Valuing HVAC Design & Installation In the HERS Index

December 5th, 2018

Introduction

Installation defects in HVAC systems are commonplace

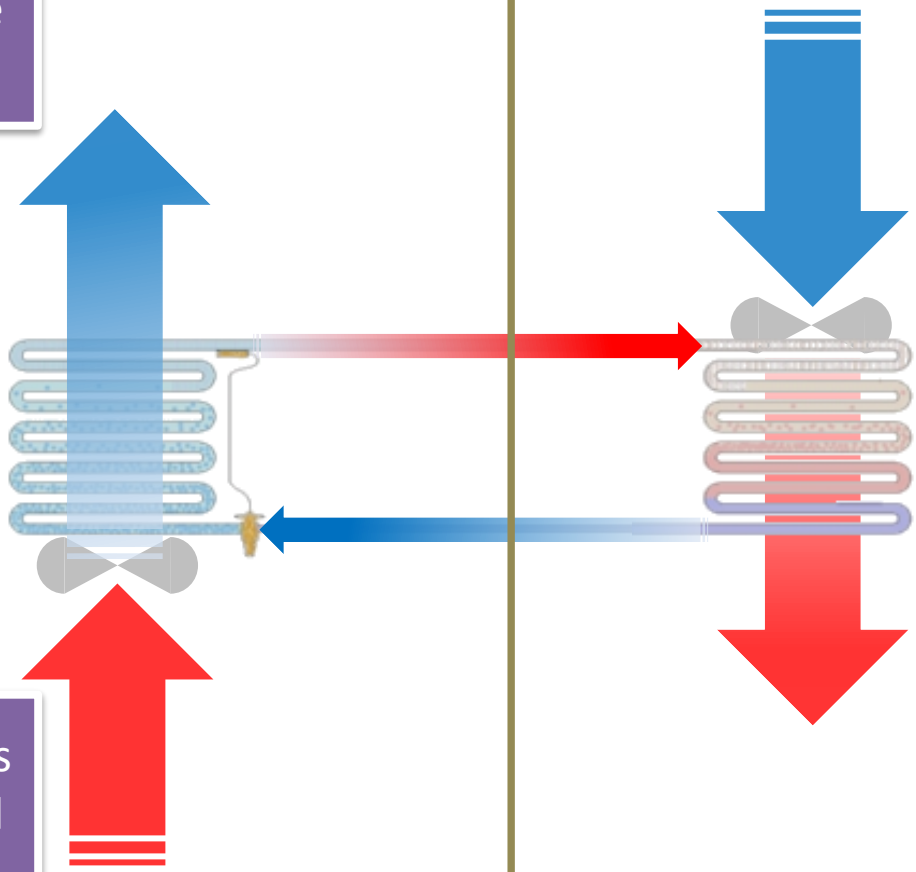
- Improper airflow.
- Incorrect refrigerant charge.

Study Author	State	Existing or New Home?	Sample Size	Average Airflow	Airflow <350 cfm	Airflow w/in 10% of 400/ton	Energy Savings Potential	Notes
Blasnik et al. 1995a	NV							
Blasnik et al. 1995b	CA							
Blasnik et al. 1996	AZ							
Hammarlund et al. 1992	CA							
Hammarlund et al. 1992	CA							
Neme et al. 1997	MD							
Palani et al. 1992	n.a.							
Parker et al. 1997	FL							
Proctor & Pernick 1992	CA							
Proctor 1991	CA							
Proctor et al. 1995a	CA							
Rodriguez et al. 1995	n.a.							
Rodriguez et al. 1995	n.a.							
VEIC/PEG 1997	NJ							
Average								

