

Building Commissioning

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Abstract

In order to detect and correct defects in a timely, cost effective manner, HVAC system commissioning has recently been used as part of building construction. Preliminary evidence suggests that proper and complete commissioning is cost effective. It is probable that more comprehensive building commissioning will become standard construction practice during the next few years.

Introduction

Problems in newly-completed or remodeled structures have created awareness that traditional building close-out procedures are not sufficiently sensitive to detect defects in building components and operation. Investigators often discover major defects in HVAC system design, construction or system balancing during investigations of occupant complaints (Levin and Phillips 1989).

HVAC System Commissioning Costs and Benefits

The costs of discovering and remedying HVAC system defects are substantial. In addition to the costs of investigation and remediation of problems, they have included costs attributable to occupant illness and absence from work; meeting time for owners, designers, contractors, employers, and occupants; and, lost revenues for landlords and tenants. The British Columbia Buildings Corporation has studied the costs and estimated avoided costs of HVAC commissioning, and it has concluded that HVAC system commissioning is cost effective (present value = \$0.20 to \$0.50 per square foot cost savings over the first five years). Table 1 is a summary of the analysis (Levin, 1989).

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Table 1. Economics of HVAC Commissioning

Item	\$/Sq Ft Based on HVAC	Comment
A. COSTS FOR COMMISSIONING:		
Designer	\$0.02 - 0.10	Additional time spent on site to witness and verify functional performance testing.
Contractor	\$0.10 - 0.20	Direct commissioning activities. If documented at beginning, results in no additional costs for construction and avoids call-backs.
Owner	\$0.025 - 0.10	Additional involvement of operational staff during construction: familiarization with systems.
SUBTOTAL	\$0.145 - 0.40	
B. AVOIDED COSTS:		
Energy	\$0.13 - 0.26 ^a	Shortens usual 3 year period for building operators to learn optimal energy operation
Maintenance	\$0.15 ^b	Estimated reduction due to proper initial functioning of equipment and training of operational staff; present value for 5 years' savings.
Construction	\$0.07	Correction of construction problems defects by contractor prior to occupancy and at no cost to owner.
Satisfied tenants	\$0.25 ^d	Avoiding meetings to resolve tenants' problems, avoiding occupants' absence due to illness.
SUBTOTAL	\$0.60 - 0.76	
C. NET RESULT: \$0.20 - 0.515 / Sq Ft savings over first five years.		

NOTES:

^a Present value calculation

^b Estimated from actual cost data

^c Based on studies of 5 buildings, 2 had serious problems, costs averaged over 5 buildings.

^d Based on the following assumptions:

Every fifth person in meetings 30 min./mo. = \$0.10/yr/sq ft

Owner meetings and direct costs = \$0.05/yr/sq ft

Every fifth person out of work (illness) 2 days/year = \$0.25/yr/sq ft.

Why HVAC Systems Commissioning?

Many indoor air quality problems have occurred during initial occupancy of newly-constructed or remodeled buildings. Some of these problems have been directly attributed to incomplete or improper construction, especially of HVAC systems (Levin 1989b; Trueman 1989). Some of these problems would be discovered by a thorough and effective commissioning process.

Large construction and development firms currently use HVAC systems commissioning as a normal construction activity. According to an executive of a major U. S. development firm, if clearly documented in the construction contract and followed during implementation, HVAC system commissioning does not cost any more at all (Brickman, 1989). And the benefits of commissioning warrant the extra effort by all parties (Trueman 1989).

In fact, commissioning is not new. The concept of HVAC commissioning has been used effectively in Europe and Canada for a long time. It is a wonder that it has not be utilized more extensively and routinely in the United States.

Guidance for HVAC System Commissioning

The American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE) is developing guidelines for HVAC system commissioning in response to the growing professional interest. A Public Review Draft Guideline for Commissioning HVAC Systems was released in June 1988 (ASHRAE 1988), and adoption of the final document is expected in June of 1989 (Levin 1989). The draft Guideline identifies the roles of the several designers, contractors and other parties. A series of papers by members of the ASHRAE committee preparing the document presents an elaboration of the outline in the draft and indicates what the final document might contain (Brickman 1989; Gill 1989; Lawson 1989; Stone 1989; Trueman 1989).

What Is HVAC System Commissioning?

The process involves comprehensive planning, thorough documentation and systematic implementation. Another way of thinking about it is that proper commissioning is merely building it right in the first place and making sure that it works right before occupying the building.

