

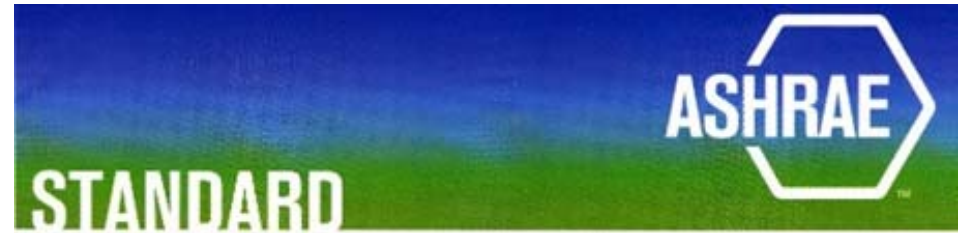


Principles of Building Commissioning: ASHRAE Guideline 0 and Standard 202



ASHRAE Guideline 0
(Supersedes ASHRAE Guideline 0-2005)

The Commissioning Process



ANSI/ASHRAE/IES Standard 202

Commissioning Process for Buildings and Systems

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EDUCATION PARTNER

Principles of Building Commissioning:
ASHRAE Guideline 0 and Standard 202

By ASHRAE

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Course ID: 920020735

Approved for:

3

General CE hours

0

LEED-specific hours



Your Instructor

Walter T. Grondzik, P.E.

Fellow ASHRAE, LEED AP BD&C, CPHC
Ball State University
Department of Architecture
Muncie, IN 47306
gzik@gzik.org





Illuminating
ENGINEERING SOCIETY



The commissioning information in this course was co-developed by:

ASHRAE

The Building Commissioning Association

The Illuminating Engineering Society

The National Environmental Balancing Bureau

Learning Objectives

- Identify the defining elements of the ASHRAE commissioning process for new construction
- Outline key commissioning activities during a building's pre-design, design, construction, and occupancy/operations phases
- Summarize key commissioning process documentation requirements
- Describe the generic benefits of the commissioning process
- Appreciate the role of the numerous commissioning guidelines and standards

Course Outline

- Why is Commissioning Needed?
- Introduction to the Commissioning Process
- Commissioning Guidance Documents
- ASHRAE Guideline 0 versus Standard 202
- Commissioning during the Pre-Design Phase
- Commissioning during the Design Phase
- Commissioning during Construction
- Commissioning during Occupancy and Operations
- Summary

WHY IS COMMISSIONING NEEDED?

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Home > Publications > FSEC-CR-878-96

Reference Publication: Cummings, J.B., C.R. Withers, N. Moyer, P. Fairey, B. McKendry, "Uncontrolled Air Flow in Non-Residential Buildings", Prepared for Florida Energy Office, Department of Community Affairs, FSEC-CR-878-96, March 29, 1996.

Disclaimer: The views and opinions expressed in this article are solely those of the authors and are not intended to represent the views and opinions of the Florida Solar Energy Center.

Uncontrolled Air Flow in Non-Residential Buildings

James B. Cummings, Charles R. Withers, Neil Moyer,
Philip Fairey, and Bruce McKendry
Florida Solar Energy Center (FSEC)

A case study on why we need commissioning

Everyday Buildings

A major goal of this study has been to characterize the nature and extent of uncontrolled air flow through testing, measurement and monitoring in 70 small commercial buildings. The study found that uncontrolled air flow is ubiquitous.

Out of the 70 buildings studied, only one was deemed to be a “good” building. Repairs were made on 20 of these buildings. Before and after monitoring showed average energy savings of 15%.

Perhaps the most profound and compelling finding of the study is that, **given the present state of practice, whether a building will avoid serious, or even catastrophic problems due to uncontrolled airflow, is primarily a matter of luck.**

Should we go with luck or with commissioning?

Everyday Buildings

The study comes to three major conclusions:

- Uncontrolled airflow is pervasive in buildings, often resulting in severe—and sometimes even catastrophic—consequences.
- Building practitioners lack the training, methods, and insight necessary to understand and avoid uncontrolled airflow in buildings.
- Given proper attention, problematic airflows in buildings can be virtually eliminated.

Stuff happens

*Stuff happens
for many
reasons*

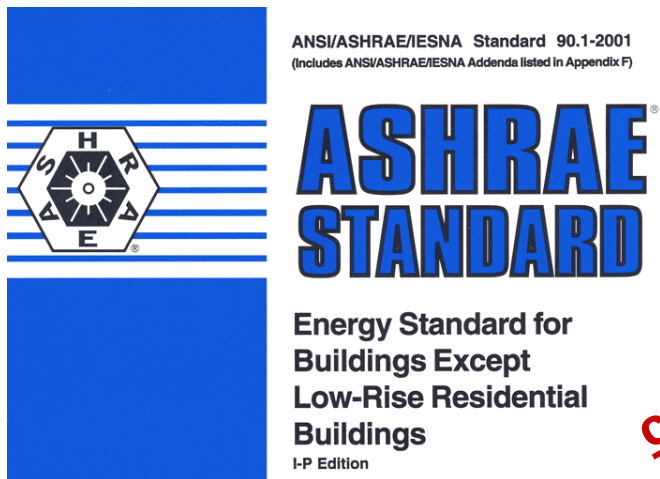
*Stuff can be
mitigated*

Commissioning is the antidote to stuff

Not Everyday Buildings

Energy efficient:

A building that *exceeds* the minimum requirements of the prevailing energy efficiency code (if that code is current)



commissioning



Not Everyday Buildings

Green:

A building that *reduces negative* environmental impacts at the site and global scales by mitigating energy, water, and materials consumption

The screenshot shows the USGBC website with the following content:

- U.S. GREEN BUILDING COUNCIL** (USGBC)
- Products and Services | Search | FAQ | Contact | Your Account | Sign In
- Navigation: ABOUT USGBC | MEMBERSHIP | LEED | EDUCATION | LEED AP | RESOURCES | CHAPTERS
- Breadcrumbs: Home > LEED
- LEED** (Large heading)
- LEED Rating Systems
- LEED Certification
- Register Your Project
- Leadership in Energy and Environmental Design** (Main article title)
- What is LEED®?
- The Leadership in Energy and Environmental Design (LEED) Green Building Rating System™ is the nationally accepted benchmark for the design, construction, and operation of high performance green buildings. LEED gives building owners and operators the tools they need to have an immediate and measurable impact on their buildings' performance. LEED promotes a whole-building approach to
- NEWS AND INFORMATION** (Section header)
- Did You Miss Greenbuild 2006? Check out USGBC's blog to catch up on everything that happened at Greenbuild 2006 in Denver. [Click here...](#)
- Learn About LEED at Your Desktop Did you miss the LEED for Existing Buildings webinar series? A complete archive is still available online. [Click here...](#)

Not Everyday Buildings

Net Zero Energy:

A building that (on an annual basis) produces from renewable site resources as much energy as it consumes from nonrenewable sources

commissioning



Not Everyday Buildings

Carbon Neutral:

A building that (on an annual basis) *produces no net carbon emissions*, thereby helping to mitigate climate change



commissioning

<http://www.aldoleopold.org/>.

Not Everyday Buildings

Sustainable:

A building that produces *no net negative environmental impacts* at the site and global scales (by very seriously addressing energy, water, and materials consumption)

commissioning

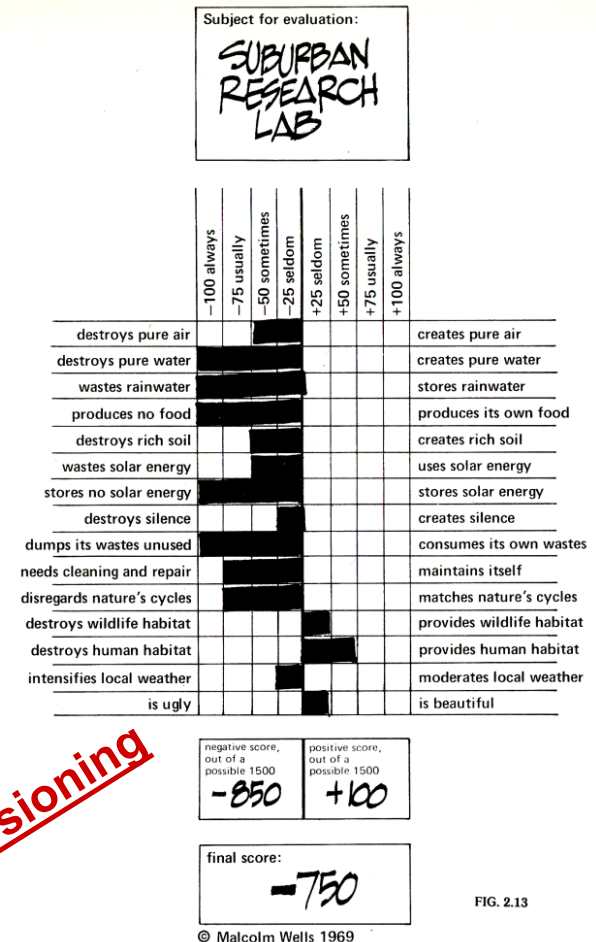


FIG. 2.13

Not Everyday Buildings

Regenerative:

A building that *produces net positive environmental impacts* at the site and global scales (by very seriously addressing energy, water, and materials consumption)



http://en.wikipedia.org/wiki/File:Eden_Project_geodesic_domes_panorama.jpg

commissioning

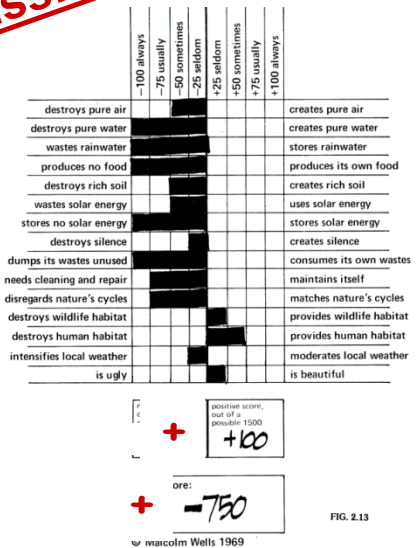


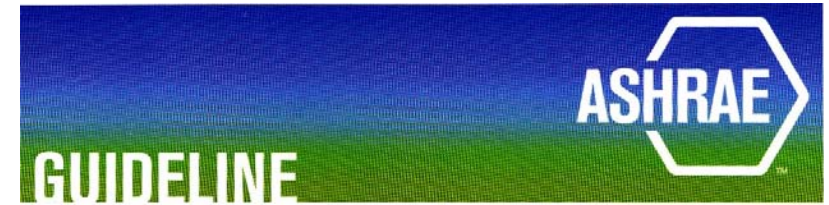
FIG. 2.13

Questions

before leaving this discussion of the rationale for commissioning?

Next section: Introduction to the Commissioning Process

INTRODUCTION TO THE COMMISSIONING PROCESS



ASHRAE Guideline 0-2013
(Supersedes ASHRAE Guideline 0-2005)

The Commissioning Process



ANSI/ASHRAE/IES Standard 202-2013

Commissioning Process for Buildings and Systems

Section Overview

- What is Building Commissioning?
- Why is Commissioning Needed?
- The Benefits of Commissioning
- Keys to Successful Commissioning
- Intent of Guideline 0 || Intent of Standard 202
- Related Commissioning Guidelines

What is Building Commissioning?

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*.

ASHRAE Guideline 0-2019: Definitions

in general, the definitions in Guideline 0 and Standard 202 should be identical

In Fewer Words, What Is Building Commissioning?

A structured ***quality assurance process*** intended to ensure that a building meets the ***owner's requirements*** upon turnover.

Fundamentally, What Is Commissioning?

It is an ongoing ***process***
(spanning from pre-design into occupancy)

It is **not** an “event”

It is **not** a short-term “task”

It is **not** just “problem” clearance

What Can Be Commissioned?

- Whole buildings**
- Building systems**
 - Active systems (dynamic)
 - Passive systems (static)
- Building sub-systems**

** Presuming the building, system, or sub-system design intent is known and has been benchmarked via criteria (resulting in a clear and comprehensive statement of *Owner's Project Requirements*.)

Why Is Commissioning Needed?

