HVAC Design Applied

RESNET 2016

Wednesday, March 2

1:30-3:00, Pueblo II

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HVAC Design Applied

What you need to know about the components of HVAC design and how to verify the proper design has made it to the field

Section 1

Design Components

What is HVAC Design?

- How many of you are familiar with the following?
  - Energy modeling software?
  - Building science
  - Home Assessments
  - Take-offs and scale drawings
- HVAC Design is <u>very</u> similar to what auditors and HERS Raters are trained to do.
  - Assess the home/review plans
  - Measure and draw the home
  - Enter information in a model
  - Work with trades to improve the outcome of the model

The Design Process

- The HVAC Design process
- Manual J
- Manual S
- Manual D/T
- What's at stake and why is proper design so important now?

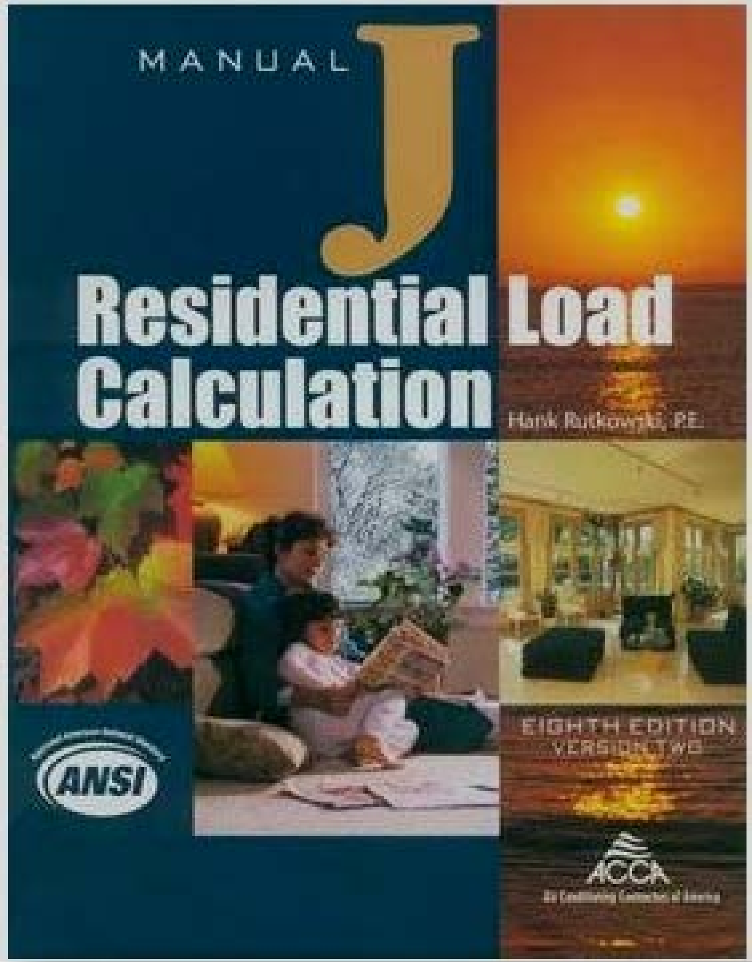
ACCA Residential System Design References

- **Manual J, Residential Load Calculation** – ACCA/ANSI Standard
- **Manual D, Residential Duct Systems** – ACCA/ANSI Standard
- **Manual S, Residential System Selection**
- **Manual T, Air Distribution Basics** - Terminal Selection
- **Manual H, Heat Pumps**
- **Manual Zr, Residential Zoning** - ACCA/ANSI Standard
- **Manual RS, Comfort, Air Quality and Efficiency by Design**

ACCA Manual J – THE Standard Procedure

Definition:

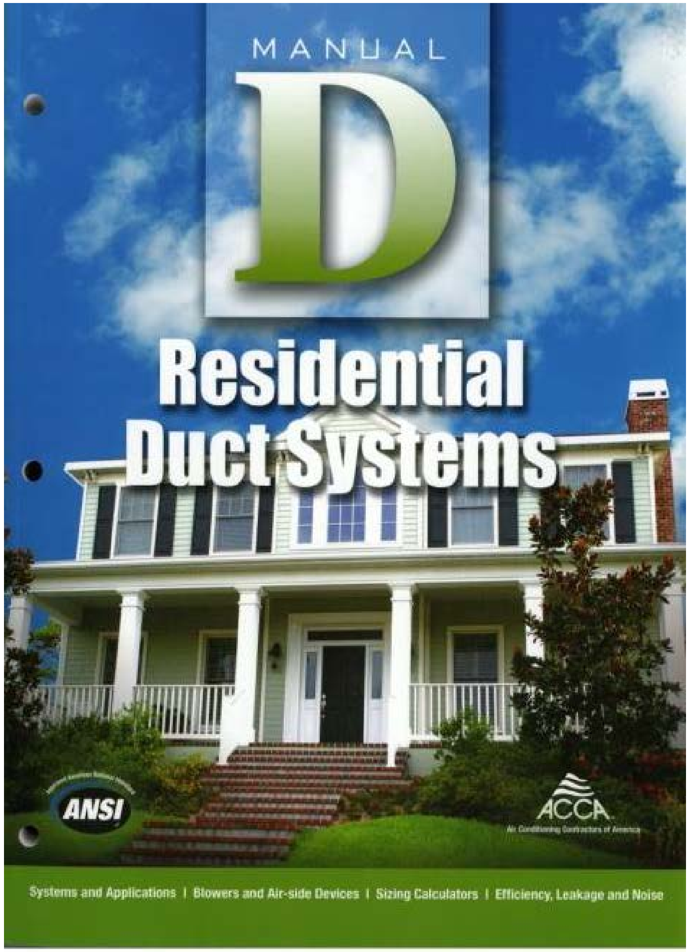
A series of data gathered and strategically calculated in order to determine the size/capacity of comfort equipment and its air distribution system for a specific structure.



Duct Design – Based on Manual J Results

Purpose:

- To use the Manual J results in determining the correct CFM requirements of each room in the structure.
- Design a distribution system that WORKS



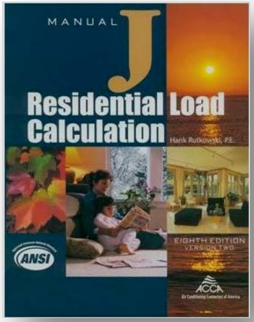
The Goal: Properly Installed and Sealed System…

…That Provides Total Comfort

- ✓ Even Temperature
- ✓ Humidity Control
- ✓ Filtration (IAQ)
- ✓ Fresh Air
- ✓ Air Circulation
- ✓ Quietness

What is HVAC Design?

The Manual J process is very straight forward



- Assess the home/review plans
- Measure and draw the home
- Interview the homeowner to identify preferences and requirements
- Enter information in an ACCA approved software program
- With the load summary, select the proper equipment by following the Manual S system selection procedure
- Work with trades/homeowner to improve the outcome of the load

The Bones of A Load Calculation

- **Resistance Value *(R-Value)***
- **U Value *(U-Value)***
- **Temperature Difference *(Δ T)***
- **Equivalent Temperature Difference *(ETD/CLTD)***
- **Heat Transfer Multiplier *(HTM)***
- **Sensible Heat**
- **Latent Heat**
- **Infiltration**
- **Internal Gains**
- **Design Values: *Indoor Temperature, Outdoor Temperature and Temperature Difference***

