BUILDING COMMISSIONING

by the

Sustainable, Energy Efficient Buildings Advisory Committee

in re

N.C.G.S. 143-135.35 thru 143-135.40
(Senate Bills 668 and 1946)

1.0 BUILDING COMMISSIONING

North Carolina General Statute 143-135.37(d) requires commissioning of major projects, as follows:

> "…The construction contract shall include provisions that require each building component and each energy and water system component to be commissioned, and these provisions shall be included at the earliest phase of the construction process as possible and in no case later than the Schematic Design Phase of the project. Such commissioning shall continue through the initial operation of the building. The project design and construction teams and the public agency shall jointly determine what level of commissioning is appropriate for the size and complexity of the building or its energy and water system components."

1.1 DEFINITION AND SCOPE OF COMMISSIONING

Commissioning is a quality assurance process that verifies and documents that building components and systems operate in accordance to the owner's project requirements and the project design documents. The party responsible for the commissioning process is defined as the *commissioning authority (CxA).*

For smaller, less complex projects commissioning can be provided under the direction and supervision of the designers when they establish specific start-up tests and documentation, followed by required detailed performance tests and documentation, to be performed by the installers and, then, participate in conducting these tests and evaluating the result. This is typically referred to as *designer-led* commissioning. This level of commissioning is typically acceptable for smaller, simpler facilities.

The best level of commissioning is that performed by an independent, third party CxA. Third party commissioning of major facilities will be necessary if any of the following conditions are satisfied:

1. Buildings greater than 20,000 gsf but less than 40,000 gsf in area, and are complex in nature. Typical building classifications, as defined by the *North Carolina State Building Code*, meeting this criteria are as follows:

   Group A-1 and A-3 (Auditoriums, gyms, assembly areas, etc)
   Group B (Educational facilities above the 12th grade, laboratories and data processing centers)
   Group I-2 and I-3 (Medical and correctional facilities)
   Group R-2 (Dormitories)
   Buildings connected to central campus energy plants

2. Buildings that exceed 40,000 gsf in area. However, buildings of the following occupancy classifications, as defined by the *North Carolina State Building Code*, typically do not require this level of commissioning since they have limited energy impact:

Group H-1 through H-5 (High-Hazard Storage Buildings)
Group S-1 and S-2 (Simple Storage Buildings)
Group U (Utility and miscellaneous shelters and structures)

3. Buildings that have central energy plant equipment such as chillers and boilers.

4. Building renovations, as defined by NCGS 143-135.35(6) (renovation costs of greater than 50% of insurance value and larger than 20,000 gsf), to existing buildings that have multiple zone control HVAC systems.

Building commissioning shall include the whole building and, specifically, the following systems:

1. Mechanical systems – including HVAC systems and equipment, building automation systems, laboratory systems, energy recovery and renewable energy systems, and Testing, Adjusting and Balancing (TAB) validation.

2. Electrical systems – including lighting systems and controls, including day lighting, and renewable energy systems.

3. Plumbing systems – including potable hot water systems and rainwater harvesting and/or gray water systems.

4. Irrigation systems – including coverage and controls.

Other systems to consider during the commissioning process include normal, standby and emergency power systems, potable water and booster pump systems, and the building envelope.

During the early design stages of each major facility, preferably during advance planning, but certainly no later than the beginning of the Schematic Design Phase, the design team and the public agency must jointly determine what level of commissioning is appropriate for the size and complexity of the building and/or its energy and water system components. Verification of the project commissioning level and, as applicable, a copy of the third-party commissioning contract, will be required for the Schematic Design submittal to the State Construction Office.

1.2 DESIGNER-LED COMMISSIONING

In the smaller, less complex buildings, designer-led commissioning may be sufficient. In this case, the designer serves as the CxA. In these cases, commissioning of the facility HVAC systems typically represents about 90%+ of the commissioning requirement. Designer-led HVAC commissioning is a process defined by ANSI/ASHRAE Standard 111, *Practices for Measurement, Testing, and Balancing of Heating, Ventilation, Air-Conditioning, and Refrigeration Systems*; ASHRAE Guideline 1.1-2007, *The HVAC&R Technical Requirements for The Commissioning Process*; and ASHRAE Guideline 0-2005, *The Commissioning Process*.

Basically, the designer-led commissioning process begins with the HVAC designer to developing the Basis of Design (BOD) document. The BOD document should be developed during the Schematic Design Phase and updated with the Design Development and Construction Document submittals. A final as-built BOD document must be completed following

building occupancy and the designers must provide training to the owner's operating staff on the BOD document.

The next step, during the Design Development Phase, is developing detailed specifications for TAB requirements, start-up procedures, and functional tests of HVAC components and systems.

In general the designer should at a minimum include the following commissioning processes in the project.

1. Specify and ensure proper start-up of HVAC components and systems, and functional testing to ensure that these components and systems are operating in conformance with the design requirements and the manufacturer's specifications.

2. Monitor the Testing, Adjusting and Balancing (TAB) to ensure that HVAC components and systems are operating at their specified capacities…airflow, water or steam flows, temperatures, etc. and follow proper TAB "set-up" procedures applicable to the designed operation.

3. Witness functional testing by the contractor to ensure components and systems respond to variations in imposed loads, etc. and that the component and system controls are operating properly. The result of function tests is to demonstrate that required environmental conditions are maintained under the full range anticipated load conditions. Functional tests must also prove that fire safety, life safety, and failure/backup interlocks operate as designed.

