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# Building for Energy Efficiency 2:

## How to design the mechanical system for a home that uses less energy at little or no additional cost

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# Session Objectives

- Understand the basic differences between the mechanical system in a standard home compared to a high performance home
- Learn the fundamentals of good residential air distribution system design in high performance homes
- Learn about air distribution system methods appropriate for high performance homes

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# Introduction

- High performance homes have different space conditioning requirements
- Standard air distribution system design, selection, and installation practices don't address high performance homes fully
- Need to engineer and install the air distribution system for improved air delivery at lower cfm
- Design and installation of the mechanical system in a high performance home helps a builder stay cost neutral


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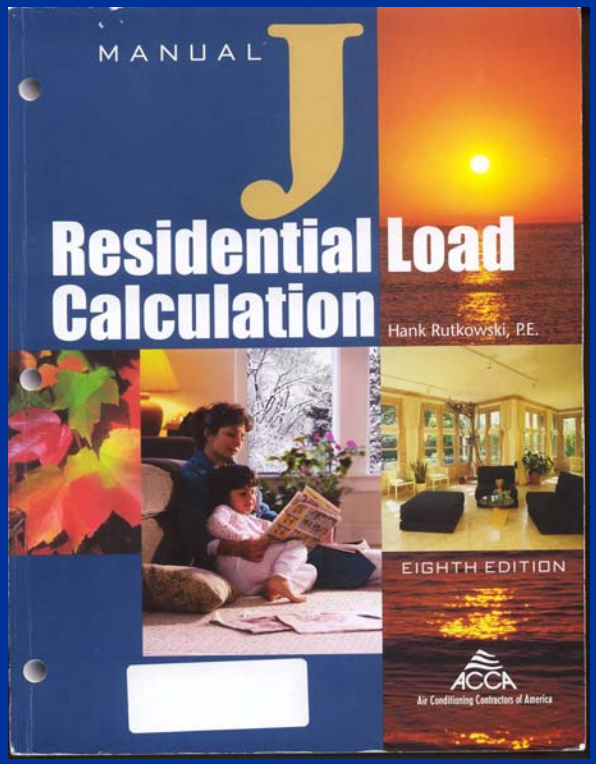
# High Performance Homes

- So what is different?
  - Improved thermal enclosure leads to reduced heating and cooling loads which results in smaller HVAC equipment
  - Used to use 400 sqft / ton as an estimation of size
  - Now 600 and up to 1000 sqft / ton
  - Improved thermal enclosure also reduces the need for perimeter air delivery
  - Reduced amount of airflow in the system
  - Standard to oversized ducts result in lower velocities
  - Lower velocities at diffusers reduce throw and mixing
  - Impact of duct leakage is amplified

# Manual J 8th Edition

- Procedure used to estimate the heat loss and gain of conventional residential structures for the purpose of HVAC sizing
- Determine room-by-room loads

- Manual J examines:
  - Enclosure elements
  - Air leakage
  - System losses / gains
  - Sun position
  - Latent and internal gains