U-value

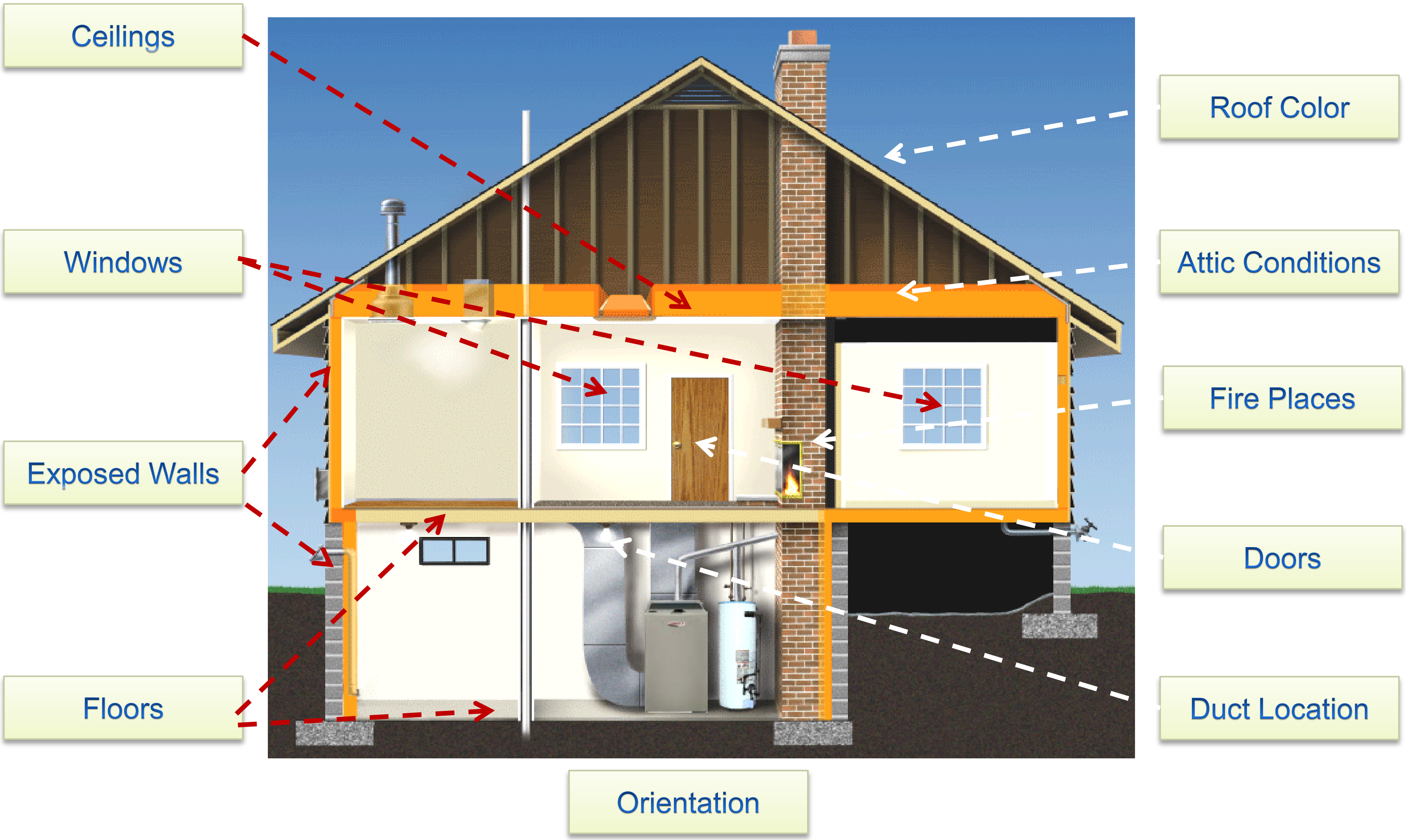
Multiplied by

ΔT

Multiplied by

Area

The Bones of A Load Calculation - Jobsite Survey



The Bones of A Load Calculation - Internal Gains

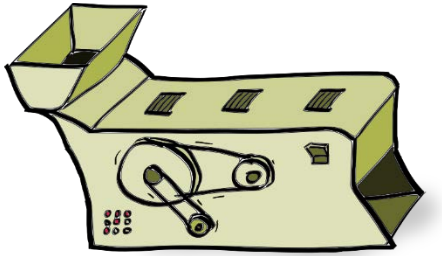
People (1 per bedroom plus 1)

Appliances

Additional Appliances

Plants

Lizard Room



Load Summary – Equipment Selection

Total Area	Construction Components	HEAT LOSS		HEAT GAIN	
252	Windows & Glass Doors	11017	12.96%	13023	21.94%
24	Skylights	1949	2.29%	3528	5.94%
42	Wood & Metal Doors	1147	1.35%	508	86.00%
1112	Above Grade Walls	18682	21.98%	8407	14.16%
	Partition Walls				
248	Below Grade Walls	2170	2.55%		
1130	Ceilings	42	37.96%	27201	45.82%
	Partition Ceilings				
	Passive Floors				
	Exposed Floors				
	Slab Floors				
	Basement Floors				
	Partition Floors				
	Infiltration	13981	16.45%	1791	3.02%
	Internal Gains			2120	3.57%
	Duct Loss & Gain				
	Ventilation	248	4.49%	1084	1.83%
	Blower Heat Gain			1707	2.88%
	Total Sensible	85009	######	26700	######
	Total Latent			7500	
	Total Cooling Load			34200	

Equipment Selection – Manual S or OEM Data

Total Load: 34,200

Sens. 26,700 Lat. 7,500

Coil Capacity: 34,300 x .78 = Sens. Cap.

Sens. 26,754 Lat. 7,546

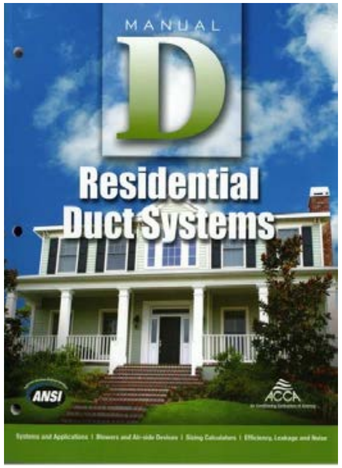
HS26–036 — C26–31(W)(FC)

Entering Wet Bulb Temperature	Total Air Volume		Outdoor Air Temperature Entering Outdoor Coil																		
			85°F (29°C)						95°F (35°C)						105°F (41°C)					
			Total Cooling Capacity		Compressor Motor Watts Input	Sensible To Total Ratio (S/T) Dry Bulb			Total Cooling Capacity		Compressor Motor Watts Input	Sensible To Total Ratio (S/T) Dry Bulb			Total Cooling Capacity		Compressor Motor Watts Input	Sensible To Total Ratio (S/T) Dry Bulb		
	L/s	cfm	kW	Btuh		75°F 24°C	80°F 27°C	85°F 29°C	kW	Btuh		75°F 24°C	80°F 27°C	85°F 29°C	kW	Btuh		75°F 24°C	80°F 27°C	85°F 29°C
63°F (17°C)	470	1000	10.1	34,400	2200	.72	.86	.97	9.7	33,200	2480	.73	.88	.99	9.4	32,000	2800	.75	.89	1.0
	565	1200	10.4	35,500	2200	.77	.91	1.0	10.1	34,300	2490	.78	.93	1.0	9.7	33,000	2810	.79	.95	1.0
	660	1400	10.7	36,400	2210	.81	.96	1.0	10.3	35,200	2490	.82	.97	1.0	9.9	33,900	2810	.84	.99	1.0
67°F (19°C)	470	1000	10.8	36,700	2210	.57	.70	.83	10.4	35,400	2490	.57	.71	.84	10.0	34,100	2810	.58	.72	.86
	565	1200	11.0	37,600	2210	.59	.74	.88	10.6	36,300	2490	.60	.75	.90	10.2	34,900	2820	.61	.77	.92
	660	1400	11.3	38,400	2220	.62	.78	.93	10.8	37,000	2500	.62	.80	.95	10.4	35,600	2830	.63	.81	.96
71°F (22°C)	470	1000	11.5	39,200	2220	.43	.55	.67	11.1	37,900	2500	.43	.55	.68	10.7	36,500	2830	.43	.56	.70
	565	1200	11.8	40,200	2230	.43	.57	.72	11.4	38,800	2510	.44	.58	.73	10.9	37,300	2840	.44	.59	.75
	660	1400	12.0	40,900	2230	.44	.60	.76	11.5	39,400	2510	.45	.61	.77	11.1	37,900	2840	.45	.62	.79

NOTE — All values are gross capacities and do not include indoor coil blower motor heat deduction.

What We Have Done So Far

- Jobsite Survey or Plan Analysis
- Owner Interview
- Load Calculation – NO Fudge Factors! No. No. No.
- System Selection – 90% to 115% of calculated load*
- Duct Design is next



Download a FREE copy of the Manual D Speed-Sheet
http://www.acca.org/standards/speedsheets

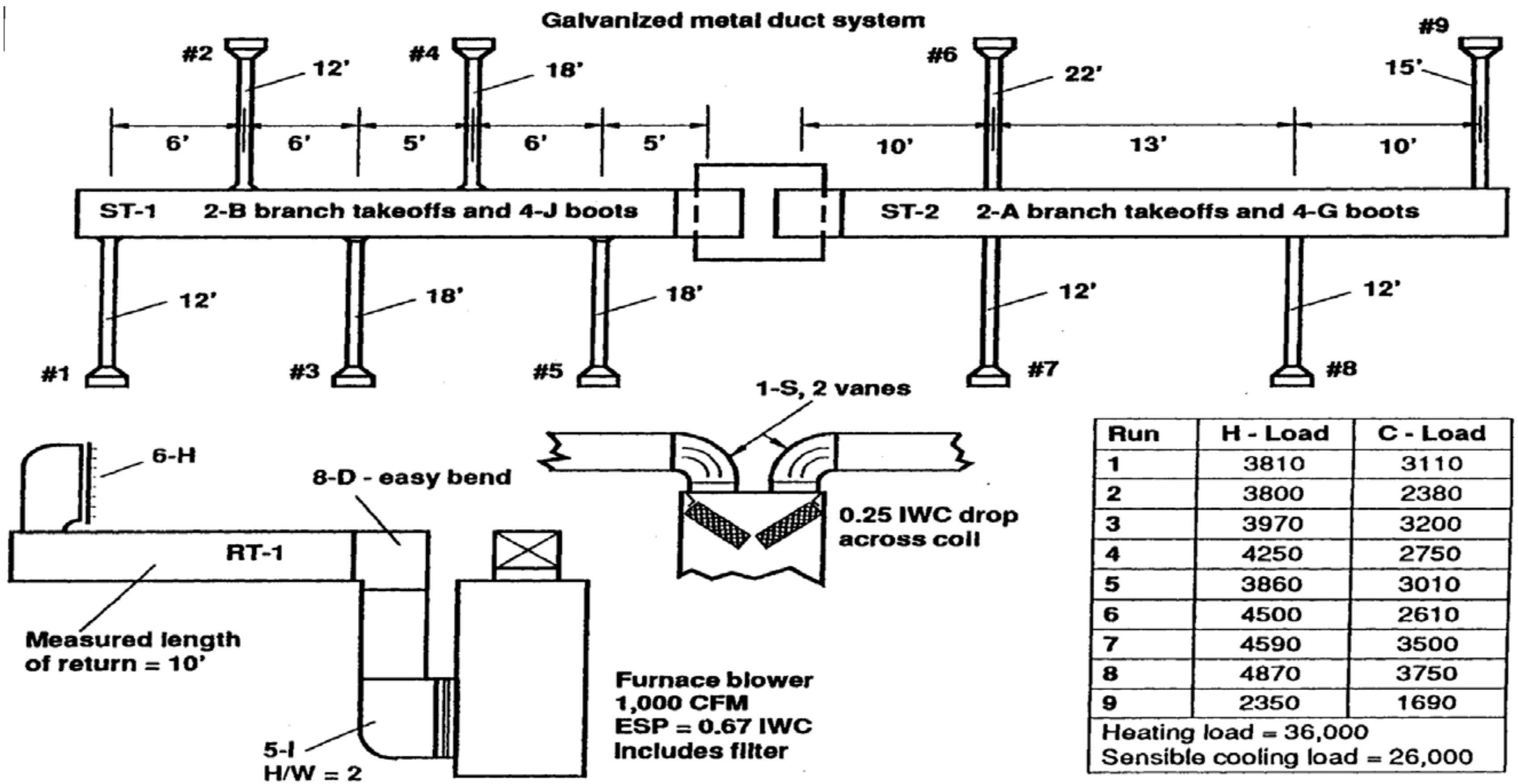
* See Appendix B, Equipment Sizing Limits, ANSI/ACCA QI Standard 5-2015.

