HEAT PUMP TECHNICAL OVERVIEW

BASIC UNDERSTANDING OF HEAT PUMPS AND HOW TO PROPERLY SIZE THEM

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WHAT ARE HEAT PUMPS

- Heat pumps are aptly named. They move – or pump – heat from one place to another using a compressor and liquid or gas refrigerant. Heat is extracted from outside sources and then pumped indoors. The compressor pumps the refrigerant between two heat exchanger coils. In one coil, the refrigerant evaporates at low pressures which allows it to absorb heat.

- The refrigerant is then compressed and sent to the second coil which cause it to condense under high pressure. The heat is then released and sent into the home.

WHAT ARE HEAT PUMPS

- Heat pump systems are reversible. This allows it to send heat into the home in the winter and draw heat out in the summer which is nothing more then a standard air conditioner
- They can be used in a dual fuel application or with an air handler which are typically outfitted with a back up heat source such as electric strip heat.

PROS AND CONS

- **Pros:**
  - Heat pumps typically have lower running costs
  - Generally, require less maintenance than combustion systems
  - Can be safer (No gas or carbon monoxide output)
  - Lower carbon emissions
  - Quiet operation
  - One system can provide heating and cooling

PROS AND CONS

- Cons:
- The heat pump cost for installation can be expensive
- Can be difficult to install
- Can struggle in extremely cold temperatures
- May not be a good fit in every application
- They require more air movement then traditional furnace

a) High efficiency furnaces average around 200 cubic feet of air per 10,000 btu's of output.

b) Heat pumps will average around 400 cubic feet of air per 10,000 btu's of output.

APPLICATIONS:

- Dual Fuel Application:

A dual fuel application means we are utilizing the heat pump as our primary source of heat and a fossil fuel (furnace) application as the secondary source of heat when the outdoor air temperature is too low for the heat pump to provide enough energy for the home

- Air handler with back up electric heat strips or without:

This application utilizes an air handler that is equipped with an electric heat source which runs separately or in conjunction with the heat pump to provide additional energy when the outdoor temperature is too low for the heat pump to provide enough energy for the home.

PROPER ANALYSIS:

- ACCA Manual J: Load Analysis
- Proper sizing begins with performing a Manual J load analysis to determine the heating and cooling needs of the home. This is important to ensure overall occupant satisfaction which includes ensuring proper equipment sizing and energy efficiency.
- Oversized equipment results in marginal part load temperature control. Oversized equipment may cause degraded humidity control and increase comfort issues. In these unfavorable conditions, occupants may experience additional discomfort and dissatisfaction. Other negative effects are higher installed costs, increased operating expenses, and increased maintenance costs. Furthermore, oversized equipment generally requires larger ducts, poses additional requirements on the power grid and may lead to more service calls due to strain on equipment

PROPER ANALYSIS

- ACCA Manual J: Load Analysis

Three main reasons for oversized equipment are:

- A guess is made on the load:
  - Many people us "rules of thumb" when sizing equipment. This can be useful in some applications however it is critical to understand the structures assembly values and infiltration rates as this can drastically alter the heat loss and heat gain of the structure.
- Mistakes are made in the load calculation:
  - Manual J software is not plug and play and the data input is critical. Many designers do not understand the data that is being put into the system. As the old saying goes, "garbage in, garbage out". This happens more frequently in retro-fit applications as it is sometimes difficult to understand the homes insulation and infiltration values.
- A lack of understanding of what the equipment's capabilities are.
  - OEM date is available for all pieces of equipment. It is important to understand the equipment's potential and how things such as altitude, humidity and outdoor temperature will impact the equipment's performance.

PROPER EQUIPMENT SIZING:

- ACCA Manual S: Equipment Selection:
- Proper equipment selection is done by understanding the manufacturer's OEM performance data. When the equipment parameters match the Manual J design parameters, occupant satisfaction is increased. It is critical to understand the performance capabilities of the equipment you are selecting. Not all equipment will perform equally.

