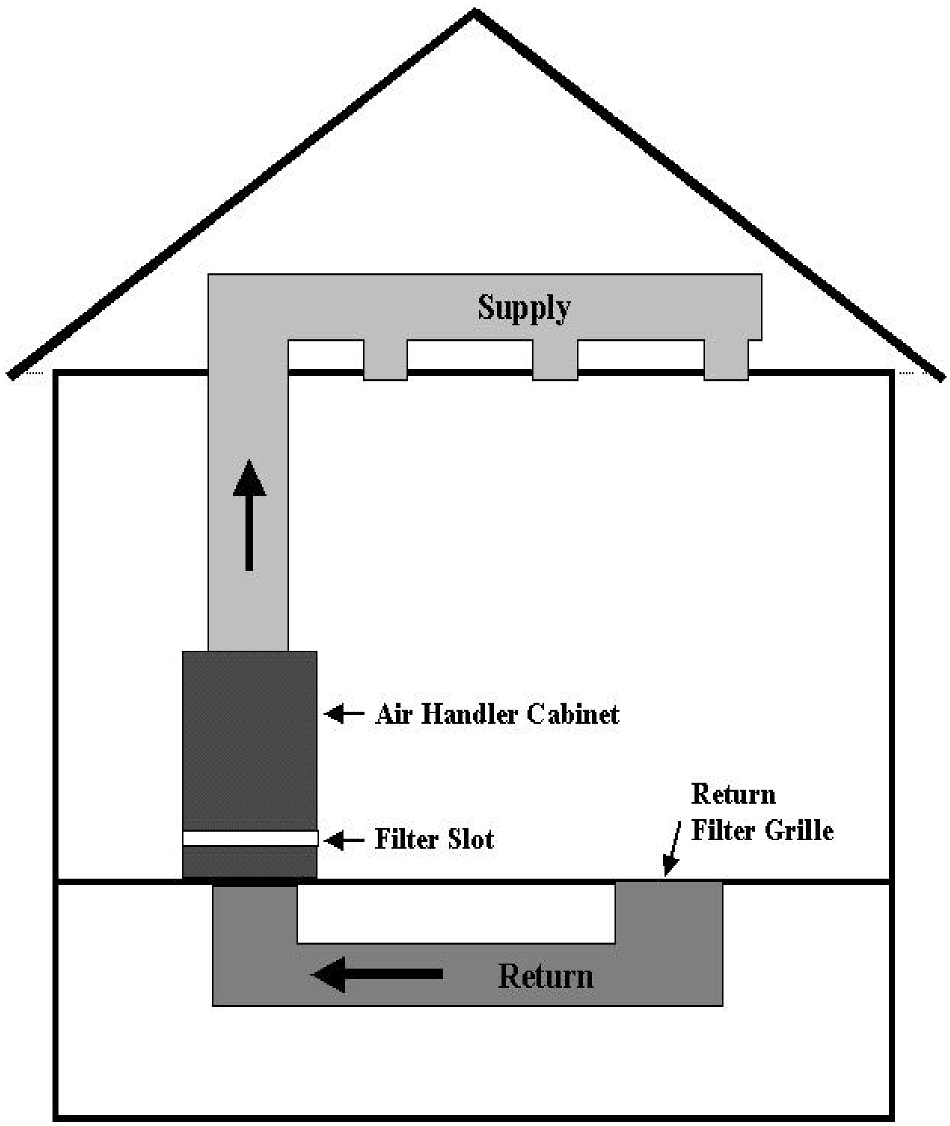
Measuring Total System Airflow in Residential HVAC Systems

