Understanding Residential HVAC Equipment Sizing

Code Requirements for Manual S

(2012 IRC, IMC, IECC)

Objectives

- Participants shall understand the current and upcoming CT code requirements for residential mechanical equipment engineering (Manual J, S & D)
- Participants shall understand the relationship between Manual J load calculations and Manual S Equipment Selection
- Participants shall understand the need for Manual S equipment sizing (in accordance with the 2012 ICC code)

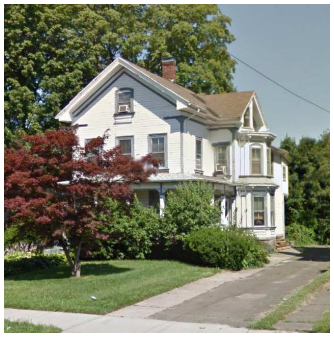
Topics

1. "Limited" Code Overview
2. Design Process Overview
3. Manual S (Equipment Selection)
4. Review & Examples

Handouts

- Copy of this presentation
- 2012 Connecticut Code Summary
- Design FAQ
- CT Code – QIV Comparison
- CT Municipal Design Table 2015
- Example OEM Engineering Data
- Example OEM Capacity Report
- Example Manual J-S Report
- Manual-S Demo Interpolation Spreadsheet

Example House #1

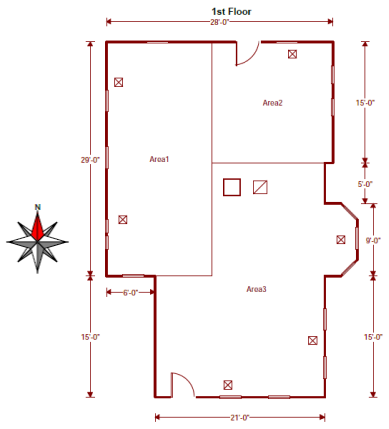


- West Haven, CT

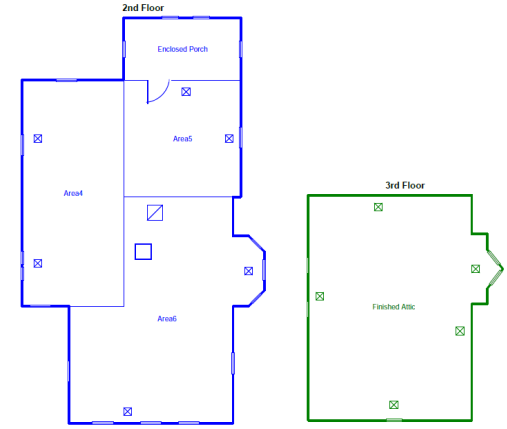
- 2 Floors + Finished Attic
- Built 1930
- 1st Flr = 1145 sq.ft.
- 2nd Flr = 1145 sq.ft.
- Attic = 632 sq.ft.
- Total = 2922 sq.ft.

- Attic Ceilings Insulated
- Windows Updated
- New "insulated" siding

Example House #1

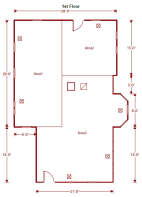


Example House #1



Example House #1

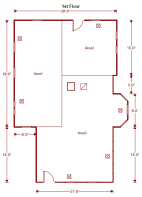
How do we typically go about "Engineering" a mechanical system for this house?



1. Determine scope of the project
2. Solicit contractor quotes
3. Hire contractor
4. Install system
5. Pay contractor

Example House #1

What is the correct way to go about "Engineering" a mechanical system for this house?



1. Determine scope of the project
2. Determine code requirements
3. Perform engineering analysis
4. Solicit bids
5. Hire contractor
6. Install system
7. Commission system
8. Pay contractor

Code Overview

State Building Codes

2005 Connecticut Code Summary
(with 2009 Amendments)

2003 International Building Code. (IBC)
2003 International Existing Building Code (IEBC)
2003 International Plumbing Code. (IPC)
2003 International Mechanical Code. (IMC)
2009 International Energy Conservation Code (IECC)
2009 International Residential Code. (IRC)
2011 National Electrical Code (NFPA-70) (NEC)

2012 Connecticut Code Summary
(Proposed Adoption Fall 2015)

2012 International Building Code. (IBC)
2012 International Existing Building Code (IEBC)
2012 International Plumbing Code. (IPC)
2012 International Mechanical Code. (IMC)
2012 International Energy Conservation Code (IECC)
2012 International Residential Code. (IRC)
2014 National Electrical Code (NFPA-70) (NEC)

2011 Connecticut Amendment

Effective: Oct 6, 2011

SECTION 29-252-1d Amended….

DELETE 2006 IECC, substitute with 2009 IECC Amendments:
403.2.1.1 Duct Insulation Values prescribed must be Installed values.
403.2.3 No building cavities may be used as supply or return "ducts". *(2003 IMC/IRC allowed returns)*

403.6 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 methods – none listed).

Referenced Standard: ACCA Manual J-02, 8th edition (not 7)
Referenced Standard: ACCA Manual S-04

2012 International Residential Code
2012 International Energy Conservation Code

N1103.6 (R403.6) Equipment sizing (Mandatory) & M1401.3 Sizing.
R403.6 Equipment Sizing (Mandatory).

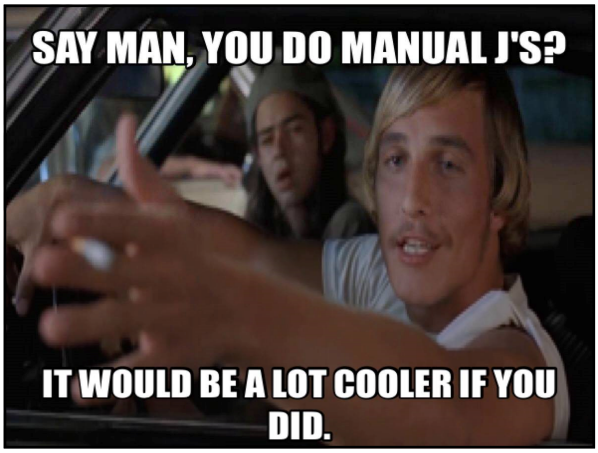
"Heating and cooling equipment shall be sized in accordance with ACCA Manual S based on building loads calculated in accordance with ACCA Manual J or other *approved* heating and cooling calculation methodologies."

