Getting the Most From Your Diagnostic Equipment

Tuesday, February 20, 2007

2007 Annual RESNET Conference

San Diego, CA

Joe Kuonen

Building Performance Institute

Learning Objectives

- Diagnostic tools and procedures to use in solving problems in homes re: energy, comfort, health & safety
- Processes, communication, reporting
- Maintenance and calibration

Tools and diagnostics

Prescription without diagnostics is malpractice.

Diagnostics without testing is just guessing.

PRIORITIES

- **Health & Safety**
- **Structural durability**
- **Comfort**
- **Efficiency**

Tools and diagnostics

- Visual inspection
- Blower door test
- Flowhood
- Duct blaster
- Pressure balancing test
- Combustion safety testing (CO, draft pressure, spillage, combustion-appliance-zone depressurization)

Tools and diagnostics

- Radon detector
- Infrared detection
- Digital psychrometer
- Moisture meters
- Manual J load calculations
- Codes and standards

Tools and diagnostics

- **Visual inspection**

Tools and diagnostics

Visual inspection

- Start before you get out of the vehicle
- House type, key junctures, typical problems
- Drainage, vent pipe termination, efflorescence, mold, discoloration
- Read the signs inside (lifestyle: closed registers, space heaters, window AC, etc.

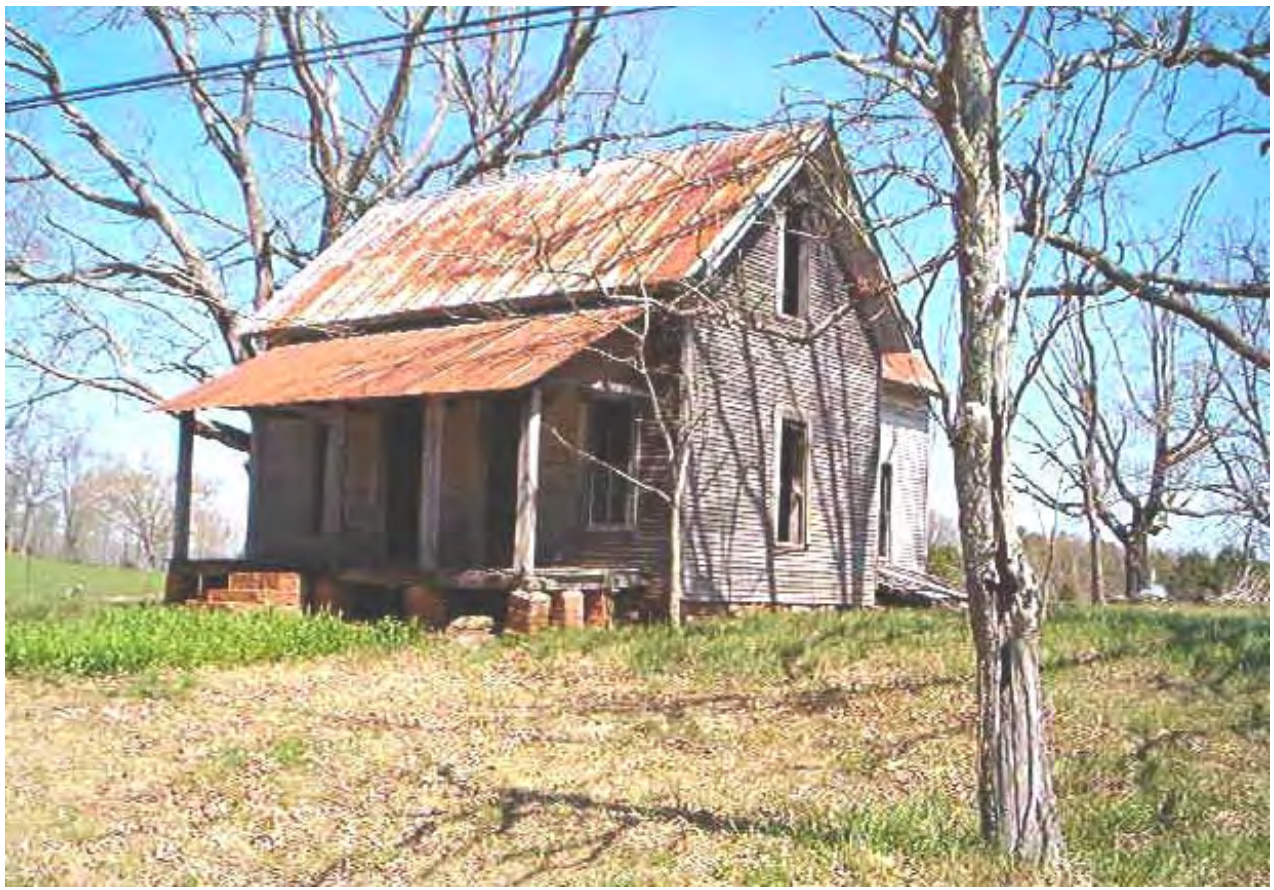
Tools and diagnostics

Visual inspection

- Never assume that anyone who ever worked on the house did anything correct
- Look especially for things that kill people and kill buildings
- If you were there, should know, and don’t report... you may buy a vacation package for a lawyer some day

That applies to houses like this…..