Gary Nelson
Energy Conservatory
Minneapolis, MN

Excellence in Building 2001
Orlando, FL

Friday, Oct. 26, 2001, 8:30 am

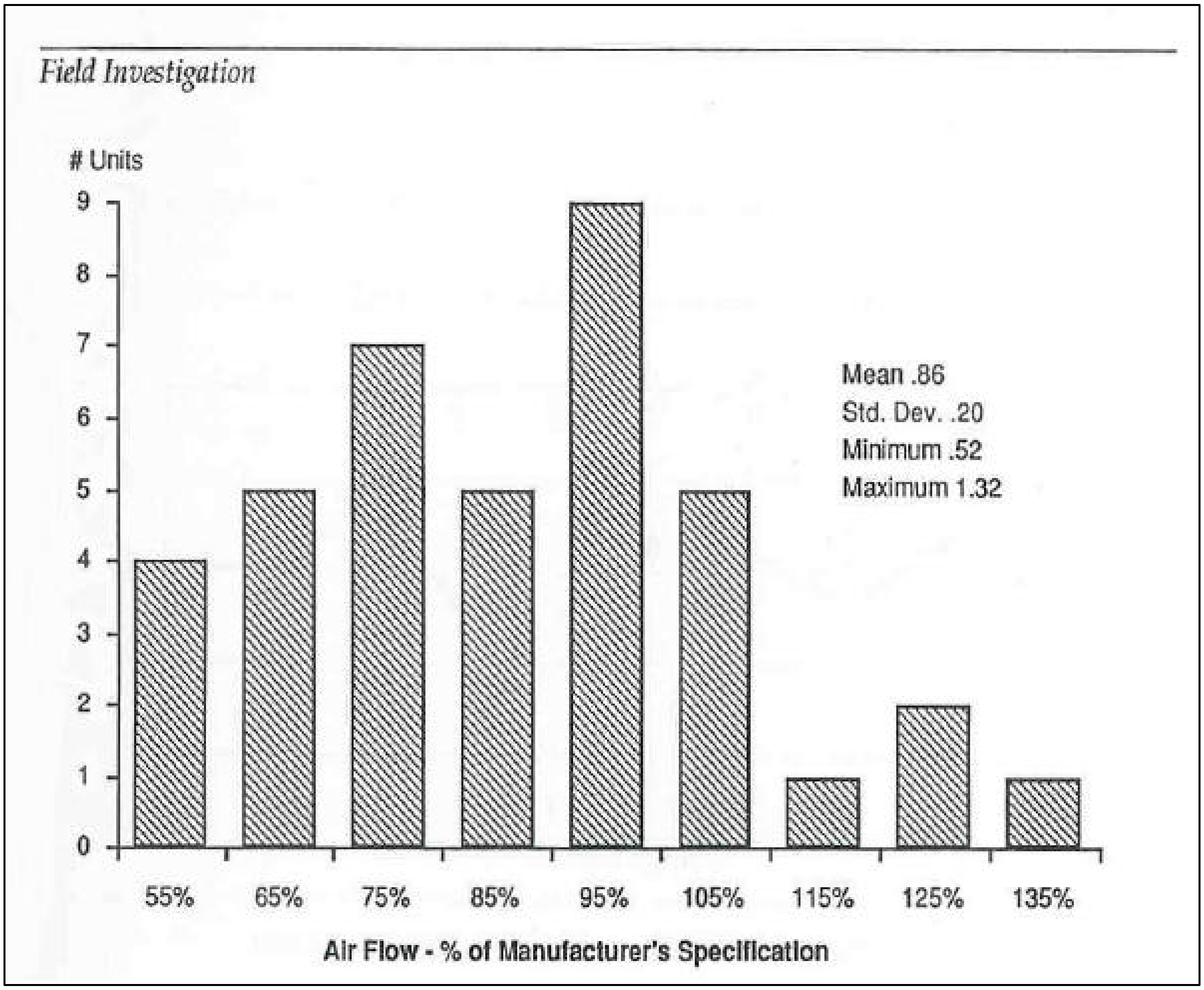

Supply
Air Handler Cabinet
Filter Slot
Return
Filter Grille
Return

Problems due to low airflow

- Low flow can seriously impact compressor performance in heat pumps and air conditioners (capacity, efficiency, durability)
- Low flow can cause furnaces to cycle on the limit switch (safety, efficiency)
- Low flow reduces throw of registers (comfort)
- Low flow, if caused by restricted ducts, may cause noise problems
- Low flow makes it impossible to check charge properly using most common method
- Duct efficiency goes down, especially with AC and heat pump

Problems due to high airflow

- High flow can cause poor moisture removal
- Noise
- High fan electrical consumption
- Comfort (drafts, cold blow)
- Impossible to check charge using common methods



From Proctor Engineering study of

New Homes for Nevada Power (1995)

Causes of improper airflow

- Duct design (size, transitions)
- Occupants closing dampers, blocking registers
- Fan selection and speed
- Filters (dirty, too much resistance, too small; maximum recommended velocity at filter grilles is only 300 FPM)
- Dirty coils and fans

Airflow measurement techniques

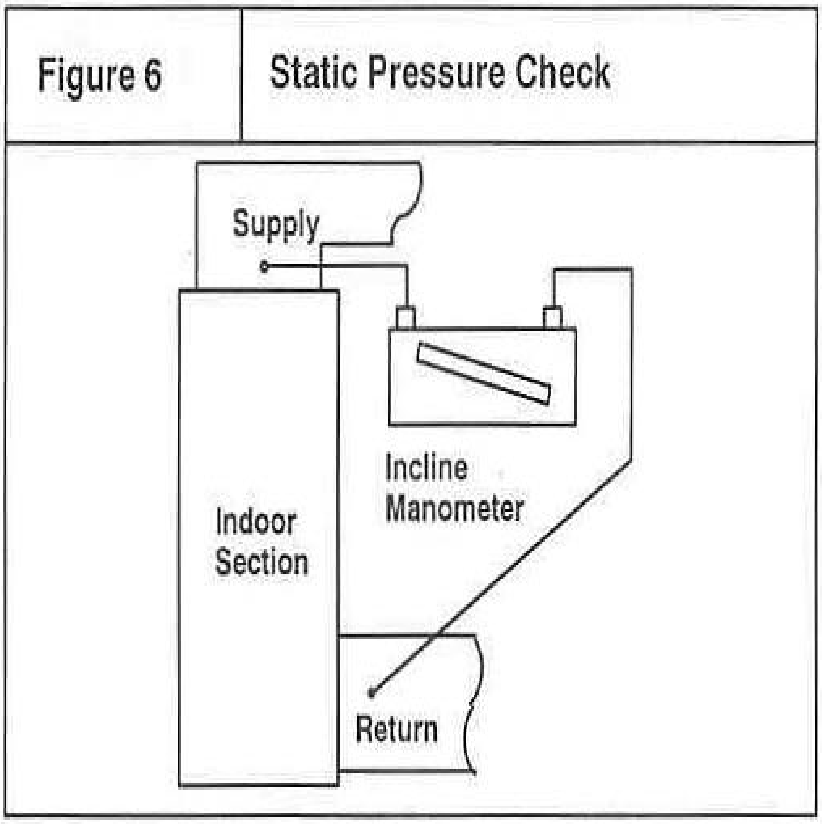
- Using manufacturer's fan curve
- Temperature rise method
- Flow capture hoods
- Duct Blaster®
- Pitot tubes
- True Flow®

- Note: all these methods need adjustments at altitudes above about 1500 feet that are not considered in this talk, but are not complicated

Using manufacturer’s fan curve

- Measure total operating static pressure
- Check what speed motor is running on
- Use manufacturer’s data to estimate flow

Example air handler fan curve



MB08	SP IN. WG.							
SPEED	VOLTS	0.1	0.2	0.3	0.4	0.5	0.6	0.7
LOW	115V	572	591	603	599	590	595	594
MED	115V	727	755	765	779	760	723	721
HIGH	115V	976	1011	1026	1018	983	915	822

Using manufacturer's fan curve - problems

- Fan curve depends on duct configuration, especially on return side, but curve was determined from only one configuration. This could cause large errors, but I haven't been able to find studies.
- Dirty fan or coil can change fan curve.
- Exactly where and how pressures are measured can change measured static pressures.
- Need to know fan speed.

Temperature rise method

- Measure supply and return air temperatures
- Measure output of furnace in Btu/hour (gas or electric furnace)

- CFM = output/1.08X(temp rise)