Manual D Procedure

The Manual D procedure is also very straight forward

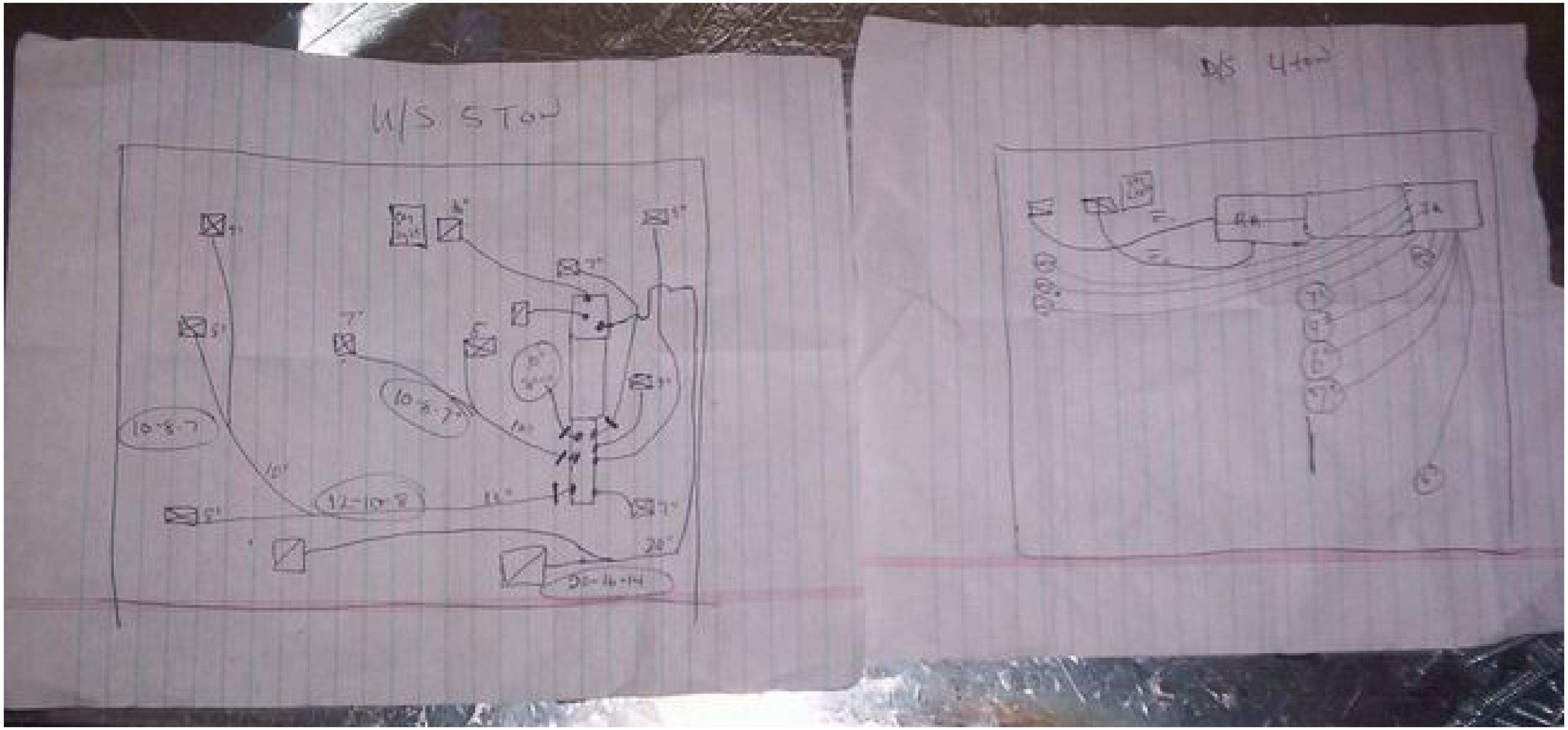
- Review the room by room load calculation
- Assess what CFM (Heating vs. Cooling) is required for each space
- Choose the design of the system to be installed
- Select the registers, filters, accessories and return grills
- Draw/model the duct system and calculated TEL
- Complete a AESP worksheet
- Size the ducts using a duct calculator
- The Manual D Speed-Sheet does all the math and eliminates the need for a duct calculator

Manual D Procedure Results



Run	H - Load	C - Load
1	3810	3110
2	3800	2380
3	3970	3200
4	4250	2750
5	3860	3010
6	4500	2610
7	4590	3500
8	4870	3750
9	2350	1690
Heating load = 36,000 Sensible cooling load = 26,000		

What the Installer Gets



The Rest is Up To the Craftsman…

...and His Helper!

Or Maybe Clever DIY Solutions

Or Maybe New Innovations in Recycling

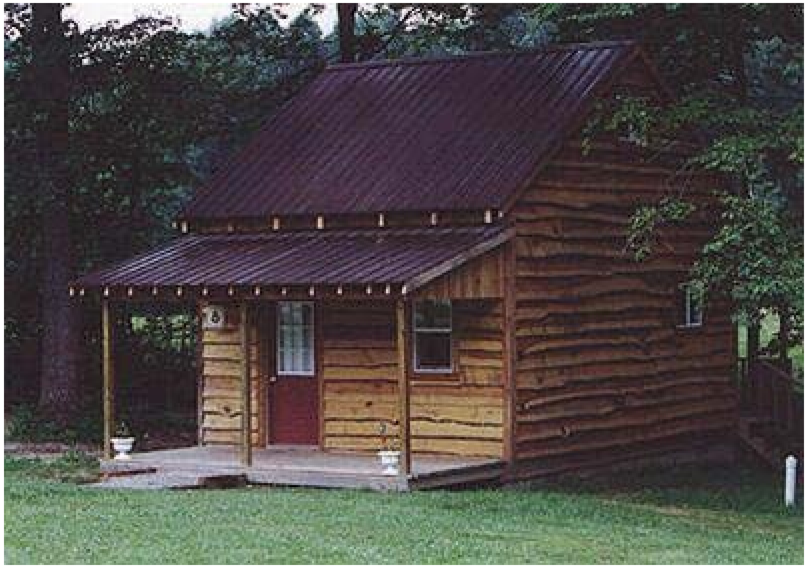
Conservation of Resources with a Single Return

HVAC Design is Continuous

Stay engaged with the trades/builder throughout the project

- Equipment Selection/Review
  - Make sure the system matches the spec in Manual S
  - Remember: Same Size doesn’t = Same Capacity
- Field Verification for System/Ducts
  - Pre-Drywall site visit to inspect ducts
  - Verify returns, registers and filters are installed as designed
  - Verify model numbers
- Proper Commissioning
  - Talk to HVAC dealers about their commissioning process
  - Static Pressure/Fan Speed Setting, ASP Worksheet verification.
  - Delivered Capacity (Tools and Standards)

Practical Exercises



Instructor Lead

Student YOYO

Section 2
Design Application

Field Application

Is this the system that can carry the design load?

Or this one?

Design without Proper Application?

