

19. Residential Heating and Cooling Load Calculations

Space heating and cooling systems in residential new construction are commonly oversized which increases installation costs, wastes energy, and reduces comfort. In homes with space cooling, oversizing also reduces moisture control. Properly sized equipment will last longer, provide greater comfort, reduce noise, and save homeowners money. Yet builders and code officials are often uncertain as to how to evaluate such calculations to make sure they meet the intent of the code and the sizing methodology approved in the Air Conditioning Contractors of America (ACCA) Manual J (or equivalent).

The first step in performing a load calculation is to calculate the net surface area and orientation of all walls, ceilings, floors, and glass that are exposed to unconditioned spaces. The second step is to inspect and identify the type of building materials used in the construction of the home, including style of windows, skylights, doors, roofing, flooring, and siding. This information is used to obtain the equivalent R-values, U-factors, and solar heat gain coefficients (SHGC) needed in the final load calculation. The final step is to combine the surface areas and building material information to calculate the sensible, latent, and heating loads for all opaque elements. The opaque element loads are then combined with the duct, infiltration, ventilation, piping, and internal loads (from occupants and appliances) to determine the total load.

The simplest method is a “block load” assessment (also known as “whole house”), which only looks at the opaque elements and glass exposed to the elements. This calculation is used for sizing central equipment. A more complex method is the “Room-by-Room” assessment that breaks down the load for each room. Room-by-Room calculations are more accurate and also allow the practitioner to determine the space conditioning air flow requirements for each room. Room load estimates are mandatory for selecting air distribution devices and for duct sizing calculations.

The most widely accepted method to perform whole-house or room-by-room calculations is to follow ACCA *Manual J*. Since performing an ACCA Manual J by hand is very tedious, the preferred approach is to use ACCA approved software.

The 2012 IECC requires sizing calculations be performed on every home according to ACCA Manual J or other approved heating and cooling load calculations. It is important to follow all instructions in Manual J, use precise area measurements, and specific data. Manual J specifies that the target value heating indoor design temperature be 70°F, and the target value cooling design temperature be 75°F.

Montana Outdoor Design Temperatures

Table IA in Section 18 of ACCA Manual J requires that the outdoor winter and summer design temperatures be based on the 99 percent value for winter, and 1 percent value for summer. Excessively oversized equipment causes short-cycling, and creates unnecessary stress on the equipment. Also, larger systems require larger duct sizes, increasing the installation cost. When designing a residential heating and cooling system, it is important to



use the correct climate data (outdoor design conditions) for the locality in which the building receiving the new system is located. This data is used when calculating the building component heating load and cooling load, which in turn are used to determine the required air flow (cubic feet per minute or CFM) for each room, design the appropriate duct work, and select the optimal equipment for the application.

Location	Elevation Feet	Latitude Degrees North	Winter	Summer					
			Heating 99% Dry Bulb	Cooling 1% Dry Bulb	Coincidence Wet Bulb	Design Grains 55% RH	Design Grains 50% RH	Design Grains 45% RH	Daily Range (DR)
Billings	3567	45	-7	90	62	-31	-24	-18	H
Bozeman	4475	45	-12	87	60	-36	-29	-23	H
Butte	5553	46	-14	84	56	-51	-44	-38	H
Cut Bank	3838	48	-16	84	59	-36	-29	-23	H
Glasgow	2760	48	-17	90	63	-28	-21	-15	H
Glendive	2456	47	-13	92	64	-26	-19	-13	H
Great Falls	3652	47	-13	88	60	-38	-31	-25	H
Great Falls, Malmstrom AFB	3525	47	-11	89	61	-11	-4	2	H
Havre	3200	48	-19	90	62	-33	-26	-20	H
Helena	3828	46	-10	87	59	-41	-34	-28	H
Kalispell	6780	48	-3	86	61	-29	-22	-16	H
Lewistown	4122	47	-12	86	60	-27	-27	-21	H
Livingston	4654	45	-14	87	60	-36	-29	-23	H
Miles City	2634	46	-13	93	65	-23	-16	-10	H
Missoula	3190	46	-1	88	61	-33	-26	-20	H

Plan Review

1. Verify that the correct outdoor design temperatures are used for the heating and cooling load calculations, and that they are consistent with values in Table 1A of ACCA Manual J.
2. Verify that the correct indoor design temperatures are used based on ACCA Manual J.
3. Verify that the building geometry and glass area match what is shown on the plans and compliance documentation. Glazing orientation is important to verify for cooling load calculations but has no effect on heat loss calculations.
4. Verify that the levels of efficiency shown in the load calculations are consistent with the energy code compliance documentation. Insulation R-values, glazing U-factor, and SHGC are important to confirm.
5. Verify that the make, model number, and equipment size as specified on the plans agree with the sizing calculations.



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Inspection

1. Verify the make and model numbers for the heating and cooling systems installed for the building, and compare those to the building plans and specifications.
2. Verify that the system has the same output capacity, and the same level of efficiency as specified in the plans and specifications.
3. Verify that the efficiency levels of insulation and windows (U-factors and SHGC) meet or exceed the levels that are called out on the permit submittal plans and specifications. Levels that are too low can cause the system to be undersized. If cooling is installed, verify that the glazing area and orientation is installed per the approved building plans.
5. Verify that the energy features of the house are installed per the manufacturer's instructions.
6. Verify that the refrigerant charge level was tested by the installer.

Code Reference

Energy Code R403.6 Equipment Sizing (Mandatory). Heating and cooling equipment shall be sized in accordance with ACCA Manual S based on building loads calculated in accordance with ACCA Manual J or other approved heating and cooling calculation methodologies.

Resources

ACCA -- Residential Load Calculation - Manual J 8th Edition, Air Conditioning Contractors of America, 2006.

2012 International Energy Conservation Code, Copyright August 2011 by the International Energy Codes Council, Inc., Falls Church, Virginia.

2012 IECC Code and Commentary, Copyright August 2012 by the International Energy Codes Council, Inc., Falls Church, Virginia.

Strategy Guideline: Accurate Heating and Cooling Load Calculations, US DOE Building Technologies Program, Arlan Burdick, Ibacos, Inc., June 2011, <https://www.nrel.gov/docs/fy11osti/51603.pdf>