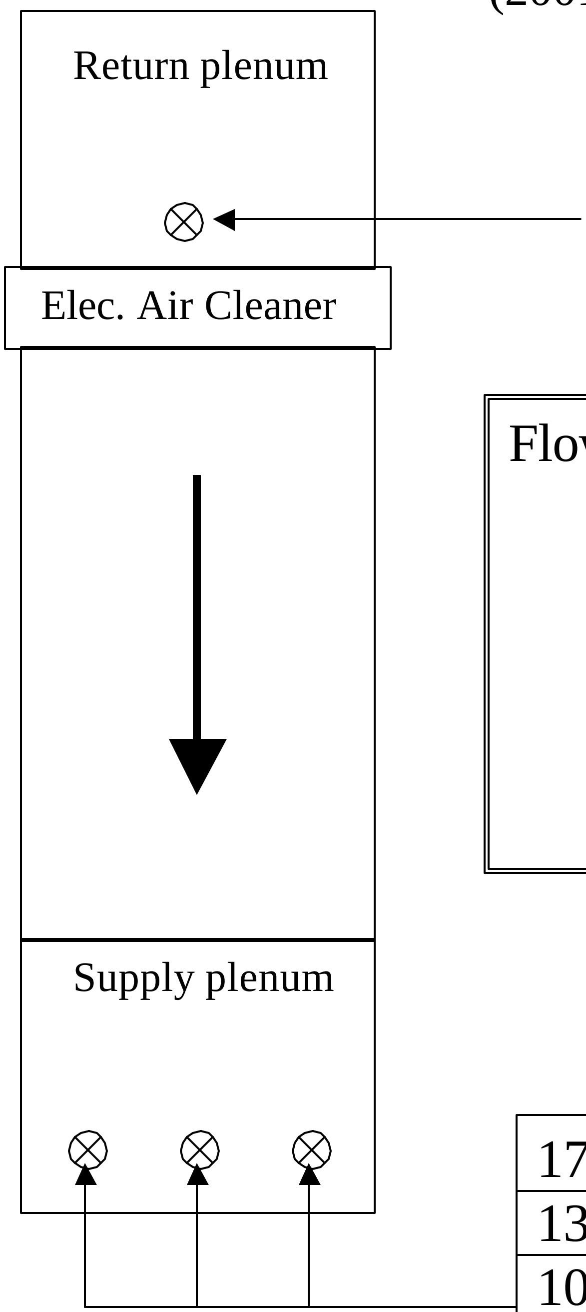
Temperature rise method - problems

- Temperatures are often very non-uniform; averaging multiple measurements doesn’t help much, if at all (although if temperatures are uniform, you will know it and accuracy should be very good)
- Can be difficult and time consuming to measure furnace output
- No way to measure AC or heat pump output

Example - temperature rise method

21.8 kW Furnace

From Paul Francisco of Ecotope's presentation at Affordable Comfort (2001)



64.0 F

Flow?	727 cfm (average Ts)
	544 cfm (center Ts)
	437 cfm (max Ts)
	1681 cfm (min Ts)
	634 cfm (Duct Blaster)
	656 cfm (True Flow)

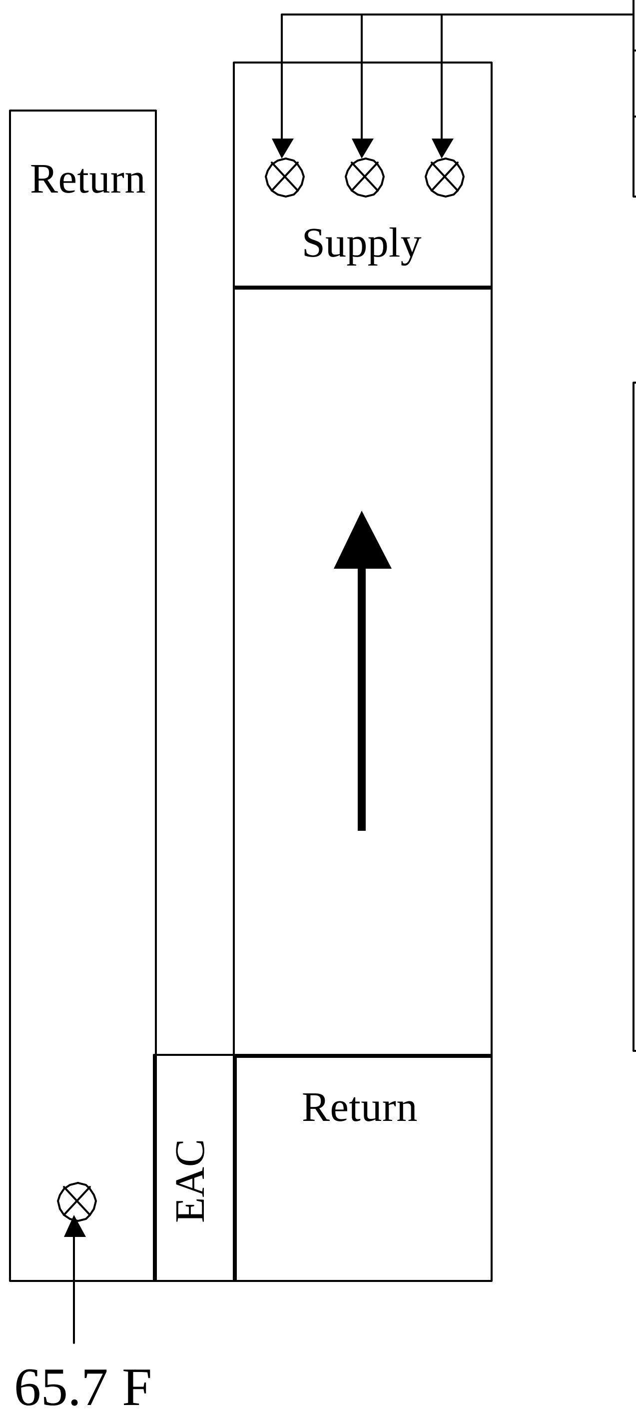
176.7	208.5	147.0
134.9	180.2	149.9
101.6	135.3	124.0

Average: 150.9 F

Example 2- temperature rise method

From Paul Francisco of Ecotope's presentation at Affordable Comfort (2001)

