Air Conditioning Sizing In the New Northwest

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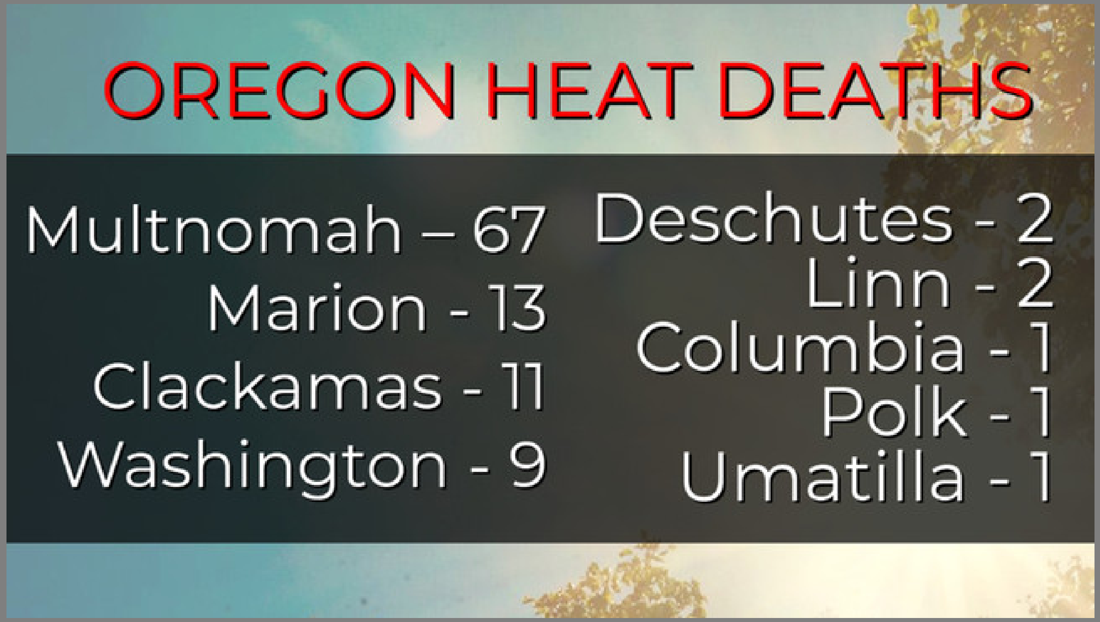
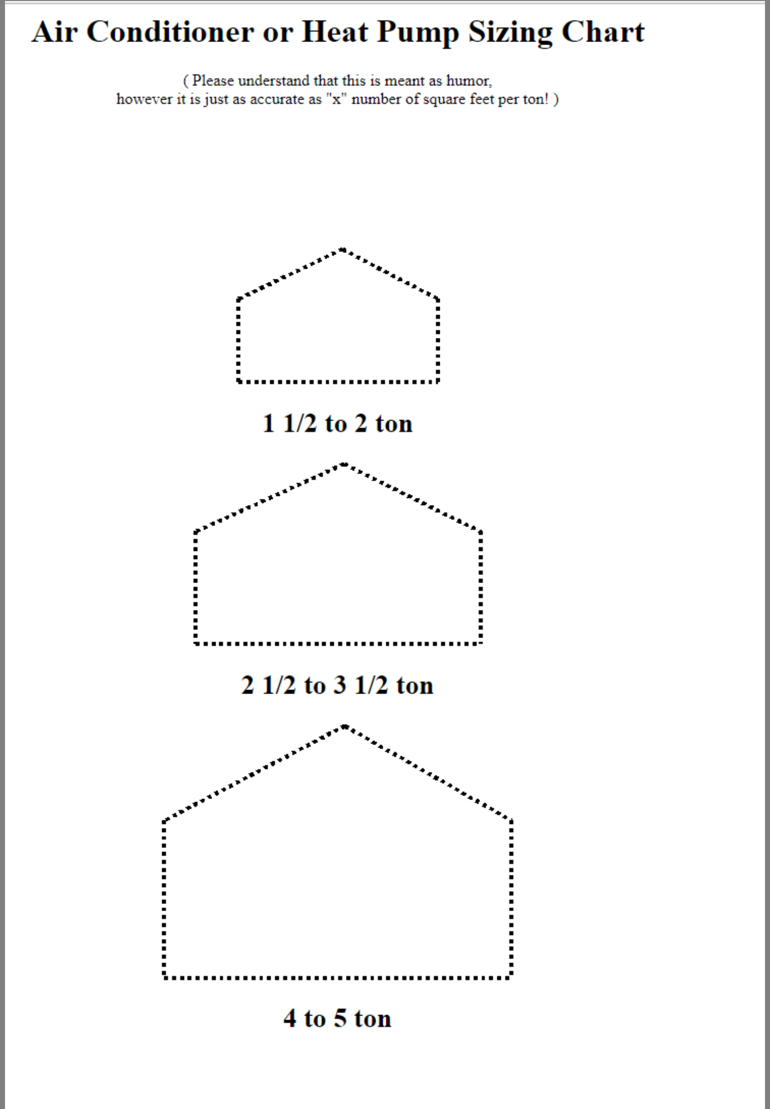
Record Highs

2nd Deadliest Natural Disaster In Oregon's History



Rules of Thumb

- One Ton Per 400 square feet
- One cfm per sq. ft. of house
- Tonnage = half the number of cylinders in the customer's biggest car/truck
- What's in the shop today
- ½ ton bigger than their neighbor
- Other



