Thermal Comfort Diagnostics

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Sierra Building Science, Inc.

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- Professional Mechanical Engineer (Licensed in California, Nevada, Colorado and Hawaii)
- 19 years of experience in the areas of HVAC design, diagnostics and consulting, energy code compliance and consulting.
- Learned residential HVAC design (ACCA) in 1988
- Ran a mechanical engineering department for a large energy consulting firm for eight years.
- Project Manager during the development of the first statewide home energy rating system in California.
- He sits on the Board of Directors for CalACCA

Russ' Experience, continued.

- Wrote and administered the California residential and nonresidential certification exams for Title 24 for three years
- Started and managed a new mechanical engineering division for a large structural engineering company.
- Started Sierra Building Science, Inc. in 2005
- Successfully diagnosed many different kinds of problems in many different kinds of homes
- Expert witness for comfort and energy related lawsuits
- Sits on two code advisory committees to the *California Building Standards Commission*

Class Member Introductions

- What is your name?
- What city are you based out of?
- What company do you work for? In what capacity?
- What is your interest in home comfort diagnostics?

Overview of Home Comfort Diagnostics

- What is "Thermal Comfort Diagnostics" (a.k.a., Home Comfort Diagnostics)?
  - Complimentary Business Opportunity for Raters
  - Provides home owners and home builders a detailed list of independent, third-party recommendations to resolve comfort problems.
  - Some items on the list can be acted upon by the homeowner some may require a licensed HVAC contractor.

- **The "Third Party" Perspective**
  - Similar to the Title 20 rules governing HERS raters for Title 24 verification.
  - Diagnosticians who are also licensed contractors can still perform work on the homes that they diagnose. Their FIRST job is diagnostics.
  - Diagnosticians should not get kickbacks or commissions from contractors who do the work.

History and Evolution of Home Comfort Diagnostics in California

- Built in California between 1985 and 2005:
  - 2.3 million single family homes and
  - 1.2 million multifamily homes were
- The vast majority of those homes have HVAC systems that were designed and built by the installing contractor.
- The vast majority of those were designed by simple rules of thumb that were developed by trial and error.
- These usually oversize the equipment and undersize the ducts.

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History and Evolution of Home Comfort Diagnostics, continued.

- Some very good residential HVAC design methodologies have been around for decades.
- Few contractors have time to use them.
- The design-build bidding process has caused many of the designs to be done on the fly.
- Many corners were cut in the design process and in the materials in order to have the low bid and win the contract.
- This has resulted in years and years of substandard HVAC systems being the "industry standard".

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History and Evolution of Home Comfort Diagnostics, continued.

Bottom Line:

There are a **LOT** of comfort problems out there.

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History and Evolution of Home Comfort Diagnostics, continued.

- Some of these problem only come to light when they are severe enough to complain about.
- Homeowners are most likely going to call an HVAC service co.
- Some are afraid to because they fear that the repairs are going to be too expensive.
- Many homes are running at a fraction of their available capacity and the homeowners just accept the problems
- These problems remain mostly hidden but continue to suck money out of the pockets of the homeowners.

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History and Evolution of Home Comfort Diagnostics, continued.

- Up until about 2000 there were very few firms providing third party design and very few builders using them.
- Without a real design methodology you have no real target for performance, no expectation with which to judge the performance of the system.
- With a formal, methodology, you set targets and then you design to meet those targets.
- This gives you a set of performance guidelines, something to compare against, something that helps you pinpoint the source of problems.

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History and Evolution of Home Comfort Diagnostics, continued.

- A good diagnostician must also be a good designer.
- The diagnostic process is very similar to the design process.
- Design: You set expectations then you specify what it takes to meet them
- Diagnostics: You set expectations and see if they have been met.

History and Evolution of Home Comfort Diagnostics, continued.

- In 20 years of designing residential systems I have received many complaint calls about homes that I designed.
- When you go out to a house armed with a good set of mechanical plans and a stack of supporting calculations it is fairly easy to diagnose a problem.

History and Evolution of Home Comfort Diagnostics, continued.