ACCA MANUAL S: EQUIPMENT SELECTION

- Sizing requirements: Proper sizing starts with understanding the parameters set by ACCA Manual S
  - Furnaces: 100% - 140% of total heating load
  - Heat pumps (heating dominated climates) 125% of cooling load
    - (Supplemental heat for heat pumps)
      - Electric: Will be based on balance point
      - Dual fuel: 100% - 140% of total heating load

OEM TABLE

Heat Pump Heating Performance – Efficiency Mode

25VNA424/FE4ANB002 Expanded Ratings Heating Efficiency Mode Condenser Entering Air Temperatures °F (°C)

INDOOR AIR	-3 (-19.4)				7 (-13.9)				17 (-8.3)				27 (-2.8)			
EDB	ID SCFM	Capacity MBtuh Total	Capacity MBtuh Integ‡	Total Sys. KW†	ID SCFM	Capacity MBtuh Total	Capacity MBtuh Integ‡	Total Sys. KW†	ID SCFM	Capacity MBtuh Total	Capacity MBtuh Integ‡	Total Sys. KW†	ID SCFM	Capacity MBtuh Total	Capacity MBtuh Integ‡	Total Sys. KW†
MAXIMUM DEMAND																
65 (18.3)		14.59	13.42	1.88		19.23	17.67	2.32		24.77	22.58	2.56		29.28	26.01	2.89
70 (21.1)	1000	14.02	12.89	2.06	1000	18.92	17.39	2.47	1000	24.40	22.25	2.69	1000	28.95	25.71	2.99
75 (23.9)		13.25	12.19	2.20		18.39	16.[illegible]	2.58		24.01	21.89	2.80		28.30	25.13	3.07
MEDIAN DEMAND																
65 (18.3)		11.71	10.77	1.59		14.12	12.[illegible]	1.67		18.84	17.18	1.81		20.33	18.06	1.78
70 (21.1)	890	11.03	10.15	1.59	890	14.26	13.[illegible]	1.71	890	18.37	16.75	1.85	890	20.87	18.54	1.86
75 (23.9)		10.79	9.93	1.61		13.95	12.82	1.74		18.01	16.42	1.90		20.46	18.18	1.91
MINIMUM DEMAND																
65 (18.3)		5.65	5.20	0.87		7.99	7.35	0.92		10.32	9.41	0.96		10.71	9.51	0.84
70 (21.1)	650	5.61	5.16	0.89	650	7.93	7.28	0.95	650	10.12	9.23	0.99	650	10.50	9.32	0.88
75 (23.9)		5.43	5.00	0.91		7.72	7.09	0.98		9.90	9.03	1.03		10.27	9.12	0.92

INDOOR AIR	37 (2.7)				47 (8.3)				57 (13.9)				67 (19.4)			
EDB	ID SCFM	Capacity MBtuh Total	Capacity MBtuh Integ‡	Total Sys. KW†	ID SCFM	Capacity MBtuh Total	Capacity MBtuh Integ‡	Total Sys. KW†	ID SCFM	Capacity MBtuh Total	Capacity MBtuh Integ‡	Total Sys. KW†	ID SCFM	Capacity MBtuh Total	Capacity MBtuh Integ‡	Total Sys. KW†
MAXIMUM DEMAND																
65 (18.3)		35.45	32.26	3.23		39.04	39.04	3.57		23.16	23.16	1.51		26.17	26.17	1.55
70 (21.1)	940	34.96	31.81	3.32	850	38.50	38.50	3.66	850	22.81	22.81	1.59	850	25.83	25.83	1.64
75 (23.9)		32.91	29.95	3.37		37.93	37.93	3.75		22.44	22.44	1.66		25.47	25.47	1.72
MEDIAN DEMAND																
65 (18.3)		20.62	18.77	1.48		23.95	23.95	1.53		17.02	17.02	0.94		20.12	20.12	0.94
70 (21.1)	845	19.89	18.10	1.54	775	23.60	23.60	1.60	775	16.67	16.67	0.99	775	19.75	19.75	1.00
75 (23.9)		19.90	18.10	1.60		23.22	23.22	1.67		16.33	16.33	1.05		19.36	19.36	1.07
MINIMUM DEMAND																
65 (18.3)		3.60	3.28	0.34		2.68	2.68	0.38		4.79	4.79	0.34		7.08	7.08	0.29
70 (21.1)	650	3.47	3.16	0.36	650	1.54	1.54	0.38	650	4.66	4.66	0.36	650	7.02	7.02	0.32
75 (23.9)		3.35	3.05	0.38		1.74	1.74	0.39		4.50	4.50	0.38		6.90	6.90	0.35