# Manual J – Heat Loss

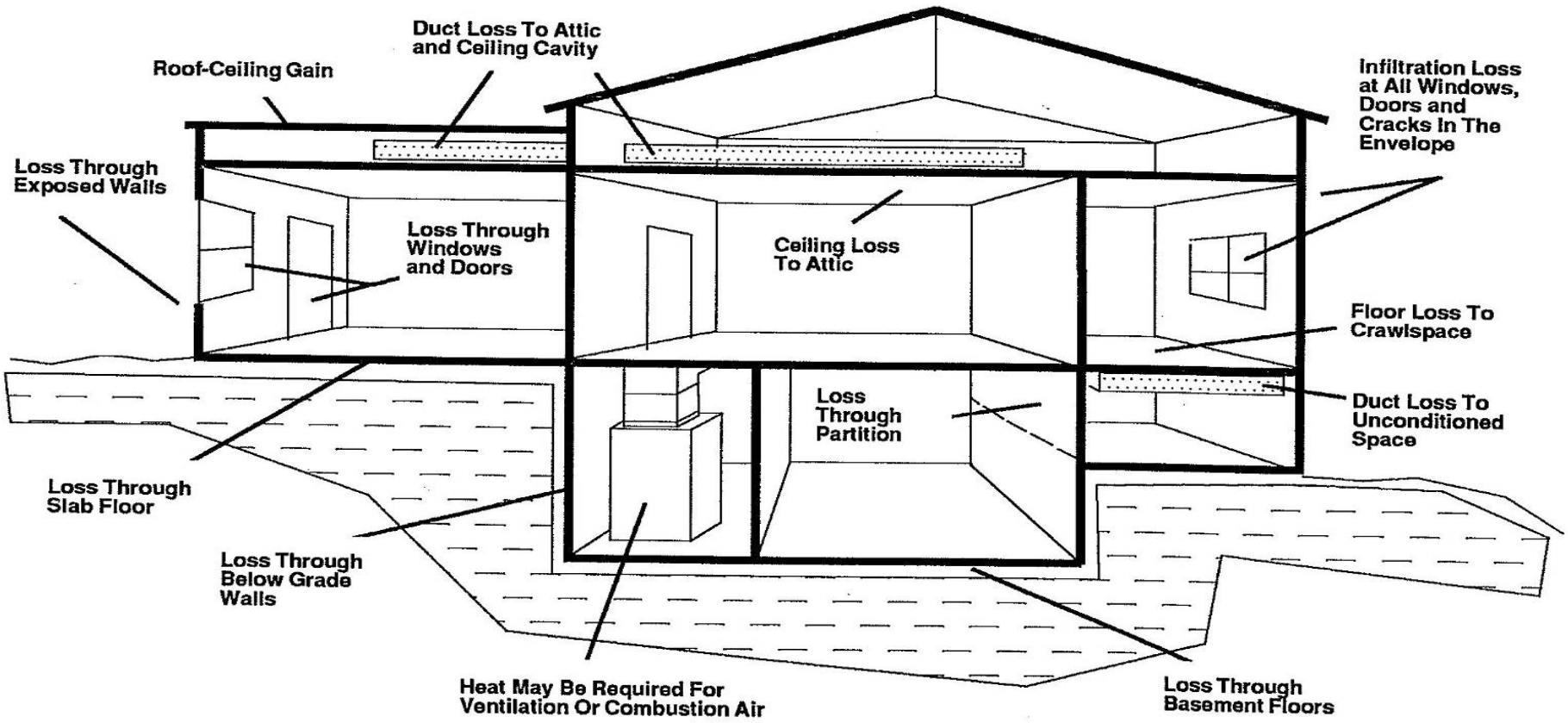



Figure 1-1

# Manual J – Heat Gain

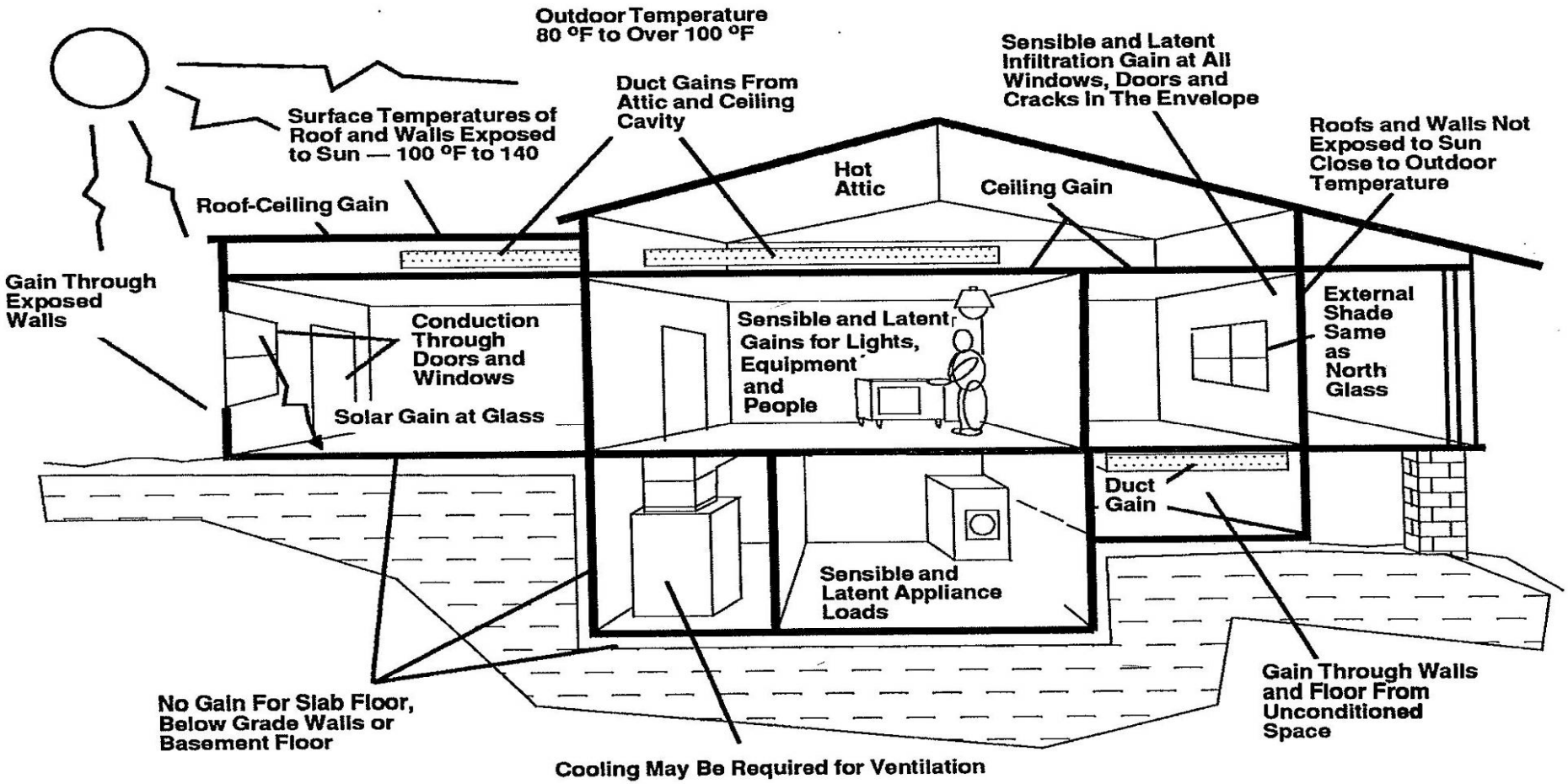



Figure 1-2

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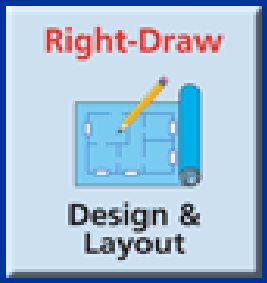
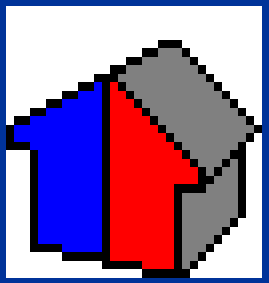
# Load Calculation Software

- Highly recommended
  - Wrightsoft
  - Elite RHVAC
  - ASHRAE
- Easy to use
  - Enter data
  - Self calculating
  - Draw building and software tallies load
- Have to know the procedure and understand the process to trust the output.