- Most comfort problems occur when:

  Load > Capacity

- This can be for the whole house or just for one room.
- In other words, what the house/room needs is greater than what it is getting.
- If you do not know what these numbers are supposed to be you are at a great disadvantage.
- Most people try to solve the problem by increasing capacity.

History and Evolution of Home Comfort Diagnostics, continued.

- The first part of diagnosing a problem is defining the problem and then identifying the source.
- Without plans or calcs, the logical course of action is to increase the airflow to the room.
- With plans and calcs it can easily be determined if the airflow is adequate using a flow hood.
- Without knowing the target load and target airflow it is very difficult to find the cause of a comfort problem.

History and Evolution of Home Comfort Diagnostics, continued.

- If the airflow is **not** adequate, then you know to look at the ducts (capacity).
  - If the duct is smaller than called out = problem
  - If the duct size is correct but kinked, crushed, disconnected, etc. = same problem, different cause
  - If the airflow **is** adequate = totally different problem Now you know to look at the load of the room.

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History and Evolution of Home Comfort Diagnostics, continued.

- Many times I was called by builder clients to look at problem homes that I did not design.
- The target airflows and calculated loads were not known or were not available.
- Sometimes the builder had access to a set of architectural plans (but rarely mechanical plans).
- The targets could be calculated *ex post facto*, after the fact, and compared to the house THEN problems could then be easily identified.

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History and Evolution of Home Comfort Diagnostics, continued.

- I also started getting called out to older homes by HVAC contractors who had worked with me on newer homes.
- These homes usually had no available architectural plans, much less mechanical plans.
- I had to create architectural plans of the house by actually measuring the house and drawing it all on paper.
- Because I knew what information was going to be used and how it was going to be used, I was able to greatly simplify this process.

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History and Evolution of Home Comfort Diagnostics, continued.

- What if the system is performing just fine.
  - The design was good.
  - The installation was good.
  - The measured numbers were meeting the targets.
- But, the homeowner was still not happy.
- These were the toughest cases.

History and Evolution of Home Comfort Diagnostics, continued.

- Another very common source of comfort problems is **poor occupant behavior**.
- This could include misusing the thermostat, leaving doors and windows open, or excessive added loads from equipment and people.
- These do not show up in any calculations and are hard to detect.
- You need a way to determine when and how the system was running over a period of time.
- This requires a high tech solution – **Monitoring**.

History and Evolution of Home Comfort Diagnostics, continued.

- There are small data loggers can recorded temperature readings over a period of time.
- This data could be downloaded to a computer, graphed and analyzed.
- By placing 6 to 8 data loggers in specific locations, it is amazing what kind of information can be learned if you know what you are looking at.
  - You can tell when a room is uncomfortable.
  - You can tell how uncomfortable a room is.
  - You can tell when and how long the system runs.
  - You can tell how the homeowners operate the thermostat.

How a System is *Supposed* to Work

Important Concept:

For the air temperature in the room to remain constant:

Btu's coming in = Btu's leaving.

How a System is *Supposed* to Work continued.

- If heat is **escaping** from a room:
  - To keep the temperature in that room constant we must add Btu's at the same rate that they are escaping.
  - We do this by blowing air into the room which has more Btu's in it (per cubic foot) than the air in the room.

How a System is *Supposed* to Work continued.

- If heat is **entering** a room:
  - To keep the temperature in that room constant we must remove Btu's at the same rate that they are entering.
  - We do this by blowing air into the room which has fewer Btu's in it per cubic foot than the air in the room.

If the cold air coming into the room has *some* Btu's in it, how can adding cold air remove Btu's from the room?

How a System is *Supposed* to Work continued.

- Every cubic foot of air that comes into the room, a cubic foot must leave by **displacement**.
- If the air leaving has more Btu's in it that the air coming in, there will be a net **reduction** of Btu's in the room.

How a System is *Supposed* to Work continued.

Important Concept:

Heating a space is adding Btu's to a space to offset Btu's that are being lost.

Cooling a space is removing Btu's from a space to offset Btu's that are being gained.