See notes on page 30

Manufacture[r] ... rves the right to change, at any time, specificat

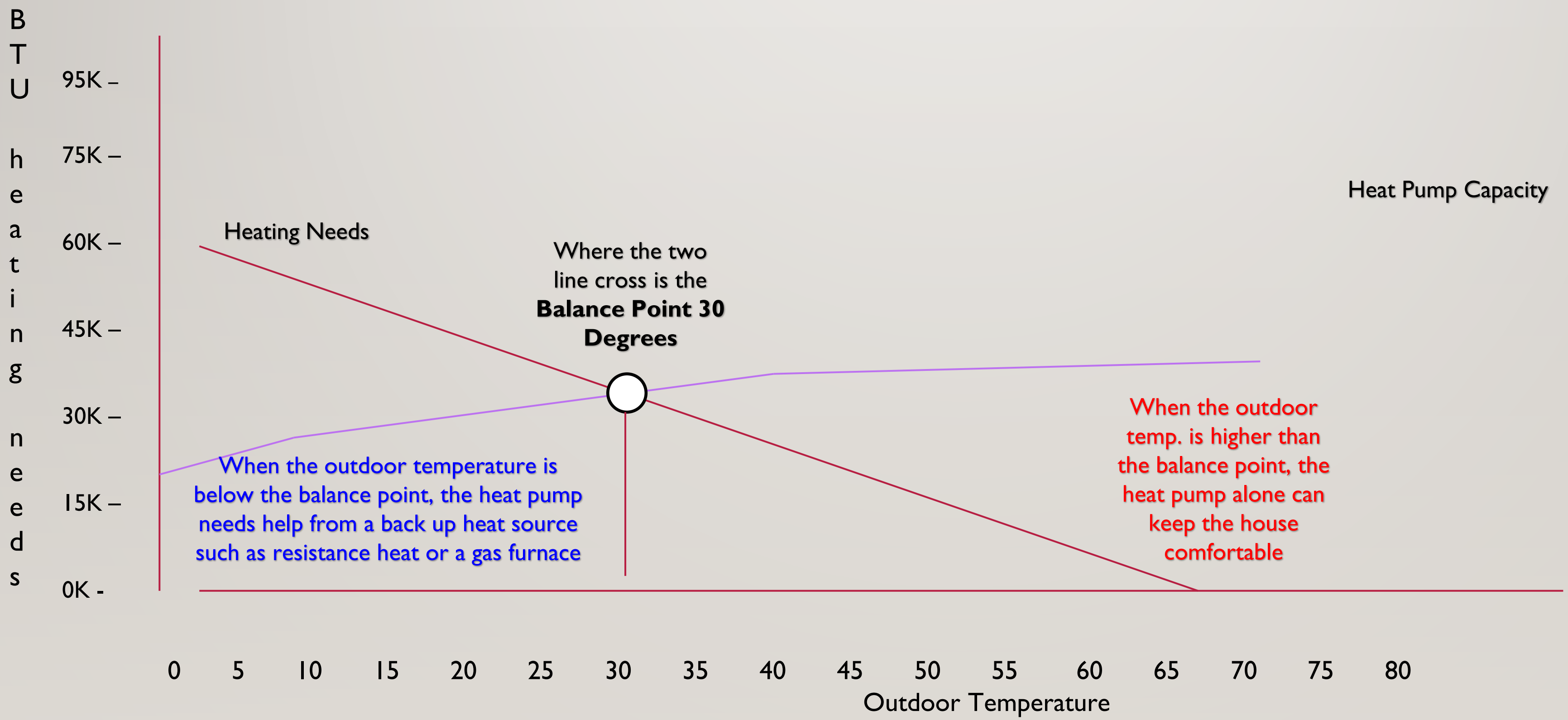
BALANCE POINT AND COEFFICIENT OF PERFORMANCE

- COP is defined as the relationship between the power (kW) that is drawn out of the heat pump as cooling or heat, and the power (kW) that is supplied to the compressor.
- If given heat pump used for air cooling has a COP = 4. This means that 4 kW of cooling/heating power is achieved for every 1 kW of power consumed by the heat pump's compressor.
- As the outdoor temperature falls, the COP will fall with it as it takes more work to provide the energy needed.