The HVAC system commissioning process requires clear descriptions of the following:

- * Sequence of actions involved in commissioning.
- * Performance required by the system(s) to be commissioned.
- * The intended use and operation of the system(s).
- * The responsibility of all entities for commissioning activities.

Suggested components of an HVAC system commissioning program are described in Table 2 below.

Table 2. HVAC System Commissioning Process

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- Design phase (by architect/engineer)
- * Establishment of clear design criteria
 - * Documentation of HVAC design criteria and systems description (see Table 3)
 - * Preparation of a commissioning plan
 - * Describe verification procedures
 - * Define documentation requirements for commissioning process including all reports, submittals, drawings, schematics, checklists, operating data, maintenance data, and as-built documentation.
- Construction phase
- * Pre-commissioning preparation for start-up
 - Personnel selection
 - Pre-commissioning meeting of designer, owner, and contractor representatives
 - * Actual system start-up: initial operation of all equipment
 - * Final start-up -- complete performance inspection
 - Temperature control system
 - Facility automation system
 - Testing and balancing
 - Equipment documentation
- Final commissioning
- * Meeting of all relevant parties to discuss system and answer any questions about system sequences, set points, operation; review all final documentation for submittal to owner.
 - * Assemble all documents for submittal to owner
 - * Train operational personnel in the following:
 - System philosophy
 - System familiarization
 - System sequence
 - System maintenance
 - System diagnosis
 - Facility automation system
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Design Documentation

A major requirement of HVAC system commissioning is clear, specific and complete design documentation. It forms the basis for identifying the components to be commissioned, the design or performance standards, the operational modes, the loads to simulate, and other essential design criteria and system descriptions. ASHRAE's draft revised ventilation standard 62-1981R also requires design documentation for its implementation (Levin 1989). A suggested set of elements to be included in the design documentation is listed in Table 3.

Table 3. Suggested Elements of Design Documentation

A. DESIGN CRITERIA:

1. Indoor design conditions (all seasons):
Temperature, relative humidity, air movement.
2. Outdoor design conditions (all seasons):
Temperature, humidity, wind direction and velocity,
location and timing of outdoor sources of air
pollutants of concern.
3. Assumed or anticipated occupant densities,
activities and use patterns for each space or type
of space in the building.
4. Assumed electrical load for light and power.
5. Any special loads which might exist.
6. Outside air supply rates under various operating
conditions and loads.
7. Assumed ventilation effectiveness for each type of
space under HVAC system mode of operation which
result in differing supply design conditions.
Assumed distribution characteristics for each
ventilation or air circulation condition including
conditions of minimal air circulation and of upper
and lower supply air temperature limits.
8. Definition of building envelope, including type and
characteristics of materials and assumed
infiltration.
9. Air quality design criteria.
10. Code requirements
11. Noise criteria.
12. Fire and safety requirements
13. Energy efficiency and projected operating cost.

B. HVAC SYSTEM DESCRIPTION:

1. Basic system types
 2. Major components
 3. Capacity and sizing requirements
 4. Redundancy provisions
 5. Intended operation in each seasonal mode, including
designed changeover conditions.
 6. Changeover procedures.
 7. Part-load operational strategies for each season.
 8. Occupied/unoccupied operation modes for each season.
 9. Design setpoints for control system, including
permissible limits of adjustments.
 10. Operation of system components in life safety modes.
 11. Energy conservation procedures.
 12. Any other engineered operational mode of the system.
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Extending Commissioning to the Whole Building

Building commissioning most commonly focuses on HVAC equipment, but some building designer, developers, and owners have extended the commissioning process to non-HVAC system materials, equipment and other building elements. Surely the plethora of technology involved in "smart" buildings warrants a thorough shakedown before the final payment is issued and the building is occupied.

Life safety systems, communications systems, transportation systems, security systems, and other "high tech" devices must be tested in place under simulated loads and real situation use conditions to initiate the warranty period and be approved for use. While commissioning appears most applicable to building equipment, it may also be applied to other building components such as thermal or moisture protection systems, shading devices, expansion joints, radon mitigation measures, and others.

Conclusion

The commissioning of HVAC systems should be standard practice in major building contracts. It is in everyone's interest. The questions that occur are 1) Will HVAC system commissioning become standard practice? and, 2) Will HVAC system commissioning be expanded to cover all components and systems in new buildings in the future? The "smart" builder will answer "yes!" to both questions.

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