

Residential Building Diagnostic Tools

BUILDER TECHNOTE

The following is a list of tools that builders can use to diagnose the performance of a residential building to improve the quality of homes they build. These tools used in PATH Field Evaluations to model and measure various parameters.

Balometer



A balometer is an instrument that measures volumetric airflows from a diffuser or grille. The capture hood can be used on both supply and exhaust openings to make fast and repeatable measurements. This allows a builder to verify air flow distribution and properly balance the flow

from registers in a building. There are several models and hood sizes available to meet the wide variety of user needs.

The Air Conditioning Contractors of America (ACCAs) Manual D should be used to determine the recommended duct flow. A balometer should then be used to verify these values.

Blower Door



The blower door test measures the amount of air that flows into or out of a house while maintaining a set pressure difference between the indoors and outside. By using a calibrated fan and metering equipment, airflow can be measured

at a variety of pressure differences up to 50 Pascals. Test results are expressed in three ways: air changes per hour, under natural conditions (ACHnat) or at test pressure (ACH50); airflow at test pressure (CFM50); or equivalent leakage area (usually sq. in.). Tighter homes have lower test scores than leaky homes.

The blower door test is used to determine the airtightness of a home. A leaky house will lose conditioned air (and hence, energy) to the outdoors or draw unconditioned air indoors. A very airtight house without ventilation can develop indoor air quality issues under some circumstances. A blower door test can also indicate construction quality as well as compliance with design or program standards.

Coheat Test

The coheat test is a procedure designed to isolate the performance of the heating/cooling distribution system in a home. This test, although time-consuming, has proven very powerful in describing the problems associated with forced-air electric heat in homes.

The coheat test is a measure of the overall heat-loss factor for the home including ceiling,

walls, windows, foundation, etc. It provides a value for the whole-house performance that combines all construction features of the building.

In the coheat procedure, a home is alternately heated with the furnace and then with an array of small (1.5 kW) heaters placed in each room with a supply register—these are known as coheaters. The test alternates between these two heating methods every two hours, collecting temperature and energy usage data every second. An automated control algorithm controls the furnace and coheaters to keep the home at essentially the same temperature during the alternating cycles. The ratio between the average power in the two heating modes is the overall system efficiency. The test periods are relatively short, minimizing thermal mass effects. Additionally, the test is conducted at night to minimize solar gain effects.

The coheat procedure is designed to collect enough information in an overnight test to provide estimates of steady-state heat delivery efficiency, cycling heat delivery efficiency, and overall system efficiency. The system efficiency is defined as the total useful heat delivered to the conditioned space during the entire furnace cycling time, divided by the power input to the furnace. System efficiency takes into account any supply leaks back into the home, plus any heat recovered by the living space when the furnace fan is off. The system efficiency's "total useful heat" refers to the power that the same home would use if equipped with electric baseboard heaters (with ducts placed in and open to the conditioned space, but with furnace off) and maintaining the

same average indoor temperatures as those provided by the furnace during normal cycling.

For more information on coheat testing, see the ToolBase website at www.toolbase.org/Docs/MainNav/Factory-builtHousing/3755_airofimportance2.pdf

Duct Blaster

Leaky ducts can be a significant source of energy loss in both new and existing homes. Leaky supply ducts can send expensive conditioned air into unconditioned spaces such as attics and crawlspaces, and can be responsible for inadequate air distribution, resulting in rooms that are too cold or too warm for occupant comfort. A measure of the air tightness of the duct system can help identify leaks; simple duct sealing methods can save energy and increase comfort.

Ducts can be tested for air tightness by a few different methods. The most common method is to pressurize the duct system with a calibrated fan. The supply registers are sealed off and the ductwork is pressurized (usually to 25 Pascals or 0.1 in. water) with a fan located near the air handler. The rate of airflow (expressed in cubic feet per minute at 25 Pascals of pressure) into the ducts is used to determine the duct tightness. Both the supply and return ducts can be tested independently. When used in conjunction with a blower door test (see description above), the duct air loss to the exterior of the house can be estimated.



