



BPI-3301-S-2019

Technical Standards for Heating Professional



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Formulated under the cognizance of the BPI Standards Technical Committee.

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Introduction

(Informative)

The Building Performance Institute, Inc. (BPI) publishes standards related to the energy efficiency and performance of residential buildings. Although this standard is primarily focused on energy conservation measures and criteria related to the heating and distribution system, it does extend beyond these measures to address that system's impact on the building as a whole. This standard assumes that the home in which the work is being done has already undergone a comprehensive home energy audit and that the workscope is the result of the findings of that audit. In cases in which an energy audit has not been completed prior to the Heating Professional entering the home, it is the responsibility of the Heating Professional to ensure to all relevant safety tests are conducted.

This standard assumes all Heating Professionals will follow in good faith their company policy and conform to the policies of any participating program sponsor or funding source, as applicable, concerning energy-savings estimates and cost-benefit analysis.

It is understood that other standards or guidelines may be required by the Authority Having Jurisdiction (AHJ) and in such instances the Heating Professional should comply with the AHJ's requirements.

This standard was developed outside of the ANSI process and is maintained as a BPI standard under the cognizance of the BPI Standards Technical Committee (consensus body) in support of programs and certified individuals currently referencing it.

1. Scope

- 1.1. This standard provides the minimum criteria for measuring and verifying the performance of fossil fuel-based heating systems; optimizing the operation and maintenance of these heating systems; and addressing their interaction with other building systems, from a building science perspective. This standard also provides the minimum criteria for worker and occupant safety with respect to carbon monoxide and combustible gases.
- 1.2. This standard is intended for use by qualified heating professionals or individuals overseeing the work of qualified heating subcontractors when completing service, installation or preventive maintenance on residential fossil fuel-based heating systems.
- 1.3. Residential building types covered are defined as existing detached single-family dwellings and townhouses that:
 - have independent mechanical systems for each dwelling unit (heating, cooling, water heating, and ventilation)
 - have direct access to outdoors for each dwelling unit
 - were designed to have continuous party walls with no penetrations to adjacent units, with such party walls extending from ground to roof where the dwelling unit is attached to one or more adjacent single-family dwelling units
- 1.4. This standard does not address all safety problems associated with its use or all applicable regulatory requirements and does not supersede local or national codes. It is the responsibility of the user of this standard to establish appropriate safety and health practices and to determine the applicability of regulatory limitations before its use.

2. Purpose

This standard addresses the heating system within the context of a whole-house approach to ensure that heating equipment is:

- Properly tested for optimization of efficiency and safe operation
- Properly diagnosed for deficiencies identified in the standard
- Installed according to manufacturer's instructions
- Properly maintained
- Not negatively impacting other building systems, indoor air quality or occupant comfort, health and safety

3. Codes, Regulations, and Programs

- 3.1. The minimum requirements of this standard may exceed but do not supersede existing local, state, or national codes and regulations, and/or State or utility program requirements.
- 3.2. All work on heating, domestic water heater, and distribution systems shall be

performed, and the installation shall be completed, in accordance with the manufacturer's instructions, industry standards and all applicable federal, state and local regulations and codes.

- 3.3. Work described in this standard may be subject to regulation by state code/credential/licensing authorities.

4. Health and Safety-Related Requirements

The following are the minimum required health and safety diagnostics and specifications for the users of this standard.

4.1. Equipment Requirements for Combustible Gas and Carbon Monoxide (CO) Detection, CO Measurement, Depressurization and Spillage Tests

- 4.1.1. Equipment requirements shall be in accordance with the current edition of ANSI/BPI-1200-S *Standard Practice for Basic Analysis of Buildings* (ANSI/BPI-1200), Section 7.1.
- 4.1.2. Instruments shall be turned on outside the building away from any combustion outlets and automobile traffic areas, set to zero, and otherwise prepared for use in accordance with manufacturer's instructions.

4.2. Indoor Ambient CO

Upon entering the building, the ambient air shall be sampled to determine the level of CO in the building by conducting measurements in the occupied space, including utility rooms. The Heating Professional shall continue to monitor CO levels in the ambient air at all times while in the work environment.

4.2.1. Indoor Ambient CO Action Levels

Actions in response to ambient CO measurements shall be taken as follows:

- 4.2.1.1. If the CO instrument indicates an ambient CO level of 70 ppm or greater, the Heating Professional shall immediately terminate the inspection and notify the homeowner/occupant of the need for all building occupants to evacuate the building. The Heating Professional shall immediately leave the building and the appropriate emergency services shall be notified from outside the home.
- 4.2.1.2. If the CO instrument indicates an ambient CO reading in the range of 36 ppm-69 ppm, the Heating Professional shall advise the homeowner/occupant that elevated levels of ambient CO have been detected. Windows and doors shall be opened. The Heating Professional shall recommend that all possible sources of CO be turned off immediately. Where it appears that the source of CO is a permanently installed appliance, the Heating Professional shall, at a minimum, recommend repair or replacement of that appliance.
- 4.2.1.3. If the CO instrument indicates an ambient CO reading in the range of 9 ppm-35 ppm, the Heating Professional shall advise the homeowner/occupant that CO has been detected and recommend that all possible sources of CO be checked, and windows and doors opened. Where it appears that the source of CO is a permanently installed appliance, the Heating Professional shall

recommend replacement of that appliance or, at a minimum, recommend the appliance be repaired.