3.5 Ton Heat Pump



87.8	87.3	88.1
87.8	87.7	87.5
87.6	87.5	86.7

Average: 87.6 F

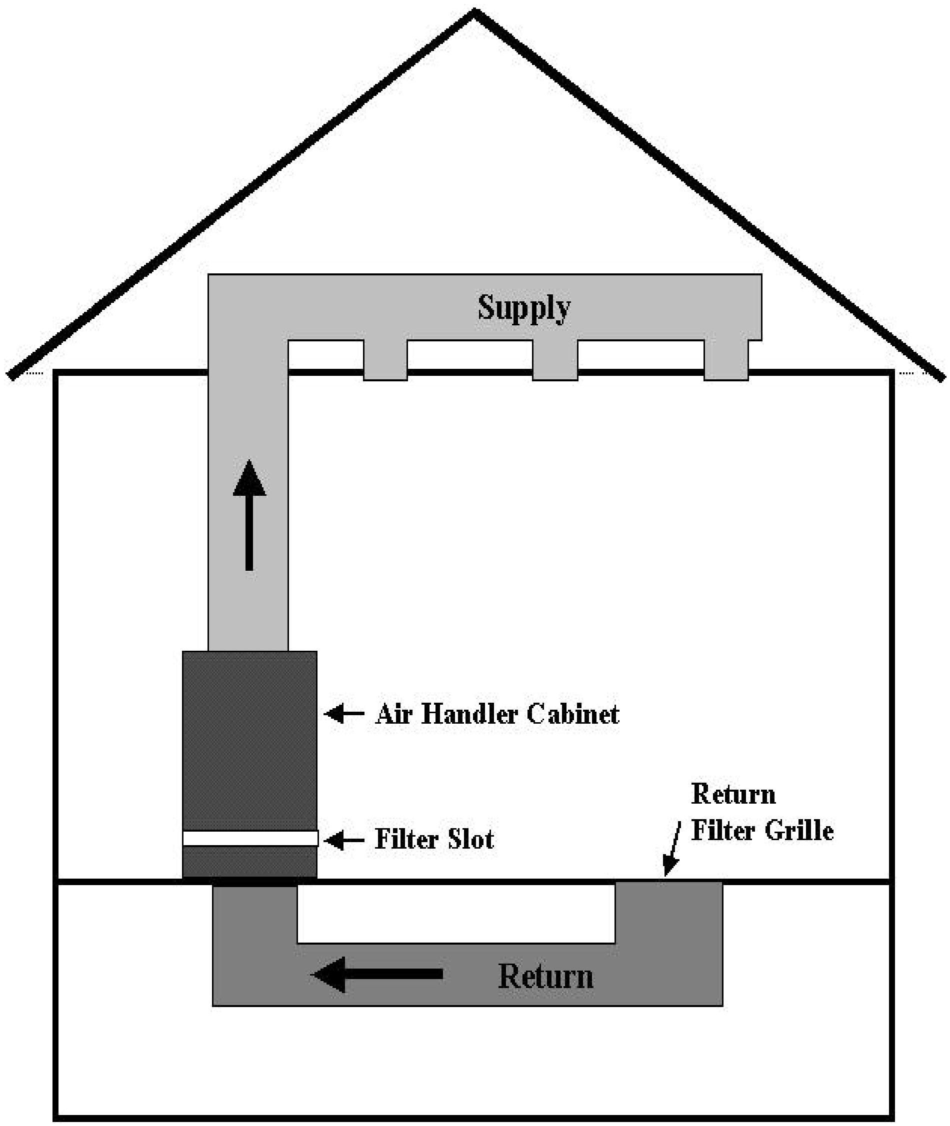
Flow?
Depends on actual compressor efficiency

If assume COP=2 and measure 3.9 kW, then flow = 1126 cfm (ok?)

flow = 956cfm (Duct Blaster)
flow = 973cfm (True Flow)

Flow capture hood method

- If there are no return leaks, flow going into returns are measured with a hood and are equal to flow going through air handler (and across coil).
- If there are no supply leaks, flow coming out of supplies are measured with a hood and are equal to flow through air handler and coil.