Stuff happens (issues detrimental to the owner's best interests will arise); this stuff may involve:

- Poorly identified owner needs/wants
- Poorly executed work
 - Design
 - Construction
 - Operations/maintenance
- Poor communications

Is Commissioning Really Needed

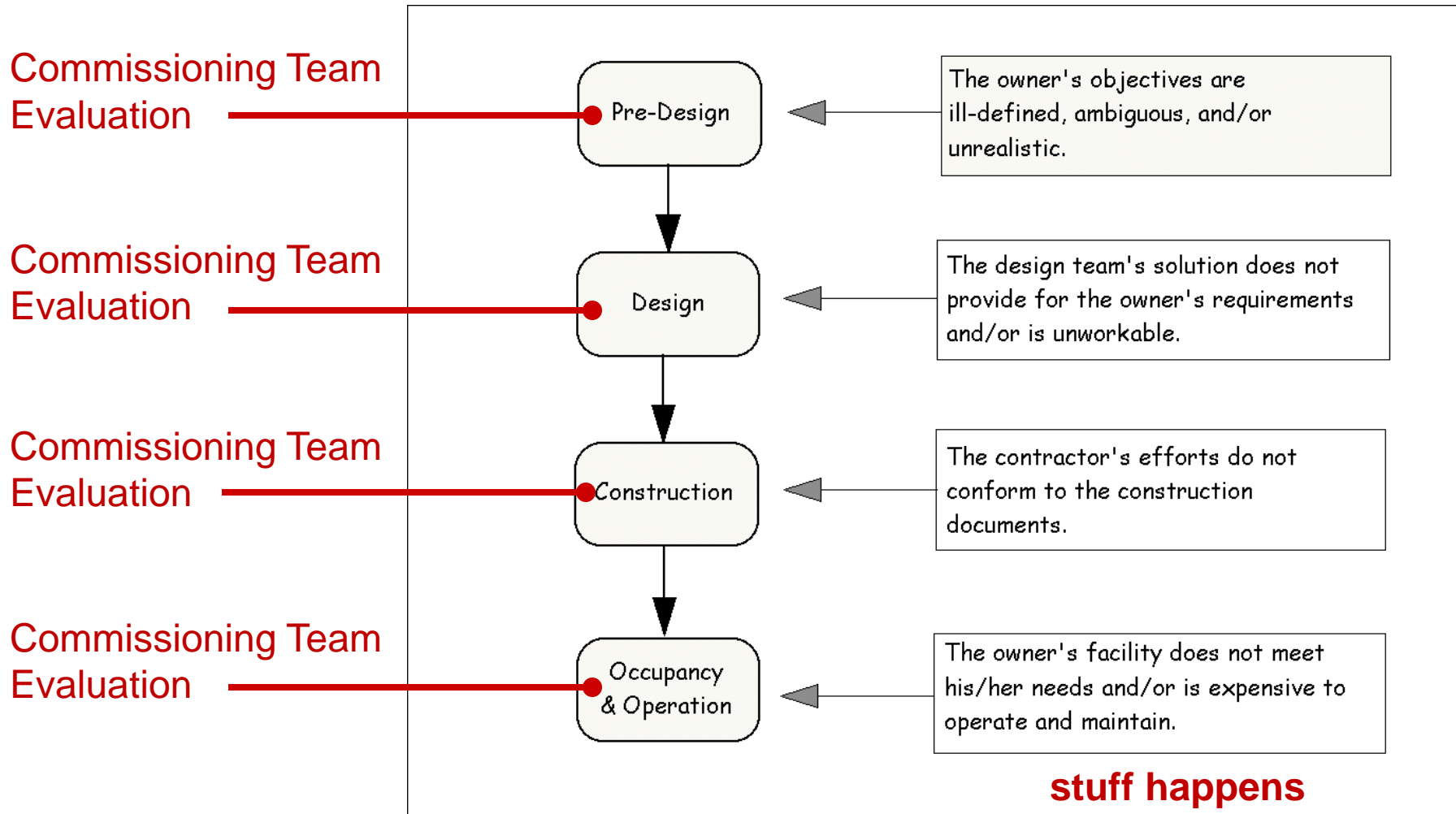


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Is Commissioning Really Needed?

Commissioning Process
Documentation
and
Commissioning Team
Communications

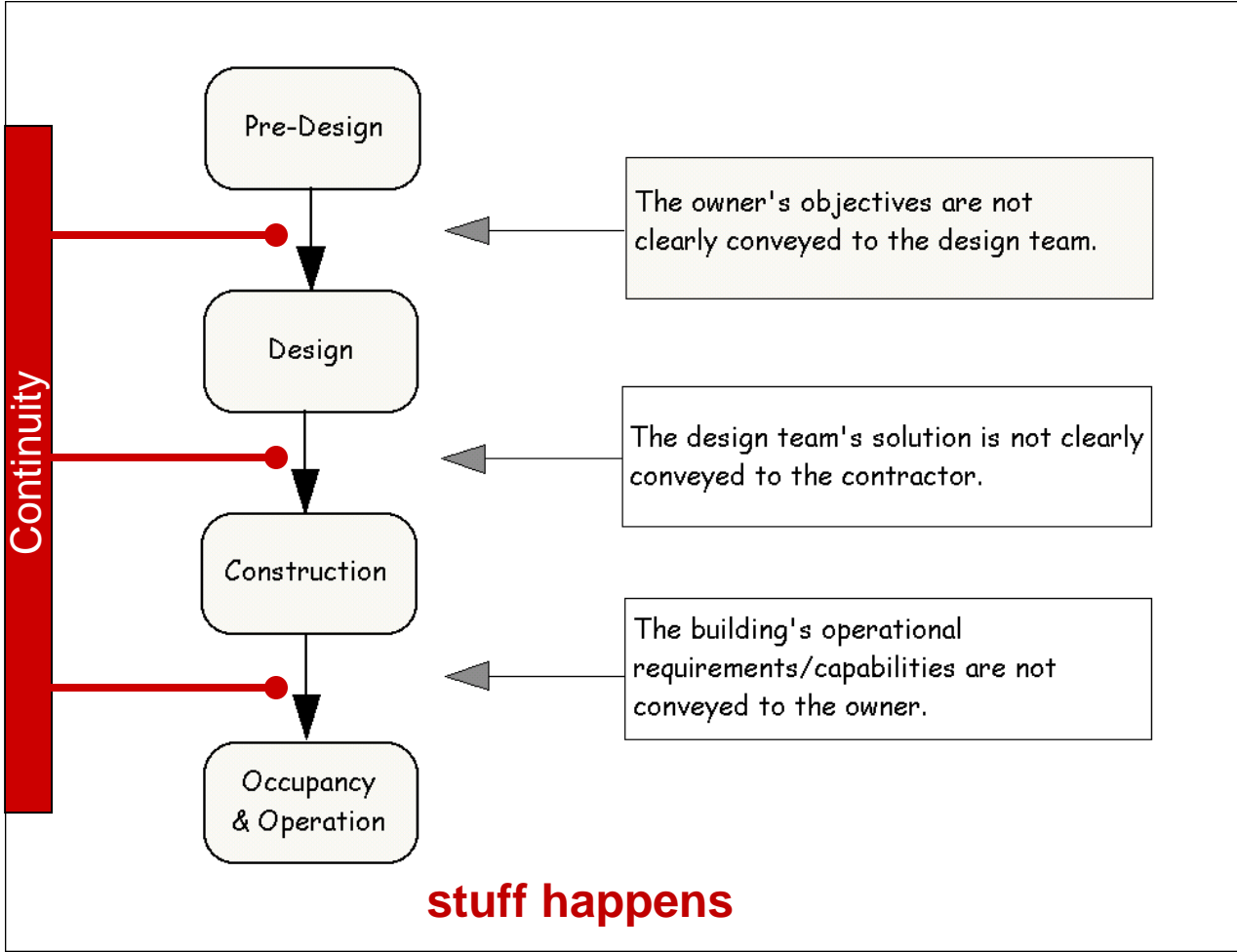


image © Walter Grondzik; used with permission

The Commissioning Process: 5000-foot View

Commissioning is essentially a process that facilitates, encourages, and rewards ongoing and effective:

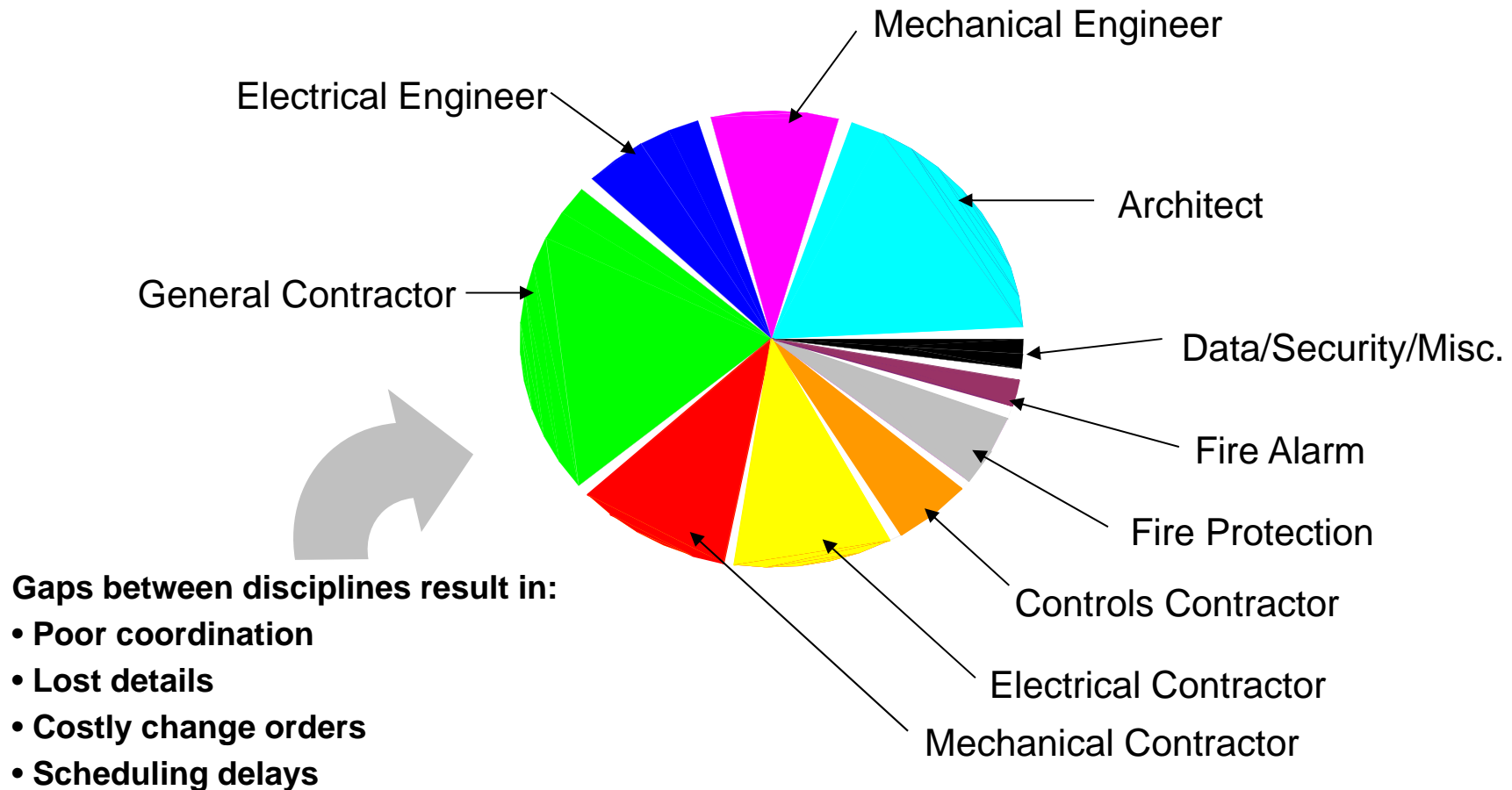
- Communication
- Documentation
- Verification (evaluation)

Across project phases and across disciplines.
The process is conducted by a team.

The Benefits of Commissioning

- A project that reflects the owner's needs and desires
- A project that works (fully) upon initial occupancy
- A project that is well documented
- Facility staff who are prepared to properly operate and care for systems and assemblies
- A project with clear performance benchmarks
- A project that has benefited from a collaborative effort of the diverse participants

The Benefits of Commissioning

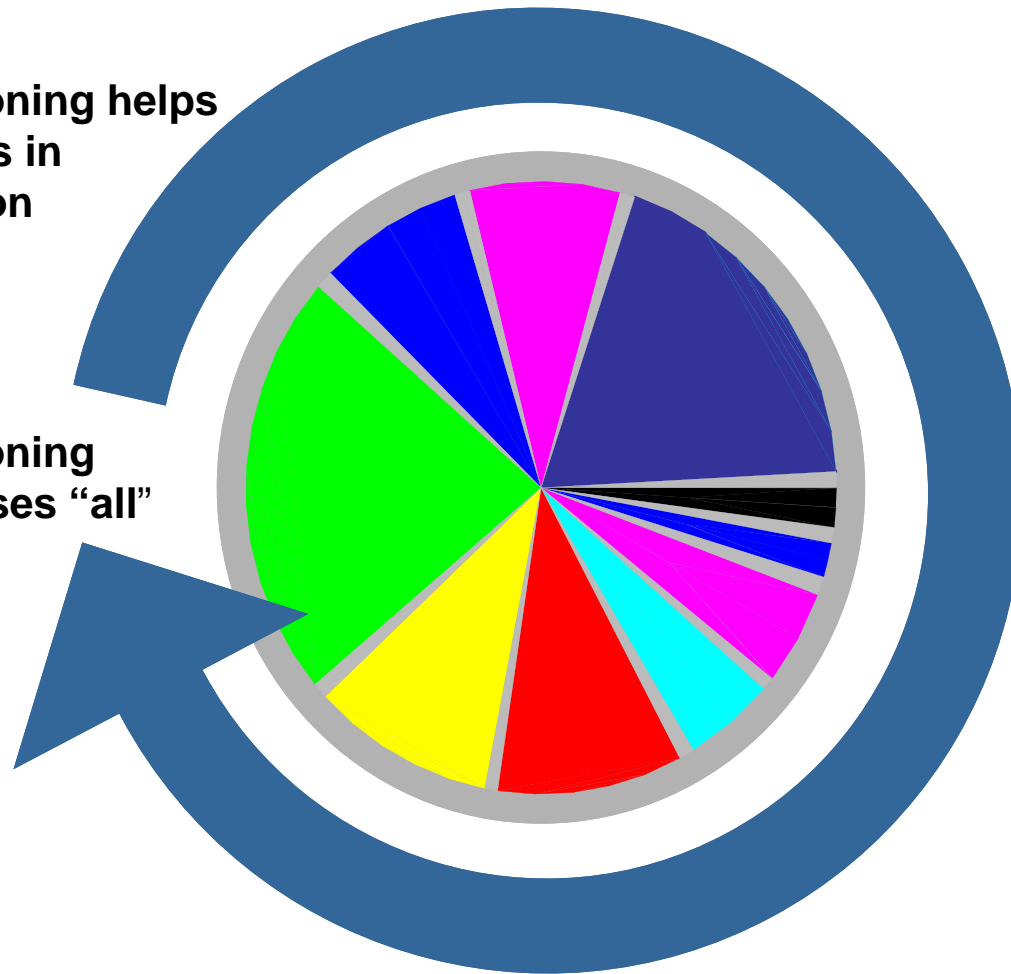


Information courtesy BCA

The Benefits of Commissioning

Commissioning helps fill the gaps in coordination

Commissioning encompasses “all”



Information courtesy BCA

Technical Keys to a Successful Commissioning Process

Good benchmarking and archiving ***documents***:

- Owner's Project Requirements
- Basis of Design
- Commissioning Plan
- Construction Checklists
- Test Protocols
- Training Plan
- Systems Manual
- Commissioning Process Reports

Technical Keys to a Successful Commissioning Process

Verification by the commissioning team

- Of all key elements—against the Owner’s Project Requirements
 - During design
 - During construction
 - During occupancy and operations
- Owner acceptance
 - Of all key deliverables/products

Procedural Keys to a Successful Commissioning Process

Effective and timely ***communications***:

— Explicit written expectations and responsibilities:

- Clear scope and contract for commissioning provider
- Professional service contracts for architect/engineer that address commissioning
- Construction specifications that clearly address commissioning

— Ongoing communications:

- Commissioning meetings
- Commissioning reports
- Issues Log

Human Keys to a Successful Commissioning Process

Well-reasoned clarity of purpose

Serious owner buy-in and support

Enforcement of commissioning-related
contract provisions

The Intent of ASHRAE Guideline 0

The purpose of this guideline is to describe the Commissioning Process capable of verifying that a facility and its systems meet the Owner's Project Requirements.