4.3. Combustible Fuel Gases

- 4.3.1. Indoor ambient air shall be sampled with the combustible gas detector (CGD) in at least one location per floor of occupied space upon entering the home.
- 4.3.2. If any measured concentrations of combustible fuel gas exceed 10% of the LEL, the Heating Professional shall inform the homeowner/occupants of the unsafe condition and advise evacuation of the home. The Heating Professional shall leave the home and the appropriate emergency services and fuel gas providers shall be notified from outside the home.¹

4.4. Natural Gas and LP Gas Piping

Where a comprehensive home energy audit including an inspection of the natural gas or LP gas piping system has not been completed in accordance with the current edition of ANSI/BPI-1200 or ANSI/ACCA Standard 12 QH *Home Evaluation and Performance Improvement* (ANSI/ACCA 12 QH) or other industry-accepted standard, the Heating Professional shall conduct this inspection in accordance with the current edition of ANSI/BPI-1200, Section 7.5. Leaks identified during the inspection shall be repaired and the system re-inspected.

- 4.4.1. If natural gas or LP gas piping system inspection has previously been completed and leaks have been identified, all leaks shall be repaired and the system re-inspected.

4.5. Oil Supply System Inspection

Where a comprehensive home energy audit including an inspection of the oil-fired appliance fuel supply system (tank, supply lines, burner) has not been completed in accordance with the current edition of ANSI/BPI-1200 or ANSI/ACCA 12 QH or other industry-accepted standard, an oil supply system inspection shall be conducted in accordance with the current edition of ANSI/BPI-1200, Section 7.6. Leaks identified during the inspection shall be repaired and the system re-inspected.

- 4.5.1. If an oil supply system inspection has previously been completed and leaks have been identified, all leaks shall be repaired and the system re-inspected.

5. Combustion Appliance Inspection

5.1. Safety Inspection:

Where a comprehensive home energy audit including a combustion appliance safety inspection has not been completed in accordance with the current edition of ANSI/BPI-1200 or ANSI/ACCA 12 QH or other industry-accepted standard, the Heating Professional shall conduct a combustion appliance safety inspection in accordance

¹ The Heating Professional shall contact the appropriate emergency services only if the homeowner/occupant is unable to do.

with the current edition of ANSI/BPI-1200 prior to performing any work.

- 5.1.1. If combustion appliance safety testing has previously been completed, the Heating Professional shall proceed with work and conduct the combustion appliance safety testing post-installation.
- 5.1.2. Combustion appliances which fail any combustion safety test, as described in the current edition of ANSI/BPI-1200 or ANSI/ACCA 12 QH, shall be tuned, repaired, replaced, or disabled.
- 5.1.3. Measured CO levels of undiluted flue gases in combustion appliances shall be compared to the CO thresholds in Table 1. Appliances with multiple burners may have multiple ports; CO shall be measured in each one.
- 5.1.4. Efforts should be made to reduce the CO level to the lowest end of the acceptable ranges as specified by the manufacturer’s instruction and operation manual, but in no case shall the level be higher than the appliance CO threshold limit in Table 1 without servicing the system to reduce its CO production.

Table 1 CO Thresholds for Fossil-Fuel Fired Combustion Appliances (adapted from ANSI Z223.1/NFPA 54, <i>National Fuel Gas Code</i> , 2015 Edition)	
Appliance	Threshold Limit
Central Furnace (all categories)	400 ppm air free*
Boiler	400 ppm air free
Floor Furnace	400 ppm air free
Gravity Furnace	400 ppm air free
Wall Furnace (BIV)	200 ppm air free
Wall Furnace (Direct Vent)	400 ppm air free
Vented Room Heater	200 ppm air free
Unvented Room Heater	200 ppm air free
Water Heater	200 ppm air free
Oven/Broiler	225 ppm as measured
Clothes Dryer	400 ppm air free
Refrigerator	25 ppm as measured
Gas Log (gas fireplace)	25 ppm as measured in vent
Gas Log (installed in wood burning fireplace)	400 ppm air free in firebox

*Air free emission levels are based on a mathematical equation (involving carbon monoxide and oxygen or carbon dioxide readings) to convert an actual diluted flue gas carbon monoxide testing sample to an undiluted air free flue gas carbon monoxide level utilized in the appliance certification standards. For natural gas or LP gas, using as-measured CO ppm and O₂ percentage:

$$CO_{AFppm} = \left(\frac{20.9}{20.9 - O_2} \right) \times CO_{ppm}$$

Where:
 CO_{AFppm} = Carbon monoxide, air-free ppm
 CO_{ppm} = As-measured combustion gas carbon monoxide ppm
 O₂ = Percentage of oxygen in combustion gas, as a percentage

An alternate method of calculating the CO air free when access to an Oxygen meter is not available:

$$CO_{AFppm} = \left(\frac{UCO_2}{CO_2} \right) \times CO$$

Where:
 UCO₂ = Ultimate concentration of carbon dioxide for the fuel being burned in percent for natural gas (12.2 percent) and LP gas (14.0 percent)

CO₂ = Measured concentration of carbon dioxide in combustion products in percent
CO = Measured concentration of carbon monoxide in combustion products in percent

5.1.5. Heat Exchanger Inspection

Forced warm air furnaces shall 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 shall be conducted to determine the source of the flame interference. Appropriate inspection techniques include the use of a combustion analyzer to identify changes in the oxygen or CO levels in the flue gas when the distribution air fan comes on or visual inspections using a mirror and flashlight. A cracked heat exchanger cannot effectively be repaired and shall be replaced by a qualified Heating Professional.

