

# HVAC COMMISSIONING IN A CODE-BASED WORLD

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## | ASHRAE 90.1-2016 Mechanical Systems Cx Requirement

### Section 6.7.2.4 – Systems Commissioning

HVAC control systems shall be tested to ensure that control elements are calibrated, adjusted, and in proper working condition. For projects larger than 50,000 ft<sup>2</sup> conditioned area, except warehouses and semi-heated spaces, detailed instructions for commissioning HVAC systems (*see Informative Appendix E*) shall be provided by the designer in plans and specifications.

## | 2015 IECC Systems Commissioning Requirement

### Section C408 – Systems Commissioning

#### C408.2 - Mechanical Systems & Service Water-heating Systems

Prior to the final mechanical and plumbing inspections, the registered design professional or approved agency shall provide evidence of mechanical systems commissioning and completion.

Construction document notes shall clearly indicate provisions for commissioning and completion requirements in accordance with this section and are permitted to refer to specifications for further requirements.

## | 2015 IECC Systems Commissioning Requirement

### Section C408 – Systems Commissioning

### C408.2 - Mechanical Systems & Service Water-heating Systems

C408.2.1 Commissioning Plan

C408.2.2 Systems Adjusting and Balancing

C408.2.3 Functional Performance Testing

C408.2.4 Preliminary Commissioning Report

C408.2.5 Documentation Requirements

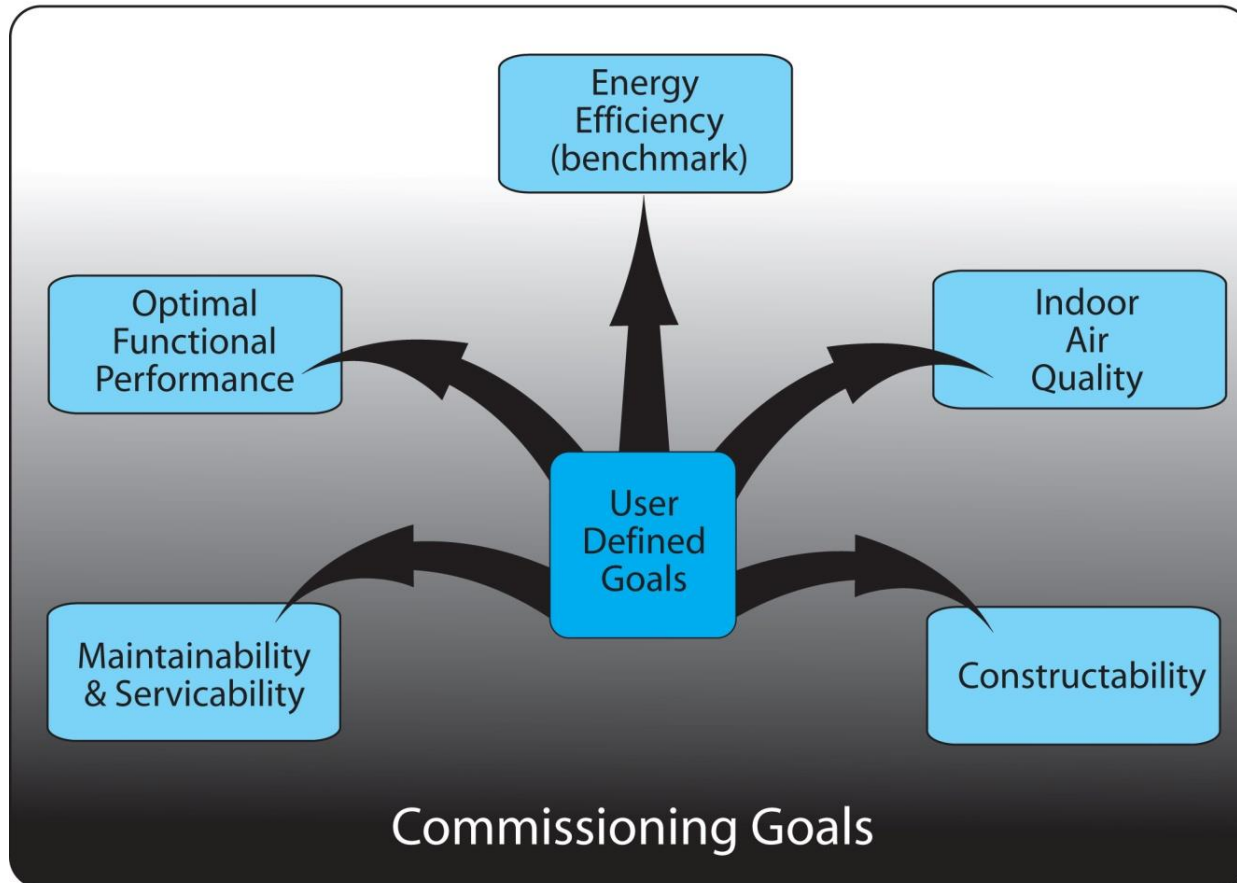
## | What is the Intent of Requiring Commissioning?