…as well as this….



Get ready for…

Combustion Safety Mood Slides!


NOTICE

FOILED!

This section of water heater flue pipe is made entirely out of aluminum foil.

Too dumb for words

This picture speaks for itself!


2006

40 years of return leaks

Mold inside plenum / irrigation

Tools and diagnostics

Blower door test


713

Tools and diagnostics

Blower door test

- Depressurize house to 50 pascals (relative to out).
- Measure airflow through fan in cubic feet per minute (cfm50). Using house volume, calculate “air changes per hour,” equivalent leakage area, etc.
- Find problems in house by tracking breezes, checking typical leakage sites, closing doors.
- Test duct leakage using pressure pan, tape-over method, or in conjunction with “duct blaster.”

Tools and diagnostics

Flowhood


ACCUBALANCE
TSI


TSI
AEROBALANCE

Tools and diagnostics

Flowhood, or Balometer

- Measures airflow at grills and registers
- Displayed in “cfm” (cubic feet per minute)
- Used to diagnose airflow problems, balance systems after installation or renovation
- Measure exhaust fan flow

Tools and diagnostics

CO detector


MONOKON II
KUONEN
OFF ON
OFF ON

Tools and diagnostics

CO detector

- Measures carbon monoxide in ppm (parts per million)
- Measure levels in house air, ducted air, oven, range top, gas logs, water heater, furnace, etc.
- CO levels in “undiluted” flue gases should not exceed 100 ppm.
- Use to identify problem appliances, venting inadequacies, life-threatening situations

Tools and diagnostics

Duct blaster

Tools and diagnostics

Duct blaster

- Used to test duct leakage by directly pressurizing the duct system, measuring airflow through the fan
- Attach fan to return grill, tape off all intentional return and supply duct openings
- Pressurize duct system to 25 pascals, or .1” of water column (residential design pressure)
- Can be used to test total duct leakage in new construction, or duct leakage to the outside only when used in conjunction with a blower door test on the whole house