Code Comparison

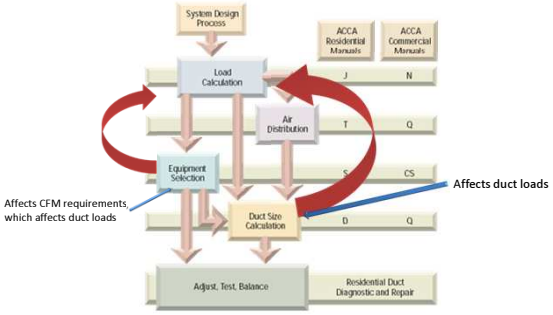
ACCA Standard 5 (Quality Install)	Component	2005 Connecticut Code (2009, 2011 & 2013 Amendments)	2012 Connecticut Code	Energy Star (Homes 3.0 / Quality Installation)
ANSI/ACCA 2 Manual J - 2011 J-8 (version 2) *(Block - Room-by-room)*	**Manual J** (Load calculations)	IRC 2009: ***M1401.3*** ACCA Manual J8-02 IECC 2009: ***403.6*** CT 2011 Amend: *(Mandatory) Load Calculation* ACCA Manual J-8 (version 2)	IRC 2012: ***M1401.3*** ACCA Manual J8-11 IECC 2012: ***403.6*** *(Mandatory)* ACCA Manual J	J-8 Required: *(Room-by-room)*
ANSI/ACCA 1 Manual D - 2009 *(None - Complete)*	**Manual D** (Duct design)	IRC 2009: ***M1601.1, M1602.2*** ACCA Manual D-09	IRC 2012: ***M1602.2*** ACCA Manual D-09 IMC 2012: ***603.2*** ACCA Manual D	Required *(Complete)*
ANSI/ACCA 3 Manual S - 2004 (2nd Edition - 2014)	**Manual S** (Equipment/component selection)	IRC 2009: ***M1401.3*** ACCA Manual S-2004 IECC 2009: ***403.6*** CT 2011 Amend: *(Mandatory) Equipment Sizing* ACCA Manual S	IRC 2012: ***M1401.3*** ACCA Manual S IECC 2012: ***403.6*** *(Mandatory)* ACCA Manual S	S-2004 Required
Estimated, recommended, or per code for new construction	**Building Infiltration** (Testing with Blower Door)	IECC 2009: *Option* ***402.4.2.1***	IECC 2012: ***R402.4.1.2*** $3\ ACH_{50}$	Required
Required: *New: 6% Total, Exist: 20% of design cfm, or 50% reduction*	**Duct Leakage** (Testing with Duct Blaster)	IECC 2009: ***403.2.2*** *Sealing (Mandatory)* ***8-12cfm/100ft²***	IRC 2012: ***N1103.2.2*** *Sealing (Mandatory)*: ***3-4cfm/100ft²*** IECC 2012: ***403.2.2*** *Sealing (Mandatory)*: ***3-4cfm/100ft²***	Required: *≤6cfm/100ft²*
Required	**Airflow Testing** (Balancing / Total / Static)	Not Cited	Not Cited	Required
Required	**Commissioning** (Charge, electrical, airflow testing & documentation)	Not Cited	Not Cited	Required

The Design Process

8:50 AM



Design Process Overview



ACCA – Contracting Business Magazine, Spring 2003

Design Process Overview

What is Manual J?

1. "Modeling" the peak building loads at local climatic conditions
   1. Do NOT change outdoor or indoor design conditions. (This will create psychrometric errors)
2. Manual J (when performed aggressively) will still over-estimate actual loads by 10% to 40%

Local Design Conditions

Connecticut Location		Connecticut Design Data					ACCA Table 1A (Reference Design Data)						
City	County	Elevation	Winter Heating 99% dB	Summer Cooling 1% dB	Cooling 1% (wb)	Miles To Reference	Design Reference City	State	Elevation	Latitude	Heating 99% (db)	Cooling 1% (db)	Cooling 1% (wb)
ABINGTON	WINDHAM	653	5	86	73	20	Norwich	CT	197	41	7	86	73
ANDOVER	TOLLAND	405	5	88	72	19	Hartford Brainard Field	CT	19	41	6	88	72
ANSONIA	NEW HAVEN	90	7	84	73	8	New Haven	CT	14	41	7	84	73
ASHFORD	WINDHAM	698	5	86	73	25	Norwich	CT	197	41	7	86	73
AVON	HARTFORD	287	5	88	72	6	Hartford Brainard Field	CT	19	41	6	88	72
BARKHAMSTED	LITCHFIELD	562	4	88	72	16	Hartford Brainard Field	CT	19	41	6	88	72
BEACON FALLS	NEW HAVEN	133	5	88	72	7	Waterbury	CT	850	41	2	85	71
BERLIN	HARTFORD	161	5	88	72	10	Hartford Brainard Field	CT	19	41	6	88	72
BETHANY	NEW HAVEN	512	5	84	73	8	New Haven	CT	14	41	7	84	73
BETHEL	FAIRFIELD	376	4	87	72	15	Waterbury	CT	850	41	2	85	71
BETHLEHEM	LITCHFIELD	833	2	85	71	10	Waterbury	CT	850	41	2	85	71
BLOOMFIELD	HARTFORD	134	6	88	72	6	Hartford Brainard Field	CT	19	41	6	88	72
BOLTON	TOLLAND	736	6	88	71	15	Windsor Locks Bradley Field	CT	197	42	8	88	71
BOZRAH	NEW LONDON	180	7	86	73	8	Norwich	CT	197	41	7	86	73
BRANFORD	NEW HAVEN	41	7	84	73	7	New Haven	CT	14	41	7	84	73
BRIDGEPORT	FAIRFIELD	28	12	84	72	2	Bridgeport	CT	10	41	12	84	72
BRIDGEWATER	LITCHFIELD	706	3	86	71	11	Waterbury	CT	850	41	2	85	71
BRISTOL	HARTFORD	312	5	88	72	12	Hartford Brainard Field	CT	19	41	6	88	72
BROOKFIELD	FAIRFIELD	498	3	86	72	12	Waterbury	CT	850	41	2	85	71
BROOKLYN	WINDHAM	211	7	86	73	16	Norwich	CT	197	41	7	86	73
BURLINGTON	HARTFORD	750	3	88	71	11	Hartford Brainard Field	CT	19	41	6	88	72
CANAAN													72
CANTERB													73
CANTON													72
CHAPLIN													73
CHESHIRE													71
CHESTER	MIDDLESEX	225	8	85	72	19	New London	CT	10	41	9	85	72
CLINTON	MIDDLESEX	63	7	84	73	20	New Haven	CT	14	41	7	84	73

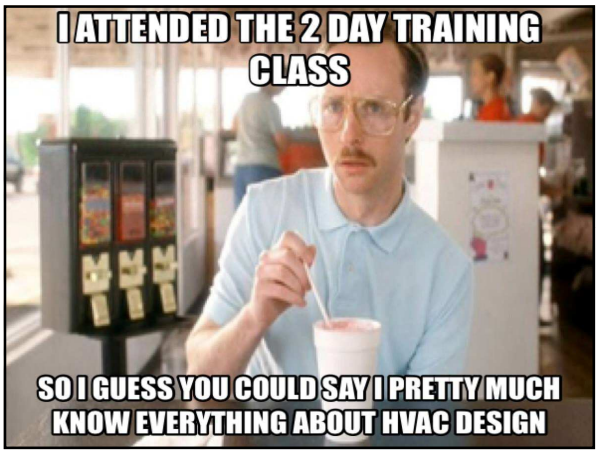
All values derived from 2009 ASHRAE Handbook-Fundamentals Chapter 1 Psychrometrics Equations 3 & 4

What is Manual S?

1. Iterative process using the "initial" loads from Manual J to select candidate equipment
2. Candidate equipment capacity is then adjusted based on:
   1. available CFM settings of air handler,
   2. altitude,
   3. outdoor air design temperature,
   4. return air entering conditions and,
   5. any line-set adjustments due to lifts or lengths

What is Manual D?