ASHRAE Guideline 0-2019: Purpose

The Intent of ASHRAE Standard 202

The purpose is to identify the minimum acceptable Commissioning Process for buildings and systems.

ASHRAE Standard 202-2018: Purpose

Applying ASHRAE Guideline 0

The application of this guideline will depend upon the Owner's Project Requirements and how the project will be designed, built, and operated. The process described in this guideline is written for a generic project and must be adapted to each project.

ASHRAE Guideline 0-2019: Utilization

Applying ASHRAE Standard 202

...scope will depend upon how the project will be designed, built and operated... scope shall be defined in the Owner's Project Requirements and the Cx Plan... *process described is written for a generic project and must be adapted to each project...* can be supplemented by companion technical documents and guidelines... can be applied to both new and renovation projects

ASHRAE Standard 202-2018: Utilization

Supplementing 0 and 202

This guideline describes the Commissioning Process and *is supplemented by companion technical guidelines*. A technical guideline describes the specific details to properly implement the Commissioning Process relative to a specific facility system or assembly.

This standard describes the Cx Process and can be *supplemented by companion technical documents and guidelines* to describe the specific details to properly implement the Cx Process relative to a specific facility, system, or assembly. T

ASHRAE Guideline 0-2019: Utilization
ASHRAE Standard 202-2018: Utilization

ASHRAE Guideline 0 Intent: The Elevator Pitch

To describe the *minimum defining characteristics* of *the ideal* commissioning process

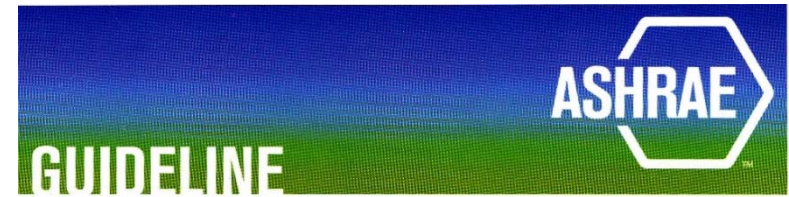
To encourage the use of such an ideal process—rather than partial implementations

ASHRAE Standard 202 Intent: The Elevator Pitch

To describe the *minimum defining characteristics* of *an acceptable* commissioning process

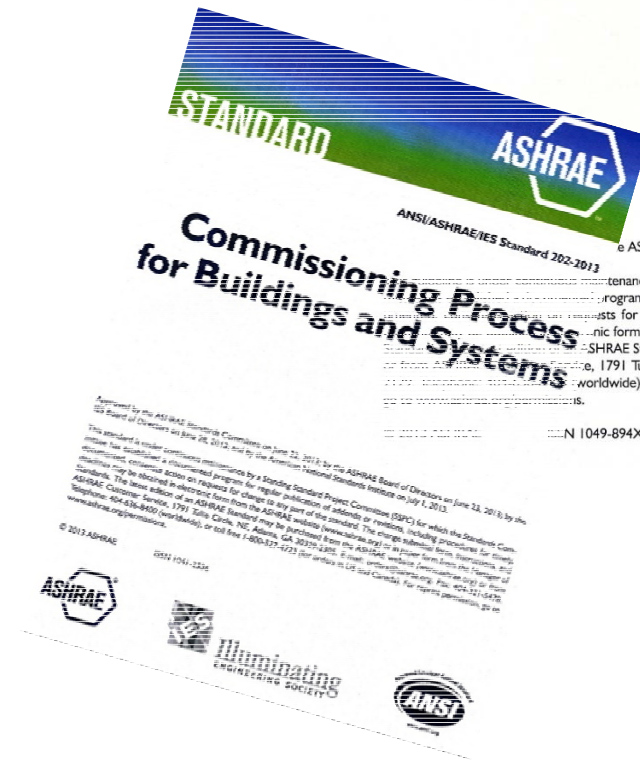
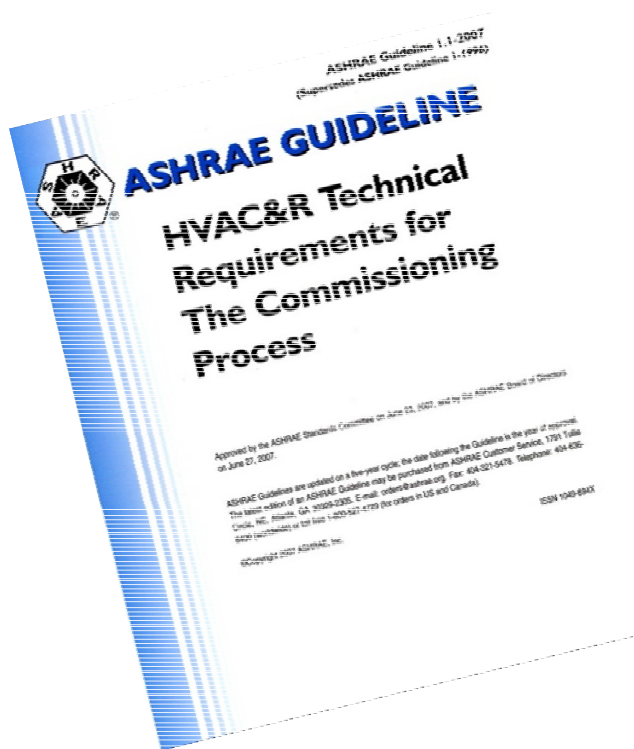
To delineate such a process such that it can be incorporated into building codes and standards

Related Commissioning Guidelines

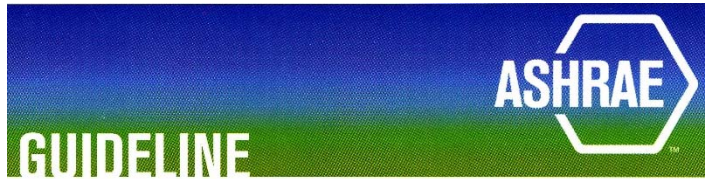


ASHRAE Guideline 0-2013
(Supersedes ASHRAE Guideline 0-2005)

The Commissioning Process



Role of Supporting Guidelines



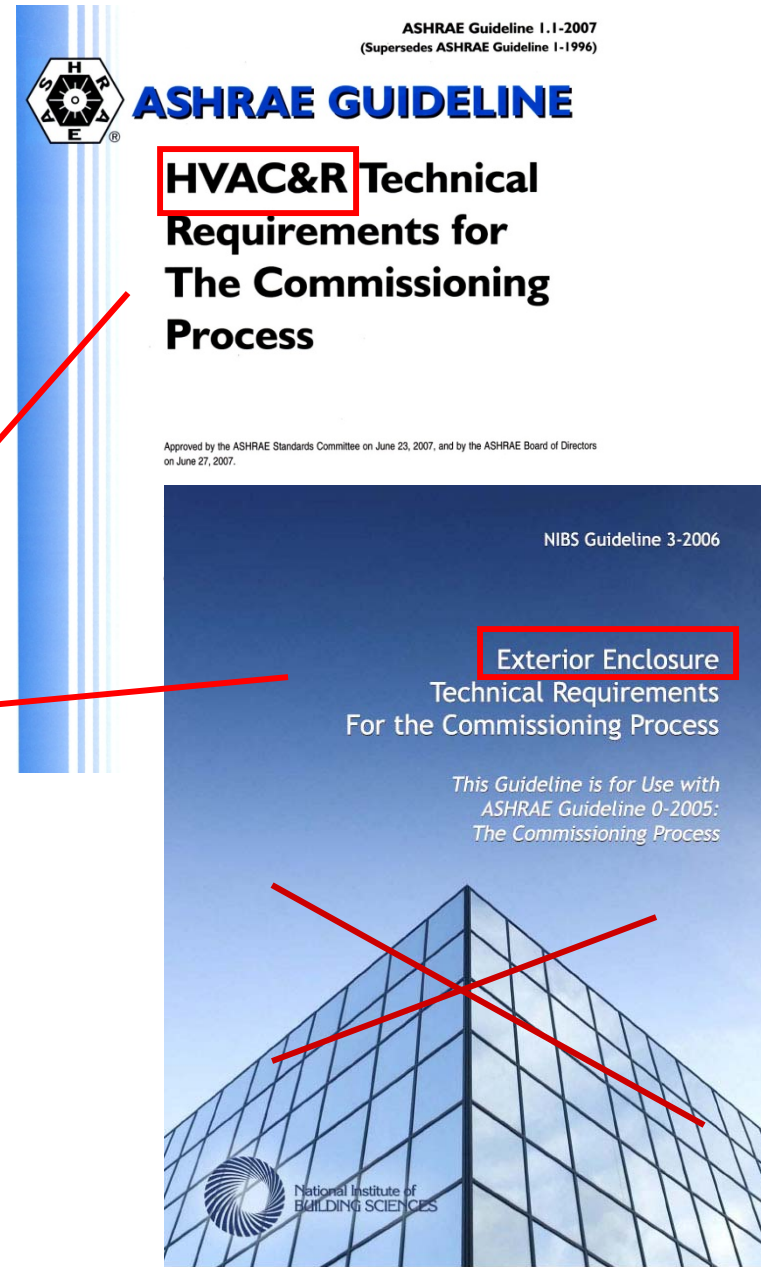
ASHRAE Guideline 0-2013
(Supersedes ASHRAE Guideline 0-2005)

The Commissioning Process

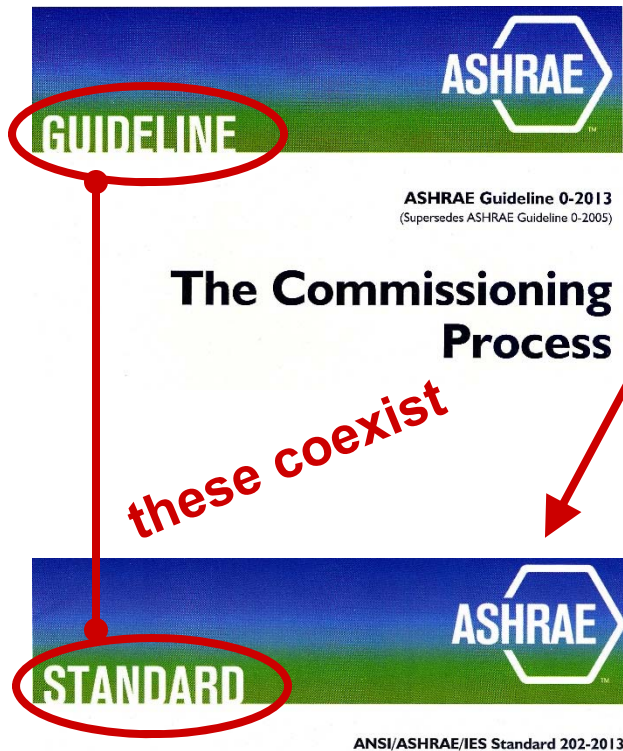
See Appendix Q for approval dates by the ASHRAE Standards Committee and the ASHRAE Board of Directors.