Heat Loss/Heat Gain Analysis

The ACCA Process Work

- Manual “J” calculates heat loss/heat gain
- Manual “S” guides in the selection process
- Manual “D” guides in the duct design process

Various Sizing Manuals

Bad Installation Trumps Good Sizing

What the Customer Wants

- To be warm in winter
- To be cool in summer

Manual J Cooling Load Inputs

Critical Inputs include windows and Internal gain

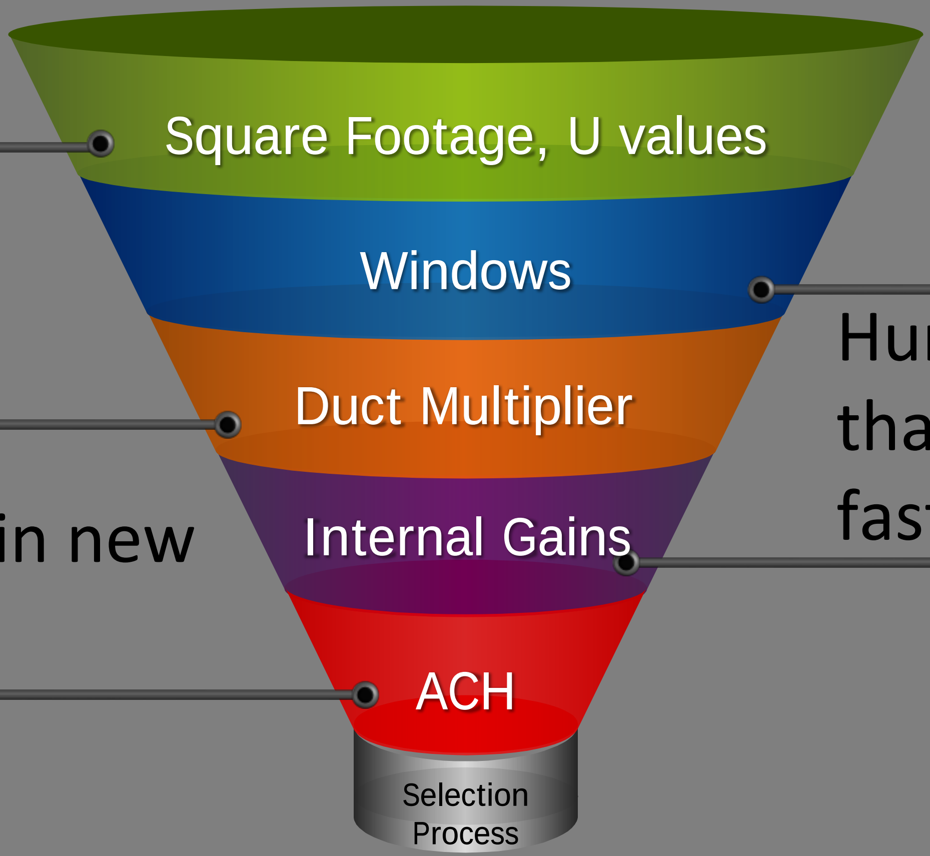
Surface areas, attics, walls ,floors and R values

U value SHGC. Shading, Orientation

It’s an estimate!

