



Avoiding Pitfalls of Air Conditioner Tuneups and Replacements



Residential Energy Efficiency Technical Update
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Gaps & Barriers

- Space Conditioning STC
 - Inability to assess and improve performance of existing heating and cooling equipment to cost effectively achieve BA multi-year energy savings goals
 - Installations resulting in excessive fan energy that hinder performance
 - Lack of use and (in some cases) applicability of design and installation standards
- Test Methods STC
 - Standardized RMS or other error analysis techniques
 - Methods for analyzing the uncertainty of indirect measurement methods
 - Accuracy of field test equipment and methods of test used for refrigerant charge and airflow may not be sufficient to deliver savings from HVAC replacements and maintenance

- **Focus:** Airflow and Refrigerant Charge
- **Retrofit Opportunities**
 - Potential cooling energy savings from tune-ups and replacement are significant (30-50% based on lab testing)
 - Head off emergency replacements
 - Replacements and tune-ups have non-energy benefits
- **Problem:** Actual savings from a California HVAC maintenance program averaged 11% of expected savings - likely a nationwide problem



Pressing Questions for Retrofit Programs

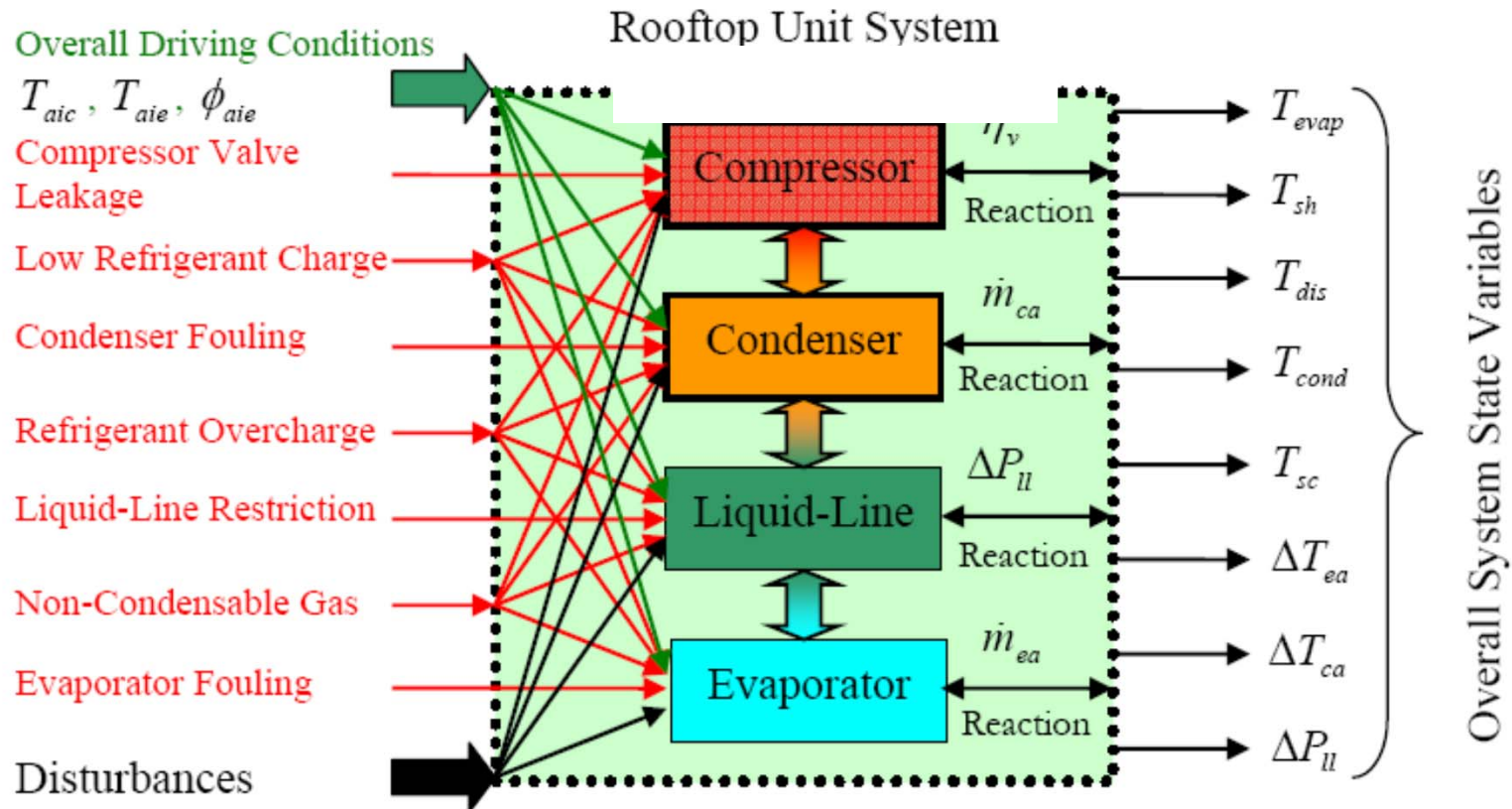
- How does one quickly determine when an HVAC system requires service?
- How does one decide when to replace instead of just service?
- In what sequence should testing and maintenance be performed?
- What are the key things to consider when testing airflow and refrigerant charge?
- How does measurement accuracy affect savings?



