

HVAC DUCT SIZING

AND REGISTER SIZING

STEP 1

LOAD CALCS & ENERGY MODELING

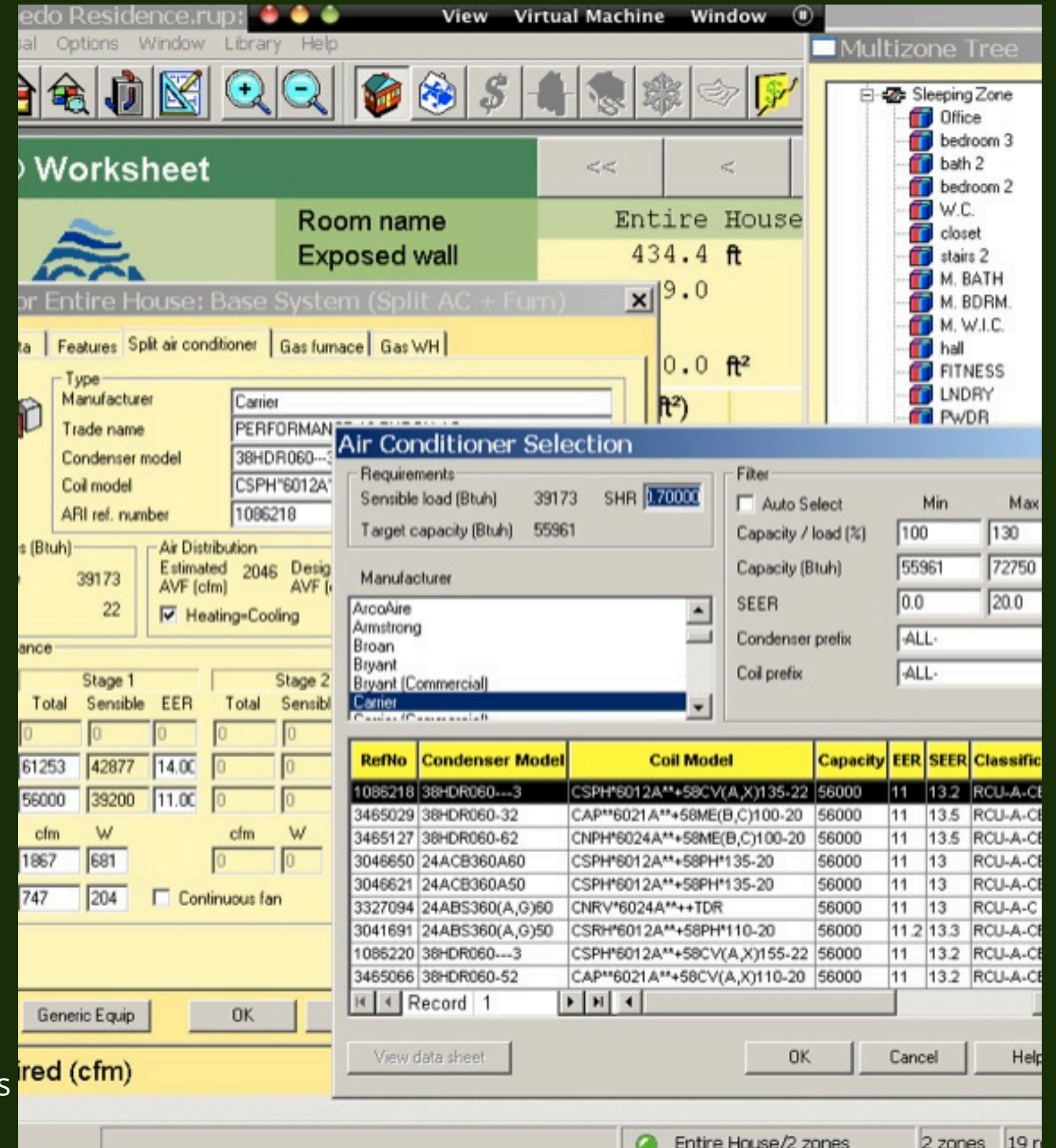
To ensure accurate load calculations, energy modeling, and compliance with energy efficiency standards, use reputable software and resources such as:

HVAC load calculation: Cool Calc Manual J, Elite CHVAC, Wrightsoft Right-Suite Universal, Trane TRACE 700 / TRACE 3D Plus, Carrier HAP

Energy modeling & compliance: EnergyPro, EnergyPlus, eQUEST, CBECC-Com / CBECC-Res, COMcheck – ASHRAE 90.1 / IECC code compliance

Industry Standards & Guidelines:

- ACCA Manuals:
 - Manual J – Residential load calculations
 - Manual S – Residential equipment selection
 - Manual D – Residential duct design
 - Manual N – Commercial load calculations
 - Manual Q – Commercial duct design
 - Manual T - Air distribution
 - Manual P - Psychrometrics
- **SMACNA Standards:** Best practices for ductwork design, fabrication, and installation
- **ASHRAE Standards**
 - ASHRAE 90.1 – Energy Standard for Buildings Except Low-Rise Residential Buildings
 - ASHRAE 62.1 – Ventilation for Acceptable Indoor Air Quality
 - ASHRAE 55-2023 – Thermal Environmental Conditions for Human Occupancy



STEP 2

DUCT & REGISTER SIZING

To achieve the desired room airflow (cfm) while staying within recommended air velocity limits

Use: $CFM = FPM \times A$; Where:

- **CFM** = cubic feet per minute (airflow)
- **FPM** = feet per minute (velocity)
- **A** = duct or register net free area (in square feet)

Velocity Guidelines: Supply: ≤ 600 fpm, Return: ≤ 500 fpm

Duct Selection by Diameter: Use round ducts for diameters $\leq 10"$; use rectangular ducts for diameters $> 10"$ (for space efficiency)

Airflow Calculations:

Airflow can be estimated from the sensible load:

- $CFM = Q_{sens} [BTU/hr] \div (1.08 \times \Delta T)$, where ΔT = Supply Air – Room Air

Rules of Thumb:

- 350–400 CFM per ton of cooling (1 ton = 12,000 BTU/hr)
- $CFM = (CFM/sf) \times \text{Room Area}$
- $CFM = (ACH \times \text{Room Volume}) \div 60$; Where: ACH = Air Changes per Hour

Determining Net Free Area and Noise Criteria (NC):

- Refer to manufacturer data for register net free area and Noise Criteria (NC).
- Select $NC \leq 25$ for quiet spaces; NC 30 may be perceived as noisy.
- Adjust for duct length using NC correction tables for supply and return.



