Testing In & Testing Out Requirements for BPI Accredited Contractors

Testing Requirements according to BPI Building Analyst Standards (v: 2/28/05 mda)

Testing Required*	When Required	Ref Pg	Additional Information	Ref Pg
Pre and post blower door tests (included in workscope)	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	3	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.	6
Pre and post safety inspection of all combustion appliances (Oven, Worst Case, spillage, draft, CO)	Whenever changes to the building envelope and/or heating system are part of the work scope	3, 17	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).	17
Gas leak detection	In homes with natural gas/propane service	3	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.	11
Pre and post duct leakage testing	When duct sealing is recommended	17	When duct sealing is recommended, the work scope must include pre and post-installation duct leakage and system airflow testing.	17
Minimum airflow calculation	Whenever changes to the building shell requiring a blower door test are part of the work scope	4		

* "Testing Required" refers only to diagnostic testing with test equipment, and not to any form of visual inspection

Testing In & Testing Out Requirements for BPI Accredited Contractors

Testing Requirements according to BPI Shell Specialist Standards (v: 2/05/03 mda)

Testing Required	When Required	Ref Pg	Additional Information	Ref Pg
Pre and post blower door tests (included in workscope)	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	3	Blower door tests must be performed before and after the 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.	4
Pre and post safety inspection of all combustion appliances (Oven, worst-case, spillage, draft, CO)	When a mechanical ventilation system is installed in a building where combustion appliances are present	3	When a mechanical ventilation system is installed in a building where combustion appliances are present, a complete post-installation combustion safety diagnostic must be conducted and conditions must meet all minimum safety requirements for draft, spillage, and CAZ depressurization as established in the BPI Building Analyst I Standards.	4
Pressure diagnostics (series leakage, add-a-hole)	Before and after installation of attic insulation and/or ventilation to ensure an effective air barrier exists between the attic and living space	3	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: Inspect the attic floor underneath the insulation to locate thermal by-passes and cavities requiring air sealing. Inspect for areas where moisture migration into the attic is apparent and determine the source of the moisture. Insulation that has turned black is an indicator of air movement through the insulation.	5
Pre and post duct Leakage testing	When duct sealing is part of the workscope	7	Duct leakage must be quantified before and after duct sealing installations. These tests may be performed by the inspector or the installer. The results of these tests must be documented and used to verify the effectiveness of the installation.	7

Testing In & Testing Out Requirements for BPI Accredited Contractors

Testing Requirements according to BPI Heating Specialist Standards (v: 11/20/07 mda)

Testing Required	When Required	Ref Pg	Additional Information	Ref Pg
Gas leak detection	In homes with natural gas/propane service	3	The entire gas 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.	8
Duct leakage testing	New installations; quantifying leakage, before work is done on a heating plant or ductwork	4	New installations of ducted distribution systems must be tested for leakage using a duct leakage testing device and duct tightness must meet or exceed the requirements set forth in the EPA standards for Energy Star Ducts. The sum of the supply and return leakage to outside, measured in cfm25, divided by the fan flow shall be no more than 10%. When quantifying duct leakage, an appropriate type of measurement system shall be used, which includes a metered and calibrated duct pressurization device.	4, 9, 10
Safety inspection of combustion appliances (Worst-case, spillage, draft, CO)	Heating plant replacement	5	Water heaters may not be left venting alone into a previously shared chimney without ensuring the chimney meets appropriate NFPA requirements under the new condition and the water heater has been tested and passed all required combustion safety tests (spillage, draft, CAZ depressurization).	5
Blower door test	Heating plant replacement	5	When atmospherically vented combustion appliances are replaced with sealed combustion units, an exhaust appliance has been removed from the home. To ensure that the building will have adequate air exchange after this retrofit, a blower door test must be completed and mechanical ventilation installed as needed to provide ventilation levels compliant with ASHRAE Standard 62-89. This procedure must be followed even if no alterations to the building shell are anticipated as part of the work scope.	5
Combustion gas analysis	For all heating plants	5	A combustion gas analysis is required on oil-fired and gas-fired furnaces and boilers, any time replacement or repair is not part of the intended work scope.	5
Temperature rise	Before and after work is performed	9	Forced air furnaces must be tested using a heat rise measurement.	9

Testing In & Testing Out Requirements for BPI Accredited Contractors

Testing Requirements according to BPI A/C, Heat-Pump Specialist Standards (v 1.1: February 2003, ckm)

Testing Required	When Required	Ref Pg	Additional Information	Ref Pg
Electrical test	During related inspection	17	Existing wiring systems must be inspected for safe installation and compliance with applicable codes. This inspection should include, but is not limited to: Checking for obvious loose connections; visual inspection of contactor contacts to verify good condition (no pitting, etc.); properly sized wire gauge as required by the circuit amp draw.	17
Electrical test	During related inspection	17	Voltage drop across contacts and relays may not occur. If a voltage drop is measured, the source must be located and corrected.	17
Duct airflow testing	During related inspection	17	System airflow may be measured using a metered and calibrated pressurization device, a metered and calibrated flow plate, or a flow capture hood designed for the flow range anticipated.	17
Duct leakage testing	When duct sealing is part of the work scope	17, 18	Pre- and post-installation duct leakage shall be measured any time that duct sealing is part of the work scope to verify the success of the installation. When quantifying duct leakage, a measurement system that includes a metered and calibrated duct pressurization device shall be used.	17, 18
Refrigerant charge	During related inspection	18	Refrigerant charge may be measured using the following methods: Use sub-cooling method for TXV-equipped systems, Use superheat method for non-TXV-equipped systems, (Alternative manufacturer-specific procedures may be allowable. Submit alternative procedures to BPI for review and approval.), If airflow is changed, the refrigerant charge must be retested.	18

Testing In & Testing Out Requirements for BPI Accredited Contractors

Testing Requirements according to Manufactured Home Standards (v 2.0: May 2003 ckm)

Testing Required	When Required	Ref Pg	Additional Information	Ref Pg
Duct system	During related inspection	6	The pressure pan shall be used to identify the location and estimate the magnitude of the duct leaks.	6
Duct system	During related inspection	6	Room-to-room pressures shall be measured in all rooms with doors. The work scope shall include strategies to mitigate room pressures that exceed 3 Pascals between rooms.	6
Infiltration	When measures are installed which may affect the airflow characteristics of the building envelope	12	Pre-installation blower door tests are required. Post-installation blower door tests are required when measures are installed which may affect the airflow characteristics of the building envelope.	12
Mechanical systems	During related inspection	14	Check for visual signs of spillage prior to testing.	14
Mechanical systems	During related inspection	14	Furnaces and water heaters should be tested for CO with the door to the furnace/water heater closet closed. CO measured after 5 minutes of operation may not exceed 100 ppm. Units producing CO in excess of 100 ppm must be repaired or replaced.	14

BUILDING PERFORMANCE INSTITUTE

TECHNICAL STANDARDS

FOR THE BUILDING ANALYST PROFESSIONAL

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 Professional 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 Professionals)

(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

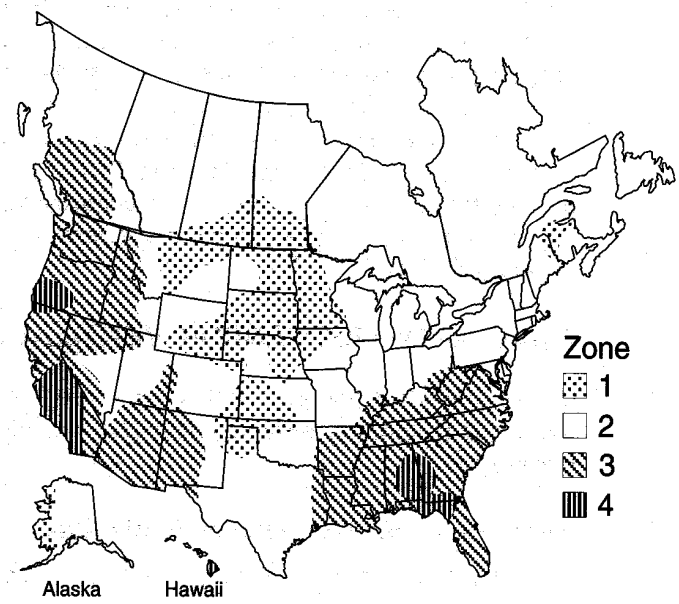
Step 2: Calculate the Ventilation Required for the People

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 an Envelope Professional 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.

Building Performance Institute, Inc.

BPI Standards

BPI 104

Envelope Professional Standard

Raising the Bar in Building Performance Contracting

August 3, 2010

BUILDING PERFORMANCE INSTITUTE
TECHNICAL STANDARDS
FOR THE ENVELOPE PROFESSIONAL

Health and Safety

Personal 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 known or suspected hazardous material is present, 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.

Refer to standards on combustion safety (Building Analyst Professional) for requirements applicable to carbon monoxide exposure

Occupant Health and Safety

Where moisture problems exist, moisture sources must be mitigated through elimination of the source, isolation of the source, or ventilation of the space around the source before proceeding with other shell-related measures.

The homeowner must be notified of any health and safety hazards identified during the course of inspections and installations in the home. These hazards include, but are not limited to: indoor air contaminant sources, moisture problems, structural problems, electrical problems, and fire protection issues. Wherever problems are identified or suspected that fall outside the technician's area of expertise, the technician must inform the client of the problem and recommend an evaluation by a professional who specializes in this subject.