Why aren't savings materializing?

- Instrument inaccuracy
- Evacuation equipment condition
- Inadequate measurement, test & verification protocols
- Measurement error
- Human factors
- Interactive and compounding effects

What can go wrong?





When to service?

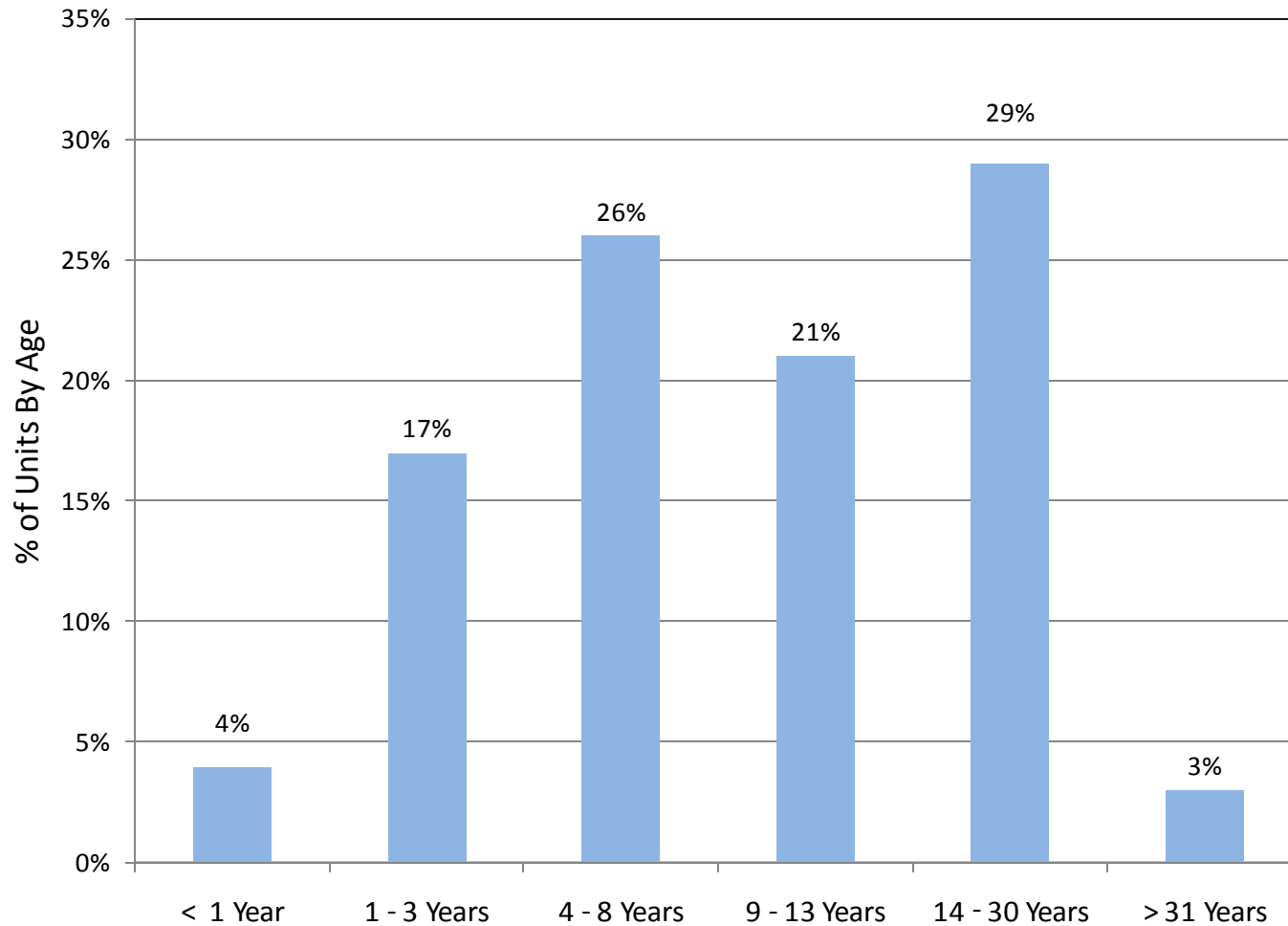
- System is inoperative or does not provide comfort
- Observations and tests show the potential for improved performance
 - Airflow and pressure
 - Refrigerant charge or temperature split
 - Visibly clogged outdoor coil
 - Noisy outdoor fan