The installing contractor(s) is then charged with the responsibility for performing the specified test procedures, with witnessing by the designer, and reporting the results to the designers, with certification by all required contracting parties that the results are correct.

1.3 THIRD PARTY COMMISSIONING

If third party commissioning is determined to be necessary, the commissioning authority (CxA) should be retained as early as possible, preferably soon after the designers are selected, and be involved in discussions relating to energy performance and HVAC issues during the pre design phase. In all cases the CxA shall be under contract and involved in the commissioning process no later than the start of the Schematic Design process. The CxA must be an independent party, under contract to the owner and not be affiliated with either the design or construction team on the project.

The CxA must be a registered engineering firm in the State of North Carolina and the owner must select the CxA using a *qualifications based selection process*, similar to that used to retain other engineers. The following is a listing of the basic qualifications that a CxA should exhibit:

1. Has acted as the principal CxA for at least three projects of comparable size, type, and scope, with demonstrated experience in "total building" commissioning, including heating, ventilating, and air-conditioning (HVAC) systems; electrical power and lighting systems; data and communication systems; building envelope; and other specialized building systems.

2. Has extensive experience in the operation and troubleshooting of HVAC systems and components and direct digital control (DDC) systems.

3. Has at least five (5) years field experience in this type of work.

4. Knowledgeable in building operation and maintenance (O&M) and in O&M training; also knowledgeable in testing, adjusting and balancing (TAB) of air and water systems.

5. Knowledgeable in the requirements of the *North Carolina State Building Code* and other codes and standards related to building systems.

6. Experience in energy-efficient equipment design and control strategy optimization.

7. Has direct experience in monitoring and analyzing building systems operation using DDC control systems trending functions and stand-alone data logging.

8. Has excellent verbal and written communication skills. Has experience in writing commissioning specifications, particularly well-defined start-up and functional test procedures.

9. Is highly organized and able to work with designers, contractors, and owners.

10. CxA project members should have a bachelor's degree in mechanical or electrical engineering. However, other technical training, past commissioning and field experience will be considered as a substitute. Certification as a Commissioning Professional or other like commissioning certification and membership in the Building Commissioning Association or similar commissioning organization is desired but not required.

Depending on the complexity of the project, the owner may want to negotiate the contract with the CxA in two parts. Part one of the contract starts at the beginning of design and ends upon completion of the project bidding process. After the scope and costs for the project are finalized, a second part of the contract would then be executed for the construction and occupancy phases of commissioning. The contract with the CxA typically is in the form of a Letter Agreement approved by the State Construction Office.

The Commissioning Process and CxA Responsibilities: In general, the following are the basic requirements for the commissioning process. Refer to ASHRAE Guideline 0-2005, *The Commissioning Process*, and ASHRAE Guideline 1.1-2007, *HVAC&R Technical Requirements for The Commissioning Process* for more detailed information.

1. **Design Phases**: The CxA will help develop the Owner's Project Requirements (OPR) to ensure the OPR is complete and appropriate for the project. The OPR will be maintained and updated throughout the project. The CxA reviews Schematic Design, Design Development and Construction Documents. The CxA will submit to the design team for inclusion in the Design and Construction Documents draft commissioning specifications for the systems to be commissioned. The CxA may provide examples of start up and functional tests typical of those to be used in the project, to help inform potential contractors of the testing assistance required during the construction phase of the project.

2. **Construction Phase**: The CxA efforts will include review of component and equipment submittals by contractors, review of systems to be commissioned, and review the contractor's pre-functional/start-up check lists. The CxA will provide the project's functional testing procedures, validate the TAB effort, and lead functional acceptance testing of commissioned systems. The CxA will also review and approve training agendas, O&M manuals, and project as-built documentation. Functional testing must be completed satisfactorily prior to final acceptance of the project.

3. **Occupancy and Operations Phase**: The CxA will perform opposite seasonal testing, coordinate a 10-month warranty review, and may participate with the owner in collecting building data for the 12-month measurement and verification of energy performance. The CxA will deliver a complete Cx systems manual to the owner.

Designer Commissioning Responsibilities: The design team members will participate in the commissioning team. The designer will be responsible for providing the Basis of Design (BOD) document. The BOD document should be developed and provided during the Schematic Design, and updated with the Design Development and Construction Document submittals. A final as-built BOD document will be completed following building occupancy and the designers will provide training to the owner's operating staff on the BOD document.

Owner Commissioning Responsibilities: To help ensure that the commissioning process is successful requires active participation by the owner in the commissioning process. A representative of the owner who will be involved in the operations and maintenance of the building shall participate in the design, construction and occupancy phases of the commissioning process. The owner's assigned project planning/ design staff and the Capital Project Coordinator will also participate in all commissioning phases.

To ensure the project budget is sufficient to support third party commissioning, it is recommended that the following commissioning cost guidance be incorporated into the budget:

Systems Commissioning:

System(s)	Approximate Commissioning Cost (Percent of Total Systems Cost)
HVAC and Controls	2.0-3.0
Electrical	1.0-2.0
HVAC, Controls, and Electrical	0-1.5

Whole Building Commissioning:

Project Complexity	Approximate Commissioning Cost (Percent of Total Construction Cost)
Simple	0.5
Moderate	1.0
Very	1.5