Tools and diagnostics

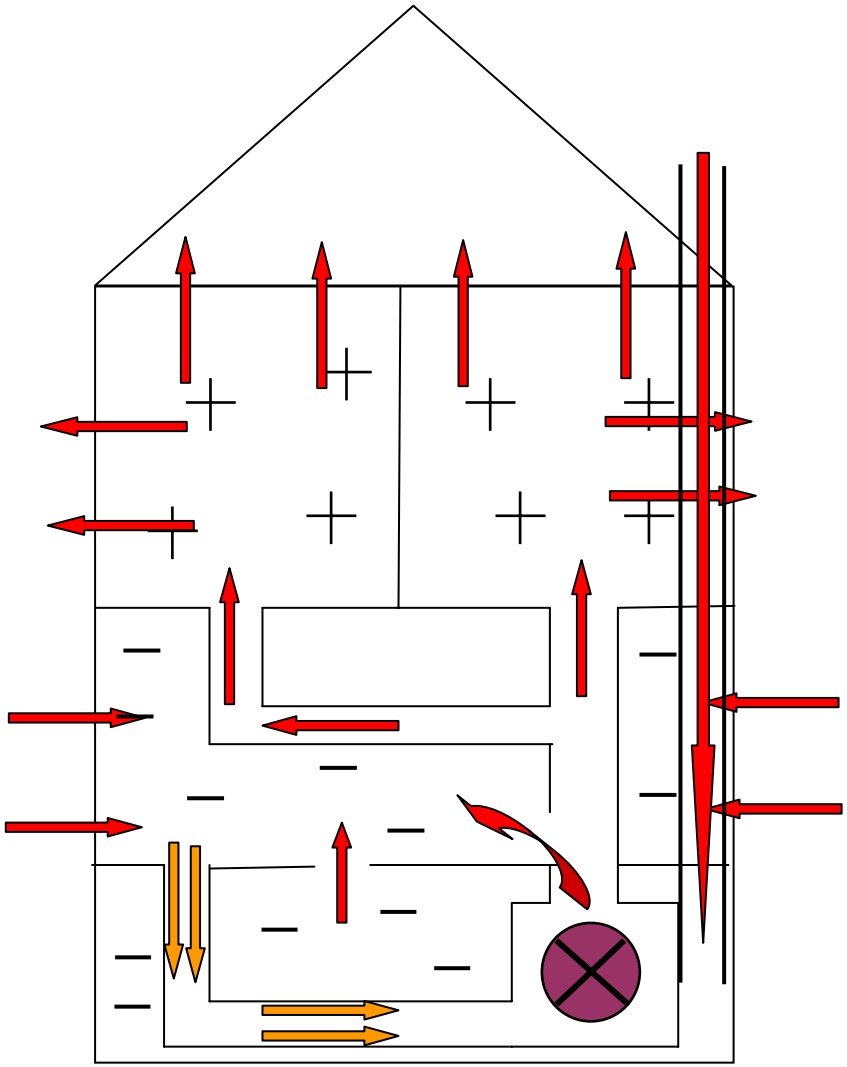
Pressure balancing testS

Tools and diagnostics

Pressure balancing and testing

- Measure pressure differences between rooms, between inside and outside, between combustion appliance zones and outside
- Prevent or correct dangerous depressurization of combustion zones (CAZ)
- Strategy for pressure relief for closed rooms
- “Test out” at end of day and at end of job
- “Worst case” depressurization test of all CAZ’s

Door Closing Effects




MINNEAPOLIS
GAUGE
-019.5
CHANNEL
MODE
RANGE

Tools and diagnostics

Combustion safety testing

Tools and diagnostics

Combustion safety testing

- Measure draft pressure in vent pipes
- Measure CAZ-to-outside (no pressures greater than – 3.0 pascals WRT outside)
- Check for adequate combustion air supply
- Inspect and/or test furnace heat exchangers
- Gas leaks
- Fire hazards
- Carbon monoxide tests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-019.4
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THE
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CONSERVATORY

“Ducts Suck”

- **The biggest fan in the house is the furnace/air conditioner fan**
- **When the supply ducts leak more than the return ducts they depressurize the house**
- **Leaky ducts can suck combustion products into the house from furnaces, water heaters, and fireplaces.**

HEALTH AND SAFETY

“Ducts Suck”

- **A large return leak in a Combustion Appliance Zone (CAZ) can depressurize the zone, cause backdrafting**
- **A single return grill in a hall or central area including a CAZ can depressurize the zone when doors are closed**
- **Sealing return leaks without pressure-balancing the CAZ for safety can result in back-drafting**

Long-term pressure-induced spillage & backdrafting

Spillage and flue-gas condensation causing corrosion of vent pipe


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NOTICE

Tools and diagnostics

Radon detection

Tools and diagnostics

Radon detection

- Test air quality of interior air
- Radon mitigation strategies are integrated into new home construction procedures
- Sub-slab gravel and piping systems required by building codes in some areas (also can assist in drainage and moisture control)

Tools and diagnostics

Infrared detection

Case studies – Mrs. Hummelbopper's ice dams

- Partition wall leakage causes ice dams

Tools and diagnostics

- **Digital psychrometer**
- **Moisture meters (for wood members, sheetrock, wall cavities, etc.)**

Moisture / humidity problems favor mold growth

Moisture problems destroy houses

Moisture problems are ugly

Moisture problems are hard to walk on

Moisture problems:
bulk water mismanagement

Condensation on ductwrap

Tools and diagnostics

Manual J load calculations

Tools and diagnostics

Manual J Load calculations

- Calculate thermal heat loss/gain of entire house and individual rooms; use for sizing equipment, duct design, and air balancing
- Climate-specific (design conditions)
- Based on all surface insulation values, infiltration rate, and duct losses, gains when located outside of conditioned space.

Tools and diagnostics

Codes & Standards

Tools and diagnostics

Codes and standards

- Be aware of code requirements in your area for new construction and remodeling
- Combustion appliances, venting, vapor barriers, insulation, ventilation, Energy Code and program standards
- Know when to say “no” to builders, homeowner, other contractors

Cover yourself & your client

- **Document**
- **Photograph**
- **Record**
- **Report**
- **Follow up / document**

New RESNET Requirements

- Starting Jan 1, 2007, HERS Providers are required to perform an annual field calibration check on Blower Door and Duct Testing pressure testing instruments and fans.
- Providers must use standards and procedures recommended by the equipment manufacturer.
- Providers must maintain a written log of the annual calibration check for a period of 3 years.