Clothes dryers, regardless of fuel type, and bathroom exhaust fans must be vented directly outside using appropriate duct materials (metal ducts are required for gas fueled clothes dryers) before proceeding with installation of air sealing, duct sealing, or enclosed cavity insulation measures. Exhaust ducts running through unconditioned space must be insulated and have a minimum ¼" rise for every foot of run towards wall or roof terminations.

The following are the minimum required health and safety diagnostics and specifications for Envelope Professional level certification. These requirements are in addition to those set forth in the BPI Technical Standards for Building Analyst Professional. 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
(Envelope Professional)

(refer to main text and the Building Analyst Professional Standards for detailed descriptions and applications of the standards below)

- Blower door tests must be performed before and after the installation of air sealing, enclosed cavity insulation representing more than 15% of the building shell area, or sealing of ductwork located outside the building envelope.
- If the measured CFM50 is less than the Building Airflow Standard, as set forth in ASHRAE 62-89, mechanical ventilation must be recommended or installed according to the standards.
- When a mechanical ventilation system is installed in a building where combustion appliances are present, a complete post-installation combustion safety diagnostic must be conducted and final conditions must meet minimum safety requirements for draft, spillage, and CAZ depressurization.
- Air sealing measures must be prioritized to reduce the stack effect and inhibit moisture migration into attics or other interstitial spaces.
- Appropriate inspection and diagnostic tests must be performed before and after installation of attic insulation and/or ventilation to ensure an effective air barrier exists between the attic and living space.
- Prior to installing insulation in an existing home, a thorough inspection of the interior and exterior of the home is required to identify areas where installation of insulation may be unsafe. Problems that are identified must be remedied prior to installation.
- Insulation may not be installed where live knob and tube wiring exists.
- Recessed can light fixtures that are not IC–rated, chimneys, and other heat producing obstructions must be baffled with an effective dam prior to insulating the area to maintain minimum clearances to insulation or other combustible products.

Airflow and Mechanical Ventilation

Blower door tests must be performed before and after the 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.

If the measured CFM50 is less than the Building Airflow Standard (BAS) as set forth in ASHRAE Standard 62-89, 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.

When a mechanical ventilation system is installed in a building where combustion appliances are present, a complete post-installation combustion safety diagnostic must be conducted and conditions must meet all minimum safety requirements for draft, spillage, and CAZ depressurization as established in the BPI Building Analyst Professional Standards.

All ventilation duct systems, including local exhaust, must be appropriately ducted to provide the most direct route outside as possible. When determining installed airflow rates, friction losses through the ducts must be accounted for either through direct measurement using a flow hood or similar device, or by calculating the friction losses and subtracting them from the rated cfm airflow of the fan.

Ventilation exhaust ductwork must have a minimum rise of ¼" per foot of run and when located outside the building shell, must be fully insulated to a minimum R-7.

Mechanical ventilation systems that include a supply and return must be tested and verified for adequate airflow and balance after installation.

Installation Requirements

An effective and continuous thermal and pressure boundary shall be established in each home through the installation of appropriate air sealing and insulation measures. Wherever possible, air sealing and insulation strategies shall be designed to align the thermal and pressure boundaries to create a single continuous Thermal Envelope. Minimum insulation levels shall be determined based on local codes. Air sealing strategies shall be determined based on blower door diagnostic results, visual inspection of critical by-pass areas, and indoor air quality evaluations for each home.

Air Sealing

Air sealing measures shall be prioritized to reduce the stack effect and inhibit moisture migration into attics or other interstitial spaces. Blower door quick tests should be performed during air sealing to track progress and verify results.

Appropriate inspection and diagnostic tests (listed below) must be performed before and after installation of attic insulation and/or ventilation to ensure an effective air barrier exists between the attic and living space.

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 is recommended, leakage paths to the attic must be given the highest priority on the work scope.

The following checklist shall be used as a guide during air sealing installations:

- ✓ Air seal communication between the attic and living space first. Areas to seal include: by-passes around chimneys, ducts, drop soffits, shower inserts or other large penetrations; interior and exterior wall top-plates; and plumbing and wiring penetrations.
- ✓ Leakage paths identified between attached or tuck-under garages and the living space must always be sealed.
- ✓ After establishing an effective air barrier between the attic and living space, basement air sealing may be completed. Areas to be sealed in basements shall be determined based on the use of the basement area. Conditioned or tempered basements shall be sealed at the rim joist and other connections to outside. In unconditioned basements, air sealing shall be targeted at reducing the communication between the basement and the conditioned space above.
- ✓ Reduce air leakage paths through building cavities by using manual air sealing, high density cavity insulation (see below) or air impermeable spray foam.
- ✓ If the house CFM50 is still higher than the Building Airflow Standard after sealing the attic, garage, and basement, interior air-sealing may be performed as needed including: sealing around plumbing penetrations, caulking around window and door casings, caulking around molding and baseboards, or other significant leakage areas identified using the blower door.

Air sealing installations must be installed to be permanent improvements to the structure. Products with an expected lifespan of less than 20 years shall not be used.

Pressure differential analysis shall be used to assist in identifying leakage paths and prioritizing air sealing measures.

Using Insulation for Air Sealing

For leakage paths through enclosed cavities which cannot be accessed or reasonably sealed using conventional air sealing techniques, BPI requires installation of high density pneumatically applied insulation - which complies with BPI-102 “Standard for Air Resistance of Thermal Insulation Used in Retrofit Cavity Applications – Material Specification” - or air impermeable foam insulation, to reduce airflow through the building shell.

Cellulose insulation used in an enclosed cavity shall be installed at 3.5 pounds per cubic foot or greater density. Blown fiber glass, mineral fiber, rock and slag wool, or spray foam used in an enclosed cavity shall be installed at or above the manufacturer’s recommended density to limit airflow that corresponds to an air permeance value of ≤ 3.5 cfm/sq ft at 50 Pascals, as measured using BPI-102 “Standard for Air Resistance of Thermal Insulation Used in Retrofit Cavity Applications – Material Specification” or ASTM C 522, E 283 or E 2178. The test report shall be provided to BPI.

Duct Sealing

Due to the fact that duct sealing may affect building airflow characteristics and air sealing measures may affect duct leakage characteristics, the Envelope Professional must evaluate the need for duct sealing and a work scope for duct sealing must be developed in conjunction with shell measures using the standards listed below.

Duct leakage must be quantified before and after duct sealing installations. These tests may be performed by the inspector or the installer. The results of these tests must be documented and used to verify the effectiveness of the installation.

Whenever possible, retrofit duct leakage rates to outside should be below the standards established by the EPA for Energy Star Ducts. The sum of the supply and return leakage to outside, measured in cfm25, divided by the fan flow should be no more than 10%.

Maximum Allowable Duct Leakage Calculation Example

System Airflow: 1200 cfm

Formula:
Total_Allowable_ Duct_Leakage = System_Airflow x 0.10

Example:
Total_Allowable_Duct_Leakage = 1200 x 0.10 = 120 cfm25

Note: This calculation is based on duct leakage to outside. Leakage to outside must be determined through direct testing using a duct leakage pressurization device in conjunction with the blower door. If a blower door is not available, duct leakage to outside may be estimated by measuring total duct leakage and estimating the percentage of measured leakage that is leaking to outside based the location of the ductwork.

When quantifying duct leakage, an appropriate type of measurement system shall be used, which includes a metered and calibrated duct pressurization device. Pre and post-installation duct leakage shall be measured and documented any time that duct sealing is part of the work scope to verify the success of the installation.

Duct leakage areas must be diagnosed using appropriate duct leakage testing equipment and/or pressure pan tests to prioritize leakage areas (treating the largest leaks and the highest pressure areas first) anytime duct sealing is installed.

Use the following checklist as a guide for prioritizing duct sealing installations:

- ✓ Seal the largest leaks first. These include: disconnected ducts, missing end-caps, and other catastrophic holes

- ✓ Seal the areas of highest pressure. These include all the connections near the air-handler cabinet and supply and return plenums, flexible canvas plenum connectors, and filter slot covers.
- ✓ Seal return leaks that may contribute to negative pressures in the combustion appliance zone.
- ✓ Seal all accessible connections between duct sections, at branches, and where take-offs connect to main trunk lines.
- ✓ Seal take-off connections to register boots and boot connections to floors, walls, and ceilings.

Sheet metal and flexible ductwork shall be sealed at all duct connections using duct mastic or similar product designed for sealing ducts. Duct tape is not an allowable duct sealing material. Aluminum FSK tape may be used on ductboard systems and at the connections to the air handler cabinet.

Insulation

Prior to installing insulation in an existing home, a thorough inspection of the interior and exterior of the home is required to identify areas where installation of insulation may be unsafe. Problem areas include: areas with knob and tube wiring, recessed light fixtures, areas where moisture is present or suspected, and structurally unsound building elements (suspended acoustical tile ceilings, wood paneling, etc.) Problems that are identified must be remedied prior to insulating.

Insulation may not be installed in areas of homes where live knob and tube wiring exists.

Attic insulation may not be installed without first verifying the presence of an effective air barrier between the attic and living space via visual inspection and pressure differential testing as identified in the standards for air sealing listed above.

Attic ventilation may not be installed without first verifying the presence of an effective air barrier and thermal barrier between the attic and the living space. Refer to local codes for minimum requirements for insulation and ventilation.

Recessed can light fixtures that are not IC rated and chimneys must be baffled with an effective dam prior to insulating to maintain a minimum 3” clearance to the insulation being installed. Single-walled flue pipes require a minimum 6” clearance to insulation or other combustible materials. Refer to NFPA 54 for additional requirements for specific chimney materials.