BALANCE POINT AND COEFFICIENT OF PERFORMANCE

- A balance point is the approximate outdoor temperature at which the maximum heating capacity of the heat pump matches the heating requirements of the home.
- The cooler the outdoor ambient air becomes, the greater the heating needs are of the home. As the temperature drops, the heat pump has a harder time absorbing energy from the outdoor air, reducing the amount it can bring into the home. When the outdoor temperature is below the balance point, the heat pump needs help from a back-up heat source, such as resistant heater or furnace. When the outdoor temp is higher than the balance point, the heat pump alone can keep the home comfortable.

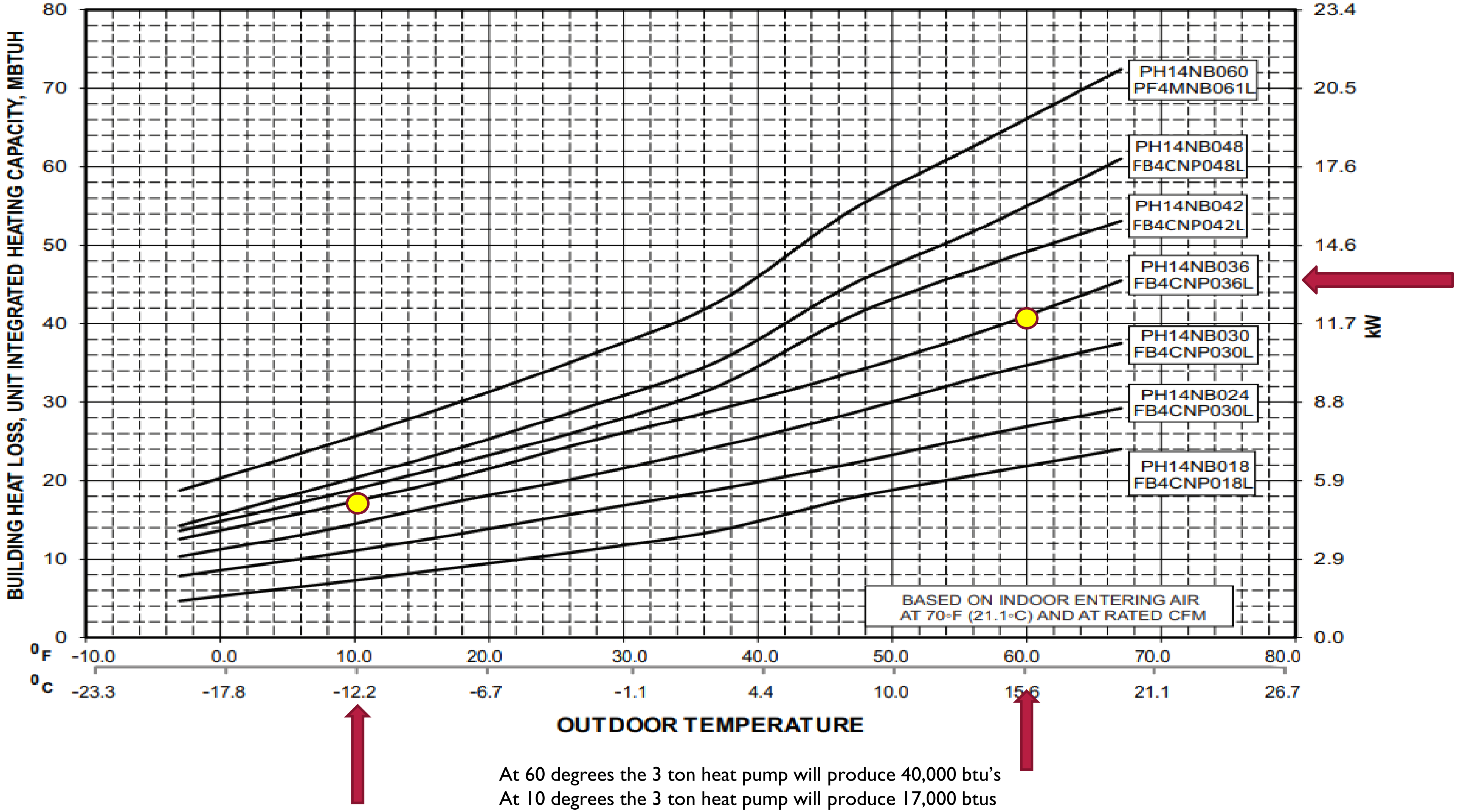
BALANCE POINT



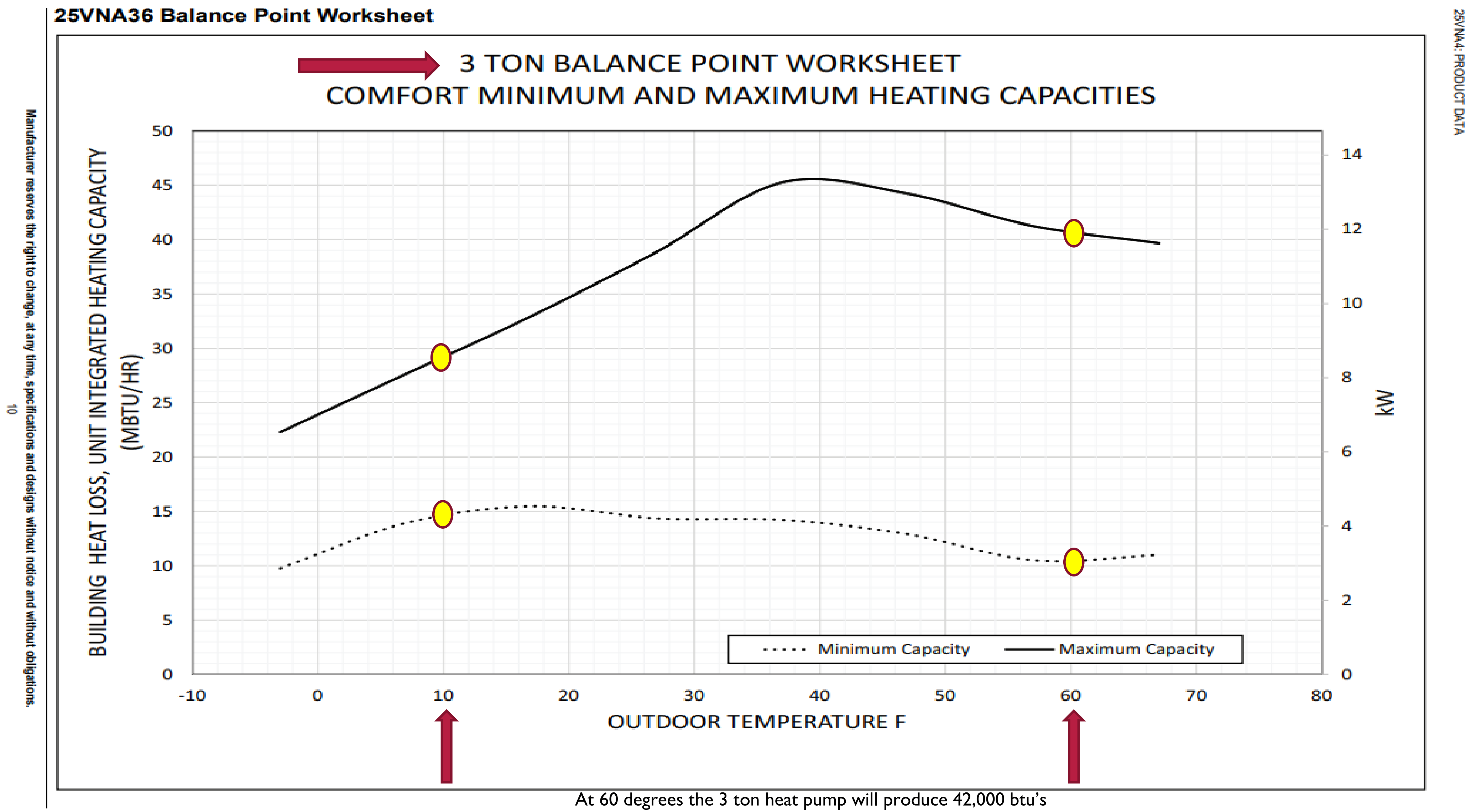
THREE WAYS TO CHANGE BALANCE POINT

1. Larger equipment: Larger equipment generally has the ability to produce more energy at lower outdoor temperatures. (Note: Duct sizes may not be able to handle the larger equipment
2. Locate equipment that is able to produce more energy at lower outdoor temperatures. Inverter and low ambient heat pumps can generally produce more energy at lower outdoor temperatures.
3. Tighten the envelope of the house and insulate properly. A tighter, more energy efficient shell will reduce the overall load on the house.