# Manual S – Equipment Selection

- Bridge between Manual J and Manual D
- Obtain detailed manufacturer's information and review it to be sure you have what you need
  - Detailed capacities for heating & cooling equipment
  - Combination ratings for cooling & heat pumps
  - Evaporator coil info
  - Fan performance info at different speeds & external static pressures

# Equipment Selection Example

## Manual J

- Peak Heating and Cooling House Loads
- Room-by-Room Loads & Required Airflows

| Manual J Loads | |
|---|---|
| Total required heating output | 65,540 |
| Required sensible cooling output | 29,362 |
| Required total cooling output | 36,058 |

**Newhouse** **Manual J calculations** back of house facing east, inground basement, bay window options

| | Peak Heating Load | | | Peak Cooling Load | | |
|---|---|---|---|---|---|---|
| **Room** | BTUH | % of total | CFM | BTUH | % of total | CFM |
| Study | 4,033 | 6.2% | 82 | 1,033 | 2.9% | 39 |
| Rec Room | 8,571 | 13.1% | 175 | 1,878 | 5.2% | 71 |
| Bath | 168 | 0.3% | 3 | 94 | 0.3% | 4 |
| Storage | 3,025 | 4.6% | 62 | 563 | 1.6% | 21 |
| Family | 6,722 | 10.3% | 137 | 5,540 | 15.4% | 210 |
| Kitchen/Nk | 4,201 | 6.4% | 86 | 4,226 | 11.7% | 161 |
| Dining | 4,705 | 7.2% | 96 | 2,348 | 6.5% | 89 |
| Living | 4,873 | 7.4% | 99 | 2,441 | 6.8% | 93 |
| Foyer | 1,512 | 2.3% | 31 | 939 | 2.6% | 36 |
| Library | 2,689 | 4.1% | 55 | 1,409 | 3.9% | 54 |
| Pwdr | 168 | 0.3% | 3 | 188 | 0.5% | 7 |
| Mstr Suite | 7,898 | 12.1% | 161 | 4,319 | 12.0% | 164 |
| Dressing | 1,849 | 2.8% | 38 | 1,127 | 3.1% | 43 |
| W.I.C | 1,344 | 2.1% | 27 | 845 | 2.3% | 32 |
| Util | 168 | 0.3% | 3 | 188 | 0.5% | 7 |
| Bed2 | 4,033 | 6.2% | 82 | 2,535 | 7.0% | 96 |
| Bath | 672 | 1.0% | 14 | 470 | 1.3% | 18 |
| Bed3 | 3,529 | 5.4% | 72 | 2,348 | 6.5% | 89 |
| Hall | 1,849 | 2.8% | 38 | 1,221 | 3.4% | 46 |
| Bed 4 | 3,529 | 5.4% | 72 | 2,348 | 6.5% | 89 |
| not used | 0 | 0.0% | 0 | 0 | 0.0% | 0 |
| | | | | | | |
| Totals | 65,540 | 100.0% | 1,335 | 36,058 | 100.0% | 1,370 |

# Equipment Efficiency

- Use the most efficient equipment the project can afford
  - Conduct iterative energy analysis to determine the impact of equipment efficiencies on energy savings
  - Translate the energy savings into cost reduction and look at the initial cost of the equipment upgrades

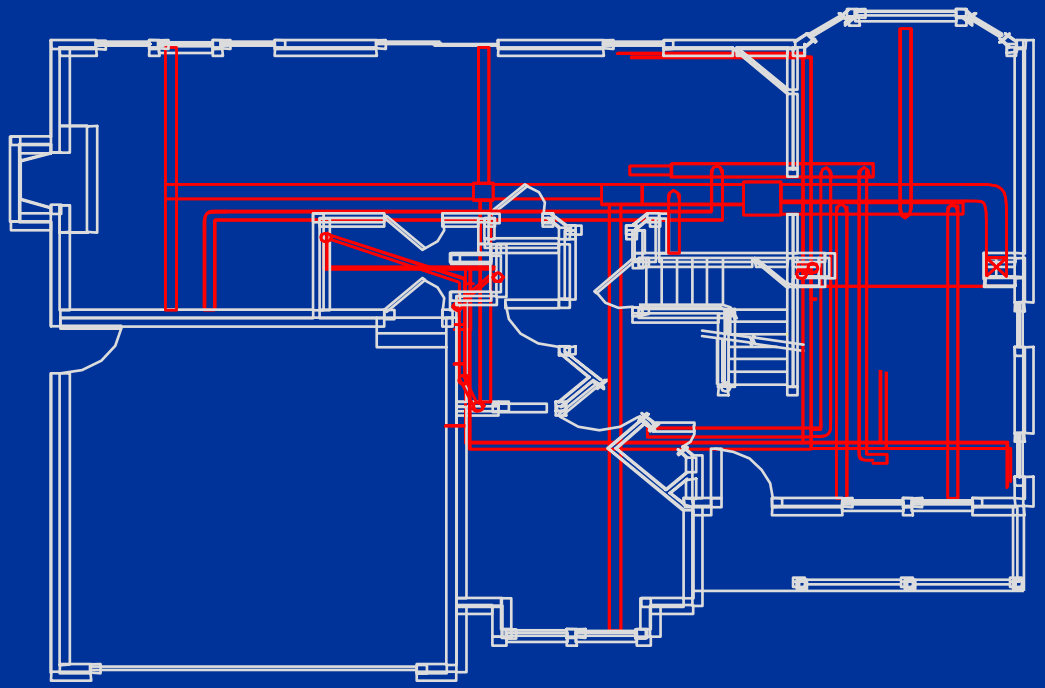
# Equipment Efficiency

- Common Industry Terminology:
  - Energy Efficiency Ratio (EER) = Btuh of cooling / watts used
  - Seasonal Energy Efficiency Ratio (SEER) = Btu cooling produced / watt-hour used
  - Annual Fuel Utilization Efficiency (AFUE) = The % of the amount of energy consumed that is actually converted to useful heat