Where soffit vents are present, and access is viable, appropriate blocking or baffles are required to provide protection from wind-washing where insulation exists.

Batt insulation shall be installed at full loft with the insulation in full contact with the warm building surface. Gaps between the insulation and the building elements must be avoided. Insulation batts shall not be compressed, folded, tucked, rolled, or otherwise compromised when installed for insulation purposes.

Insulation installed in kneewalls or other exposed vertical areas must be covered on the cold side with an air barrier such as plywood or housewrap to protect the insulation from wind-washing and free convection within the insulation. This measure is not necessary if rigid foam insulation is used.

Blown insulation shall be installed at appropriate air pressure and material quantity to ensure complete coverage and manufacuturer's recommended density to achieve the prescribed R-value without voids, gaps, or settling in enclosed cavities.

All attic access openings, including doors, hatches, and pull-down stairs shall have a tightly fitting cover which is insulated to a minimum R-14.

Windows

Windows shall be installed according to manufacturer's instructions to assure proper operation and moisture protection. Rough openings shall be sealed to be air tight prior to installation of casings and sills. Newly installed windows shall be inspected and verified for proper operation of all hardware and locking mechanisms.

Refer to EPA guidelines and local codes for requirements for retrofit window installations in locations where lead and/or asbestos may be present.

BUILDING PERFORMANCE INSTITUTE TECHNICAL STANDARDS FOR CERTIFIED HEATING SPECIALISTS

Health and Safety

Personal 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 known or suspected hazardous material is present, 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 (Building Analyst I) for requirements applicable to carbon monoxide exposure.

Electrical power must be shut off before working on mechanical equipment.

Occupant Safety

A deteriorated chimney must be repaired or relined and the cause corrected before reusing. Repairs and/or replacements must be installed in compliance with the following standards: NFPA 31 for oil fired units, NFPA 54 for gas fired units, NFPA 211 for solid fuel units.

Measured carbon monoxide levels of undiluted flue gases in combustion appliances should be below 25 ppm. Appliances with multiple burners may have multiple ports and CO must be measured in each one. Efforts should be made to lower the CO level if it is higher than 25 ppm, but in no case should the level be higher than 100 ppm without servicing the system to reduce its CO production. If CO levels exceed 100 ppm and the appliance spills under natural conditions, the problem must be repaired before proceeding with other measures.

A thorough inspection of the fuel supply for both oil and gas must be conducted to ensure the system is leak free. Leaks that are found must be repaired prior to proceeding with work on the system.

The following are the minimum required health and safety diagnostics and specifications for Heating Specialist level certification. These requirements are in addition to those set forth in the BPI Technical Standards for Certified Building Analyst I. 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
(Heating Specialist)

(refer to main text and the Building Analyst I Standards for detailed descriptions and applications of the standards below)

- Combustion appliances which fail any combustion safety test, as described in the Building Analyst I Standards, must be adjusted, repaired, or replaced; and the problem effectively remedied before proceeding with additional installations.
- When atmospherically vented combustion appliances are removed or replaced with sealed combustion units, a blower door test must be done to verify adequate air exchange across the building shell. Mechanical ventilation must be added, as needed to provide adequate air exchange in compliance with ASHRAE 62-89.
- When a high efficiency appliance, such as a furnace, is installed and no longer requires chimney venting, "orphaned" water heaters must be tested and verified for safe operation.
- In homes with natural gas service, the gas line must be inspected thoroughly and all leaks repaired.
- Forced warm air furnaces must be inspected for flame interference and additional heat exchanger integrity tests must be performed as indicated by the flame interference inspection. Cracked heat exchangers must be replaced.
- Steam distribution system pipes must be insulated in all accessible locations.
- All water heaters must have a pressure and temperature relief valve and a safety discharge pipe. Install a relief valve and discharge pipe if none exists.

Heating System Replacement and New Installations

Replacement System Sizing
New installations of heating systems must be designed and sized based on actual heating load calculations for the building. Acceptable sizing calculation methods include ACCA Manual J and Manual S, IBR load calculations, or other comparable calculation procedures. Replacement systems may not be sized larger than the existing system without providing a load calculation verifying the need for a larger system. Gas and electrically fueled heating systems must be sized within 25% of calculated design loads. Oil fueled heating systems must use the smallest available burner size that meets the calculated heating load for the building.

It is recommended that blower door test results are used to determine the building air leakage rates input into load calculations.

Hydronic Systems
New installations of hydronic distribution systems shall be designed based on actual calculated Btu loads for the space being conditioned utilizing Manual J or comparable calculation methodology. Radiator size must be within 20% of calculated loads for the space being conditioned.

Ducted Distribution Systems
New installations of ducted distribution systems shall be designed to provide the appropriate airflow based on actual calculated Btu loads for the space being conditioned using Manual J or comparable calculation methodology. Duct systems shall incorporate provisions for friction losses in the design, and shall provide for balanced supply and return airflows in each zone of the building. After installation, register airflows must be measured and verified to deliver airflows that are within 20% of design airflows. Deviations from design criteria greater than 20% must be corrected.

New installations of ducted distribution systems must be tested for leakage using a duct leakage testing device and duct tightness must meet or exceed the requirements set forth in the EPA standards for Energy Star Ducts. The sum of the supply and return leakage to outside, measured in cfm25, divided by the fan flow shall be no more than 10%.

When quantifying duct leakage, an appropriate type of measurement system shall be used, which includes a metered and calibrated duct pressurization device.

Maximum Allowable Duct Leakage Calculation Example

System Airflow: 1200 cfm

Formula:
Total_Allowable_ Duct_Leakage = System_Airflow x 0.10

Example:
Total_Allowable_Duct_Leakage = 1200 x 0.10 = 120 cfm25

Note: This calculation is based on duct leakage to outside. Leakage to outside must be determined through direct testing using a duct leakage pressurization device in conjunction with the blower door. If a blower door is not available, duct leakage to outside may be estimated by measuring total duct leakage and estimating the percentage of measured leakage that is leaking to outside based the location of the ductwork.

Replacing Naturally Vented Appliances
When atmospherically vented combustion appliances are replaced with sealed combustion units, an exhaust appliance has been removed from the home. To ensure that the building will have adequate air exchange after this retrofit, a blower door test must be completed and mechanical ventilation installed as needed to provide ventilation levels compliant with ASHRAE Standard 62-89. This procedure must be followed even if no alterations to the building shell are anticipated as part of the work scope.

When a high efficiency appliance, such as a furnace, is installed and no longer requires chimney venting, "orphaned" water heaters must be tested for safe operation. Water heaters may not be left venting alone into a previously shared chimney without ensuring the chimney meets appropriate NFPA requirements under the new condition and the water heater has been tested and passed all required combustion safety tests (spillage, draft, CAZ depressurization).

Water Heater Replacements
Domestic hot water heater replacements shall be sized according to the guidelines established by the Gas Appliance Manufacturer's Association (GAMA). The first hour rating for new systems shall match the calculated peak hour demand within 1-2 gallons. When installing new water heating systems or retrofitting existing systems, measures to reduce the peak demand should be recommended as part of the work scope.

General Heating System Inspections

Combustion Gas Analysis
A combustion gas analysis is required on oil-fired and gas-fired furnaces and boilers, any time replacement or repair is not part of the intended work scope.

A complete clean and tune of the heating system shall be recommended whenever:

- The system shows signs of neglect or the customer indicates it has not been serviced within 1 year for oil systems or 2 years for gas systems.
- Safety diagnostics indicate a problem.
- Airflow diagnostics indicate incorrect flow that is not readily correctable.

Default Multipliers for Heating System Efficiencies

If you have manufacturers rated AFUE for the system, use it to calculate the system efficiency

If you do not have the manufacturers rated AFUE, for forced air furnaces, use the furnace Steady State Efficiency as determined by completing a Combustion Efficiency Test. The efficiency of the forced air system equals the efficiency determined by the Steady State Efficiency Test result multiplied by the distribution efficiency.

For the following types of heating systems use the measured Steady State Efficiency multiplied by the default from the table below multiplied by the distribution efficiency to get the system efficiency.

	System Type	**Default Multipliers**
Air	Forced Air	Use test value
	Gravity Feed	0.8
	Freestanding Heater	0.95
	Floor Furnace	0.9
	Wall Furnace	0.85
Water	Forced Circulation (high mass)	0.85
	Forced Circulation (low mass)	0.9
	Gravity Feed	0.85
	Steam	0.75

For use in savings calculations and system sizing, seasonal efficiency must be calculated and applied. To determine the seasonal efficiency, first obtain the rated AFUE for the system. AFUE is assigned efficiency of an appliance. A standard efficiency forced air furnace will have an AFUE of approximately 65%, while a newer non-condensing furnace will have a nominal AFUE of 80%. A condensing furnace will have an AFUE of 90% or greater. (Actual AFUE ratings may be found in the GAMA listing.)

Associate efficiency to the distribution system using the chart below, or use accepted modeling tools that take distribution losses into account. The seasonal efficiency is equal to the AFUE multiplied by the distribution efficiency.