Electric Moisture Meter



The electric moisture meter is a simple tool that can easily determine moisture levels in a material to help diagnose potential problems. This tool can be used for quality control to ensure proper moisture levels of building components prior to installation.

There are two types of moisture meters: conductance and dielectric. Conductance meters have two to four probes that are physically inserted into the material being tested. They read the moisture content of the material through the electric conductance detected between electrodes. Higher moisture levels facilitate better conductance, thus higher moisture readings. Dielectric-type moisture meters are non-invasive. They generate an electrical field through flat platens located on the bottom of the meter. These, in turn, analyze characteristics about the electric field to generate a moisture content reading.

Enetics Energy Meter



Enetics, Inc. provides complete monitoring and management solutions including recording equipment, communications, and software for the collection and analysis of energy data. The Enetics meters are used in PATH Field Evaluations to monitor and understand the electricity consumption in a particular house.

The Enetics SPEED™ (Single Point End-user Energy Disaggregation) recorder can be used to obtain total residence energy consumption, as well as the energy consumption of larger individual electronic

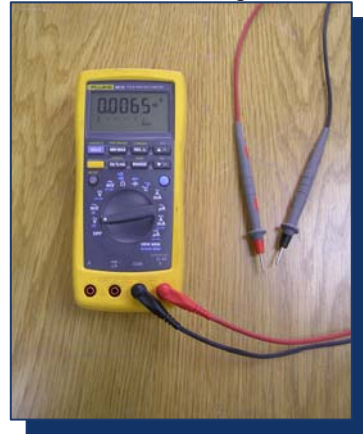
appliances in the residence. This information can be used for load research, monitoring demand-side management programs, and addressing high energy bill concerns.

SPEED™ technology determines energy consumption of individual loads by installing a special function metering device at a single point, either at the meter or at the breaker panel.

For more information on the Enetics Energy meter, see www.enetics.com/index.html.

Power Meters

Power meters are used for measuring power consumption and troubleshooting and there



are different types of meters to fit each situation.

Portable power meters are plugged into the wall and then the appliance is plugged into the meter. The meter displays how much power the appliance is currently consuming and how much total energy the appliance has consumed since the meter was last reset. Some meters can incorporate energy prices to determine and display associated costs. Portable power meters are excellent for locating high-demand appliances, measuring

intermittent loads of cyclical appliances (i.e. refrigerators), and performing time-in-use energy studies.

Handheld power meters measure power by simply connecting two voltage leads and clamping on the current probe. They perform current and voltage measurements in True RMS and provide immediate readings of Power Factor (PF), Active Power (kW), Reactive Power (kVar), Apparent Power (kVA), and Frequency (Hz).

Pressure Meter

Pressure meters are used to determine the pressure difference between two spaces. They can determine the pressure difference between a conditioned space and an unconditioned space, such as a garage, crawlspace, or attic. They also can be used to find the pressure difference between rooms while the HVAC system is operating. In addition, they are useful to determine the pressure difference between the house and the outdoors when gas appliances are operating.

Thermal Infrared Camera

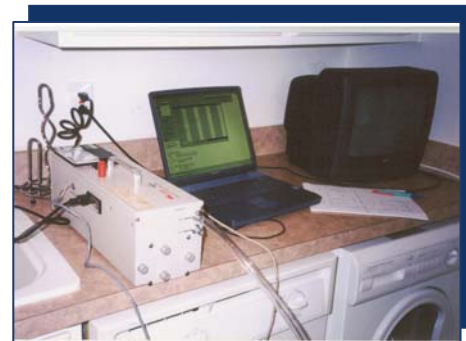
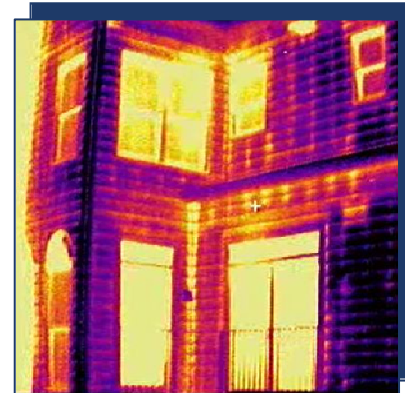
A thermal infrared camera is a useful tool in a home energy audit. It can reveal damaged or missing insulation, improper caulking, incorrectly installed materials, gaps in construction framing/studwork, mold, and water damage. It can also illustrate water heater performance, electric circuits, structural water leaks, and leaking pipelines. Training and certification from the camera manufacturers is vital in the creation and interpretation of images to ensure the information is applied properly.

