BUILDING PERFORMANCE INSTITUTE

TECHNICAL STANDARDS

FOR CERTIFIED BUILDING ANALYST I

Health and Safety

All technicians performing diagnostic tests, inspections, or installations, must have access to all necessary personal safety equipment required by OSHA. Required safety equipment includes, but is not limited to:

- ✓ Fitted respirators with canister filters
- ✓ Dust masks
- ✓ Gloves
- ✓ Protective clothing
- ✓ Safety glasses
- ✓ Hard hats, as required

Technicians must be trained in proper use and applications for these devices and must adhere to OSHA regulations when on the job site.

All hand tools, power tools, ladders, and diagnostic equipment must be handled and used in a safe manner and kept in good working condition. Equipment and diagnostic tools must be maintained and calibrated according to manufacturer's specifications.

A copy of the Material Safety Data Sheets (MSDS) for all materials used on the job and installed in the home, must be kept on each crew vehicle and made available to all workers and clients upon request.

Where the presence of asbestos, lead, mold and/or other potentially hazardous material is known or suspected, all relevant state and federal (EPA) guidelines must be followed to ensure technician and occupant safety. Blower door depressurization tests may not be performed in homes where there is a risk of asbestos becoming airborne and being drawn into the dwelling.

Respirators with filter cartridges must be worn when working in areas where exposure to airborne mold, asbestos, lead, fiberglass, or formaldehyde is a risk.

Carbon monoxide levels in the ambient air around the technician must be monitored throughout all combustion safety tests. Diagnostic evaluations and inspections must be aborted if ambient CO concentrations greater than 35 ppm are recorded. CO producing appliances must be disabled and repaired before proceeding with additional diagnostics or inspections.

Refer to standards on combustion safety for complete requirements applicable to carbon monoxide exposure limits and action levels.

The following are the minimum required health and safety diagnostics and specifications for the Building Analyst I certification. Minimum health and safety requirements apply to all jobs with work related to energy efficiency and/or indoor air quality performed by BPI accredited firms.

Minimum Health and Safety Requirements
(Building Analyst I)

(refer to main text for detailed descriptions and applications of the standards below)

- When air sealing, enclosed cavity insulation representing 15% or more of the total building shell area, or sealing of the ducts outside the thermal envelope are recommended, the work scope must include pre and post-installation blower door tests.
- Whenever blower door tests are required, the results must be compared to the Building Airflow Standard to verify compliance with ASHRAE 62-89 requirements for ventilation. If natural ventilation is inadequate according to the ASHRAE standard, mechanical ventilation must be installed or recommended as part of the work scope to increase the ventilation to required levels (refer to page 6 for specific requirements).
- A preliminary and post-installation safety inspection of all combustion appliances must be completed whenever changes to the building envelope and/or heating system are part of the work scope.
- The combustion appliance safety inspection includes all of the following: carbon monoxide test, draft measurement, spillage evaluation, and worst-case depressurization of the combustion appliance zone.
- In homes with natural gas/propane service, the gas line must be inspected thoroughly and all leaks repaired.
- Combustion safety test results must be acted upon appropriately according to the Combustion Safety Action Level Table.
- Whenever an appliance fails any of the combustion safety test, appropriate repairs must be completed or specified in the work scope according to the requirements listed (refer to tables on page 13).
- Appropriate inspection and diagnostic tests must be included in the workscope when attic insulation and/or ventilation are specified.
- Whenever air sealing or other shell-tightening measures are recommended, leakage paths to the attic must be given highest priority on the work scope.

Building Airflow

Whenever changes to the building shell requiring a blower door test are part of the work scope, a Building Airflow Standard must be calculated for the home according to the air exchange requirements provided by ASHRAE standard 62-89. Actual occupancy of the building must be used when calculating the Building Airflow Standard. An example of the calculation is shown below:

Minimum Building Airflow Standard Example Calculation (ASHRAE 62-89)

BUILDING DATA

Living Space Area = 1500 sqft
Basement Area = 700 sqft
# of Occupants = 4
# of Stories Above Grade= 2
Location = Albany, NY

Step 1: Calculate the Ventilation Required for the Building

AIRFLOW(b) = 0.35 x volume / 60
volume = 8 x (1500 + 700) = 17600 cubic feet
AIRFLOW(b) = 0.35 x 17600 / 60
= 102 cfm