How a System is Designed (the Correct Way)

- HVAC design is all about supply and demand:
  - being able to supply the right amount of heating or cooling to meet the demand of the house.
- In HVAC terms we call it *capacity* and *load*.
  - *Capacity* is how much heating and cooling the equipment can provide. (Supply)
  - *Load* is how much heating and cooling the house needs. (Demand)

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How a System is Designed (the Correct Way), continued.

- To properly heat and cool a house, the equipment must provide at least as much heating and cooling as the house needs.
- In order to figure out how much capacity you need you must first calculate the load of the house.

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How a System is Designed (the Correct Way), continued.

- Heating and cooling loads are the calculated heat loss and heat gain of the house.
- Heat loss and gain are calculated on a per hour basis – Btu's per hour.
- They can either be done for the entire house or on a room-by-room basis, which is critical to designing the distribution system (ducts).

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How a System is Designed (the Correct Way), continued.

Loads vs. Reality

- Typical HVAC systems usually only have two speeds, whether heating or cooling – ON and OFF.
- Some systems have multiple stages.
- There are no buttons like in your car that turn the A/C up or down.
- There is no knob like on your stove that turns the furnace flames higher and lower.
- When the system is running it is running at its maximum capacity.

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How a System is Designed (the Correct Way), continued.

- Because the system only runs at one speed but the load can vary, the system must cycle on and off so that it does not overcondition the space.
- If you look the total input over an extended period of time it will be equal to the averaged load of the house during that time.

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How a System is Designed (the Correct Way), continued.

Important concept:

When the *capacity* is *greater* than the *load* the system will cycle on and off.

When the *capacity* is *less* than the *load* the system will run continuously (until the load drops below the capacity and the system can catch up).

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How a System is Designed (the Correct Way), continued.

- Calculating the heating load for a house is basically an exercise in adding up all of the heat losses.
- Once that is done, you then need to pick a furnace that meets or exceeds that load.
- You need a good set of plans and a list of energy features, the information from these will be used to calculate the various heat losses.

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How a System is Designed (the Correct Way), continued.

Calculating Cooling Load –

- Cooling load calculations are very similar to heating load calculations
  - The heat is going in the opposite direction – out to in, rather than in to out.
  - There is a significant radiant load – solar gains – which is the sun shining in through the windows.
  - The majority of heat gain in the cooling loads comes from solar gains.

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How a System is Designed (the Correct Way), continued.

Equipment Sizing -

- It is important to understand that some equipment serve more than one function.
- A furnace, for example is not just a heater.
- In cooling mode it is the fan
- So the sizing of the furnace must be considered both for heating and for cooling purposes.

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How a System is Designed (the Correct Way), continued.

Determining Cooling Capacity –

- Air conditioners extract heat from inside the house and dump it to the outside.
- This discussion is beyond the scope of this training and there are many good reference books on the topic.
- All a diagnostician needs to understand at this point is that because of the way airconditioners work, their actual capacity is very dependent on several things.
- These things are good to know later on when we talk about how to improve cooling capacity.

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How a System is Designed (the Correct Way), continued.

The things that affect cooling capacity are:

- **outdoor temperature** – as the outdoor temperature goes up, it is harder to "dump" heat to the outside and the air conditioners capacity goes down.
- **airflow across coil** – higher airflow (indoor air) across the coil improves the coils ability to extract heat from the air, improving cooling capacity
- **inside wet bulb temperature** – when there is more moisture there is in the indoor air more of the cooling capacity is used up when this moisture condenses on the coil.
- **inside dry bulb temperature** – when the indoor air is colder it is more difficult to extract heat from it and the cooling capacity goes down.

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How a System is Designed (the Correct Way), continued.

Ducts and Comfort

- Sizing ducts can be quite complicated and is one of the most common places where people take short cuts.
- Improper duct sizing is probably the number one cause of comfort problems.
- An important concept that you need to know are that pressure is what moves air through the ducts.
- Every inch that the air moves through the ducts a little bit of pressure is lost (also called friction losses).

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How a System is Designed (the Correct Way), continued.