When to replace?

- Service cannot restore function
- System is near the end of its useful life, is visibly damaged, or “high mileage”
- System uses CFC refrigerant (R-12 production was prohibited after 1996)
- Needed replacement parts are unavailable
- Significant downsizing required due to improvements in enclosure
- Replacement with high performance equipment can be economically justified

Age of Condensing Units in CA



Testing and Maintenance

- Test instruments must be accurate, calibrated, and suitable for the application
- Must fix airflow first!
- California Study (Proctor)
 - Maintenance improved efficiency by an average of 24%
 - 19-35% improvement from refrigerant replacement and correct charge
 - 29% were deemed to have contaminated refrigerant



How does reduced airflow affect performance?

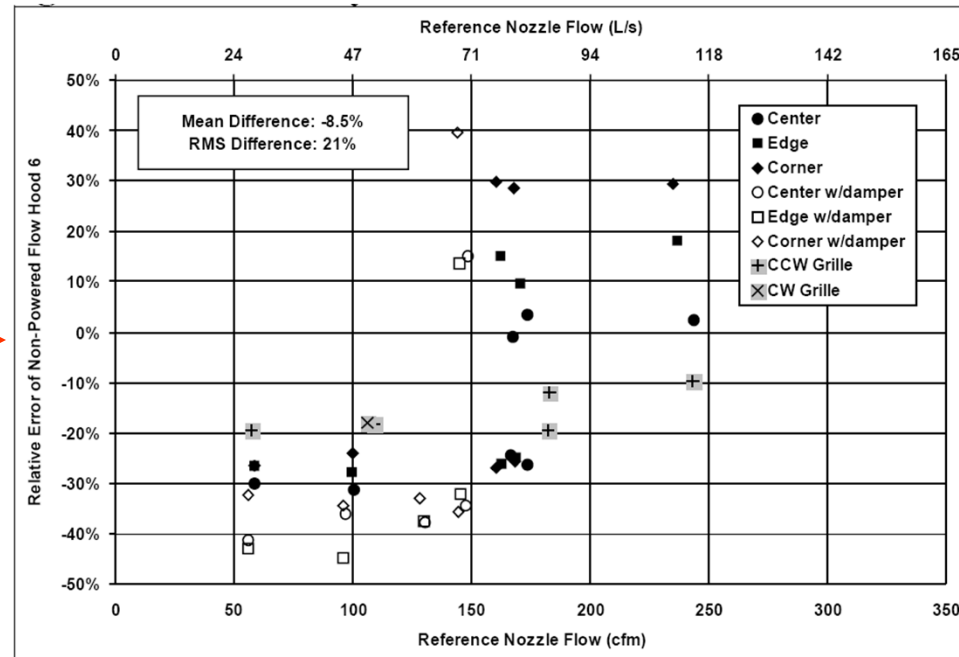
- Reduces condenser EER
- Increased fan energy (especially ECM's)
- Potential for coil freeze-up
- Reduced distribution and comfort

Reduction in Evaporator Airflow	Percent of Variation		
	Capacity (Btu/h)	Power (W)	EER (Btu/Wh)
25%	-7.51	-3.54	-4.2
50%	-14.71	-8.93	-6.51
75%	-44.71	-15.43	-34.63
90%	-76.11	-17.22	-71.14