1. The process to design a ducted distribution system based on the CFM requirements determined by the Manual J and Manual S process.
2. Although re-engineering existing duct systems is not required – the designer/mechanic better be able to recognize the very common problems of insufficient return duct, grille and filter sizing.
3. If installing a hydronic only system, many of the Manual J software suites will help size baseboard lengths for the project.



Acceptable Software Tools/Methods

- Manual J is too complex to perform by hand or with a spreadsheet! The design practitioner MUST use approved software.
  - There are currently 6 software packages available for load calculations. They are NOT equal in their capabilities.

ADTEK SOFTWARE

CARMEL SOFTWARE
ResLoad-J for IPAD

EnergyGauge®

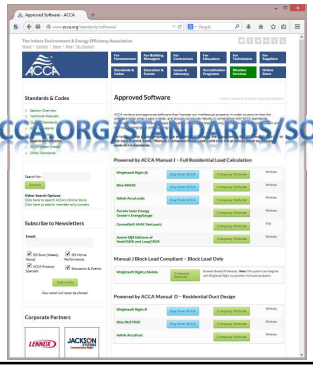
HeatCAD™


Avenir

Elite Software
RHVAC RESIDENTIAL HVAC LOADS

wrightsoft right-suite UNIVERSAL

ACCA Approved Software



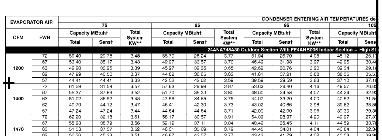
Software Not ACCA Approved

MrHVAC.com
HVAC-Calc
Fire Dragon Net
O'Brien Quick Loads Pro
Qwickload
Loadcalc.net

Code Officials Note: None of these packages will calculate duct loads or air-conditioning loads correctly. They may be close enough for hydronic heating loads, but they are not vetted by ACCA for either.

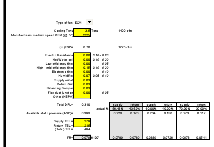
Acceptable Software Tools/Methods

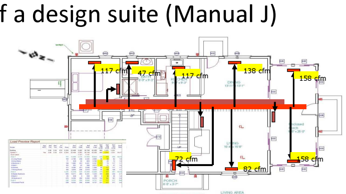
- Manual S requires Psychrometric calculations and detailed OEM performance data. It can be preformed with charts and tables, however there are a lot of numbers involved and is easy to miss-read or transcribe numbers from OEM charts. It is better to use OEM software and either Psychrometric software, or other tool (including Manual J software) to perform the calculations when possible.
  - NONE of the current Manual J software suites does this perfectly or at all in some cases!



Acceptable Software Tools/Methods

- Manual D can be performed on paper and spreadsheet by someone familiar with the steps, however we highly recommend using the duct design calculators that are available in or as part of a design suite (Manual J)

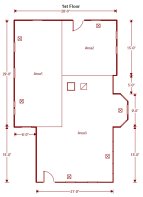




Design Summary

- Manual J
  - Determine local conditions
- Manual S
  - Select equipment with capacity adjusted for local conditions
- Manual D
  - Based on design CFM requirements

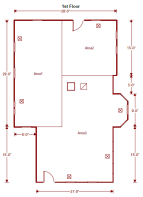
Example House #1



1. Determine scope of the project

1. Replace 1st floor furnace and Air Conditioner
2. Replace boiler that serves 2nd floor and finished attic
3. Add new air conditioner system to 2nd floor and attic

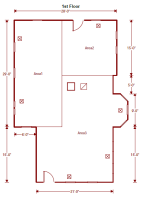
Example House #1



2. Determine code requirements

1. Manual J (Entire building)
2. Manual S (all systems)
3. Manual D – New A/C system only

Example House #1



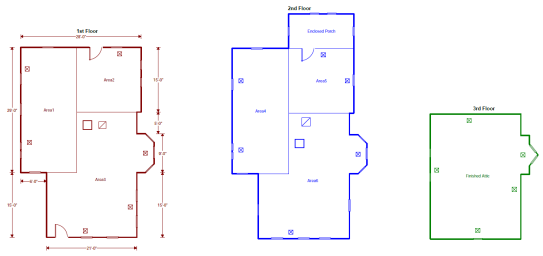
3. Perform engineering analysis

1. Manual J (Entire building)
2. Manual S (all systems)
3. Manual D – New A/C system only

Local Design Conditions

Connecticut Location		Connecticut Design Data					ACCA Table 1A (Reference Design Data)						
City	County	Elevation	Winter Heating 99% dB	Summer Cooling 1% dB	Cooling 1% (wb)	Miles To Reference	Design Reference City	State	Elevation	Latitude	Heating 99% (db)	Cooling 1% (db)	Cooling 1% (wb)
THOMASTON	LITCHFIELD	407	4	87	72	11	Waterbury	CT	850	41	2	85	71
THOMPSON	WINDHAM	634	6	84	70	19	Worcester	MA	986	42	5	83	69
TOLLAND	TOLLAND	629	6	88	71	15	Windsor Locks Bradley Field	CT	197	42	8	88	71
TORRINGTON	LITCHFIELD	753	3	88	71	16	Hartford Brainard Field	CT	19	41	6	88	72
TRUMBULL	FAIRFIELD	289	11	84	72	6	Bridgeport	CT	10	41	12	84	72
UNION	TOLLAND	864	6	88	70	20	Windsor Locks Bradley Field	CT	197	42	8	88	71
VERNON	TOLLAND	527	7	88	71	11	Windsor Locks Bradley Field	CT	197	42	8	88	71
VOLUNTOWN	NEW LONDON	275	7	86	73	8	Norwich	CT	197	41	7	86	73
WALLINGFORD	NEW HAVEN	88	7	84	73	12	New Haven	CT	14	41	7	84	73
WARREN	LITCHFIELD	1292	0	85	71	22	Waterbury	CT	850	41	2	85	71
WASHINGTON	LITCHFIELD	847	2	85	71	12	Waterbury	CT	850	41	2	85	71
WATERBURY	NEW HAVEN	588	3	86	71	7	Waterbury	CT	850	41	2	85	71
WATERFORD	NEW LONDON	78	9	85	72	2	New London	CT	10	41	9	85	72
WATERTOWN	LITCHFIELD	619	3	86	71	7	Waterbury	CT	850	41	2	85	71
WEST HARTFORD	HARTFORD	176	5	88	72	1	Hartford Brainard Field	CT	19	41	6	88	72
WEST HAVEN	NEW HAVEN	70	7	84	73	3	New Haven	CT	14	41	7	84	73
WESTBROOK	MIDDLESEX	30	9	85	72	19	New London	CT	10	41	9	85	72
WESTON	FAIRFIELD	310	9	84	71	7	Norwalk	CT	397	41	9	84	71
WESTPORT	FAIRFIELD	25	10	85	72	5	Norwalk	CT	397	41	9	84	71
WETHERSFIELD	HARTFORD	70	6	88	72	5	Hartford Brainard Field	CT	19	41	6	88	72
WILLINGTON	TOLLAND	768	6	88	71	20	Windsor Locks Bradley Field	CT	197	42	8	88	71
WILTON	FAIRFIELD	333	9	84	71	5	Norwalk	CT	397	41	9	84	71
WINCHESTER	LITCHFIELD	1324	1	88	71	22	Hartford Brainard Field	CT	19	41	6	88	72
WINDHAM	WINDHAM	310	7	86	73	11	Norwich	CT	197	41	7	86	73
WINDSOR	HARTFORD	55	9	89	71	5	Windsor Locks Bradley Field	CT	197	42	8	88	71
WINDSOR LOCKS	HARTFORD	130	8	88	71	0	Windsor Locks Bradley Field	CT	197	42	8	88	71
WOLCOTT	NEW HAVEN	605	3	86	71	11	Waterbury	CT	850	41	2	85	71
WOODBRIDGE	NEW HAVEN	332	6	84	73	6	New Haven	CT	14	41	7	84	73
WOODBURY	LITCHFIELD	269	4	87	72	5	Waterbury	CT	850	41	2	85	71
WOODSTOCK	WINDHAM	572	6	84	70	23	Worcester	MA	986	42	5	83	69