- The equation is quite simple:

Starting Pressure – Pressure Losses = Ending Pressure

- Improving airflow is a simple matter of increasing the starting pressure or decreasing losses, or both.
- Diagnosticians need to be experts at this.

How a System is Designed (the Correct Way), continued.

Comfort and Supply Registers and Return Grilles

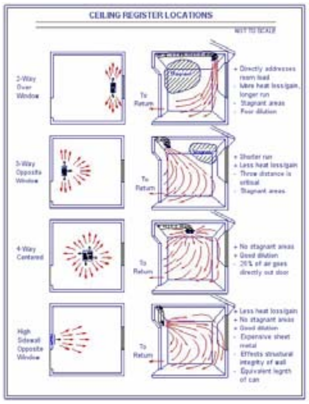
- ACCA has a manual just for sizing and selecting registers it is called ACCA Manual T.
- There are several schools of thought on where is the best place to put supply registers in the ceiling.
  - One is that you should always put them right over a window.
  - One is that you should put them near the interior wall and blow out toward the exterior wall.
  - One is to put a square register near the center of the room (this is the most common approach in the Las Vegas area).

How a System is Designed (the Correct Way), continued.

- Ceiling registers
- Floor registers.
- Side wall registers.

Determined by:

- Construction of the house,
- Location of the furnace,
- Size of the room
- Personal preference.



How a System is Designed (the Correct Way), continued.

- One is not *significantly* better than the others.
- They all have advantages and disadvantages.
- The key is which ever one they decide on, do it correctly.
- It is amazing how often it is not done correctly.

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How a System is Designed (the Correct Way), continued.

Supply Registers – how to select

The criteria that must be taken into account when selecting and sizing supply registers are:

- Static pressure drop
- Airflow
- Sound Rating
- Direction of flow
- Throw distance

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How a System is Designed (the Correct Way), continued.

Static pressure drop –

- How much resistance to airflow the register will create.
- ACCA Manual D recommends using a number of .03.

How a System is Designed (the Correct Way), continued.

Airflow –

- How much air is expected to pass through the register
- The main factor that determines the size of the register

How a System is Designed (the Correct Way), continued.

Sound rating –

- Noise is created by excessive face velocity (the speed of the air as it exits the register).
- Different registers have difference noise criteria.
- The selected register should have a sound rating below a certain recommended number.

How a System is Designed (the Correct Way), continued.

Direction of flow –

- One of the simplest, and most important, yet most often screwed up factors of a register.
- If they use the wrong type, the airflow does not circulate properly and this can cause significant comfort issues.
- Note: 1-way registers are an acceptable substitute for 3-way registers.
- Note: Sidewall registers should be bar-type registers and not directional stamped-face registers.

How a System is Designed (the Correct Way), continued.

Throw distance –

- How far the register will "throw" the air.
- Different manufacturers measure it in different ways.
- The air does not need to hit the wall, just reach it.

How a System is Designed (the Correct Way), continued.

Return Grilles

- Return grilles are sized by airflow primarily, but consideration must be given to velocity and noise.
- Where to locate return grilles is a big source of controversy.
- Many people feel that returns pull air from the space. It is more accurate to think of a return as just a place that the supply air likes to go .

How a System is Designed (the Correct Way), continued.

- Returns are most often located in a central hallway .
- Having a full size return on each floor of a two story house is desirable but usually architecturally difficult to accomplish and usually not worth the effort.
- Some contractors insist that a system will not work properly if it does not have a high and a low return.
- This is not supported by any empirical or theoretical information.
- They put too much emphasis on where the returns go and then undersize it.
- It is safe to say that you can not oversize a return but you can definitely undersize one.

How a System is Designed (the Correct Way), continued.

- Sometimes it is a good idea to put a return in a very large room that has a door on it.
- This return should be sized to match the total supply air that is going to the room side of the door.
- The general rule of thumb is if more than about 250-300 cfm is going on one side of a door, put a return on that side of the door.

How a System is Designed (the Correct Way), continued.