5.1.6. Gas Appliance Safety Inspection

In addition to the testing and inspection procedures set forth in the current edition of ANSI/BPI-1200, Section 7, the following inspections shall be completed on gas appliances.

- 5.1.6.1. No significant carbon buildup should be visible anywhere in the unit. This includes the draft hood, heat exchanger, and burners. If significant carbon is present, it shall be totally removed, and the source of the combustion problems shall be determined and remedied.
- 5.1.6.2. The burner flames shall 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 manifolds and jets shall be cleaned and adjusted as necessary.
- 5.1.6.3. Thermostat heat anticipator settings shall be adjusted, as needed, to match the amperage measured in the control circuit or to meet the thermostat manufacturer's specifications.

5.1.7. Oil Appliance Safety Inspection

In addition to the testing and inspection procedures set forth in the current edition of ANSI/BPI-1200, Section 7, the following inspections shall be completed on oil-fueled appliances and corrective actions included in the work scope.

- 5.1.7.1. All oil-fired heating exhaust venting systems shall be equipped with a properly installed barometric draft control, unless the manufacturer specifies none is required.
- 5.1.7.2. Oil lines shall be free of leaks and equipped with an oil safety valve or an oil line protective sleeve unless the oil burner is located above the oil storage tank and the entire oil supply line is connected to and above the top of the tank.

- 5.1.7.3. CAD cell or stack control activation shall be timed to verify that the burner will shut off if the fuel is not ignited. Recommend that CAD cells are inspected and serviced annually to ensure proper operation. The combustion chamber shall be visually inspected for integrity.

5.2. General Heating System Inspections and Adjustments

5.2.1. Heating System Maintenance

The heating system shall be serviced as specified in the current edition of ANSI/ACCA QM 4: *Maintenance of Residential HVAC Systems* (ACCA QM 4), or the manufacturer's instructions, or by procedures accepted by AHJ, where any of the following conditions exist:

- The system shows signs of neglect or the customer indicates it has not been serviced within two years
- Safety diagnostics indicate a problem
- Airflow diagnostics indicate incorrect flow that is not readily correctable
- Combustion analysis indicates an issue

5.2.2. Combustion Analysis

A combustion 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. The combustion analysis shall be conducted in accordance with the current editions of ANSI/ACCA *Standard 4: Maintenance of Residential HVAC Systems* (ANSI/ACCA 4 QM), and ANSI/ACCA 5 QI, *HVAC Quality Installation Specification* (ANSI/ACCA 5 QI).

5.2.3. Fuel Oil Supply System Inspection

- 5.2.3.1. Fuel oil supplied to a combustion appliance shall be free of water and other contaminants. In cold climates, steps, such as recommending a winter blend, shall be taken to ensure continuous flow and to avoid freeze-ups.
- 5.2.3.2. When a replacement oil heating system is installed, the existing oil filter shall be replaced. Tank and oil lines shall be in compliance with the current edition of NFPA 31, *Standard for the Installation of Oil-Burning Equipment*.

5.2.4. Furnaces with Forced Air Distribution Systems

- 5.2.4.1. Ensure that temperature limits are set in accordance with manufacturer's specifications. In the absence of manufacturer's specifications, the fan off temperature shall be set as close to 90-degree F as possible.
- 5.2.4.2. The fan on temperature shall 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 (unless otherwise specified by the equipment manufacturer).
- 5.2.4.3. If the high 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, or the maximum

value specified by the equipment manufacturer.

5.2.5. Boilers with Hydronic/Steam Distribution Systems

5.2.5.1. Hydronic System Safety and Efficiency Inspection

- 5.2.5.1.1. All systems shall have a properly-sized pressure relief valve, an operating pressure gauge, low water cut-off, and an elevated temperature aquastat, as required by code and in accordance with the manufacturer's specifications.
- 5.2.5.1.2. All water leaks shall be identified and repaired.
- 5.2.5.1.3. All systems shall have a safety control that will disable the gas valve when the high water temperature setting has been exceeded.
- 5.2.5.1.4. Open expansion tanks shall be replaced with sealed and pressurized expansion tanks or at a minimum such replacement shall be recommended.
- 5.2.5.1.5. An effective air-excluding device shall be installed as part of any new/replacement hydronic system.
- 5.2.5.1.6. All heating supply pipes in unconditioned areas shall be insulated with a sealed closed-cell foam or fiberglass pipe insulation. Insulation shall be recommended for accessible pipes not used as a heating source with operating temperatures exceeding 130°F in conditioned spaces.
- 5.2.5.1.7. Thermostatic radiator valves may be used to balance temperatures from room to room but shall not be installed on series loop systems.