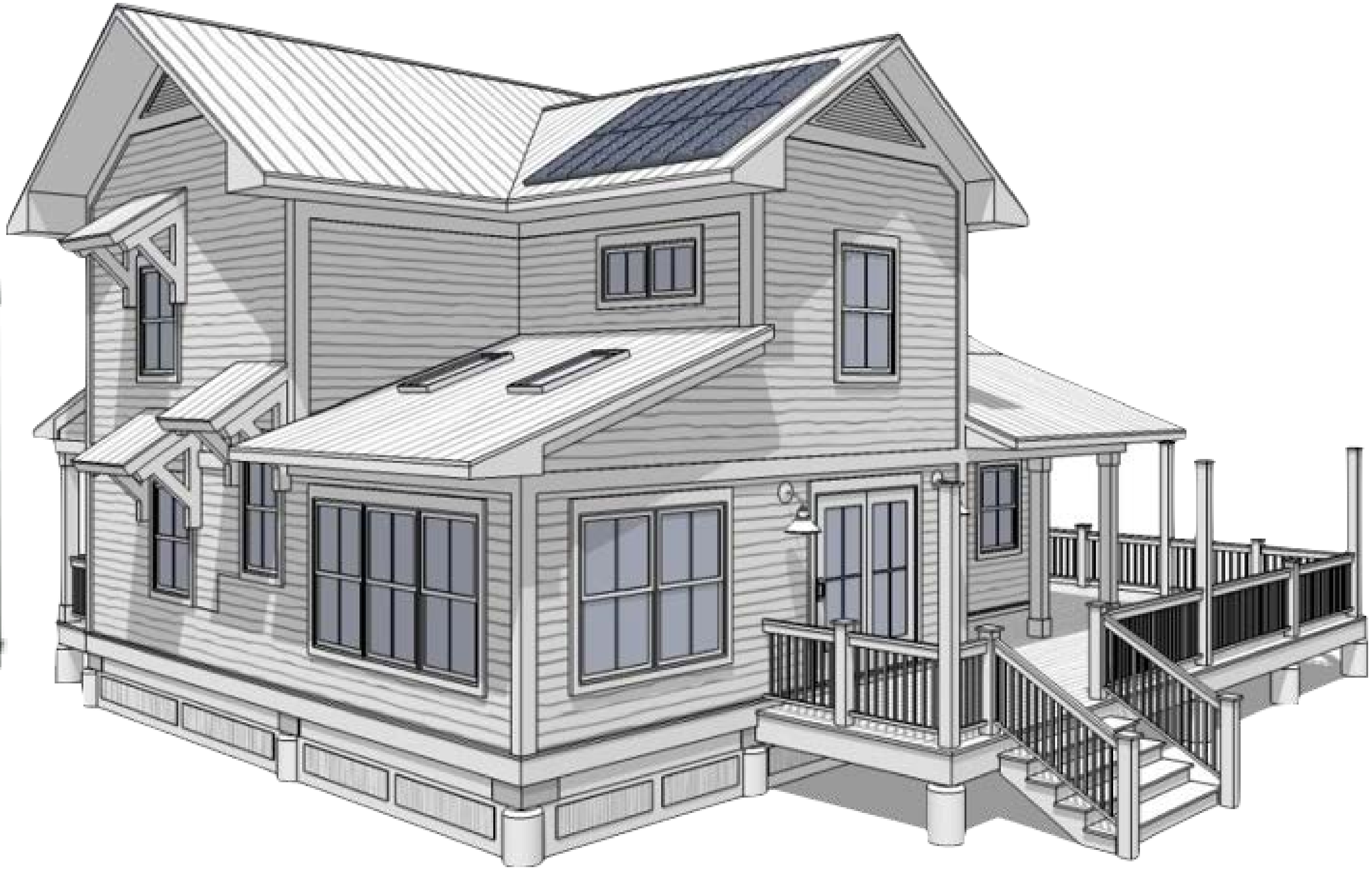
Things we hear in the HVAC industry

- The load is close to a 3 ton so let's use a 3.5 <u>or</u> 4 ton if they choose a higher SEER.
- Sizing isn't important with variable capacity systems…
- YOU aren't the one responsible for call backs when the system doesn't keep up.
- What does the energy auditor know about air conditioning.
- HVAC is priced by the tonnage, you're costing me money to put in a system that I know won't work!
- I've been doing this for years, I know that system is too small.
- Let me check my ductulator… That'll never work!

Things That Happen

- System is <u>upsized</u> and installed with ducts sized for the smaller system.
- Ducts are installed according to the contractors standard practices, not the design.
- Products in your meticulous design weren't installed in the field.
- Excessive and crushed duct runs result in poor airflow.
- **<u>System isn't commissioned properly</u>!!!!!**

What Really Happens….



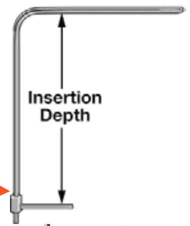
Application

- **Proper Equipment Selection**
  - Verify Equipment Matches the Design
- **Good Mechanical Installation**
  - Follow Manufactures Guidance
- **Airflow Verification and Commissioning**
  - Fan Speed, Static Pressure and Blower Sizing
- **Accessory Installation**
  - Verify IAQ, Filtration and Ventilation
- **Vacuum and Charge**
  - Follow Manufactures Guidance
- **Start-Up and Final Commissioning**

Airflow Measurement Methods

The first of the two adjustable parameters.

- Static Pressure Drop
- Temperature Rise
- True Flow Grid
- Flow Averaging Sensor
- Pitot tube
- Hot Wire Anemometer
- Rotating Mini-Vane
- DuctBlaster® Pressure Matching Method



Supply and Return Terminal Measurements

“Delivered” Airflow

- Large Vane Anemometer
- FlowBlaster®
- Flow Hood
- FlowFinder® Powered Flow Hood
- Exhaust Fan Flow Meter
- Large Vane Anemometer and “Mini-Hood"
- Garbage bag Inflation

In-duct Airflow Measurement Methods

- Temperature Rise Method
  - Heat Flow Equation
- Pitot Tube
  - Tube in a tube: need a manometer
- Thermal Anemometer (Hot Wire)
  - Wind Chill effect – lick your fingertip
- Wilson Flow Grid (TrueFlow grid)
  - Pitot Array
- Static pressure drop across coils, filters, heat exchangers
  - (Provided there is a CFM look up chart)
- Rotating Mini-vane Anemometer

What is a CFM?

- C = Cubic
- F = Feet
- M = per Minute
- It's a volume flow rate
- How much air per minute
- CFM = Velocity x Area
  - If the Velocity is off, the CFM will also be off!!
  - If the Area is off, the CFM will also be off!
  - Open Area factor
- How many CF of air in a pound of air?

Temperature Rise Method

$$CFM = \frac{\text{BTUH output}}{1.08 \times \Delta t}$$

Static Pressure

- The measure of resistance to air flow in HVAC systems
- Total External Static Pressure (TESP) is the pressure external to the equipment the blower shipped in
- Static Pressure and Velocity Pressure have a push pull relationship with Air flow
- Static Pressure can be visualized as the pressure that keeps a balloon inflated

Static Pressure

- Field test to verify duct design(TESP and ASP)
- Easy way to test air flow(TESP w/fan chart or Pressure drop across a clean coil)
- A quick way to determine if the evaporator coil is dirty
- To verify a blower is within its operating parameters
- Identify restrictions in the system

Blower Static Pressure

Total
External
Static
Pressure

0.53 iwc

Blower Table

Blower Performance CFM - Any Position (without filter) - Left Side Return

Models	Speed	Left Side Airflow Data (SCFM)									
		Ext. Static Pressure (in. H2O)									
		0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
TG9S040A08MP11	High	1131	1091	1053	1003	965	921	862	800	733	659
	Medium High	982	959	935	887	846	795	745	675	628	595
	Medium Low	772	736	715	689	661	642	599	568	531	493
	Low	636	618	585	569	546	522	486	460	455	370
TG9S060A10MP11	High	1431	1375	1304	1244	1178	1109	1040	963	861	805
	Medium High	1280	1226	1171	1117	1059	1004	930	865	781	731
	Medium Low	1099	1050	1008	970	919	866	814	759	710	626
	Low	914	876	842	812	770	728	694	661	612	545
TG9S060B12MP11	High	1470	1406	1361	1309	1241	1155	1060	920	775	628
	Medium High	1211	1186	1139	1101	1042	980	896	796	681	545
	Medium Low	970	957	927	889	853	796	745	660	568	450
	Low	793	781	756	724	694	653	585	530	469	382
TG9S080B12MP11	High	1605	1562	1514	1454	1393	1330	1251	1169	1073	940
	Medium High	1372	1318	1280	1255	1205	1161	1093	1023	943	849
	Medium Low	1087	1073	1052	1003	993	953	897	843	775	709
	Low	916	896	881	854	831	802	757	708	642	574

Confirm cooling blower speed tap and use the TESP to find the system's CFM: 1158 CFM (interpolated)

Types of Blower Motors

PSC Blower Motor

ECM Blower Motor

Name these items

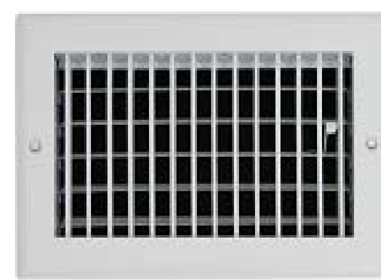
- Restriction to Airflow !

- Restriction to Airflow !

Name these items

- Restriction to Airflow !

- Restriction to Airflow !