BALANCE POINT WORKSHEET



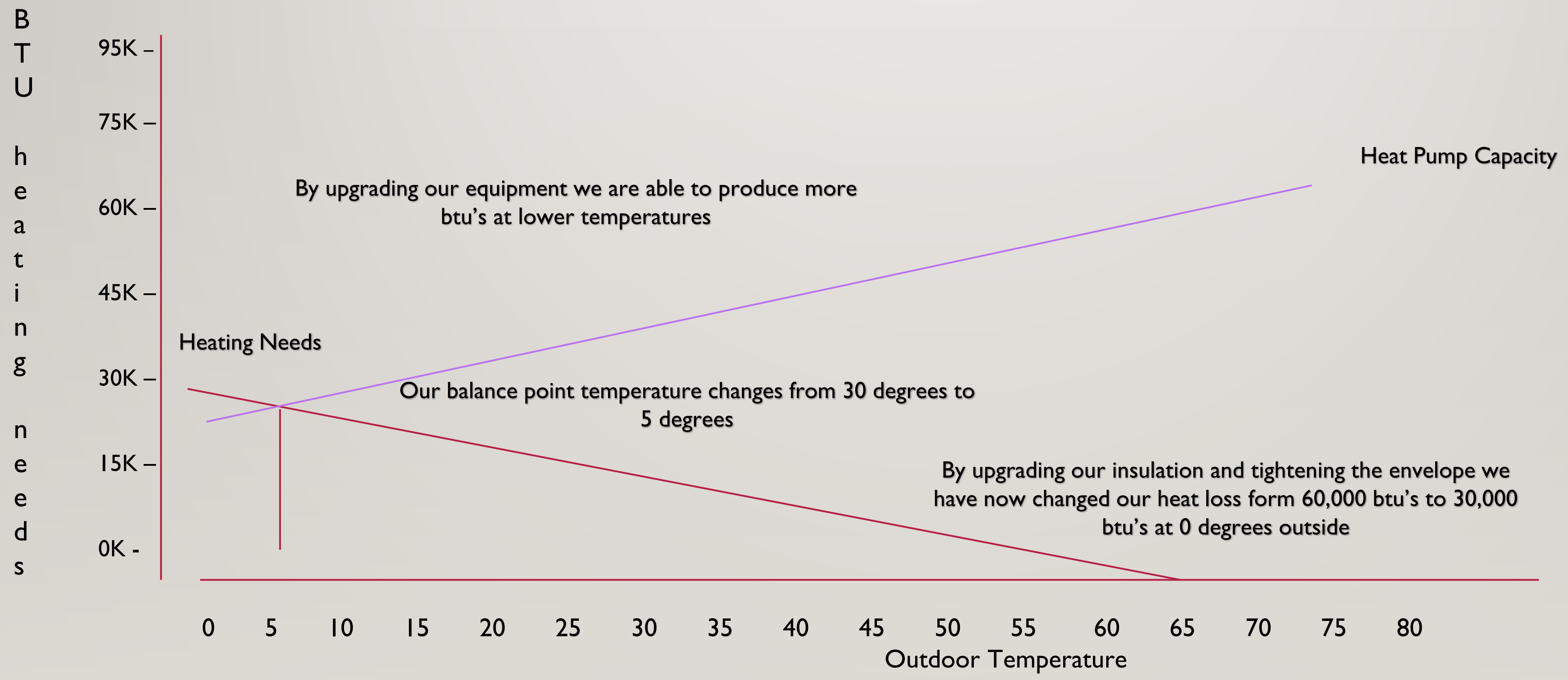
At 60 degrees the 3 ton heat pump will produce 40,000 btu's
At 10 degrees the 3 ton heat pump will produce 17,000 btus



At 60 degrees the 3 ton heat pump will produce 42,000 btu's
At 10 degrees the 3 ton heat pump will produce 28,000 btus

BALANCE POINT MODIFICATION

THE ENVELOPE WAS TIGHTENED AND THE EQUIPMENT WAS UPGRADED



DISTRIBUTION SYSTEMS

- A proper duct system is just as important as the equipment and design when considering looking at the overall energy efficiency and delivery potential of your equipment
- Inadequate duct system can significantly decrease the equipment's ability to produce energy at the level it is design to do as well as create comfort issues within the home.
- Retro-fit application need have special attention to the existing duct system to ensure they are a good fit for the application as heat pumps generally require more air then a conventional forces air system.

What Does a Properly Designed HVAC Duct System Provide Or Prevent?