Distribution Efficiency Look-up Table

Distribution Efficiency Table

System Charateristics (there are 3 questions you need to answer about the distirbution system)

1 What percentage of the ducts are located within the conditioned space
2 How well are the connections on the duct system sealed
3 What is the insulation value on the ducts for the portion outside the conditioned space

	1. % within conditioned space			2. Duct leakage Charateristics					3. Duct insulation value		
Distribution Efficiency	90% or more inside envelope	50% or more inside envelope	less than 50% inside envelope	Connections sealed w/mastic	No observable leaks	Some observable leaks	Significant leaks	Catastrophic leaks	Ducts outside envelope R-8 or greater	Ducts outside envelope R-4 - R-7	Ducts outside envelope < R-4
95%	XXX			XXX					XXX		
94%	XXX			XXX						XXX	
93%	XXX			XXX							XXX
94%	XXX				XXX				XXX		
93%	XXX				XXX					XXX	
92%	XXX				XXX						XXX
90%	XXX					XXX			XXX		
89%	XXX					XXX				XXX	
88%	XXX					XXX					XXX
85%	XXX						XXX		XXX		
84%	XXX						XXX			XXX	
83%	XXX						XXX				XXX
80%	XXX							XXX	XXX		
79%	XXX							XXX		XXX	
78%	XXX							XXX			XXX
90%		XXX		XXX					XXX		
89%		XXX		XXX						XXX	
88%		XXX		XXX							XXX
84%		XXX			XXX				XXX		
83%		XXX			XXX					XXX	
82%		XXX			XXX						XXX
80%		XXX				XXX			XXX		
79%		XXX				XXX				XXX	
78%		XXX				XXX					XXX
75%		XXX					XXX		XXX		
74%		XXX					XXX			XXX	
73%		XXX					XXX				XXX
70%		XXX						XXX	XXX		
69%		XXX						XXX		XXX	
68%		XXX						XXX			XXX
80%			XXX	XXX					XXX		
79%			XXX	XXX						XXX	
78%			XXX	XXX							XXX
74%			XXX		XXX				XXX		
73%			XXX		XXX					XXX	
72%			XXX		XXX						XXX
70%			XXX			XXX			XXX		
69%			XXX			XXX				XXX	
68%			XXX			XXX					XXX
65%			XXX				XXX		XXX		
64%			XXX				XXX			XXX	
63%			XXX				XXX				XXX
60%			XXX					XXX	XXX		
59%			XXX					XXX		XXX	
58%			XXX					XXX			XXX

Example: **If you have a system with more than 90% inside the conditioned space (i.e. in a heated basement) and the system is sealed with mastic and the portion of the duct system that is not in the heated space has an R-value of R-4, the distribution efficiency of the system is 94%.**

Gas Systems

Gas Supply Safety
The entire gas 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.

Gas Appliance Safety Inspection
In addition to the testing and inspection procedures set forth in the BPI Technical Standards for Building Analyst I, the following inspections shall be completed.

No significant carbon buildup should be visible anywhere in the unit. This includes the draft hood, heat exchanger, and burners. If carbon is present, it must be totally removed and the source of the combustion problems must be determined and remedied before proceeding.

The burner flames must be directly inspected to ensure that all burners are operating properly. The flames should be consistent with the burner design. All sections of the burner should be ignited properly with no irregularities in the flame, ghosting, or white tips on the flames. If the flames are not firing properly, the burner jets must be cleaned.

Thermostat anticipator settings must be adjusted, as needed, to match the amperage measured in the control circuit or to meet the thermostat manufacturer's specifications.

Oil Systems

Oil Supply Systems
Fuel oil supplied to a combustion appliance must be free of water and other contaminants. In cold climates, steps shall be taken to ensure continuous flow and to avoid freeze ups.

Fuel oil storage system integrity must be checked and appropriate necessary repairs included in the work scope.

When a new oil heating system is installed, the oil filter must be replaced and deposits at the bottom of the tank must be removed. Tank and oil lines must be in compliance with NFPA 31.

Oil Appliance Safety Inspection
In addition to the testing and inspection procedures set forth in the BPI Technical Standards for Building Analyst I, the following inspections shall be completed.

All oil-fired heating systems must be equipped with a barometric draft control, except for systems with high-static pressure burners or mobile home units.

CAD cell or stack control activation must be timed to verify that the burner will shut off if the fuel is not ignited.

Oil Burner Replacements
Where burner and nozzle replacements are installed, the assembly must be sized according to actual building heat load calculations. Oil systems may be downsized by replacing the nozzle using the following criteria:

- With cast iron head burners, the firing rate may not be reduced below the manufacturer's rating. (Check the nameplate for acceptable firing rates.)
- With flame retention head burners, the flue gas exit temperature must not go below 325 degrees F.

Where CAZ depressurization is a problem, a high static pressure retention head may be installed as an alternative to providing make-up air to the system as long as no other combustion appliances exist in the CAZ.

Furnaces and Forced Air Distribution

Heat Exchanger 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. Appropriate inspection techniques include visual inspections using a mirror and flashlight or tracer gas tests when the problem is not visually apparent. This problem must be referred to a heating system service contractor for repairs. A cracked heat exchanger cannot effectively be repaired and must be replaced.

Furnace Airflow
Heating system airflow shall be measured before and after work is performed on the system or its ductwork. Forced air furnaces must be tested using a heat rise measurement.

Forced air furnace airflow must be within manufacturer's specifications. Where the rated temperature rise range is not indicated on the furnace nameplate, ensure the measured temperature rise is within 40-70 degrees F. For standard efficiency furnaces where the rated temperature rise range is not indicated on the furnace nameplate, ensure the measured temperature rise is within 70-100 degrees F. For 80% and 90% AFUE units, the heat rise will vary depending on the manufacturer. In most cases, it will fall within 20-60 degrees F.

If the heat rise on a forced air furnace is higher than manufacturer's specifications, repairs must be completed to increase the airflow. Measures may include: cleaning of filters or removing blockages in the ductwork, adding returns, and increasing the fan speed.

If the heat rise is lower than the manufacturer's specifications and the customer has indicated concerns of uncomfortable conditions in the home, (i.e. cool delivery temperatures), check that the fan speed is not set too high. On rare occasions the gas input may be may be too low or the orifice may be too small. If you suspect this, measure the gas input and adjust it to the correct recommended pressure, or chance the orifice to the correct size.

The fan off temperature must be set as close to 90 degree F as possible.

The fan on temperature must be set as close to the fan off temperature as possible (usually 120-130 degrees F), but the fan on delay may be no shorter than 20 seconds after the gas valve is energized.

If the limit switch setting is low enough to cause cycling during a 5-minute test, the switch can be reset, but never above 275 degrees F.

Duct Leakage
When quantifying duct leakage, an appropriate type of measurement system shall be used, which includes a metered and calibrated duct pressurization device. Pre and post-installation duct leakage shall be measured any time that duct sealing is part of the work scope to verify the success of the installation.

Duct leakage areas must be diagnosed using appropriate duct leakage testing equipment and/or pressure pan tests to prioritize leakage areas (treating the largest leaks and the highest pressure areas first) anytime duct sealing is installed.

Use the following checklist as a guide for prioritizing duct sealing installations:

- ✓ Seal the largest leaks first. These include: disconnected ducts, missing end-caps, and other catastrophic holes
- ✓ Seal the areas of highest pressure. These included all the connections near the air-handler cabinet and supply and return plenums, flexible canvas plenum connectors, and filter slot covers.
- ✓ Seal all return leaks which may be contributing to negative pressures in the combustion appliance zone.
- ✓ Seal all accessible connections between duct sections, at branches, and where take-offs connect to main trunk lines.
- ✓ Seal take-off connections to register boots and boot connections to floors, walls, and ceilings.

Sheet metal and flexible ductwork shall be sealed at all duct connections using duct mastic or similar product designed for sealing ducts. Duct tape is not an allowable duct sealing material. Aluminum FSK tape may be used on ductboard systems and at the connections to the air handler cabinet.

Filter slots must be tightly covered and the cover must be easily removed for cleaning and/or replacement. The homeowner should be instructed to replace the filter at every month for oil systems and every three months for heat pumps and gas systems.

Boilers and Hydronic Distribution

Hydronic System Safety and Efficiency Inspection
All systems must have an appropriate pressure relief valve, an operating pressure gauge, and a high temperature aquastat.

All water leaks must be identified and repaired.

All systems must have an operating control that will disable the gas valve when the high water temperature setting has been reached.

Open expansion tanks must be replaced with sealed and pressurized expansion tanks.

An effective air-excluding device must be installed as part of any new hydronic system.

All heating supply pipes in unconditioned areas must be insulated with closed-cell foam or fiberglass pipe insulation.

Thermostatic radiator valves may be used to balance temperatures from room to room, but cannot be installed on series loop systems.

Steam Distribution

Steam System Safety and Efficiency Inspection
Steam boilers must be equipped with high pressure limits and low-water cut-off controls. High pressure limit controls must be set at or below 10 psi.

Low-water cut-off flush valves that leak or are inoperable must be repaired or replaced.

Steam vents must be operable and all radiators must receive steam during every cycle. Unplug vents as necessary.

Check steam traps with a digital thermometer or listening device to detect any steam escaping from the radiators through the condensate return. Replace leaking steam traps or their thermostatic elements. Repair leaks on the steam supply piping and on the condensate return piping.

All exposed steam piping in conditioned and unconditioned areas must be insulated with pipe wrap rated for steam pipes.

Domestic Hot Water Systems

All water heaters must have a pressure and temperature relief valve and a safety discharge pipe. Install a relief valve and discharge pipe if none exists. The pipe must terminate 6 inches above the floor and be made of copper or high temperature plastic.

Water heater insulation wraps shall not cover the top of oil or gas systems, and shall not obstruct the pressure relief valve, thermostats, hi-limit switch, plumbing pipes, or access plates. A minimum 2-inch clearance is required from the access door for gas burners.