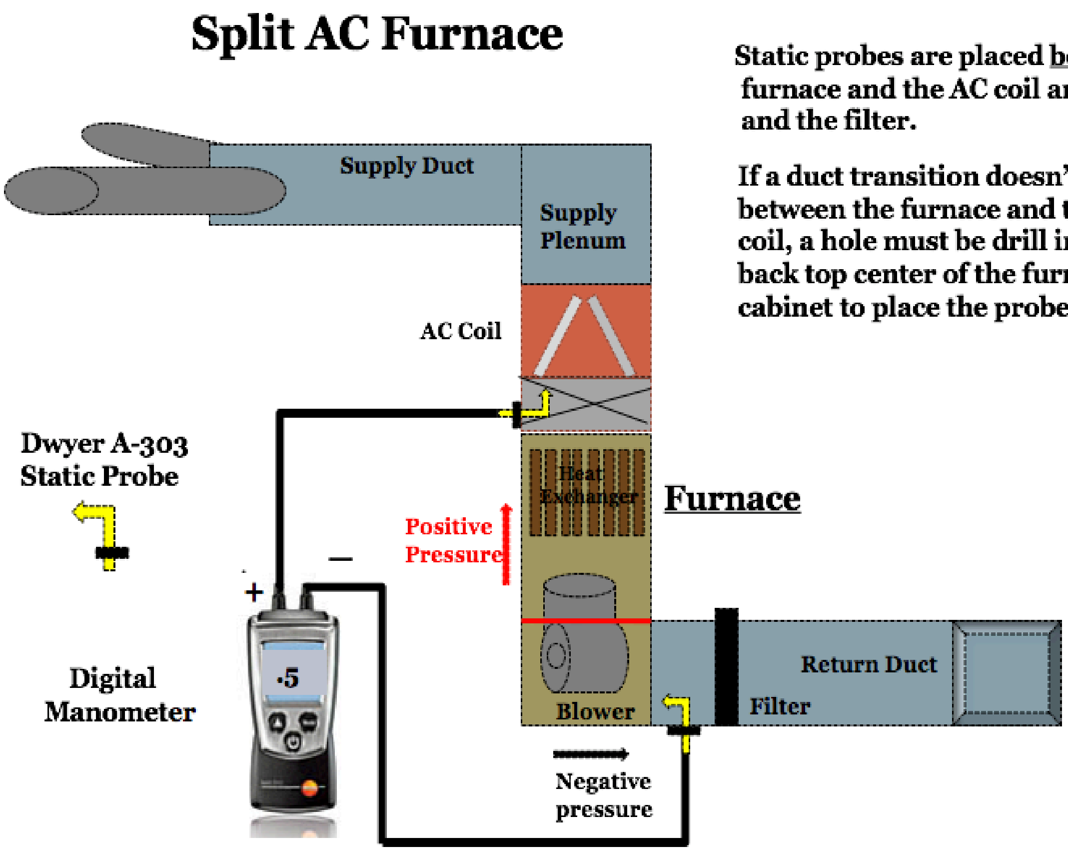
Name these items

Pangolin

What Do We Need

The Tools

TESP Test Locations

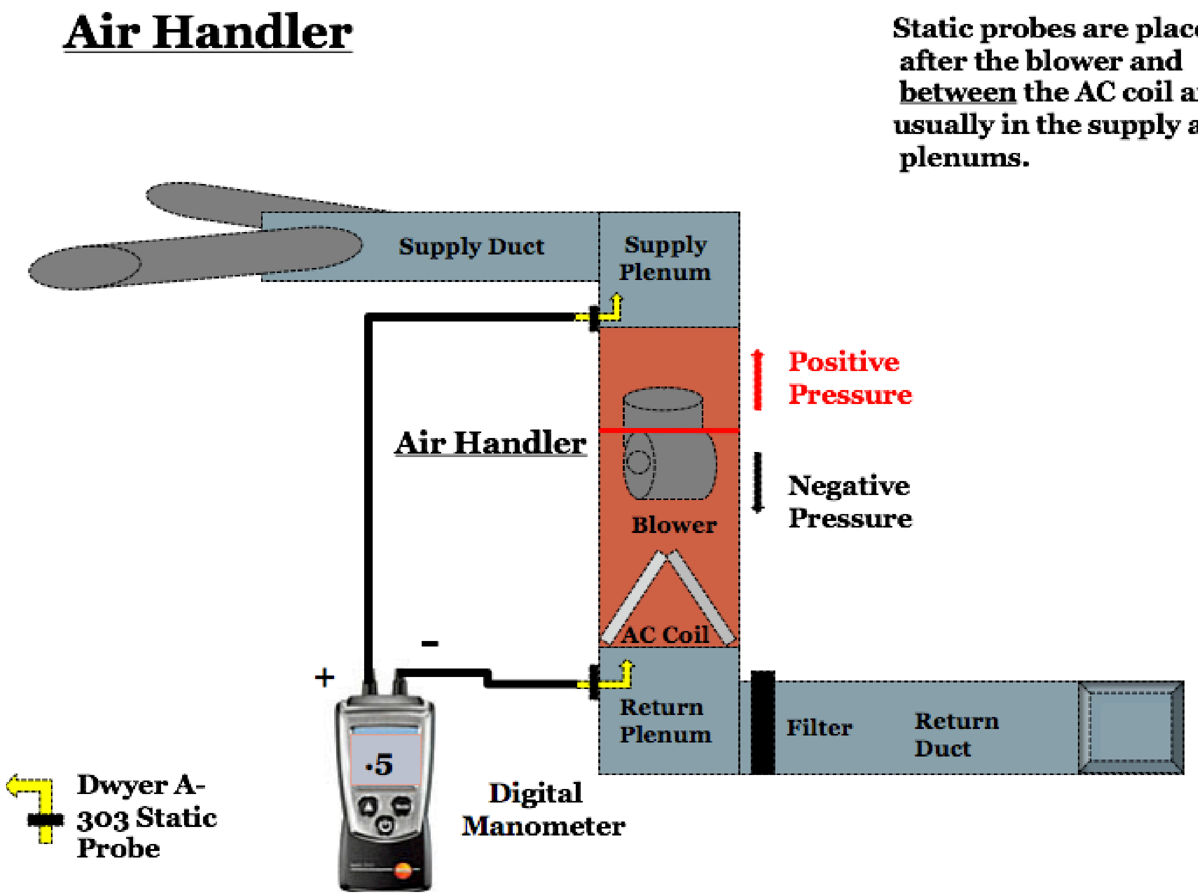


Static probes are placed between the furnace and the AC coil and furnace and the filter.

If a duct transition doesn't exist between the furnace and the coil, a hole must be drill in the back top center of the furnace cabinet to place the probe.

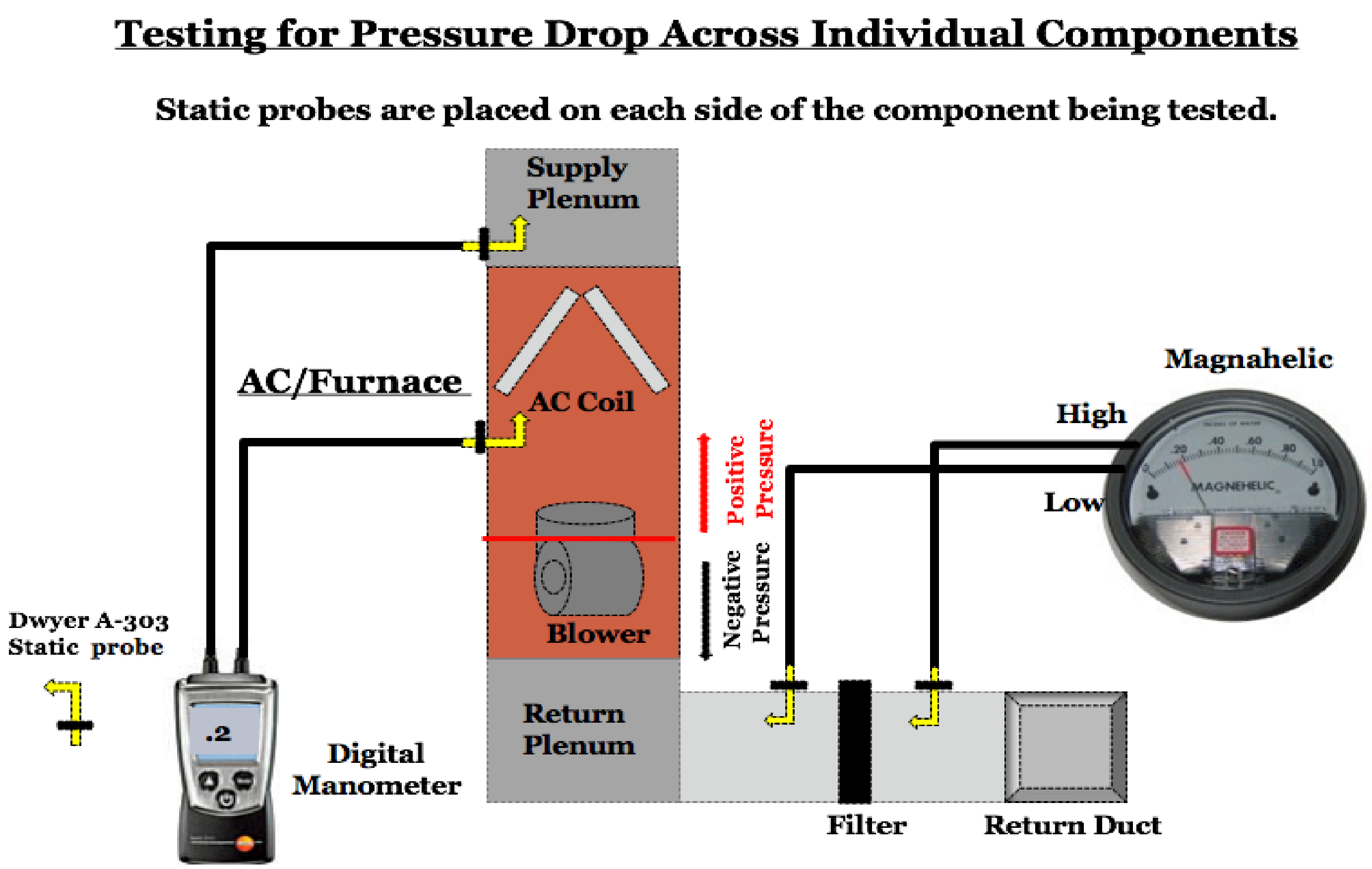
1. Identify the Rated Appliance
2. Look for Drops/Restrictions
3. Find the Best Test Location
4. Drill/Remove Screws
5. Test!

