CxP Supporting Technical Guidelines

Charles E. Dorgan, PhD, PE

Professor Emeritus

University of Wisconsin - Madison

GovEnergy

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TOTAL BUILDING COMMISSIONING PROCESS

ASHRAE Guideline 0-2005: The Commissioning Process
(Used as the foundation of ASHRAE Guideline 1,
NIBS Guideline 3, and
other Total Building Commissioning Process technical guidelines)

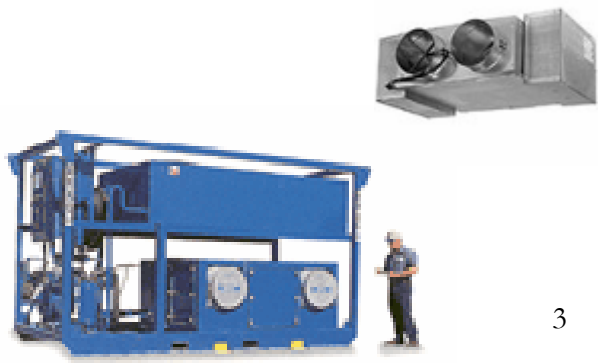
ASHRAE
Guideline 1-2006
HVAC&R
Technical
Requirements for
The Commissioning
Process

NIBS
Guideline 3-2006
Exterior Enclosure
Technical
Requirements for
The Commissioning
Process

Guidelines
2-200X & 4-200X
through 14-200X
Technical commissioning
guidelines dealing with
structure, electrical,
lighting, interiors,
plumbing, etc.

"HVAC&R Technical Requirements for The Commissioning Process"

ASHRAE Guideline 1-2007 (tentatively)

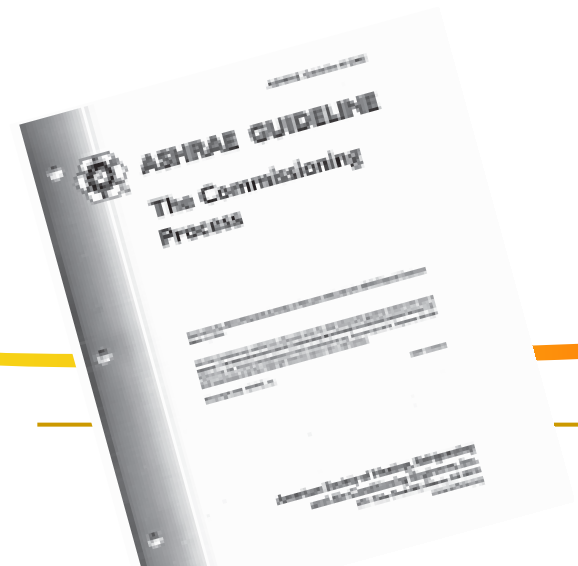


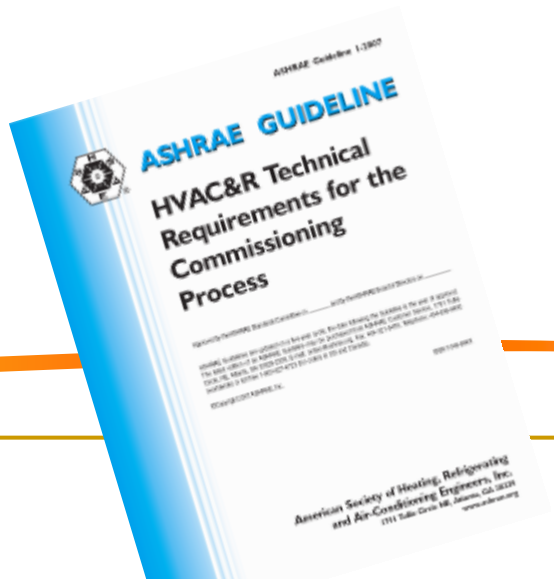
Some General Comments

- Before I go into Guideline 1-2007, I would like to share a few comments on the Commissioning Process Guidelines
- First the guidelines are just that, guides, but said they do have a lot of useful information
- If my introductory remarks do not apply to you, then ignore them, as some of you are actively using the guidelines, maybe everyone in this room.

Value of CxP

- <u>No one</u> uses the **POWER** of the commissioning guidelines (0, 1, and 3)
- Maybe no one understands them?
- Has everyone or anyone seriously read them?





Up to You!!

- **Only those in this room** and others like you can make the CxP business as usually and allow us to delivery high quality constructed projects and reduce the cost of delivering buildings and facilities 5-20%.
- Yes, the potential is a cost reduction of 5-20% using a quality process, versus isolated expert process at each phase of a building's Life

Value of the CxP Guidelines

- The current development cost of Guidelines 0-2005 and 1-2007 is:
  - over $1.3 million in volunteer time at $100/hour, plus travel and other costs
  - these committees met 4 times a year for 2 days each over a period of 7 years

Value of the CxP Guidelines

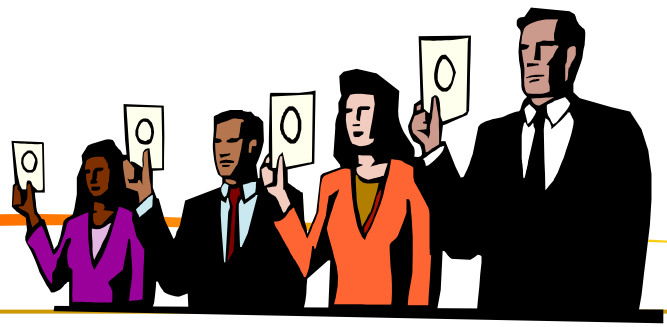
- You could not afford to hire this committee's members to develop these "effective", "comprehensive" guideline, with their leading experience in implementing the CxP
- The guidelines are not perfect, but the l reference you currently have

Sad Situation of Current Practice

- The current practice of Cx and CxP is improving, but a long way from Guidelines 0, 1, and 3 on almost all projects that I have been involved or have reviewed the results of a commissioning effort.
- Recently was aware of an owner who skipped the Lessons Learned Workshop, even though it was already in the cost of CxP