The Energy Conservatory (TEC)

Recommended Calibration Check Procedures

TEC
Recommended Calibration Check Procedures

Digital Pressure Gauges

(choose either method)

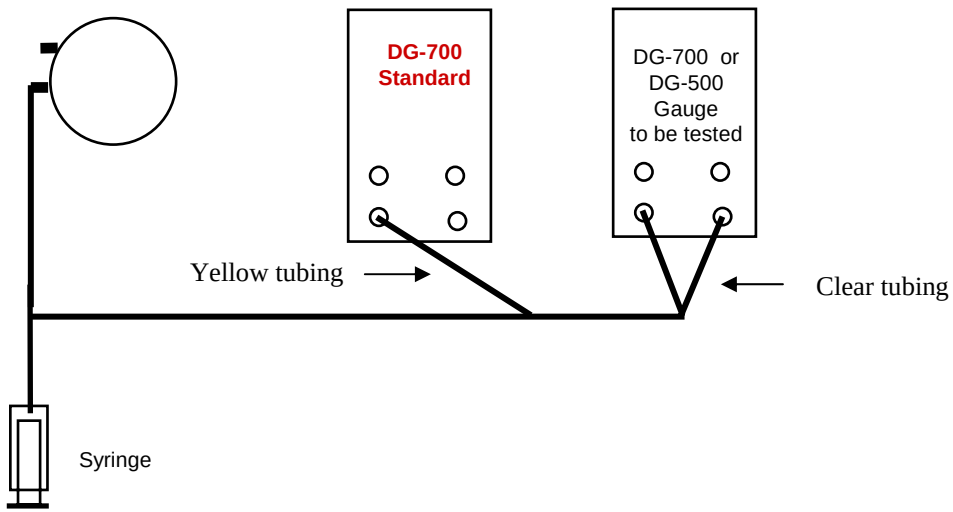
- Perform the digital gauge field calibration check procedure found at **www.energyconservatory.com/support/support7.htm**

or

- Recalibrate gauge at TEC factory - $50.

Digital Gauge Field Calibration Check

- Field check procedure consists of comparing digital gauges against a DG-700 gauge that is being used as an “in-house” pressure standard.
- This procedure involves comparing pressure readings from the DG-700 Standard gauge with the gauge being tested (DG-700 or DG-3) at a number of different pressures.



Digital Gauge Field Calibration Check

- Readings are recorded and the difference between the readings is determined.
- If the difference is smaller than the maximum allowed, gauge passes the field calibration check.
- If difference is larger than the maximum allowed, gauge should be sent to TEC for calibration.

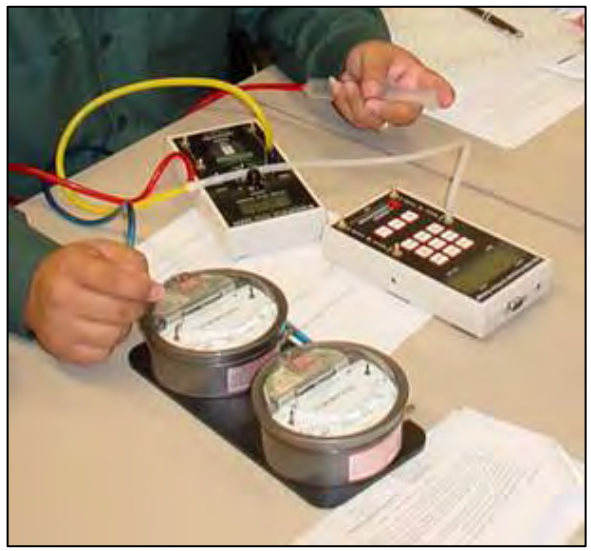
Gauge Serial # _____ Date _____ Technician _____

Last Factory Calibration Date _____

Pressure Station (Pa)	DG-700 Standard (Pa)	Channel A DG-700 Being Tested (Pa)	Channel B DG-700 Being Tested (Pa)	Channel A Difference (Pa)	Channel B Difference (Pa)	Maximum Allowable Difference (Pa)
+500						5 Pa
+50						0.5 Pa
-500						5 Pa
-50						0.5 Pa

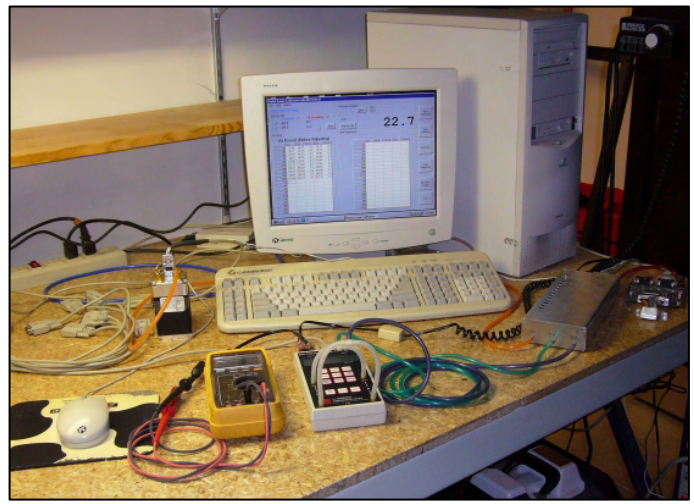
Digital Gauge Field Calibration Check

- Ideally, the DG-700 Standard should be recalibrated once every 6 months and only used as a pressure standard (not used in field).
- Otherwise, using a DG-700 that has just been returned from TEC calibration is acceptable.
- Pressures are created by syringe for field check (TEC has them available). Syringe is placed on table and pressures are allowed to stabilize before readings are made.
- Magnehelic gauge is used only to prevent over-pressurization.