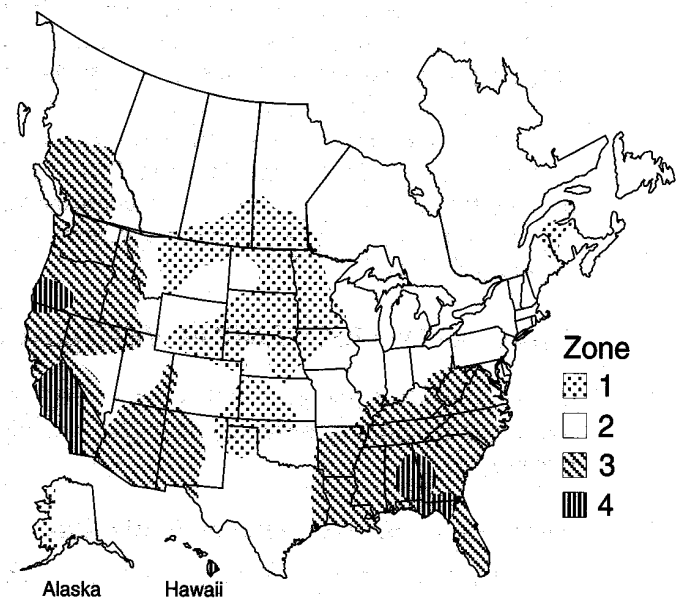
Step 2: Calculate the Ventilation Required for the People

AIRFLOW(p) = 15 x occupants
AIRFLOW(p) = 15 x 4
= 60 cfm

Step 3: Using the Higher Airflow Requirement, Convert to CFM50

MINIMUM_CFM50 = AIRFLOW x N
Where N is the LBL conversion factor (see chart)
MINIMUM_CFM50 = 102 x 15.4 = 1570 CFM50

Converting Between CFM 50 and Natural Airflow



LBL "N" Factors

Zone	N Factor
1	14-17
2	17-20
3	20-23
4	23-26

# of Stories	Height Correction Factor
1	1
1.5	0.89
2	0.81
2.5	0.76
3	0.72

To determine the correct multiplier, identify the N-factor for your region and multiply the result by the appropriate height correction factor
CFM50/N = Natural Airflow (cfm)

Height-Corrected N-Factors for New York

Number of Stories	N-Factor
1	19
1.5	16.8
2	15.4
2.5	14.4
3	13.7

A blower door test must be completed before and after installation of any of the following measures:

- Attic insulation, in order to quantify improvements to the air barrier between the attic and the living space.
- Enclosed cavity insulation representing an area greater than 15% of the total building shell area.
- Air sealing
- Sealing of ductwork located outside the building envelope or significant duct modifications within the building envelope.

Fires in woodstoves and/or fireplaces must be fully extinguished prior to performing a blower door test. Pressurization tests are not recommended under these conditions due to the fire safety risks.

If the measured CFM50 is less than the Building Airflow Standard (BAS), mechanical ventilation must be recommended or installed according to the following standards:

Condition	**Action**
BAS > final CFM50 > (0.7 x BAS)	Mechanical ventilation rated for continuous operation must be *recommended* to the customer as part of the work scope. System must be sized to make up the difference between the BAS and the final CFM50.
(0.7 x BAS) > final CFM50	Mechanical ventilation rated for continuous operation must be *installed* as part of the work scope. System must be sized to provide 100% of the ventilation requirement by mechanical means.

Recommended or installed mechanical ventilation must be designed appropriately to provide adequate air exchange to meet the occupancy ventilation requirements provided by ASHRAE 62-89.

Building Evaluation

Heat Loss and Savings Calculations
For heat loss and savings calculations, building components must be measured and area and volume calculations must be accurate +/- 10%. For use in heat loss and savings calculations use the following criteria for building component evaluations:

- R-values of installed insulation shall be determined based on an actual measurement of the insulation depth and the R-value per inch for that product.

- Voids in insulation must be accounted for by determining the net square footage of uninsulated area and recording it as a separate component of the building.
- Gaps between batt insulation and framing must be accounted for by determining the effective R-value for the insulation using the Effective R-value for Batt Insulation Chart provided below.
- Windows and doors must be measured and assigned appropriate R-values consistent with the material type and the ratings established by the National Fenestration Rating Council (NFRC). NFRC numbers are stamped on the metal spacer on most double-glazed (or better) units. This number may be looked up in the NFRC guide to determine the precise U-value and Solar Heat Gain Coefficient (SHGC).