Sad Situation of Current Practice

- I have review a number of projects that claim to use Cx or CxP, but they shortcut the quality principles and wonder why they have failures
  - They list failures during the commissioning testing (most call functional performance – which is a joke, as it is not a quality delivery approach) and wonder why they have failed systems at the end of construction
  - Why, because it **was business as usual**, with just another expert, the commissioning authority or agent, not a quality team and team leader



Objective of this Presentation

1. Give you an overview of Guideline 1-2007 and some information on 3-2006, if time allows
2. Perk your interest in the CxP and hopefully you will investigate in sufficient details to make the difficult change to a QUALITY CONSTRUCTED PROJECT DELIVERY SYSTEM

Existing Buildings

- Although, not covered in this presentation:
  - The real power of the CxP procedures and principles is **EXISTING BUILDINGS** AND FACILITIES. **Everyone has lots of them!!**
  - Frequently it is easier to learn the principles on existing buildings first, then apply to new construction or rehab projects.
  - When I was active in consulting, approximately 60% of my clients originated after a successful "existing building" project

Guideline 1-2007

To restate: Purpose of this presentation is:

- to assist in understanding the role of supporting technical guidelines,
- examples of additional information for HVAC&R systems, and
- assist with effectively using supporting guidelines

Scope of Guideline 1-2007

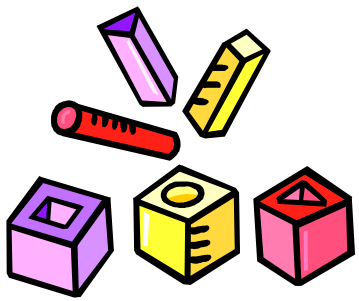
- Information on support of the commissioning process for HVAC&R systems with specific emphasis on:
  - HVAC&R systems to fully support The Commissioning Process activities of Guideline 0-2005,
  - verification during each phase of The Commissioning Process,
  - acceptance during each phase,
  - documentation during each phase,
  - Systems Manual specific requirements, and
  - training for operations and maintenance personnel and occupants

Use With Guideline 0-2005

- Cannot be used alone
- An attempt was made to prevent duplicating procedures and requirements stated in GLD 0-2005
  - Three reasons
    - To allow updates to 0-2005, without conflicts with other technical guidelines
    - To reduce the size of each guideline
    - To allow multiple systems and assemblies to be included in the scope of implementing the CxP, that is selected multiple supporting guidelines that apply to the specific project

Matching Sections and Sub-Sections

- As required by Annex A of GLD 0-2005, all Sections and sub-sections match same sections numbers in GLD 0-2005



Example of Additional Supporting Information

“ 5.2.1 Commissioning Team Members

*In addition to those detailed in ASHRAE Guideline 0-2005 (5.2.1.3), the essential members of the Commissioning Team relative to HVAC&R systems during the **Pre-Design Phase** include:*

- *Facilities engineer,*
- *Owner’s automatic controls and building automation technician,*
- *Facility IT Network manager or technician*
- *Owner’s HVAC&R technician,*
- *Architect,*
- *HVAC&R design professional,*
- *Electrical design professional.*”

Key Milestones that need to be Identified during the Pre-Design Phase for a Successful HVAC&R

"5.2.4.2 *Milestones*

During the Pre-Design Phase it is critical to document key commissioning process ***milestones*** *relative to the HVAC&R systems during Design, Construction, and Occupancy and Operations Phases. These include:*

a) *Pre-design meeting,*

b) *Design review (multiple), including the Basis of Design requirements with each design submittal,*

Key Milestones that need to be Identified during the **Pre-Design Phase** for a Successful HVAC&R

"5.2.4.2 *Milestones*

c) *Design Phase updated Commissioning Plan,*

d) *Construction pre-bid meeting,*

e) *Pre-construction CxP meeting,*

f) *Construction Phase updated Commissioning Plan,*

Key Milestones that need to be Identified during the Pre-Design Phase for a Successful HVAC&R

g) *Commissioning meetings,*

h) *Material and equipment submittal (including manufacturer's operations and maintenance documentation) review, – including control equipment.*

i) *Coordination drawing submission,*

j) *Initial Systems Manual submission -- xx days after submittal approval,*

Key Milestones that need to be Identified during the Pre-Design Phase for a Successful HVAC&R

k) *Submission of automatic control and building automation controls logic diagrams,*

l) *Submission of automatic control and building automation controls software xx days after submittal acceptance,*

m) *Training program implementation plan,*

Key Milestones that need to be Identified during the **Pre-Design Phase** for a Successful HVAC&R

n) *Construction Checklist completion and tracking,*

o) *Equipment factory testing,*

p) *Equipment placement review,*

q) *Testing procedure development (update Commissioning Plan),*

Key Milestones that need to be Identified during the Pre-Design Phase for a Successful HVAC&R

r) *Contractor required test verification (duct pressure testing, pipe pressure testing, etc.)*

s) *Initial automatic controls and building automation system acceptance,*

t) *Testing, adjusting, and balancing report and verification,*

u) *Final automatic controls and building automation system acceptance,*

Key Milestones that need to be Identified during the Pre-Design Phase for a Successful HVAC&R

v) *HVAC&R system testing,*

w) *Final Systems Manual submission,*

Key Milestones that need to be Identified during the Pre-Design Phase for a Successful HVAC&R

x) *Operator, maintenance, and occupant training,*

y) *Turnover of systems/HVAC&R systems acceptance – start of warranties,*

z) *Draft Commissioning Process Report,*

Key Milestones that need to be Identified during the Pre-Design Phase for a Successful HVAC&R

aa) *Commissioning Authority site visits during first year of operation,*

bb) *Operator, maintenance, occupant additional training,*

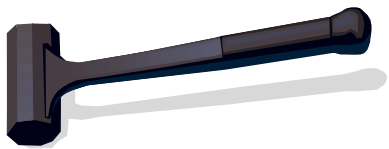
cc) *Seasonal testing,*

Key Milestones that need to be Identified during the Pre-Design Phase for a Successful HVAC&R

dd) *XX-month warranty walk-through and verification,*

ee) *Lessons learned meeting or workshop,*

ff) *Final Commissioning Process Report."*



For HVAC&R Success there are Key Activities in both Pre-Design & **Occupancy**

"8.2.6.4 As part of the first year site visits, it is also the commissioning team's role to facilitate the integration of the commissioning process activities into on-going operations and maintenance procedures. This includes the following key activities: (this is the lifetime needs of the facility)

a) *<u>Maintaining the Owner's Project Requirements</u> document to reflect changes in use and operation of the HVAC&R systems and facility.*