Humans plus all their stuff that plugs in. Its growing fast

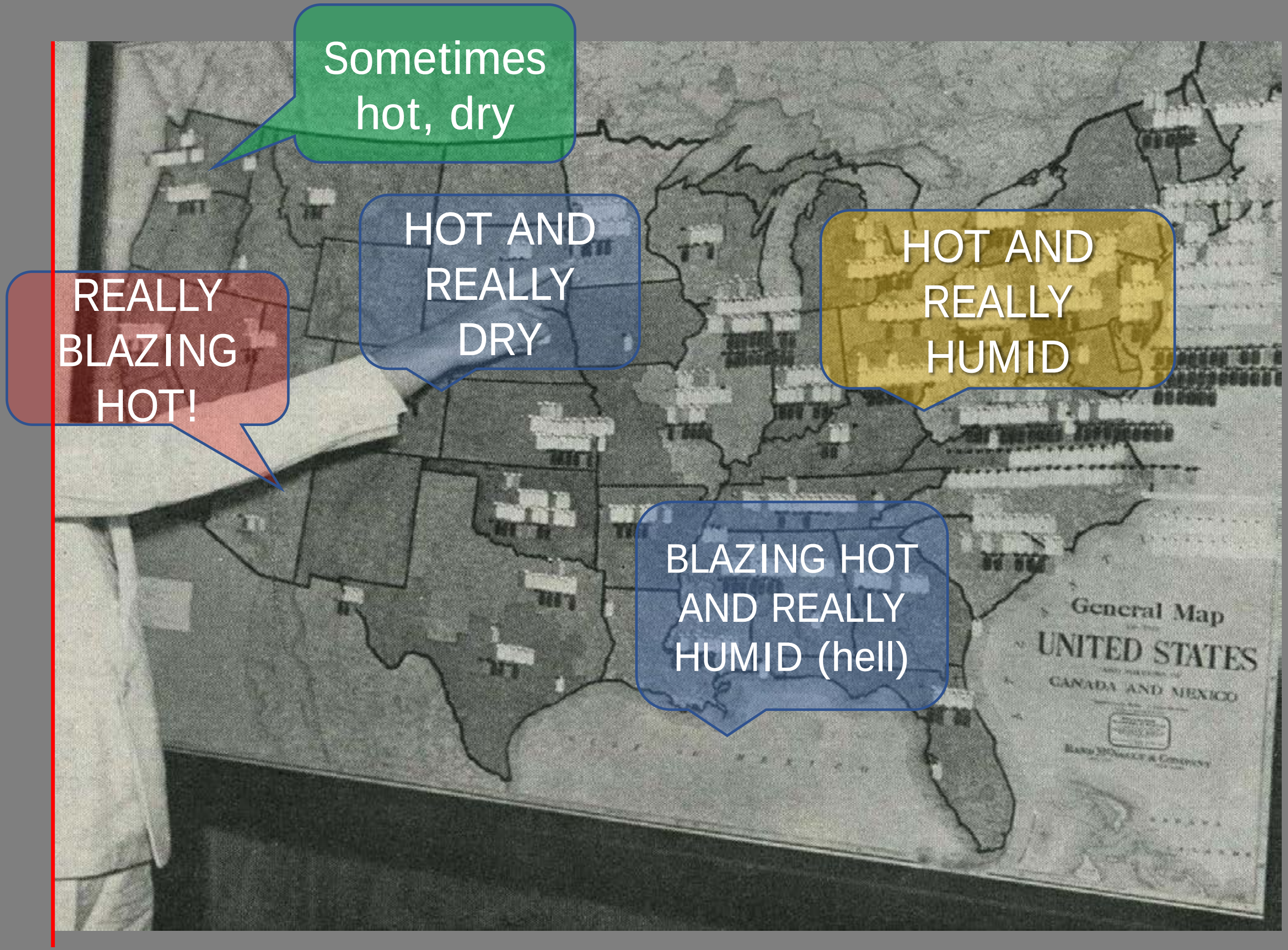
Narrower range in new construction



7 Choices

1.5 2.0 2.5 3.0 3.5 4.0 5.0

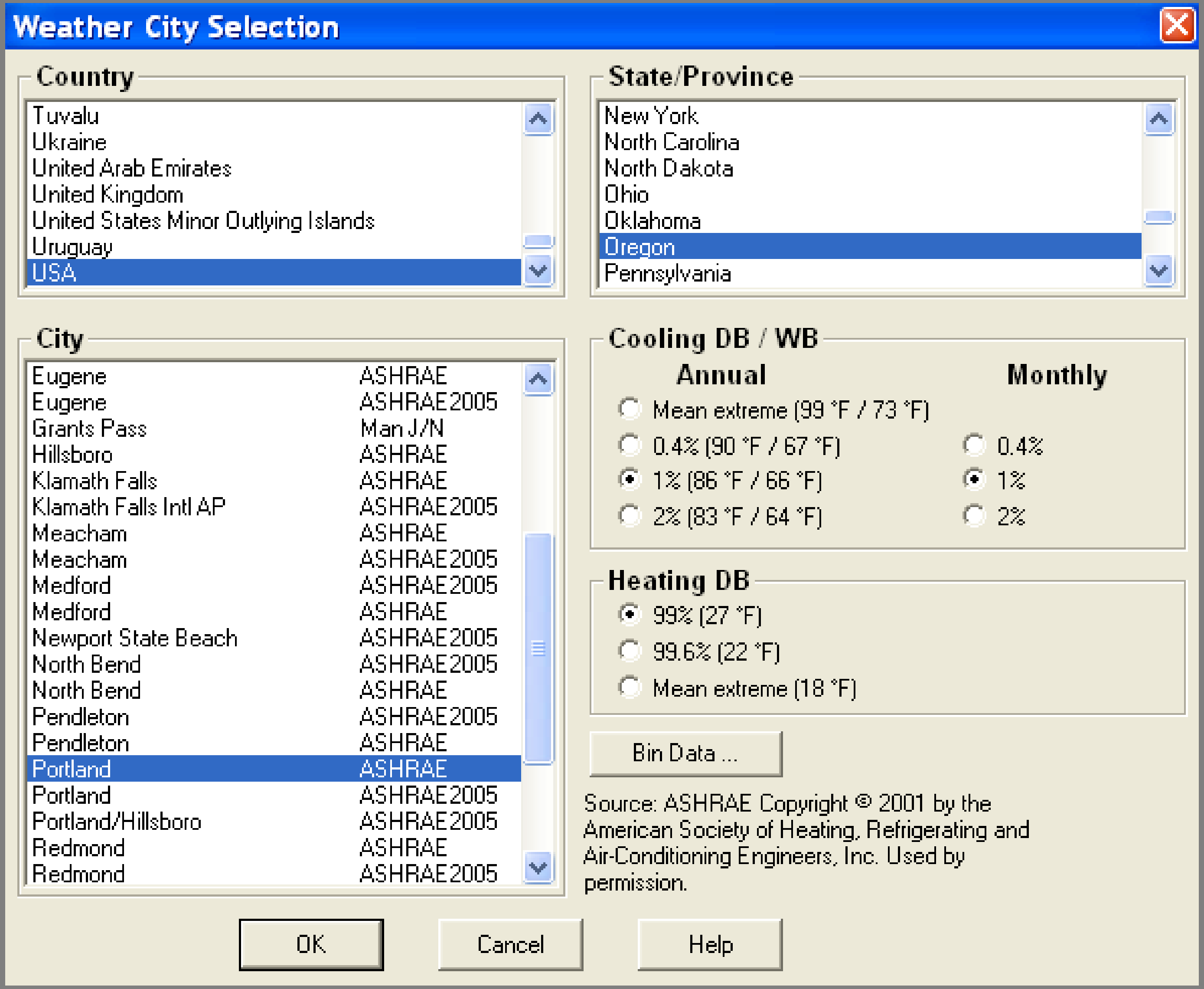
The Official Summer Climate Map of America



Definitions: Design Conditions

- **Design Temperature is not the coldest day or hottest day of the year**
- **Winter Design Conditions: It only gets colder than this 1%-2.5% of the time**
- **Boise:**
  - Average coldest temp is -2° F (the mean extreme)
  - Winter Design Condition is 9° F
  - Summer: I don’t care about what the design temp is, I want it cool now
- **Portland:**
  - Winter 23° F
  - Summer 86° F
  - What about mean extreme?