Default Values for Insulation

When manufacturer's rated R-values for insulation are not available, use the chart below to estimate the R-value per inch for the installed product.

Typical Insulation R-values

Insulation Type	R-value per inch	Typical Applications
Cellulose, loose fill	3.7	Attic Floor
Cellulose, high density	3.2	Walls, Enclosed Cavities, Framing Transitions
Fiberglass, batts	3.0*	Basement Ceiling, Open Stud Walls, Attic Floor*
Fiberglass, loose fill	2.8	Attic Floor, Walls (existing)
Fiberglass, loose fill, fluffed below manufacturer's standards	uncertain	Do not install, or correct by blowing over with higher density
Rockwool	3.0	Attic Floor, Walls, Basement Ceiling (may be loose or batts)
Vermiculite	2.7	Attic Floor
Poly-isocyanurate, rigid board	7.0	Foundation Walls, Attic Access Doors
Polystyrene, expanded rigid board	4.0	Foundation Walls, Sill Plate
Polystyrene, extruded rigid board	5.0	Foundation Walls, Sub-Slab, Sill Plate
Low Density Urethane, sprayed foam	3.7	Attics, Walls (new construction); Sill Plate, Band Joist, Framing Transitions
Urethane, sprayed foam	6.0	Attics, Walls (new construction); Sill Plate, Band Joist, Framing Transitions
Urea Formaldehyde Foam	4.0	Attics, Walls (existing)

**see chart below for existing fiberglass batt evaluation*

Use the following chart to determine effective R-values for batt insulation installed in attics:

Effective R-values for Batt Insulation*

	"Good"	**"Fair"**	**"Poor"**
Measured Batt Thickness (inches)	Effective R-value (2.5 per inch)	Effective R-value (1.8 per inch)	Effective R-value (0.7 per inch)
0	0	0	0
1	3	2	1
2	5	4	1.5
3	8	5	2
4	10	7	3
5	13	9	3.5
6	15	11	4
7	18	13	5
8	20	14	5.5
9	23	16	6
10	25	18	7
11	28	20	8
12	30	22	8.5

1. *Measure the insulation thickness.*
2. *Determine the condition of the installation using the following criteria:*
   - ✓ *Good – No gaps or other imperfections*
   - ✓ *Fair – Gaps over 2.5% of the insulated area. (This equals 3/8 inch space along a 14.5 inch batt.)*
   - ✓ *Poor – Gaps over 5% of the insulated area. (This equals ¾ inch space along a 14.5 inch batt.)*
3. *Look up the effective R-value of the installed insulation using the condition and measured inches.*

**Derived from ASHRAE document "Heat Transmission Coefficients for Walls, Roofs, Ceilings, and Floors" 1996*

Default Values for Windows

Where NFRC numbers are not available, use the following chart to estimate the U-value and Solar Heat Gain Coefficient (SHGC) for windows and glazed areas of doors. If there is not a label etched on the glass identifying the presence of a low-e coating, this can be verified using a spectrally selective metering device. The values shown below are only estimates. They do not account for all possible window configurations and variations due to airspace thickness, insulated frames, mullions, etc. Since U-values can vary greatly depending on the window type (double-hung, casement, fixed) even within the same manufacturer's model line, it is strongly recommended that NFRC ratings are used whenever the windows are appropriately labeled.

Default Window Values

Frame Type	Glazing Type	U-Value	SHGC	U-Value with low e	SHGC with low e
Wood	Single	.90	.65	NA	NA
	Single w/ Storm	.49	.71	NA	NA
	Double	.49	.58	.39	.45
	Triple	.39	.53	.30	.45
Vinyl	Double	.46	.57	.36	.45
	Triple	.36	.52	.36	.45
Metal	Single	1.31	.80	NA	NA
	Double	.87	.73	NA	NA
Metal w/ Thermal Break	Double	.65	.66	.53	.52
	Triple	.53	.60	.43	.52

Combustion Safety and Carbon Monoxide Protection

A preliminary and post-installation safety inspection of all combustion appliances must be completed whenever changes to the building envelope and/or heating system are part of the work scope. This inspection includes all of the following tests: carbon monoxide (CO) measurement at each appliance, draft measurement and spillage evaluation for atmospherically vented appliances, and worst-case negative pressure measurement for each combustion appliance zone (CAZ). Combustion safety test results must be acted upon according to the Combustion Safety Action Level table.