Source: Palani, O'Neal and Haberl, 1992

Measuring system airflow

- What's the metric?
- Flow hood accuracy →
- Impact of duct leaks
- Impact of bypass dampers



Source: Wray, Walker, and Sherman (2002)

A better way →



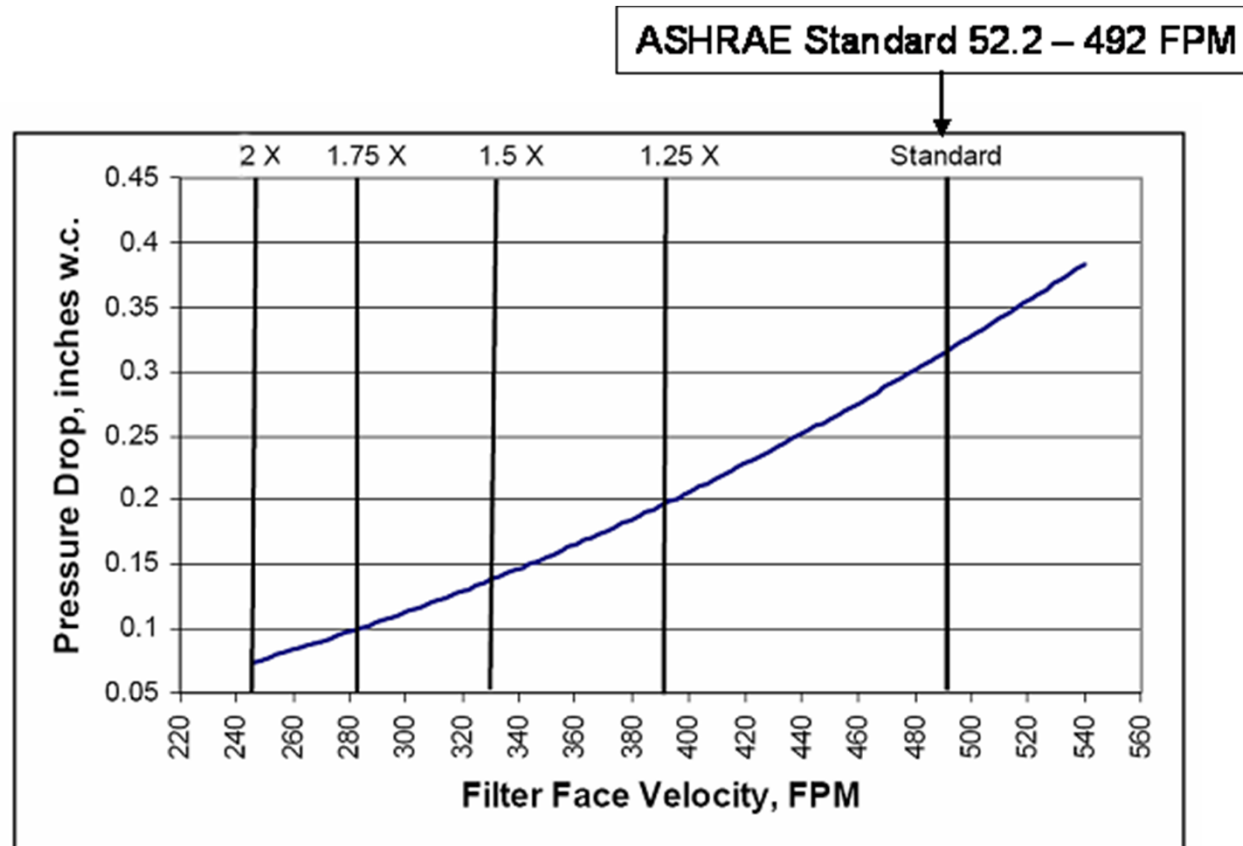
Low airflow can be caused by:

- Undersized filter
- Dirty filter
- Dirty coil
- Bypass damper
- Excessive supply duct pressures (sizing)
- Bad fan motor
- All of the above



