

Getting it Right: A Brief Discussion of Commissioning, Testing, and Balancing Requirements in ASHRAE Standard 90.1 and the IECC

You can design the best building in the world and still end up with a building that doesn't perform to its full potential if something isn't done right. Commissioning, testing, and balancing are all ways of identifying things that "aren't right" and fixing them.

A recent report from Lawrence Berkeley National Laboratory¹ (LBNL) discusses the importance of commissioning by pointing out that an evaluation of nearly 99 million square feet of commissioned buildings showed savings of 13% and 16% of whole building energy use for new construction and existing buildings, respectively. Table 2 of the LBNL report lists the 13 most common faults found in commercial buildings during commissioning (out of a total list of over 100), including leaking ducts, HVAC systems left on in unoccupied space, lights left on in unoccupied space, air flow not balanced, improper refrigerant charge, dampers not working properly, insufficient evaporator air flow, improper controls setup, control component failure or degradation, software programming errors, improper controls hardware installation, air-cooled condenser fouling, and valve leakage.

Why do these problems occur? Systems are getting more complex. Interactions within systems can mean components may be set up properly on their own



but are not set up to work optimally in combination with other components. Installers may not be adequately trained to find and fix problems or may not be paid to fine tune the systems they install.

Energy codes have included HVAC system balancing for a long time, starting with ASHRAE Standard 90-75 and the 1986 Council of American Building Officials (CABO) Model Energy Code (MEC)². But for a long time, energy codes and standards did not contain much in the way of commissioning and testing requirements because the codes and standards themselves were focused on "design," not "construction,"



¹ Building Commissioning - A Golden Opportunity for Reducing Energy Costs and Greenhouse-Gas Emissions, Evan Mills, 2009, Lawrence Berkeley National Laboratory. Available at <http://cx.lbl.gov/2009-assessment.html>.

² Balancing requirements for low-rise residential buildings were removed from the IECC in 2006.

and certainly not on anything that takes place after “construction” in the building lifecycle process. The assumption was that if the code required good systems and equipment, and if the installers did their jobs properly, then the building would work as designed. The key part of that assumption is “if the installers did their jobs properly.” With complex building systems, it is not always possible to quickly and easily determine “if the installers did their jobs right.” As interest in energy efficiency has increased over the years, more and more focus has been placed on making sure buildings actually deliver the energy savings that they should based on their design, and that means more emphasis has been put on verifying that the building should be energy efficient. This document provides definitions of commissioning, testing, and balancing, as well as an overview of these requirements.

The codes covered in this topic brief are listed in Table 1.

Table 1. Codes Covered in this Topic Brief

Commercial and High-Rise Multi-family Residential	Low-Rise Residential
ASHRAE Standard 90.1-2007 2009 IECC ASHRAE Standard 90.1-2010 2012 IECC	2009 IECC 2012 IECC

Definitions

Balancing, air system (ASHRAE Standards 90.1-2007 and 2010) – adjusting air flow rates through air distribution system devices, such as fans and diffusers, by manually adjusting the position of dampers, splitter vanes, extractors, etc., or by using automatic control devices, such as constant air volume or variable-air-volume (VAV) boxes.

Balancing, hydronic system (ASHRAE Standards 90.1-2007 and 2010) – adjusting water flow rates through hydronic distribution system devices, such as pumps and coils, by manually adjusting the position valves or by using automatic control devices, such as automatic flow control valves.

Building commissioning (2012 IECC) – a process that verifies and documents that the selected building systems have been designed, installed, and function according to the owner’s project requirements and construction documents, and to the minimum code requirements.

Commissioning plan (ASHRAE Standard 189.1-2011³) – a document that outlines the organization, schedule, allocation of resources, and documentation requirements of the building commissioning process.

Commissioning process (ASHRAE Standard 189.1-2011) – a quality focused process for enhancing the delivery of a project. The process focuses on verifying and documenting that the facility and all of its systems and assemblies are planned, designed, installed, tested, operated, and maintained to meet the owner’s project requirements.

Test – this term is not defined in either ASHRAE Standard 90.1-2007 or 2010, or in the 2009 or 2012 IECC, but is used in ASHRAE Standard 90.1-2007 and 2010 in the phrase “shall be tested to ensure that control elements⁴ are calibrated, adjusted, and in proper working condition.” This implies that the word “test” is defined as “ensure that control elements are calibrated, adjusted, and in proper working condition.” ASHRAE Standard 90.1-2010 also uses the term “functional testing” for lighting in the phrase “lighting control devices and controls systems shall be tested to ensure that control hardware and software are calibrated, adjusted, programmed, and in proper working condition in accordance with the construction documents and manufacturer’s installation instructions.” Again the implication is that testing

³ While ASHRAE Standard 189.1-2011 is not one of the standards or codes covered in this document, it does provide some useful definitions that do not appear elsewhere.