Carbon Monoxide Tests
CO shall be measured of undiluted flue gases, in the throat or flue of the appliance using a digital gauge and measured in parts per million (ppm).

Do not drill holes in flues for power vented or sealed combustion units. Instead, measure CO at the exterior outlet of the flue and proceed with appropriate actions according to the CO limits identified in the Combustion Safety Action Level table.

For all combustion appliances, CO shall be measured at steady-state operating conditions. Measurements shall be taken of undiluted flue gases.

With the exception of unvented gas or propane cooking appliances, CO must be tested in all combustion appliances under worst-case conditions and normal draft conditions (when the appliance fails under worst-case). In addition, it is recommended that CO be tested under a mild down-draft if conditions are safe.

For gas ovens, CO shall be measured at steady state (usually after 5-10 minutes of operation) at the highest setting. When measuring CO on gas ovens, it is recommended to turn on the exhaust hood and open a window to reduce risk of exposure to elevated ambient CO levels.

Ambient CO levels shall be monitored upon entering the combustion appliance zone and during the test period for all appliances. If ambient levels exceed 35 ppm at any time, turn off the appliance immediately and make appropriate repair recommendations according to the charts provided.

Spillage and Draft Tests
Spillage and draft tests must be completed for all natural and induced draft space heating systems and water heaters. Spillage and draft must first be tested under worst-case conditions (see procedure below) and then repeated for natural conditions if the appliance fails under worst-case.

When a chimney is shared by multiple appliances the appliance with the smallest Btu input rating shall be tested first and remaining appliances tested in order of increasing input rate.

Induced draft heating systems shall be checked for spillage at the base of the chimney liner or flue. If a chimney is shared between and induced draft heating system and a natural draft water heater, spillage shall be checked at the water heater draft diverter.

Vent draft pressure shall be measured at steady-state operating conditions for all natural draft heating and hot water appliances. Draft test location should be approximately 1-2' downstream of the appliance draft diverter. The test hole must be sealed with an appropriate plug after the test. Acceptable draft test results are shown below:

Acceptable Draft Test Ranges

Outside Temperature (degree F)	Minimum Draft Pressure Standard (Pa)
<10	-2.5
10-90	(T_out ÷ 40) – 2.75
>90	-0.5

Most appliances will spill upon startup with a cold chimney. Document the amount of time it takes for spillage to stop and a positive draft to be established. Any appliance that continues to spill flue gases beyond the time limits established in the statement below has failed the spillage test.

Acceptable Appliance Spillage Periods

Vented appliances, regardless of type, that spill flue gases for more than 60 seconds after startup, fail the spillage test.

Worst-Case CAZ Depressurization

The worst-case depressurization test is configured by determining the largest combustion appliance zone depressurization due to the combined effects of door position, exhaust appliance operation, and air handler fan operation. A base pressure must be measured with all fans off and doors open. The worst-case depressurization is the pressure difference between worst-case and the base pressure.

A recommended protocol for completing all of the combustion safety tests for vented appliances follows. This step-by-step procedure is recommended to guide technicians through a complete combustion safety analysis safely and efficiently: (see chart on following page)

Gas Supply Safety

The entire gas/propane line must be examined and all leaks repaired. Particular care should be made in the immediate vicinity of the appliances and at the joints, shutoff valves, and pilot lines. Identify leaks using a gas leak detector and accurately locate the source of the leak using a soap bubble solution.

Flexible gas lines must be replaced if they are: kinked, corroded or show signs of visible wear, the line was manufactured before 1973 (date is stamped on the date ring attached to the line), or the line has any soldered connections.