Study Author	State	Existing or New Homes?	Sample Size	Charge correct to mfg spec	% over charge	% under charge	Energy Savings Potential	Notes
Blasnik et al. 1995a	NV	New	30	35%	5%	59%	17%	Est @ 67% combined charge/air flow correction benefits
Blasnik et al. 1995b	CA	New	10				8%	Est @ 67% combined charge/air flow correction benefits
Blasnik et al. 1996	AZ	New	22	18%	4%	78%	21%	Est @ 67% combined charge/air flow correction benefits
Farzad & O'Neal 1993	n.a.	n.a.	n.a.				5%	Lab test of TXV; 8% loss @20% overchg; 2% loss @20% underchg
Farzad & O'Neal 1993	n.a.	n.a.	n.a.				17%	Lab test of Orifice; 13% loss @20% overchg; 21% loss @ 20% underchg
Hammarlund et al. 1992	CA	New	12				12%	Single family results
Hammarlund et al. 1992	CA	New	66	31%	61%	8%	12%	Multi-family results
Katz 1997	NC/SC	New	22	14%	64%	23%		Charge measured in 22 systems in 13 homes
Proctor & Pernick 1992	CA	Existing	175	44%	33%	23%		Results from PG&E Model Energy Communities Program
Proctor 1991	CA	Existing	15	44%				Fresno homes
Proctor et al. 1995a	CA	Existing	30	11%	33%	56%		
Proctor et al. 1997a	NJ	New	52				13%	Est @ 67% combined charge/air flow correction benefits
Rodriguez et al. 1995	n.a.	n.a.	n.a.				6%	Lab test of TXV EER; 6% loss at both 20% overchg & 20% underchg
Rodriguez et al. 1995	n.a.	n.a.	n.a.				15%	Lab test of Orifice EER; 7% loss @20% overchg, 22% loss @ 20% underchg
Average				28%	33%	41%	12%	

Installation defects in HVAC systems are commonplace

1. Warm indoor air is blown over a cold refrigerant coil.
2. The air's heat is transferred to the refrigerant.
3. Outdoor air is blown over the hot refrigerant coil.
4. The refrigerant's heat is transferred to the outdoor air.



Installation defects in HVAC systems are commonplace

- Airflow is impacted by the installation:
  - Fan-speed setting
  - Components attached to the system (like the filter)
  - Duct system installed
- Refrigerant charge is impacted by the installation:
  - Length of refrigerant line
  - Change in height between indoor and outdoor sections

Lessons learned from the ENERGY STAR Certified Homes program

+ This is an area that deserves a lot of attention.
+ Our partners all benefit from understanding and communicating about this.
+ Requirements that can easily be verified by Raters results in improvement.
- The industry, as a whole, doesn't deliver proper design and installation by default yet.
- Lack of uniform, practical, standards led to inconsistencies between contractors and raters.
- Workflow challenges trumped technical challenges.
- No credit in the HERS/ERI index was a significant obstacle.

Where Do We Go From Here?

- ACCA initiated a proposal that RESNET include an evaluation of HVAC design and installation in the HERS index.
- In Summer 2016, EPA started leading a working group to draft a standard that will accomplish this.
- The working group encompasses a diverse set of stakeholders interested in solving this problem:

Jim Bergman, Measure Quick	Laurel Elam, RESNET	Brian Mount, Tempo Air
Tommy Blair, AE	Philip Fairey, FSEC	Dave Roberts, NREL
Michael Brown, ICF	Dean Gamble, EPA	Dennis Stroer, CalcsPlus
Greg Cobb, Inglenook Financial	Dan Granback, EI	Iain Walker, LBNL
Wes Davis, ACCA	James Jackson, Emerson	Dan Wildenhaus, TRC
Brett Dillon, IBS Advisors	Rob Minnick, Minnick's Inc.	Jon Winkler, NREL

Guiding Principles

- Take a ‘carrot’ rather than a ‘stick’ approach.
- Reward incremental improvement by HVAC professionals and Raters.
- Rely upon procedures that:
  - Can be performed by both HVAC professionals and Raters.
  - Favor consistency over breadth.
  - Provide value in and of themselves.