TESP Test Locations



Static probes are placed after the blower and between the AC coil and filter, usually in the supply and return plenums.

Pressure Drop Test Locations



Static Pressure

- Coil Pressure Drop

Model No.	Air Volume		Total Air Resistance			
			Dry Coil		Wet Coil	
	cfm	L/s	in. w.g.	Pa	in. w.g.	Pa
CX34-38A-6F	800	380	0.13	32	0.14	35
	1000	470	0.19	47	0.21	52
	1200	565	0.27	67	0.30	75
	1400	660	0.34	85	0.39	97
	1600	755	0.45	112	0.51	127
CX34-42B-6F	1000	470	0.13	32	0.16	40
	1200	565	0.17	42	0.21	52
	1400	660	0.22	55	0.28	70
	1600	755	0.29	72	0.34	85
	1800	850	0.34	85	0.42	104

Static Pressure Diagnostics

TESP

- Coil Restrictions
- Filter Performance
- Verification of Design
- Accessory Impacts

Pressure Drop

- Verification of Design
- Airflow Verification
- Blower Range
- Noise Problems

$CFM \times 4.5 \times \Delta q =$

Total Capacity

- Measure CFM
- 4.5 is a constant that converts CFM to pounds of air per hour
- Measure coil entering and leaving Wet Bulb temperatures
- Convert Wet Bulb temperatures to Enthalpy (q) and calculate difference
- Enthalpy is heat content of air in BTUs per pound
- Do the math and you'll get the current capacity in BTUs per hour!
- Total Capacity should be at least 90% of nominal or AHRI rating

Tools and Standards

- ACCA Standard 5-2015, HVAC Quality Installation Specification
- ACCA Standard 9, QI Installation Verification Protocols
- Bluetooth/Wifi Connected Tools
- Onboard Diagnostics
- Smart Thermostats
- iManifold / iConnect

HVAC Design Applied Successfully

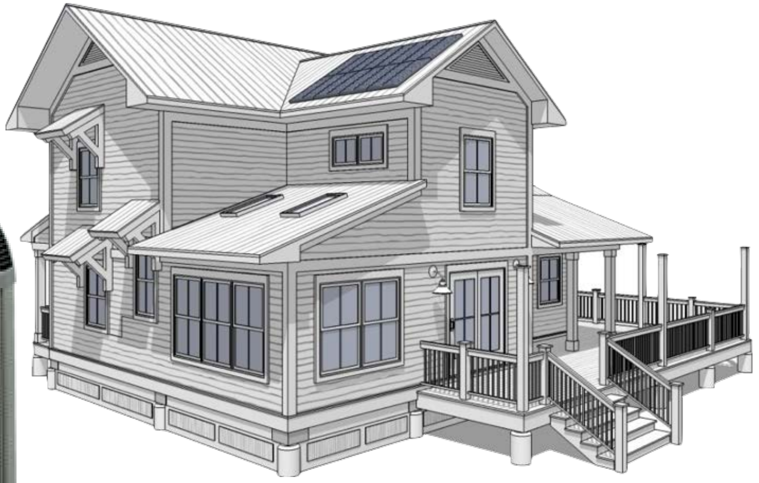
- ✓ Even Temperature – Manual D was followed and each room has adequate airflow
- ✓ Humidity Control – Manual J and S were followed and the system can carry the latent load. Airflow was field verified
- ✓ Filtration – Manual D was followed and verified to allow for good filtration to be installed
- ✓ Fresh Air – Verified and included in Manual J
- ✓ Air Circulation – Manuals D and T were followed and field verified
- ✓ Quietness – All items above were done properly and field verified

Section 3

Load Calculation Mistakes

Ten Common Load Calculation Mistakes

Rob George



RESNET 2016

Contents

- Introduction and Background
- Load Calculation QAQC Program Methodology
- Analysis Results
- The Ten Most Common Load Calculation Mistakes
- Conclusions
- Summary of Consequences
- Reasons for doing it right.
- Recommendations for 2016 and Beyond

Load Calculation Analysis

- 32 Contractors contacted by phone and email.
- 31 Load calculations received.
- 5 Contractors did not respond after three requests.
- NOTE: Maintaining a load calculation on file for three years is a condition of participating in the Program.

Load Calculation Analysis (Contd.)

Of the 7 Properly Sized Systems:

- 4 used software that used appropriate Manual J design conditions (Rheem DesignStar).
- 3 used other procedures that used appropriate Manual J design conditions and did not bump it up a size.

Manual J8 Caveats:

- The ACCA Manual J procedure has built-in safety factors.
- It is not necessary or desirable to include fudge factors "just in case".
- Accurate construction data and design conditions must be used.
- Make defensible equipment size adjustments *after* an accurate load calculation.
- *Trust* Manual J results – they are based on sound science and engineering; not guesswork.

QAQC Evaluation Checklist

Load Calculation Checklist	
HVAC Contractor	
Project Name	
Project Address	
Inspector	Zone ________of _______ Zones
Load Calculation Method: ACCA Manual J ❑ Rrightsoft® ❑ Elite® ❑ Other	
Design Conditions	
City ❑ County ❑ ____	
Summer Outdoor Design Temperature: Manual J Table 1-A Value ______________°F, Value Used _______________°F	
Summer Indoor Design Temp. _______________°F Summer Temp. Difference: _________________°F	
Summer Outdoor Design Grains Diff.: Manual J Table 1-A Value ______________°F, Value Used _______________°F	
Winter Outdoor Design Temperature: Manual J Table 1-A Value ______________°F, Value Used _______________°F	
Winter Indoor Design Temp. _______________°F Winter Temp. Difference: _________________°F	
Floor Area of Conditioned Zone _______________Square Feet	
NOTE: A deviation from Table 1-A values, Summer indoor design temp. of 75 and winter indoor design temp of 70 requires justificatio	
Calculated Loads	
Sensible Cooling Load __________________ BTUh	
Latent Cooling Load ____________________ BTUh	
Total Cooling Load _____________________ Btuh	
S/T Ratio (Sensible Load ÷ Total Load) _____________	
Equipment Sizing Load (Can be Total Cooling Load ± 15%) _________________ BTUh Tons: _________	
Conditioned Area Sq. Ft. ______________________ ÷ _______________ Tons = _____________________ Sq. Ft. / Ton	
Rate Swing Multiplier used? Yes ❑ No ❑ (A 'Yes' tends to oversize)	
Equipment Sizing Load Adjusted for 70 SHR? Yes ❑ No ❑ (A 'Yes' tends to oversize)	
Sensible Heating Load: ________________ BTUh	
Heating Equipment Sizing Load: ________________ (Can be up to 140% of Sensible Heating Load)	
Blower Tonage: __________________	

Load Calculation Analysis

- **Of the 31 Load Calculations Submitted:**
  - 7 were properly sized per the properly calculated load.
  - 22 were oversized or questionable.
  - 2 had inadequate data to quantify.

- **Load calculation methodologies:**
  - 12 used a very questionable outdated short form that tends to oversize.
  - 7 used a procedure of unrecognized origin.
  - 1 used an internet procedure from www.loadcalc.net.
  - 5 used Wrightsoft software that leads to oversizing.
  - 1 submitted OEM performance data only with no load calculation.
  - 5 used Rheem DesignStar that generated good results.

Load Calculation Analysis – cont.

- **Of the 22 Oversized or Questionable Systems:**
  - 17 used software design values outside Manual J recommendations.
  - Outdoor design temperatures were above Table 1-A values (increases TD and load). A TD that is 5° high will increase the cooling load by 7%.
  - Indoor design temperatures were below the recommended 75°. (increases TD and load).
  - Wrightsoft Software uses obsolete rate swing multiplier (increases load).
  - Wrightsoft also uses another multiplier to increase size for a non-existing latent load.
  - Most practitioners selected the next larger size equipment regardless.
  - Equipment oversized .5 to 1 ton (which is common throughout the industry).
  - At least 4 systems used variable drive or multi-stage equipment that compensated for the oversizing.

The Ten Most Common Errors

1. **Not Trusting the Manual J Procedure:**
   - Calculation must be as accurate as possible because:
   - Affects every aspect of system design procedure.
     - Equipment selection.
     - Air distribution hardware.
     - Duct routing and airway sizing.
   - Matched equipment delivers comfort, reliability, efficiency over entire range of operating conditions.
   - Determines total air delivery requirements.
   - Room CFM values determine supply and return terminals (Manual D).
   - Used to estimate energy usage and costs.

