.

For additional information on duct sealing, see the *Builder's Field Guide's Supplement A*, "Improving Forced Air Heating Systems."