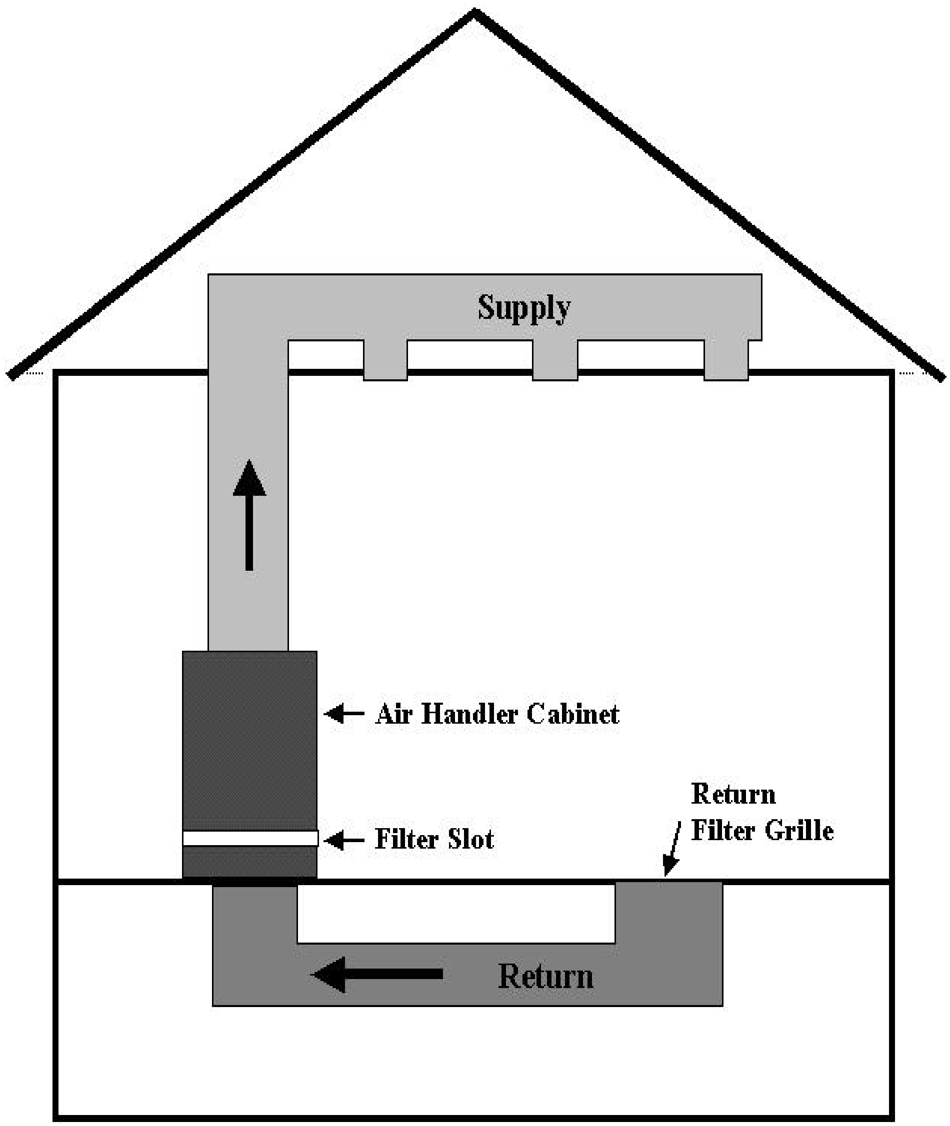

Supply
Air Handler Cabinet
Filter Slot
Return
Filter Grille
Return

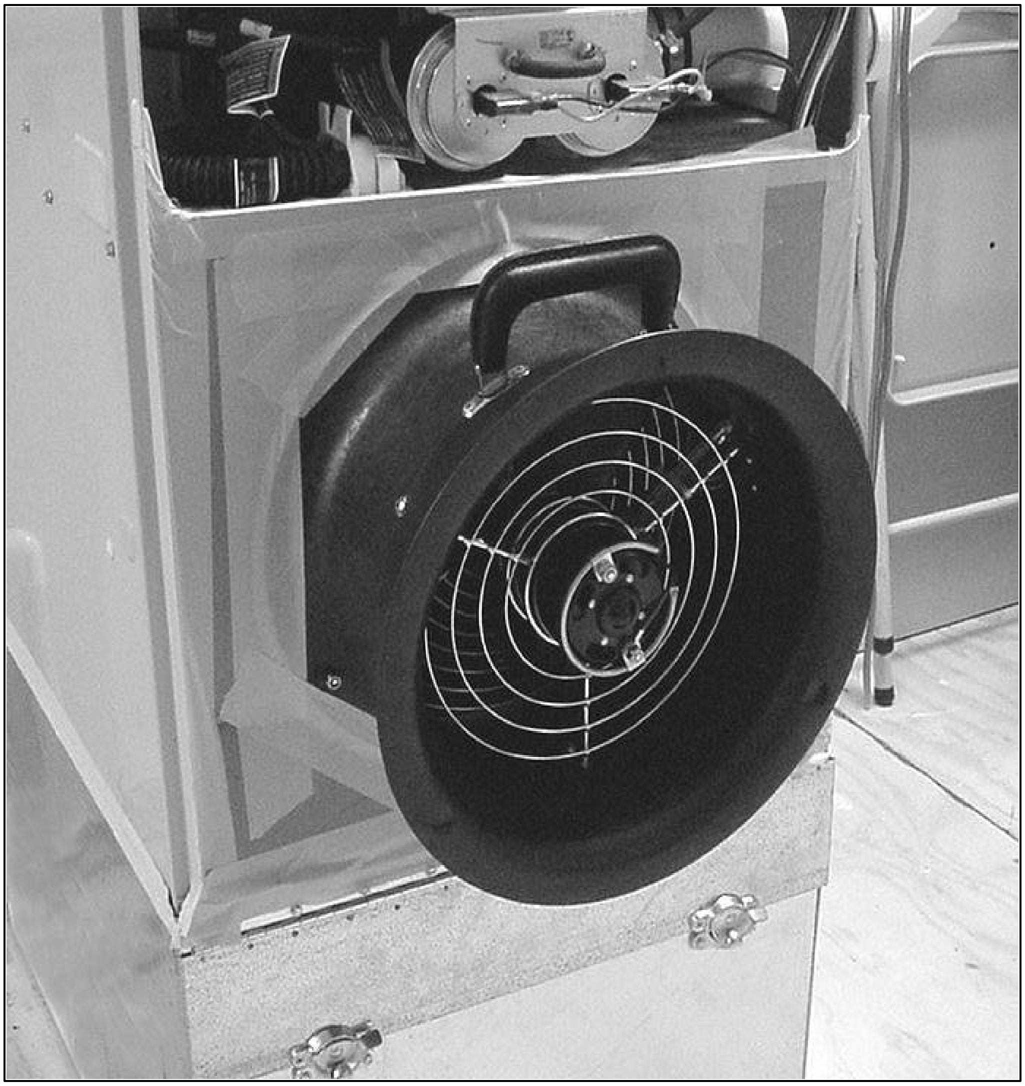
Flow capture hood method - problems

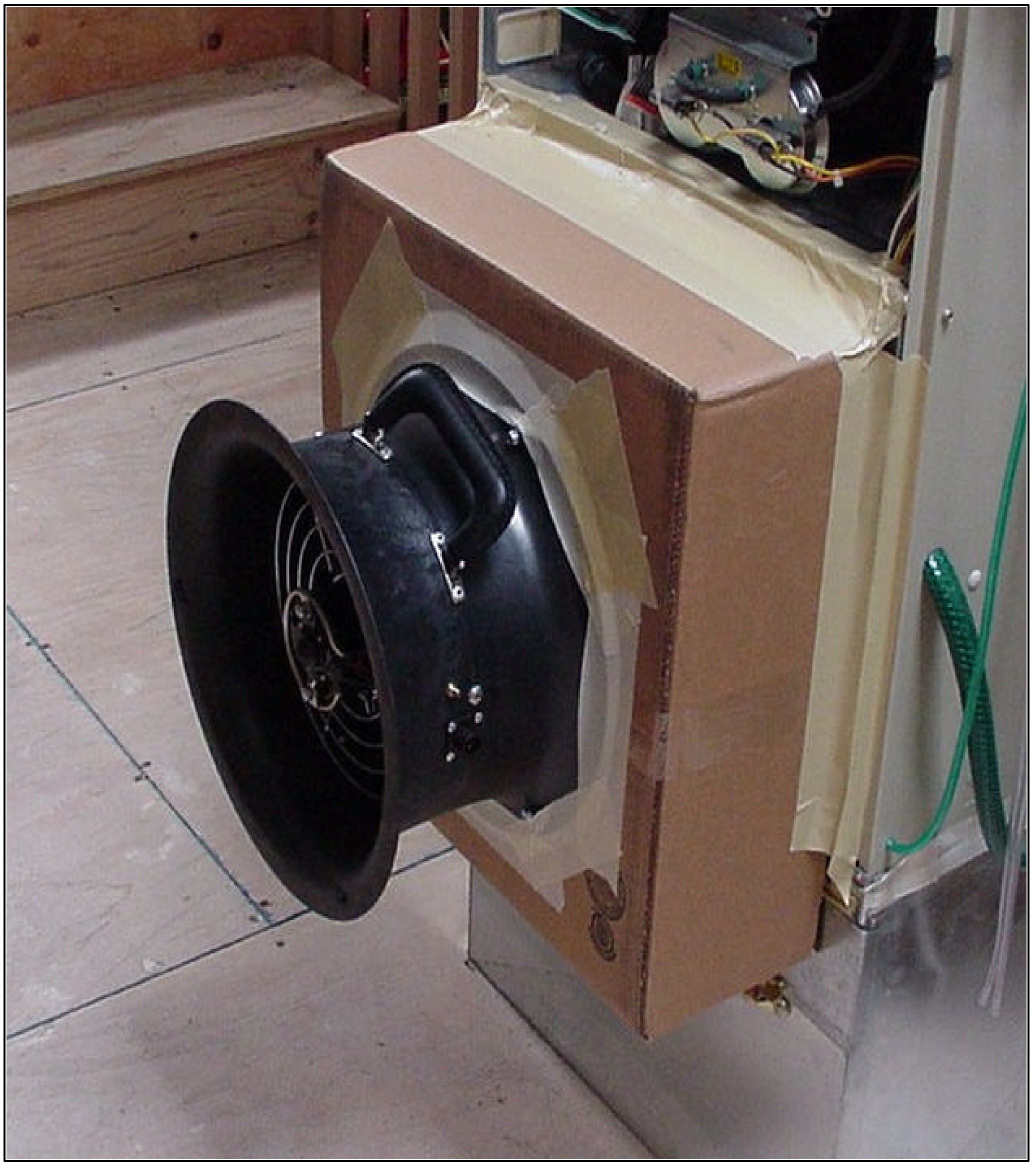
- Duct leaks cause low results
- Accuracy of capture hoods has been found to be a problem, especially with residential supply registers. An ASHRAE standard requires calibrating the hood to each type of register, which hasn't been done.
- It should be possible for hoods to measure return flows accurately, but there have also been problems with some hoods.
- Some registers difficult to do (kickspace supplies, hall wall returns that restrict entrance to hood)