5.2.5.2. Low Pressure Steam Distribution Systems Safety and Efficiency Inspection

- 5.2.5.2.1. Steam boilers shall be equipped with high pressure limits and low-water cut-off controls. High pressure limit controls shall be set at or below 15 psi.
- 5.2.5.2.2. Low-water cut-off flush valves that leak or are inoperable shall be repaired or replaced.
- 5.2.5.2.3. Steam vents shall be operable, and all radiators shall receive steam during every cycle. Unplug vents as necessary.
- 5.2.5.2.4. 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.
- 5.2.5.2.5. All exposed steam piping in unconditioned areas shall be insulated with pipe wrap rated for steam pipes.

5.2.6. Domestic Hot Water Systems

- 5.2.6.1. All water heaters shall have an unobstructed temperature and pressure relief valve and a safety discharge pipe. Install a relief valve and discharge pipe if none exists. The pipe shall terminate a maximum of 6 inches above the floor and be made of material in accordance with equipment manufacturer's specifications or allowed by AHJ.
- 5.2.6.2. Where a storage tank-type water heater is installed/replaced in a location where leakage may cause damage, then a drain pan and drain pipe shall be installed in accordance with equipment manufacturer's specifications, and code.
- 5.2.6.3. Water heater insulation wraps shall not cover the top of oil or gas systems, shall not impede draft or combustion air, and shall not obstruct the temperature and pressure relief valve, thermostats, high-limit switch, plumbing pipes, or access plates. A minimum 2-inch clearance is required from the access door for gas burners.
- 5.2.6.4. Water heater insulation wraps shall not be installed/replaced where forbidden by the manufacturer's nameplate instructions.

6. Space Heating System Replacement and New Installations in Existing Buildings

6.1. System Sizing

Heating systems shall be designed and sized based on the design requirements in ANSI/ACCA 5 QI *HVAC Quality Installation Specification* (ANSI/ACCA 5 QI). Acceptable sizing calculation and system selection methods include ANSI/ACCA 2 Manual J-*Residential Load Calculation* (ANSI/ACCA 2 Manual J) and Section 2.2-*Sizing Guidelines* of ANSI/ACCA 3 Manual S-*Residential Equipment Selection* (ANSI/ACCA 3 Manual S), other comparable and industry-accepted calculation procedures, or in the case of combined space and water heating systems, per manufacturer's specifications. Oil-fueled heating systems shall use the smallest available burner size that meets the calculated heating load for the building. Documentation of sizing calculation used shall be made available upon request.

6.1.1 Blower door test results shall be required to determine the building air leakage rates input into load calculations. Blower door testing shall be conducted in accordance with one of the following methods:

- Current edition of RESNET/ICC 380 *Standard for Testing Air Tightness of Building Enclosures, Air Tightness of Heating and Cooling Air Distribution Systems and Air Flow of Mechanical Ventilation Systems*
- Current edition of ANSI/ASTM E-779-10, *Standard Test Method for Determining Air Leakage Rate by Fan Pressurization*

6.2. Hydronic Distribution Systems

Installations of hydronic distribution systems shall be designed and sized in accordance with the design requirements in ANSI/ACCA 5 QI *HVAC Quality Installation Specification* (ANSI/ACCA 5 QI) and based on actual room-by-room heating loads for the space being conditioned utilizing ANSI/ACCA 2 Manual J or comparable calculation methodology. Radiator size shall be within 20% of calculated loads for the space being conditioned. Documentation of sizing calculation used shall be made available upon request.

6.3. Ducted Distribution Systems

6.3.1. Duct Installations

6.3.1.1. 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 *ANSI/ACCA 1 Manual D-Residential Duct Systems* (ANSI/ACCA 1 Manual D) or comparable calculation methodology.

6.3.1.2. Duct systems shall incorporate provisions for friction losses in the design and shall provide for balanced supply and return airflows for each room within the greater of +/-20 percent or 25cfm.

6.3.1.3. Ducts shall be installed to the minimum requirements of Section 6.3.8 of this standard and in accordance with the manufacturer's instructions, industry standards and all applicable federal, state and local regulations and codes.

6.3.1.4. After installation, all supply and return register airflows shall be measured in accordance with ANSI/ACCA 5 QI and verified to deliver airflows that are within 20% of design airflows. Deviations from design criteria greater than 20% shall be corrected.

6.3.2. Quantitative Duct Leakage Testing and Verification

Duct replacement installations in existing homes shall be tested for leakage using one of the following methods:

6.3.2.1. Methods in accordance with the current edition of ANSI/ACCA 5 QI, Section 5.1

OR

6.3.2.2. Whole house pressurization/depressurization procedure (e.g., Delta Q) in accordance with the manufacturer's instructions

6.3.3. Duct tightness shall meet or exceed the following requirements set forth in the EPA standards for ENERGY STAR Certified Homes, Edition 3/3/1 (Rev. 08)

6.3.3.1. Total Duct Leakage

Rough-in: The limit for total duct leakage shall not exceed the greater of ≤ 4 CFM25 per 100 sq. ft. of CFA or ≤ 40 CFM, with air handler & all ducts, building cavities used as ducts, & duct boots installed. In addition, all duct boots shall be sealed to the finished surface and verified at the final inspection.

Final: The limit for total duct leakage shall not exceed the greater of ≤ 8 CFM25 per 100 sq. ft. of CFA or ≤ 80 CFM, with the air handler and all ducts, building cavities used as ducts, duct boots, and register grilles atop the finished surface (e.g., drywall, floor) installed.