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Commissioning Guidelines Lineup



ASHRAE Guideline 0: Process (new project)
 ASHRAE Guideline 0.2: Process (existing project)
 ASHRAE Standard 202: Process (generic)
ASHRAE Standard 230P: Process (existing)

ASHRAE Guideline 1.1: HVAC&R Details (new)
 ASHRAE Guideline 1.2: HVAC&R Details (existing)
 ASHRAE Guideline 1.3: Operator Training Support
 ASHRAE Guideline 1.4: Systems Manual Support
 ASHRAE Guideline 1.5: Smoke Control Details
ASHRAE Guideline 1.6: Data Centers

IES DG-29:

Lighting Systems Details

NIBS Guideline 3:

Enclosure Systems Details

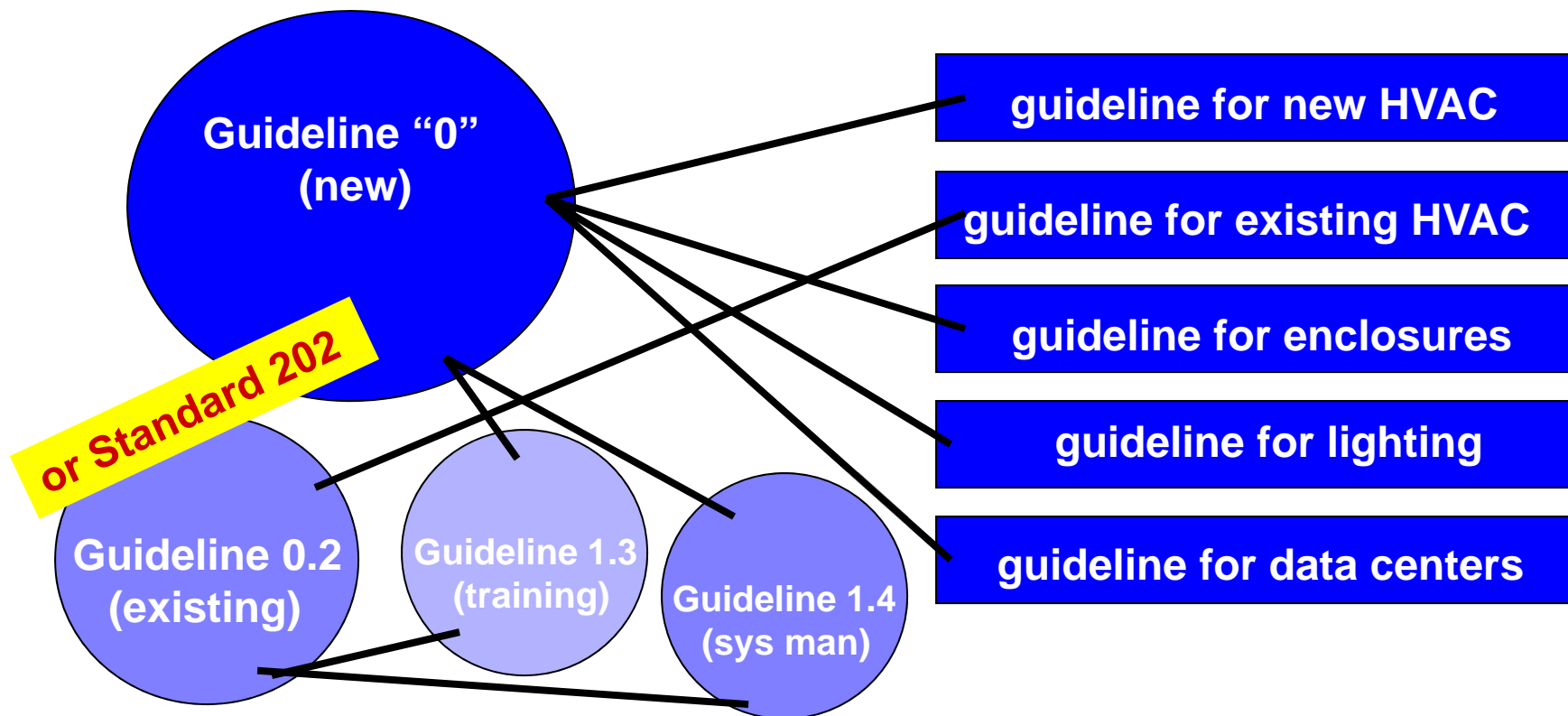
.....
 ASTM E2813: Enclosure Systems process

**Commissioning Process
 for Buildings and Systems**

NIBS = National Institute of Building Sciences | IES = Illuminating Engineering Society

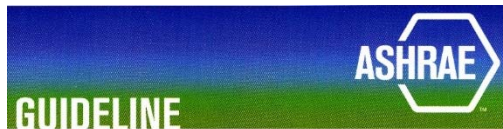
Commissioning Guidelines Roadmap

Process → Technical Support



This slide shows work in progress; the final products may vary.

Guideline/ Standard Utilization



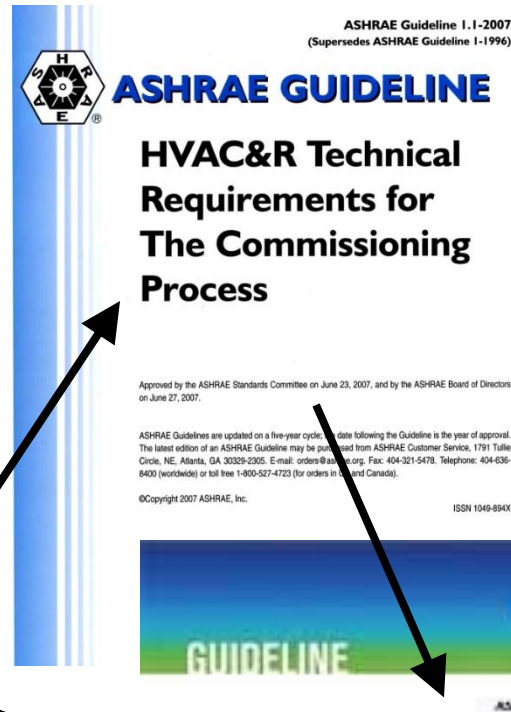
ASHRAE Guideline 0-2013
(Supersedes ASHRAE Guideline 0-2005)

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ASHRAE Guideline 1.1-2007
(Supersedes ASHRAE Guideline 1-1996)

ASHRAE GUIDELINE

HVAC&R Technical Requirements for The Commissioning Process

Approved by the ASHRAE Standards Committee on June 23, 2007, and by the ASHRAE Board of Directors on June 27, 2007.

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ASHRAE Guideline 1.3-2012

The Commissioning Process for Smoke Control Systems

Approved by the ASHRAE Standards Committee on June 22, 2012, and by the ASHRAE Board of Directors on June 27, 2012.

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Specific project

Standard 202 vs. Guideline 0

ASHRAE STANDARD 202

- Written in code language
- Intended to present the minimum acceptable characteristics of a **viable** commissioning process
- Allows for adaptation to a specific project context
- Systems and assemblies to be commissioned may be selected by the owner (unless otherwise dictated by a referring code / legislation)

ASHRAE GUIDELINE 0

- Written in guideline language
- Intended to present the minimum acceptable characteristics of an **ideal** commissioning process
- Allows for adaptation to a specific project context
- Systems and assemblies to be commissioned are intended to be selected by the owner

Standard 202 vs. Guideline 0

ASHRAE STANDARD 202

- Organized around documents that capture commissioning activities and responsibilities

ASHRAE GUIDELINE 0

- Organized around phases of the building acquisition process (design-bid-build is assumed; but other options can be inferred)

The following sections of the course are structured around project phases (as in Guideline 0). The documents that are the basis for Standard 202 are fully discussed within these phases.

Questions

before leaving this discussion of the background and context of the commissioning process?

Next section: Pre-Design Phase Commissioning

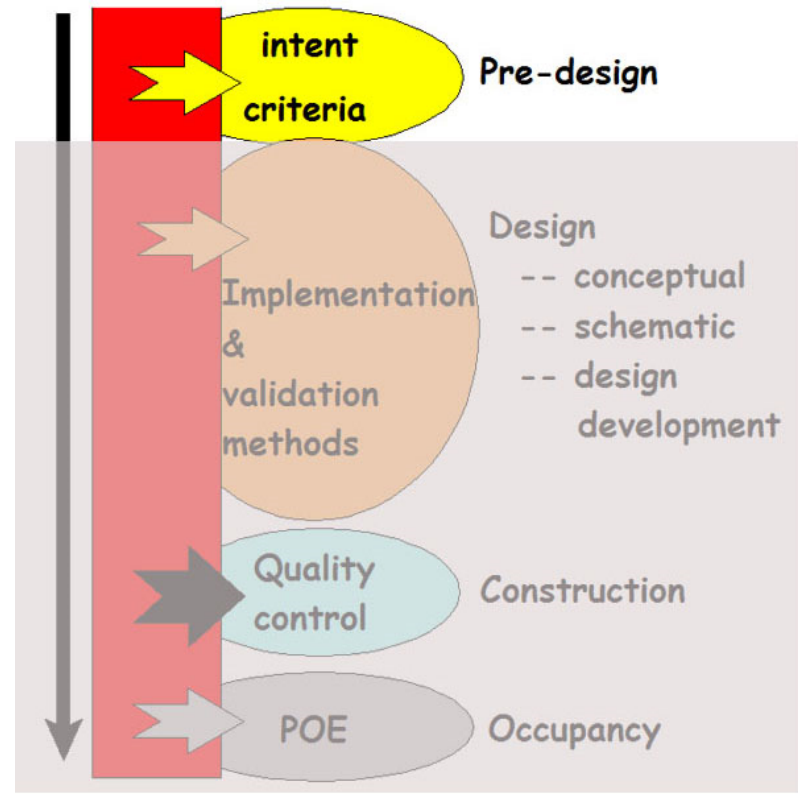
Building Commissioning



Image courtesy of NEBB.

Because stuff happens!

Pre-Design Phase Commissioning



Outline: Pre-Design Phase

- Commissioning Process Objectives during the Pre-Design Phase
- Key Pre-Design Commissioning Activities
- The Commissioning Provider
- The Commissioning Team
- Pre-Design Commissioning Documents

A Reminder

ASHRAE Guideline 0 and Standard 202 both describe a commissioning process with three essential elements:

- Communication
- Documentation
- Verification

These elements are **first addressed** in Pre-design and continue through all project phases.

Critically Important ASHRAE Recommendations

- **Initiate commissioning during pre-design** ← ← ←
- Use an independent commissioning provider
- Establish a viable commissioning team
- The design team is responsible for design
- The contractor is responsible for construction
- The *Owner's Project Requirements* are the validation benchmark (not just the CDs)
- Consider statistical sampling (versus 100% verification)
- All activities should be explicitly defined in advance

Commissioning Objectives During Pre-Design

- Develop the *Owner's Project Requirements*
- Identify commissioning scope and budget
- Develop the initial *Commissioning Plan*
- Accept pre-design commissioning activities
- Review/use lessons from previous projects

ASHRAE Guideline 0-2019: Pre-Design Phase Objectives

Pre-Design Objectives

To start the commissioning process
off on the right foot

Unofficially

Key Pre-Design Phase Commissioning Activities

- Owner gains an understanding of the commissioning process and develops a commissioning request for proposals (RFPs)
- Hire commissioning provider
- Establish commissioning process scope/budget
- Develop draft *Commissioning Plan*
- Develop *Owner's Project Requirements* (OPR)
- Develop commissioning services requirements for design team professional services contracts
- Develop *Design Checklists* (if to be used on project)
- Obtain owner acceptance of documents

Terms shown in Caps/Italic are formal commissioning process documents

The Commissioning Provider

- Should have actual and perceived independence of action (an unbiased party)
- Should have a background and experience to match project expectations
- Will act in the best interests of the owner
- Will interact with owner's representatives, the design team, the contractor, and subcontractors
- Will lead the commissioning team and team meetings
- Should have outstanding people skills

The Commissioning Provider

- Provider versus “agent” or “authority”
 - An agent can act as the owner (this is not intended)
 - Authority overlaps with AHJ (authority having jurisdiction)
- Professional services contract must spell out roles and responsibilities for this crucial party—including scope of work to be conducted
- The commissioning provider should be an independent entity or come from the owner’s in-house staff
- **The commissioning provider will not single-handedly commission a project**

This entity was previously called the commissioning “authority”

Multi-Project Commissioning Process Manager

A *Commissioning Process Manager* is an individual who oversees and coordinates the commissioning process on behalf of the building owner. The person who performs this function communicates on behalf of the building owner with the commissioning provider and the commissioning team. For some projects, the commissioning provider may perform the function of the commissioning process manager, but for other projects, another individual performs these functions.

private communication, June 2009

The Commissioning Process Team

- Includes many members
- Members (numbers and bodies) will change from phase to phase
- The team is led by the commissioning provider
- The team will complete a variety of tasks
- Responsibility for team members must be clearly allocated and contractually assigned
- Specific pre-design roles and responsibilities will vary from project to project

Pre-Design Phase Commissioning Team

- Commissioning provider
- Programming consultants (if involved)
- Owner's representatives (users, operating and maintenance staff, project manager)
- Design team representatives (if possible)
- Contractor representatives (if possible)

Intent: assemble a team that can help prepare a complete and viable OPR document

Pre-Design Commissioning Documents

- *Commissioning Plan* → begun in pre-design
 - Includes the beginnings of a *Training Plan*
- *Owner's Project Requirements* → completed in pre-design
- Commissioning responsibilities placed into design services contracts → necessary agreements developed during pre-design
- *Issues Log* → set format and begin to implement during pre-design
- *Systems Manual* → set format, determine champion during pre-design
- *Design Checklists* → develop (if to be used on project)

Commissioning Plan

This is a roadmap to the commissioning process that will evolve throughout the various project phases; the following will be addressed during pre-design:

- Scope of process: clearly define
- Budget: establish and verify
- Schedule: detailed for design, less so for construction
- Details of design phase activities and roles/responsibilities
- Outline of later-phase activities and roles/responsibilities

Owner's Project Requirements (OPR)

- This document explicitly calls out the minimum characteristics that will define a successful project from the owner's perspective
- Must address quality as well as quantity
- Must include verifiable benchmarks (criteria)
- OPR is *completed* during pre-design
- This document becomes the basis for all commissioning verification efforts—and is thus **critical** to a successful commissioning outcome

Design Checklists

- These are pre-prepared forms used to structure and facilitate verifications (evaluations) conducted as part of the commissioning process
- These may be completed in stages as design reviews progress
- Checklists can provide a pre-structured tool to help catch deviations before they become problems
- When completed, they become a part of the *Commissioning Process Report* and can assist with subsequent commissioning efforts

Who Might Do These Documents?