Duct Blaster® method

- Measure static pressure in supply plenum under normal operating conditions.
- Seal return connection to air handler and install Duct Blaster at blower access panel (or, if return ducts are known to be tight, can install at a large return).
- Turn on air handler and Duct Blaster. Adjust to get same pressure in supply plenum.
- Measure flow through Duct Blaster.
- We think this is the most accurate field method available, but field testing of accuracy is difficult.


Supply
Air Handler Cabinet
Return
Filter Grille
Filter Slot
Return





Duct Blaster method - problems

- Can be time consuming and difficult to seal return connection to air handler
- Can be time consuming to seal Duct Blaster to blower access panel
- Can only directly measure flow up to about 1600 cfm, although can probably extrapolate up to 2000 cfm without much loss in accuracy

Pitot tube (or hot wire anemometer) method

- In a long, straight section of supply or return plenum (10 plenum diameters recommended) use pitot tube or hot wire anemometer to measure velocity in center of plenum.
- Multiply this velocity (in feet per minute) by .9 and by the area of the duct (in square feet) to get cfm.
- For better accuracy, divide duct into 9 or 16 equal areas, measure velocities in center of each and calculate the average. Multiply average by area to get cfm.

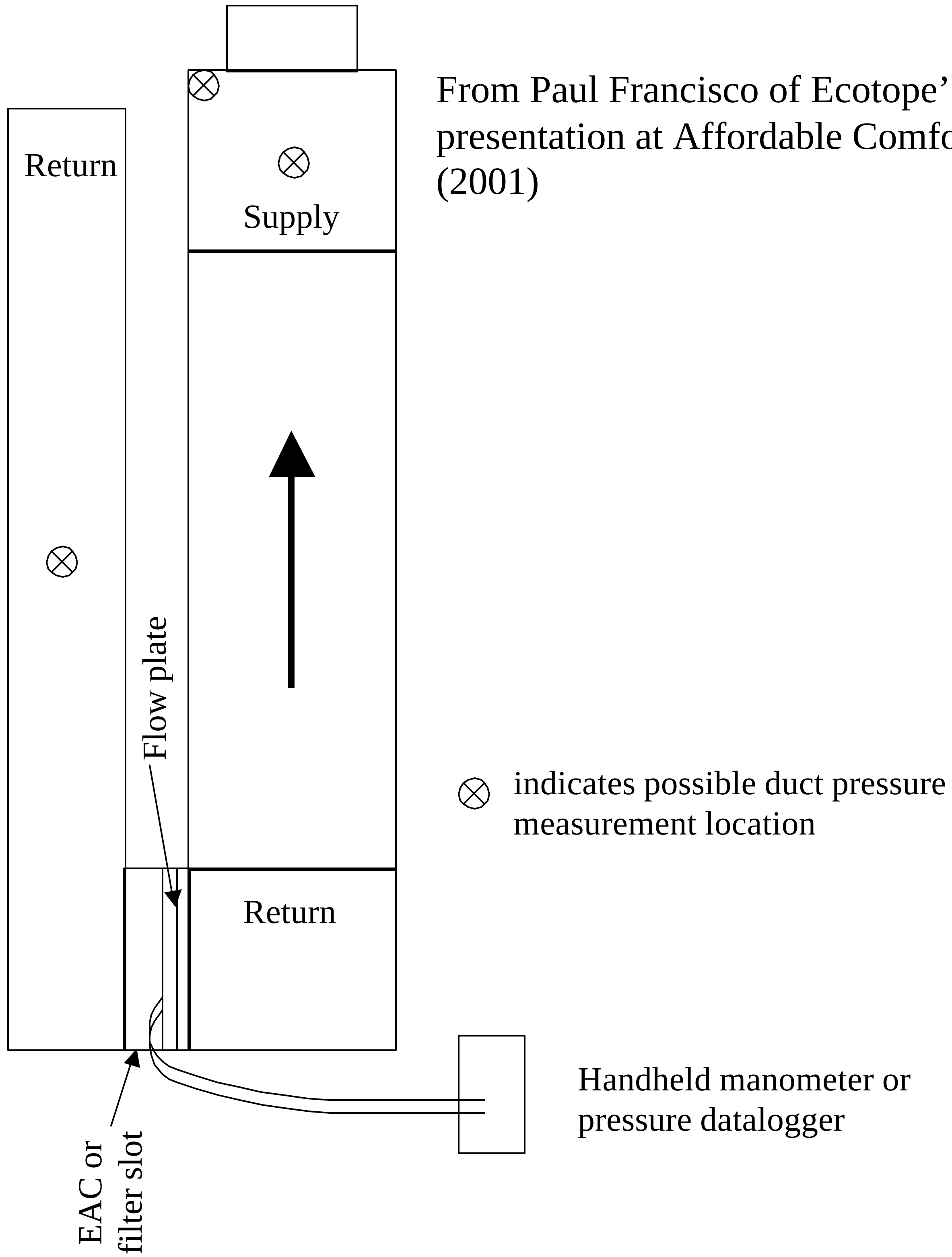
Pitot tube (or hot wire anemometer) method - problems

- Usually don't have the required length of straight duct.

True Flow® method

- Insert static pressure probe in supply plenum and measure normal operating static pressure.
- Install flow plate into filter slot near or in air handler (or at large return grille, if return ducts are known to be tight.
- Turn on air handler, measure flow through True Flow and measure new static operating pressure.
- Adjust measured flow for change in supply plenum static by multiplying flow by correction factor from table in manual.