Grading Concept

- Follow the insulation quality-installation model:
  - Grade III: The default. No QI is done. No penalty and no credit.
  - Grade II: Rater reviews key design parameters for accuracy and takes accurate measurements of key installation parameters. The resulting values indicate that the system is not great, but not terrible.
  - Grade I: Rater duplicates the tasks in Grade II, but the resulting values indicate that the system is pretty top-notch.

Where Are We Now?

Status Update

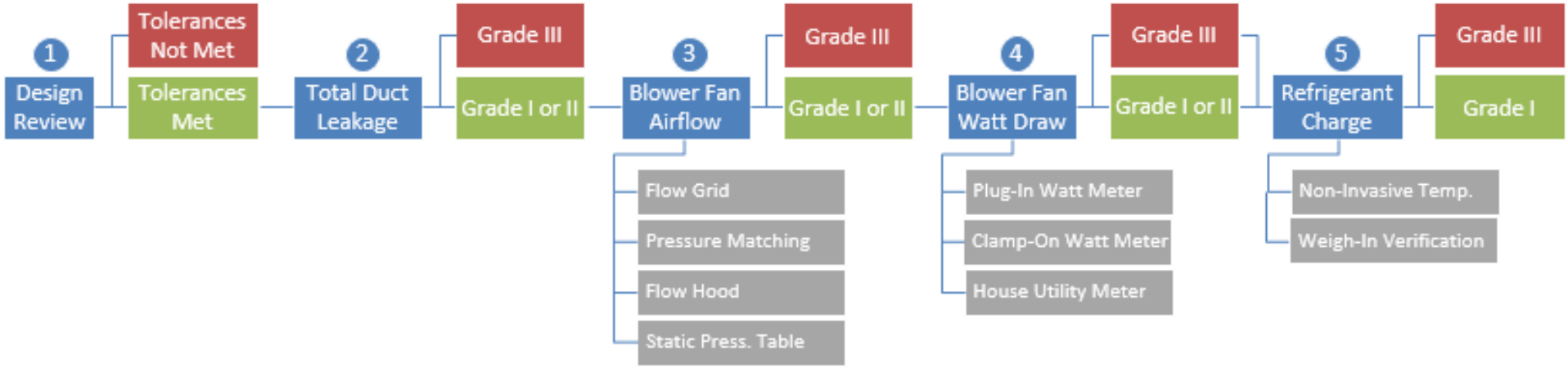
- Two major parts:
  - Standard 310: Standard for Grading the Installation of HVAC Systems
    - Brand new standard.
    - Covers all the things that the Rater will do.
  - Standard 301: Standard for the Calculation and Labeling..
    - Updated so that Standard 310 impacts the HERS index.

Status Update

- This week, we've reached a major milestone – a final draft will be sent from the task group to RESNET for formal review.
- Once RESNET and ACCA sign off, the standard will proceed to public comment.
- Once we address public comments, the standard will become final. Then:
  - An implementation date will be set.
  - Raters will be trained.
  - Software will be updated.

Overview of Standard 310

Std. 310: Standard for Grading the Installation of HVAC Systems



Key Terms in the Standard

- HVAC System – Cooling-only, heating-only, or combined cooling-heating equipment, including any supply and/or return distribution systems.
- Forced-Air HVAC System – A type of HVAC System that incorporates a Blower Fan to move conditioned air.
- Blower Fan – The fan inside the equipment of a Forced-Air HVAC System that forces the heated and/or cooled air to be distributed within the Dwelling or Dwelling Unit.

Std. 310: Evaluating the Design of the Forced-Air System

- ENERGY STAR Partners are already doing this!
- Step 1: Collect design information for the dwelling with the forced-air HVAC system under test.
  - Similar data to what's in the ENERGY STAR HVAC Design Report, though slightly expanded.
- Step 2: Rater reviews design information to verify all required information is documented.
- Step 3: Rater reviews key features to compare design information to the home to be rated.
  - Similar to ENERGY STAR Rater Design Review Checklist
  - Key features include design temperatures, conditioned floor area, window area and SHGC, etc.