The Ten Most Common Errors

2. Using safety or ‘fudge’ factors:

- Manual J has built-in safety factors.
- Research and experience indicate aggressive use of MJ procedures provides an adequate safety factor (10% to 25%)
- Load must be based on accurate information.
  - Envelope construction.
  - Duct system efficiency.
  - Internal loads and use.
  - Eliminate uncertainty – fudge factors have an unknown effect.
  - Defend your choices.
- Consider performance of the builder and HVAC contractor.
- Document assumptions and make sure stakeholders understand and agree before proceeding.

The Ten Most Common Errors

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3. **Not Understanding Manual J Values.**
   - R-value: Total of all the component R-values; Reciprocal of the U-value.
   - U-value; Reciprocal of the R-value; Manual J tables.
   - Temperature Difference:
     - Design TD: between outside design and inside design.
     - Cooling Load TD: CLTD; Effect of solar radiation.
     - Solar Heat Gain Coefficient: SHGC; % of solar radiation admitted through unshaded glass; lower is better.
   - Grains: Amount of moisture per pound of air; 7000 in a pound of water; humidity load.
   - S/T ratio, SHR: % of total load that is sensible; sensible ÷ total; affected by CFM.
   - Heat Transfer Multiplier: HTM; U-value x TD; MJ look-up tables.
   - Load: HTM x area of component.

The Ten Most Common Errors

4. Using Inappropriate Design Conditions:

- Use ENERGY STAR County-Level Design Temperature Reference Guide.
- http://www.energystar.gov/ia/partners/bldrs_lenders_raters/downloads/County%20Level%20Design%20Temperature%20Reference%20Guide%20-%202015-06-24.pdf
- County design conditions based on MJ8, ASHRAE Fundamentals 2013 and nearest weather station.
- Use a cooling design temp. that is less than or equal to table value.
- Use a heating design temp. that is equal to or greater than table value.
- Exception – local jurisdiction authority specification.

State	County	1% Cooling Temperature (°F)	99% Heating Temperature (°F)	HDD/CDD Ratio	Weather Station Selected for Cooling Temperature	Reference	Weather Station Selected for Heating Temperature	Reference
Texas								
Texas	Anderson	98	27	0.3	Palestine City Office Texas	Manual J	Palestine City Office Texas	Manual J
Texas	Andrews	99	27	0.4	ODESSA SCHLEMEYER FL TX	ASHRAE	ODESSA SCHLEMEYER FL TX	ASHRAE
Texas	Angelina	96	29	0.3	ANGELINA CO TX	ASHRAE	Lufkin Angelina Co. Airport Texas	Manual J
Texas	Aransas	91	39	0.1	ARANSAS CO TX	ASHRAE	ARANSAS CO TX	ASHRAE
Texas	Archer	100	21	0.5	WICHITA FALLS/SHEPS TX	ASHRAE	Wichita Falls Municipal Airport Texas	Manual J
Texas	Armstrong	95	14	1.0	Amarillo International Airport Texas	Manual J	Amarillo International Airport Texas	Manual J
Texas	Atascosa	99	31	0.2	Kelly Air Force Base Texas	Manual J	San Antonio Randolph Air Force Base Texas	Manual J

The Ten Most Common Errors

4. **Using Inappropriate Design Conditions (Contd.):**
   - ENERGY STAR County-Level Design Temperature Reference Guide.
   - Outdoor design temperatures-cooling above table value (increases TD and load).
   - Indoor design temperatures-cooling below the recommended 75˚ (increases TD and load).
   - A TD that is 5˚ high will increase the cooling load by 7%.

City	County	Heating 99% Dry Bulb	Cooling 1% Dry Bulb	Grains Moisture
Houston	Harris	33	95	51
Galveston	Galveston	37	91	58
Laredo	Webb	38	101	21
Corpus	Nueces	37	95	58
McAllen	Hidalgo	41	99	-32

The Ten Most Common Errors

5. Using Questionable HTM Values:

- HTMs come from Manual J look-up tables
- Most types of construction are covered
- HTM = U-Value from table x TD

Construction Number 12
Frame Walls and Partitions

Wall or partition with brick veneer, plus interior finish (40 to 50 Lb / SqFt)
Wall with siding or stucco, or light partition, plus interior finish (7 to 20 Lb / SqFt)
Exterior finish code: b = brick veneer; s = stucco or siding
Framing code: w = wood, m = metal (studs 16 Inches on center, 75% cavity, 25% framing)
Reference Area = Gross Wall Area - Area of Window and Door Openings

Construction Number	Insulation R-Values	Description of Construction	Exterior Finish	U-Value with Wood Studs	Group Number
12A — No Insulation In Stud Cavity					
12A-0b w 12A-0s w	Cavity:None Board:None	Frame construction, no cavity insulation, no board insulation, wood sheathing	Brick Siding	0.253 0.240	E A
12A-2b w 12A-2s w	Cavity:None Board:R-2	Frame construction, no cavity insulation, R-2 board insulation	Brick Siding	0.194 0.186	E A
12A-3b w 12A-3s w	Cavity:None Board:R-3	Frame construction, no cavity insulation, R-3 board insulation	Brick Siding	0.162 0.157	F B
12A-4b w 12A-4s w	Cavity:None Board:R-4	Frame construction, no cavity insulation, R-4 board insulation	Brick Siding	0.139 0.135	F B
12A-5b w 12A-5s w	Cavity:None Board:R-5	Frame construction, no cavity insulation, R-5 board insulation	Brick Siding	0.122 0.119	G C
12A-6b w 12A-6s w	Cavity:None Board:R-6	Frame construction, no cavity insulation, R-6 board insulation	Brick Siding	0.109 0.106	G C

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5. Using Questionable HTM Values (contd.)

- Individual R-values in Table 4-3 (add up for unlisted component)

R-Values of Common Building Materials
(Degrees F x SqFt) / Btuh

Material	Thickness (inch)	Density Lb / CuFT	R — Per Inch	R — As Listed
7) Ceiling and Roof Deck Materials (Continued)				
b) Roof Decking - Wood or Cane Fiber Plank or Board	1.50	15	~	4.29
	2.00			5.72
	3.00			8.58
	1.00		2.86	~
c) Cement and Wood Fiber Slab	1.00	26	1.90	~
d) Cement and Mineral Fiber Slab	1.00	22	1.75	~
e) Mineral Fiberboard, Wet Felted	1.00	16 – 17	2.94	~
f) Shingles and Roll Material (R-Value)	Shingles: Slate (0.05) Asphalt (0.21) Wood (0.94) Asphalt Roll Material (0.15)			
8) Blanket and Batt Insulation				

Questionable Short Form

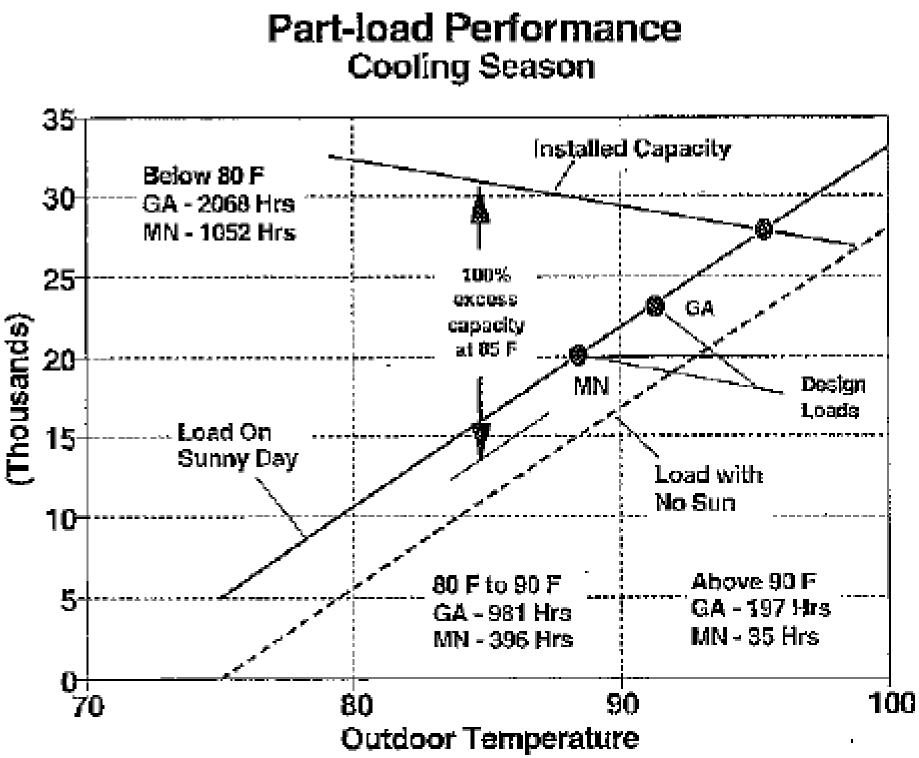
Locally Developed Short Form:

- Cooling only – no heating.
- Wrong outdoor design temperature.
- Wrong design TD.
- Unidentifiable Load factors (HTM).
- Questionable infiltration factors.
- Obsolete people loads.
- Degradation due to age?