Which Design Temp Do You Want?



The Difference Between The Mean Extreme And The Design temperature:

- In traditional HOT climates the difference might be less than 5 degrees F

- In traditional mild climates the difference can easily be 15 F to 25F

- But please don’t use 115 as your design temp

From Manual J

- 5-3 Design Conditions

- “The outdoor or indoor design conditions may be dictated by code or regulation. If there is no enforceable law or regulation, the contractor and the homeowner should mutually agree on the design conditions.”

What Contributes to the Cooling Load?

- Conduction through walls and attics
- Solar gain and conduction through windows and skylights
- Floors exposed to outside temperatures
- People
- Ducts outside conditioned space (conduction and leakage)
- Infiltration/exfiltration
- Appliances
- Ventilation

Making Reasonable Estimates of Insulation Levels and Windows is Critical

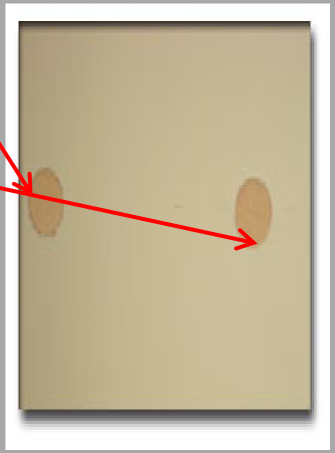
OREGON CODE PRACTICES						
Year	Attic	Floor	Walls	Basement Walls	Windows	Slab
1973	R-19	R-9 or Foil on floor or R4.5 on crawl wall	R-11	R 0	Na	
1979	R-30	R19	R-11	R11 to 12 below grade	Dual Pane	
1986	R30	R19	R19	R11 to 12 below grade	Dual Pane	
1990	R38	R19	R19	R11 to 12 below grade	Dual Pane	
1992	R38	R25	R21	R21	.40 U value	R15 Edge
2008	R38	R30	R21	R21	.35 U Value	R15 Edge

Washington State Code History

Year	Attic	Floors	Walls	Windows
King County 1978	30	11	11	Dual Pane
1980	30	11	11	Dual Pane
1986	38	19	19	Dual Pane
1989	38	19	19	Class 40 window for Electric, Class 65 for gas
2001	38	19	19	Class 40 windows for all

Checking For Wall Insulation

Wooden plugs that cover insulation access holes before filling and painting



Walls that have been insulated post construction will have patched holes on the interior walls or exterior walls. Look for 2-1/2 inch holes that have been filled and painted over

Removing the outlet cover and sliding a non-conductive probe such a plastic crochet hook or a chop stick between the sheetrock and the outlet base can help to determine if the walls are insulated

Wall Insulation

- Wall Insulation is the hardest to determine the R value
- As a rule, homes built since 1970 have wall insulation. All homes built by code have wall insulation since 1990.
- 2 x 4 walls with insulation have an R value of R-11
- 2 x 6 walls have an R value of R-19

- Many homes have had insulation blown into the wall cavities after they were built

Basements: The Critical Details

- First Question: Are you planning on conditioning the basement?
- How many feet below and above grade
- Is it insulated
- Does the sun actually "see" the glass

Manufactured Home R Value Guide

Manufactured Home R Value Guide				
Timeframe	Ceiling	Floor	Wall	Windows
Pre 1975	7	7	7	1.1
76- 94 HUD Code	11	11	11	0.75
90 -94 Super Good Cents	38	33	21	0.38
Present HUD Code	22	22	11	0.48
95 to Present NEEM	38	33	21	0.38
2000 to Present Energy Star	40	33	21	0.36