- Return air locations relative to the thermostat are important to comfort.
- The air will be moving toward the return so it helps to put the thermostat in the path of this air so that it can best read the average temperature in the house.
- If the return is in the middle of a hallway with the living spaces on one side and the bedrooms on the other, putting the thermostat on the wall even with the return is a good idea.
- Putting it to one side or the other will only allow it to read the average temperature of the rooms on that side of the return, to the possible detriment of the other side of the house.

How a System is Designed (the Correct Way), continued.

Thermostats and Comfort

- There is no perfect place to put a thermostat, only lots of OK places and even more bad places.
- Thermostats in their most basic form only do two simple but very different things:
  - 1. they turn a system on; and
  - 2. they turn a system off.

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How a System is Designed (the Correct Way), continued.

- In doing these two important things they are operating in two very different conditions:
  - 1. the system is on; and
  - 2. the system is off.

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How a System is Designed (the Correct Way), continued.

- When the system is off there is no air circulation in the house.
- When this occurs it is virtually impossible for the thermostat to accurately sense the average temperature in the house.
- If the thermostat is located in a central hallway, it could easily be 8-10 degrees warmer in a west facing room with lots of glass before the heat reaches the thermostat and turns the system on.
- This is always a potential problem in any home; however, it does not always manifest itself in a noticeable comfort problem.

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How a System is Designed (the Correct Way), continued.

Zoning –

- Zoning is used when a house is too big or too spread out to be adequately controlled by a single thermostat or adequately conditioned by a single system.

How a System is Designed (the Correct Way), continued.

As homes have gotten more and more energy efficient, the load has gotten less and less per square foot.

- a 2600 square foot house built in the early '80's might need TWO 3-ton units
- a 2600 square foot house built today might only call for a single 4-ton.

How a System is Designed (the Correct Way), continued.

- The largest normal residential HVAC system is 5-tons.
- This can easily serve a house up to 3500 square feet (again, this depends on a LOT of factors).
- But it would be very difficult to adequately control a 3500 square foot house with a single system, especially if it is a two story home.
- That is when an "automatic zonal control" system is a good idea.
- This type of system utilizes motorized dampers, each controlled by a thermostat.
- Using multiple dampers and multiple controls, the system can independently control different parts of the house without the need for multiple HVAC systems.

Comfort Problems: Identification, Diagnosis, and Resolution

- The first step in solving comfort problems is to identify what the problem actually is.
- Home owners speak from their own perspective with their own biases and opinions.
- Comfort problems are very personal and very subjective.
- Get the home owner to understand the basic aspects of the comfort problem and get them to use more standard terminology.

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Comfort Problems: Identification, Diagnosis, and Resolution, continued

- For example a homeowner may say "Our bedroom is miserable." This is not helpful.
  - Is it miserably hot or miserably cold?
  - Is it drafty?
  - Is it noisy?
  - Is it humid?
  - When does this occur?
  - How long does it last?
  - When does it not occur?
  - What have they done to try to alleviate the problem?

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Comfort Problems: Identification, Diagnosis, and Resolution, continued

- These types of questions are answered by using a good home owner interview form.
- The interview must guide the homeowner.
- Get them to think in terms of
  - over-conditioning (too much air) and
  - under-conditioning (too little air)

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Comfort Problems:
Identification, Diagnosis, and Resolution, continued

- Before you begin to diagnose the specific problem, you must first find out how the system is being operated.
  - Go to the thermostat and check the current settings.
  - Check the Date and time setting. Does it match the actual date and time?
  - Check the current room temperature. Use a laser thermometer to check the wall temperature all around the thermostat (about a 12" radius). Do the numbers match?

Comfort Problems:
Identification, Diagnosis, and Resolution, continued

- What mode is the thermostat currently set to? (heat, cool, off)
- What is the fan switch set to? (on, auto)
- What is the program mode set to? (manual, hold, program)

Comfort Problems:
Identification, Diagnosis, and Resolution, continued

- What is the programmed schedule?