Water heater insulation wraps shall not be installed where forbidden by the manufacturer's instructions found on the nameplate.

BUILDING PERFORMANCE INSTITUTE, INC.

TECHNICAL STANDARDS
FOR
AIR CONDITIONING & HEAT PUMP SPECIALISTS

TABLE OF CONTENTS:

VERSION 1.1, FEBRUARY 2003, CKM

ACKNOWLEDGEMENTS

The following standards were developed for the Building Performance Institute, Inc. (BPI) with assistance from an expert panel, the BPI Technical Advisory Council, and the BPI Technical Committee. These groups include industry stake-holders including: contractors, licensing and code officials, weatherization agencies, program administrators, equipment manufacturers, researchers, and trainers. This document, released in 2003, is the result of their efforts. For additional information, contact BPI.

BPI AIR CONDITIONING AND HEAT PUMP EXPERT PANEL PARTICIPANTS:

Robert DeKieffer, *Boulder Design Alliance*
Patrick Murphy, *North American Technician Excellence*
Terry Norris, *Advanced Energy Corporation*
John Proctor, *Proctor Engineering Group*

Additional thanks goes to the New York State Energy Research and Development Authority (NYSERDA) and the U.S. Environmental Protection Agency (EPA) for providing necessary funding to support this project.

USE AND DISTRIBUTION OF BPI STANDARDS

This document was prepared by BPI to provide a guiding set of technical performance standards for use by BPI certified technicians. The certification process ensures technicians utilizing these standards have demonstrated competency at both the skill and knowledge required to apply the techniques and applications referenced herein. BPI makes no claim as to the competency of any persons engaging in any application of these standards without holding current, valid BPI certification in the relevant discipline.

	Module	Category	Standard	Method or Technique	Special Materials or Equipment
1	**Health and Safety**				
1.1.1	Health and Safety	Personal	All technicians performing diagnostic tests, inspections, or installations, must have access to all necessary personal safety equipment required by OSHA.	Occupational Safety and Health Act	Hard hats, safety glasses, gloves, dust masks and/or respirators, as required
1.1.2	Health and Safety	Personal	Safety glasses and gloves must be worn when handling refrigerant or when brazing.	Occupational Safety and Health Act	Safety glasses and gloves
1.1.3	Health and Safety	Personal	Technicians must be trained in proper use and applications of all personal safety devices and must adhere to OSHA regulations when on the job site.	Occupational Safety and Health Act	OSHA standards
1.2.1	Health and Safety	Occupant	The building occupants must be informed of the likelihood of airborne contaminants (asbestos, fiberglass, mold, etc.) in the home during and after inspection and improvement of airflow to the AC or heating system.	NA	NA
1.3.1	Health and Safety	Electrical	Electrical power must be shut off before working on mechanical equipment.	Shut off switch or circuit breaker	NA
1.3.2	Health and Safety	Electrical	Electrical wiring for HP/AC units must be in compliance with relevant codes. Improper connections, wire sizing and other problems identified must be corrected prior to proceeding to system diagnostics or repairs.	National Electrical Code, state, and local codes	NA

	MODULE	CATEGORY	STANDARD	METHOD OR TECHNIQUE	SPECIAL MATERIALS OR EQUIPMENT
1.4.1	Health and Safety	Refrigerant	Refrigerant must be handled and stored in compliance with EPA Section 608 standards at all times, including charging, recovery, reclamation, storage, and transportation requirements.	U.S. Environmental Protection Agency, Clean Air Act, Section 608	Reclamation and storage equipment as required for each type of refrigerant used.
1.4.2	Health and Safety	Refrigerant	Only EPA certified technicians may install or service small residential (smaller than 5 ton capacity) central air conditioning or heat pump equipment.	U.S. Environmental Protection Agency, Clean Air Act, Section 608	EPA 608 Universal or Type 2 Certification

	MODULE	CATEGORY	STANDARD	METHOD OR TECHNIQUE	SPECIAL MATERIALS OR EQUIPMENT
2	**Installation**				
2.1.1	Installation	Design	Sizing for new and replacement central air conditioning and heat pump systems must be based on heating/cooling load calculations for the building using a recognized calculation method.	Whole house load calculation using ACCA's Manual J (or equivalent method)	ACCA's Manual J (or equivalent method)
2.1.2	Installation	Design	New and replacement air conditioning systems must be sized no larger than 115% (or the next nearest size available from the manufacturer) of total load at design conditions. (Systems must be sized based on load calculations referenced in **Section 2.1**)	Whole house load calculation using Air Conditioner Contractor's Association, Manual J (or equivalent method)	ACCA's Manual J (or equivalent method), Manufacturer's expanded performance tables
2.1.3	Installation	Design	New and replacement heat pump systems must be sized no larger than 125% (or next nearest size available from the manufacturer) of total load at design conditions. (Systems must be sized based on load calculations referenced in **Section 2.1**.)	Whole house load calculation using Air Conditioner Contractor's Association, Manual J (or equivalent method)	ACCA's Manual J (or equivalent method), Manufacturer's expanded performance tables
2.1.4	Installation	Design	When installing new systems or replacing the air-handler and/or the compressor unit for existing systems, the indoor evaporator coil must be correctly matched to the outdoor coil for the system according to the manufacturer's specifications or ARI standards.	Manufacturer's specifications, ARI standards	Manufacturer's specifications, ARI standards

	MODULE	CATEGORY	STANDARD	METHOD OR TECHNIQUE	SPECIAL MATERIALS OR EQUIPMENT
2.1.5	Installation	Design	Blower door test results are **recommended** to determine air leakage rates input into load calculations. Blower door ACH conversion: ACH = CFM50 ÷ N (use lowest N-factor for the region). If using Manual J version 8, enter CFM50	Determine CFM50 based on single point blower door test.	.
2.1.6	Installation	Design	New ducted distribution systems must be designed to provide +/- 15% of room airflow requirements to satisfy calculated Btu loads for each room being conditioned.	Room-by-room load calculation and duct design using ACCA's Manual D or equivalent.	ACCA's Manual J and ACCA's Manual D (or equivalent)
2.1.7	Installation	Design	New ducted distribution system designs shall be based on the available external static pressure from the air handler, the pressure drop of external devices, the equivalent length of the runs, as well as the size, type and configuration of the ducts.	Room-by-room load calculation and duct design using ACCA's Manual D (or equivalent method).	ACCA's Manual J and ACCA's Manual D (or equivalent method)
2.1.8	Installation	Design	Airflow terminations for newly installed duct systems must have a documented design for proper spread and throw to effectively distribute heating/cooling to the room. Design throw must be between 80-120% of the distance to the furthest room surface (wall, ceiling, floor) from the termination.	Duct layout plan, blueprint, or equivalent documentation	Terminal Manufacturer's Specifications and ACCA's Manual T

	MODULE	CATEGORY	STANDARD	METHOD OR TECHNIQUE	SPECIAL MATERIALS OR EQUIPMENT
2.2.1	Installation	Airflow	For all new duct systems: • Measured heat pump airflow must be between 375-450 CFM/Ton, or within manufacturer's specifications when measured over a dry coil (*i.e.* tested in heating mode.) • Measured air conditioner airflow must be at least 350 CFM/Ton unless the manufacturer specifies a lower airflow for the local design condition, when measured over a wet coil after a minimum of 15 minutes of run time.	Refer to BPI standard (**5.2.1**) for airflow testing Manufacturer's specifications	Refer to BPI standard (**5.2.1**) for airflow testing Manufacturer's specifications
2.2.2	Installation	Airflow	For new systems (when not installing new ductwork): Air conditioner or heat pump airflow must be within the design parameters of the manufacturer's specifications with a minimum of 325 CFM/Ton before proceeding with refrigerant charge corrections based on the results of the appropriate charging tests.	Refer to BPI standard (**5.2.1**) for airflow testing Manufacturer's specifications	Refer to BPI standard (**5.2.1**) for airflow testing Manufacturer's specifications

	MODULE	CATEGORY	STANDARD	METHOD OR TECHNIQUE	SPECIAL MATERIALS OR EQUIPMENT
2.2.3	Installations	Airflow	For new systems (when not installing new ductwork): The contractor must attempt to bring the airflow within the ranges set in **2.2.1** by opening registers, opening dampers, changing blower speed, replacing filters, and removing obvious easily repaired kinks in flex duct systems. If the above repairs do not bring the unit into compliance, the contractor shall inform the customer that duct system revisions are necessary.	Refer to BPI standard **2.2.1** for new installations for acceptable airflow limits; manufacturer's specifications	Manufacturer's specifications
2.3.1	Installation	Duct Systems	New ducted distribution systems must provide for adequate return air pathways to minimize pressure imbalances in the conditioned space. Room to room pressure differences may not exceed 3 Pascals.	Room-by-room load calculation and post-installation pressure measurement	ACCA's Manual J (or equivalent method) and digital manometer
2.3.2	Installation	Duct Systems	Filter slots must be tightly covered and the cover must be easily removed for cleaning and/or replacement.	NA	Field manufactured covers can meet this standard. Tapes and other non-permanent devices do not meet the standard.