For HVAC&R Success there are Key Activities in both Pre-Design & **Occupancy**

b) *<u>Maintaining the Basis of Design</u> to reflect changes in HVAC&R systems and components due to renovations or in response to changes in the Owner's Project Requirements.*

c) *<u>Periodic (seasonal, annual, or bi-annual) evaluation</u> of achievement of the current Owner's Project Requirements (may desire to change to CFR) against previous benchmarks by the use of appropriate tests.*

For HVAC&R Success there are Key Activities in both Pre-Design & **Occupancy**

d) *<u>Maintaining the Systems Manual</u> to reflect changes in the Owner's Project Requirements, Basis of Design, and systems/assemblies.*

e) *<u>On-going training</u> of operations and maintenance personnel and occupants on current Owner's Project Requirements and Basis of Design, changes in HVAC&R systems and operation, and on maintaining current Record Drawings.*

Information in Annexes

Like Guideline 3-2006 (Exterior Envelopes), the most important information in GLD 1-2007 may be the <u>specific examples</u> to assist the owner in effectively implementing the CxP included in the annexes.

Following are examples of substantial Annexes (note page numbers will be less in the published version of GLD 1-2007

- Annex G – CxPlan: 19 pages
- Annex H – Acceptance Plan: 5 pages
- Annex J – Owner's Project Requirements: 34 pages
- Annex K – Basis of Design: 14 pages
- Annex L – Specifications: 23 pages
- Annex M – Checklists: 33 pages

2. Design Checklist for the Mechanical Engineer's First Design Submittal
ASHRAE - Guideline 1-200X 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.

Item	Task Description	Location of Information: Document, Drawing, or draft Project Manual	Response
1	**Owner's Project Requirements**		
A	**Key Owner's Project Requirements**	Complete	
1	Commissioning Plan Updated, provide date and enclose with this submittal		Yes No
2	Basis of Design for controls completed	Yes	No
3	Basis of Design for accessibility completed	Yes	No
4	Sustainability and LEED issues coordination addressed		Yes No
5	Do the general HVAC&R requirements the current OPR requirements? Has justification been document and approved by owner's Project Manager?	Yes	No
6	Control format, BACnet requirements complete and documented		Yes No
B	**Owner' Objectives**		
1	Preliminary mechanical room layout complete	Yes	No
2	Energy analysis meeting goal of 30% less than ASHRAE 90?		Yes No
3	Single line diagrams developed for controls and systems		Yes No
4	Report on safety factors and tolerance for facility system operations		Yes No
5	Have chillers been sized and pre-order to meet occupancy goal		Yes No
6	Environmental and sustainability initial design complete		Yes No
C	**General Owner's Needs**		
1	Is current HVAC and control systems budget enclosed and within initial budget		Yes No
2	Mechanical rooms space and location coordinated with shops		Yes No
3	Has Electrical, Plumbing, Lighting and Communications coordination been completed?		Yes No
4	Does the initial design meet all Benchmark Established for HVAC&R? Document?		Yes No
5	Constructability and maintainability analysis completed		Yes No

Examples are both given and information included on the use of the information

Annex I, OPR Workshop includes a number of typical questions that can be used related to HVAC&R Systems. Following is one example question included in the annex:

"8. What are your training requirements? *This question is for the O&M staff, and sometimes the occupants, to understand what is needed to understand the systems and building. The knowledge base of the expected maintenance crew is key to defining the training requirements defined in the construction and commissioning documents."*

GLD 1-2007 is a "GUIDELINE"

This is a guideline, it is not a standard 'means'

- It does provide a standard format for implementing the commissioning process.
- Using these guidelines as the basis for implementing the CxP will allow a more uniform and cost effective implementation of the commissioning process
- However, it does allow owners to modify the details to meet specific project or organization needs

Continuous Improvement of CxP Guidelines

- Hopefully they will allow a means for input as owners and practitioners develop improved means and methods for delivering a quality-based constructed project.
- Remember, only 15-20 professionals developed these guidelines and there is a limited time and resource for the committee to develop a guideline

Use of CxP Guidelines

- Do not take CxP guidelines as the fixed means and method for implementing the CxP
- If we did not use information from practitioners and owners, we would have a guideline that express the process as practiced in 1980
- Guidelines are essentially out-of-date the day they are published

Use of CxP Guidelines

Use Guidelines to assist you, not cramp a better approach developed by a specific owner

Would you like to know more about this session?

- Chuck Dorgan
- University of Wisconsin - Madison
  and Dorgan Associates
- cedorgan@wisc.edu or,
- cedorgan@charter.net

- Don’t forget to fill out and drop off your session evaluations.