Heat	time	temp	time	temp	time	temp	time	temp
Weekday								
Weekend								

Cool	time	temp	time	temp	time	temp	time	temp
Weekday								
Weekend								

Comfort Problems:
Identification, Diagnosis, and Resolution, continued

- Ask them to describe how they typically operate the thermostat.
- Ask them what kind of an impact does this have on their comfort problems?
- Does it make it worse or better when they operate the thermostat in a certain way?

Comfort Problems:
Identification, Diagnosis, and Resolution, continued

Diagnosing the specific problems

- First identify rooms/areas of the house where the problem occurs.

Comfort Problems:
Identification, Diagnosis, and Resolution, continued

- Then separate heating and cooling problems:
  - Does this problem room/area have a noticeable problem in the winter when the heater is running?
  - Does this problem room/area have a noticeable problem in the summer when the A/C is running?

Comfort Problems:
Identification, Diagnosis, and Resolution, continued

- Focusing on heating first, determine the nature of that problem.
  - Is it a **temperature** problem? (yes, no)
  - Is it a **noise** problem? (yes, no)
  - Is it a **draft** problem? (yes, no)
  - Is it a **humidity** problem? (yes, no)
  - Other? (describe)

Comfort Problems:
Identification, Diagnosis, and Resolution, continued

- Determine when the problem occurs.
  - Does the problem occur more when the heating system is off?
  - Does the problem occur more when the heating system is on?
  - What time of day or night is the heating problem more apparent?
  - What time of year?

Comfort Problems:
Identification, Diagnosis, and Resolution, continued

- Does the heating problem coincide with any particular activities? (gatherings, physical activity, cooking, showers, coming home from work, etc.)
- When this problem occurs are there any other rooms/areas that are having a similar problem?
- When this heating problem occurs, are there any other rooms (on the same system) that are especially comfortable?

Comfort Problems:
Identification, Diagnosis, and Resolution, continued

Find out what previous work has been done to try to alleviate the problem.

Comfort Problems:
Identification, Diagnosis, and Resolution, continued

Repeat for Cooling.

Repeat for other rooms/areas.

Comfort Problems:
Identification, Diagnosis, and Resolution, continued

- Some problems are not specifically a heating problem or cooling problem
  - **Problem**: Drafts (when system is on) Air blows on bed, stove, etc.
  - **Example Diagnosis**: Turn thermostat fan switch to “on”. Use “air current tester” (smoke pen) to visually confirm direction of air flow.

Comfort Problems:
Identification, Diagnosis, and Resolution, continued

- Notice that some resolutions may be automatically resolved by resolving other problems.
- Also notice that some resolutions can possibly create other problems.
- When this occurs, you must pick the lesser of two evils.
- In this example, using a different register may cause an air mixing problem.

Comfort Problems:
Identification, Diagnosis, and Resolution, continued

Some problems can be very vague.

- **Problem**: System runs erratically.
- **Example Diagnosis**:
  - Turn thermostat fan switch to "on" and try to duplicate erratic operation.
  - Check thermostat programming.
  - Check thermostat operation.
  - Check for leakage around thermostat from hole in drywall.

Comfort Problems:
Identification, Diagnosis, and Resolution, continued

- **Recommended action(s):**
  - Program thermostat.
  - Seal hole behind drywall with expansive foam or caulk.
  - Replace thermostat.

Comfort Problems:
Identification, Diagnosis, and Resolution, continued

Some problems are not necessarily related to temperature or humidity.

- **Problem**: Noise from return grill
- **Example Diagnosis**:
  - Turn thermostat fan switch to "on".
  - Determine if noise is from fan motor/blades or from excessive face velocity.

Comfort Problems:
Identification, Diagnosis, and Resolution, continued

- **Recommended Action(s)**:
  - If sound is mechanical squeaking, clicking, rattling from fan motor, suggest repairs by qualified technician.
  - If sound is a low droning sound, see if return duct (if any) is too short (less than 10 feet) and or straight.
  - Consider adding additional length (additional 10-15 feet) of flex duct to return.