< suggestions, not requirements >

- *Commissioning Plan* → commissioning provider
- *Owner's Project Requirements* → owner or programming consultant or commissioning provider (with substantial input from commissioning team)
- Design services contracts → owner with input from commissioning provider (establish expectations for involvement of design professionals in commissioning process)
- *Issues Log* (establish and start to use) → commissioning provider (more later)
- *Systems Manual* → decide who will be responsible for this important document (more later)
- *Design Checklists* → commissioning provider

Building Commissioning



image courtesy of NEBB

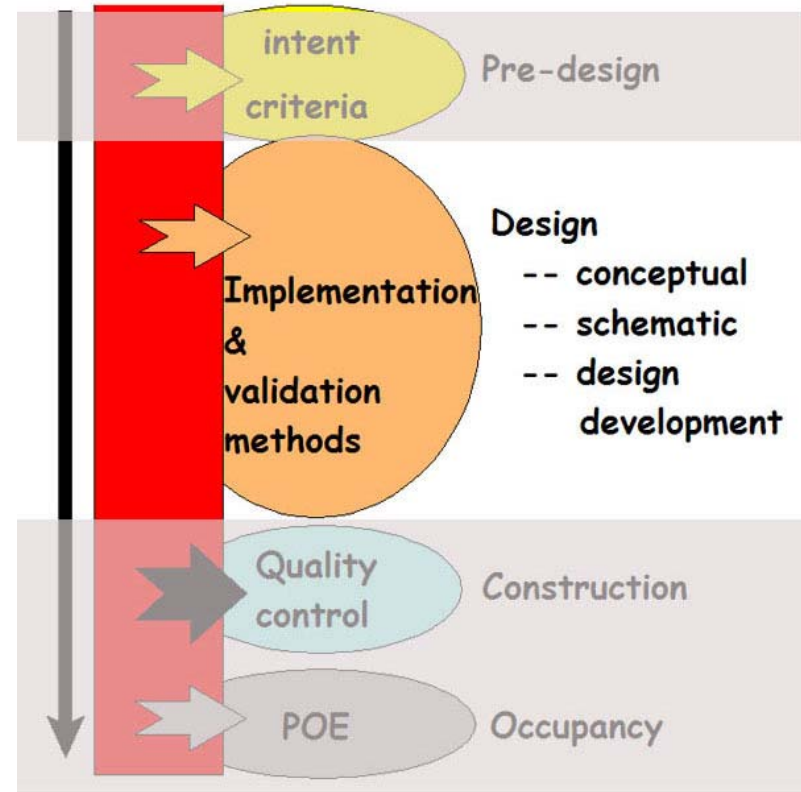
Because stuff (crazy stuff) happens!

Questions

before leaving this discussion of
the commissioning process during pre-design?

Next section: Design Phase Commissioning

Design Phase Commissioning



Outline: Design Phase

- Commissioning Process Objectives during the Design Phase
- Key Design Phase Commissioning Activities
- The Commissioning Team
- Updating Pre-Design Commissioning Documents
- Design Phase Commissioning Documents
- Ensuring the Contractor is on Board
- Design Phase Verifications

Design Phase Commissioning Process Objectives

- Update the *Commissioning Plan*
- Verify the *Basis of Design*
- Develop commissioning process requirements for the *Construction Documents*
- Develop draft *Construction Checklists*
- Develop draft *Test Procedures*
- Define training requirements
- Perform OPR-based design review
- Update the *OPR*

ASHRAE Guideline 0-2019: Design Phase Objectives

Design Phase Objectives

To prepare for commissioning activities in the upcoming construction phase

To verify design decisions and documentation

Unofficially

Key Design Phase Commissioning Activities

- Conduct commissioning team meetings
- Verify *Basis of Design*
- Develop *Construction Checklists* and *Test Procedures*
- Incorporate commissioning process requirements into project specifications
- Develop training program requirements
- Review design phase documents against *OPR* (may involve use of *Design Checklists*)
- Update *OPR* and *Commissioning Plan* (including training aspects)
- Track *OPR* deviations in the *Issues Log*

Terms shown in *Caps/Italics* are formal process documents

Design Phase Commissioning Team

- Commissioning provider
- Owner's representatives (project manager, operations and maintenance staff)
- Design team representatives (including specialty consultants)
- Contractor representatives (if possible → input on development of viable *Construction Checklists* and testing procedures can be exceptionally valuable)
- Major equipment/assembly manufacturers' representatives

Goal: ensure that design can deliver OPR; prepare for construction phase activities

Design Phase

Commissioning Documents

- *Commissioning Plan* → update and expand
- *Owner's Project Requirements* → update
- *Basis of Design* → develop
- *Design Checklists* → use
- *Construction Checklists* → develop
- *Test Procedures* → develop
- *Commissioning Process Requirements for the Construction Documents* → develop
- *Systems Manual* → develop/convey requirements
- *Training Plan* → update and expand
- *Issues Log* → use

Design Phase Commissioning Documents

- *Commissioning Plan*

- This is a continually developing roadmap for upcoming activities and record of completed activities
- During the design phase, the plan ***will be updated*** to provide details regarding construction phase commissioning activities; an outline of occupancy and operations phase activities will be included
- A more detailed *Training Plan* will be developed as a stand-alone document or a section of the *Commissioning Plan*
- Ensure that the *Commissioning Plan* adequately addresses commissioning process activities, responsibilities, and schedule

Design Phase

Commissioning Documents

- *Owner's Project Requirements*
 - This document establishes the minimum characteristics that will define a successful project from the owner's perspective
 - Must address quality as well as quantity
 - Must include verifiable benchmarks (criteria)
 - Completed during pre-design
 - ***Will be updated*** during design
 - To reflect changes in owner circumstances
 - To reflect desire-meets-reality conflicts

Design Phase

Commissioning Documents

- *Basis of Design*
 - This is a formal commissioning process document that captures—in a usable format—key design-influencing assumptions, methods, selections, and decisions
 - The purpose of the *Basis of Design* is to give other parties easy access to the rationale behind design decisions
 - The *Construction Documents* show **what** was selected—but not **why**
 - The “why” can be very important when considering a contractor-proposed substitution or making a decision on building operations
 - This document is valuable when design proposals are compared against OPR

Design Phase

Commissioning Documents

- Typical contents of a *Basis of Design* document
 - Codes, standards, guidelines used
 - Basis for system/assembly selection
 - System and assembly options considered
 - Calculation/analysis methods used
 - Key inputs to calculations/analysis
 - Data (U-factors, climate, etc.)
 - Assumptions (energy costs, maintenance capabilities, etc.)
 - Narrative descriptions of system/assembly operations
 - Narrative descriptions of system/assembly control sequences
 - Equipment/products used as a Basis of Design

ASHRAE Guideline 0-2019: Basis of Design Documentation

Design Phase Commissioning Documents

- *Construction Checklists*
 - These are pre-prepared forms used to structure and facilitate verifications conducted as part of the commissioning process
 - Ideally, they would be part of the *Construction Documents* (or be provided as “for information” documents)
 - Typically will be completed in stages as construction progresses
 - Properly used, they can help in catching deviations before they become problems
 - When completed, they become a part of the *Systems Manual* and can assist with ongoing building operations

Design Phase Commissioning Documents

- Recommended *Construction Checklist* sequence of verifications (*preceded by submittal verifications*)
 - Safe delivery of the correct equipment/component: Was what was specified and approved delivered in undamaged condition?
 - Pre-installation condition: After sitting on site for some period of time and being moved around, is the equipment/component still undamaged?
 - Quality of installation: Was the correct element correctly installed in the correct location?
 - At this stage of verification, reference to the Owner's Project Requirements becomes very important—a “normal” standard of installation care (say ductwork tightness) may not be acceptable on a project seeking high energy efficiency

Principles of Building Commissioning, John Wiley & Sons.

Design Phase

Commissioning Documents

- Recommended *Construction Checklist* sequence of verifications (*continued*)
 - Proper operation of the element in isolation: Does the equipment or component operate as a stand-alone element as intended and expected?
 - Negative issues encountered: Ideally the construction checklists will be completed with the majority of “checks” falling in “yes” boxes; when this is not the case, a clear description of the deviation must be noted along with an anticipated corrective action (this finding should become part of the *Issues Log*)
 - Linkages to test data forms that benchmark equipment performance and/or its operation as part of a larger system

Principles of Building Commissioning, John Wiley & Sons.

Sample Construction Checklist

8A. HVAC Piping: Insulation ASHRAE Guideline 1.1 Example Checklist

Instructions: Step 1: Circle Yes or No and fill in with requested information.
Step 2: Explain all "No" responses at the bottom of the checklist.
Step 3: Samples of installed ductwork will be periodically reviewed to verify compliance.

General Overall (Total Job) HVAC Piping Insulation Requirement

Item	Task Description	Response	
		Submitted	Delivered
1	System Checks		
A	Installation Checks		
1	Piping is clean, dry and free of damage prior to installation.	Yes	No
2	Pressure and leakage tests performed and reports have been submitted prior to insulation installation.	Yes	No
3	All chilled water piping is insulated with 1 1/2 inch thick fiberglass pipe insulation with vapor barrier except runouts to radiant cooling panels located beyond 1'-0" within room being served.	Yes	No
4	Secondary chilled water, low temperature chilled water (2 1/2 inch thick), fan coil drain piping (1/2" thick), and piping with electric trace freeze protection is insulated in the same manner as the chilled water pipes.	Yes	No
5	All chilled water pumps are insulated with a 1 1/2 inch thick rectangular box made of Manville 817 rigid fiberglass board having a density of 6 lb/ft ³ with a rated vinyl coated and embossed laminate vapor seal (ASJ) jacket.	Yes	No
6	The insulation box for the pump is open at top and bottom with a removable top to effect a complete insulation for each base mounted pump.	Yes	No
7	The pipe insulation sections are firmly butted together and the longitudinal seam of the vapor barrier is cemented with Foster No. 85-75.	Yes	No
8	End joints are sealed with a minimum of 3 inch wide factory furnished vapor barrier strips cemented with Foster No. 85-75.	Yes	No
9	All fittings, valves, strainers etc. is insulated as described in the specifications.	Yes	No
10	Exterior piping has a 0.016 inch aluminum jacket with moisture barrier lock seam and Gasco of equal factory applied fittings in lieu of glass cloth jackets. A sample is submitted.	Yes	No

"No" Responses

Item	Date	Reason for "No" Response

ASHRAE Guideline 1.1-2007,
HVAC&R Technical Requirements for the Commissioning Process

Design Phase Commissioning Documents

- *Test Procedures*
 - *Test Procedures* are an extension of verification procedures beyond the level of complexity that can reasonably be handled by *Construction Checklists*
 - An example: a protocol to verify that upon smoke detection in an atrium, the HVAC, electrical and alarm systems do what they should to meet the OPR
 - Another example: a protocol to verify that the HVAC system functions as it should to meet the OPR under a range of anticipated interior loading and weather conditions
 - Test Procedures must be scripted and ideally will allow for easy recording and archiving of results (for inclusion in the *Systems Manual*)

Design Phase

Commissioning Documents

- *Specifications*: communicating *commissioning process requirements* to the contractor
 - General conditions requirements
 - Participation in activities
 - Ramifications for non-compliance
 - Section-specific requirements
 - Construction Checklists
 - Test Procedures
 - Training
 - Provide a clear picture of responsibilities
 - Allow for a reasonable bid to be prepared
 - Permit impacts on schedule to be reasonably estimated

Specifications are the means by which the contractor is brought on board

Design Phase

Commissioning Documents

- *Systems Manual*
 - A truly critical document for the owner
 - Requires input from:
 - Design team → need for input called out during pre-design and product verified during design phase
 - Contractor → responsibilities must be included in the contract documents during design phase
 - Commissioning provider
 - This document really needs a champion (a responsible and capable party)
 - Without a good *Systems Manual*, many of the ongoing benefits of commissioning will be lost during occupancy and operations

Design Phase

Commissioning Documents

- *Training Plan*
 - Either stand-alone or a defined section of the *Commissioning Plan*
 - Lays out training needs and expectations
 - Lists training requirements:
 - Intended audience
 - Expected outcomes
 - Suggests venue/approach
 - Estimates time allocations
 - Outlines training verification requirements
 - Must be detailed enough to permit reasonable bidding and scheduling by contractor
 - Will likely include involvement of design team members

Design Phase Commissioning Documents

- *Issues Log*
 - The *Issues Log* is essentially the collective memory of the commissioning team (owner, commissioning provider, design team, contractor, etc.) regarding stuff that comes up during the commissioning process
 - It should be easy to access and use
 - It should be helpful (not litigious)
 - It should show all (or most) issues resolved upon occupancy
 - Resolution may take many routes (a change in OPR, a change in design, a change in component, an adjustment, etc.)

In Standard 202, this is the *Issues and Resolution Log*

Sample Issues Log

ISSUE NUMBER	DATE ENTERED	ENTERED BY	OPR CONSIDERATION	DESCRIPTION OF ISSUE	SUGGESTED RESOLUTION	RESOLVED? NO/YES (DATE)
1	1 Nov 12	ar	Usability of user interface for building systems	General approach to controls not available for review	Define interface approach to be used for competition and normal use	
2	1 Nov 12	ar	Usability of user interface for building systems	Scope of automatic controls not available for review	Define scope of automatic controls (HVAC, lighting, appliances, PV, ...)	
3	1 Nov 12	ar	Usability of user interface for building systems	Control backup logic not available for review	Define backup modes and actions	
4	1 Nov 12	ar	Usability of user interface for building systems	Specific hardware not available for review	Select hardware platform and associated software	
5	1 Nov 12	ar	Usability of user interface for building systems	User's Manual not available for review	Define and develop user training for controls	
6	1 Nov 12	ar	Usability of user interface for building systems	Role of user interface during contests not available for review	Define role of user interface during the SD contests	
7	1 Nov 12	cr	General livability	Kitchen perceived as being tight	Review kitchen layout for functionality	

Developed to support the Phoenix House solar decathlon entry.

Who Might Do These Documents?

< suggestions, not requirements >

- *Commissioning Plan* → commissioning provider
- *OPR* → commissioning team
- *Basis of Design* → design team
- *Design Checklists* → commissioning provider/team
- *Construction Checklists* → design team and commissioning provider/team
- *Test Procedures* → commissioning provider/team and design team
- Commissioning Process Requirements for the *Construction Documents* → design team and commissioning provider/team
- *Systems Manual* → design team (both content and *Contract Document* requirements)
- *Training Plan* → design team and commissioning provider/team
- *Issues Log* → commissioning team

Comments on Design Verification

- Intent is not to second guess (or to become) the design team
- Intent is to verify that design and design artifacts will reasonably deliver the Owner's Project Requirements
- Sampling of design documents is highly recommended as a procedure—but this is a project-specific decision
- The owner possesses acceptance authority

Design Phase Verifications

(perhaps using *Design Checklists*)

- *Owner's Project Requirements* (updates)
- *Basis of Design*
- *Systems Manual*
- *Construction Documents* (via sampling)
 - general quality
 - interdisciplinary coordination
 - discipline-specific drawings
 - discipline-specific specifications

Building Commissioning



Image courtesy of NEBB.