Questions

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New Orleans

August 5-8

Exterior Enclosure Technical Requirements for the Commissioning Process

NIBS Guideline 3-2006

Slide courtesy of Earle Kennett

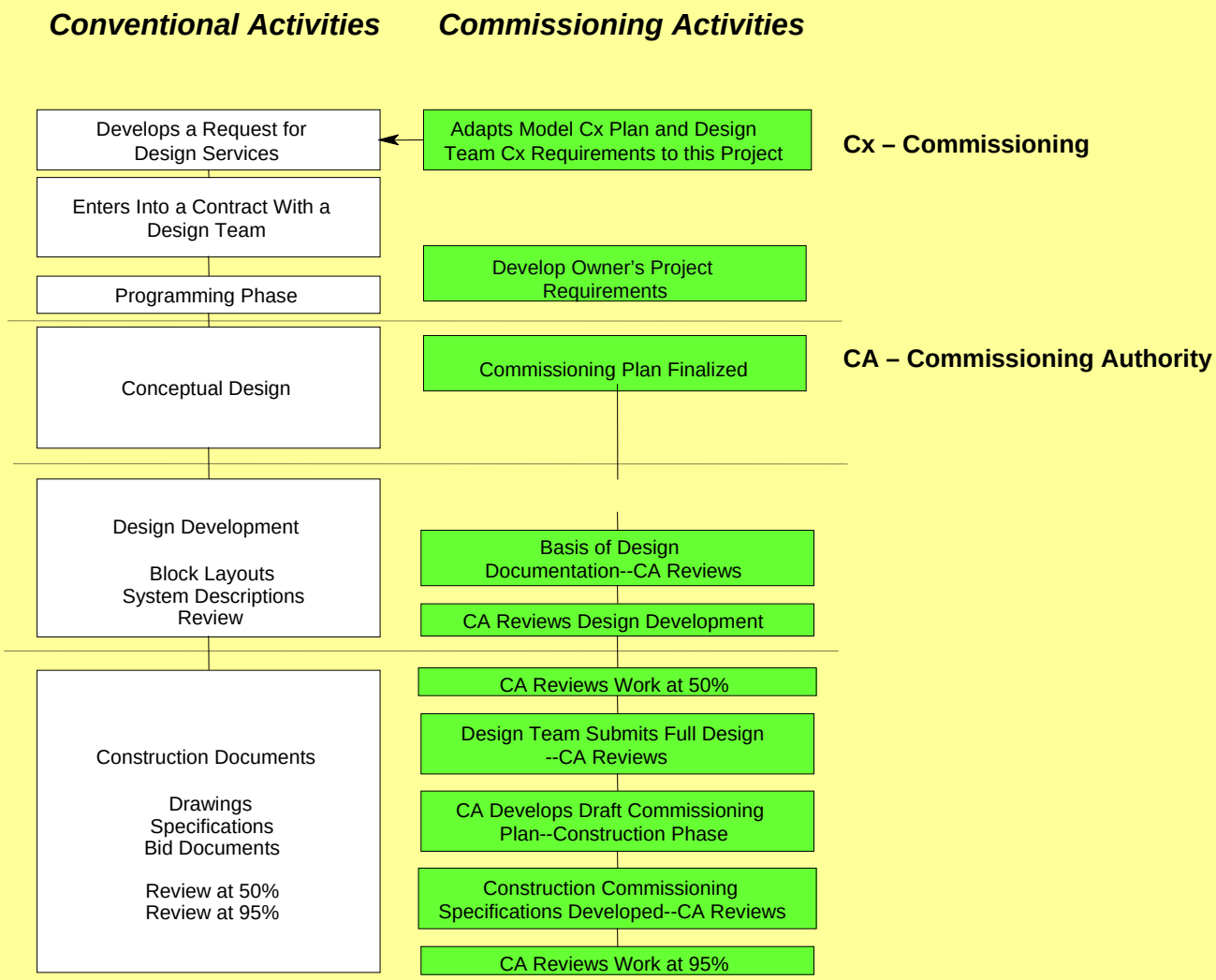
National Institute of Building Sciences

and Joe Deringer, AIA

President, Deringer Group

National Institute of BUILDING SCIENCES

COMMISSIONING PROCESS



NIBS Guideline 3-2006

Exterior Enclosure Technical Requirements For the Commissioning Process

This Guideline is for Use with ASHRAE Guideline 0-2005: The Commissioning Process

National Institute of BUILDING SCIENCES

STRUCTURE

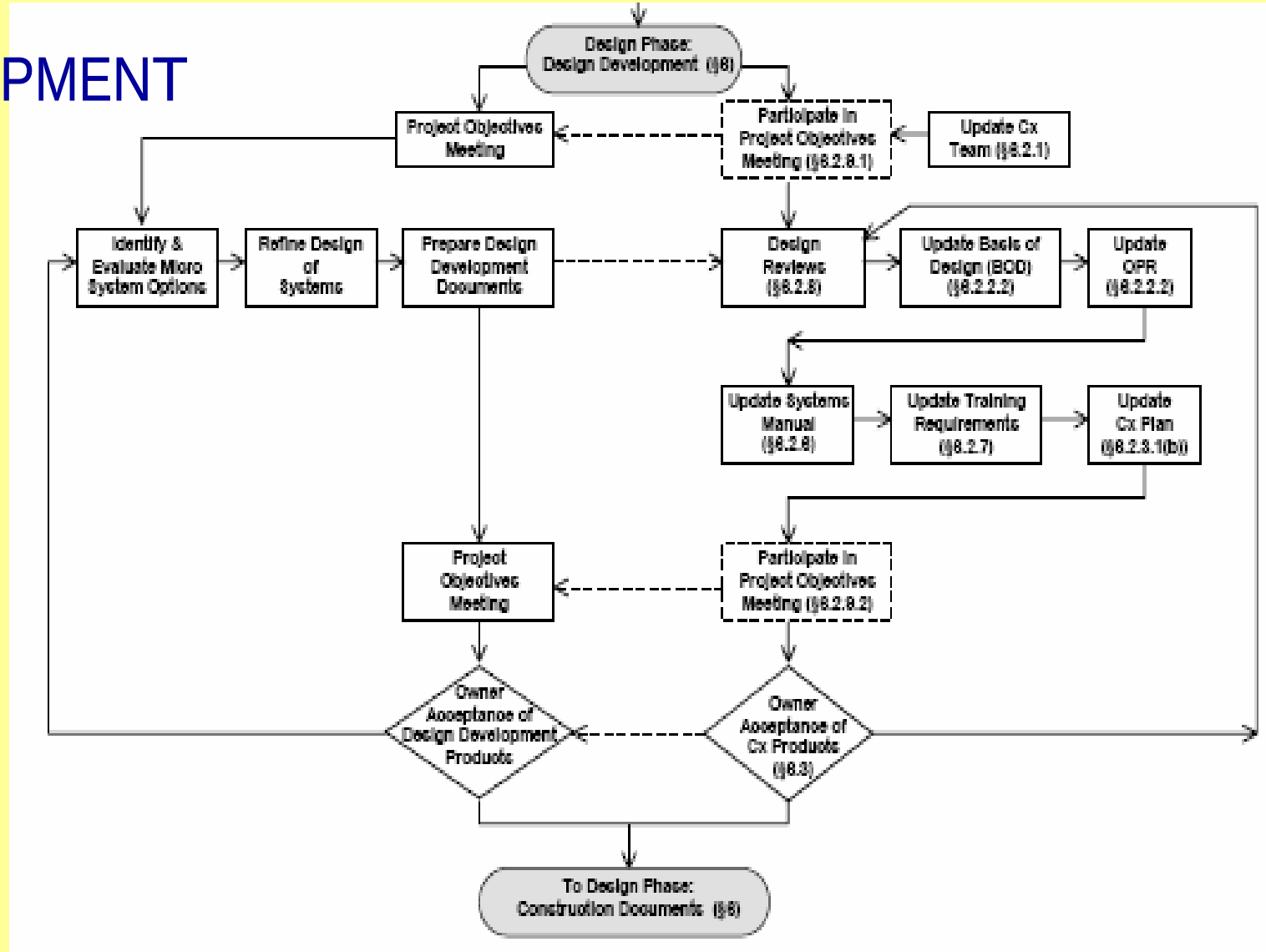
- Table of Contents
  - **Foreword**
  - **1. Purpose**
  - **2. Scope**
  - **3. Utilization**
  - **4. Definitions**
  - **5. Pre-Design Phase**
  - **6. Design Phase**
  - **7. Construction Phase**
  - **8. Occupancy and Operations Phase**
  - **Annexes**

