A Demonstration of New Automated Equipment and Techniques for Easier and More Precise Measurement of Pressures and Airflow in Buildings

Introduction:

Building diagnosticians routinely use measurements of differential pressures, building and duct system airtightness, and mechanical system airflow when investigating air quality, comfort, durability, and energy use problems in commercial and residential buildings. Unfortunately, wind and other sources of noise can create large pressure fluctuations which significantly increase the variability of these measurements, often to the point where they can not be relied upon in the diagnosis of performance problems, or as quality control indicators.

Automated Performance Testing (APT) System:

The Energy Conservatory has developed a multi-functional data acquisition and fan control system which significantly improves the precision of pressure and airtightness measurements in buildings. The APT system includes 2 on-board precision auto-zeroing pressure channels, and 8 analog voltage channels for optional sensors. An analog output signal allows the APT system to control the speed of a calibrated blower door or duct pressurization testing system. Types of measurements that will be improved by the APT system include:

- building depressurization or pressurization due to exhaust fans, imbalanced duct leakage or imbalanced distribution systems.
- pressures in building zones (e.g. attics, crawlspaces, garages) which are used to estimate zonal leakage rates and prioritize airsealing activities.
- airtightness measurements of buildings and ducts.
- simultaneous monitoring of key building pressures and other parameters for diagnosing performance problems in buildings (backdrafting combustion appliances, CO levels etc.).

Three programs have been developed to operate the APT system. Each of the programs is being demonstrated at one of our three poster stations.

AUTOAT:	• Automated Airtightness Testing of Buildings and Duct Systems.
TECLOG:	• Continuous simultaneous monitoring and data storage of 2 building pressures and 8 analog sensors.
ONOFF:	• Precise measurement of small changes in building pressures using the 2 on-board pressure channels and a signal averaging technique to reduce noise from wind and other sources.

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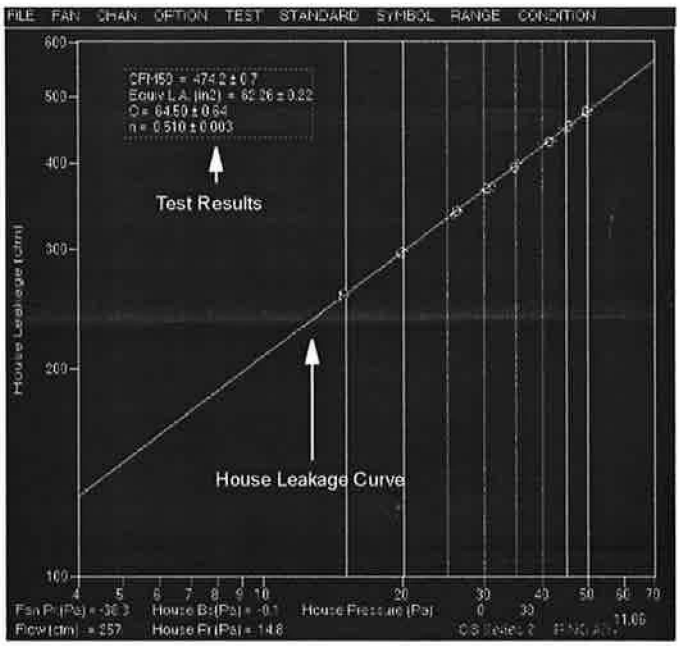
AUTOAT
Automated Airtightness Testing Program

- Computer Controlled Airtightness Testing of Buildings and Duct Systems.
- Simultaneous Precision Measurement of Fan Flow and Building (Duct) Pressures.
- Automated Baseline Pressure Measurements and Sensor Zeroing.
- Cruise Control for Maintaining Constant Building (Duct) Pressures.
- Calculation of Test Results, Estimation of Uncertainties, Uniform Reporting and File Storage.
- Automated Test Procedure Reduces Variability of Test Results From Wind and Operator Error.
- Choice of Testing Procedures (CGSB, ASTM, Customized)

Direct measurement of building and duct system airtightness using a blower door or duct pressurization system has become an important diagnostic technique. Wind and differences in operator testing procedures can significantly increase the variability of airtightness test results. This variability often makes it difficult to use test results as a consistent measure of quality control and program effectiveness.