Std. 310: Evaluating the Total Duct Leakage

- ENERGY STAR Partners are already doing this!
- Rater measures total duct leakage according to Std. 380, evaluates the results, and assigns a grade:

Grade	Test Stage	# Returns	Total Leakage Limit
I	Rough-In	< 3	4 CFM/100 sqft or 40 CFM
	Rough-In	≥ 3	6 CFM/100 sqft or 60 CFM
	Final	< 3	8 CFM/100 sqft or 80 CFM
	Final	≥ 3	12 CFM/100 sqft or 120 CFM
II	Rough-In	< 3	6 CFM/100 sqft or 60 CFM
	Rough-In	≥ 3	8 CFM/100 sqft or 80 CFM
	Final	< 3	10 CFM/100 sqft or 100 CFM
	Final	≥ 3	14 CFM/100 sqft or 140 CFM
III	N/A	N/A	No Limit

- Then, in the procedure to evaluate Blower Fan airflow:
  - Any test procedure can be used if Grade I duct leakage is achieved.
  - A subset of procedures can be used if Grade II duct leakage is achieved.
  - Airflow testing not permitted if Grade III duct leakage is achieved.

Std. 310: Evaluating the Blower Fan Volumetric Airflow

1. Pressure Matching
2. Flow Grid
3. Flow Hood
4. OEM Static Pressure Table

Std. 310: Evaluating the Blower Fan Volumetric Airflow

#1. Pressure Matching

1. Measure static pressure created in supply plenum during operation of HVAC system.
2. Turn off HVAC system, connect a fan-flowmeter at the return or at the blower fan compartment.
3. Turn on the HVAC system and the flowmeter fan and adjust to achieve same static pressure in supply plenum.
4. Determine HVAC airflow by recording airflow of flowmeter fan.

Std. 310: Evaluating the Blower Fan Volumetric Airflow

#1. Pressure Matching

Pros	Cons
Accurate: +/- 3%	Can't reach high flows for big systems: needs extrapolation
Uses equipment many Raters already own	Need at least one large return duct with low airflow resistance or connect at equipment
	Requires hole in supply plenum

Std. 310: Evaluating the Blower Fan Volumetric Airflow

#2. Flow Grid

1. Measure static pressure created in supply plenum during operation of HVAC system.
2. Install calibrated flow grid in filter slot.
3. Measure pressure difference using flow grid. Correct pressure using value measure in Step 1.
4. Determine HVAC airflow by converting corrected pressure to airflow.

Std. 310: Evaluating the Blower Fan Volumetric Airflow

#2. Flow Grid

Pros	Cons
Easy/simple for many systems	Multiple filters in single system are hard to deal with
Can work at higher flows	Need to make sure a good seal is achieved around the plate perimeter
	Slightly less accurate +/- 7%
	Requires hole in supply plenum

Std. 310: Evaluating the Blower Fan Volumetric Airflow

#3. Flow Hood

1. Turn on HVAC system.
2. Connect flow hood to return grille.
3. Turn on flow hood and allow reading to stabilize.
4. Resulting airflow of flow hood determines HVAC airflow.

- May require additional step to account for back-pressure.
- For example, some manufacturers require you to test twice – once with a flap open and again with a flap closed.
- While other manufacturers do this correction automatically without user intervention.

Std. 310: Evaluating the Blower Fan Volumetric Airflow

#3. Flow Hood

Pros	Cons
Accurate: +/- 3%	Can be heavy/unwieldy
Easy to use	Can be sensitive to placement
Does not require hole in supply plenum	Can be expensive
	Will not always fit around air inlet

Std. 310: Evaluating the Blower Fan Volumetric Airflow

#4. OEM Static Pressure Table

1. Turn on HVAC system.
2. Measure external static pressure of system's supply side and return side.
3. Determine fan-speed setting through visual inspection.
4. Using blower table information, look up total external static pressure and fan-speed setting to determine airflow.