ANNEXES: *Focus on Exterior Enclosure*

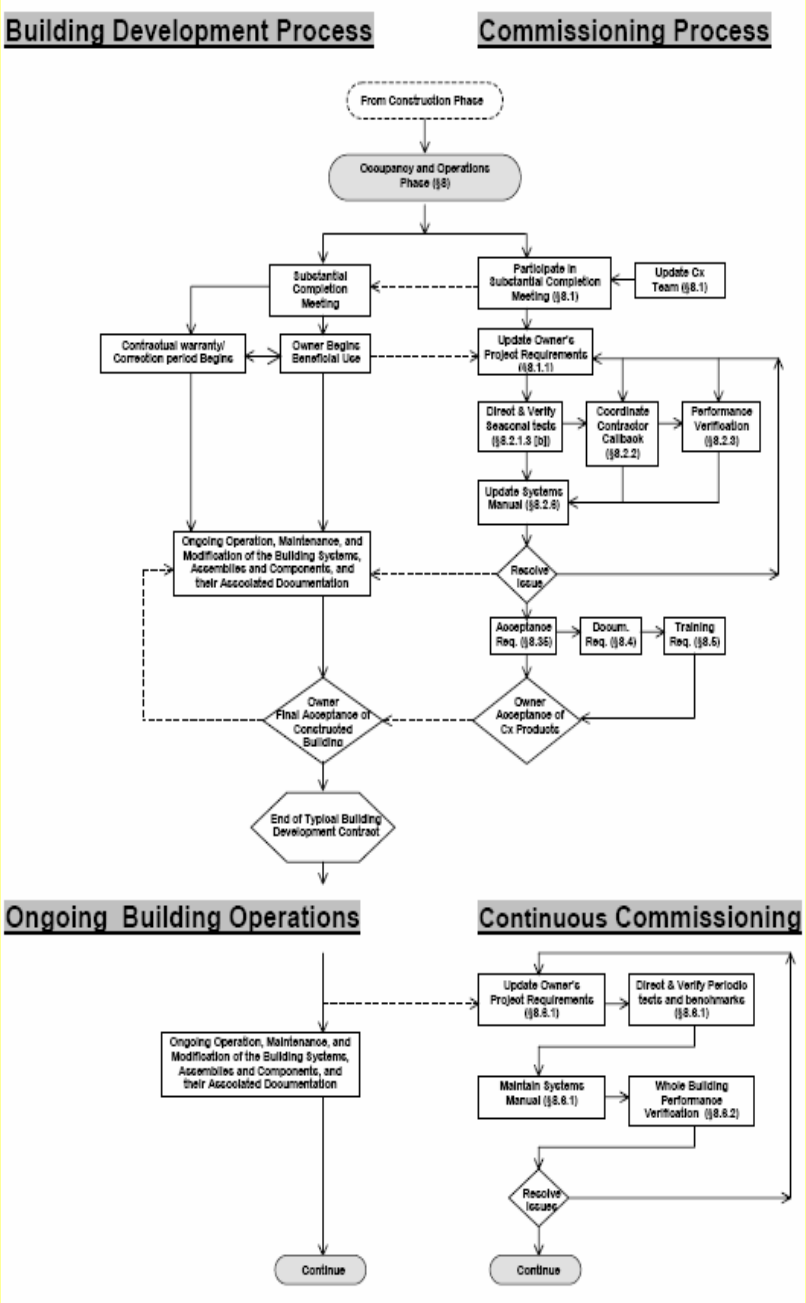
B - Commissioning Process Flowchart
C - Costs and Benefits
D - Documentation and Responsibilities
F - Roles and Responsibilities - Cx Team Members
J - Owner's Project Requirements
K - Basis of Design
L - Specifications
M - Construction Checklists
O - Systems Manual
R – Integration Requirements
S – Interference and Coordination with other Systems
U - Exterior Enclosure Testing Procedures
Z - List of Example Calculation Procedures and Tools