⁴ The term “control elements” is not well defined in the codes either. ASHRAE Standard 90.1-2010 defines “control” as “to regulate the operation of equipment” and “control device” as “a specialized device used to regulate the operation of equipment”. The term “control elements” can be expected to include any sensors, any electronic or mechanical connections or interfaces, and any devices such as dampers, valves, switches, etc. that are controlled in the system.

is for control elements and that the focus is on making sure the controls function properly. The term “test” is also used in conjunction with duct testing requirements in all of the codes considered here, but with specific reference to a test procedure. The term “test” is also used in terms of test procedures for equipment efficiency, roof solar reflectance and thermal emittance, and the building envelope testing option in the 2012 IECC, again all without a formal definition of “test” but with a reference to a test procedure. The term “test” is also mentioned in the IECC in Section 104.7 (2009 IECC) and C104.7 and R104.7 (2012 IECC) in terms of reinspection and testing and approval, with the direction that, “When any work or installation does not pass an initial test or inspection, the necessary corrections shall be made so as to achieve compliance with this code,” and, “After the prescribed tests and inspections indicate that the work complies in all respects with this code, a notice of approval shall be issued by the code official.”

As seen in Table 2, the main focus of residential testing is air leakage requirements, either through the building thermal envelope or from ducts to unconditioned spaces or the outside.⁵ No functional testing or balancing of HVAC systems or lighting is required.

Table 2. Residential Commissioning, Testing, and Balancing in the 2009 IECC and 2012 IECC

Requirement	2009 IECC	2012 IECC
Envelope Air Leakage Testing	402.4.2.1 (optional)	R402.4.1.2
Duct Tightness	403.2	R403.2.2

⁵ Sections 403.2 and R403.2.2 provide an exception to the testing requirement if the air handlers and all ducts are located within conditioned space.

Table 3. Commercial and High-Rise, Multi-family Residential Commissioning, Testing, and Balancing in ASHRAE Standard 90.1-2007, ASHRAE Standard 90.1-2010, the 2009 IECC, and the 2012 IECC

Requirement	ASHRAE Standard 90.1-2007	2009 IECC	ASHRAE Standard 90.1-2010	2012 IECC
Envelope Air Leakage Testing	Not required	Not required	Not required	C402.4.1.2.3 (optional)
Duct Leakage Testing	6.4.4.2.2 (high pressure only)	503.2.7.1.3 (high pressure only)	6.4.4.2.2 (high pressure only)	C402.2.7.1.3 (high pressure only)
HVAC System Narrative	6.7.2.2	503.2.9.3	6.7.2.2	C408
HVAC System Balancing	6.7.2.3	503.2.9.1 and 503.2.9.2	6.7.2.3	C408
HVAC System Testing	6.7.2.4	Not required	6.7.2.4	C408 (HVAC systems greater than 480 kBtu/h cooling and 600 kBtu/h heating)
HVAC System Commissioning Plan	6.7.2.4 (projects greater than 50,000 ft ² only)	Not required	6.7.2.4 (projects greater than 50,000 ft ² only)	C408 (HVAC systems greater than 480 kBtu/h cooling and 600 kBtu/h heating)
HVAC System Commissioning	Not required	Not required	Not required	C408
Lighting System Functional Testing	Not required	Not required	9.4.4	C408
Lighting System Commissioning	Not required	Not required	Not required	C408

The array of testing, balancing, and commissioning requirements for commercial and high-rise multi-family residential buildings is much larger than that for low-rise residential buildings. This reflects the increased complexity of commercial systems versus typical, low-rise residential systems.

One item to note is the increasing number of testing, balancing, and commissioning requirements over time. While ASHRAE Standard 90.1-2007 has five such requirements, ASHRAE Standard 90.1-2010 has six. The IECC has progressed from three requirements in the 2009 IECC to eight in the 2012 IECC (nine if the optional envelope air leakage testing is included). Future versions of both ASHRAE Standard 90.1 and the IECC can be expected to have more testing, balancing, and commissioning requirements.

Further Resources

Residential Duct Testing—www.energycodes.gov/sites/default/files/documents/res_duct_testing_topic_brief.pdf

Building Commissioning from the Whole-Building Design Guide—www.wbdg.org/project/buildingcomm.php

Building Commissioning from ASHRAE—ASHRAE Guideline 0 – 2005 www.techstreet.com/ashrae/cgi-bin/detail?product_id=1619765

Building Commissioning from the National Environmental Balancing Bureau (NEBB)—Procedural Standards for Whole Building Systems Commissioning of New Construction - www.techstreet.com/ashrae/cgi-bin/detail?product_id=1703737

Building Commissioning Plans and Guide from Portland Energy Conservation, Inc. (PECI)—www.peci.org/model-commissioning-plans-guide-specifications

Functional Testing Guidance from PECI—www.peci.org/ftguide/ftg/Functional_Testing_Guide_from_the_Fundamentals_to_the_Field.htm