TrueFlow™
Air Handler
Flow Meter
The ENERGY
CONSERVATORY



From Paul Francisco of Ecotope's presentation at Affordable Comfort (2001)

Raw flow = flow coefficient*sqrt(flow plate pressure)

$$\text{Corrected flow} = \text{raw flow}*\text{sqrt}\left(\frac{\text{duct pressure with filter}}{\text{duct pressure with flow plate}}\right)$$

True Flow method - problems

- There isn't always a filter slot near or in the air handler.
- There may be duct configurations that haven't been found that cause accuracy to be poor (although we have tested under conditions we would think would be near worst case).

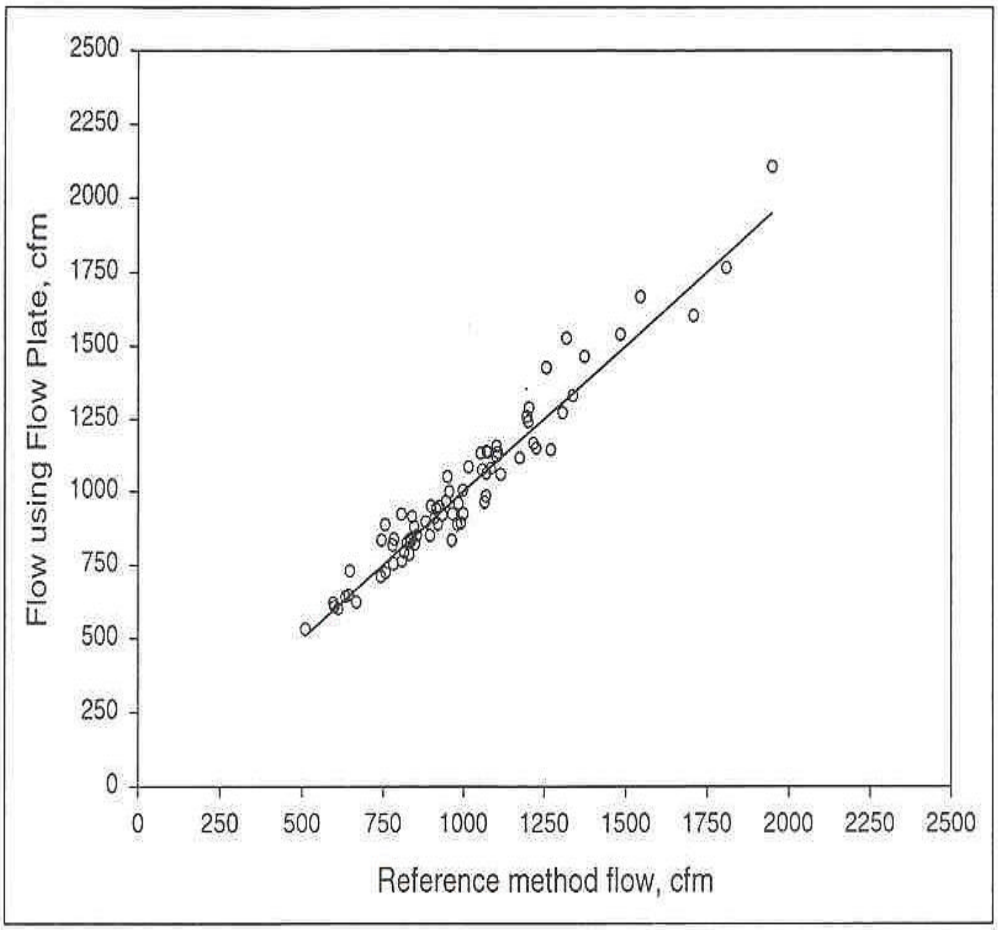


Fig. 11. Comparison of flow estimated using the flow plate to that measured by the reference standard. The line represents perfect agreement.

From Ecotope final report to DOE on development of the True Flow device (2000)