- Ensures that the systems are designed, installed, functionally tested and capable of being operated and maintained according to the owner's operational needs as defined by a design intent document.”  
*Building Commissioning Association*
- Prevents and resolves problems during the early stages of a project when costs are lower
- Provides a sanity check during “Value Engineering” Process.
- Verifies by testing and documenting that the building systems perform according to design intent.

## | Top 10 HVAC Deficiencies Found in Non-Commissioned Buildings

1. Incorrect scheduling of HVAC and lighting
2. Incorrect cooling and heating sequence of operation
3. Incorrect calibration of sensors and instrumentation
4. Lack of control strategies for optimum comfort and efficient operation
5. Malfunctioning air and water side economizer cycles
6. Under-utilized computer based control systems
7. Short cycling of HVAC equipment leading to premature failure
8. Lack of design intent and building documentation
9. Lack of training for building operators
10. Missing or unspecified equipment

## | Commissioning Goals and Desired Outcomes



## | Minimum Expectations for Commissioning

- Owner's Project Requirements
- Commissioning Specifications
- Commissioning Plan
- Functional Performance Tests
- Air & Water Balancing and Report
- Operations Manual
- Commissioning Report



## | Owner's Project Requirements (OPR)

Start with the end in mind

- ASHRAE 202 identifies the Commissioning Authority (CxA) to lead documentation of the OPR
- OPR should contain the following:
  - Expected number of occupants and occupancy schedule
  - Cost constraints – both first cost and life cycle
  - Expected equipment, system and building operating metrics such as:
    - Useful life
    - Energy performance
    - Maintenance requirements
  - Benchmarks for project success

# Owner's Project Requirements (OPR) FORM GRN 20

## Compliance Form

2017 Los Angeles Green Building Code  
and 2016 California Energy Code

**COMPLETE AND INCORPORATE THIS FORM INTO THE PLANS**

Project Address: \_\_\_\_\_ Permit Number: \_\_\_\_\_

ITEM #	OPR ITEMS	PAGE NUMBER IN OPR DOCUMENT
<b>PROJECT PROGRAM</b>		
1	General building information (size, stories, construction type, occupancy type and number)	
2	Intended uses and schedules	
3	Future expandability and flexibility of spaces	
4	Quality and/or durability of materials and desired building lifespan	
5	Budget or operation constraints	
<b>ENVIRONMENTAL AND SUSTAINABILITY GOALS</b>		
6	Level of compliance with the Los Angeles Green Building Code: Mandatory, Tier 1, or Tier 2	
7	Specific environmental or sustainability goals (e.g. water efficiency, water reuse, CO <sub>2</sub> monitoring, xeriscaping, etc.)	
<b>ENERGY EFFICIENCY GOALS</b>		
8	Overall efficiency of building: meet California Energy Code or exceed by (%)	
9	Lighting system efficiency: meet California Energy Code or exceed by (%)	
10	HVAC equipment efficiency and characteristics	
11	Other measures affecting energy efficiency desired by owner (e.g. building orientation, shading, envelope and fenestration, roof, renewable power, net-zero energy use, etc.)	
<b>INDOOR ENVIRONMENTAL QUALITY REQUIREMENTS</b>		
12	Lighting	
13	Temperature and Humidity	
14	Acoustics	
15	Air quality, ventilation, and filtration	
16	Desired adjustability of system controls	
17	Accommodations for after-hours use	
18	Other owner requirements (e.g. natural ventilation, daylight, views, etc.)	

<b>EQUIPMENT AND SYSTEMS EXPECTATIONS</b>		
19	Level of quality, reliability, equipment type, flexibility, maintenance, and complexity desired	
20	Specific efficiency targets, desired technologies, or preferred manufacturers for building systems, acoustics and vibration	
21	Degree of system integration, automation, and functionality for controls (i.e. load shedding, demand response, energy management)	
<b>BUILDING OCCUPANT AND O&amp;M PERSONNEL EXPECTATIONS</b>		
22	Description of how the building will be operated and by whom	
23	Level of training and orientation required to understand, operate and use the building systems for building operation and maintenance staff, as well as occupants	
24	Building operation and maintenance staff location and capabilities	
<b>COMMISSIONING AGENT INFORMATION</b>		
25	Name of Commissioning Agency:	
26	Address of Agency:	
27	Contact person(s) Name(s):	

**Owner/Owner Representative Acknowledgement**

Owner's Project Requirements (OPR). The expectations and requirements of the building appropriate to its phase shall be documented before the design phase of the project begins. The OPR includes the elements listed above and have been approved by the Owner or Owner Representative.