	MODULE	CATEGORY	STANDARD	METHOD OR TECHNIQUE	SPECIAL MATERIALS OR EQUIPMENT
2.3.3	Installation	Duct Systems	New ducted distribution systems must have sheet metal and flexible ductwork **both** mechanically fastened and sealed at all connections. Sealing shall use duct mastic or similar product designed for sealing ducts. Duct tape is not an allowable duct sealing material. UL standard (UL 181, UL 181A, or UL 181B) duct tape may be used only at the plenum connection to the air handler cabinet.	NA	Duct mastic, mesh tape, UL 181 compliant tape
2.4.1	Installation	Refrigerant	The orifice size must match the system: • Fixed orifice metering devices must match the outdoor unit (when replacing or installing new systems) • Piston-type metering devices: If the indoor coil has a different sized piston than the one on the outdoor unit, the indoor coil piston must be replaced with the correct size. When the installation is complete, attach the label that comes with the correct piston to the indoor coil. • Capillary tube equipped systems must have matched indoor and outdoor coils. • TXV metering device: must be properly sized to match the outdoor unit	Manufacturer's Specifications	Manufacturer's Specifications

	MODULE	CATEGORY	STANDARD	METHOD OR TECHNIQUE	SPECIAL MATERIALS OR EQUIPMENT
2.4.2	Installation	Refrigerant	Refrigerant lines and indoor coil must be purged with inert gas during brazing to prevent oxidation.	NA	Nitrogen
2.4.3	Installation	Refrigerant	New systems must be evacuated to 500 microns or less. Isolate the system from the vacuum pump and let it sit. The micron gauge should not rise more than 300 microns (or the manufacturer's specified limit, whichever is less) in 5 minutes above the initial vacuum level.	NA	Analog or Digital Micron Gauge
2.4.4	Installation	Refrigerant	Proper charge must be verified using the superheat or sub-cooling method. When weather conditions do not allow for proper AC testing (super-heat or sub-cooling), the charge may be "weighed in". The charge must be calculated according to the manufacturer's specifications	Use super-heat method for non-TXV systems. Use sub-cooling method for TXV systems.	Temperature gauge and thermocouples to measure wet and dry bulb temperatures, P/T gauges appropriate to refrigerant being used, P/T charts, manufacturer's instructions

	MODULE	CATEGORY	STANDARD	METHOD OR TECHNIQUE	SPECIAL MATERIALS OR EQUIPMENT
2.5.1	Installation	Controls	Heat pump controls shall stage the compressor based heating first, followed by one or more stages of back-up heating. The first stage of heating shall not include electric resistance heating	Activate Stage 1 and verify that unit is heating and electric resistance elements are not operating	
2.5.2	Installation	Controls	If the rated SEER or HSPF for the unit is dependent on a particular option (Thermostatic Expansion Valve and/or Time Delay Relay) that option must be installed.		Manufacturer's Specification
2.6.1	Installation	Commissioning	Newly installed AC and heat pump systems must be run through a heating and/or cooling cycle as noted in **2.2.1, 2.2.2, 2.2.3, 2.3.1, 2.4.4, 2.5.1, and 3.1.1** to verify proper performance of airflow, charge, controls, room pressures, and delivery of heating/cooling to the living space These parameters can be verified singly or in groups.	Refer to BPI standards for measuring, charge, airflow, and room pressures; manufacturer's specifications	Refer to BPI standards for measuring charge, airflow, and room pressures; manufacturer's specifications

	MODULE	CATEGORY	STANDARD	METHOD OR TECHNIQUE	SPECIAL MATERIALS OR EQUIPMENT
3	**Commissioning**				
3.1.1	Commissioning	Airflow	New ducted distribution systems require register airflows to be measured and verified. The system shall deliver +/- 20% of design airflows for each conditioned room. Deviations from design criteria greater than 20% must be corrected	ACCA's Manual J and ACCA's Manual D (or equivalent method)	Flow capture hood (or equivalent measurement device)
3.2.2	Commissioning	Duct Systems	Duct tightness for newly installed duct systems must meet or exceed the requirements set forth in the EPA standards for Energy Star Ducts. The sum of supply and return leakage measured at 25 Pascals of pressure shall be no more than 10% of the measured system airflow . (Example: With a measured 1200 CFM system airflow, the total duct leakage may not exceed 120 CFM25.)	Refer to BPI standards for duct leakage and airflow testing methods	Refer to BPI standards for duct leakage and airflow testing methods

	MODULE	CATEGORY	STANDARD	METHOD OR TECHNIQUE	SPECIAL MATERIALS OR EQUIPMENT
4	**Service and Repair**				
4.1.1	Service	Duct Systems	Sheet metal and flexible ductwork shall be mechanically fastened and sealed at all connections. Sealing shall use duct mastic or similar product designed for sealing ducts. Duct tape is not an allowable duct sealing material. UL standard (UL 181, UL 181A, or UL 181B) duct tape may be used only at the plenum connection to the air handler cabinet.	NA	Duct mastic, mesh tape, UL 181 compliant tape
4.1.2	Service	Duct Systems	Filter slots must be tightly covered and the cover must be easily removed for cleaning and/or replacement.	NA	Field manufactured covers can meet this standard. Tapes and other non-permanent devices do not meet the standard.

	MODULE	CATEGORY	STANDARD	METHOD OR TECHNIQUE	SPECIAL MATERIALS OR EQUIPMENT
4.2.1	Service	Refrigerant	Refrigerant charge may not be added to a system with leaks. If refrigerant was previously added and unit has undercharge, the system must be tested for leaks following established protocols for leak detection. Leaks must be repaired or the client must be informed that the system cannot be charged.	Manufacturer's specifications	P/T charts, P/T gauges appropriate to the refrigerant being used, charging equipment, leak detecting equipment
4.2.2	Service	Refrigerant	Refrigerant charge corrections must be verified using the appropriate charge measurement method (superheat or sub-cooling) Air conditioner or heat pump airflow must be within the design parameters of the manufacturer's specifications with a minimum of 325 CFM/Ton before proceeding with refrigerant charge corrections based on the results of the appropriate charging tests. If airflow adjustments are made the refrigerant charge test must be rerun.	Manufacturer's Specifications	P/T charts, P/T gauges appropriate to the refrigerant being used

	MODULE	CATEGORY	STANDARD	METHOD OR TECHNIQUE	SPECIAL MATERIALS OR EQUIPMENT
4.3.1	Service	Airflow	System airflow must be measured and • Measured heat pump airflow should be between 375-450 CFM/Ton, or within manufacturer's specifications when measured over a dry coil (*i.e.* tested in heating mode.) • Measured air conditioner airflow should be at least 350 CFM/Ton unless the manufacturer specifies a lower airflow for the local design condition, when measured over a wet coil (*i.e.* tested in cooling mode after a minimum of 15 minutes of run time.).	Refer to BPI standards for airflow testing methods (5.2.1)	Refer to BPI standards for airflow testing methods (5.2.1)
4.3.2	Service	Airflow	For existing systems: The contractor must attempt to bring the airflow within the ranges set in **4.3.1** by opening registers, opening dampers, changing blower speed, replacing filters, and removing obvious easily repaired kinks in flex duct systems. If the above repairs do not bring the unit into compliance, the contractor shall inform the customer that indoor coil cleaning or duct system revisions are necessary.	Refer to BPI standards for new installations for acceptable airflow limits; manufacturer's specifications	Manufacturer's specifications

	MODULE	CATEGORY	STANDARD	METHOD OR TECHNIQUE	SPECIAL MATERIALS OR EQUIPMENT
4.3.4	Service	Airflow	If repairs are made that effect airflow, the system airflow shall be measured before and after repairs are completed.	Refer to BPI standard (**5.2.1**) for airflow testing	Refer to BPI standard **5.2.1**

	MODULE	CATEGORY	STANDARD	METHOD OR TECHNIQUE	SPECIAL MATERIALS OR EQUIPMENT
5	**Diagnostic Tests**				
5.1.1	Diagnostic Tests	Electrical	Existing wiring systems must be inspected for safe installation and compliance with applicable codes. This inspection should include, but is not limited to: • Checking for obvious loose connections • Visual inspection of contactor contacts to verify good condition (no pitting, etc.) • Properly sized wire gauge as required by the circuit amp draw	NEC, state, and local electrical codes	NA
5.1.2	Diagnostic Tests	Electrical	Voltage drop across contacts and relays may not occur. If a voltage drop is measured, the source must be located and corrected.	NA	Voltmeter
5.2.1	Diagnostic Tests	Airflow	System airflow may be measured using a metered and calibrated pressurization device, a metered and calibrated flow plate, or a flow capture hood designed for the flow range anticipated.	Refer to product manufacturer's instructions for proper diagnostic applications.	Duct Blaster™ (or equivalent), Flow Grid™ (or equivalent), or low-flow flow capture hood
5.3.1	Diagnostic Tests	Duct Systems	Pre- and Post-installation duct leakage shall be measured any time that duct sealing is part of the work-scope to verify the success of the installation.	Refer to BPI standards for duct leakage testing methods.	Refer to BPI standards for duct leakage testing methods.