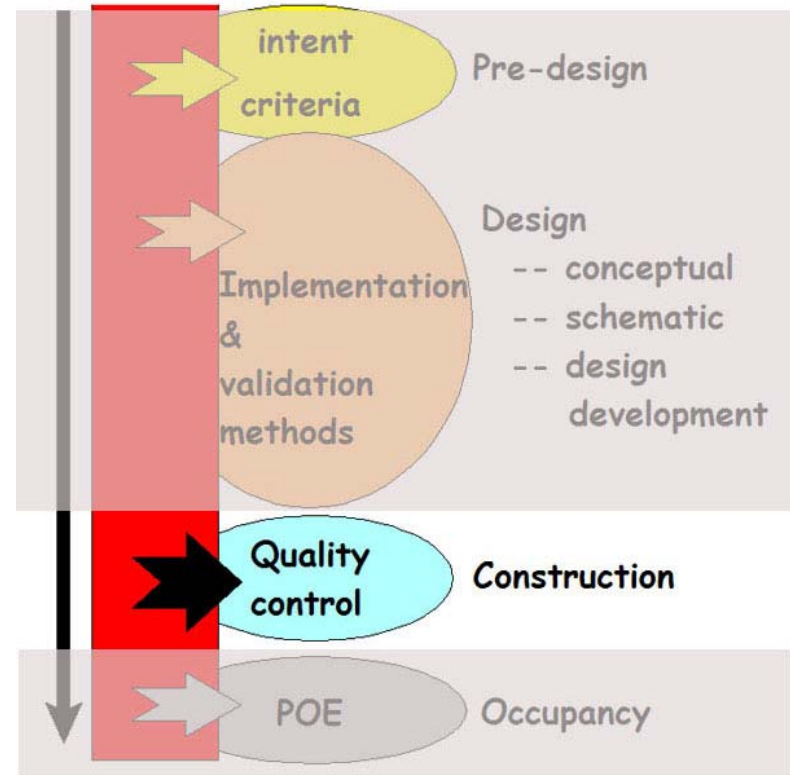
Because odd stuff happens!

Questions

before leaving this discussion of the commissioning process during the design phase?

Next section: Construction Phase Commissioning

Construction Phase Commissioning



Outline: Construction Phase

- Commissioning Process Objectives during the Construction Phase
- Meetings and Communications
- Updating Commissioning Documents
- Submittal Verification Reviews
- Employing Construction Checklists and Test Procedures
- Training

Construction Phase Commissioning Process Objectives

- Verify that submittals meet the *OPR*
- Finalize *Construction Checklists* and *Test Procedures*
- Verify that systems and assemblies meet the *OPR*
- Verify training of owner's personnel
- Verify the *Systems Manual*
- Update the *OPR* and the *Commissioning Plan*

ASHRAE Guideline 0-2019: Construction Phase Objectives

Construction Phase Objectives

To verify construction activities comply with the *OPR*

To prepare for project handover to the owner

Unofficially

Key Construction Phase Commissioning Activities

- Facilitate constructive communications
- Update *Commissioning Plan*
- Update *Owner's Project Requirements*
- Update *Basis of Design*
- Implement *Checklists/Test Procedures*
- Implement *Training Plan*
- Prepare/verify *Systems Manual*
- Obtain owner acceptance of work

Terms shown in *Caps/Italics* are formal process documents

Construction Phase Communications

- The commissioning team is the avenue for effective communications
 - Via regular meetings and
 - Skillful use of the *Issues Log*
- Commissioning team members:
 - Commissioning provider
 - Owner's representatives (project manager, operations and maintenance staff)
 - Design team representatives (including specialty consultants)
 - Contractor representatives (including subcontractors, particularly controls and TAB professionals for HVAC systems)
 - Major equipment/assembly manufacturer representatives

Intent: ensure facility can deliver OPR; prepare for the owner's use of facility

Construction Phase Commissioning Documents

- *Commissioning Plan* → update and expand
- *Owner's Project Requirements* → update as required by owner change orders, and as needed to deal with contractor substitutions
- *Basis of Design* → update as required by owner change orders and contractor substitutions
- *Construction Checklists* → finalize and implement
- *Test Procedures* → finalize and implement
- *Systems Manual* → complete and verify
- *Training Plan* → implement and verify
- *Issues Log* → use (and attempt to “clear”)

These documents have been addressed during discussion of earlier project phases

Who Might Do These Documents?

< suggestions, not requirements >

- *Commissioning Plan* update → commissioning provider
- *Owner's Project Requirements* update → commissioning team (with owner's explicit agreement)
- *Basis of Design* update → design team (a commissioning-effective services contract is important)
- *Construction Checklists* → used by contractor, verified by commissioning team
- *Test Procedures* → used by contractor, verified by commissioning team
- *Systems Manual* → completed by assigned party, verified by commissioning team
- *Training Plan* → implemented by contractor, design team and commissioning provider, and verified by commissioning provider
- *Issues Log* → used by commissioning team

Construction Phase Verifications

- Principles:
 - The purpose of verifications is NOT to provide the contractor with free quality control services; it is to provide the *owner* with assurance that the OPR are going to be delivered
 - ASHRAE recommends that a sampling strategy be used for all verifications—but this is project specific
 - The sampling frequency will be established by the commissioning provider; 5% to 10% is generally recommended
 - Sampling is a controversial issue—and each commissioning provider will have his/her own take on how to approach this
 - If deviations are found during sampling, a pre-established response is implemented. This may involve additional sampling or rejection of the activity
 - *Financial responsibility for re-verification activities must be spelled out in construction contracts and professional service contracts*

Construction Phase Verifications

- Potential quandaries:
 - ASHRAE sets the *Owner's Project Requirements* as the benchmark against which verifications are to be conducted
 - The contractor is not contractually bound (generally) to meet the OPR, but rather the *Contract Documents*
 - If deviations are found relative to the *Contract Documents*, corrective action is reasonably easy to justify
 - If deviations are found relative to the OPR—but not the *Contract Documents*—then things become more interesting
 - Contingencies for addressing the above scenario should be spelled out for all interested parties
 - In theory, verification of design documents should head off OPR versus built-artifact conflicts

Construction Phase Verifications

- Of submittals:
 - The commissioning provider verifies that a sample of the submissions meets owner quality expectations and conforms with the *OPR* and *Construction Documents*
 - The verification process is looking for systemic problems
 - Minor deviations would be addressed via the *Issues Log*
 - Major deviations might require concerted action from the commissioning team
 - The owner retains ultimate acceptance responsibility for deviations that negatively impact the OPR

Construction Phase Verifications

- Of work:
 - *Construction Checklist* elements and *Test Procedures* that involve “activating” a device, system, or assembly should generally be done by the contractor under the observation of the commissioning provider and other interested parties (the owner’s operating personnel may be *very* interested)
 - Verification of such activities would be based upon witnessing of tests and review of testing documentation
 - Verifications of documents (such as the *Systems Manual*) would normally be accomplished through commissioning provider/team review
 - Verification of training might be accomplished by witnessing, testing, and/or interviews

Construction Phase Verifications

- Using *Construction Checklists*:
 - The commissioning provider conducts some checking, witnesses other checking, and verifies that a sample of the *Construction Checklists* meets owner expectations and demonstrates quality that conforms with the *OPR* and *Construction Documents*
 - The verification process is looking for systemic problems
 - Minor deviations would be addressed via the *Issues Log*
 - Major deviations might require concerted action from the commissioning team
 - The owner retains ultimate acceptance responsibility for deviations that negatively impact the *OPR*

Reminder: Sample Construction Checklist

ASHRAE Guideline 1.1-2007,
*HVAC&R Technical
Requirements for the
Commissioning Process*

8A. HVAC Piping: Insulation ASHRAE Guideline 1.1 Example Checklist

Instructions: Step 1: Circle Yes or No and fill in with requested information.
Step 2: Explain all "No" responses at the bottom of the checklist.
Step 3: Samples of installed ductwork will be periodically reviewed to verify compliance.

General Overall (Total Job) HVAC Piping Insulation Requirement

Item	Task Description	Response	
		Submitted	Delivered
1	System Checks		
A	Installation Checks		
1	Piping is clean, dry and free of damage prior to installation.	Yes	No
2	Pressure and leakage tests performed and reports have been submitted prior to insulation installation.	Yes	No
3	All chilled water piping is insulated with 1 1/2 inch thick fiberglass pipe insulation with vapor barrier except runouts to radiant cooling panels located beyond 1'-0" within room being served.	Yes	No
4	Secondary chilled water, low temperature chilled water (2 1/2 inch thick), fan coil drain piping (1/2" thick), and piping with electric trace freeze protection is insulated in the same manner as the chilled water pipes.	Yes	No
5	All chilled water pumps are insulated with a 1 1/2 inch thick rectangular box made of Manville 817 rigid fiberglass board having a density of 6 lb/ft ³ with a rated vinyl coated and embossed laminate vapor seal (ASJ) jacket.	Yes	No
6	The insulation box for the pump is open at top and bottom with a removable top to effect a complete insulation for each base mounted pump.	Yes	No
7	The pipe insulation sections are firmly butted together and the longitudinal seam of the vapor barrier is cemented with Foster No. 85-75.	Yes	No
8	End joints are sealed with a minimum of 3 inch wide factory furnished vapor barrier strips cemented with Foster No. 85-75.	Yes	No
9	All fittings, valves, strainers etc. is insulated as described in the specifications.	Yes	No
10	Exterior piping has a 0.016 inch aluminum jacket with moisture barrier lock seam and Gasco of equal factory applied fittings in lieu of glass cloth jackets. A sample is submitted.	Yes	No

"No" Responses

Item	Date	Reason for "No" Response

Construction Phase Verifications

- Using *Test Procedures (Protocols)*:
 - The commissioning provider witnesses selected tests and verifies that the results of the *Test Procedures* meet quality expectations and conform with the *OPR* and *Contract Documents*
 - The verification process is looking for systemic problems with coordination and interfaces—although at this level, any problem may be systemic
 - Minor deviations would be addressed via the *Issues Log*
 - Major deviations might require concerted action from the commissioning team
 - The owner retains ultimate acceptance responsibility for deviations that negatively impact the *OPR*

Sample Test Procedure

ASHRAE Guideline 1.1-2007,
*HVAC&R Technical
Requirements for the
Commissioning Process*

(This annex is not part of this guideline. It is merely informative and does not contain requirements necessary for conformance to the guideline.)

INFORMATIVE ANNEX U— TEST PROCEDURES AND DATA FORMS

This annex provides an example of how to implement part of Guidelines 0 and 1.1. It is not intended to be a comprehensive representation or a best practice example. Practitioners applying the Commissioning Process should carefully follow Guideline 0, Guideline 1.1, and applicable commissioning technical guidelines tailored to their specific projects.

This sample commissioning process test procedure is to be accomplished during any season whenever the project is ready for commissioning process test implementation. The intent of accomplishing the complete commissioning process test procedure prior to owner acceptance is to verify to the best of our ability achievement of the OPR. Some of the individual scenarios will need to be accomplished during other seasons to verify achievement of the OPR during seasonal ambient conditions.

Comfort OPR Commissioning Process Test Procedure

Test Number: _____ Date: _____ Time: _____

____ New ____ Retest

Background: Verifying achievement of the comfort OPR prior to occupancy is accomplished through the execution of this commissioning process test procedure, which is composed of several operational scenarios. It is important to understand that this final commissioning process test procedure is focused on achievement of the OPR, which means evaluating the performance of the facility, not a single component or system.

This scenario approach works in the context that the individual components and systems have been verified throughout design and during construction from delivery through startup utilizing the construction checklists. This test procedure is accomplished to verify achievement of success (OPR) – it is not the intent to identify a significant number of issues at this stage in construction, because the commissioning process implementation should have identified and resolved the majority of issues earlier in the project.

OPR to be Verified: Comfort is the focus of this commissioning process test procedure. Comfort has been defined by the owner in the OPR as consistent temperature from space to space to avoid having occupants feel variations in temperature as they move throughout the facility.

Facility Scenarios: The operational scenarios to be implemented through this commissioning process test procedure to verify achievement of the comfort OPR are:

1. Morning Warm-up – Cloudy Day: For this scenario, the perimeter spaces are 10°F cooler than set point and interior are 2-5°F cooler than set point.
2. Morning Warm-up – Clear Day: For this scenario, the west perimeter is 10°F cooler than set point, the interior spaces 2-

5°F cooler than set point, and the East perimeter 0-5°F warmer than set point.

3. Morning Cool-down – Cloudy Day: For this scenario, the perimeter is 10°F warmer than set point and the interior 2-5°F warmer than set point.
4. Morning Cool-down – Clear Day: For this scenario, the East perimeter is 10°F warmer than set point, interior is 2-5°F warmer than set point, and West perimeter 0-5°F warmer than set point.
5. Peak Cooling: For this scenario, all spaces start at 5-10°F warmer than set point.
6. Peak Heating: For this scenario, all spaces start 5-10°F cooler than set point.
7. Afternoon Cooling: For this scenario, the West perimeter is 5°F warmer than set point, remaining spaces at set point.
8. Conference Room Load: For this scenario, the conference room is 10°F warmer than set point, other spaces 2-5°F warmer than set point.

Systems/Assemblies/Equipment/Components Evaluated: The comfort OPR is impacted by most systems and assemblies in the facility. The following systems and assemblies are the primary ones that are evaluated during completion of this commissioning test procedure:

- Chilled Water System
- Hot Water System
- Air Distribution System
- Air Handling Unit
- Variable Air Volume Terminal Units
- Room Air Diffusers
- Exterior Envelope
- Interior Partitions
- Building Automation Management System (BAMS)

Ambient Conditions: The scenarios that are to be implemented under this commissioning test procedure are intended to evaluate the performance of the entire facility to maintain consistent temperatures from space to space. Each scenario starts with spaces at realistic initial conditions that are expected to occur sometime throughout the year. Implementing this commissioning test procedure then evaluates how quickly and effectively the systems respond to achieve consistent space temperatures. Evaluating the recorded results will determine if consistent temperatures are expected to be maintained under actual operation throughout the year.