Manual J – Load Calculations



wrightsoft Load Short Form

Job:
Date: May 01, 2015

Design Information

	Htg	Clg		
Outside db (°F)	7	84	Infiltration	
Inside db (°F)	70	75	Method	Simplified
Design TD (°F)	63	9	Construction quality	Loose
Daily range	-	M	Fireplaces	1 (Semi-loose)
Inside humidity (%)	50	50		
Moisture difference (gr/lb)	48	40		

HEATING EQUIPMENT

Make n/a
Trade n/a
Model n/a
AHRI ref n/a

Efficiency n/a
Heating input

COOLING EQUIPMENT

Make n/a
Trade n/a
Cond n/a
Coil n/a
AHRI ref n/a

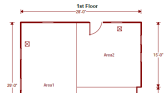
Efficiency n/a
Sensible cooling 0 Btuh

ROOM NAME		Area (ft²)	Htg load (Btuh)	Clg load (Btuh)	Baseboard (ft) Low	Baseboard (ft) High	Clg AVF (cfm)
Boiler	d	1777	58557	23490	98	69	1100
Furnace	d	1145	36351	12703	61	43	587
Entire House	d	2922	94909	36195	158	112	1845
Other equip loads				0			
Equip. @ 1.00 RSM				36195			
Latent cooling				8693			
TOTALS		2922	94909	44888	158	112	1845

Calculations approved by ACCA to meet all requirements of Manual J 8th Ed.

wrightsoft

Manual J – Load Calculations



wrightsoft Load Short Form
Furnace
Rollay Inc. Energy Services

Project Information

For: Manual S Demo
West Haven, CT 06516

Design Information

HEATING EQUIPMENT

COOLING EQUIPMENT

ROOM NAME		Area (ft²)	Htg load (Btuh)	Clg load (Btuh)	Baseboard (ft) Low	Baseboard (ft) High	Clg AVF (cfm)
1st Floor Zone	p	1145	36351	13868	61	43	641
Furnace	d	1145	36351	12703	61	43	587
Other equip loads				0			
Equip. @ 1.00 RSM				12703			
Latent cooling				4308			
TOTALS		1145	36351	17010	61	43	587

Calculations approved by ACCA to meet all requirements of Manual J 8th Ed.

wrightsoft

Manual J – Load Calculations

wrightsoft Load Short Form
Boiler
Rollay Inc. Energy Services

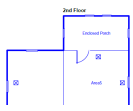
Project Information

For: Manual S Demo
West Haven, CT 06516

Design Information

HEATING EQUIPMENT

COOLING EQUIPMENT



ROOM NAME		Area (ft²)	Htg load (Btuh)	Clg load (Btuh)	Baseboard (ft) Low	Baseboard (ft) High	Clg AVF (cfm)
2nd Floor Zone	p	1145	30096	16567	50	35	773
Attic Zone	p	632	28461	9246	47	33	431
Boiler	d	1777	58557	23490	98	69	1100
Other equip loads			0	0			
Equip. @ 1.00 RSM				23490			
Latent cooling				4385			
TOTALS		1777	58557	27876	98	69	1100

Calculations approved by ACCA to meet all requirements of Manual J 8th Ed.

wrightsoft

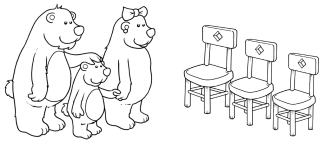
Manual S

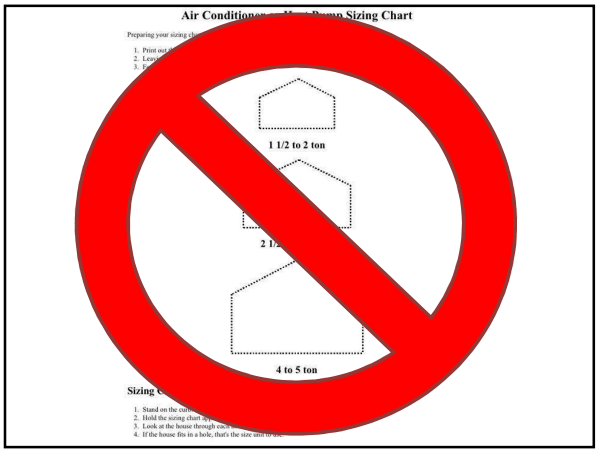
The Practical Definition

9:10 AM

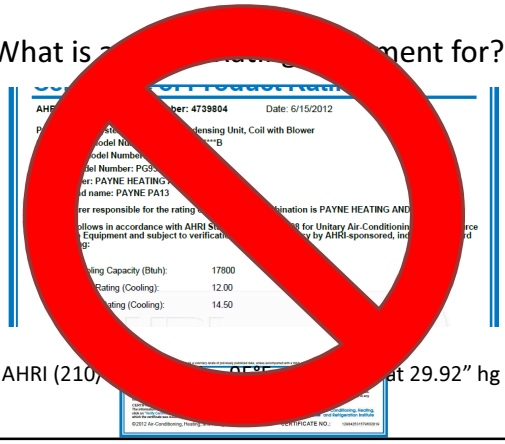
Manual S Definition

- The process by which the design practitioner determines the suitability of a candidate mechanical comfort system to meet the design loads of a building.





What is a ment for?



AHRI (210/ at 29.92" hg

What is an AHRI Rating Document for?

- DOE requires it.
- It only tells us what it can do in a lab – for comparison to other systems at the same conditions.
- It does NOT predict how it will perform on our project!

Manual S Procedure

- Adjust capacity for the following effects/factors:
  1. Altitude
  2. Entering coil air conditions
     1. Adjusted for Duct gains/losses (leakage, R-values)
     2. Ventilation
  3. CFM Settings
     1. Airflow set for Sensible Heat Ratio (Cooling)
  4. Line-Sets

WHY?

- Why do we need to do a load calculation (Manual J) and equipment selection (Manual S) on an existing house?
  - Can't I just use the same size as what was already there before if the customer isn't complaining?