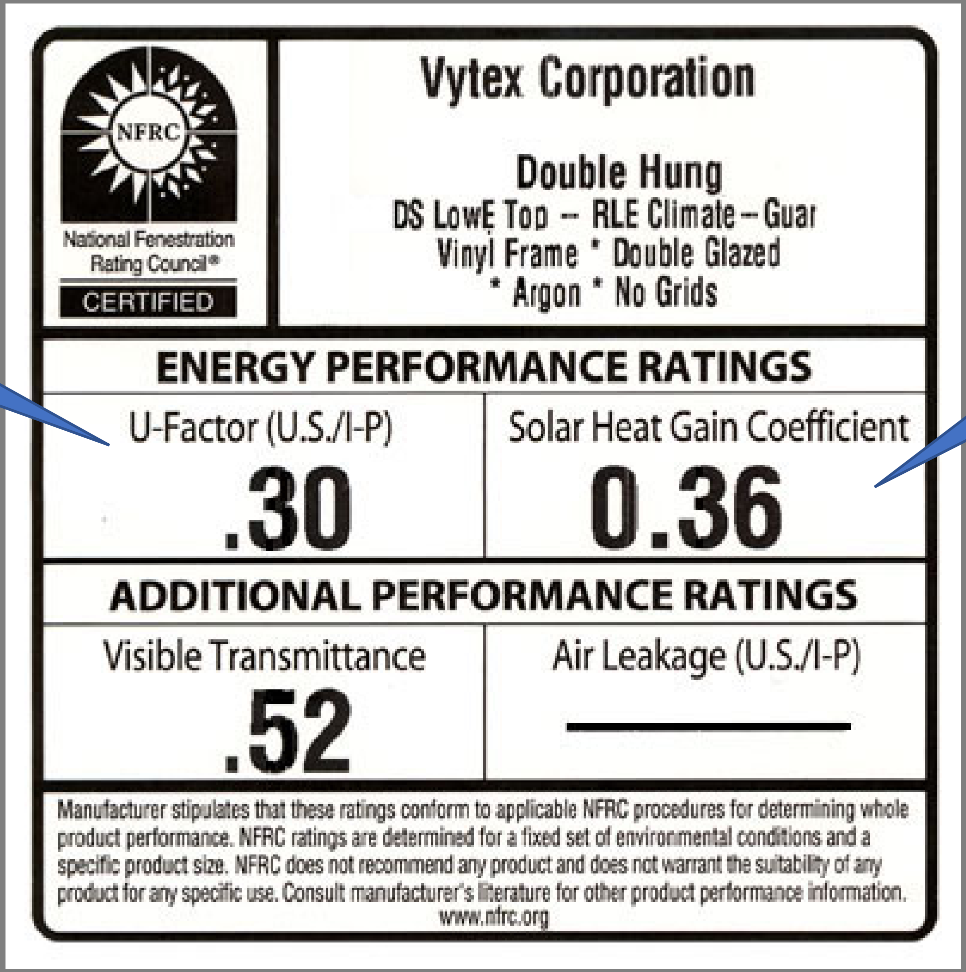
Determining How Leaky or Tight A House is:

ACH Rates: Always an Estimate

Year Built	Winter ACH	Summer ACH
Non 4 X 8 Sheet Goods	1	.5
4 X 8 Sheet Goods pre 1970	.70	.25
1970 to 1990	.5	.25
1990 to 2010	.35	.15
2010 to Present	.25	.15

What’s on that Window Sticker

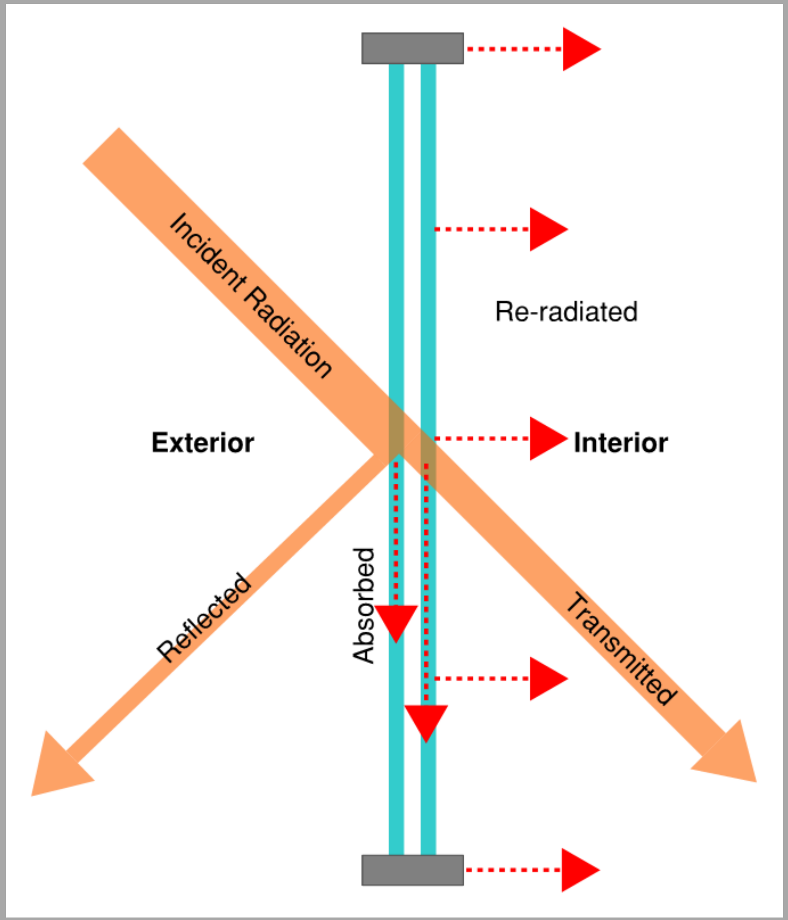
U Value



SHGC

Windows, the details

- Solar Heat Gain Coefficient (SHGC)
  - The percentage of solar radiation hitting the outside of the window assembly that is transmitted to inside the house
  - In the Northwest Most SHGC ratings are very similar to the U value



A Word About Duct Multipliers

- Typically between 5%-20%.
- 10%: Tight & insulated outside conditioned space
- 20%: Leaky or disconnected ducts outside conditioned space
- 30%: Leaky old ducts under rodent barrier in manufactured home

Fix the ducts if they are at 20% or worse

Duct Multipliers

	Duct Location	Duct R	Duct Sealing	Heating Multiplier	Cooling Multiplier
House Low R	100% attic	R4	average	0.25	0.4
House High R	100% attic	R4	average	0.31	0.51
House High R	100% attic	R8	average	0.21	0.33
House Low R	100% attic	R4	semi tight	0.28	0.43
House High R	100% attic	R4	semi tight	0.28	0.43
House High R	100% attic	R8	semi tight	0.17	0.28
House High R	100% Attic	R2	semi Leaky	0.59	1.07
House High R	50% attic 50% Inside	R2	semi Leaky	0.29	0.54
House High R	50% attic 50% Inside	R4	semi tight	0.14	0.22
House High R	50% attic 50% Inside	R8	semi Tight	0.09	0.14
House High R	50% attic 50% Inside	R8	average	0.11	0.17
House High R	15% attic, 85% crawlspace	R8	average	0.12	0.1
House High R	15% attic, 85% crawlspace	R4	semi leaky	0.29	0.22
House High R	15% attic, 85% crawlspace	R8	semi tight	0.09	0.08

Duct Multipliers and Variable Speed Equipment

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Efficiency optimization of a variable-capacity/variable-blower-speed residential heat-pump system with ductwork

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The Lab Set Up

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Fig. 3. Layout of ducts and grilles in the outdoor environmental chamber at the Western Cooling Efficiency Center, University of California – Davis.