The AUTOAT program improves the accuracy and repeatability of airtightness tests by combining an automated test procedure with precision measurement of test variables. The AUTOAT program automatically adjusts the speed of the calibrated test fan while simultaneously monitoring the building (or duct) pressure and fan flow using 2 precision auto-zeroing pressure sensors. At each pressure station, the AUTOAT program zeros the 2 pressure sensors and then quickly collects a minimum of 30 separate readings of building (or duct) pressure and fan flow. In addition, the program automatically measures the baseline building (or duct) pressure and adjusts all readings by the baseline value. The precision multiple measurement of test variables significantly reduces the effect of wind and other noise on test results. In addition, by automating the test procedure, operator error is reduced and time is freed up to collect other data or to interview the building occupants. The AUTOAT program is also an important research tool which is currently being used by The Energy Conservatory to better understand the leakage characteristics of buildings and duct systems, and to improve standardized testing procedures.

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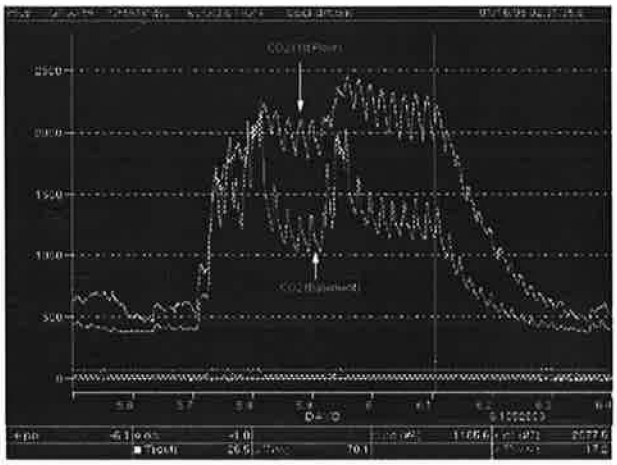
TECLOG (Data Acquisition/Monitoring Program)

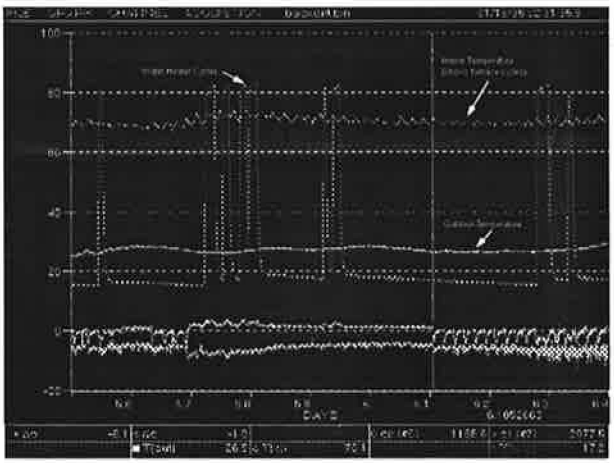
- Graphical Display of 2 Precision Pressure Channels and 8 Analog Voltage Channels.
- Real-Time Data Monitoring, Data Storage and File Retrieval/Viewing.
- User Configurable Viewing, Data Logging and Channel Calibration.

Example Application (Backdraft):

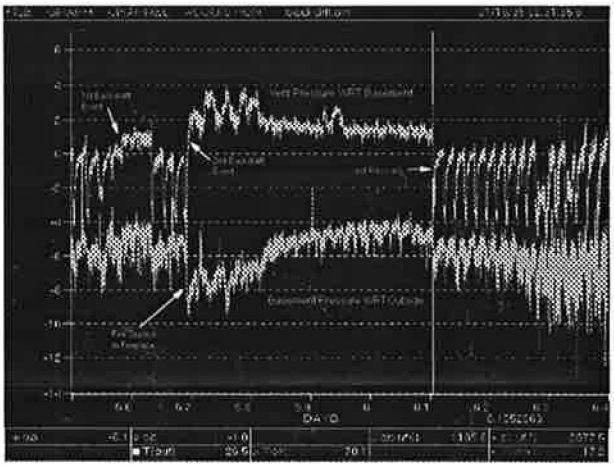
The 3 graphs to the right show data monitoring in a house over the same 1 day period. The top graph shows elevated CO_2 levels in the house during a backdrafting event. Once the vent re-establishes a draft, CO_2 levels begin to immediately decay.



In the 2nd graph, the y-axis has been rescaled to show greater detail for the other data logging channels including water heater cycles, indoor temperature (which shows furnace cycles), and outdoor temperature. From the 2nd graph we can see the effect of water heater cycling on CO_2 levels in the house. At the bottom of the 2nd graph, vent pressure and basement pressure are displayed.