Annexes A, E, G, H, I, N, P, T, V, W, X, Y are not used, see GL0

ANNEX B – DESIGN DEVELOPMENT



ANNEX B – OCCUPACY AND OPERATIONS



ANNEX C – COSTS (for Cx EE)

- General Estimate of Cx Costs for Exterior Enclosures
- Recommended Structure for estimating Cx EE Costs
  - OPR
  - BOD
  - Design Review
  - Construction Checklist Creation
  - Site Visits
  - Testing
  - Documentation
  - Total

ANNEX F –ROLES & RESPONSIBILITIES (1)

Phase & GL-3 Section number	Document	Owner	CxA	Design Team						ExEncl		Contractors					Specialists								Bldg Ops			Notes
		Owner, or Owner's Representative	Commissioning Authority	Architect	Structural Engineer	Mechanical Engineer	Electrical Design Engineer	Lighting Design professioinal	Interior Systems Design Prof.	Exterior Enclosure Consultant	Ext. Enclosure Manufacturers	Construction Manager	General contractor	Exterior Enclosure Contractors	Testing contractor	Electrical Contractor	Indoor Air Quality Specialist	Acoustic specialist	Vibratoin specialist	Moisture/mildew specialist	Measurement/verification specialist	Information technology specialist	Physical security specialist	Blast (and Chem-bio) Security	Facilities management	Facilities engineer (O&M)	Occupants	
Pre-Design																												
5.2.2	Owner's Project Requirements	A	R	I	I	I	I	I	I	I		P													I	I	I	Design Team not hired yet?
5.2.3	Allocation	P/A	U	U	U	U	U	U	U			P													I	I		Design Team not hired yet?
5.2.4	Commissioning Plan	A	P	I	I	I	I	I		I															I	I	I	Design Team not hired yet?
5.2.4.4	Issues Log & Report	R	P	U	U	U	U	U		I	U	U	U	U	U	U									I	I		Design Team not hired yet?
5.3.1	Acceptance & Commissioning Process Report	R	P	U	U	U	U	U		U	U	U	U	U	U										U	U		Close of Phase report
Design																												
6.1.1	Owner's Project Requirements (OPR) Update	A	P	I	I	I	I	I		I		I					I			I					I	I	I	
6.1.1.1	OPR - Schematic Design Phase	A	P	I	I	I	I	I		I		I					I	I	I	I	I	I	I	I	I	I	I	
6.1.1.2	OPR - Design Development Phase	A	P	I	I	I	I	I		I		I					I			I					I	I	I	
6.1.1.3	Phase	A	P	I	I	I	I	I		I		I					I			I					I	I	I	
6.2.2	Basis of Design	A	R	P	I	I	I	I		I							I			I					I	I	I	
6.2.2.1	BOD - Schematic Design Phase	A	R	P	I	I	I	I		I							I	I	I	I	I	I	I	I	I	I	I	
6.2.2.2	BOD - Design Development Phase	A	R	P	I	I	I	I		I							I			I					I	I	I	
6.2.2.3	BOD - Construction Document	A	R	P	I	I	I	I		I							I			I					I	I	I	
6.2.3	Commissioning Plan - Update	R	P	U						U	U	U													I	I		
6.2.4	Construction Specifications for Commissioning	R	P	U						I	I	R													I	I		May also be provided by Owner's Rep
6.2.4	Construction Checklists	R	A	R						R	I	R													I	I		Contractor may not be hired yet
6.2.5	Systems Manual Outline -	A	P	I	I	I	I	I		I		R													U	U		Contractor may not be hired yet
6.2.6	Specifications	A	R							I		R						I		I					I	I		
6.2.7	Commissioning -Focused Design Reviews	A	P	U	U	U	U	U		I		U						I		I					I	I	I	
	Issues Log & Report	A	P	U	U	U	U	U		I		U						I		I					I	I		
6.3, 6.4	Acceptance & Commissioning Process Report	A	P	U	U	U	U	U		I		I						I		I					I	I	I	Close of Phase report

Key

P	Provided by
A	Approved by
R	Reviewed by
R/A	Reviewed/Approved by
I	Input from
U	Used by

ANNEX F –ROLES & RESPONSIBILITIES (2)