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STEP 3 DUCT SIZING TOOLS

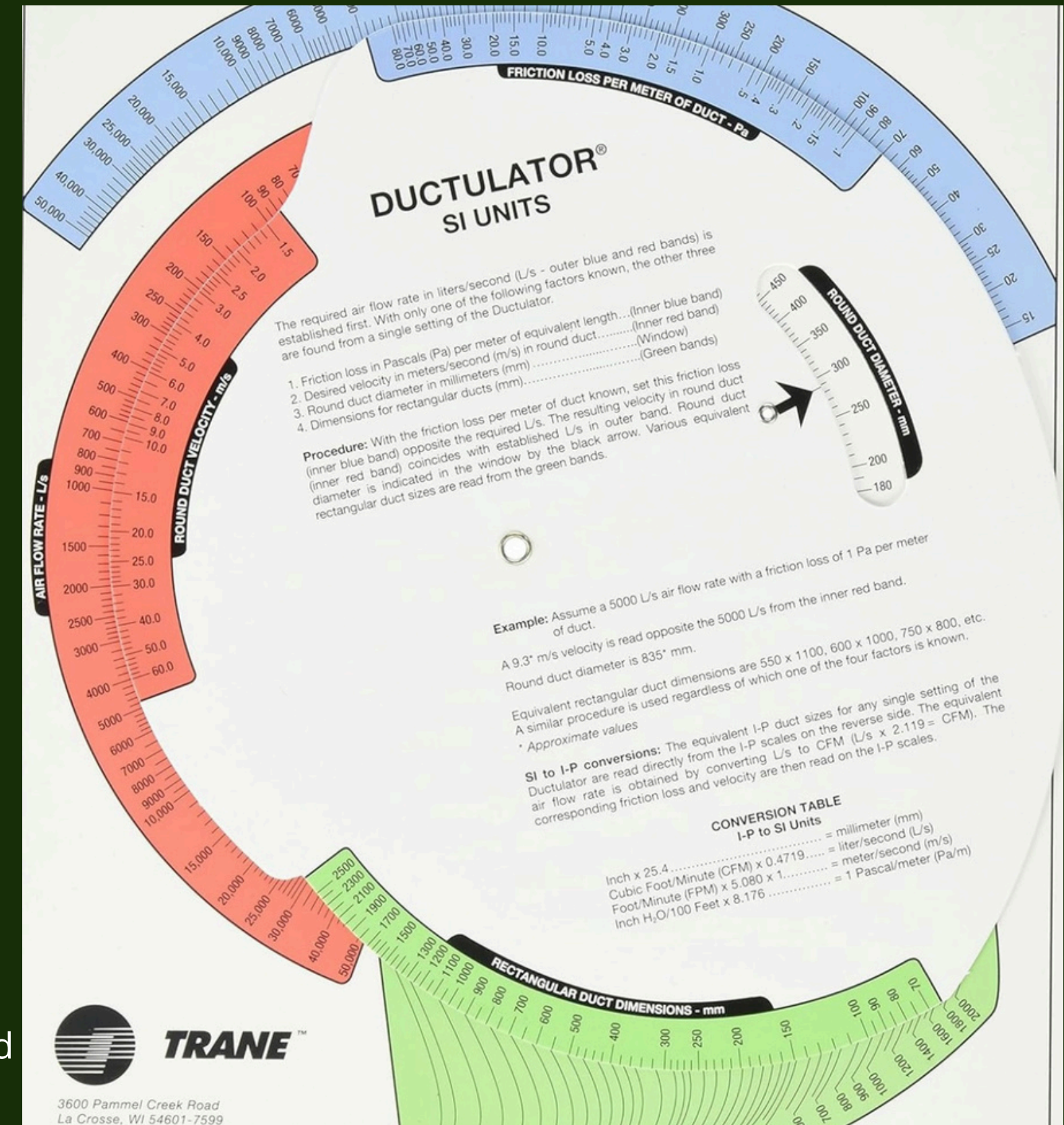
Tools like the Trane TD1 Ductulator and online Ductulators help determine optimal duct diameter (round) or dimensions (rectangular) based on:

- Airflow rate (CFM)
- Air velocity (FPM)
- Duct material roughness / friction factor (in w.c./100')
- This ensures efficient airflow, minimal pressure loss, and compliance with recommended velocity limits.

Typical friction factors:

- Smooth round ducts: Supply 0.10, Return 0.08
- Smooth rectangular ducts: 0.10 – 0.15
- Long duct runs / high-performance homes: 0.06–0.07
- https://engineeringtoolbox.com/duct-friction-pressure-loss-d_444.html

Blower Verification: Final airflow must be confirmed using the manufacturer's blower performance curve, not just load calculations. Most residential/light commercial air handlers and fan coil units are rated at 0.5 in. w.g. Total External Static Pressure (TESP) per AHRI/ASHRAE standards. This accounts for typical pressure losses across filters, coils, and ductwork. Actual duct static pressure should be coordinated with fan capability to ensure required CFM delivery.



STEP 4

DESIGN AIRFLOW

Perform load calculations to size each room's design airflow (cfm) for heating, cooling, dehumidification, and ventilation. Size HVAC equipment based on the highest required airflow rate to ensure the system meets each room's peak demand.

Load Calculations Consider:

- Internal factors: occupants, equipment, lighting, etc.
- External factors: solar heat gain, outdoor air temperature, and building envelope.

Space or Zone Load

- The total heating, cooling, and dehumidification required to maintain desired indoor conditions. This load accounts for all internal and external sources of heat and moisture gain or loss.
- Space Load → Calculated for an individual room or modeled space.
- Zone Load → Calculated for a thermostat-controlled area, which may include multiple spaces.