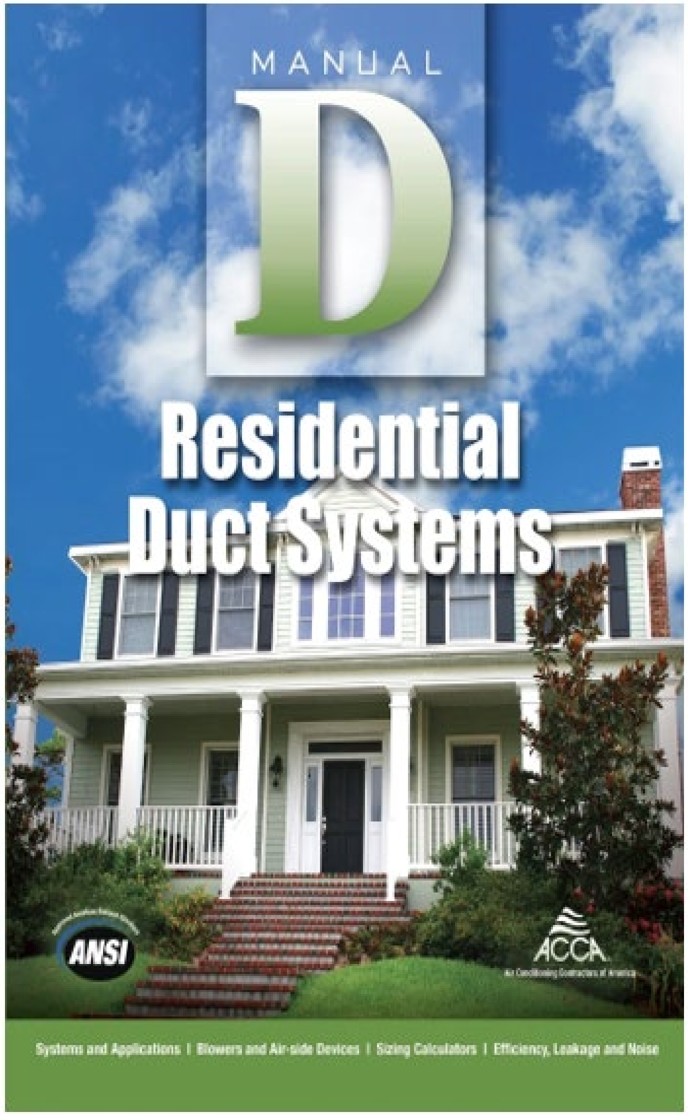
1. Ductwork designed by Manual D is critical for proper performance of your heat pump system.
2. A less expensive system with a proper duct design often performs better then a high SEER system with a poor duct design.
3. A poor duct design results in much higher heating and cooling utility bills
4. Poorly designed duct layouts will require your HVAC unit too run longer and/or more frequently.
5. An improper duct design and result in inadequate air flow causing HVAC compressor issues and can cause the evaporator coil to freeze up.
6. A poor duct system will cause uneven temperature distribution throughout the home.
7. Because the unit is working harder it may not last as long as it should.
8. Improperly sealed ductwork has leaks and will reduce the overall efficiency of your system as the energy designed to condition the living space is often lost in building cavities.
9. Improperly sealed ductwork can also increase the chances of mold to develop in unconditioned areas such as attics or crawlspaces.

Important considerations when designing the distribution system in new construction applications:

ACCA's Manual D Residential Duct Design Checklist.

Key Items:

- **Information from load calculation**
  - CFM for each room: Does each room have a heating and cooling CFM assigned proportioned air based on Manual J8 room by room load calculations?
- **Manufacturer's data:**
  - Total external static pressure and accessory pressure losses. Did the contractor submit this data?
- **Manual D friction worksheet**
  - Available static pressure (ASP): Are the outlets, return grills listed at standard .03"
  - Total Effective Length (TEL): Did the contractor calculate the TEL correctly?
  - Friction Rate design value: Did the contractor use the correct friction rate calculator?
- **Air distribution system design**
  - Branch lead size
  - Trunk size
  - Return trunk duct velocities
  - Return air path
- **Manual T**
  - Register and grille face velocities are correct.
  - Are the registers and grills in the correct location



