ACTION ITEM:

Investigate duct sealing scopes for varying regions and programs. Include the practices of the DOE's Building America program, its participants and outlets. Report back to the Subcommittee the findings.

BACKGROUND:

Standard 90.2 is currently silent on duct leakage and does not provide guidance via methods or design strategies to limit loses through air distribution system leaks. This should be a concern because of the potential impact on operation efficiency, initial construction costs, equipment and building durability, system performance and ultimately occupant comfort. Several studies have shown that duct system efficiency cannot be reliably determined without good estimates of duct leakage. Duct leakage should be quantified as the primary variable used to determine energy losses from forced air heating and cooling systems. HVAC systems can account for up to 40% of residential annual energy use. In turn, duct leakage can account for up to 25% of the energy use in a house and in many cases can exceed envelope infiltration impacts.

Specifically, for energy calculations, it is the duct leakage to the outside at the calculated design operating conditions that is required. However, delivery effectiveness of the supply air is beginning to increase in significance. The conditioned air that is lost inside the thermal envelope prior to reaching either a supply air outlet (from the indoor unit to the outlet) or the blower (from the return grille to the indoor unit) cannot be discounted. In higher performing houses, similar to homes at Energy Star© levels and beyond, duct leakage impacts have acute impacts on occupant comfort, equipment efficiency and building operation.

ASTM has had a standard for measuring duct leakage for many years. This standard is widely used and understood by the two most common methods for measuring duct leakage: duct pressurization and blower door subtraction. Both of these procedures were intended to calculate leakage of the air distribution system under fixed experimental conditions. Issues exist with each of these methods, but these methods are widely accepted and proven to work. Research and field trials have shown that duct pressurization methods are easier to use and provide greater accuracy. However, current and past research suggests that neither of these methods can measure the air leakage under actual operating conditions. This is a result of the difficultly with supply-side and return-side measurements.

Researchers have been working diligently over the past few years to develop new methods and test procedures. Some alternative procedures of measuring duct leakage have been developed, but due to the complexity they have not been released to the public. This work will continue and we should expect improved methods and test procedures in the future. Measuring leakage using the pressurization method is far superior to not having any recommendations. Standard 90.2 does not contain any guidance regarding duct leakage, nor is there any language detailing placement of the air distribution system in the house. Duct leakage testing using the pressurization method is considered the best method and will provide all involved in the testing valuable insight.

Program Requirements:

Energy & Environmental Building Association:

- Total ductwork leakage for ducts distributing conditioned air should be limited to 10.0 percent of the total air handling system rated air flow at high speed determined by pressurization testing at 25 Pa.
- Ductwork leakage to the exterior for ducts distributing conditioned air should be limited to 5.0 percent of the total air handling system rated air flow at high speed determined by pressurization testing at 25 Pa.

NAHB Green Certification:

- All inside the conditioned space, no ductwork in building cavities and not ductwork in exterior walls
- Less than 5% of rated blower capacity to the unconditioned space
- Total leakage less than 10% of rater blower capacity

LEED:

- Do not use wall cavities, all interior structural runs must be fully ducted and inside the thermal envelope
- Less than or equal to 4cfm @ 25 Pa per 100 sq/ft of conditioned floor area (for each installed system) – minimum prerequisite
- Less than or equal to 1cfm @ 25 Pa per 100 sq/ft or conditioned floor area (for each installed system) – Points achieved

Energy Star:

- Ducts must be sealed and tested to be ≤ 6 cfm to outdoors / 100 sq. ft. of conditioned floor area, as determined and documented by a RESNET-certified rater using a RESNET-approved testing protocol. If total duct leakage is < 6 cfm to outdoors / 100 sq.ft. of conditioned floor area, then leakage to outdoors does not need to be tested
- Duct leakage testing can be waived if all ducts and air handling equipment are located in conditioned space (i.e., within the home's air and thermal barriers) AND the envelope leakage has been tested to be ≤ 3 ACH50 OR ≤ 0.25 CFM 50 per sq. ft. of the building envelope
- Note that mechanical ventilation will be required in this situation

RECOMMENDATION TO THE SUBCOMMITTEE:

Depending on the direction that this information is taken, it can be a complex proposal and not simply answered by quoting a percentage or loss location. My recommendation encompasses consideration for materials, retrofit applications, current new construction practices, proposed national code changes and the confirmed trend towards increased thermal envelope performance. In addition, our experience with high performance HVAC equipment and air distribution systems in high performance homes was applied in the decision making process. The recommended process can be divided into two encompassing test results – duct leakage to the outside and total duct leakage.

- Total air distribution system duct leakage must be less than five percent of the total air handling system rated air flow at high speed (nominal 350 to 400 CFM per ton) determined by pressurization testing at 25 Pa. This test is also widely known as the blower door subtraction method. Two compliance mechanisms are acceptable: (1) test total duct leakage at finish stage, or (2) test total duct leakage at duct rough-in stage. Preferably duct tightness testing would be completed at both stages of construction. When more than one air handler exists, each air handling system must individually meet the requirement. If zoning is used, all zone dampers must be open. Manual or motorized outside air ventilation dampers must be closed.
- less than 10% of total peak design system flow to the inside
- None ducted systems shall be entirely inside the conditioned envelope

These prerequisite requirements shall accompany the aforementioned testing parameters:

- Traditionally duct sealing has been specified by SMACNA's three distinct duct sealing classes (A, B, or C), which differ in their requirements for sealing the transverse joint, longitudinal seams, and duct penetrations. This language can be easily simplified by stating, "All joints, seams, holes and penetrations of the air distribution system shall be sealed using UL-181, and high velocity water based mastic"
    - Duct tape is not permissible for sealing
- All ductwork to be located inside the conditioned envelope
- Building cavities shall not be used as pathways for transmitting supply and return air
    - Cavities and chases inside the conditioned envelope can contain ductwork, but must be fully ducted