	MODULE	CATEGORY	STANDARD	METHOD OR TECHNIQUE	SPECIAL MATERIALS OR EQUIPMENT
5.3.2	Diagnostic Tests	Duct Systems	When quantifying duct leakage, a measurement system that includes a metered and calibrated duct pressurization device shall be used.	Duct Blaster™ total leakage test (or equivalent method); refer to BPI standards for approved system airflow measurement methods	Duct Blaster™ (or equivalent testing device)
5.4.1	Diagnostic Tests	Refrigerant	Refrigerant charge may be measured using the following methods: • Use sub-cooling method for TXV equipped systems • Use superheat method for non-TXV equipped systems (Alternative manufacturer-specific procedures may be allowable. Submit alternative procedures to BPI for review and approval.) If airflow is changed, the refrigerant charge must be retested.	Use super-heat method for non-TXV systems. Use sub-cooling method for TXV systems.	Temperature gauge and thermocouples to measure wet and dry bulb temperatures, P/T gauges appropriate to refrigerant being used, P/T charts, manufacturer's instructions

COMBUSTION SAFETY TEST PROCEDURE FOR VENTED APPLIANCES

1. **Measure the Base Pressure.** Start with all exterior doors and windows closed and the fireplace damper closed. Set all combustion appliances to the pilot setting or turn off the service disconnect. Combustion appliances include: boiler, furnace, space-heaters, and water heater. With the home in this configuration, measure and record the baseline pressure of the mechanical room WRT outside.

2. **Establish the Worst Case.** Turn on the dryer and all exhaust fans. Close all 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 the CO at the flue at steady-state (if steady state is not achieved within 10 minutes, take the 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 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 outside. Repeat the process 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.

RANGES AND OVENS*

1. Remove any items/foil in or on oven/range top

2. Make sure self-cleaning features are not activated

3. Test oven in vent sleeve, before dilution air

4. **100 ppm to 300 ppm** as measured you must install a carbon monoxide detector and recommendation for service must be made to the consumer.

   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

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

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 damper commonly vented with water heater	-5
Individual natural draft boiler or furnace	-5
Induced draft boiler or furnace commonly vented with water heater	-5
Power vented or induced draft boiler or furnace alone, or fan assisted DHW alone	-15
Chimney-top draft inducer; exhausto type or equivalent; high static pressure flame retention head oil burner; Direct vented appliances; Sealed combustion appliances	-50

ACCEPTABLE APPLIANCE SPILLAGE PERIODS

Appliance Type	Spillage Test Period (minutes)
Water Heater, Gravity Furnace, Boiler	1.0
Space Heater	1.0
Forced Air Furnace	1.0

ACCEPTABLE DRAFT TEST RANGES

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

BUILDING PERFORMANCE INSTITUTE, INC.

TECHNICAL STANDARDS

FOR

MOBILE HOME SPECIALISTS

TABLE OF CONTENTS:

ACKNOWLEDGEMENTS

The following standards were developed for the Building Performance Institute, Inc. (BPI) with assistance from an expert panel, the BPI Technical Advisory Council, and the BPI Technical Committee. These groups include industry stake-holders including: contractors, licensing and code officials, weatherization agencies, program administrators, equipment manufacturers, researchers, and trainers. This document, released in 2003, is the result of their efforts. For additional information, contact BPI.

BPI MOBILE HOMES EXPERT PANEL PARTICIPANTS:

Robert deKieffer, *Boulder Design Alliance*
Robert DeSoto, *U.S. Department of Energy*
Cal Steiner, *Community Action Program*
Barry York, *Mid-Iowa Community Action*

Additional thanks goes to the New York State Energy Research and Development Authority (NYSERDA) for providing necessary funding to support this project.

USE AND DISTRIBUTION OF BPI STANDARDS

This document was prepared by BPI to provide a guiding set of technical performance standards for use by BPI certified technicians. The certification process ensures technicians utilizing these standards have demonstrated competency at both the skill and knowledge required to apply the techniques and applications referenced herein. BPI makes no claim as to the competency of any persons engaging in any application of these standards without holding current, valid BPI certification in the relevant discipline.

	Module	Category	Standard	Method or Technique	Special Materials or Equipment
1	**Health and Safety**				
1.1.1	Health and Safety	Personal	All technicians performing diagnostic tests, inspections, or installations, must have access to all necessary personal safety equipment required by OSHA.	Occupational Safety and Health Administration	Hard hats, safety glasses, gloves, dust masks and/or respirators, harnesses, as required
1.1.2	Health and Safety	Personal	Technicians must be trained in proper use and applications of all personal safety devices and must adhere to OSHA regulations when on the job site	Occupational Safety and Health Administration	OSHA standards
1.1.3	Health and Safety	Personal	Ambient CO MUST be monitored throughout all combustion safety tests. Testing shall be aborted if ambient levels exceed 35ppm. Testing may resume only after repairs have been made and ambient CO levels are below 35 ppm.	Occupational Safety and Health Administration	OSHA standards, BPI BA-I standards
1.1.4	Health and Safety	Personal	Respirators with proper cartridges must be worn when working in areas where exposure to airborne mold, asbestos, lead, fiberglass, cellulose, or formaldehyde is at risk	Occupational Safety and Health Administration	OSHA standards
1.2.1	Health and Safety	Personal / Occupant	A copy of the MSDS for ALL materials on the job or installed in the home, must be kept on each crew vehicle, at the main office, and made available to all workers and clients upon request	Occupational Safety and Health Administration	OSHA standards, manufacturer's Material Safety Data Sheets

	MODULE	CATEGORY	STANDARD	METHOD OR TECHNIQUE	SPECIAL MATERIALS OR EQUIPMENT
1.2.2	Health and Safety	Personal / Occupant	Where the presence of asbestos, lead, mold, and/or other potentially hazardous material is known or suspected, all relevant state and federal guidelines must be followed**. Blower door depressurization tests may NOT be performed where there is a risk of asbestos becoming airborne or where other hazardous materials could be drawn into the dwelling**	State / Federal guidelines	State / Federal guidelines
1.2.3	Health and Safety	Personal / Occupant	The building occupants must be informed of the likelihood of airborne contaminants (asbestos, fiberglass, mold, etc.) in the home during and after inspection and improvement of airflow to the AC or heating system.	NA	NA
1.2.4	Health and Safety	Personal / Occupant	A minimum of one UL-2034 compliant CO detector must be installed in each home. Smoke and CO detectors must be installed per manufacturer's instructions.	Per Manufacturers Instructions	BPI BA-I Standards
1.3.1	Health and Safety	Electrical	Electrical power must be shut off before working on mechanical equipment.	Shut off switch or circuit breaker	NA

	Module	Category	Standard	Method or Technique	Special Materials or Equipment
1.3.2	Health and Safety	Electrical	Wiring must be checked for the presence of aluminum wire. If found, a qualified electrician must do a full load test and verify safe installation before ANY work is done.	Certified/Licensed Electrician	NA
1.3.3	Health and Safety	Electrical	Any wiring hit by drills, etc. should be fixed properly and immediately	Shut off switch or circuit breaker	NA
1.3.4	Health and Safety	Electrical	Pre and Post electrical circuit inspections should be completed to check for proper ground and polarity of each circuit when installing enclosed cavity insulation.	Test with electronic GFI/Circuit Tester	GFI/Circuit Tester
1.3.5	Health and Safety	Electrical	Lighting fixtures installed in the ceiling must be checked for proper operation before any roof insulation is installed.	NA	NA
1.4.1	Health and Safety	Solid Fuel Appliances	Solid fuel appliances are not allowable in mobile homes. Work may not proceed where solid fuel appliances are present in the mobile home.	NA	NA
1.4.2	Health and Safety	Moisture and Plumbing leaks	All plumbing leaks and moisture problems must be addressed prior to work commencing on the mobile home.	See section 9 of these standards	NA

	Module	Category	Standard	Method or Technique	Special Materials or Equipment
2	**Ducts**				
2.1.1	Duct System	Inspection	A thorough inspection of the duct system must be completed prior to treatment of the home to identify blockages, disconnects, or other catastrophic leaks.	See BPI Best Practices	Flashlight, inspection mirror
2.2.1	Duct System	Testing	The Pressure Pan shall be used to identify the location and estimate the magnitude of the duct leaks	See BPI Best Practices	Blower Door, Pressure Pan, digital manometer
2.2.2	Duct System	Testing	Room-to-room pressures shall be measured in all rooms with doors. The work scope shall include strategies to mitigate pressure which exceed 3 Pascals between rooms.	See BPI Best Practices	Digital manometer
2.3.1	Duct System	Repair	Mastic and mechanical fasteners must be used to seal ducts and ensure that they are attached to the structure. Caulk is an acceptable material only for sealing register boots to the floor • Ducts should be cleaned before applying mastics	Se BPI Best Practices	Duct Mastic (UL-181), mesh tape, metal straps, self-tapping metal screws, electric drill, solvent for cleaning
2.3.2	Duct System	Repair	Remove, eliminate, and seal all cold air return systems in the belly and attic and provide alternate return air grill	N/A	Sheet metal, Duct Mastic (UL-181)
2.3.3	Duct System	Repair	The end caps of all duct runs must be examined and sealed if the end of the duct is determined to be leaking.	N/A	Duct Mastic (UL-181), mesh tape

	MODULE	CATEGORY	STANDARD	METHOD OR TECHNIQUE	SPECIAL MATERIALS OR EQUIPMENT
2.3.4	Duct System	Repair	Repair, seal, and support all crossover ducts. • Must be insulated to R-11 minimum • Must be securely fastened • Must be off the ground	N/A	Duct Mastic (UL-181), mesh tape, metal straps, self-tapping metal screws, electric drill, solvent for cleaning, insulation
2.3.5	Duct System	Repair	Clean and seal connections between the furnace and duct plenums using appropriate duct sealing materials.	N/A	Duct Mastic (UL-181) with mesh tape, or UL-181 compliant duct sealing tape (NOT STANDARD DUCT TAPE), solvent for cleaning