# Standard Systems

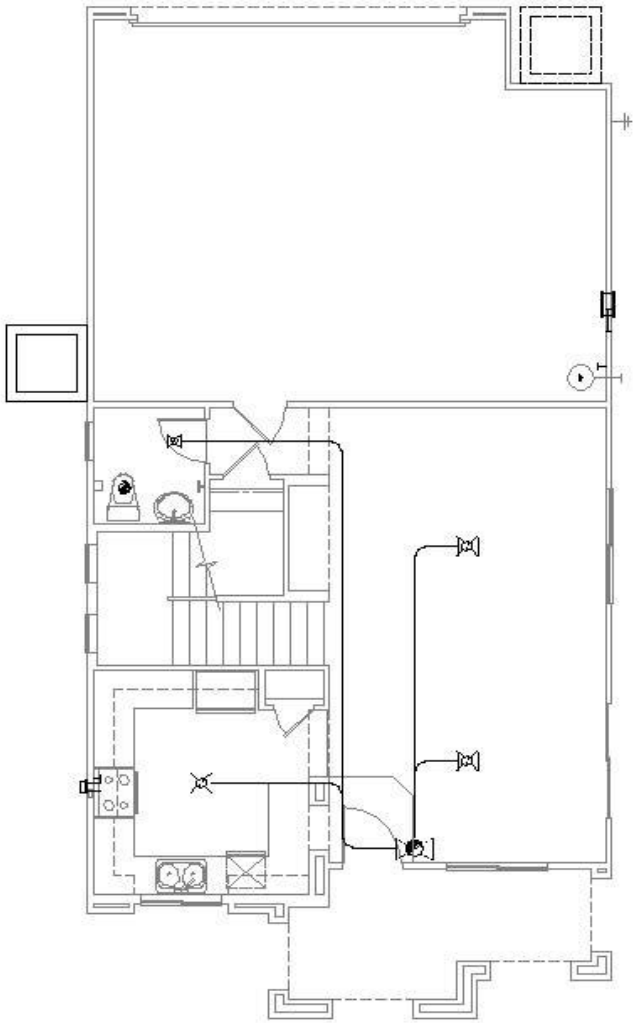
- Standard thermal enclosure requires larger mechanical equipment that may even be oversized
- Multiple supply trunks with long branches routed to the perimeter of the thermal enclosure
- Poor return strategies
- Ductwork is not sealed and is therefore leaky
- More energy is consumed and less comfort is delivered

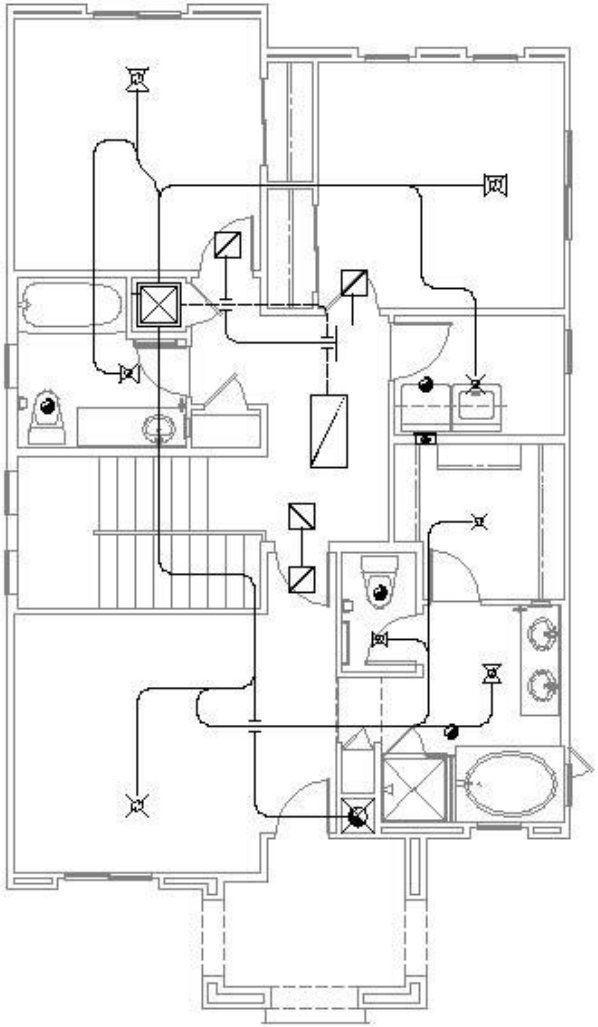
# Standard Systems



- No integration with the other aspects of the house
- Perimeter delivery of supply air
- Room by room returns or worse

# Standard Systems





# High Performance Air Distribution Design

- Use ACCA's Residential Duct System Manual D
- Integrate the distribution system into the floor plan of the house
- Locate equipment and ducts in conditioned space
- Size system for balanced air flows and quite operation
- Use central return systems
- Understand duct design is an iterative, back and forth process: velocity, friction, throw, diffuser…