6.3.3.2. Duct Leakage to Outdoors

The limit for duct leakage to outdoors shall not exceed the greater of ≤ 4 CFM25 per 100 sq. ft. of CFA or ≤ 40 CFM25

Note: Leakage to outside shall be determined through direct testing using a duct leakage pressurization device in conjunction with the blower door.

6.3.4. Existing Ducted Distribution Systems

This section pertains to work completed on an existing duct system where a partial replacement and/or duct sealing is installed.

6.3.4.1. Duct Leakage Testing and Verification

6.3.4.1.1. Post-installation duct leakage testing shall be conducted after installation of partial replacement of duct system and/or duct sealing using one of the following methods:

6.3.4.1.1.1. Quantitative testing methods described in Section 6.3.2

6.3.4.1.1.2. Qualitative testing using a gasketed pan in accordance with the manufacturer's instructions and in conjunction with a blower door.

6.3.4.2. If building cavities are used as return air ducts, the Heating Professional shall test for duct leakage to the outside

6.3.4.3. Duct Leakage Limits for Existing Duct Systems

Duct tightness shall meet or exceed the following requirements for existing ducted distribution systems:

6.3.4.3.1. For quantified duct leakage test, the leakage rate shall be indicated as a percentage of the measured or estimated total airflow [as determined in accordance with Section 7 below]. Limits shall be in accordance with the current edition of ANSI/ACCA 5 QI, Section 5.1.1.b. When these limits are exceeded, further duct sealing shall be recommended.

6.3.4.3.2. For qualified duct leakage test, when cumulative pressure difference within a given distribution system exceeds 3 Pa, further duct sealing of that system shall be recommended.

6.3.5. Duct Sealing Materials and Procedures

Duct sealing shall be performed to the specifications below.

6.3.5.1. All surfaces that require air sealing shall be clean, dry and oil-free before any mastic or tape is installed.

6.3.5.2. UL 181-compliant duct sealing products or aerosol-based duct sealants that

are UL Classified and tested in accordance with UL 723 and are appropriate to the duct material being sealed, shall be used for sealing duct seams, joints, and other possible air-leakage sites, using one or a combination of the techniques described in Sections 6.3.5.2.1 and 6.3.5.2.2.

Exception: Permanent sealant materials shall not be applied in locations that interfere with the operation of filter access covers or service panels that may need to be removed for maintenance.

- 6.3.5.2.1. External sealing: UL 181-compliant duct sealants that are appropriate to the duct material being sealed as defined in the UL 181 standards shall be used for sealing external duct seams, joints, penetrations, and other possible air-leakage sites. Mastic shall be reinforced using fabric mesh when bridging gaps or covering openings that exceed $\frac{1}{4}$ inch but not more than $\frac{3}{4}$ inch, or according to manufacturer's specifications.
Exception: Combustion air openings shall remain open.
- 6.3.5.2.2. Internal sealing: UL Classified aerosol-based sealant tested in accordance with UL 723 and applicable portions of UL181 shall be used in accordance with manufacturer's instructions for sealing internal duct seams, joints, or other possible air-leakage sites up to $\frac{5}{8}$ inch span.
- 6.3.5.3. Duct boots shall be mechanically fastened to framing around boot penetrations to prevent movement and all seams shall be sealed to prevent air leakage.
- 6.3.5.4. Openings in metal ducts or plenums measuring more than $\frac{3}{4}$ inch shall be closed with galvanized sheet metal, duct board, or duct material rated for use in heating and cooling ductwork; or the damaged section shall be replaced prior to sealing.
- 6.3.5.5. Damaged sections of flex duct shall be replaced entirely, or the damaged sections removed and spliced with a metal sleeve sized to fit the duct in accordance with the current edition of Air Duct Council (ADC) *Flexible Duct Performance & Installation Standards*, Section 4.
- 6.3.5.6. Damaged duct board shall be repaired in accordance with the current edition of the North American Insulation Manufacturers Association (NAIMA) *Fibrous Glass Residential Duct Construction Standards*, Section 7. Note: Special tools are required when working with duct board.
 - 6.3.5.6.1. For duct board damaged beyond repair, fabricate an entire panel using the U-style assembly method as defined in the current edition of NAIMA *Fibrous Glass Residential Duct Construction Standards*, Section II.
- 6.3.5.7. When building cavities are used as return air ducts, and leakage exceeds the duct leakage limits in 6.3.3.2, the feasibility of replacement with hard ducting shall be evaluated.

6.3.6. System Airflow Measurement and Adjustment

System airflow measurement and adjustment shall be conducted as part of retrocommissioning², air handler replacement, or duct installation to ensure proper airflow across the heat exchanger or cooling coil in accordance with the current edition of ANSI/ACCA 5 QI, Section 4. System airflow operational limits shall be in accordance with the current edition of ANSI/ACCA 5 QI, Section 4.1.1.

6.3.6.1. Blower Speed Adjustment

When modifications are made to airflow by adjusting blower speed, they shall be completed as follows:

- 6.3.6.1.1. If airflow exceeds acceptable ranges as determined in Section 6.3.6 of this standard, adjust the blower speed to reduce airflow to within acceptable ranges. If airflow is below acceptable ranges as determined in Section 6.3.6 of this standard, adjust blower speed to increase airflow to within acceptable ranges.
- 6.3.6.1.2. External Static Pressure (ESP) shall be measured after blower speed adjustment and compared to manufacturer's blower performance table rating.
- 6.3.6.1.3. Duct system modifications to satisfy airflow shall be recommended if the air handler's maximum ESP exceeds manufacturer's specifications.

