



# **HVAC Hacks #3: Heating and Cooling Load Calculations – Essential Tips & Rules of Thumb**

**An Online Continuing Education Course for Engineers**

**Course Number: HV-6027**

**Credit: 6 Hours / 6 PDH / 6 CPD**

# HVAC Hacks #3: Heating and Cooling Load Calculations – Essential Tips & Rules of Thumb



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Struggling with time-consuming HVAC load calculations? Learn to master HVAC loads the easy way. This course unlocks the factors that influence HVAC loads, providing the foundation for designing ideal climate control systems. We'll explore the critical concepts of heat gain and heat loss calculations. This 6-hour course covers a broad range of topics, including:



- a. Heat Transfer Concepts: Grasp the key concepts of sensible heat, latent heat, and total heat load, the building blocks of HVAC calculations.
- b. Climatic Conditions: Analyze how climate and location significantly impact the heating and cooling needs of your building.
- c. Architectural Design and Construction: Comprehend how building envelope properties (walls, windows, glazing, etc.) influence heat gain and loss.
- d. Beyond the Basics: Factor in occupancy, ventilation, lighting, equipment, and other internal loads that affect indoor environments.
- e. Shortcut Savvy: Discover valuable shortcuts to estimate loads quickly for preliminary design stages.
- f. Energy Optimization: Learn best practices and strategies to optimize energy efficiency and sustainability in your HVAC systems.
- g. Real-World Ready: Analyze practical case studies that reinforce HVAC load calculation concepts and prepare you for real-world application.

The course includes essential metrics, practical tips, and handy rules of thumb for estimating HVAC loads based on floor area, climate zones, and specific building applications. Let's get started with essential metrics and rules of thumb.





## HVAC CAPACITY

	Description	Rules of Thumb
	Air-conditioning Capacity (Tons)	<p>A ton of refrigeration (TR or simply ton) is the ability of an air conditioner to remove 12,000 British Thermal Units (BTUs) of heat per hour, or approximately 3.5 kW (Thermal).</p> <p>1 ton = 12000 BTU/hr            1 KW = 3414 BTU/hr            1 ton = 12000/3414 = 3.5 KW (Thermal)</p>
	Estimating Capacity	<p><i>Cooling capacity can vary depending on the building's climate zone, construction type, and usage. For the conceptual design phase of a building, a common rule of thumb is to allocate 1 ton of cooling capacity (TR) for every 200 square feet of floor area.</i></p> <p><i>In modern buildings with good construction quality, consider approximately 30 to 40 BTU/h per square foot or 1 ton of air-conditioning for every 400 to 300 square feet of floor area in a mixed climate zone (CZ-4).</i></p>



## DESIGN CRITERIA FOR LOAD CALCULATIONS



	Description	Rules of Thumb
	Design Basis	<p><i>Heating loads shall be based on nighttime conditions, with no credit for solar, people, lighting, or equipment.</i></p> <p><i>Cooling loads shall be based on peak hour day conditions and include all credit for solar, people, lighting, equipment, ventilation, and infiltration.</i></p>
	Components of Cooling Load	<p><i>Cooling load comprises sensible load + latent load.</i></p> <ol style="list-style-type: none"> <li><i>a. Sensible load affects the temperature of the space. Sources: Solar heat gain through walls, roofs, and windows, heat gain from lighting, equipment, people, and ventilation air.</i></li> <li><i>b. Latent loads affect the moisture level in the space. Sources: Ventilation air, occupants breathing, cooking, floor mopping, hot baths, and other processes that generate water vapor.</i></li> </ol>

## BUILDING MATERIAL CHARACTERISTICS







	Description	Rules of Thumb
	R-value (Thermal resistance)	<i>R-value measures a material's resistance to heat flow. A high R-value is preferred. A high R-value means better insulation.</i>
	U-factor (coefficient of heat transmission)	<i>U-factor measures how much heat flows through a material per unit area and per unit temperature difference. A low U-factor is preferred. A high U-factor means high conductivity, while a <b>lower U-factor</b> indicates superior thermal insulation.</i>
	k-value (Thermal conductivity)	<i>k-value measures how well a material conducts heat. A lower k-value means the better the material will resist heat.</i>
	HC (Heat capacity – thermal mass)	<i>HC measures how well a material can store heat energy. Materials with higher HC can help regulate temperature fluctuations and reduce the need for additional heating or cooling. As a rule of thumb, HC should be high in hot and dry regions and moderate to light in humid areas.</i>











## GLAZING CHARACTERISTICS

	Parameter	Recommended Value
	U-factor	<i>A low U-factor is desirable for better insulation and reduced heat gain or heat loss. Typical U-factors for different glass types:</i> <ol style="list-style-type: none"> <li>a. Single glass: Typical U-value: 1.1 BTU/hrft<sup>2</sup>°F</li> <li>b. Double glass: Typical U-value: 0.57 BTU/hrft<sup>2</sup>°F</li> <li>c. Triple pane glass: Typical U-value: 0.38 BTU/hrft<sup>2</sup>°F</li> </ol> <i>As a rule of thumb, choose glazing with a U-factor of 0.35 or lower, especially in cold climates. In warm and hot climates, the U-factor is less critical than the Solar Heat Gain Coefficient (SHGC).</i>
	The Solar Heat Gain Coefficient (SHGC)	<i>Low SHGC values are desirable in hot climates to reduce cooling loads and the need for artificial cooling. High SHGC values are desirable in buildings requiring passive solar heating. Recommended values:</i> <i>Cooling-dominated areas: SHGC of 0.40 or lower.</i> <i>For moderate air conditioning requirements, Choose an SHGC of 0.55 or lower.</i>