Motor Speed	Tons AC[1]	External Static Pressure, (Inches Water Column)												
		0.1		0.2		0.3		0.4		0.5		0.6	0.7	0.8
		CFM	Rise	CFM	Rise	CFM	Rise	CFM	Rise	CFM	Rise	CFM	CFM	CFM
High	3	1,498	N/A	1,446	N/A	1,368	N/A	1,302	N/A	1,227	N/A	1,145	1,059	954
Med	2.5	1,223	N/A	1,182	N/A	1,153	30	1,099	31	1,051	32	982	901	813
Med-Lo	2	983	35	971	35	945	36	919	37	878	39	813	746	659
Low	1.5	816	42	794	43	758	45	734	46	678	50	637	597	523

Std. 310: Evaluating the Blower Fan Volumetric Airflow

#4. OEM Static Pressure Table

Pros	Cons
Inexpensive equipment	Rater required to get OEM Blower Table for installed equipment
Works for systems of all sizes and airflows	Needs carefully-placed hole in supply-side and return-side, sometimes in equipment housing

Std. 310: Evaluating the Blower Fan Watt Draw

1. Plug-In Watt Meter: Direct Measurement
2. Clamp-On Watt Meter: Direct Measurement
3. Utility Meter: Indirect Measurement

Std. 310: Evaluating the Blower Fan Watt Draw

#1. Plug-In Watt Meter: Direct Measurement

1. Plug in the watt meter and blower fan equipment into standard electrical receptacle.
2. Turn on equipment in required mode.
3. Record reading from portable watt meter.

Std. 310: Evaluating the Blower Fan Watt Draw

#1. Plug-In Watt Meter: Direct Measurement

Pros	Cons
Simple	Not usable with hard-wired equipment
Direct measurement of equipment (accurate)	

Std. 310: Evaluating the Blower Fan Watt Draw

#2. Clamp-On Watt Meter: Direct Measurement

1. Turn on equipment in required mode.
2. Connect clamp-on watt meter to measure voltage and current at either the service disconnect or through a service panel (not at breaker panel).
3. Record reading from clamp-on watt meter.

Std. 310: Evaluating the Blower Fan Watt Draw

#2. Clamp-On Watt Meter: Direct Measurement

Pros	Cons
Useable with hardwired equipment that has service panel or service disconnect	Requires proper training and safety equipment
Direct measurement of equipment (accurate)	

Std. 310: Evaluating the Blower Fan Watt Draw

#3. Utility Meter: Indirect Measurement

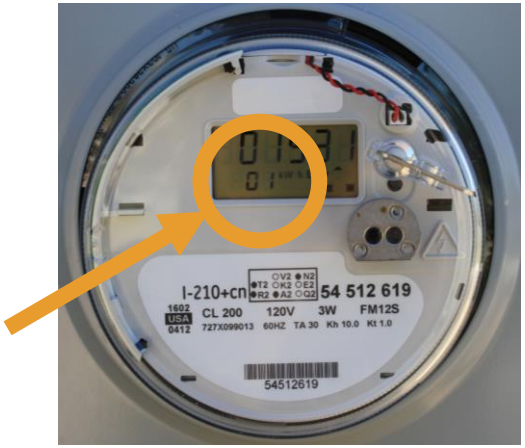
1. Turn off all circuits except air handler's.
2. Turn on equipment in required mode.