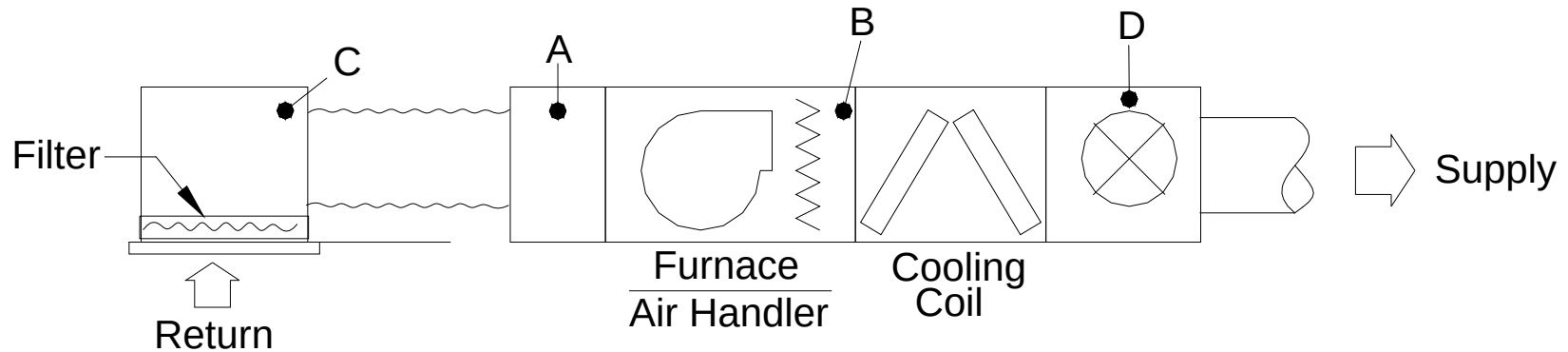
Outdoor units need air too!

Filters are a problem!



Best performing MERV 8 filter has 2.8 x the pressure drop of a typical fiberglass filter (CARB/DEG tests)