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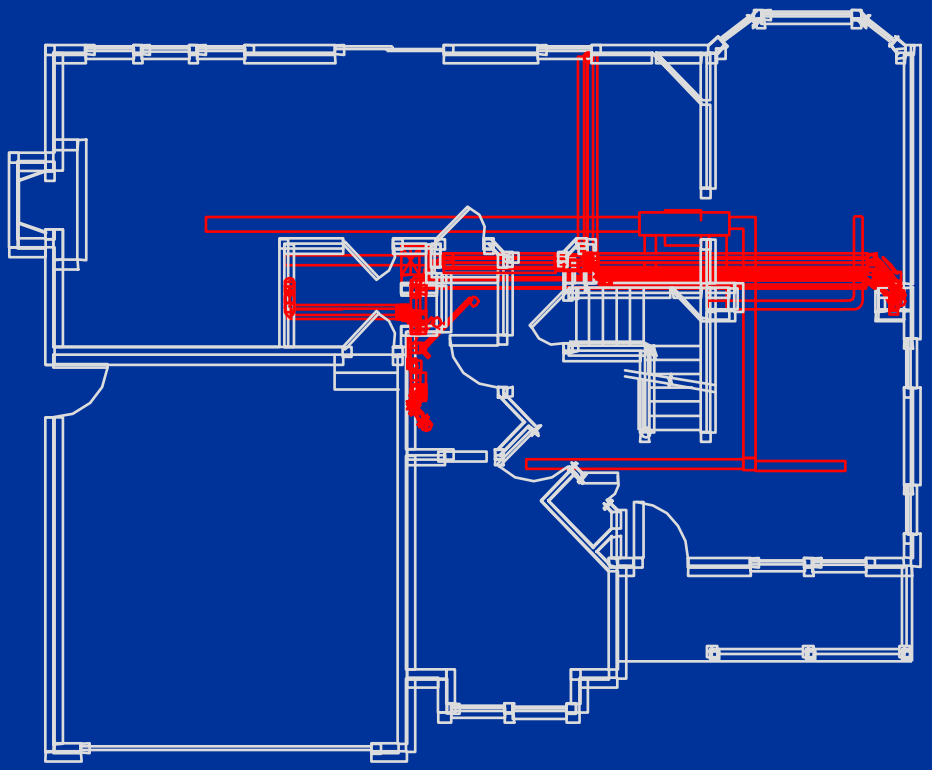
# High-Performance System



- Fully engineered and integrated design
- Centerline supply with high sidewall distribution
- Central return with jump ducts or transfer grilles

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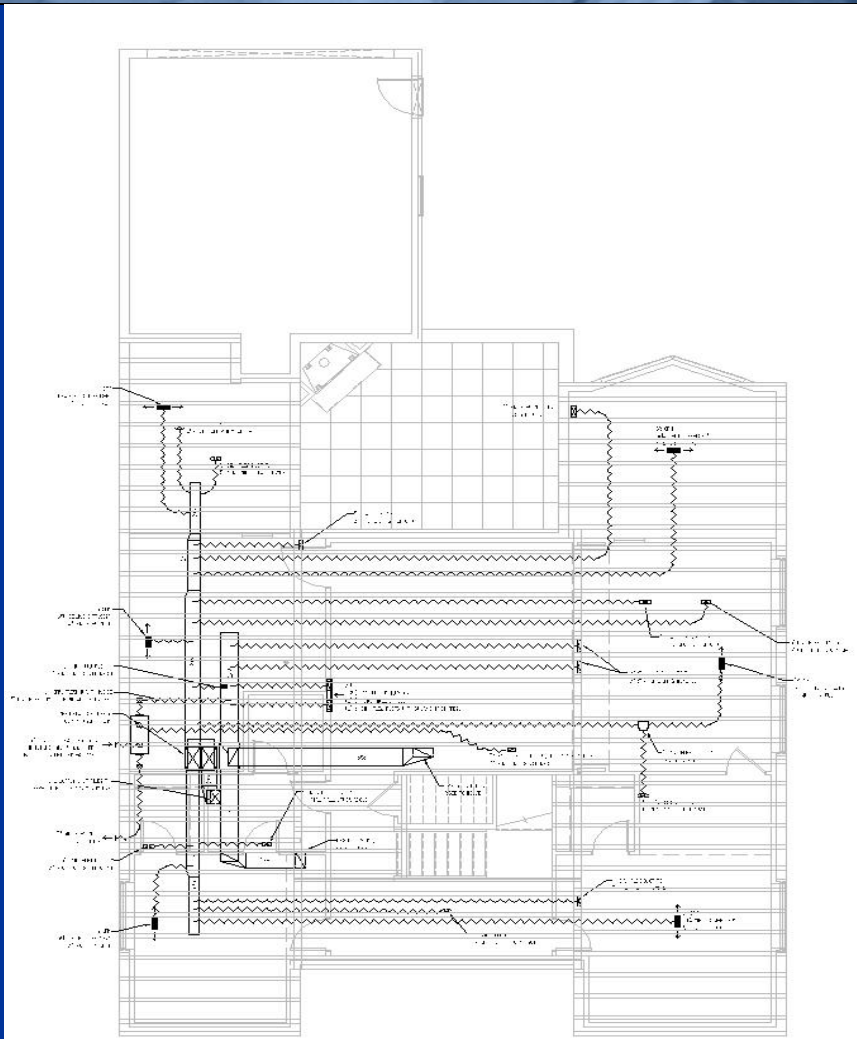
# High-Performance System

- Equipment and ductwork in conditioned space
- Short and efficient supply distribution
- Central returns
- Reduced total equivalent length utilizing shorter and more straight trunks and branches
- Right-sized ducts deliver air at needed velocities