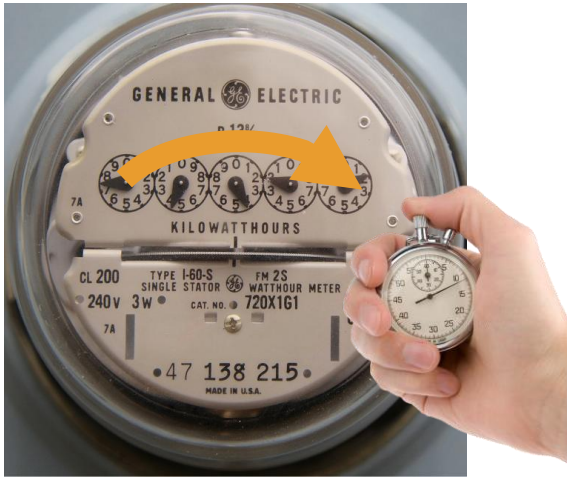
<u>For a digital utility meter:</u>

3. Record watt draw from utility meter.

<u>For an analog utility meter:</u>

3. For 90+ seconds, record the number of meter revolutions and time.
4. Calculate watt draw.





Std. 310: Evaluating the Blower Fan Watt Draw

#3. Utility Meter: Indirect Measurement

Pros	Cons
Works with all equipment	More steps required (turning off all other circuits)
No new equipment needed	

Std. 310: Evaluating the Refrigerant Charge

1. Non-Invasive Test
2. Weigh-In Verification (only used for select equipment and conditions)

Std. 310: Evaluating the Refrigerant Charge

#1. Non-Invasive Test

1. Determine key equipment characteristics.
2. Measure outdoor air and return air temperatures.
3. Calculate target refrigerant line temperatures.
4. Measure refrigerant line temperature.
5. Compare.

Std. 310: Evaluating the Refrigerant Charge

#1. Non-Invasive Test

Pros	Cons
No refrigerant handling certification needed	New procedure to learn
No risk of refrigerant contamination and leaks	Minimum outdoor air temperature required
Less Rater liability	

Std. 310: Evaluating the Refrigerant Charge

#2. Weigh-In Verification

1. Contractor provides:
    1. Weight of refrigerant added / removed
    2. Line length and diameter
    3. Default line length from factory charge (usually 15 feet)
    4. Factory supplied charge
    5. Geotagged photo of scale with weight added / removed
2. Rater then:
    1. Measures line length and diameter
    2. Uses lookup table to determine how much refrigerant should have been added / removed
3. Rater verifies the following:
    1. Deviation between lookup and contractor value within tolerance
    2. Location of geotagged photo matches “in the judgment of the party conducting the evaluation” the location of the equipment

Std. 310: Evaluating the Refrigerant Charge

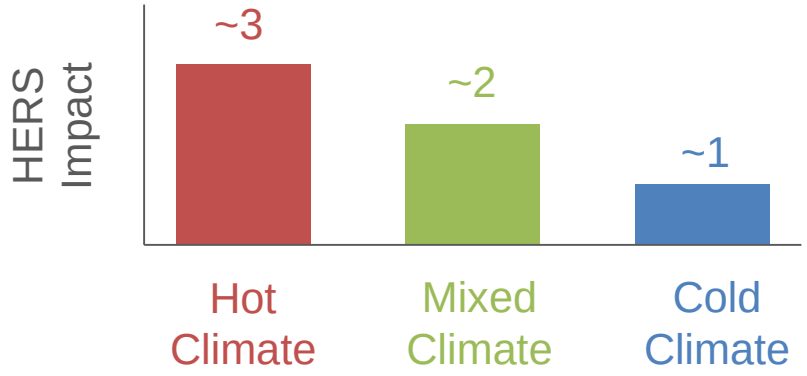
#2. Weigh-In Verification

Pros	Cons
No refrigerant handling certification needed	Requires information from contractor
Works at any outdoor temperature	Not a true performance test

Potential HERS Points

Potential HERS Impact Summary

- For homes where the HVAC design and installation is not assessed, score should be about the same as today.
- For homes where the HVAC design and installation is assessed, impact will be dependent on climate, how efficient the home is, and how well the system is designed and installed.
- Our goal and prediction is to have the following rough impacts for an ENERGY STAR home:



Summary

Summary

- Standard 310 will be a new standard for evaluating the design and installation quality of HVAC systems.
- It should be available for use towards the end of 2019.
- If you're doing ENERGY STAR today, this new standard will look very familiar to you. The key difference will be the field tests.
- This should allow ENERGY STAR builders to get more HERS points for things that they're already doing today.
- This will be a major step towards unifying the ENERGY STAR program and HERS ratings.

Questions?

ENERGY STAR Certified Homes

Web:

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