COMBUSTION SAFETY TEST PROCEDURE FOR VENTED APPLIANCES

1. **Measure the Base Pressure.** Start with all exterior doors, windows, and fireplace damper(s) closed. Set all combustion appliances to the pilot setting or turn off the service disconnect, including: boiler, furnace, space-heaters, and water heater. With the home in this configuration, measure and record the base pressure of the combustion appliance zone (CAZ) WRT outside.
2. **Establish the Worst Case.** Turn on the dryer and all exhaust fans. Close interior doors that make the CAZ pressure more negative. Turn on the air handler, if present, and leave on if the pressure in the CAZ becomes more negative, then recheck the door positions. Measure the net change in pressure from the CAZ to outside, correcting for the base pressure. Record the "worst case depressurization" and compare to the CAZ Depressurization Limit Table.
3. **Measure Worst Case Spillage, Draft, CO.** Fire the appliance with the smallest Btu capacity first, test for spillage at the draft diverter with a mirror or smoke test, and test for CO at the flue at steady-state (if steady-state is not achieved within 10 minutes, take CO readings at the 10 minute mark). If the spillage test fails under worst-case go to step 4. If spillage ends within 1 minute, test the draft in the connector 1-2' after the diverter or first elbow. Fire all other connected appliances simultaneously and test the draft diverter of each appliance for spillage. Test for CO in all appliances in the flue, before the draft diverter.
4. **Measure Spillage, Draft, CO under Natural Conditions.** If spillage fails under worst case, turn off the appliance, the exhaust fans, open the interior doors, and allow the vent to cool before re-testing. Test for CO, spillage, and draft under "natural conditions". Measure the net change in pressure from worst case to natural in the CAZ to confirm the "worst case depressurization" taken in step 2. Repeat for each appliance, allowing the vent to cool between tests.
5. **Ambient CO.** Monitor the ambient CO in the breathing zone during the test procedure and abort the test if ambient CO goes over 35 ppm. Turn off the appliance, ventilate the space, and evacuate the building. The building may be reentered once ambient CO levels have gone below 35 ppm. The appliance must be repaired and the problem corrected prior to completing the combustion safety diagnostics. If the ambient levels exceed 35 ppm during testing under natural conditions, disable the appliance and instruct the homeowner to have the appliance repaired prior to operating it again.
6. **Action Levels.** Make recommendations or complete work order for repairs based on test results and the Combustion Safety Test Action Level Tables.

Combustion Safety Test Action Levels

CO Test Result*	And/ Or	Spillage and Draft Test Results	Retrofit Action
0 – 25 ppm	*And*	**Passes**	Proceed with work
26 – 100 ppm	*And*	**Passes**	Recommend that the CO problem be fixed
26 – 100 ppm	*And*	**Fails at worst case only**	Recommend a service call for the appliance and/or repairs to the home to correct the problem
100 - 400 ppm	*Or*	**Fails under natural conditions**	Stop Work: Work may not proceed until the system is serviced and the problem is corrected
> 400 ppm	*And*	**Passes**	Stop Work: Work may not proceed until the system is serviced and the problem is corrected
> 400 ppm	*And*	**Fails under any condition**	Emergency: Shut off fuel to the appliance and have the homeowner to call for service immediately

**CO measurements for undiluted flue gases at steady state*

When CAZ depressurization limits are exceeded under worst-case conditions according to the CAZ Depressurization Limit table, make up air must be provided or other modifications to the building shell or exhaust appliances must be included in the work scope to bring the depressurization within acceptable limits. Worst-case CAZ depressurization limits are shown below:

CAZ Depressurization Limits

Venting Condition	Limit (Pascals)
Orphan natural draft water heater (including outside chimneys)	-2
Natural draft boiler or furnace commonly vented with water heater	-3
Natural draft boiler or furnace with vent damper commonly vented with water heater	-5
Individual natural draft boiler or furnace	-5
Mechanically assisted draft boiler or furnace commonly vented with water heater	-5
Mechanically assisted draft boiler or furnace alone, or fan assisted DHW alone	-15
Exhausto chimney-top draft inducer (fan at chimney top); High static pressure flame retention head oil burner; Sealed combustion appliances;	-50

If the CO in any appliance is measured greater than 100 ppm during diagnostic testing, or the ambient CO in the home exceeds 35 ppm during appliance operation, an appliance clean and tune must be completed as part of the work scope.

The homeowner shall be notified of the results of all combustion safety tests.

Unvented Appliances
No unvented combustion appliances may operate in the living space with the exception of gas ranges/ovens. Exhaust ventilation must always be recommended whenever a gas or propane cooking appliance exists. See table below for testing instructions and action levels.

Interim Gas/Propane Oven Testing Procedure

Range tops and ovens produce moisture and oxides of nitrogen. Excess moisture is not good for the durability of the home (possibly contributing to mold problems) and NOX is not healthy. These combustion appliances are capable of producing CO, which is a health hazard. In all cases a carbon monoxide detector is recommended and homeowners should use exhaust ventilation when using these appliances. New appliances may require an extended warm up period to reach steady state.