Duct Gain Increases as Duct Velocity Decreases

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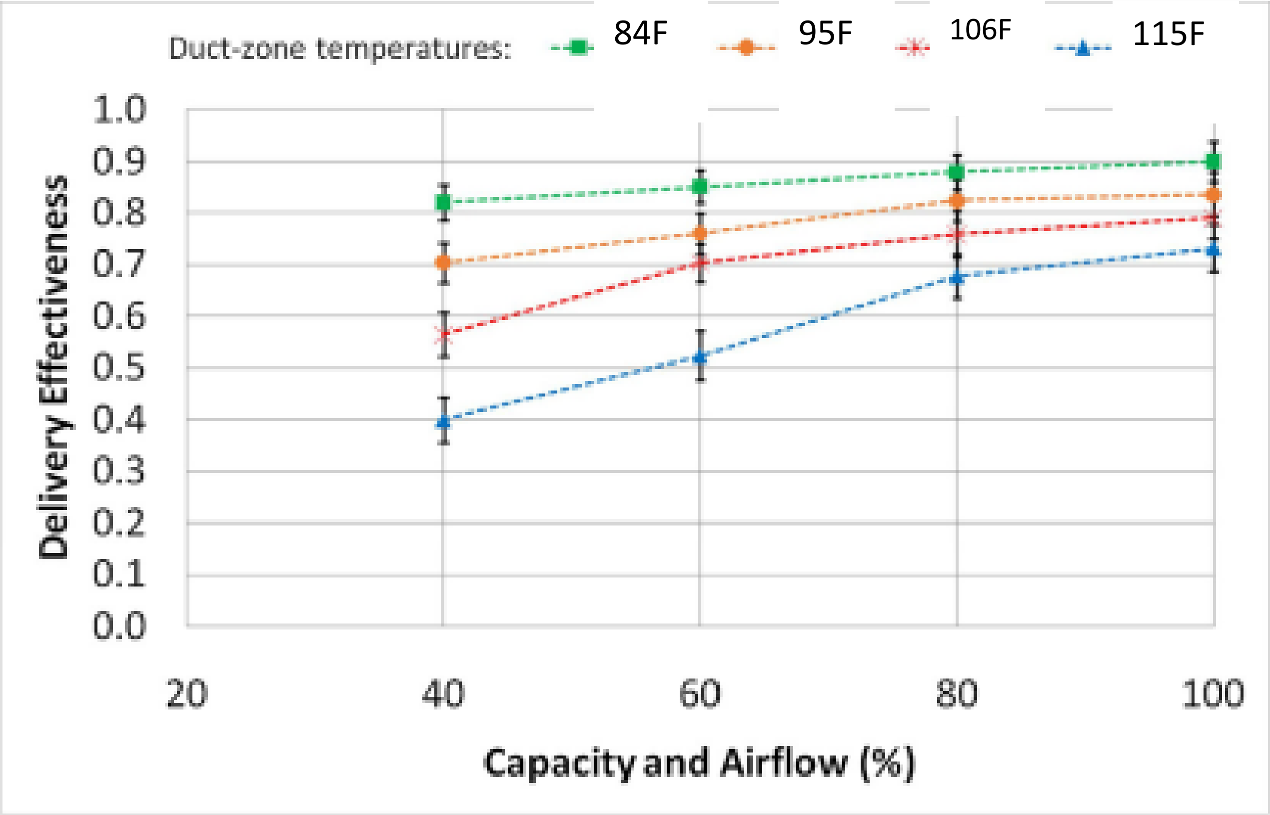


Fig. 5. Delivery effectiveness vs. Capacity/Airflow percentages for different duct-zone temperatures at 24 °C DB/17 °C WB indoor condition. Vertical error bars represent uncertainties.

Windows: Sweat the Details

BTUS/HR/Sq.FT. of Window 35 Delta T 40 Degree Latitude.					BTUS/HR. Total		
Orientation	Single Pane U value =.98 SHGC=.74	Double Pane U value =.42 SHGC= .61	Double Pane U value=.42 SHGC =.35	SQ . FT. of Window	Single Pane U value =.98 SHGC=.74	Double Pane U value =.42 SHGC= .61	Double Pane U value=.42 SHGC =.35
North	49	26	19	40	1,960	1,040	760
NE or NW	80	53	32	40	3,200	2,120	1,280
East or West	104	72	42	80	8,320	5,760	3,360
SE or SW	93	63	37	40	3,720	2,520	1,480
South	65	40	25	40	2,600	1,600	1,000
Totals				240	19,800	13,040	7,880
					11,920	5,160	

1 ton difference

.5 ton difference

What Is Meant by Equipment Sizing?

The goal of all HVAC equipment sizing is to find the best match between the house and the equipment.

Optimal size is the best match, or balance, between the rate of heat loss or heat gain of the house and the capacity of the HVAC equipment.