Comfort Problems:
Identification, Diagnosis, and Resolution, continued

- If FAU is closet mounted and return is a platform return, consider lining inside return with duct board. Consider adding sheet metal or duct board baffle.
- If sound is from grill, check if it is caused by filter.
- Consider a different type of filter.
- Consider changing stamped face grill to bar type.
- Consider enlarging grill.
- Consider adding a second grill on another side of closet.

Comfort Problems:
Identification, Diagnosis, and Resolution, continued

- **Problem**: Noise from supply register
- **Example Diagnosis**:
  - Turn system fan on.
  - Verify noise is from high velocity at face of register.

Comfort Problems:
Identification, Diagnosis, and Resolution, continued

- **Recommended Action(s)**:
  - If excessive airflow is diagnosed at this register from the air balance evaluation, reducing airflow alone might resolve the issue.
  - Consider replacing stamped face register with bar-type.
  - Consider enlarging register and boot. (expensive, requires access)
  - Consider adding second register, boot and duct. (expensive, requires access)

Comfort Problems:
Identification, Diagnosis, and Resolution, continued

Common Causes of Comfort Problems (in no particular order) – Primarily Cooling

- Leaky supply ducts – conditioned air is escaping from ducts before it reaches house
  - **Symptoms**: low air flow, high energy bills, house depressurizes
  - **Example Diagnosis**: duct leakage test w/smoke, register pressure evaluations.
  - **Resolution:** seal ducts

Comfort Problems:
Identification, Diagnosis, and Resolution, continued

Common Causes of Comfort Problems (in no particular order) – Primarily Cooling

- Leaky return ducts – unconditioned (and unfiltered) air is being introduced
  - **Symptoms**: high energy bills, house pressurizes, dusty
  - **Example Diagnosis**: duct leakage test w/smoke
  - **Resolution:** seal ducts

Comfort Problems:
Identification, Diagnosis, and Resolution, continued

Common Causes of Comfort Problems (in no particular order) – Primarily Cooling

- Leaky house – excessive unconditioned outside air is entering house
  - **Symptoms**: high energy bills, drafts, dust
  - **Example Diagnosis**: blower door test
  - **Resolution:** seal house

Comfort Problems:
Identification, Diagnosis, and Resolution, continued

Common Causes of Comfort Problems (in no particular order) – Primarily Cooling

- Note: It assumed that the system is in good mechanical working order. None of the mechanical components are “broken”.

Comfort Problems:
Identification, Diagnosis, and Resolution, continued

Common Causes of Comfort Problems (in no particular order) – Primarily Cooling

- Most of these problems will become apparent during the basic air balance analysis.
- Some will require additional diagnostic testing such as duct leakage, blower door or dataloggers.

Basic Field Data Collection

Tools and Equipment

- Recommended to perform the basic service:
  - a laptop computer with cell-phone card
  - a portable printer/scanner/fax (e.g., Brother MFC-210CN)
  - a duct leakage test equipment
  - Fog machine
  - a flow hood (e.g., TSI Accubalance Flow Hood)
  - Tape measurers (25' regular, laser, and rolling)

Basic Field Data Collection, continued

- Tools and Equipment, continued
  - a digital camera
  - an air-probe thermometer
  - a laser thermometer
  - a low-E window detector (E-Tekt AE 1600)
  - compass
  - misc. equip: clip boards, ladders, respirator, drop cloths, eye protection, shoe covers, etc.

Basic Field Data Collection, continued

Tools and Equipment, continued

- Recommended to perform the additional services:
  - blower door
  - data loggers (12-24)
  - infra-red camera (future item)

Basic Field Data Collection, continued

- Measurements
  - Static Pressure
  - Supply Airflow (every register)
    - Door open
    - Door closed (if closeable door between register and return) in problem rooms
  - Supply air temperatures (sample)
  - Return Airflow
  - Digital photos (4 sides, equipment, other interesting items)

Data Logger Analysis

- Performing test –
  - In order to get the most useful data, you need good operating conditions.
  - Give the homeowners a copy of the instructions.
  - (note to RESNET attendees: specific datalogger placement and analysis techniques mentioned in the presentation are proprietary to SBSI and are not reproduced here.)

The End

For more information,
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