Phase & GL-3 Section number	Document	Owner	CxA	Design Team						ExEncl		Contractors					Specialists								Bldg Ops			Notes
		Owner, or Owner's Representative	Commissioning Authority	Architect	Structural Engineer	Mechanical Engineer	Electrical Design Engineer	Lighting Design professioinal	Interior Systems Design Prof.	Exterior Enclosure Consultant	Ext. Enclosure Manufacturers	Construction Manager	General contractor	Exterior Enclosure Contractors	Testing contractor	Electrical Contractor	Indoor Air Quality Specialist	Acoustic specialist	Vibratoin specialist	Moisture/mildew specialist	Measurement/verification specialist	Information technology specialist	Physical security specialist	Blast (and Chem-bio) Security	Facilities management	Facilities engineer (O&M)	Occupants	
Construction																												
7.2.2	Pre-Bid Conference Commissioning Briefing	R	**P**	I						I		**U**						I		I					I			
7.2.4	Owner's Project Requirements Update	**A**	U	**P**								U													I			
7.2.5	Commissioning Plan & Inspection Checklists Update	**R**	**P**	I						I	U	U	U	**U**	U			I		I					I			
7.2.6	Pre-Construction Commissioning Process Briefing	**A**	**P**	I						I	U	U	U	**U**	U			I		I					I			
7.2.7	Submittal Review Comments	R	**P**	U						I	U	U	U	U	U			I		I					I			
7.2.8	Commissioning Milestone Schedule	**A**	**P**	I						I	U	**U**	**U**	U	U			I		I					I			
7.2.9	Test Procedures	**A**	**P**	I						**I**	I	U		**U**	**U**		I	I	I	I			I	I	**I**			
	Test Procedures - Components	**A**	**P**	I						**I**	I	U		**U**	**U**		I	I	I	I			I	I	**I**			
	Test Procedures - Systems	**A**	**P**	I						**I**	I	U		**U**	**U**		I	I	I	I			I	I	**I**			
	Mockups	**A**	**R**	I						**I**	I	U		**P**	**U**		I	I	I	I			I	I	**I**			
7.2.10	Test Data Reports	**A**	**R**	I						I	**I**	U		**U**	**P**		I			I					I			
7.2.11	Commissioning Meeting Record	**A**	**P**	R						R	U	R	**U**	**U**	U		R	R	R	R					R	R		
7.2.12	Site Visit Record	**A**	**P**	R						R	U	R	**U**	U	U		R	R	R	R					R	R		
7.2.13	Test Verification Record	R	**A**	R						R	U	U	P	P	**P**		R	R	R	R					R	R		
7.2.14	Training Plans	R	**P**	I						I		**U**	U	U	U		I			I					**A**	R		
7.2.15	Construction Phase Commissioning Process Report	A	**P**	I						I	U	U	U	U	U		I			I			I	I	R	R		Prior to Occupancy
7.2.16	Systems Manual Update	**A**	**P**	I						I	I	I	I	I	**I**		I			I			I	I	R	R		
7.2.16	Issues Log & Report	**R**	**P**							I	U	**U**	U	**U**	U		I			I					I	I		
7.2.17	Basis of Design Update	**R**	R	**P**						I	U	U	U	U	U		I			I			I	I	I	I		
7.4	Construction Phase Acceptance & Commissioning Process Report	**A**	**P**	R						I	U	U	U	U	U		I			I			I	I	I	I		Close of Phase report
7.5	Training	**A**	**R**	R						I		U	P	**P**	P										U	U		
Occupancy and Operations																												
8.2.1	Owner's Project Requirements Compliance Update	**A**	**P**	R		I				I		I	R	I			I				I				**A**	R		
8.2.3	Seasonal Testing Record	A	**R**	R						I		R	R	**P**	U		I				I				**A**	R		
8.2.4	Deferred Training Record	A	R							I			R	**P**	U		I				I				**A**	R		
8.30	Acceptance & Commissioning Process Report	**A**	**P**	R								**R**	U	U	U		I				I				A	R		Final report
8.4.1	System Manual Update	**A**	**P**	I						I		I	I	I	I		I				I				A	R		
8.4.2	Continuous Commissioning Plan	A	**P**	I						I		R	I	I	I		I				I				**A**	R		
8.5	Training Update	A	**P**	I								R		R											**A**	R		

Key

P	Provided by
A	Approved by
R	Reviewed by
R/A	Reviewed/Approved by
I	Input from
U	Used by

ANNEX J – OWNER'S PROJECT REQUIREMENTS (OPR)

- Commentary
- Example Checklist for an OPR *(example below)*
- Example OPR from a project

ANNEX GL3 - J: Exterior Enclosure Checklist for Owner's Project Requirements (OPR)

1. Building Objectives	List the objectives that are unique to exterior enclosure and that expand upon the objectives and goals described in the Whole Building Commissioning.
2. Site Description and Requirements	List criteria that have a major influence on the Architectural development of the building design. Coordinate with Site/Civil.
2.1. Neighborhood / Context	Describe the influence of the project site, neighborhood and context on the building design.
2.2. Existing Buildings	Describe existing buildings and their influence on the design.
2.3. Master Plan	Describe existing or in progress master planning issues which affect the design
2.4. Circulation / Access	Describe the opportunities and constraints imposed by circulation issues and required access.
	Major Building Access:
	Secondary Building Access:

ANNEX K – BASIS OF DESIGN

- Commentary
- Example Checklist for BOD *(example below)*
- Example BOD from a project

1. Exterior Envelope Thermal Performance	Describe compliance with criteria for the thermal performance of the exterior envelope.
1.1.1	Describe the method of analysis used.
1.1.2	Coordinate this section carefully with the Mechanical Engineers and with other paragraphs below describing the exterior systems.
1.1. Alternate Compliance	Describe alternate analysis methodology if used, to verify compliance.
1.1.1. Envelope Method	
1.1.2. Total Building Method	

ANNEX L – SPECIFICATIONS

- Likely Specification Sections with Cx EE specs
- Cx EE MasterSpec Section
- Example from project

ANNEX L – SPECIFICATION T of C

Part of a 3-page listing

Preliminary Table of Contents
of
Sections That May Include
Facility Exterior Envelope Commissioning Requirements

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DIVISION 02 - EXISTING CONDITIONS	

ANNEX L – MASTERSPEC SECTION 019115

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SECTION 019115 – FACILITY EXTERIOR ENCLOSURE COMMISSIONING

Revise this Section by deleting and inserting text to meet Project-specific requirements.

This Section uses the term "Architect." Change this term to match that used to identify the design professional as defined in the General and Supplementary Conditions.

Verify that Section titles referenced in this Section are correct for this Project's Specifications; Section titles may have changed.

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

Retain or delete this article in all Sections of Project Manual.

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 1 Specification Sections, apply to this Section.

Documents referenced in paragraph below should be created during schematic design phase or earlier and updated as design progresses. They may be provided to the Contractor when the commissioning process is implemented on the Project.

B. Owner's Project Requirements and Basis of Design documentation are included for information only.

ANNEX L – EXAMPLE SPEC FROM A PROJECT

SECTION 01810

COMMISSIONING REQUIREMENTS

PART 1 – GENERAL

1.01 SUMMARY

A. Commissioning: Commissioning is a systematic process of ensuring that all building systems perform interactively according to the Owner's Project Requirements and Performance Criteria. This is achieved by beginning in the design phase and documenting the Owner's Project Requirements and Performance Criteria and continuing through construction, acceptance and the warranty period with actual verification of performance. The commissioning process shall encompass and coordinate the traditionally separate functions of system documentation, equipment start-up, control system calibration, testing and balancing, as well as performance testing and training.