Total Cooling Load: Sensible and Latent

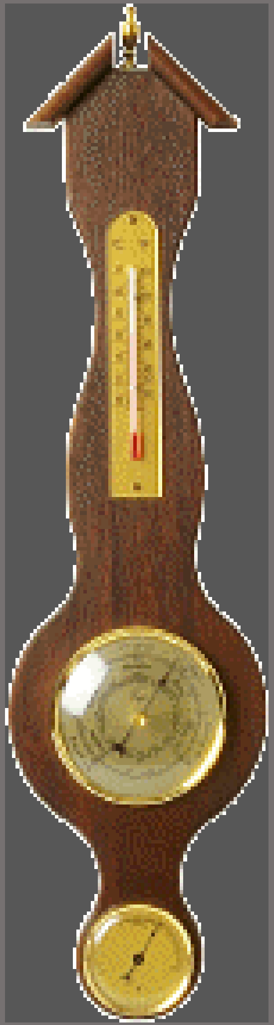
Sensible cooling load:

- The part of the cooling load that involves lowering the dry bulb temperature.

Latent cooling load:

- The part of the cooling load that involves removing water vapor from the air (dehumidification).

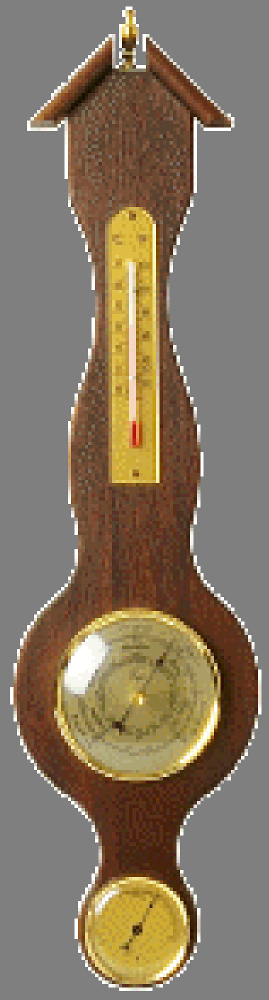
Cooling process will reduce both temperature and moisture



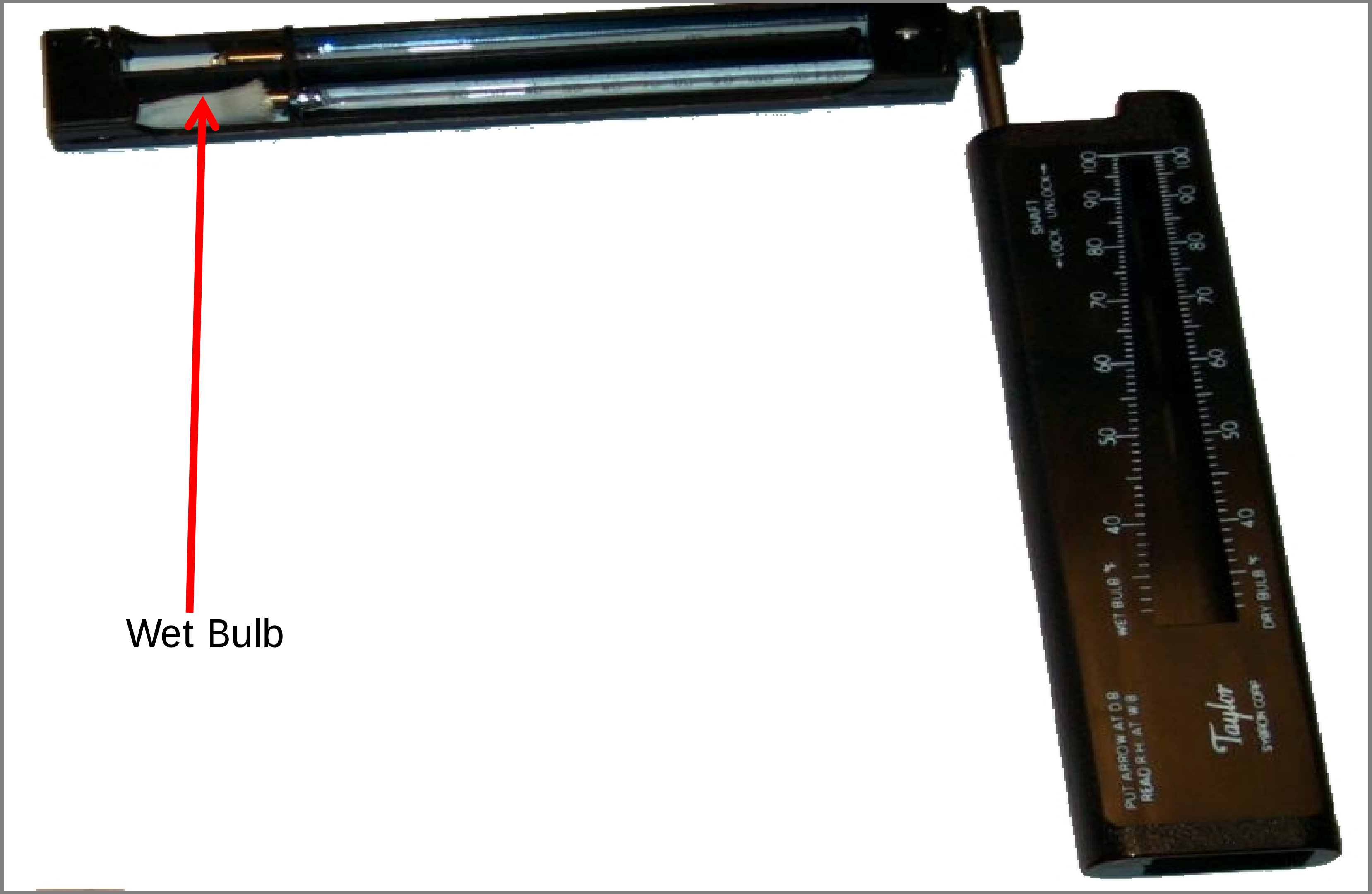
Psychrometric Definitions

Dry Bulb Temperature:

- The dry bulb temperature is measured by an ordinary room thermometer or thermostat.