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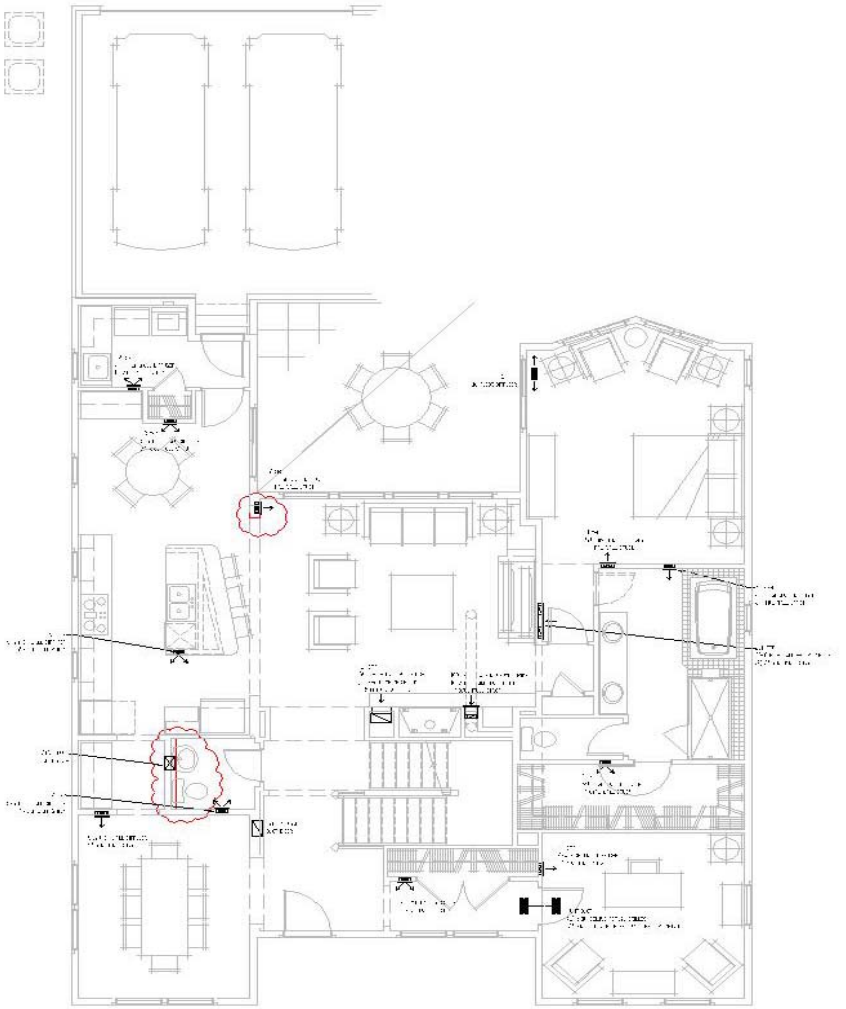
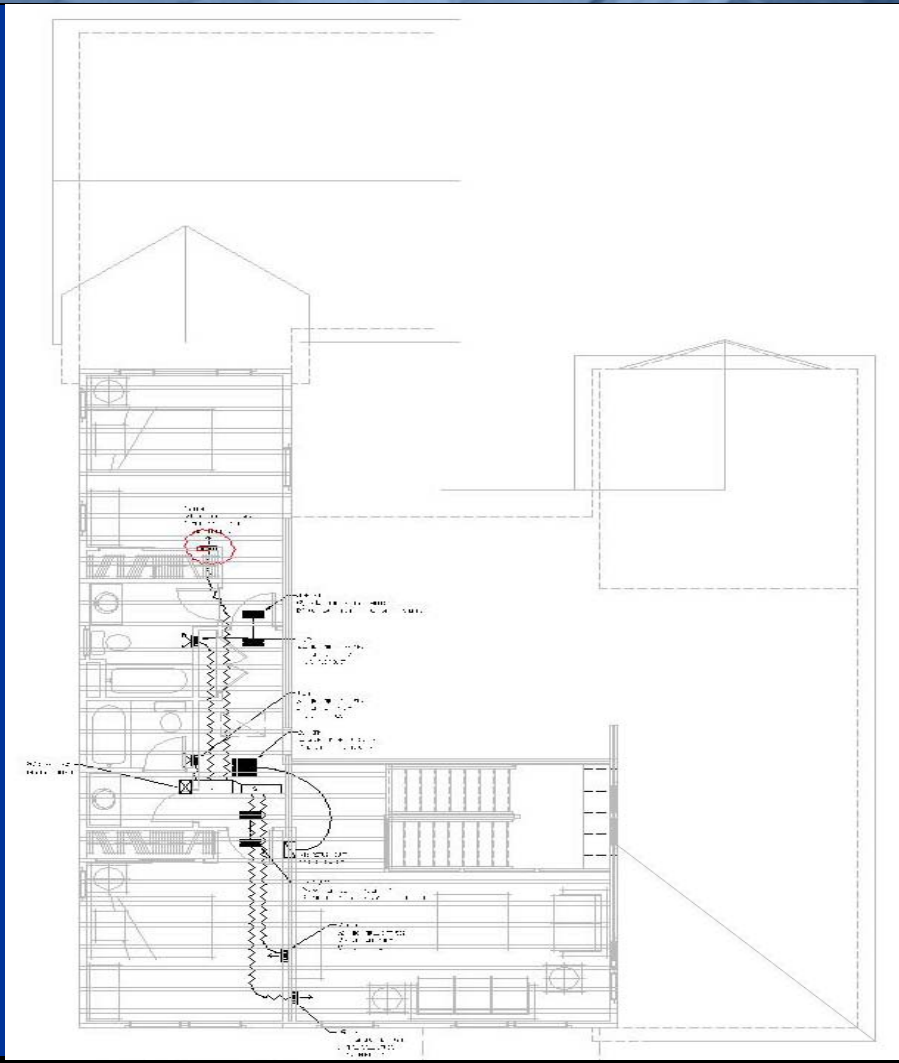
# High-Performance System

- Relatively open floor plan reduces the amount of wall space available
- Use of high sidewall diffusers more centrally located to reduce duct length
- Central return to optimize air distribution system
- Transfer grilles used to connect enclosed rooms



# High-Performance System

- Supply and return risers routed from the basement
- Short and compact supply trunk in the second floor structure.
- High sidewall diffuser locations to reduce the duct length as much as possible
- Central return with transfer grilles
- Right-sized ducts deliver air at needed velocities