BECAUSE

- The original system was MOST likely not properly engineered to begin with,
- Buildings change over time:
  - Weatherization
  - Improvements: Insulation, windows, etcetera…
  - Additional space: additions, finished basements, attics, etcetera.
- Modern equipment doesn't necessarily work the same as the system that is being replaced.

SO?

- OK – so isn't equipment selection based on the loads? Can't I just pick as system based on the loads?
- Well no!

Manual J ≠ Equipment Selection

Equipment capacity is rated at certain laboratory conditions. The designer needs to determine how it will operate at local climatic and building operating conditions.

AHRI Rating – Cooling (& HP's)

- Doesn't include affects of:
  - Altitude
  - Duct thermal gains/losses
  - Duct static pressures
    - Affects fan power and heat
    - Affects airflow and actual Sensible Heat Ratio
  - Outdoor air temperature (difference)
  - Line-sets
    - Charge adjustments to compensate for length, lifts, size

AHRI Rating – Heating (Combustion)

- Doesn't include affects of:
  - Altitude
  - Duct thermal gains/losses (not significant)
  - Duct static pressures
    - Affects fan power and heat (not significant)

Manual S (Equipment Selection)

Line Sets

VAPOR LINE SIZING AND COOLING CAPACITY LOSS
PURON REFRIGERANT 1-STAGE AIR CONDITIONER APPLICATIONS

LONG LINE APPLICATION: An application is considered "Long line" when the total equivalent tubing length exceeds 80 ft or when there is more than 20 Ft vertical separation between indoor and outdoor units. These applications require additional accessories and system modifications for reliable system operation. The maximum allowable total equivalent length is 250Ft. The maximum vertical separation is 200 Ft when outdoor unit is above indoor unit, and 80 Ft when the outdoor unit is below the indoor unit. Refer to Accessory Usage Guideline below for required accessories. See Long-Line Application Guideline for required piping and system modifications. Also, refer to the table below for the acceptable vapor tube diameters based on the total length to minimize the cooling capacity loss.

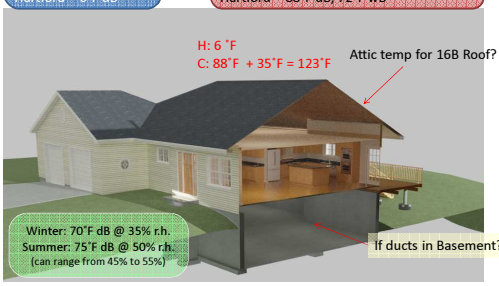
Unit Nominal Size (Btuh)	Acceptable Liquid Line Diameters (in. OD)	Acceptable Vapor Line Diameters (in. OD)	Cooling Capacity Loss (%) Total Equivalent Line Length (ft.)									
			Standard Application			Long Line Application Requires Accessories						
			25	50	80	80+	100	125	150	175	200	225	250
18000 1 Stage Puron AC	3/8	1/2	1	2	3	3	4	6	7	8	9	10	12
		5/8	0	0	1	1	1	1	2	2	3	3	3
24000 1 Stage Puron AC	3/8	5/8	0	1	1	1	2	3	3	4	4	5	6
		3/4	0	0	0	0	0	1	1	1	1	1	2
		7/8	0	0	0	0	0	0	0	0	0	0	1
30000 1 Stage Puron AC	3/8	5/8	1	2	3	3	3	4	5	6	7	8	9
		3/4	0	0	1	1	1	1	2	2	2	3	3
		7/8	0	0	0	1	0	1	1	1	1	1	1
36000 1 Stage Puron AC	3/8	5/8	1	2	4	4	5	6	7	9	10	11	13
		3/4	0	0	1	1	1	2	2	3	3	4	4
		7/8	0	0	0	0	0	1	1	1	1	2	2
42000 1 Stage Puron AC	3/8	3/4	0	1	2	2	2	3	4	4	5	6	6
		7/8	0	0	1	1	1	1	2	2	2	3	3
		1 1/8	0	0	0	0	0	0	0	0	0	0	1
48000 1 Stage Puron AC	3/8	3/4	0	1	2	2	3	4	5	5	6	7	8
		7/8	0	0	1	1	1	2	2	3	3	3	4
		1 1/8	0	0	0	0	0	0	0	0	1	1	1
60000 1 Stage Puron AC	3/8	3/4	1	2	4	4	5	6	7	9	10	11	12
		7/8	0	1	2	2	2	3	4	4	5	5	6
		1 1/8	0	0	0	0	1	1	1	1	1	1	2

Standard Length = 80 Ft or less total equivalvent length
Applications in this area are long line. Accessories are required as shown recommended on Long Line Application Guidelines
Applications in this area may have height restrictions that limit allowable total equivalent length, when outdoor unit is below indoor unit. See Long Line Application Guidelines

Design Conditions - Ducts

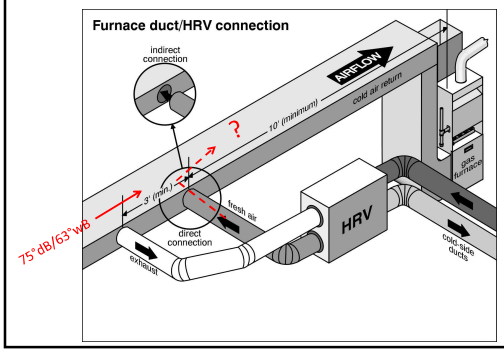
Winter: 99% dB
Hartford = 6˚F dB

Summer: 1% dB and 1% (coincidence) wB
Hartford = 88˚F dB, 72˚F wB

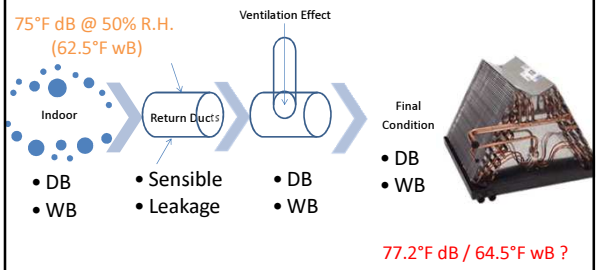


H: 50˚F + (6˚F x 0.3) = 51.8˚F
C: 75˚F

Ventilation

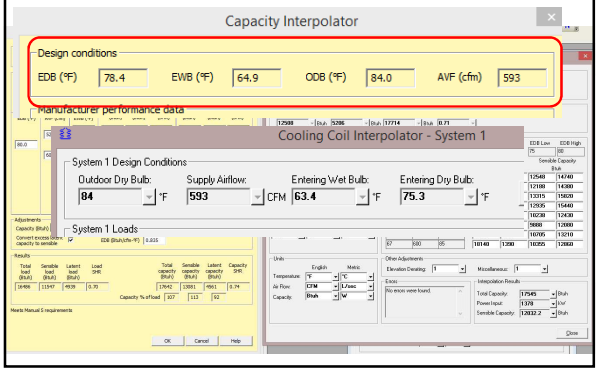


Manual S (Equipment Selection)

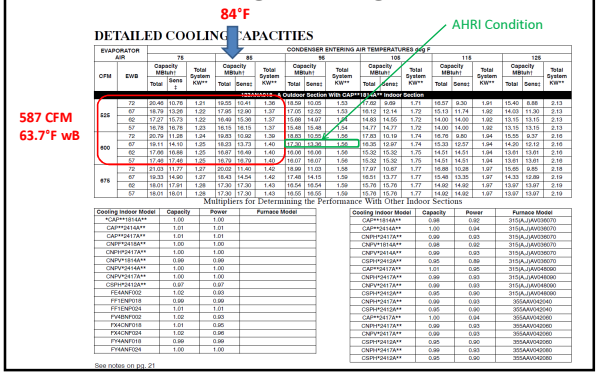


77.2°F dB / 64.5°F wB ?