1. Remove any items/foil in or on oven.
2. Make sure self cleaning features are not activated, set oven to highest setting.
3. Test oven for CO in the flue, before dilution air.
4. After 5 minutes of operation, check for steady state:

Level I Action - 100 ppm to 300 ppm as measured you must install a carbon monoxide detector and recommendation for service must be made to the consumer.

Level II Action - Greater than 300 ppm as measured - the unit must be serviced prior to work. If greater than 300 ppm after servicing, exhaust ventilation must be provided with a capacity of 25 CFM continuous or 100 CFM intermittent.

***Continually monitor ambient CO levels during test.**

Since all gas cooktops generate CO and it is difficult to simulate an actual operating condition for these appliances during the course of a typical house inspection, specific action levels for these burners are not specified by BPI. However, technicians must specify appropriate measures to mitigate potentially dangerous CO production of these units. ASHRAE exposure limits for CO shall be referenced when making recommendations for CO control in these areas. The recommended ASHRAE limit for 24-hour exposure of 9 ppm shall be applied to building occupants. In most cases, it will not be possible to effectively test for this condition, however the following measures shall be recommended whenever gas cooktops exist in the home:

- ✓ If burners do not ignite properly or do not burn cleanly, a clean and tune of the appliance shall be recommended.
- ✓ If the appliance is located in a confined space and mechanical ventilation is not readily available, mechanical ventilation shall be recommended.

Ventilation provided for unvented gas ovens must provide a minimum capacity of 25 cfm continuous airflow or 100 cfm intermittant.

CO Detectors

At least one CO detector meeting UL-2034 requirements shall be installed according to manufacturer's instructions in every home with an attached garage and/or combustion appliances. It is recommended that additional CO detectors are installed, as needed, to provide a separate detector for each floor of the building.

Furnace Inspection

Forced warm air furnaces must be inspected for flame interference. Visually inspect the burner as the blower fan comes on. If the flames burn differently when the blower comes on, a complete analysis needs to be done to find the source of the flame interference. This problem must be referred to a heating contractor. A cracked heat exchanger cannot effectively be repaired and must be replaced.

Attached Garages

Garage to living space connections must be tested for air tightness using a smoke stick in conjunction with the blower door. Air leaks between the garage and living space must be sealed as part of the work scope.

Work Scope Requirements

Insulation and Air Sealing
Attic ventilation shall not be recommended or installed without first verifying the presence of an effective air barrier and thermal barrier between the attic and the living space or specifying appropriate attic air sealing as part of the work scope.

Attic insulation shall not be recommended or installed without first verifying the presence of an effective air barrier between the attic and living space or specifying appropriate attic air sealing as part of the work scope.

Appropriate inspection and diagnostic tests (listed below) must be recommended as part of the work scope for a Shell Specialist when attic insulation and/or ventilation are recommended.

The effectiveness of the air barrier shall be determined using the following techniques:

- ✓ Pressure differential diagnosis, including: series leakage tests and/or "add a hole" method where applicable. (Refer to the blower door instruction manual for details on how to perform these tests.)
- ✓ Visual inspection of the attic. Visual indicators include all of the following:
  - o Inspect the attic floor underneath the insulation to locate thermal by-passes and cavities requiring air sealing.
  - o Inspect for areas where moisture migration into the attic is apparent and determine the source of the moisture.
  - o Insulation that has turned black is an indicator of air movement through the insulation. Identify the source.
- ✓ With the blower door running under depressurization, use a smoke stick in the attic to verify the integrity of installed air sealing measures.

If communication between the attic and living space is identified using any of the tests listed above, the area must be sealed prior to installation of insulation and/or ventilation in the attic. Whenever air sealing or other shell-tightening measures are recommended, leakage paths to the attic must be given the highest priority on the work scope.

Refer to local codes for minimum required insulation levels.

Where air sealing, enclosed cavity insulation representing 15% or more of the total building shell area, or sealing of ducts outside the thermal envelope are recommended, the work scope must include pre and post-installation blower door testing.

Ductwork
When duct sealing is recommended, the work scope must include pre and post-installation duct leakage and system airflow testing.

When heating ducts are located outside the building envelope or cooling ducts are located in attic spaces, they must always be sealed underneath the duct wrap, at all accessible connections with duct mastic and insulated to a minimum R-5 as part of the work scope.