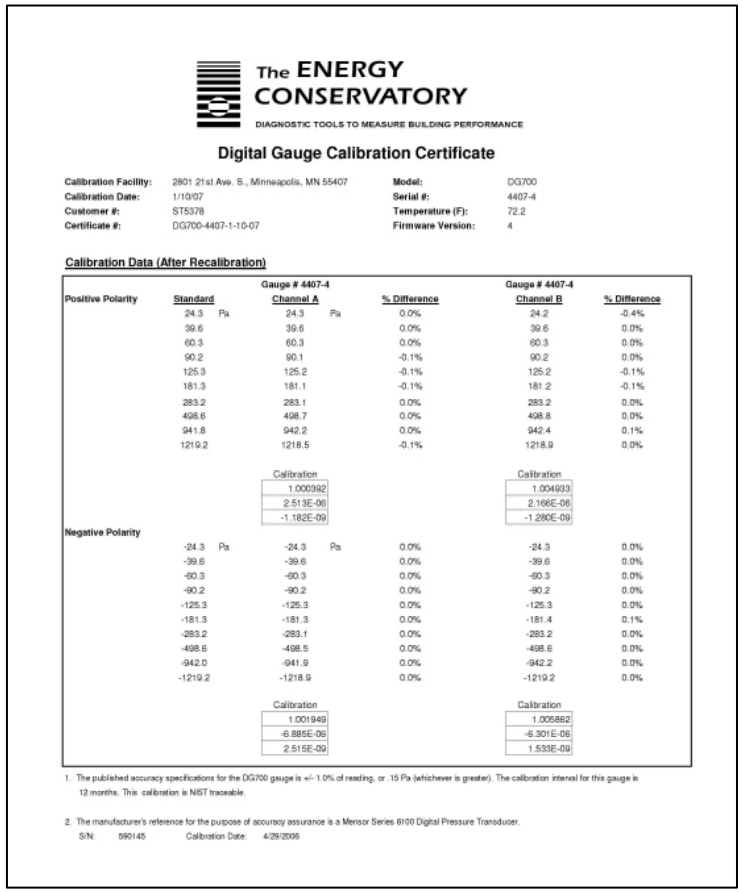
TEC
Factory Digital Gauge Calibration

- Gauge is tested against a NIST traceable pressure standard at 20 different pressure values.
- Gauge is recalibrated and tested again.
- Calibration certificate is provided.
- $50 cost includes ground UPS shipping back to customer.
- Turn around time at TEC is typically 3-4 days (assuming no repairs needed).



TEC
Factory Digital Gauge Calibration

- Digital gauge calibration certificate looks like this.



The ENERGY CONSERVATORY

DIAGNOSTIC TOOLS TO MEASURE BUILDING PERFORMANCE

Digital Gauge Calibration Certificate

Calibration Facility:	2801 21st Ave. S., Minneapolis, MN 55407	**Model:**	DG700
Calibration Date:	1/10/07	**Serial #:**	4407-4
Customer #:	ST5378	**Temperature (F):**	72.2
Certificate #:	DG700-4407-1-10-07	**Firmware Version:**	4

Calibration Data (After Recalibration)

		Gauge # 4407-4		Gauge # 4407-4	
Positive Polarity	**Standard**	**Channel A**	**% Difference**	**Channel B**	**% Difference**
	24.3 Pa	24.3 Pa	0.0%	24.2	-0.4%
	39.6	39.6	0.0%	39.6	0.0%
	60.3	60.3	0.0%	60.3	0.0%
	90.2	90.1	-0.1%	90.2	0.0%
	125.3	125.2	-0.1%	125.2	-0.1%
	181.3	181.1	-0.1%	181.2	-0.1%
	283.2	283.1	0.0%	283.2	0.0%
	498.6	498.7	0.0%	498.8	0.0%
	941.8	942.2	0.0%	942.4	0.1%
	1219.2	1218.5	-0.1%	1218.9	0.0%
		Calibration		Calibration	
		1.000392		1.004933	
		2.513E-06		2.166E-06	
		-1.182E-09		-1.280E-09	
Negative Polarity					
	-24.3 Pa	-24.3 Pa	0.0%	-24.3	0.0%
	-39.6	-39.6	0.0%	-39.6	0.0%
	-60.3	-60.3	0.0%	-60.3	0.0%
	-90.2	-90.2	0.0%	-90.2	0.0%
	-125.3	-125.3	0.0%	-125.3	0.0%
	-181.3	-181.3	0.0%	-181.4	0.1%
	-283.2	-283.1	0.0%	-283.2	0.0%
	-498.6	-498.5	0.0%	-498.6	0.0%
	-942.0	-941.9	0.0%	-942.2	0.0%
	-1219.2	-1218.9	0.0%	-1219.2	0.0%
		Calibration		Calibration	
		1.001949		1.005862	
		-6.885E-06		-6.301E-06	
		2.515E-09		1.533E-09	