Entering Air



OEM Engineering Data



OEM Engineering Data

DETAILED COOLING CAPACITIES#

EVAPORATOR AIR		75 (23.9)			85 (29.4		
CFM	EWB °F (°C)	Capacity MBtuh† Total	Capacity MBtuh† Sens‡	Total Sys-tem KW**	Capacity MBtuh† Total	Capacity MBtuh† Sens‡	Total Sys-tem KW**
							PA13NA018– B Outdoor See
525	72 (22.2)	20.35	10.09	1.18	19.43	9.75	1.35
	67 (19.4)	18.72	12.43	1.19	17.86	12.09	1.37
	62 (16.7)	17.21	14.74	1.21	16.41	14.38	1.38
	57 (13.9)	16.70	16.70	1.22	16.05	16.05	1.38
600	72 (22.2)	20.73	10.59	1.20	19.69	10.22	1.37
	67 (19.4)	19.03	13.21	1.22	18.14	12.86	1.39
	62 (16.7)	17.59	15.82	1.23	16.78	15.44	1.40
	57 (13.9)	17.38	17.38	1.24	16.69	16.69	1.40
675	72 (22.2)	21.01	11.06	1.22	19.88	10.67	1.39
	67 (19.4)	19.25	13.95	1.24	18.34	13.61	1.41
	62 (16.7)	17.94	17.79	1.26	17.20	17.20	1.43
	57 (13.9)	17.92	17.92	1.26	17.20	17.20	1.43

Detailed cooling capacities are based on indoor and outdoor unit at the same elevation per ARI standard 210/240–94. If additional tubing length and/or indoor unit is located above outdoor unit, a slight variation in capacity may occur.

* Tested combination.

† Total and sensible capacities are net capacities. Blower motor heat has been subtracted.

‡ Sensible capacities shown are based on 80°F (27°C) entering air at the indoor coil. For sensible capacities at other than 80°F (27°C), deduct 825 Btuh (245 kW) per 1000 CFM (480 L/S) of indoor coil air for each degree below 80°F (27°C) or add 825 Btuh (245 kW) per 1000 CFM (480 L/S) of indoor coil air per degree above 80°F (27°C).
When the required data falls between the published data, interpolation may be performed.

** System kw is total of indoor and outdoor unit kilowatts.

†† At TVA rating indoor condition (75°F edb/63°F ewb). All other indoor air temperatures are at 80°F edb.

NOTE: When the required data falls between the published data, interpolation may be performed. Extrapolation is not an acceptable practice.

EWB — Entering Wet Bulb

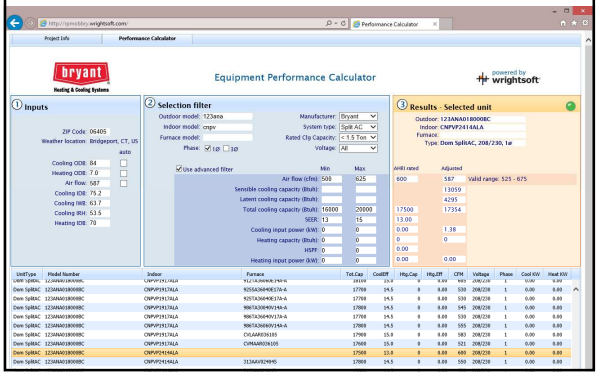
NOTE: When the required data fall between the published data, interpolation may be performed. Extrapolation is not an acceptable practice.

Interpolate OEM Data

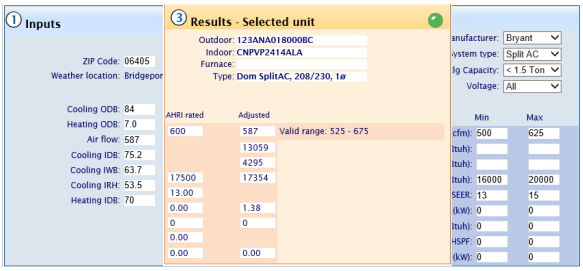
DEMO - Manual S Interpolating Calculator

			Outdoor Ambient						
CFM	587		75		85		84		
Amb	84		Total	Sensible	Total	Sensible	Total	Sensible	Adj Sens @ 75.2F
dB	75.2	525	67	18790	13260	17950	12900	18034.0	12936.0	10831.8
wB	63.7	525	62	17270	15730	16490	15360	16568.0	15397.0	13292.8
		600	67	19110	14100	18230	13730	18318.0	13767.0	11362.2
		600	62	17660	16880	16870	16490	16949.0	16529.0	14124.2
		5				wB Adj	525	17066.4	14560.3	12456.1
		1.7	0.835				600	17414.5	15589.9	13185.1
BTU Adj / 1000 cfm		835				CFM Adj	75	4.640267	13.7288	9.7208
							62	17354	15411	13059
							SHR:	0.753		

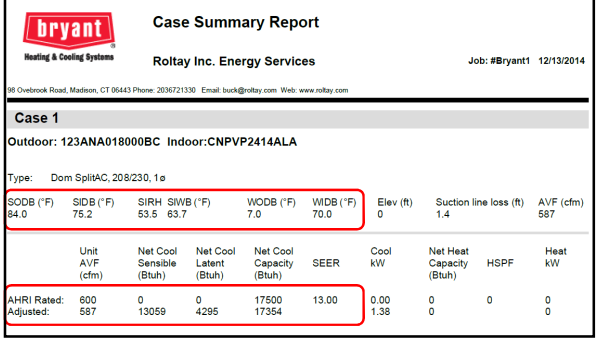
OEM Tools



OEM Tools



OEM Tools



Using 3rd party coils

- Manual S requires extended performance rating data.
- OEM must provide tools or custom calculations to meet the requirements for Manual S.
  - Many 3rd party coils do not currently provide such tools, or
  - 3rd party coils instructs designer to use OEM data for their products!

Using 3rd party coils

HEATING PERFORMANCE DATA							
UNIT MODEL	NOMINAL COOLING BTUH	HEAT CFM	GPM HTG	BTUH (1000) AT ENTERING WATER TEMPERATURE			
				120°F	130°F	140°F	180°F
24EVBQ	18,000 / 24,000	800	3.5	26.1	31.2	36.5	57.3
		700		24.0	28.8	33.6	52.8
		600		21.8	26.2	30.5	48.0
		500		19.4	23.2	27.1	42.6
36EVBQ	30,000 / 36,000	1200	3.5	34.0	40.7	47.5	74.7
		1050		31.2	37.4	43.7	68.6
		900		28.5	34.2	39.9	62.7
		750		25.5	30.6	35.7	56.1
48EVBQ	42,000 / 48,000	1600	3.5	48.3	57.9	67.6	106.2
		1400		44.6	53.5	62.4	98.1
		1200		40.2	48.2	56.3	88.4
		1000		35.9	43.0	50.2	78.9

NOTES:
1. Heating output of fan coil will not exceed net output of water heater.
2. Approved for installation with 0" clearance to combustible materials.
3. Heat BTUH is at 70°F entering air temperature.
4. 180° EWT and these capacities are not available with standard water heaters.