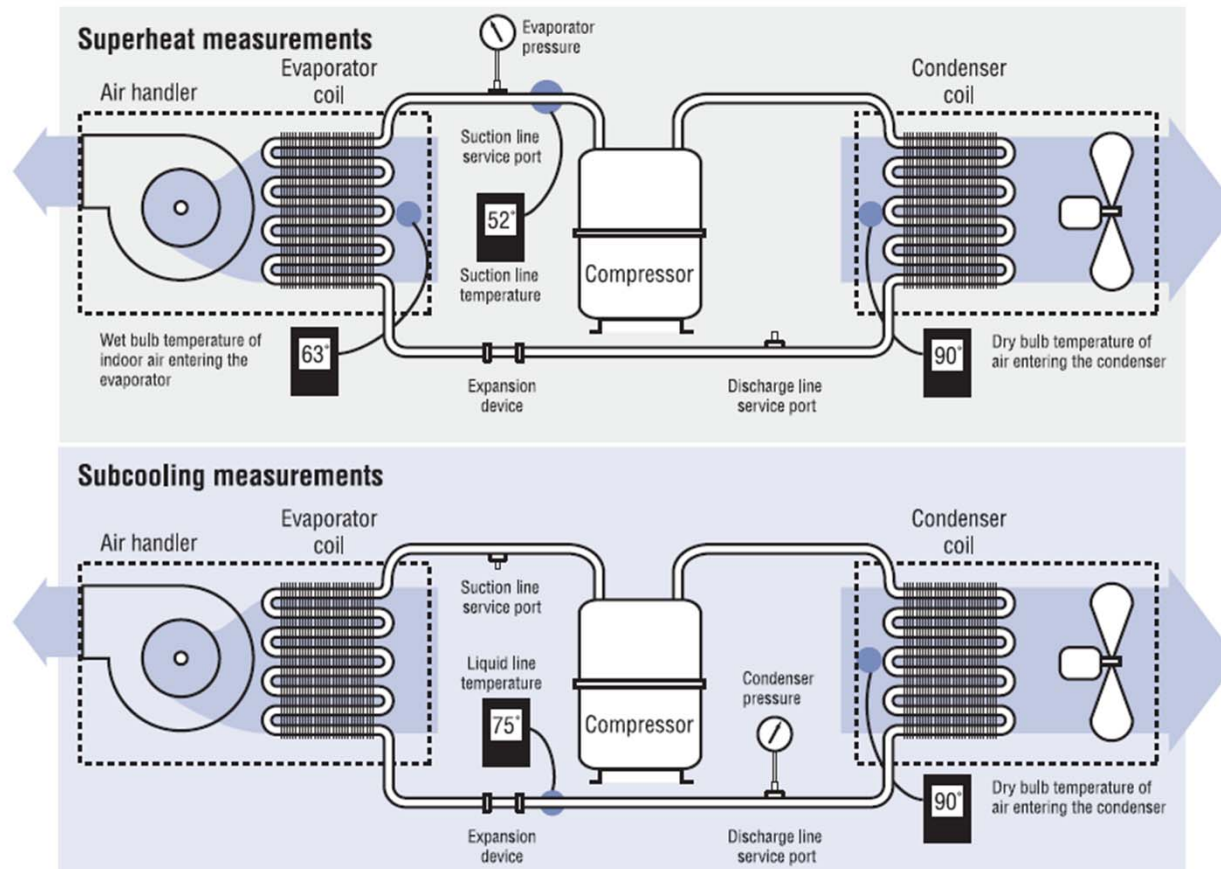
A simple diagnostic approach



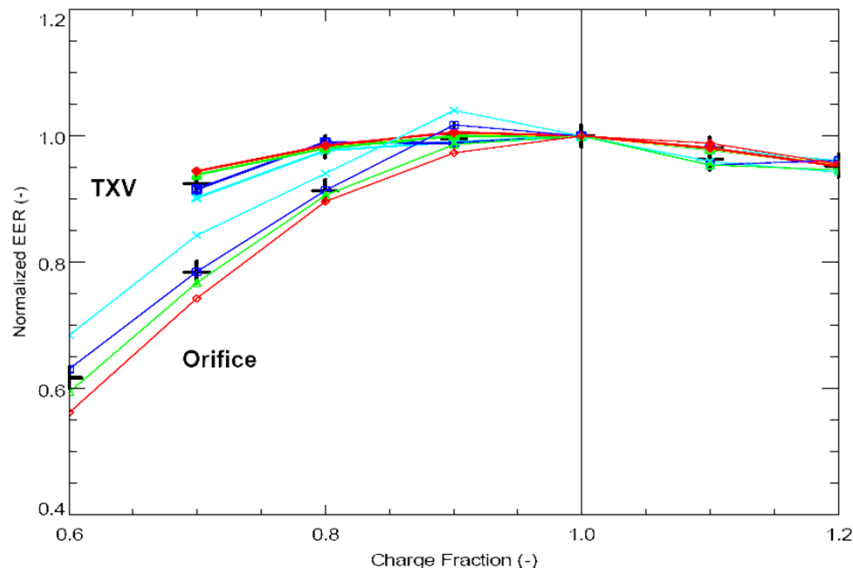
Return	Pressure Drop	Cummulative Pressure	Measurement Point
Return Grille	0.10		
Filter	0.05	-0.15	C
Return Duct	0.05	-0.20	A
Supply			
Supply Ducts	0.18	0.18	D
Cooling Coil	0.27	0.45	B
Total	0.65	0.65	A-B