Residential Air Conditioning Load Sheet 25.1							
			Houston Texas 77018			August 20, 2015	
Customer			Address			Date	
Design conditions: 75° Inside Temperature, 100° Outside Temperature, T.D. 25°							
Area (Square Feet):						1,278.0	
Ceiling Height:						8.0	
Construction Factor / Air Changes per Hour (.4 Best, .8 Avg, 1.2 Poor):						1.2	
Infiltration CFM = Area Sq. Ft. x Avg Ceiling Height x Air Changes per Hour x 0.0167 =							255
Item	BTU/HR per Sq. Ft.				Enter Load Factors Below	Area in Sq. Ft.	BTU/HR
Windows & Glass Doors	Double	Single					
	Clear	Tinted	Reflective	Clear			
North	18	24	23	26	18	55.7	1,003
East & West	48	55	52	60	48	93.0	4,664
South	27	33	32	36	27	59.0	1,593
Skylights	(Clear use 172, Translucent use 124) -->						-
Doors (other than glass)	Wood or Metal - Uninsulated				16.5	20.0	330
	Wood or Metal - Polystyrene Core				13.4		-
	Metal - Urethane Core				5.4		-
Net Wall Area				Insulation			
				R - 0	7.8		-
				R - 11	2.6		-
				R - 13	? 2.3	1,212.0	2,788
				R - 15	2.1		-
				R - 17	1.9		-
				R - 19	1.7		-
Ceiling Area				Insulation			
				R - 0	21.4		-
				R - 11	? 4.1		-
				R - 19	2.6		-
				R - 26	1.9	1,278.0	2,428
				R - 30	1.6		-
				R - 38	1.3		-
Floor				Insulation			
	Slab or Over unvented space			--------	0		-
	Over open or vented space			R - 0	? 7.7		-
	Over open or vented space			R - 11	1.7	1278.0	2,173
	Over open or vented space			R - 13	1.5		-
	Over open or vented space			R - 19	1.1		-
People Load, Sensible (2 people per bedroom)					230 ~~300~~	6	1,800
Miscellaneous Appliances							-
Sensible Infiltration Mode (CFM x 1.1 x 25)							7,013
Subtotal Sensible Load							23,792
Duct Load (Subtotal Sensible Load x [.15 for R-5, .125 for R-6, .10 for R-8])					Enter Factor-->	0.1	2,379
Latent Infiltration Load (CFM x .68 x 47)							8,150
People Load, Latent (2 people per bedroom)					200 ~~230~~	6	1,380
Subtotal Sensible & Latent Load							35,701
Total Load (Add 10% to account for performance degredation over time. [Total Load x 1.1]) ?							39,271
Tons Required (Total Load / 12,000)							3.27

6. Ignoring Part Load Performance:

- Sensible cooling load vs. capacity
- Load and capacity depend on outdoor temperature and solar gain.



- 1/2 ton excess cooling capacity at summer design conditions (88° for MN; 92° for GA).
- Equipment capacity about twice as large as the load when ODT is 85° and 1/3 more than needed when the ODT is 90°.
- Equipment is significantly oversized for all bin temperatures below 90° (more than 90% of the cooling season.
- Surplus cooling capacity translates to diminished humidity control at part load conditions (for most of the summer).

The Ten Most Common Errors

6. **Ignoring Part Load Performance (Contd.):**
   - Part Load days more important than design load days:
   - Homeowners overly concerned with extreme weather or entertaining – very few hours a year.
   - Uninformed about the significance of part-load conditions for thousands of hours.
   - Pressures contractors to oversize:
     - More expensive systems.
     - Less efficient.
     - Less comfort for most of the season.
     - Less reliable.
     - ***Greater load on electric distribution system!***
   - Solution? Consumer education.

7. **Humidity Control During the Cooling Season:**
   - High latent loads in hot-humid (wet-coil) climates.
   - When summer design condition occurs (a few dozen hours per season):
     - Properly sized equipment will operate continuously (or almost).
     - Sensible and latent loads will be completely neutralized.
     - Occupants will be comfortable.
   - Moderated temperatures for thousands of hours per season.
     - Substantial reduction in sensible cooling load (about 50% average).
     - Normally not matched by a proportional reduction in latent load.
     - Indoor Rh increases because of shortened run times.
   - Reduce possibility of comfort problems by:
     - Use County outdoor design conditions.
     - Use default indoor design conditions.
     - Make an accurate load estimate.
     - Select equipment using OEM expanded engineering data.

The Ten Most Common Errors

8. **Using Rules of Thumb:**
   - Square feet per ton:
     - Floor area to tonnage ratios can be anywhere from less than 500 SF/T to more than 1200 SF/T.
     - Rotating a home on the site can change it from 100 to 400 SF/T.
     - Has resulted in comfort issues and legal actions.
   - For replacements, do not use existing equipment size – high probability it is oversized or load has changed.
   - Other guesstimates produce designs that generate customer complaints, poor temperature and humidity control.
     - “I have been doing it this way for thirty years” syndrome.
     - “Adjust the load” or “provide a safety factor”.
   - Comfort system performance is only as good as the accuracy of the load calculation.

The Ten Most Common Errors

9. Oversizing for any reason:

- Oversized equipment causes short-cycles.
- Marginalizes part-load temperature control.
- Creates pockets of stagnant air (unless the blower operates continuously – but then you have the issue of re-evaporating condensate!).
- Degrades humidity control in the cooling season.
- Requires larger duct runs.
- Increases installation cost.
- Increases operating cost.
- ***Increases installed load on the grid.***
- Causes unnecessary stress on the machinery.
- Undersizing:
  - Obvious problem if significantly undersized.
  - Slight undersizing (10% or less) may provide more comfort at a lower cost.

The Ten Most Common Errors

10. **Using obsolete, inaccurate, or corrupted load calculation procedures:**

    - Wrightsoft uses obsolete Rate Swing Multiplier and leads you to select a tonnage for a bogus S/T ratio – both tend to oversize.
    - Using software or procedure that uses outdated Manual J 7th edition values.
    - Using a locally-produced short form that has unverified load factors.
    - Using a locally-produced short form for a dissimilar area.
    - Making poor infiltration load estimates.
    - Making poor guesses on a jobsite survey.
    - Skewing load factors to drive an unknown oversized load.

Conclusions

There is a tendency throughout the industry to oversize.

- Many contractors purposely oversize.
- Many very sincere contractors use questionable procedures because they simply don't know any better, don't really understand manual J, use something because they trust the source, someone else has been using it or it's easy.
- Oversizing can have unintended consequences.

Summary of Consequences

Errors (accidental or an effort to manipulate output) in the load estimate filter through the entire design and cause the installation to miss the mark. Incorrect load estimates:

- Cause discomfort during design-day weather.
- Produce marginal or unacceptable comfort at part-load conditions.
- Reduce the equipment’s ability to control indoor humidity.
- Cause short-cycling which effects comfort, system efficiency, operating cost and reduces equipment life.
- Translate to larger equipment, larger duct airways, larger duct loads, and related system efficiency.
- Larger equipment on existing inadequate duct systems results in high velocity noise, higher duct leakage, higher static pressures, reduced airflow, and higher power consumption.
- Increase the installed cost and operating cost.
- ***Impose unnecessary loads on the electric grid.***
- Produce price quotes that are less competitive.
- Are less defensible in a court of law.

Reasons to do it Right

Successful businesses differentiate themselves from the competition. By focusing on comfort system performance and what it takes to get there, your surveys, system design calculations and reports demonstrate that:

- Your client is important (has access to your time and attention).
- You are selling quality, performance and dependability (a professionally prepared load calculation report distinguishes you from the run-of-the-mill contractor).
- The comfort system is professionally designed and exceeds minimum standards and practices.
- Your price is competitive because smaller equipment has been justified by an accurate load estimate.
- Money spent on design work is a far better investment than money spent on excess capacity.
- You are providing value-added service and not just selling boxes.
- You can be trusted to do things the right way.
- You care.

Recommendations for Contractors

- Develop a thorough understanding of the Manual J procedures; be honest and aggressive.
- Trust the built-in safety factor - Manual J is a proven engineering tool that has an inherent and appropriate factor of safety.
- Study manual J – there's more there than you think!
- Use design conditions specified in the County-Level Design Guide.
- Verify construction details and use the Manual J tables to develop HTMs.
- Use verified and reputable load calculation short forms, spreadsheet calculators, or software. The MJ8ae J-1 Speed Sheet is an excellent free load calculation program.
- Consider sensible and latent performance over the full range of operation when selecting matched equipment, especially at part load conditions.
- Avoid intentional oversizing – you will likely select equipment with extra capacity anyway (up to 15%) and don't want to overdo it by an unknown quantity.

Other Recommendations for Contractors

- Take credit for overhangs, internal shading, insect screens, external shading and documented U-Values and SHGC values for fenestration.
- Take full credit for the rated or tested performance of construction materials, insulation materials and construction features.
- Take full credit of the tightness of the envelope.
- Follow Manual J procedures for infiltration and ventilation.
- Take credit for well sealed and insulated ductwork.
- Make sure occupancy and internal gains are compatible with Manual J defaults.
- Educate consumers!

Thank you

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Thank You!

For comments or suggestions, please contact:

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