While the ambient conditions will impact the results of the test (e.g., if it is hot outside, the heating tests will not be as realistic as desired), the scenarios have been created to limit this impact. Ideally, this commissioning test will be accomplished under non-peak outdoor design conditions to limit impact on overall results. However, if the test is being performed during a peak outdoor condition, then the similar season scenarios will be accomplished during the peak outdoor conditions (e.g., the cooling scenarios) and the opposite season scenarios (e.g., the heating scenarios) will be accomplished at night to limit ambient conditions on test results.

Sample Test Procedure (continued)

Definitely not “yes or no.”

ASHRAE Guideline 1.1-2007,
HVAC&R Technical Requirements for the Commissioning Process

Prerequisites: The following pre-requisites must be accomplished prior to implementing this commissioning test:

- Construction checklists for the systems, assemblies, equipment and components must be completed by the contractor and verification by the commissioning authority accomplished.
- The testing, adjusting and balancing (TAB) work must be completed and the final report verified by the commissioning authority.

Items to be Recorded: The system response time to a change for this facility is estimated to be 5 minutes (the time it takes for a change to be seen in the space once the set point has been changed). Therefore, the frequency of recording data should be less than the system response time to be able to identify anomalies and issues. For this commissioning test the frequency of recording data is to be every 2 minutes.

The following items are to be recorded:

- Chilled water system
 - Chilled water supply temperature
 - Chilled water return temperature
 - Condenser water supply temperature
 - Condenser water return temperature
 - Primary and secondary pump status
 - Secondary pump speed
 - System pressure
 - Chiller electrical usage
- Hot water system
 - Hot water supply temperature
 - Hot water return temperature
 - Primary and secondary pump status
 - Secondary pump speed
 - System pressure
 - Boiler gas usage
 - Stack temperature
- Air handling units
 - Supply air temperature
 - Return air temperature
 - Mixed air temperature
 - Chilled water valve position
 - Hot water valve position
 - Supply fan speed
- Variable air volume terminal units
 - Airflow

- Reheat valve position
- Supply air temperature
- Mode of operation
- Spaces
 - Set point
 - Temperature
 - Humidity (where sensor present)
- Outdoors
 - Temperature
 - Humidity
 - Unique conditions (cloudy, precipitation, wind)

Participants: The following participants shall be present during the implementation of this commissioning test:

- Commissioning Authority – oversees and directs the test and records the results.
- BAMS Contractor – helps in setting up and switching scenarios and provides electronic files of recorded information.
- Operation and Maintenance Personnel – helps in recording results and implementing the test.

The following participants will be invited, but are not required to attend:

- Mechanical Contractor – technician may be required to fix items to continue implementing the test.
- Electrical Contractor – technician may be required to fix items to continue implementing the test.
- General Contractor – to understand tests and results in case of failure.
- Design Professionals – to understand tests and results in case of failure.

Expected Performance: The systems should be able to achieve stable, consistent space temperatures within 20 minutes from the change of set point (this is based on an air-change-rate of 3 per hour on average). Therefore, the expected performance is that all space temperatures should be at set point within 20 minutes of initiating the scenario (within set point means $\pm 2^\circ\text{F}$ of set point for any space due to accuracy of the space sensors).

Test Procedures: The following table shall be followed in implementing and recording the results of this commissioning process test procedure, with occupied cooling and heating set point being 74°F :

Sample Test Procedure (continued)

ASHRAE Guideline 1.1-2007,
HVAC&R Technical Requirements for the Commissioning Process

Test	Step	Expected	Actual	Pass/Fail
Morning Warm-up – Cloudy Day	Set Perimeter Spaces to 64°F (10°F cooler than set point)			
	Set Interior Spaces to 69°F (5°F cooler than set point)			
	Record Results			
	Record Time to Stability	20 minutes		
	Record Issues Identified			
Morning Warm-up – Clear Day	Set South, West, and North Perimeter Spaces to 64°F (10°F cooler than set point)			
	Set East Perimeter to 79°F (5°F warmer than set point)			
	Set Interior Spaces to 69°F (5°F cooler than set point)			
	Record Results			
	Record Time to Stability	20 minutes		
Morning Cool-down – Cloudy Day	Record Issues Identified			
	Set Perimeter Spaces to 84°F (10°F warmer than set point)			
	Set Interior Spaces to 79°F (5°F warmer than set point)			
	Record Results			
	Record Time to Stability	20 minutes		
Morning Cool-down – Clear Day	Record Issues Identified			
	Set South and North Perimeter and Interior Spaces to 79°F (5°F warmer than set point)			
	Set East Perimeter to 84°F (10°F warmer than set point)			
	Set West Perimeter to 76°F (2°F warmer than set point)			
	Record Results			
Peak Cooling	Record Time to Stability	20 minutes		
	Record Issues Identified			
	Set All Spaces to 84°F (10°F warmer than set point)			
	Record Results			
	Record Time to Stability	20 minutes		

Construction Phase Verifications

- Of training:
 - The commissioning provider verifies that a sample of the training activities (as defined by the *Training Plan*) meets quality expectations and conforms with the *OPR* and *Contract Documents*
 - The verification process is looking for systemic problems
 - Minor deviations would be addressed via the *Issues Log*
 - Major deviations might require concerted action from the commissioning team
 - The owner retains ultimate acceptance responsibility for deviations that negatively impact the OPR

Construction Phase Verifications

- Of the *Systems Manual*:
 - The commissioning provider verifies that the *Systems Manual* is complete (to the extent possible at this phase) and that a sample of the manual meets quality expectations and conforms with the *OPR* and *Contract Documents*
 - The verification process is looking for systemic problems that would impair or decrease facility and document usability by the owner's staff
 - Minor deviations would be addressed via the *Issues Log*
 - Major deviations might require concerted action from the commissioning team
 - The owner retains ultimate acceptance responsibility for deviations that negatively impact the *OPR*

Building Commissioning



images courtesy of NEBB

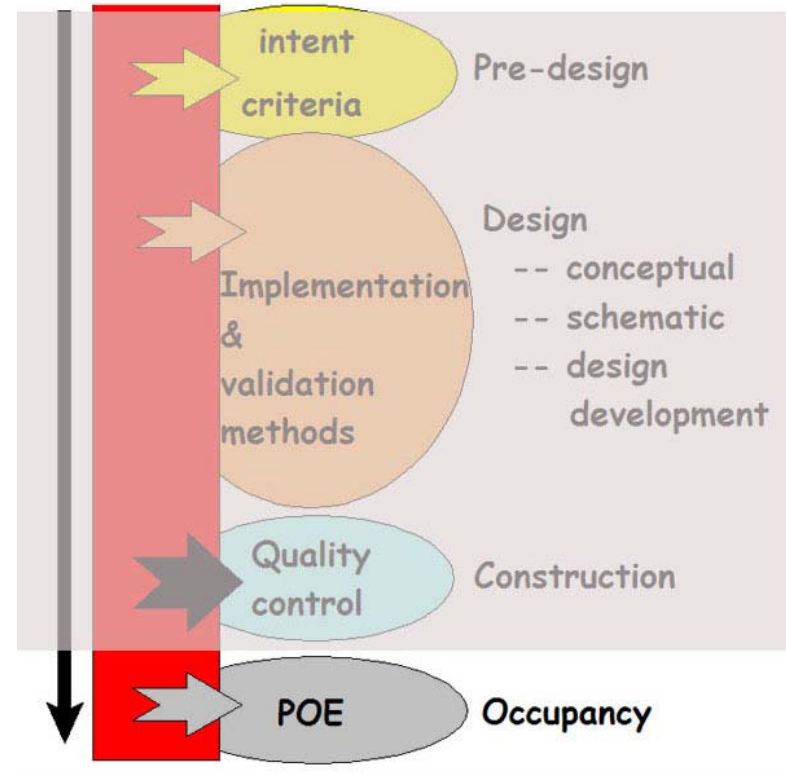
Because stuff happens (even to static systems)!

Questions

before leaving this discussion of
the commissioning process
during the construction phase?

Next section: Occupancy and Operations Phase Commissioning

Occupancy and Operations Phase Commissioning



Outline: Occupancy and Operations

- Commissioning Process Objectives during Occupancy and Operations
- The Commissioning Team
- Updating Commissioning Documents
- Lessons-Learned Workshop
- Final Commissioning Report
- Ongoing Commissioning

Occupancy and Operations Commissioning Process Objectives

- Complete seasonal or deferred testing
- Minimize contractor callbacks
- Document lessons learned
- Assist with any warranty issues
- Provide assistance with ongoing facility operations to meet the *OPR*
- Close out the commissioning process via formal owner acceptance of final report

ASHRAE Guideline 0-2019: Occupancy and Operations Phase Objectives

Occupancy and Operations Objectives

To close out the (initial) commissioning process

To prepare the owner for long-term beneficial use
of the facility

Unofficially

Key Occupancy and Operations Commissioning Activities

- Update *OPR* and *Commissioning Plan*
- Coordinate contractor callbacks
- Verify seasonal and deferred testing
- Verify training during occupancy and operations
- Verify completion and updating of the *Systems Manual*
- Close out the *Issues Log*
- Convene a lessons-learned workshop
- Complete and deliver the *Final Commissioning Process Report*

Terms shown in *Caps/Italics* are formal process documents

Occupancy and Operations Phase Commissioning Team

- Commissioning provider
- Owner's representatives (project manager, operations and maintenance staff)
- Design team representatives (as required)
- Contractor representatives (including subcontractors)
- Major equipment/assembly manufacturer representatives (as required)

Intent: use commissioning team to prepare owner for the long-term beneficial use of facility

Occupancy and Operations Commissioning Documents

- *Commissioning Plan* → update
- *OPR* and *Basis of Design* → update as necessary
- Training Materials → verify and incorporate into *Systems Manual*
- *Systems Manual* → verify and employ
- *Issues Log* → close out
- *Final Commissioning Process Report* → develop and deliver

Who Might Do These Documents?

< suggestions, not requirements >

- *Commissioning Plan* → commissioning provider
- *OPR and Basis of Design* updates → commissioning provider (and perhaps design team)
- Training Materials → verify (commissioning provider) and incorporate into *Systems Manual* (designated party)
- *Systems Manual* → verify (commissioning provider) and employ (commissioning team, transitioning to owner's staff)
- *Issues Log* close out → commissioning team
- *Final Commissioning Process Report* → commissioning provider

Lessons-Learned Workshop

- Although most project parties are ready to move on at this stage, all can benefit from reflection upon the commissioning process
- The owner can benefit from information gleaned by the various parties that relates completed product performance to the original Owner's Project Requirements
- The design team can benefit from experiences that relate design process to implementation of design intent and criteria (objectives and benchmarks) via the *Construction Documents*
- The contractor can benefit from experiences that relate construction quality control to design intent and the construction process
- The commissioning provider can benefit from feedback on all aspects of the process

Final Report Highlights

- Identify any systems or assemblies that do not perform in accordance with the *OPR*—and note likely ramifications of such deviations
- Evaluate operating condition of systems/assemblies upon completion of testing
- Summarize the contents of the *Issues Log*—extent of concerns, costs, operational impacts
- System performance benchmarks
- Lessons learned
- Ideally, provide a sense of the worth of the commissioning process on the project
 - Without pointing fingers: suggest problems avoided, costs avoided, performance improved, potentials improved, etc.

Ongoing Commissioning Process

- Ongoing commissioning extends the process beyond the termination of the original commissioning services agreement (typically about a year into building occupancy, upon major equipment warranty expiration)
- The intent is to continue to assist the owner in maximizing beneficial use of the facility for the long term
- It is likely that ASHRAE Guideline 0 will, in the future, include more information on the ongoing commissioning process, through the addition of a new section. Standard 202 will not likely do the same because of the scope of most codes.

Building Commissioning

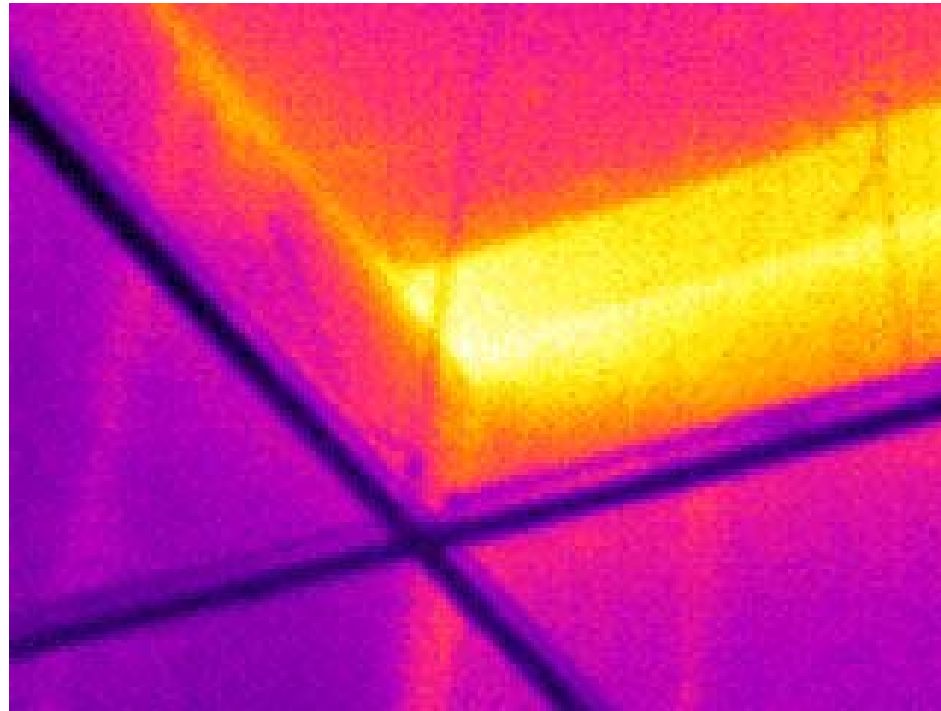


Image courtesy of NEBB.