6.3.6.2. Duct System Modifications to Increase Airflow

The following methods shall be used as appropriate when airflow is to be corrected in conjunction with, or in place of, blower speed adjustment.

² **Retrocommissioning*** is the application of the commissioning process to existing buildings. Retrocommissioning is a process that seeks to improve how building equipment and systems function together. Depending on the age of the building, retrocommissioning can often resolve problems that occurred during design or construction, or address problems that have developed throughout the building's life. In all, retrocommissioning improves a building's operations and maintenance (O&M) procedures to enhance overall building performance.
(<http://cx.lbl.gov/definition.html>)

*For the purposes of this standard, retrocommissioning includes duct system sealing.

- 6.3.6.2.1. Remove kinks in flex duct.
- 6.3.6.2.2. Correct 90-degree bends in flex ducts that do not have a centerline radius of at least one duct diameter or replace with a 90-degree metal elbow of the same diameter.
- 6.3.6.2.3. Replace crushed sections of flex or solid metal duct.
- 6.3.6.2.4. Add supports as appropriate to correct sagging ducts in accordance with manufacturer's specifications. Flex ducts shall be supported at no greater than 4-foot intervals horizontally and at no greater than 6-foot intervals vertically. (See Section 6.3.8.3.3 of this standard.) For specifications refer to the current edition of NAIMA *Fibrous Glass Residential Duct Construction Standards*, or ADC *Flexible Duct Performance and Installation Standards*.
- 6.3.6.2.5. Modify the return plenum to accommodate a less restrictive filter.
- 6.3.6.2.6. Install turning vanes in 90-degree supply and/or return plenum as appropriate.
- 6.3.6.2.7. Provide jumper ducts, through-the-wall fittings (transfer grilles) or increase door undercuts to reduce airflow restrictions.
- 6.3.6.2.8. Add or enlarge plenums, ducts and registers/grilles.
 - 6.3.6.2.8.1. Add one or more return ducts or enlarge existing return(s).
 - 6.3.6.2.8.2. Add one or more supply ducts or enlarge existing supply ducts and registers. This requires a room-by-room load calculation and shall be done in conjunction with a full airflow-balancing procedure such as that described in Normative Annex B-1 of this standard.
- 6.3.6.3. Air Filters
 - 6.3.6.3.1. Filters shall be secured with a retainer to prevent filter from moving.
 - 6.3.6.3.2. Filters and retainer assemblies shall be constructed so that all return air passes through the filter with no potential for bypass.
 - 6.3.6.3.3. Filter slots at an air handler shall be covered with an accessible, removable, substantially air-tight cover to prevent air leakage, as well as allow access.
 - 6.3.6.3.4. Filters shall have the maximum Minimum Efficiency Reporting Value (MERV) rating possible given space constraints while still being within the system's recommended ESP limits. The Heating Professional shall select

a MERV rating that corresponds with the pressure drop specified by manufacturer.

6.3.6.3.5. The Heating Professional shall instruct the occupant/homeowner on filter maintenance and replacement.

6.3.7. Duct Insulation and Heat Transfer

Ducts, plenums and distribution boxes located in zones outside the thermal envelope shall be insulated as part of air handler replacement or duct installation to reduce heat transfer.

6.3.7.1. Duct insulation R-value shall meet or exceed the insulation requirements of the AHJ. If no requirement exists, the ducts shall be insulated to a minimum of R-8 for ducts in vented attics, garages, and in other unconditioned zones, including encapsulated attics and semi-conditioned crawl spaces.

6.3.7.2. In humid climate zones, metal cooling system ducts and plenums located inside the thermal boundary shall be insulated. In other climate zones, duct insulation shall be recommended if there is a possibility that condensation will accumulate on the ductwork. To prevent condensation from occurring on duct work, the insulation R-value installed shall be a minimum of R-8 and insulation facing seams shall be sealed.

6.3.7.2.1. Duct insulation shall be installed with facing exposed.

6.3.7.2.2. All seams in the insulation facing shall be taped to prevent air convection into the insulation which could lead to condensation on the metal duct. Where mechanical fastening is needed to maintain integrity of tape-sealed seam, mechanical fasteners shall be used.

6.3.7.2.3. Duct insulation shall be cut to the recommended stretched-out dimension.

6.3.7.2.4. Compressed thickness shall not be less than 75 percent of original thickness.

6.3.7.2.5. Compression of insulation at corners and bends shall be avoided.

6.3.8. Duct Materials and Installation

Ductwork shall be installed in accordance with the requirements below specific to the duct material being used and building cavities shall not be used as supply or return plenums.

6.3.8.1. Metal Ducts

Installation shall be in accordance with the current edition of Sheet Metal and Air Conditioning Contractors' National Association (SMACNA) *HVAC Duct Construction Standards*.

6.3.8.1.1. Ducts shall be fastened with mechanical connectors or screws designed for this purpose.

6.3.8.1.2. All joints and seams shall be sealed with duct mastic in accordance with Section 6.3.5 of this standard.

6.3.8.1.3. Ducts and plenums shall be insulated in accordance with Section 6.3.7 of this standard.

6.3.8.2. Fibrous Duct Board

Fibrous duct board requires careful compliance with manufacturer assembly and installation instructions. Installation shall be in accordance with the current edition of NAIMA *Fibrous Glass Residential Duct Construction Standard*.