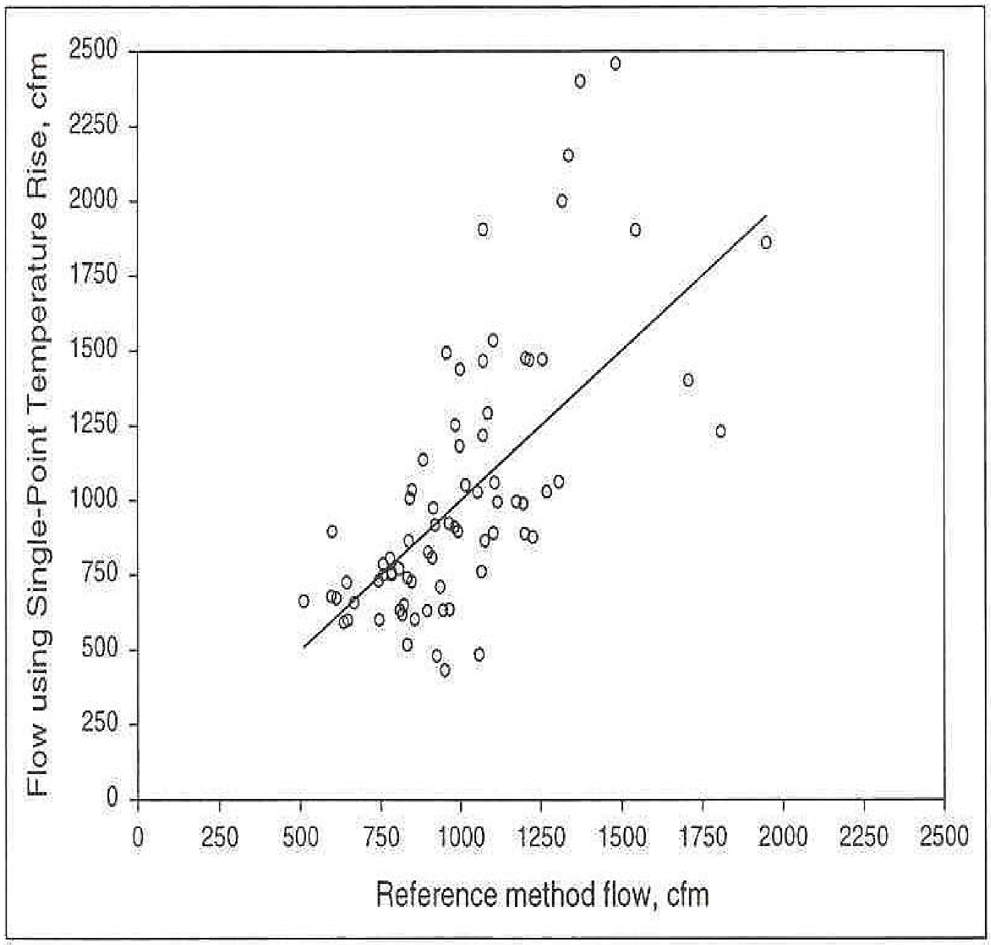
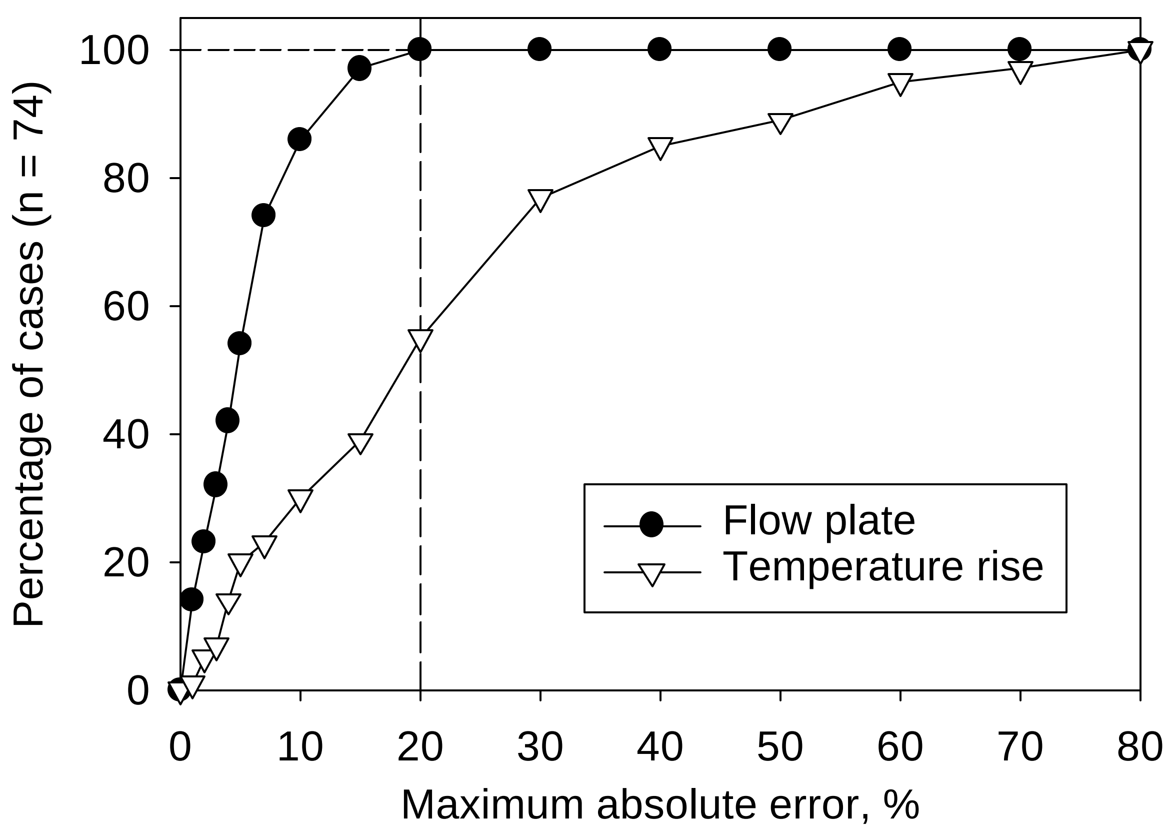


Fig. 12. Comparison of flow estimated using a single-point temperature rise to that measured by the reference standard. The line represents perfect agreement.

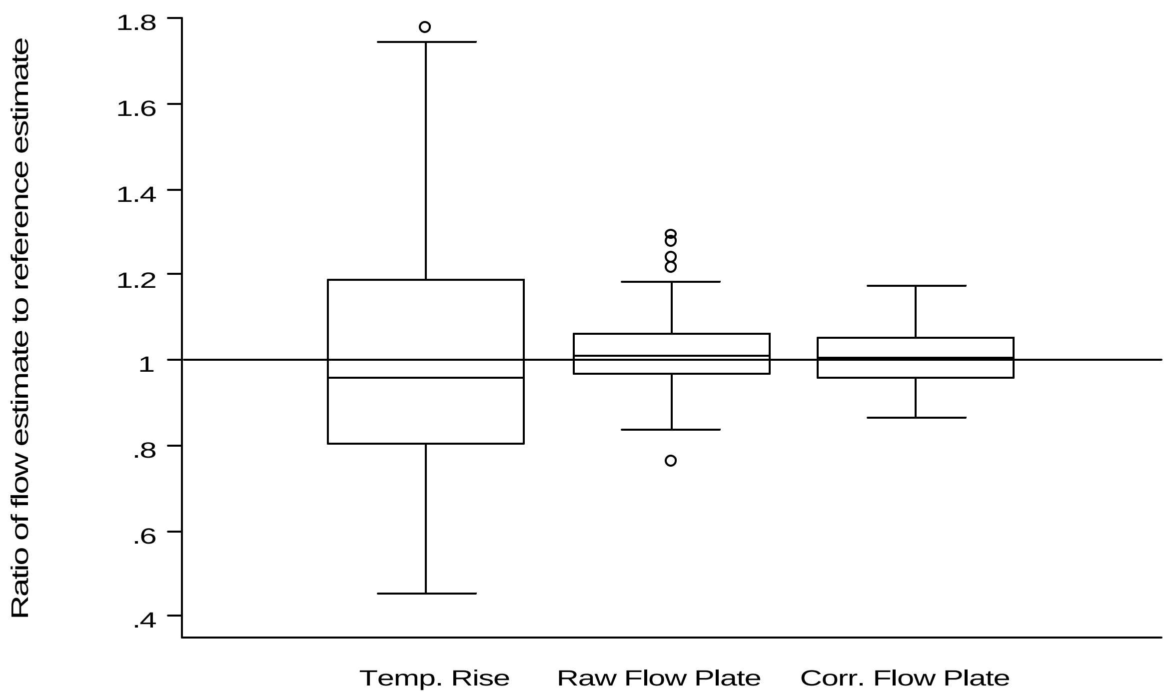
From Ecotope final report to DOE on development of the True Flow device (2000)

Accuracy, flow plate vs. temperature rise



From Ecotope final report to DOE on development of the True Flow device (2000)

Accuracy, flow plate vs. temperature rise



From Ecotope final report to DOE on development of the True Flow device (2000)

From Paul Francisco of Ecotope's presentation at Affordable Comfort (2001)

From Paul Francisco of Ecotope's presentation at Affordable Comfort (2001)

Conclusions

- Proper airflow is very important to system performance, especially air conditioners and heat pumps.
- There are many ways to measure.
- How you should measure depends on the accuracy you need, the time it takes, and the tools you have.
- Expect what you inspect!