What About Heating?

Table 18 – Altitude Derate Multiplier for U.S.A.

ALTITUDE		PERCENT OF DERATE	DERATE MULTIPLIER FACTOR*
FT.	M		
0–2000	0–610	0	1.00
2001–3000	610–914	4–6	0.95
3001–4000	914–1219	6–8	0.93
4001–5000	1219–1524	8–10	0.91
5001–6000	1524–1829	10–12	0.89
6001–7000	1829–2134	12–14	0.87
7001–8000	2134–2438	14–16	0.85
8001–9000	2438–2743	16–18	0.83
9001–10,000	2743–3048	18–20	0.81

*Derate multiplier factors are based on midpoint altitude for altitude range.

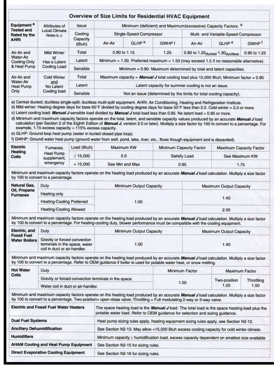
What About Heating?

TABLE 11 - ORIFICE SIZE* AND MANIFOLD PRESSURES FOR GAS INPUT RATE
(TABULATED DATA BASED ON 20,000 BTUH HIGH-HEAT / 13,000 BTUH LOW-HEAT PER BURNER, DERATED 2%/1000 FT ABOVE SEA LEVEL)

ALTITUDE RANGE		AVG. GAS HEAT VALUE AT ALTITUDE (Btu/cu ft)	SPECIFIC GRAVITY OF NATURAL GAS							
			0.58		0.60		0.62		0.64	
	(ft)		Orifice No.	Mnfld Press High/Low	Orifice No.	Mnfld Press High/Low	Orifice No.	Mnfld Press High/Low	Orifice No.	Mnfld Press High/Low
U.S.A. and Canada	0 to 2000	900	43	3.5 / 1.5	43	3.6 / 1.5	43	3.8 / 1.6	42	3.2 / 1.3
		925	44	3.8 / 1.6	43	3.5 / 1.5	43	3.6 / 1.5	43	3.7 / 1.6
		950	44	3.6 / 1.5	44	3.8 / 1.6	43	3.4 / 1.4	43	3.5 / 1.5
		975	44	3.4 / 1.5	44	3.6 / 1.5	44	3.7 / 1.6	44	3.8 / 1.6
		1000	44	3.3 / 1.4	44	3.4 / 1.4	44	3.5 / 1.5	44	3.6 / 1.5
		1025	45	3.8 / 1.6	44	3.2 / 1.4	44	3.3 / 1.4	44	3.4 / 1.5
		1050	45	3.6 / 1.5	45	3.7 / 1.6	45	3.8 / 1.6	44	3.3 / 1.4
		1075	45	3.4 / 1.4	45	3.5 / 1.5	45	3.7 / 1.5	45	3.8 / 1.6
		1100	45	3.3 / 1.4	45	3.4 / 1.4	45	3.5 / 1.5	45	3.6 / 1.5

This is an example for 94% AFUE Natural Gas Furnace

Sizing Goals


Overview of Size Limits for Residential HVAC Equipment

ACCA's summary page of sizing parameters.

There are important footnotes for differences between wet climate zones and dry climate zones as well as cold winters and not so cold winter zones.

Sizing Factors for Connecticut

General Cooling Capacity Factors			
Equipment Tested and Rated by AHRI	Single Speed Compressors	Multi/Variable Speed Compressors	GWHP
Total Maximum sizing factor	1.15	1.20 (multi), 1.30 (variable)	1.25(single), 1.30(multi), 1.35(variable)
Latent	Minimum = 1.0 (may go to 1.50 or higher if needed to meet sensible minimum)		
Sensible	Minimum = 0.90		
General Heating Capacity Factors			
Minimum	1.0		
Maximum	1.4 (up to 2.0 allowed)		

ANSI/ACCA 3 Manual S – 2014 summary page of sizing parameters – boiled down for Connecticut.

Sizing Heat Pumps

- Heat Pumps are sized to the **COOLING** load only.
- The balance of any heating that cannot be met by the compressors shall be provided by a supplemental system (stage)
  - Electric resistance
  - Hot water coil
  - Baseboard
  - Radiant

A/C Sizing Exceptions

- For cooling - multi / variable speed systems usually come only in **1-ton** increments. The latest Manual S addresses this with the higher sizing factors, however you may still end up over the maximum on smaller houses (loads).
  - Sizing factors are static and make it more difficult for smaller loads (smaller houses have a penalty versus larger houses).
  - Base/old sizing factor is 1.15, now up to 1.3 for high-end variable refrigerant flow systems

Sizing Boilers

- For heating with boilers that also serve DHW, an additional water load sizing should be considered given that peak heating loads usually occur just before dawn, and it is possible that occupants may be using showers at the same time.
  - Newest Manual S tries to address this with upper limit factor of 2.0 (base/old limit is 1.4).
  - Better addressed by adding storage tank (60 gal +) and sizing boiler within 1.4 factor, or
  - Use Tankless water heater!

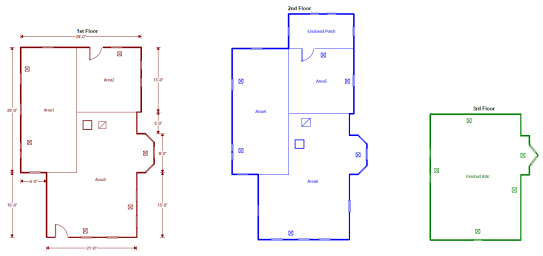
Newer Variable Capacity Systems

- Allowed to oversize by 30% (1.3 sizing factor)
- Heat Pumps are sized to COOLING load
- High-End Heat Pumps
  - Use higher capacity compressor (digital or DC drive), and
  - May have capacity controls to limit system capacity
- A/C units (some examples):
  - Mini-splits (not all)
  - Lennox XC-25
  - Maytag iQ Drive series
  - Waterfurnace 7-series

Documentation

9:45 AM

Manual S – Documents



Manual S Documents

bryant
Heating & Cooling Systems

Case Summary Report

Roltay Inc. Energy Services

Job: #Bryant1 12/13/2014

98 Ovebrook Road, Madison, CT 06443 Phone: 2036721330 Email: buck@roltay.com Web: www.roltay.com

Case 1

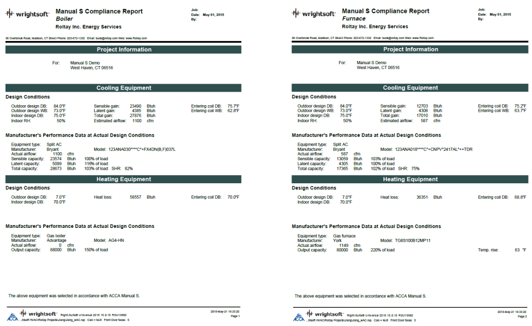
Outdoor: 123ANA018000BC Indoor:CNPVP2414ALA