6.3.8.2.1. Duct board shall be fastened securely to the air handler or furnace with a 3-inch collar and termination bar, which is screwed through the duct board and into the air handler flange.

6.3.8.2.2. Duct board shall be supported by 3-inch x 1-inch 26-gauge metal channels hung by either 12-gauge wire or by 1-inch 26-gauge straps. Supports shall be spaced no further than 6 feet apart for ducts less than 12 inches in depth, and every 8 feet for ducts at least 12 inches deep. Additional supports shall be provided at each turn in direction or take-off.

6.3.8.2.3. Take-offs shall be designed for use with duct board. Flex duct take-offs shall be beaded to ensure a tight fit.

6.3.8.3. Insulated Flex Duct

Flex duct shall not be installed in areas exposed to UV radiation or moisture as this will affect its longevity. Damaged or deteriorated flex duct shall be replaced as part of retrocommissioning or air handler replacement. Installation shall be in accordance with the current edition of ADC *Flexible Duct Performance and Installation Standards*.

6.3.8.3.1. Flex duct shall be replaced when it is punctured, deteriorated, or otherwise damaged.

6.3.8.3.2. Replacement flex duct shall be stretched as recommended by the manufacturer before installation. Sections shall be cut to size to avoid excess length.

Note: Flex duct friction rates increase proportionally with compression. Published friction rates apply only when duct is stretched within 4% of fullest length.

6.3.8.3.3. Horizontal flex duct shall be straight and level and supported by straps no further than 4 feet apart. Vertical flex duct shall be supported by straps no

further than 6 feet apart. Support straps shall be at least 1.5-inches wide and shall not compress the inner core.

- 6.3.8.3.4. Flex duct 90-degree bends shall have a centerline radius of at least one duct diameter and shall be fastened in place using straps or corner bracing. Metal elbows shall be recommended to eliminate the possibility of an incorrect radius.
- 6.3.8.3.5. Metallic worm-gear clamps shall be used on fittings without beads and on ducts larger than 6 inches.
- 6.3.8.3.6. Flex duct to metal fitting connections shall be attached with the inner core and outer jacket fastened individually with tool-tightened draw bands.
- 6.3.8.3.7. Seal all joints and seams with duct mastic in accordance with Section 6.5 of this standard.
- 6.3.8.3.8. Flex ducts shall not be in contact with one another to decrease the potential for condensation issues.
- 6.3.8.3.9. Flex duct may be supported by ceiling joists or other horizontal framing in lieu of straps providing it does not displace ceiling insulation and the spacing of the supports is sufficient to avoid sagging of the flex duct.
- 6.3.8.4. Wood Plenums and Duct Runs
 - 6.3.8.4.1. Duct systems shall not include wood supply and return plenums or duct runs.
 - 6.3.8.4.2. Penetrations in the plenum liner shall be sealed with a UL 181-compliant sealant.

6.3.8.5. Other Duct Materials

The manufacturer's specifications and installation requirements shall be followed.

6.4. Orphaned Equipment

- 6.4.1. When a commonly vented natural draft appliance becomes "orphaned", that appliance shall be tested for safe operation in accordance with the current edition of ANSI/BPI-1200. Orphaned appliances shall not be left venting alone into a previously shared chimney without ensuring the chimney meets the appropriate requirements of the current edition of NFPA 54/ANSI z223.1: *National Fuel Gas Code*, Chapter 13, and the appliance has been tested and passed all required combustion safety tests in accordance with the current edition of ANSI/BPI-1200.

6.4.2. Addition of Exhaust Equipment

If the scope of work includes the addition of equipment that exhausts to the exterior and naturally drafting combustion appliances remain, those appliances

shall be tested for safety in accordance with the current edition of ANSI/BPI-1200 Section 7.9 or ANSI/SACCA 12 QH 12 Section 3.2 after exhaust equipment is installed or modified.

6.5. Water Heater Replacements

Domestic hot water heater replacements shall be sized according to the Air-Conditioning, Heating, Refrigeration Institute (AHRI) Water Heater Calculator. The first hour rating for hot water systems shall match the calculated peak hour demand within 5% or the next available size. When installing water heating systems or retrofitting existing systems, measures to reduce the peak demand should be recommended as part of the work scope. Furthermore, such systems shall be tested for safety in accordance with the current edition of ANSI/BPI-1200 or ANSI/SACCA 12 QH Section 3.2. Results shall be reviewed with the occupant/homeowner and appropriate remediation shall be undertaken as needed.

6.6. Oil Burner Replacements

Where burner replacements are installed on existing equipment, the assembly shall be sized according to the boiler/furnace equipment manufacturer's specifications or equipment nameplate rating.

6.7. Oil Burner Nozzle Replacements

Oil systems may be downsized below equipment manufacturer's specifications by replacing the nozzle with a nozzle that is one size below equipment nameplate rating to match the building heat load. The appliance shall be tested to ensure the flue gas exit temperature does not go below 325 degrees F net when the appliance has reached steady state under design conditions.