Sling Psychrometer



Sizing for Air Conditioning

- **REMEMBER WE LIVE IN A DRY SUMMER CLIMATE!**
  - Find the outside design temp.
  - Determine your cfm.
  - Pick the lowest Entering Wet Bulb (EWB) temp
  - Locate the sensible capacity

DETAILED COOLING CAPACITIES*

Evaporator Air		CONDENSER ENTERING AIR TEMPERATURES °F											
		85			95			105			115		
CFM	EWB	Capacity MBtuh† Total	Capacity MBtuh† Sens‡	Total System KW**	Capacity MBtuh† Total	Capacity MBtuh† Sens‡	Total System KW**	Capacity MBtuh† Total	Capacity MBtuh† Sens‡	Total System KW**	Capacity MBtuh† Total	Capacity MBtuh† Sens‡	Total System KW**
544B024 Outdoor Section With 517EN030 Indoor Section													
800	72	26.3	13.1	2.41	24.8	12.6	2.60	23.3	12.0	2.76	21.8	11.5	2.95
	67	23.9	16.8	2.36	22.5	16.2	2.54	21.1	15.7	2.71	19.8	15.1	2.87
	62	21.7	20.3	2.32	20.6	19.6	2.48	19.3	18.9	2.65	18.2	18.1	2.81
	57	21.2	21.2	2.31	20.2	20.2	2.48	19.2	19.2	2.64	18.2	18.2	2.81
900	72	26.6	13.6	2.46	25.1	13.1	2.65	23.6	12.5	2.83	22.0	12.0	3.01
	67	24.2	17.7	2.41	22.8	17.1	2.59	21.4	16.6	2.77	20.0	16.0	2.93
	62	22.2	21.4	2.37	20.9	20.6	2.54	19.8	19.8	2.71	18.7	18.7	2.88
	57	21.9	21.9	2.37	20.8	20.8	2.54	19.8	19.8	2.71	18.7	18.7	2.88
1000	72	26.9	14.1	2.51	25.3	13.5	2.70	23.8	13.0	2.88	22.2	12.4	3.07
	67	24.5	18.5	2.46	23.0	17.9	2.64	21.6	17.3	2.82	20.1	16.8	2.99
	62	22.5	22.3	2.43	21.4	21.4	2.60	20.2	20.2	2.77	19.1	19.1	2.95
	57	22.5	22.5	2.42	21.4	21.4	2.60	20.2	20.2	2.77	19.1	19.1	2.95
Multipliers for Determining the Performance With Other Indoor Sections													

What Manual S Says About Cooling

- **Don't oversize by more than 115%, or 125% if it's a heat pump.**
- **Why:**
  - Because they are very concerned about dehumidification.
    (But the West is not humid)
  - Because older air conditioners became very inefficient when cycling. (Newer equipment doesn't have this problem.)

Nerd Alert

- C_d or C sub D
- The C_d is the coefficient of degradation. It is used to describe how the efficiency of air conditioners or heat pumps is degraded by cycling.
- New equipment has very low C_ds
- This means that in dry summer climates, the effect of oversizing by a ton is in the neighborhood of a 4% penalty.

Guidelines for Variable Speed Equipment

- If ducts are in the attic:
  - Seal. Insulate
  - Oversizing will lead to warmer delivered air temps
  - Oversizing will lead to decreased efficiency
  - DON'T RUN FAN 24/7 . Ducts in the attic are a heat exchanger

Manual S: Cooling

- **Understand that latent and sensible cooling loads are separate.**
  - The unit selected must meet each to obtain and maintain comfort in the cooling mode.

  - **Infiltration accounts for most of the latent load**
    - Humid climates: leaky homes have higher latent loads than tight homes.
    - Dry climates: leaky homes have lower latent loads than tight homes.

Sizing for Cooling

MOST PARTS OF THE WEST REQUIRE ONLY SENSIBLE COOLING (VERY LOW HUMIDITY LEVELS).

“AIR CONDITIONING” ORIGINALLY MEANT (IN LARGE PART) DEHUMIDIFICATION. OVERSIZED EQUIPMENT WILL NOT DEHUMIDIFY WELL. IN DRY PLACES, OVERSIZING DOESN’T MATTER SINCE (ALMOST) ALL COOLING IS SENSIBLE.

INSULATION OF THE HOUSE IS IMPORTANT TO COOLING LOAD BUT WINDOWS AND DUCTS ARE EVEN MORE IMPORTANT.

EQUIPMENT OUTPUT TABLES MUST BE LOOKED AT CAREFULLY.

The Sweat The Details Stuff

1. Insulation Levels, (none, some, fair amount a lot!)
2. House Tightness : usually between .35 ACH an .8
3. Windows: Solar Heat Gain Coefficient is critical! Orientation
4. Duct Multiplier: Between 5% and 40%. If it's worst than that. Fix it
5. House Size
6. Capacity of heat pump at desired balanced point
7. Pick the right weather station!

Questions?

Thank you!