Type: Dom SplitAC, 208/230, 1ø

SODB (°F)	SIDB (°F)	SIRH	SIWB (°F)	WODB (°F)	WIDB (°F)	Elev (ft)	Suction line loss (ft)	AVF (cfm)
84.0	75.2	53.5	63.7	7.0	70.0	0	1.4	587

	Unit AVF (cfm)	Net Cool Sensible (Btuh)	Net Cool Latent (Btuh)	Net Cool Capacity (Btuh)	SEER	Cool kW	Net Heat Capacity (Btuh)	HSPF	Heat kW
AHRI Rated:	600	0	0	17500	13.00	0.00	0	0	0
Adjusted:	587	13059	4295	17354		1.38	0		0

Manual S – Documents



Manual S – Documents

Cooling Equipment

Design Conditions

Outdoor design DB: 84.0°F
Outdoor design WB: 73.0°F
Indoor design DB: 75.0°F
Indoor RH: 50%

Sensible gain: 12703 Btuh
Latent gain: 4308 Btuh
Total gain: 17010 Btuh
Estimated airflow: 587 cfm

Entering coil DB: 75.2°F
Entering coil WB: 63.7°F

Manufacturer's Performance Data at Actual Design Conditions

Equipment type: Split AC
Manufacturer: Bryant
Model: 123ANA018****C*+CNPV*2417AL*++TDR
Actual airflow: 587 cfm
Sensible capacity: 13059 Btuh 103% of load
Latent capacity: 4305 Btuh 100% of load
Total capacity: 17365 Btuh 102% of load SHR: 75%

Heating Equipment

Design Conditions

Outdoor design DB: 7.0°F
Indoor design DB: 70.0°F

Heat loss: 36351 Btuh

Entering coil DB: 68.8°F

Manufacturer's Performance Data at Actual Design Conditions

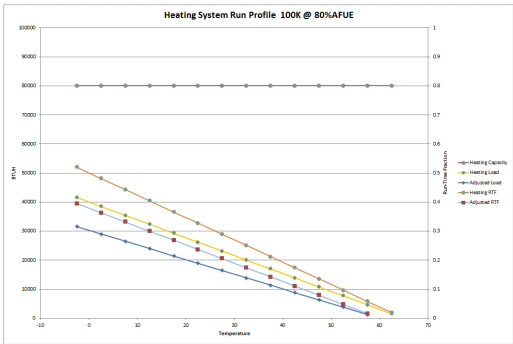
Equipment type: Gas furnace
Manufacturer: York
Model: TG8S100B12MP11
Actual airflow: 1149 cfm
Output capacity: 80000 Btuh 220% of load
Temp. rise: 63 °F

Oversizing

Gross	AFUE	Net	Δ T	CFM	Annual Run Hrs.	Flue BTU	Annual Flue BTU	Fraction Flue
70000	72	50400	80	583	1880	19600	36848000	1
100000	72	72000	80	833	1316	28000	36848000	1
100000	80	80000	70	1058	1184	20000	23680000	0.64264
100000	86	86000	65	1225	1101	14000	15414000	0.41831
100000	94	94000	50	1741	1008	6000	6048000	0.16413
48000	94	45120	45	928	2100	2880	6048000	0.16413

Contractors tend to size replacements "like for like". This results in potential (significant) issues with airflow and draft (flue gasses condensing prematurely)!

Oversizing



Manual S – Documents

Cooling Equipment

Design Conditions

Outdoor design DB:	84.0°F	Sensible gain:	23490	Btuh	Entering coil DB:	75.7°F
Outdoor design WB:	73.0°F	Latent gain:	4385	Btuh	Entering coil WB:	62.8°F
Indoor design DB:	75.0°F	Total gain:	27876	Btuh		
Indoor RH:	50%	Estimated airflow:	1100	cfm		

Manufacturer's Performance Data at Actual Design Conditions

Equipment type:	Split AC			
Manufacturer:	Bryant		Model:	123ANA030***C*+FX4DN(B,F)037L
Actual airflow:	1100	cfm		
Sensible capacity:	23574	Btuh	100% of load	
Latent capacity:	5099	Btuh	116% of load	
Total capacity:	28673	Btuh	103% of load	SHR: 82%

Heating Equipment

Design Conditions

Outdoor design DB:	7.0°F	Heat loss:	58557	Btuh	Entering coil DB:	70.0°F
Indoor design DB:	70.0°F					

Manufacturer's Performance Data at Actual Design Conditions

Equipment type:	Gas boiler			
Manufacturer:	Advantage		Model:	AG4-HN
Actual airflow:	0	cfm		
Output capacity:	88000	Btuh	150% of load	

Resources

- www.ct.gov/dcs/
- publicecodes.cyberregs.com/icod/index.htm
- www.acca.org
- www.hvac-quality.com

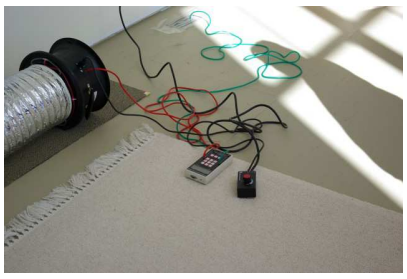
Questions?

9:55 AM

Other

9:55 AM

Duct Blaster



Duct Sealing Note

- Seal Duct system correctly – these are examples of thoughtlessness!


Duct Sealing Note

- Ducts get sealed first, then insulated.
  - In this case, these ducts are lined.


Blower Door – Infiltration Testing

Infiltration Testing

- IECC 2009: Optional
- IECC 2012: 3 Air Changes per Hour at 50 pascals aka 3 ACH_{50} (0.2 i.w.c.)

Infiltration Comparison

Example Typical Infiltration Rates for Homes (Air Changes per Hour)		
Type of Treatment	ACH50	**ACHnat***
2012 Connecticut Code	3.0	**0.17 - 0.23**
New home with special airtight construction and a controlled ventilation system	1.5 – 2.5	**0.10 – 0.17**
Energy efficient home with continuous air barrier system	4.0 – 6.0	**0.27 – 0.41**
Standard new home	7.0 – 15.0	**0.47 – 1.01**
Standard existing home	10.0 – 25.0	**0.68 – 1.69**
Older, leaky home	20.0 – 50.0	**1.35 – 3.38**
***The conversion between ACH50 and ACHnat is only an estimate for normal exposure for 2-story home. ACHnat is used in load calculations.**		

Infiltration & Duct Leakage

- Both affect heat loss/gain and comfort.
- Both can cause unwanted effects to combustion appliances.
- Both affect the sizing of the A/C system and CFM requirements – which can affect duct sizing.
- Duct leakage can drive (or induce) building infiltration.

Thank you

Buck Taylor

Roltay Inc. Energy Services
98 Overbrook Road
Madison, CT 06443
(203) 672-1330
buck@roltay.com

10:00 AM