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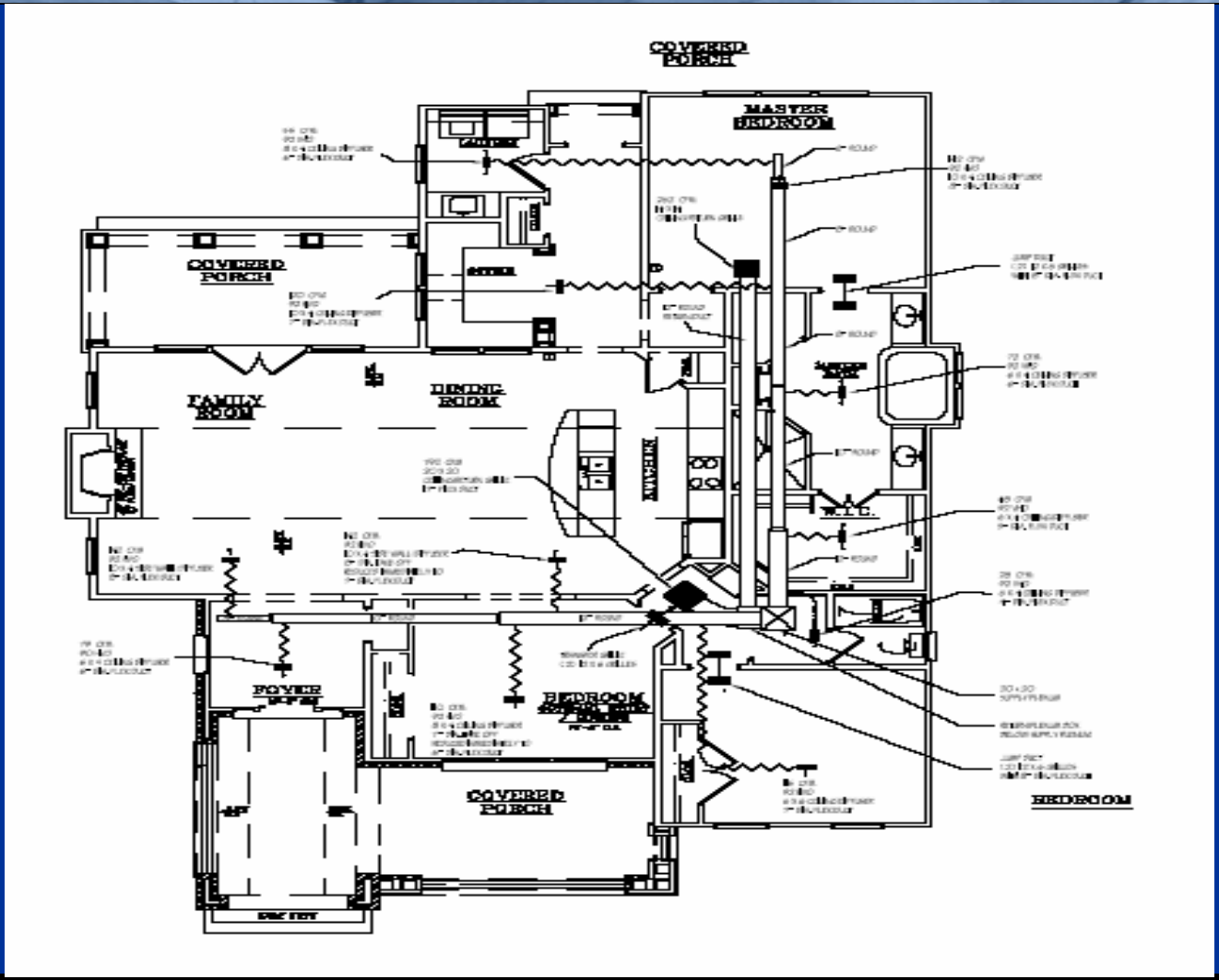
# High-Performance System

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*as a healthy, energy efficient, affordable town*

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# Duct Sealing

- No conventional duct tape
- Use of UL 181 rated duct mastic on all joints and seams
- Seal all ductwork even in conditioned space.