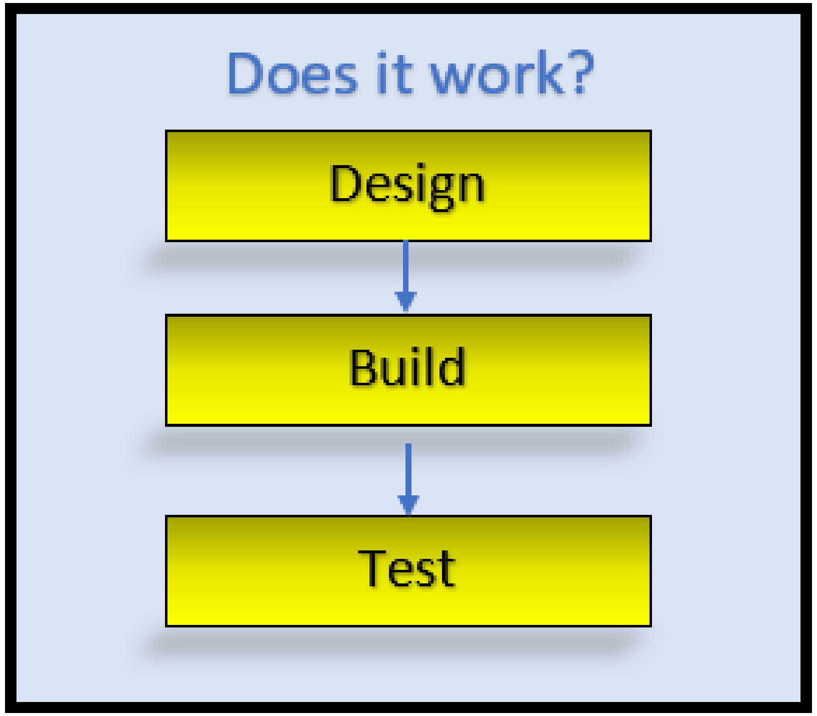
Important considerations when looking at the distribution system for retro-fit applications:

1. Can the distribution system support the airflow requirements of the new equipment?
   - Take time to test the duct system by measuring TESP and flow across the existing evaporator coil/heat exchanger to determine the duct capacity levels.

2. Can the distribution system deliver the necessary energy to each room.
   - It is recommended to measure the output of each register to understand how the existing delivery system is performing.

3. Does the existing system have significant duct leakage?
   - Significant duct leakage should be repaired prior to any large investment into high efficiency equipment.

System Commissioning



HVAC SYSTEMS HAVE TO BE COMMISSIONED

A big mistake many HVAC contractors make is assuming if they follow a Manual D or engineered design the HVAC system is ready to go right out of the box. It is critical the system be commissioned and balanced after the installation has been completed. A common misconception is the design is the only aspect of the system.

What is HVAC commissioning?

HVAC commissioning is ensuring the system is operating per the design and the equipment is operating per the manufacturer's specifications. Commissioning also requires verification that all of the building's components interact well so that one piece of equipment does not cause unintended consequences. An example would be a large kitchen hood back drafting and natural draft water heater. Unfortunately, most residential and commercial systems are not commissioned because it is not required. After all, once the equipment is hooked up it is supposed to work.... Right?

System Commissioning

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ACCA Standard 5

STANDARD NUMBER: ANSI/ACCA 5 QI–2010

HVAC Quality Installation Specification

Residential and Commercial Heating, Ventilating, and Air Conditioning (HVAC) Applications

ACCA Standard 5 and should be followed to ensure the system is installed per the design and are in compliance with ANSI/ACCA 5 QI HVAC Quality Installation Specifications.

- Verify air flow through the indoor unit is within acceptable CFM ranges per design and manufacturer's specifications.

- Verify total external static pressure (TESP) is within OEM specified acceptable range.

- Verify the HVAC system has the correct refrigerant charge.

- Ensure the system has the correct firing rate per the manufacturer's name plate. Verification through measuring and adjusting fuel gas pressure, analyzing temperature split and performing a combustion analysis. (Dual Fuel Applications)

ACCA Standard 5 and should be followed to ensure the system is installed per the design and are in compliance with ANSI/ACCA 5 QI HVAC Quality Installation Specifications.

- Determine whether or not room airflows meet the design application requirements.

- Measure and verify room pressures do not exceed + or – 3 pascals.

- Combustion appliance zone testing for systems utilizing natural draft venting.
  (This does not necessarily apply to heat pump installation but duct systems can impact natural drafting appliances.)

- Documentation of all services performed.