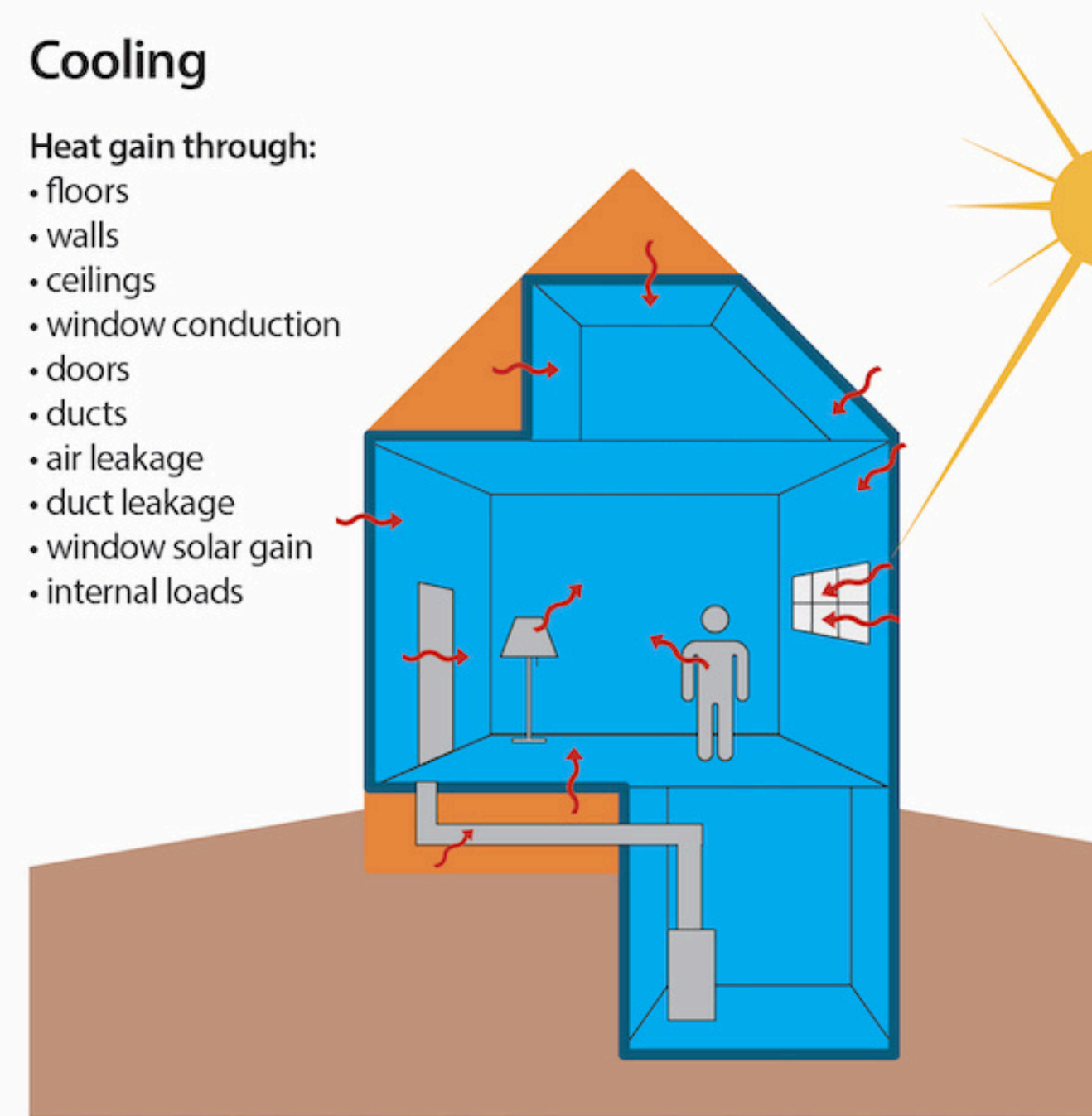
Cooling Coil Load:

- The total load on the cooling coil, which may serve multiple rooms or zones. It includes the sum of space loads, ventilation air, internal equipment heat, and system inefficiencies (e.g., duct losses).
- This value is used to size the cooling coil and determine the overall capacity of the air handling system.