6.8. Condensing boilers shall be installed per manufacturer's specifications, including, but not limited to, outdoor reset controls and water quality specifications.

blower

Annex A | BPI-3301 Referenced Documents (Normative)

Referenced Documents
Air Duct Council (ADC) Flexible Duct Performance & Installation Standards
ANSI/ACCA 4 QH: Maintenance of Residential HVAC Systems
ANSI/ACCA 5 QI: HVAC Quality Installation Specification
ANSI/ACCA 12 QH: Home Evaluation and Performance Improvement
ANSI/ACCA -1 Manual D-Residential Duct Systems
ANSI/ACCA - 2 Manual J-Residential Load Calculation
ANSI/ACCA -3 Manual S-Residential Equipment Selection
ACCA Manual T - Air Distribution Basics
ANSI Z223.1/NFPA 54: National Fuel Gas Code
ANSI/ASTM E-779-10, Standard Test Method for Determining Air Leakage Rate by Fan Pressurization
ANSI/BPI-1200-S Standard Practice for Basic Analysis of Buildings
EPA Standards for ENERGY STAR Certified Homes, Edition 3/3/1 (Rev. 08)
North American Insulation Manufacturers Association Fibrous Glass Residential Duct Construction Standards
ANSI/RESNET/ICC 380-2016 "Standard for Testing Air Tightness of Building Enclosures, Air Tightness of Heating and Cooling Air Distribution Systems and Air Flow of Mechanical Ventilation
Sheet Metal and Air Conditioning Contractors' National Association HVAC Duct Construction Standards

Documents can be ordered from the following:

ACCA: Air Conditioning Contractors of America
2800 Shirlington Road, Suite 300
Arlington, VA 22206
(703) 575-4477
www.acca.org

ADC: Air Duct Council
1901 N. Roselle Road, Suite 800
Schaumburg, Illinois 60195
(847) 706-6750
info@flexibleduct.org

ANSI: American National Standards Institute
1899 L Street, NW
11th Floor
Washington, DC, 20036
www.ansi.org

ASTM: ASTM International
100 Barr Harbor Drive, PO Box C700
West Conshohocken, PA, 19428
(877) 909-2786
www.astm.org

BPI: Building Performance Institute, Inc.
107 Hermes Road, Suite 210
Malta, NY 12020
(877) 274-1274
www.bpi.org

NAIMA: North American Insulation Manufacturers
Association
44 Canal Center Plaza, Suite 310
Alexandria, VA 22314
(703) 684-0427
www.naima.org

NFPA: National Fire Protection Association
1 Batterymarch Park
Quincy, MA 02169-7471
(617) 770-3000
www.nfpa.org

RESNET: Residential Energy Services Network,
Inc.
P.O. Box 4561
Oceanside, CA 92052-4561
www.resnet.us

SMACNA: Sheet Metal and Air Conditioning
Contractors' National Association
4201 Lafayette Center Drive
Chantilly, Virginia 20151-1219
(703) 803-2980

U.S. Environmental Protection Agency
1200 Pennsylvania Avenue, NW
Washington, DC 20460
(202) 564-4700
www.epa.gov

Annex B | Additional Elements for Proper Air Distribution for ~~New~~ Duct System Installations (Normative)

B.1 Room Airflow Testing and Balancing

Airflow testing and balancing is strongly recommended for all forced air HVAC systems. When conducting room airflow testing and balancing, use the following procedure:

- B.1.1 Perform/obtain a room-by-room load calculation prior to balancing.
- B.1.2 The airflow at each supply diffuser shall be measured using a calibrated anemometer, flow hood, or other method with similar accuracy.
- B.1.3 In-line balancing dampers shall be used to adjust the air delivered to each room in proportion to the room-by-room design load.
- B.1.4 Room-to-room pressure differences shall be measured using a calibrated manometer to verify if rooms are influenced by positive or negative pressure once the air handler is operated. Each room tested shall not exceed a maximum pressure differential of 3 Pascal across all door(s) to the main portion of the home.

B.2 Verify Heating and Cooling Capacity is Appropriate for Design Loads

B.2.1 ~~New~~ Duct Systems

- A.2.1.1 ~~New~~ duct systems shall be designed in accordance with the procedures outlined in the current editions of ANSI/ACCA 1 Manual D and ACCA Manual T - *Air Distribution Basics* (ACCA Manual T).
- B.2.1.2 ~~A new duct system~~ Duct systems shall be designed to match the capacity of source equipment (air handler, coil, furnace, or condenser). The duct system shall be designed to operate at an ESP of up to 0.5 IWC or no higher than the actual ESP specified by the air handler manufacturer.
- A.2.1.3 ~~New source~~ Heating ventilation and air conditioning (HVAC) equipment shall comply with sizing and selection procedures outlined in the latest editions of ANSI/SACCA 2 Manual J and ACCA Manual S.

B.2.2 Modifications to Existing Duct Systems

- B.2.2.1 Modifications to an existing duct system shall be designed to achieve desired system and room airflow targets. ANSI/SACCA 1 Manual D provides guidance for sizing ducts. ACCA Manual T provides guidance for sizing air diffusers (registers).
- B.2.2.2 Modifications to existing ducts shall be recommended when newly installed ~~source equipment~~ HVAC system airflow requirements exceed the capacity of the duct system.

Annex C | Prioritizing Duct Sealing (Informative)

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 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.