1. The published accuracy specifications for the DG700 gauge is +/- 1.0% of reading, or .15 Pa (whichever is greater). The calibration interval for this gauge is 12 months. This calibration is NIST traceable.

2. The manufacturer's reference for the purpose of accuracy assurance is a Mensor Series 6100 Digital Pressure Transducer.
S/N: 590145 Calibration Date: 4/29/2006

TEC
Recommended Calibration Check Procedures

Blower Door and Duct Blaster Fans

(choose either method)

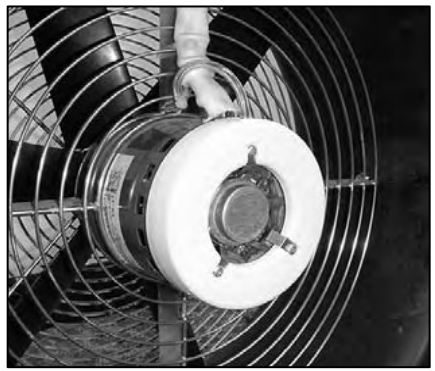
- Perform the fan field check procedure found at **www.energyconservatory.com/support/support7.htm**

or

- Recalibrate fan at TEC factory - $200.

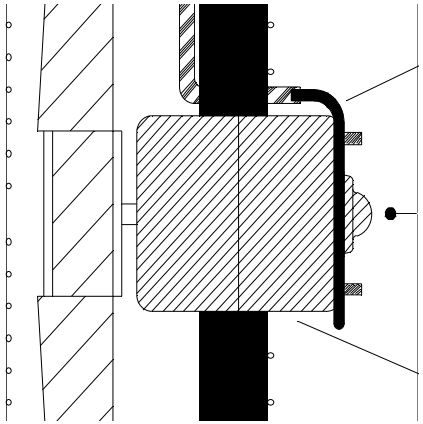
Fan Field Check Procedure

- The 2 most important aspects to maintaining proper fan calibration (Blower Door and Duct Blaster):
  - No leaks in flow sensor.
  - Sensor in proper position.
- Damaged fan housing (e.g. broken flange) and broken/ missing blades can also effect calibration and should be repaired.



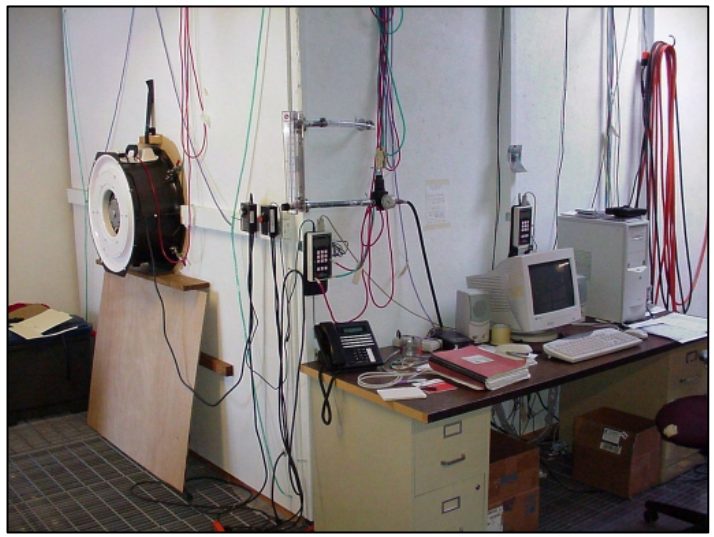
Fan Field Check Procedure

- Simple procedures and forms for checking flow sensor position and flow sensor integrity are contained in the fan field check document.
- If fan meets specifications listed in the procedure, the fan passes the field check.
- If fan does not meet specifications, contact TEC for adjustment/repair instructions.