Name: \_\_\_\_\_  Owner  Owner Representative

Company Name (if applicable): \_\_\_\_\_

Signature: \_\_\_\_\_ Date: \_\_\_\_\_

## | Commissioning Plan

- Narrative description of the activities during each phase of the project, including the personnel intended to accomplish each of the activities
- List of the specific equipment and systems to be tested
  - Description of the tests
  - Functions to be tested
  - Conditions under which the test will be performed.
  - Measurable criteria for performance.

## | Commissioning Specifications

- 01 91 13 General Commissioning Requirements
  - Define roles and responsibilities of Cx team
    - Commissioning Authority
    - Contractor(s)
    - Design Professionals
    - Owner
  - Define functional testing process
    - Who writes the test procedures
    - Who conducts them
    - Who documents the results
  
- 23 08 00 Commissioning of HVAC
  - Reference 01 91 13
  - Provide list of equipment and systems included in Cx process

# Functional Performance Testing

- Customized, project-specific tests
- All modes of operation are tested
- Failure scenarios are tested
- Verification of:
  - Alarms
  - Alarm set points
  - System-to-system connections
  - Graphical representations
  - Sensor calibrations

The screenshot displays a testing interface with three attempts at the top. Attempt #1 (04/11/2012) is FAILED with 60% completion. Attempt #2 (08/24/2012) is FAILED with 62% completion. Attempt #3 (08/16/2012) is INCOMPLETE with 14% completion. A 'New Attempt' button is visible on the right.

The detailed view for 'Attempt 3' (INCOMPLETE) includes a 'Mark as Passed' dropdown and a 'Reorder' button. The test steps are as follows:

Step	Initial Conditions	Nameplate Data	Setpoints
1	INITIAL CONDITIONS		
2	NAMEPLATE DATA		
3	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Skip <input type="checkbox"/> N/A <input type="button" value="Add Issue"/>	Record the manufacturer of the unit. <i>Trane</i>	
4	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Skip <input type="checkbox"/> N/A <input type="button" value="Add Issue"/>	Record the model number. <i>MR21000</i>	
5	SETPOINTS		
6	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Skip <input type="checkbox"/> N/A <input type="button" value="Add Issue"/>	Record the supply air temperature setpoint. <i>Setpoint</i>	
7	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Skip <input type="checkbox"/> N/A <input type="button" value="Add Issue"/>	Record the outdoor air temperature.	
8	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Skip <input type="checkbox"/> N/A <input type="button" value="Add Issue"/>	Record the outdoor air relative humidity.	
9	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Skip <input type="checkbox"/> N/A <input type="button" value="Add Issue"/>	Record the actual space (Studio) temperature.	
10	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Skip <input type="checkbox"/> N/A <input type="button" value="Add Issue"/>	Record the actual space relative humidity.	
11	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Skip <input type="checkbox"/> N/A <input type="button" value="Add Issue"/>	Record the space relative humidity setpoint.	
12	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Skip <input type="checkbox"/> N/A <input type="button" value="Add Issue"/>	Record the space temperature setpoint.	
13	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Skip <input type="checkbox"/> N/A <input type="button" value="Add Issue"/>	Is the AHU programmed to run continuously at all times of day?	
14	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Skip <input type="checkbox"/> N/A <input type="button" value="Add Issue"/>	Record space high/low temperature alarm setpoints.	
15	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Skip <input type="checkbox"/> N/A <input type="button" value="Add Issue"/>	Record space high/low relative humidity alarm setpoints.	

## | Commissioning Report Contents

The report should include an executive summary, list of participants and roles, brief building description, and the following sections:

- Equipment Summary including asset information
- Design Review Reports (*optional*)
- Submittal Review Reports (*optional*)
- Field Observation Reports (*optional*)
- Completed Pre-functional Checklists (*optional*)
- Passed Functional Performance Test Results
- Testing, Adjusting & Balancing Report
- Complete Deficiency Log sorted by Discipline
- Open Deficiency Log sorted by Discipline
- List of any Deferred Functional Tests

## | Plan Review Checklist

- Owner's Project Requirements
- Statement that the Designer's Basis of Design (BOD) meets the Owner's Project Requirements
- Commissioning Specifications
  - 01 91 13 General Commissioning Requirements
  - 23 08 00 Commissioning of HVAC Systems
- Operations Manual Specifications
  - Specify that the documents be provided to the building owner within 90 days of the date of receipt of the certificate of occupancy.
- Commissioning Plan

## | Certificate of Occupancy Checklist

- Air & Water Balance Report
- Preliminary Cx Report
  - Organized with mechanical and service hot water findings in separate sections
  - Itemization of deficiencies found during testing that have not been corrected at the time of report
  - Deferred tests that cannot be performed at the time of report preparation
  - Climatic conditions required for the deferred tests.
- Operations Manual (draft or table of contents)



## | THANK YOU

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Shameless plug for Living Building Project at Georgia Tech:  
<http://livingbuilding.kendedafund.org/>