Thermographic scans for the building envelope are commonly used in conjunction with the blower door test. The blower door exaggerates air leaking through defects in the shell.

Tracer Gas Testing

Tracer gas tests are another tool to measure the rate of air filtration into a building during its normal operation. This testing can identify leaky ducts or HVAC units, and can provide an accurate measure of the air exchange with the outdoors during normal operation. This test can help identify conditions where the air-tightness may be too low, resulting in potential indoor air problems.

Sulfur hexafluoride (SF_6) is most commonly used as the tracer gas in this test since it is non-reactive, non-toxic, odorless, colorless, and it is detectable in small concentrations by a recognized measurement technique as low as parts per trillion.



Weather Stations

Remote weather stations measure and report on a variety of parameters depending on the extensiveness of the equipment. Typically, an outdoor weather station includes a thermo-hygrometer to measure outdoor temperature and humidity, an anemometer to measure wind speed and direction, and a rain gauge. They also can measure solar irradiance. An indoor station includes a baro-hygrometer to measure indoor temperature, humidity, and barometric pressure.

Weather stations are used to record daily temperature swings and compare long-term averages with annual data. The data can be used to evaluate the performance of heating and cooling systems and calibrate simulation models.

Energy Gauge USA Software

Energy Gauge was developed by the Florida Solar Energy Center. It is a user-friendly, PC-based software program created to allow simple, yet detailed, performance-based analysis of building energy use. The software will perform energy code calculations and create compliance reports. It also can perform economic analysis of proposed energy improvements. www.energygauge.com/

EnergyPlus Software

Energy Plus is a U.S. Department of Energy simulation program that is used to create an energy model of a building. It models the building's heating, cooling, lighting, ventilation, and other

energy flows. Its capabilities include time steps of less than an hour, modular systems, multi-zone air flow, thermal comfort, and photovoltaic systems.

www.eere.energy.gov/buildings/energyplus/

Manual D

Manual D is published by the ACCA as a method for designing residential duct systems. This procedure can be applied to constant volume systems and zoned, variable air volume systems for all duct construction materials. Visit www.acca.org to find out more.

Manual J

Manual J is published by the ACCA as a guide for estimating residential heating and cooling loads. This manual is the accepted industry standard for the proper sizing and selection of HVAC equipment in residential homes. The eighth edition (published in 2004) is the most recent revision, which incorporates a new comprehensive approach to ensuring that indoor environmental systems are as efficient as possible. The manual can be found at www.acca.org/

REM/Design Software

REM/Design software is produced by the Architectural Energy Corporation. It calculates heating, cooling, domestic hot water, lighting and appliance loads, consumption, and costs based on a description of the home's design and construction features, as well as local climate and energy



cost data. Additionally, REM/Design is DOE-approved for Weatherization Assistance Programs in all states. Visit www.archenergy.com.

REScheck Software

The REScheck program is a useful tool to demonstrate compliance with the Model Energy Code (MEC), the International Energy Conservation Code (IECC), and a number of state codes. This U.S. Department of Energy software allows designers and builders to determine whether new homes and additions meet the requirements of the current code. It is also used by building officials, plan checkers, and inspectors to determine if a building will meet the energy code. The REScheck software simplifies this process by generating a report for plan checking and field inspection. Find out more at www.energycodes.gov/rescheck/download.stm.