Refrigerant charge

SUPERHEAT AND SUBCOOL METHODS

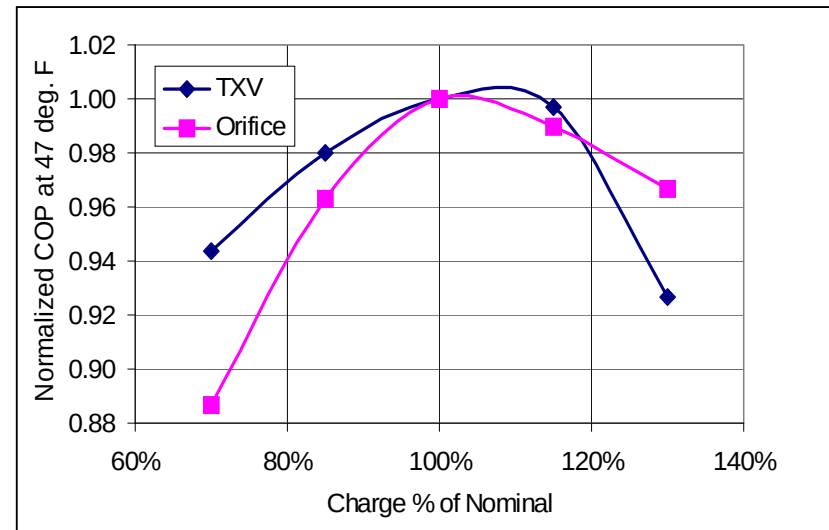


Importance of refrigerant charge



Split System Air Conditioner

Source: Sachs, 2009



Heat Pump

Source: Shen, 2011



Impact of non-compressible gases

- Produce a 27% decrease in performance per ounce of non-refrigerant gas (Mowris)
- Most technicians not evacuating below 500 microns because of improperly maintained vacuum pumps (< 250 microns recommended)



How significant is field measurement error?

- Title 24 specification:
 - $\pm 3\%$ for pressure measurement
 - $\pm 1.3^{\circ}\text{F}$ for temperature measurement
- Commonly used temperature devices
 - Type K: $\pm 2^{\circ}\text{F}$
 - Type T: $\pm 0.9^{\circ}\text{F}$
 - Typical clamp-on: $\pm 3.4^{\circ}\text{F}$
 - Some up to 18° off (per Robert Davis)

Measurement Uncertainty

- What matters:
 - Types of sensors (RTD vs. thermocouple)
 - Instrument calibration errors
 - Where and how measurements are taken

	Lab	Field	
	Herrick, Intertek, PG&E	2004 AEC RCA	Contractor Current
Superheat °F	+/- 0.33 to 1.02	+/- 1.68	+/- 3.54
Subcooling °F	+/- 0.36 to 1.09	+/- 2.83	+/- 4.21
	Lab	EM&V	
EER (Btuh/Wh)	+/- 0.2 to 2.17	+/- 0.95	
kWh/year		> +/- 20%	

Source: Hunt, 2010



Additional gaps & barriers

- How to insure quality of service and installation
- How to improve field measurement accuracy and practices
- Detection of “hidden” problems in existing systems
 - Dirty coil
 - Contaminated refrigerant



HVAC Maintenance Standards

- ANSI/ACCA Standard 4-2008: Maintenance of Residential HVAC Systems. Describes screening tasks that could be useful in maintenance programs.
- ANSI/ACCA Standard 5-2007: HVAC Quality Installation Specification. Covers installation of air conditioners and ducts.
- ANSI/ACCA Standard 9-2009: HVAC Quality Installation Verification Protocols. Sets forth verification procedures for Standard 5.



California HVAC Action Plan

- Create an industry recognized “quality” label (similar to Energy Star®) that can be used as proof of quality installation practices and high levels of HVAC technician competence.
- Increase customer demand for quality installations through a public education campaign that explains the consequences of a poor quality installation and encourages customers to ask for the quality label to ensure their system will perform and operate as advertised.
- Work with building officials to increase the level of code compliance (and quality installations) to create a new compliance tracking database designed to create a level playing field for HVAC contractors in the replacement market.
- Increase the number of trained technicians qualified to perform HVAC system installations that meet the Air Conditioning Contractors of America (ACCA) Quality Installation specifications and motivated to receive recognition for their verified quality work.
- Obtain a commitment from local governments, state agencies, utilities, and local building departments to devote more resources to educating customers, building energy inspections, and streamlining of the permitting process.
- Seek regulatory policy changes designed to encourage utilities to achieve larger scale market outcomes by estimating the energy savings achieved by the HVAC quality initiatives proposed here at the overall market level in addition to the program level.



References

- Hunt, M., K. Heinemeyer, M. Hoeschele. 2010. "HVAC Energy Efficiency Maintenance Study." Southern California Edison.
- Proctor, J., and T. Downey, 1999. "Transforming Routine Air Conditioner Maintenance Practices to Improve Equipment Efficiency and Performance." In Proceedings of the 1999 International Energy Program Evaluation Conference, Oregon, Wis.:1999 International Energy Program Evaluation Conference.
- Engage 360 – "CA Energy Efficiency Strategic Plan: HVAC Action Plan 2010 - 2012" www.engage360.com
- Wray, C., I. Walker, M. Sherman. 2002. 2002. "Accuracy of Flow Hoods in Residential Applications". American Council for An Energy Efficient Economy. 2002 Summer Study on Energy Efficiency.