In the 3rd graph, the y-axis has been rescaled again to show higher resolution for the vent and basement pressure channels. The main backdrafting event coincides precisely with a sudden basement depressurization caused by operation of the fireplace. Once the fire burns out and the basement depressurization is reduced, the vent re-establishes itself during a furnace on cycle (at exactly 02:31:35 a.m.). Note that at the time of vent re-establishment, the basement becomes further depressurized due to the vent changing from an air inlet to an air outlet.



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ONOFF
(Pressure Measurement and Signal Averaging Program)

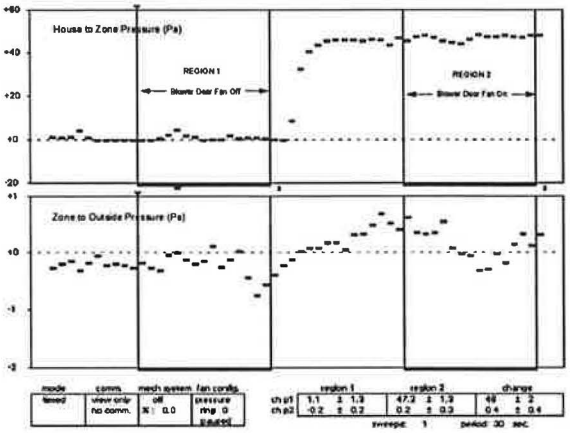
- Computer Controlled Measurement of 2 Differential Pressures.
- Automated Signal Averaging Reduces Noise in Pressure Measurements.
- Estimation of Uncertainties Due to Pressure Fluctuations.

Example Application: (Zone Pressures)

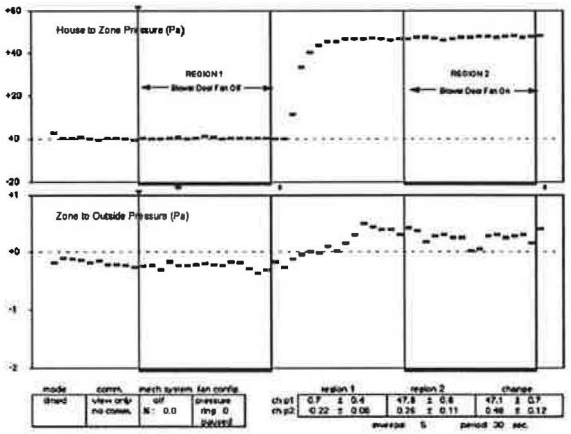
Air leakage paths between a house and a connected zone (e.g. attic, crawlspace, garage) will cause the pressure in the zone to change during a blower door test. Measurement of these small changes in zone pressures can be used to estimate air leakage rates through the zone and help prioritize airsealing efforts. Unfortunately, wind and other noise sources can create significant pressure fluctuations which hinder our ability to measure small zone pressures.

The 3 figures on the right show changes in zone pressures during repetitive "on-off" blower door tests controlled by the program. Each figure contains two graphs, with the top graph showing house to attic pressure, and the bottom graph showing attic to outside pressure. The graphs each contain 60 time bins (each bin represents one-half second), with one-half of the bins collected with the blower door on, and one-half with the blower door off. The average values of the on and off regions and their estimated uncertainties are displayed at the bottom of each figure.

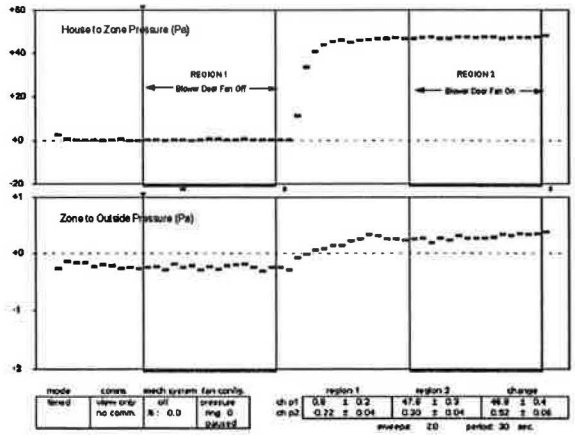
From the top figure we can see that after one 60 bin sweep (top figure), the changes in zone pressures caused by the blower door are not well determined, particularly the attic to outside pressure. After 5 sweeps (middle figure), the change in attic to outside pressure becomes more distinct and the error estimate of the change is reduced. Following 20 sweeps (bottom figure), the precision of the zone pressure measurement is good enough to make an informed decision on whether to concentrate air-sealing efforts on this boundary.



1 sweep



5 sweeps



20 sweeps

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