	Visible Transmittance (VT)	<i>Higher VT values are desirable to maximize daylight. Recommended values: VT &gt;70%.</i>
	Air Leakage (AL)	<i>Lower air leakage (AL) is desirable to minimize the infiltration of outside air. Choose fenestration and glazing products with lower AL.</i>

## COOLING LOAD CALCULATIONS AND ASSUMPTIONS




	Description	Rules of Thumb
	Location	<i>Location affects outdoor temperature and humidity. For climatic conditions in international cities, refer to the ASHRAE Fundamentals Handbook and ASHRAE Std. 183 or the ASHRAE Handbook of Fundamentals.</i>
	Outdoor Conditions	<b><i>For hot and dry locations,</i></b> select design values for peak outdoor summer dry bulb temperature (DBT) and mean coincident wet bulb temperature (WBT) at 2.5 percent occurrence.  <b><i>For hot and humid locations:</i></b> Select design values for peak outdoor wet-bulb temperature (WBT) and mean coincident dry-bulb temperature (DBT) at 2.5 percent occurrence.
	Indoor Conditions	<i>Use indoor design conditions of 75°F DBT and 50% RH.</i>
	Glazing – U Factor	<i>The U-factor generally falls between 0.2 and 1.20. The lower the U-factor, the lower the heat gain and heat loss.</i> <ol style="list-style-type: none"> <li><i>U-factor is particularly important in cold climates, and the recommended value is 0.35 or less.</i></li> <li><i>U-factor is less critical in hot, humid, or dry climates. The recommended value is to limit the maximum U-value to 0.48.</i></li> </ol>
	Glazing - Solar Heat Gain Coefficient (SHGC)	<i>The lower the SHGC, the better a product is at blocking unwanted heat gain. It is an important measure in hot climates.</i> <ol style="list-style-type: none"> <li><i>A typical glass shading coefficient is 0.87 for clear glass and 0.5 or less for tinted glass.</i></li> <li><i>Use low SHGC materials (&lt; 0.3) in warm climates to reduce heat gain from sunlight.</i></li> <li><i>Use high SHGC materials (&gt; 0.4) in cold climates to let more sunlight warm up a building.</i></li> </ol>
	Window Leakage	<i>Standard leakage rates are 0.3 CFM/ft<sup>2</sup> while tight units can be as low as 0.01 CFM/ft<sup>2</sup>.</i>

	<b>Description</b>	<b>Rules of Thumb</b>
	Building Materials, Roof	<p><i>Depends on the building location in a specific climate zone. Commonly used is R-30 insulation.</i></p> <p><i>a. Recommended R-values: R-30 to R-60</i></p> <p><i>b. Recommended U-values: 0.03 to 0.017 BTU/(ft<sup>2</sup>·°F)</i></p> <p><i>Use higher insulation (R-value) and lower U-value in cold climates.</i></p>
	Building Materials, Walls	<p><i>Depends on the building location in a specific climate zone. Commonly used insulation is R-19.</i></p> <p><i>a. Recommended R-values: R-13 to R20</i></p> <p><i>b. Recommended U-values: 0.065 to 0.050 BTU/(ft<sup>2</sup>·°F)</i></p> <p><i>Use higher insulation (R-value) and lower U-value in cold climates.</i></p>
	Lighting Type	<i>Assume 0.6 to 2 watts per square foot (LED lights).</i>
	Equipment Load	<p><i>Assume 3 to 4 watts per square foot (computers and other electronic equipment).</i></p> <p><i>Assume 20 to 40 watts per sq. ft. for server rooms, data centers, and electrical and telecom rooms.</i></p>
	Occupancy Density	<i>Assume 100 to 150 sq. ft per person, depending on the building application.</i>
	Occupant Heat Gain	<i>Assume an average heat gain of 500 BTU/hr for each person. Sensible heat of 250-400 BTU/hr per person and a latent heat gain of 100-150 BTU/hr per person.</i>
	Ventilation Rate	<i>Assume outside air for ventilation is 20 CFM per person.</i>
	Air changes/hour	<p><i>Assume an average air change rate of 1-2 air changes per hour (ACH) for air-conditioned buildings.</i></p> <p><i>Toilet exhausts @ 10 ACH</i></p>
	Infiltration	<i>Assume an infiltration rate of 0.1 to 0.2 ACH.</i>
	Duct Leakage	<i>Assume 10% duct leakage.</i>



## COOLING LOAD METHODS

	Description	Rules of Thumb
	Cooling Load Methods	<p>Commercial load calculation typically incorporates one of these methods:</p> <ol style="list-style-type: none"> <li>The cooling load temperature difference/cooling load factor (CLTD/CLF) method</li> <li>Total equivalent temperature difference/time averaging (TETD/TA) method</li> <li>Transfer function method (TFM)</li> <li>Radiant time series (RTS) method</li> <li>Hourly Heat Balance (HR) method</li> </ol> <p>The CLTD/CLF method is the most commonly used method used by air conditioning engineers. Error tends to be large. See ASHRAE Engineering Handbook, Tables and Figures 16.1 through 16.10.</p>

## DIVERSITY FACTORS

	Description	Rules of Thumb
	Building Capacity	Capacity, kW
	Building Floor Area	Capacity, kW per 1000 sq ft
	Building Blower	Capacity, kW to 0.9 is

## SAFETY FACTORS

	Description	Rules of Thumb
	Safety factors	10% safety factor for sensible load and a 5% safety factor for latent load to account for uncertainties.
	Pick-up Loads	10% Maximum system capacity allowance for morning cool-down cycles.

To view the remainder of the course material and to take the quiz for PDH credit, you must purchase the course.

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