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# What To Look For

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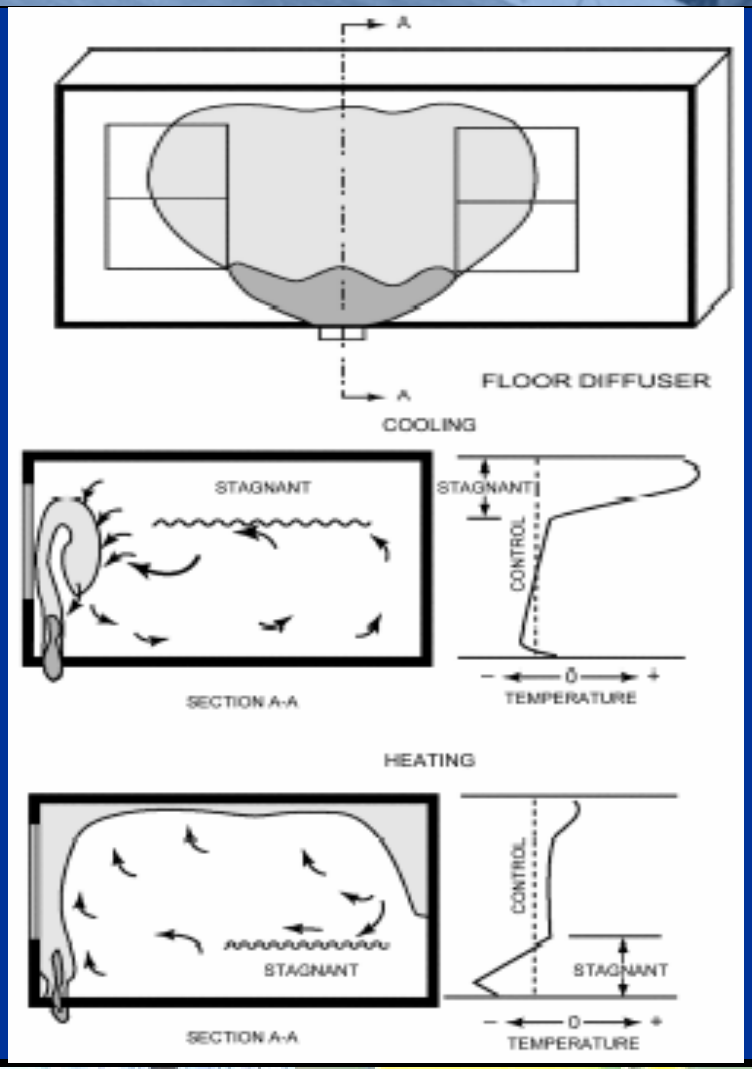
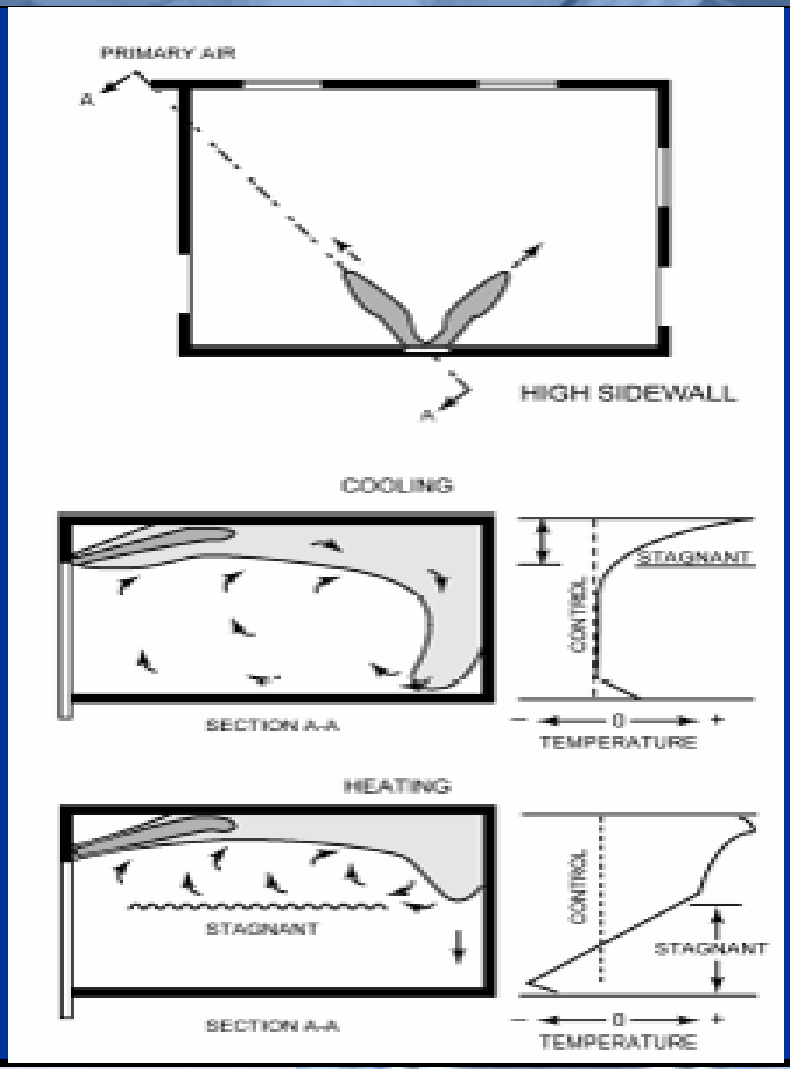
# Diffuser Selection and Design

## Diffuser Comparisons

| Room Designation | Throw Desired | CFM | Desired Selection VHO & HVO | | Contractor Selection 6" x 10" & 6" x 12" | | Generic Selection RZ682 | |
|---|---|---|---|---|---|---|---|---|
| | | | Size | Throw | Size | Throw | Size | Throw |
| Laundry | 4' | 55 | 8 x 4 | 6.6' | 6 x 10 | 3.6' | 8 x 4 | 6.6' |
| Bedroom/Study | 4.5' | 110 | 8 x 4 | 13.3' | 6 x 10 | 9.6' | 6 x 10 | 9.1' |
| Family Rm | 16' | 142 | 10 x 4 | 15.8' | 6 x 10 | 12.4' | 6 x 10 | 9.1' |
| Family Rm | 16' | 142 | 10 x 4 | 15.8' | 6 x 12 | 10.9' | 6 x 10 | 9.1' |
| Mstr. Bath | 7.5' | 72 | 6 x 4 | 9.7' | 6 x 10 | 6.3' | 6 x 6 | 8.1' |
| Mstr. Bed | 7.8' | 142 | 10 x 4 | 12.3' | 6 x 10 | 9.6' | 8 x 8 | 11.2' |
| Office | 7' | 120 | 10 x 4 | 13.4 | 6 x 10 | 10.5' | 12 x 4 | 11.5 |

# Diffuser Selection and Design

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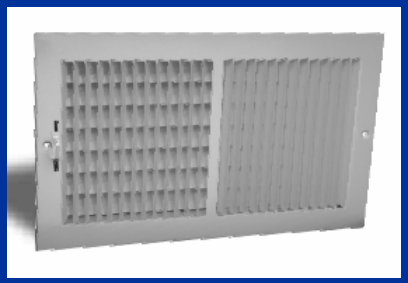
# Diffuser Test Plan

## Supply Outlets

Adjustable-Blade Single Deflection



Fixed-Blade 2-Way Throw

High-Velocity Slot

Adjustable-Blade Double Deflection

# System Commissioning

- No conventional duct tape
- Use of UL 181 rated duct mastic on all joints and seams
- Seal all ductwork – even in conditioned space.
- Leakage of the system should be less than 5% of the fan capacity

# System Commissioning

Verify fan performance and system flows

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# System Commissioning

Use flow hood measurements to balance, based off measured total flow

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# System Commissioning

Measure adequacy of pressure balancing and return strategy