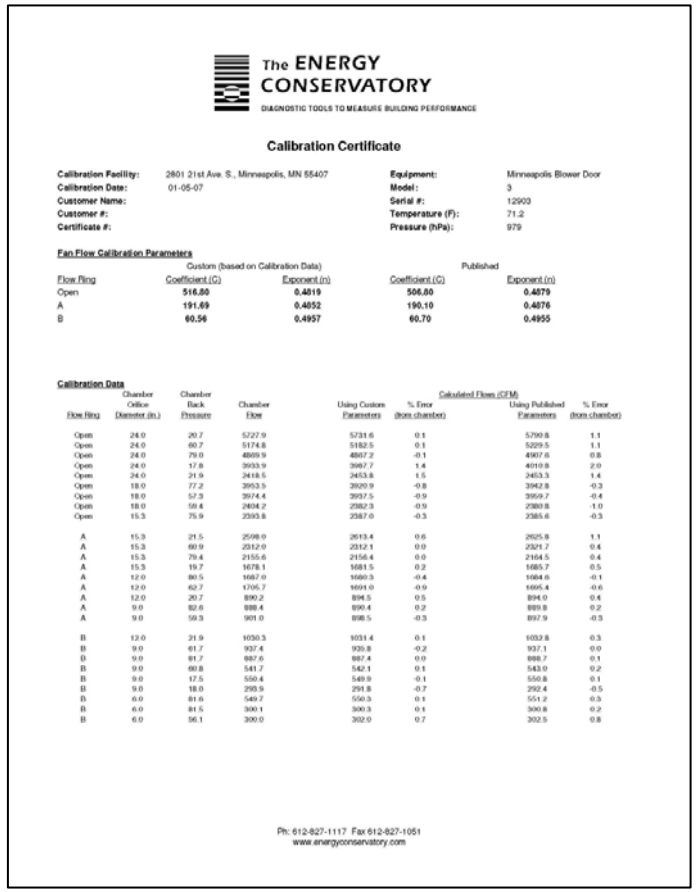
TEC
Factory Fan Calibration

- Fan is calibrated using ASTM Standard E1258 with a test chamber constructed according to ASHRAE 51/AMCA 210.
- Calibration certificate is provided including custom calibration parameters.
- $200 cost (shipping is extra).
- Turn around time at TEC is typically 4-5 days (assuming no repairs needed).



TEC
Factory Fan Calibration

- Fan calibration certificate looks like this.
- Custom fan calibration parameters can be input into TEC software (TECTITE or TECBLAST) for greater test accuracy.



The ENERGY CONSERVATORY
DIAGNOSTIC TOOLS TO MEASURE BUILDING PERFORMANCE

Calibration Certificate

Calibration Facility:	2801 21st Ave. S., Minneapolis, MN 55407	**Equipment:**	Minneapolis Blower Door
Calibration Date:	01-05-07	**Model:**	3
Customer Name:		**Serial #:**	12903
Customer #:		**Temperature (F):**	71.2
Certificate #:		**Pressure (hPa):**	979

Fan Flow Calibration Parameters

	Custom (based on Calibration Data)		Published	
Flow Ring	Coefficient (C)	Exponent (n)	Coefficient (C)	Exponent (n)
Open	516.80	0.4819	506.80	0.4879
A	191.69	0.4852	190.10	0.4876
B	60.56	0.4957	60.70	0.4955

Calibration Data

	Chamber Orifice	Chamber Back	Chamber	Calculated Flows (CFM)			
Flow Ring	Diameter (in.)	Pressure	Flow	Using Custom Parameters	% Error (from chamber)	Using Published Parameters	% Error (from chamber)
Open	24.0	20.7	5727.9	5731.6	0.1	5790.8	1.1
Open	24.0	60.7	5174.8	5182.5	0.1	5229.5	1.1
Open	24.0	79.0	4869.9	4867.2	-0.1	4907.6	0.8
Open	24.0	17.8	3933.9	3987.7	1.4	4010.6	2.0
Open	24.0	21.9	2418.5	2453.8	1.5	2453.3	1.4
Open	18.0	77.2	3953.5	3920.9	-0.8	3942.8	-0.3
Open	18.0	57.3	3674.4	3657.5	-0.9	3659.7	-0.4
Open	18.0	59.4	2404.2	2382.3	-0.9	2380.8	-1.0
Open	15.3	75.9	2393.8	2387.0	-0.3	2385.6	-0.3
A	15.3	21.5	2598.0	2613.4	0.6	2625.8	1.1
A	15.3	60.9	2312.0	2312.1	0.0	2321.7	0.4
A	15.3	79.4	2155.6	2156.4	0.0	2164.5	0.4
A	15.3	19.7	1678.1	1681.5	0.2	1685.7	0.5
A	12.0	80.5	1687.0	1680.3	-0.4	1684.6	-0.1
A	12.0	62.7	1705.7	1691.0	-0.9	1695.4	-0.6
A	12.0	20.7	890.2	894.5	0.5	894.0	0.4
A	9.0	82.6	888.4	890.4	0.2	889.8	0.2
A	9.0	59.3	901.0	898.5	-0.3	897.9	-0.3
B	12.0	21.9	1030.3	1031.4	0.1	1032.8	0.3
B	9.0	61.7	937.4	935.8	-0.2	937.1	0.0
B	9.0	81.7	887.6	887.4	0.0	888.7	0.1
B	9.0	60.8	541.7	542.1	0.1	543.0	0.2
B	9.0	17.5	550.4	549.9	-0.1	550.8	0.1
B	9.0	18.0	293.9	291.8	-0.7	292.4	-0.5
B	6.0	81.6	549.7	550.3	0.1	551.2	0.3
B	6.0	81.5	300.1	300.3	0.1	300.8	0.2
B	6.0	96.1	300.0	302.0	0.7	302.5	0.8