Cooling

Heat gain through:

- floors
- walls
- ceilings
- window conduction
- doors
- ducts
- air leakage
- duct leakage
- window solar gain
- internal loads



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LOAD FACTORS & VENTILATION RATES

Measuring Room Area and Exterior Walls for Heat Gain:

- Measure room area to the interior face of all walls.
- Measure exposed wall length along interior surfaces (excluding shared conditioned walls).

Outside Air (OSA) Requirements:

OSA ensures acceptable indoor air quality (IAQ) and occupant health. To determine minimum ventilation (OSA) and exhaust rates:

- Input the room area and occupancy category into energy modeling software.
- Refer to the applicable standard based on project location:

Location	Ventilation Rate Standard	Exhaust Rate Standard	Lighting Power Density Standard	Key Consideration
California	CEC Table 120.1-A (CFM/sf)	CEC Table 120.1-B		Use the higher of CEC CFM/sf or ASHRAE CFM/person
			ASHRAE Standard 90.1-2019, Table 9.6.1 or ASHRAE Handbook—Fundamentals (2021), Chapter 18, Section 6, Table 2	
United States	ASHRAE 62.1 Table 6.2.2.1 (CFM/person and CFM/sf)	ASHRAE 62.1 Table 6.5		
International	IMC Table 402.1	IMC Table 403.3.1.1		

Dominant Load Factors by Space Type:

- Offices in Warm Climates
 - Cooling loads dominate due to high ambient temperatures and internal heat gains from equipment and occupants.
- Clean Rooms
 - Require high air change rates and specialized filtration systems to meet cleanliness standards.
- High-Occupancy Spaces with High Latent Loads (e.g., Gyms)
 - Ventilation and dehumidification are critical for managing humidity and maintaining IAQ.
- Kitchens with Exhaust Hoods / Laboratories with Fume Hoods
 - High exhaust requirements significantly impact HVAC design and airflow rates to ensure safe removal of contaminants.

STEP 6

REGISTER PLACEMENT

Optimizing Air Distribution for Energy Savings and Occupant Comfort:

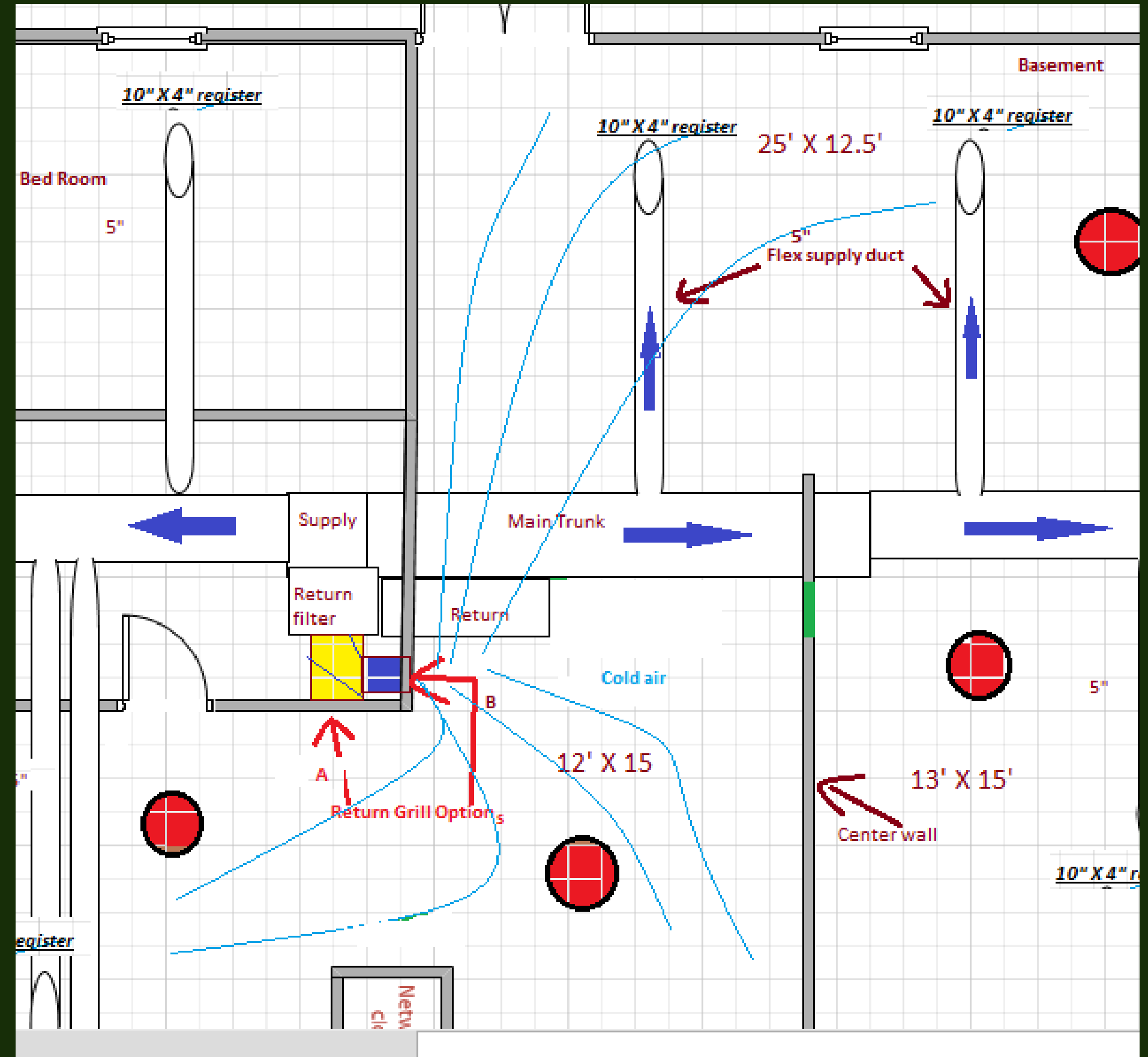
- Use fewer return grilles than supply diffusers to simplify ductwork and improve return air flow paths.
- Place supply diffusers near windows to offset heat gain/loss and reduce drafts.
- Locate return grilles in hallways or near doors to promote circulation and effective return airflow.
- In bathrooms, provide an exhaust grille and, for comfort, often a supply diffuser — but exclude return grilles to prevent moisture and odor recirculation.

Strategic Return Grille Placement:

Instead of installing a return grille in every room, place them in central or common areas such as:

- Hallways
- Large open spaces
- High-occupancy zones

This approach improves overall air circulation, reduces noise, and increases HVAC system efficiency.



STEP 7

INDUSTRY STANDARDS & CODES

Familiarity with the following organizations and codes is essential for HVAC and building systems design:

- ACCA – Air Conditioning Contractors of America
- AHRI – Air-Conditioning, Heating, and Refrigeration Institute
- ASHRAE – American Society of Heating, Refrigerating and Air-Conditioning Engineers
- ASME – American Society of Mechanical Engineers
- ANSI – American National Standards Institute
- ICC – International Code Council (includes IBC, IMC, IPC, IECC)
- CCR – California Code of Regulations
- Title 24 / CBSC – California Building Standards Code
- CALGreen – California Green Building Standards Code (Part 11 of Title 24)
- CEC – California Energy Commission
- SMACNA – Sheet Metal and Air Conditioning Contractors' National Association
- NFPA – National Fire Protection Association
- NEC – National Electrical Code
- UMC / UPC – Uniform Mechanical Code / Uniform Plumbing Code
- LEED – Leadership in Energy and Environmental Design
- USGBC – U.S. Green Building Council

Free Resources for Code Access and Reference:

- <https://up.codes> – Interactive access to building codes and local amendments
- <https://icc.org> – Official publisher of I-Codes
- <https://ashrae.org> – Technical standards and design guidelines



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