	Module	Category	Standard	Method or Technique	Special Materials or Equipment
3	**Belly**				
3.1.1	Belly	Inspection	Conduct thorough inspection of the **entire belly**. • Condition of the belly board / rodent barrier • Construction techniques including the direction of the joists and blocking • Location of all plumbing and ducts	N/A	Flashlight, personal protective gear
3.1.2	Belly	Inspection	Measure the existing insulation levels in the belly if any. Take note at this time of amount of room for insulation in the wings and center	N/A	Flashlight, personal protective gear, measuring tape, probe, knife
3.1.3	Belly	Inspection	De-rate insulation to reflect actual performance	Use chart provided by BPI	BPI BA-I standards
3.2.1	Belly	Repair / Soft Patch	All holes average fist size or larger must be patched • Soft patch shall be done on all soft bellies using mechanical fasteners and adhesive	N/A	Stitch stapler, utility knife, caulk or adhesive, belly patching material, metal building insulation
3.2.2	Belly	Repair / Hard Patch	Hard patches <u>less than 1”</u>, can be made with materials that are not mechanically fastened if you are insulating the belly Hard patches <u>larger than 1”</u> must be mechanically fastened to the belly	N/A	Screws, nail gun, screw gun, rigid insulation, old paneling, 1x2’s, metal or plastic washers, buffalo board, rigid patches of various materials

	MODULE	CATEGORY	STANDARD	METHOD OR TECHNIQUE	SPECIAL MATERIALS OR EQUIPMENT
3.2.3	Belly	Repair	Repair all holes from the interior, particularly in ductwork, prior to insulating, so that belly insulation will not be blown into the home or ductwork	N/A	N/A
3.3.1	Belly	Insulation	Belly insulation shall be installed at the following densities: 1.5-2.0 lbs/f^3 in the wings, and 1.0-1.5 lbs/f^3 in the center. • Blow tube should be not be more than 1 foot from desired insulation area • Calculate and verify bag count as you insulate to ensure proper density	N/A	½" drill with a clutch, 2-9/16" wood bit
3.4.1	Belly	Skirting	**Insulated skirting is ONLY recommended if the belly is totally inaccessible and unrepairable**	N/A	N/A

	MODULE	CATEGORY	STANDARD	METHOD OR TECHNIQUE	SPECIAL MATERIALS OR EQUIPMENT
4	**Wall Insulation**				
4.1.1	Wall Insulation	Inspection	Inspect at least one full wall cavity or more by physical inspection Physically remove a piece of insulation to inspect • Define the construction type • Define the depth of cavity • Evaluate the interior and exterior cavities for defects • De-rate insulation materials to reflect actual performance	Use chart provided by BPI	BPI BA-I standards
4.2.1	Wall Insulation	Installation	Wall Insulation should be installed when cost-effective. It can be blown, stuffed, or a combination. Techniques used shall be in accordance with BPI Best Practices.	See BPI Best Practices	See BPI Best Practices
4.2.2	Wall Insulation	Installation	After insulation is installed, siding shall be replaced without bulging or damage to the siding or paneling.	NA	NA

	Module	Category	Standard	Method or Technique	Special Materials or Equipment
5	**Roof Insulation**				
5.1.1	Roof Insulation	Inspection	Physically inspect the ceiling cavity by drilling a viewing hole. • Define the depth of cavity • Define construction techniques and type and depth of insulation • De-rate insulation materials for actual performance	Use chart provided by BPI	BPI BA-I Standards
5.1.2	Roof Insulation	Inspection	Inspect both interior and exterior surfaces for structural integrity before proceeding with installation of insulation	N/A	N/A
5.1.3	Roof Insulation	Inspection	Exhaust fan vents must be fully ducted and vented outside. Exhaust ducts in unheated space must be insulated.	N/A	Flashlight
5.2.1	Roof Insulation	Installation	Wherever roof access is made, ensure a weatherproof seal after insulation by closing the opening and installing latex elastomeric roof coating on all seams and penetrations	See BPI Best Practices	
5.2.2	Roof Insulation	Installation	Flues must be properly blocked to provide adequate clearance to combustible materials when installing insulation	NFPA 54 HUD	Rigid material for damming around flues
5.2.3	Roof Insulation	Installation	Peal-and-seal must be installed over the seams of building penetrations (swamp coolers, flues, vents). Finish with latex elastomeric roof coating	See BPI Best Practices	Peal-and-seal, torch, white wash brush, latex elastomeric roof coating

	Module	Category	Standard	Method or Technique	Special Materials or Equipment
6	**Infiltration**				
6.1.1	Infiltration	Testing	Pre-installation blower door tests are required. Post blower door tests are required when measures are installed which may affect the airflow characteristics of the building envelope.	N/A	BPI BA-I Standards, blower door
6.2.1	Infiltration	Insulation	Prepare home for insulation measures by repairing large holes where insulation may enter the living space	N/A	N/A
6.3.1	Infiltration	Insulation / Air Sealing	Install insulation measures before any additional air sealing measures are conducted	N/A	N/A
6.3.2	Infiltration	Air Sealing	**Do not conduct additional air sealing measures until insulation is completed. Do not seal the home if below 1500 CFM_{50}**	N/A	N/A
6.4.1	Infiltration	Mechanical Ventilation	**If home is below 800 CFM50, make sure kitchen and bath fans must operate correctly and exhausting air outside, or install a balanced mechanical ventilation system to provide ventilation in accordance with ASHRAE 62-89.**	See BPI Best Practices	Digital manometer

	Module	Category	Standard	Method or Technique	Special Materials or Equipment
7	**Mechanical Systems**				
7.1.1	Mechanical Systems	Inspection	Perform a visual inspection of the venting system to ensure compliance with NFPA standards.	NFPA 54	N/A
7.1.2	Mechanical Systems	Inspection	Floor in the water heater closet must be checked for structural integrity • The water heater must be level and adequately supported.	N/A	N/A
7.2.1	Mechanical Systems	Testing	Check for visual signs of spillage prior to testing	N/A	N/A
7.2.2	Mechanical Systems	Testing	Furnaces and water heaters should be tested for CO with the door to the furnace/water heater closet closed. CO measured after 5 minutes of operation may not exceed 100 ppm. Units producing CO in excess of 100 ppm must be repaired or replaced.	See BPI Best Practices	Digital CO meter
7.3.1	Mechanical Systems	Heating System	Isolate the water heater closet from the rest of the home through air sealing • Water heater closets should be sealed from any communication with the furnace closet	See BPI Best Practices	Air sealing materials

	Module	Category	Standard	Method or Technique	Special Materials or Equipment
7.3.2	Mechanical Systems	Heating System	Non-sealed combustion heating systems must be replaced with sealed combustion units or units approved for use in mobile homes. Combustion air must come from outside the mobile home and not the door.	Installed per manufacturers instructions	N/A
7.3.3	Mechanical Systems	Heating System	For all sealed combustion systems you must locate the source of combustion air and verify proper operation	Manufacturer's specifications	N/A
7.4.1	Mechanical Systems	Water Heater	Any water heater accessible from the interior of the home must be sealed combustion. Make up air should come from under the mobile home.	See BPI Best Practices, Manufacturer's specifications	N/A
7.4.2	Mechanical Systems	Water Heater	All water heaters must be approved for use in mobile homes	Manufacturer's specifications	N/A
7.4.3	Mechanical Systems	Water Heater	Water heaters without switchable gas valves must be replaced with mobile home approved water heaters	N/A	N/A
7.4.4	Mechanical Systems	Water Heater	The water heater closet should be air sealed from the rest of the home and any communication with the furnace closet • Insulate tank and pipes when cost-effective based on climate based SIR	See BPI Best Practices	Air sealing materials, pipe insulation, tank wrap

	MODULE	CATEGORY	STANDARD	METHOD OR TECHNIQUE	SPECIAL MATERIALS OR EQUIPMENT
7.5.1	Mechanical Systems	Unvented Appliances	Unvented space heaters, appliances, etc. are NOT permitted and work must cease until the such units are removed from the home. (Gas ovens are an exception and must be tested according to BPI standards for ovens.)	N/A	BPI BA-I Standards

	MODULE	CATEGORY	STANDARD	METHOD OR TECHNIQUE	SPECIAL MATERIALS OR EQUIPMENT
8	**Windows and Doors**				
8.1.1	Windows	Inspection	• Inspect all windows for proper fit and operation • Assess all windows for operation and effectiveness	N/A	N/A
8.1.2	Doors	Inspection	Inspect doors for integrity, operation and efficiency • Replace door if nonfunctional	N/A	N/A

	Module	Category	Standard	Method or Technique	Special Materials or Equipment
	Plumbing and Moisture				
9.1.1	Plumbing	Inspection	All leaks on the water supply system must be repaired before work begins	N/A	N/A
9.1.2	Plumbing	Inspection	All leaks on the water drain system must be repaired before work begins	N/A	N/A
9.1.3	Plumbing	Inspection	Sewage leaks must be fixed and isolated before any work is done.	N/A	N/A
9.1.4	Moisture	Inspection/Source Control	Review all potential moisture problems and correct prior to installing measures which may affect the air infiltration properties of the building envelope.	N/A	BPI BA-I Standards
9.2.1	Moisture	Source Control	Where a moisture source is present, ground vapor barriers must be installed to control moisture migration into the building.	See BPI Best Practices	6-mil polyethelene
9.2.2	Moisture	Source Control	Penetrations between the living space and cavities or areas where moisture is present must be sealed.	N/A	Caulk, foam, rigid baffles, as needed
9.3.1	Moisture	Mechanical Ventilation	Mechanical ventilation must be added if moisture source cannot be removed	N/A	N/A