Ph: 612-827-1117 Fax 612-827-1051
www.energyconservatory.com

TEC
Recommended Calibration Check Procedures

Duct Blaster System Field Check

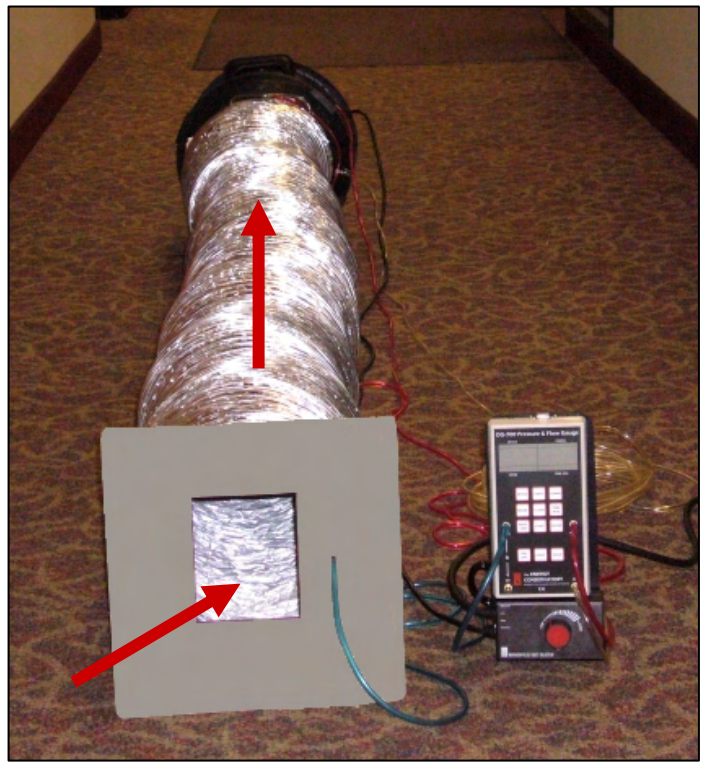
(meets requirements for both the Fan and Gauge)

- Perform the Duct Blaster System field check procedure using an approved orifice plate.

  This procedure will be available on the TEC website in the Spring 07. Approved orifice plates will also be available at that time.

Duct Blaster System Field Check Procedure

- Approved orifice plate is attached to the end of the square transition piece.
- Air is drawn through orifice plate and into the flex duct.
- Fan is adjusted to specified test pressure.
- Measured flow (or hole size) from digital gauge is compared to standard listed in the procedure.
- Pass/fail criteria listed in the procedure.



TEC
Recommended Calibration Check Procedures

Magnehelic Gauges

- TEC will perform an accuracy check on Magnehelic gauges for $15 per gauge (at the TEC factory).
- The accuracy of the gauges will be tested and recorded, however, calibration adjustments on Magnehelic gauges will no longer be performed.

Check Tubing for Leaks or Obstructions

- Tubing should be periodically checked for leaks and obstructions.
- Periodically trim off ¼” off the ends of tubing to remove damaged ends.
- If tubing leaks or is obstructed, replace it immediately.

Maintenance Tips for Digital Gauges

- Operating temperature range: 32 F to 120 F.
- Storage temperatures - 4 F to 160 F (best to keep it warm during cold weather).
- Avoid conditions where condensation could occur, for example taking a gauge from a hot humid environment into a cool environment.
- Do not store gauge in the same container as your chemical smoke. The smoke can and does cause corrosion.
- Use alkaline or rechargeable batteries.
- Avoid exposing the gauge to excessive pressures, such as caused by tubing slammed in a door.

Maintenance Tips for Blower Door Fans

- Use a vacuum with a brush attachment to remove dust, or blow out the dust with compressed air.
- Do not reverse the fan (using the flow direction switch) while the blades are turning.
- For long-term operation, such as maintaining house pressure while air-sealing, use a Flow Ring whenever possible to ensure good airflow over the fan.
- Do not run the fan for long periods of time in reverse.
- Do not use ungrounded outlets or adapter plugs.
- If the fan housing, fan guards, blade, controller or cords become damaged, do not operate the fan until repairs have been made.

THANK YOU!

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