Because stuff happens (even if we can't see it)!

Questions

before leaving this discussion of the commissioning process during occupancy and operations?

Next section: Summary

Principles of Building Commissioning: ASHRAE Guideline 0 and Standard 202

Summary

Building Commissioning is —

A structured ***quality assurance process*** intended to ensure that a building, when delivered, meets the ***owner's requirements*** upon turnover (and ideally well into the life of the facility).

Building Commissioning is —

An ongoing **process**
spanning from pre-design into occupancy

It is **not** an “event”

It is **not** a short-term “task”

The Commissioning Process Can be Applied to —

- Whole Buildings
- Building Systems
 - **Renewable Energy Systems**
 - HVAC&R Systems
 - Plumbing Systems
 - **Envelope Systems**
 - Power Distribution
 - Lighting and **Lighting Controls**
 - Etc.
- Building Sub-Systems
 - **DDC Controls**
 - Security and Fire Alarm Systems
 - Voice/Data Systems
 - Standby Power Systems
 - **Daylighting Controls**
 - Etc.

Systems in bold should be considered prime candidates for commissioning

Commissioning Is Needed Because —

Stuff that leads to low-performance happens:

- Poorly identified owner needs/wants
- Poorly executed work
 - Design
 - Construction
 - Operations/maintenance
- Poor communications among stakeholders

The Commissioning Process Involves Three Key Elements —

- Communication
- Documentation
- Verification

Implemented across all project phases
and across disciplines for selected systems

A Successful Commissioning Process Will Display —

- Explicitly stated expectations and responsibilities
- Good document development and utilization
- Verification of design and construction artifacts
- Collaborative and nonconfrontational communications

Successful Commissioning Will Help Deliver —

- A project that generally reflects the owner's needs and desires
- A project that works (fully) upon initial occupancy
- A project that is well documented
- Facility staff that are prepared to properly operate and care for systems and assemblies
- A project with clear performance benchmarks
- A project that has benefited from a collaborative effort of the diverse participants

Successful Commissioning
Will Help Deliver —

An **everyday** building without
major glitches

and/or

**A HIGH-PERFORMANCE BUILDING THAT
PERFORMS AS INTENDED**

The Costs of Commissioning

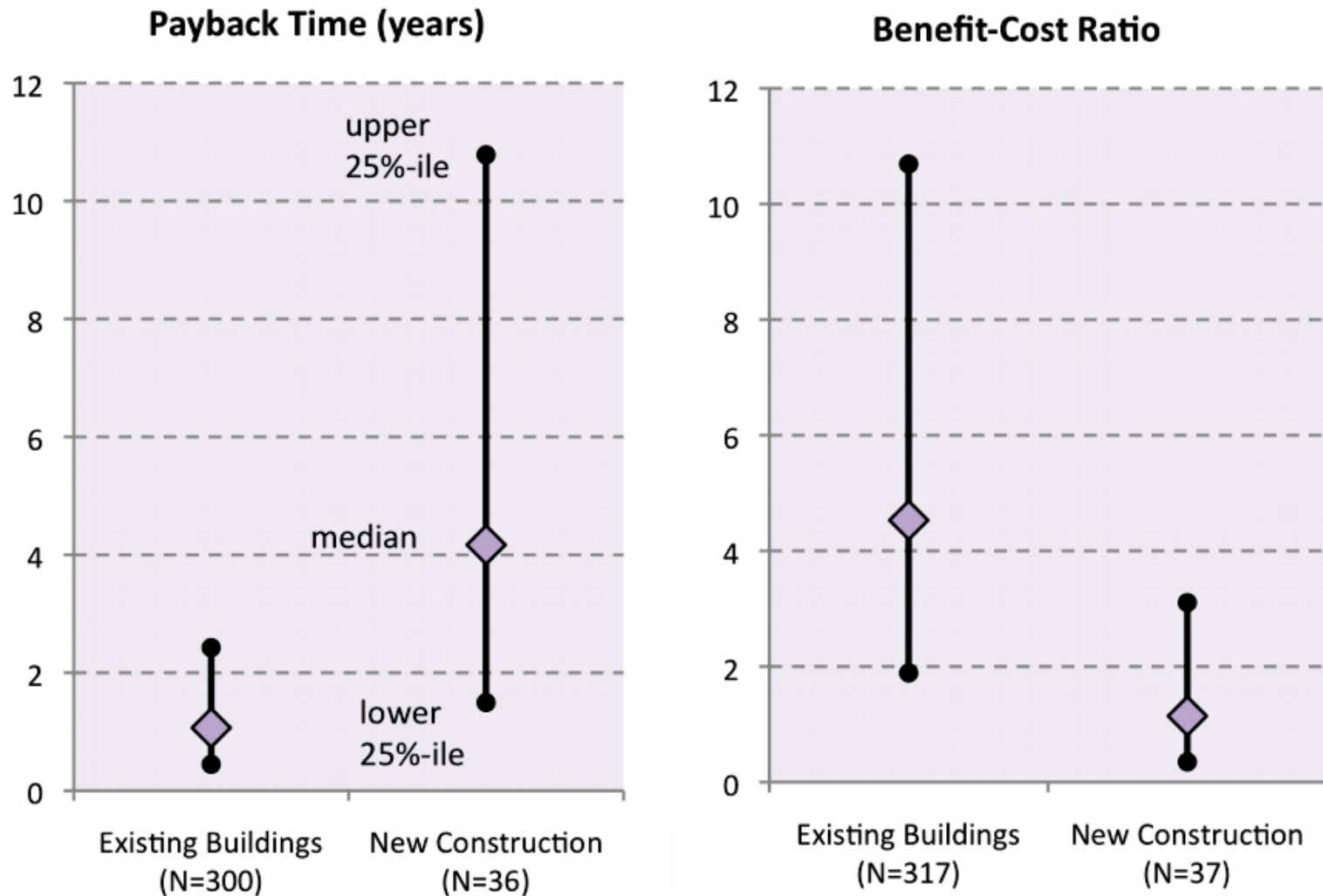
- Will vary with project type (simple versus complex)
- Will vary with market conditions (competition)
- Will vary with system(s) being commissioned
- Will vary with owner expectations (commodity versus service)
- Will vary with owner expectations (OPR)
- Will not be inconsequential—but should be viewed as an investment rather than as an expense
- Might be reasonably viewed as a risk management hedge—as insurance

Varying Commissioning Costs



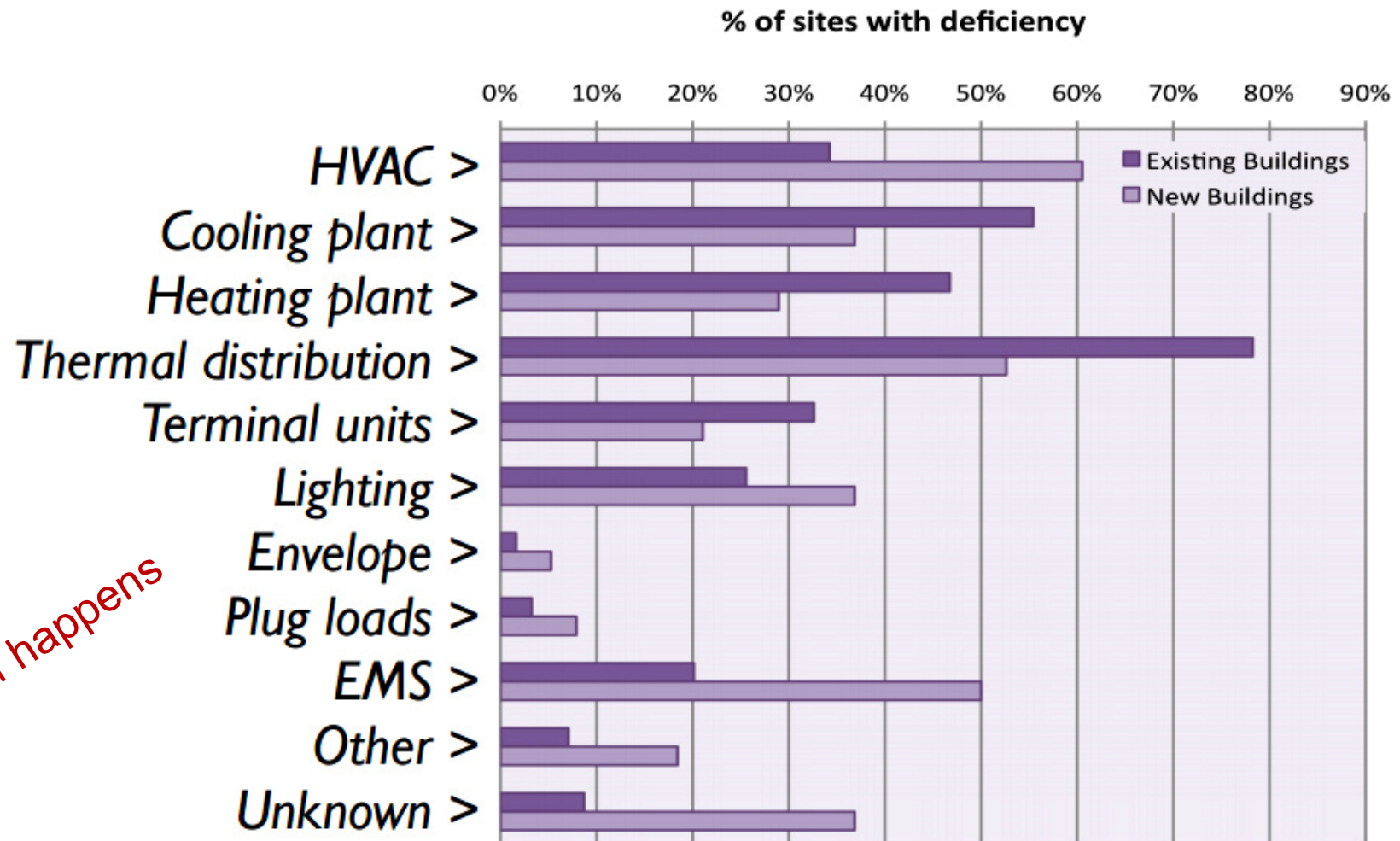
<http://evanmills.lbl.gov/presentations/cx-business-case.pdf>.

Varying Commissioning Cost



<http://evanmills.lbl.gov/presentations/cx-business-case.pdf>.

Varying Commissioning Issues

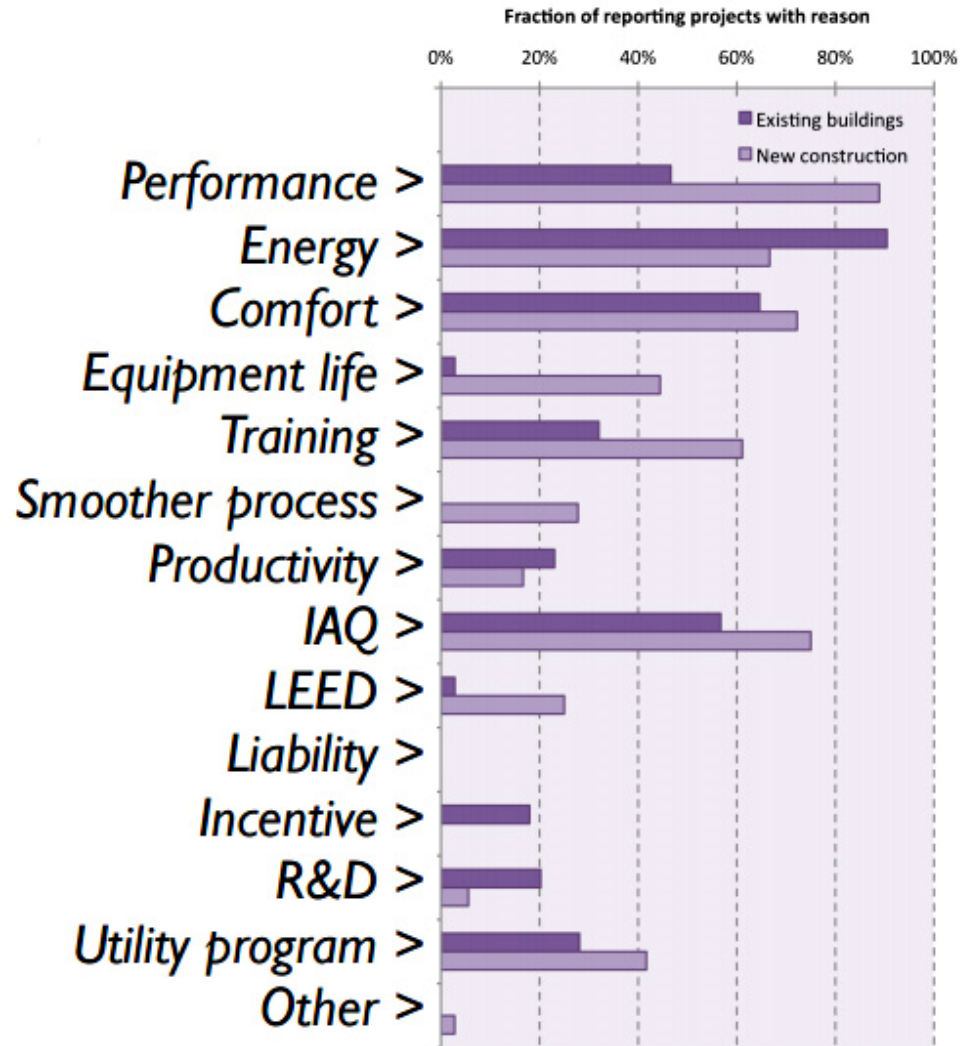


stuff happens

<http://evanmills.lbl.gov/presentations/cx-business-case.pdf>

Varying Commissioning Drivers

OPR vary



<http://evanmills.lbl.gov/presentations/cx-business-case.pdf>

Building Commissioning



Image courtesy of NEBB.

Because stuff happens (and gets left that way)!

Final Questions?

Walter T. Grondzik, P.E.

Ball State University

Department of Architecture

gzik@gzik.org

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