Commissioning during the construction phase is intended to achieve the following specific objectives according to the Contract Documents:

1. Verify that applicable equipment and systems are installed according to the manufacturer's recommendations and to industry accepted minimum standards and that they receive adequate operational checkout by installing contractors.
2. Verify and document proper performance of equipment and systems.
3. Verify that O&M documentation left on site is complete.
4. Verify that the Owner's operating personnel are adequately trained.

B. The commissioning process does not take away from or reduce the responsibility of the system designers or installing contractors to provide a finished and fully functioning product.

C. Abbreviations: The following are common abbreviations used in the *Specifications* and in the *Commissioning Plan*. Definitions are found in 1.06 of this Section.

A/E =	Architect And Design Engineers	MC =	Mechanical Contractor
CA =	Commissioning Authority	O&M =	Operations & Maintenance
CC =	Controls Contractor	PC =	Prefunctional Checklist
EC =	Electrical Contractor	PM =	Project Manager (Of AMB Realty)
FT =	Functional Performance Test	SC =	Sealant Contractor
GC	General Contractor	SMC =	Sheet Metal Contractor
GLC =	Glazing Contractor	Subs =	Subcontractors To GC
HVAC =	Heating, Ventilation & Air Conditioning	TABC =	Test And Balance Contractor
LVC =	Limestone Veneer Contractor		

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ANNEX M – CONSTRUCTION CHECKLISTS

Prefunctional Checklist

BUILDING ENVELOP SYSTEM

Components included: ___ unit masonry, ___ limestone veneer, ___ cast stone, ___ sheet metal flashing & trim, ___ roof, ___ joint sealants, ___ wood windows/doors

1. Submittal / Approvals

Submittal: The above components and systems integral to them are complete and ready for functional testing. The checklist items are complete and have been checked off only by parties having direct knowledge of the event, as marked below, respective to each responsible contractor. This prefunctional checklist is submitted for approval, subject to an attached list of outstanding items yet to be completed. A Statement of Correction will be submitted upon completion of any outstanding areas. None of the outstanding items preclude safe and reliable functional tests being performed. ___ List attached.

Sealant Contractor	Date	Glazing Contractor	Date
Ext. Limestone Veneer Contractor	Date	Sheet Metal Contractor	Date
Masonry/Cast Stone Contractor	Date	Steel Fabricator	Date
General Contractor	Date	Roof Contractor	Date

Prefunctional checklist items are to be completed as part of installation & initial checkout, preparatory to functional testing.

- This checklist does not take the place of the manufacturer's recommended checkout and installation procedures or reporting requirements.
- Items that do not apply shall be noted with the reasons on this form (N/A = not applicable, BO = by others).
- Contractors' assigned responsibility for sections of the checklist shall be responsible to see that checklist items by their subcontractors are completed and checked off.
- "Contr." column or abbreviations in brackets to the right of an item refer to the contractor responsible to verify completion of this item. A/E = architect/engineer, All = all contractors, CA = commissioning agent, GC = general contractor, LVC = limestone veneer/sheet metal contractor, SC = sealant contractor, GLC = glazing contractor, LMC = masonry/cast stone/sheet metal contractor, RC = roof contractor, SMC = sheet metal contractor

Approvals: This filled-out checklist has been reviewed. Its completion is approved with the exceptions noted below.

Commissioning Agent	Date	Owner's Representative	Date

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April 29, 2003

ANNEX O – SYSTEMS MANUAL

- Outline of Structure of an Example Systems Manual
- Several Example Sections

ANNEX R – INTEGRATION REQUIREMENTS

1st - Within Exterior Enclosure Subsystems

	Material/System Type or Criteria D = Direct Interrelationship P = Possible Interrelationship	**Air flow Control**	Air Barrier	Natural Ventilation	Biological/Chemical Isolation	**Water Vapor Flow Control**	Vapor Retarder	Self-Drying Assemblies	**Rain Penetration/Water Control**	Drainable/Rain Screen Systems	Thin Barrier Systems	Massive Barrier Systems	Double Facades	High Below-grade Watertable	**Heat Flow Control**	Increased enclosure insul	Thermal Mass	Structure Outside of Thermal Envelope	Reflective Solar Barrier	**Temperature and Humidity Control**	Daylighting	Shading	Glare Control	Photovoltaic Generation	RF/EMI Control	Green Roof	**Noise and Vibration Control**	Acoustic Isolation	Vibration Control	**Noise and Vibration Control**	Passive Fire Protection	Active Fire Protection	Catastrophic Fire Protection	Seismic Resistance	Blast Resistance	Forced Entry Resistance	Hurricane/High Wind Loads	Stiffness of Structure	High-Rise Buildings	Geotechnical Bearing Capacity	Life Span
I	**Air flow Control**																																								
I.a	Air Barrier		*	P	D		D	D		D	D	D	D			P	P	P								D		P			P										D
I.b	Natural/Hybrid Ventilation		P	*	D		P	D				P	D			P	P				P							D					P		P	P	P				
I.c	Biological/Chemical Isolation		D	P	*		D			P	P	P	P																		P		P	P	P	P	P	P			
II	**Water Vapor Flow Control**																																								
II.a	Vapor Retarder		D	P	D		*	D		D	D	D	D	D		D	P									D															P
II.b	Self-Drying Assemblies		D	P				*		P		D	P			P	D																								P
III	**Rain Penetration/Water Control**																																								
III.a	Drainable/Rain Screen Systems		D	P	P		D	P		*			D			D	P	D	P									P	P					P			P	P	P	P	D
III.b	Thin Barrier Systems		D		P		D	P			*					P	P																P	P		P	P	P	P	P	P
III.c	Massive Barrier Systems		D	P			P	DD				*	P			D	D				D	P	P					D	P		P		P	D	D	D	P	D	D	D	D
III.d	Double Facades		D	D	P		D	P		D	P	P	*			D	D	P	P		D	D	D					D	P		P	P	P				P	P	P	P	P
III.e	Below-Grade Systems/ Foundations						P					P		*																										D	D
IV	**Heat Flow Control**																																								
IV.a	Reduce Heat Loss		P	P			D	P		P	P		D			*	P		P							D		P					D								
IV.b	Thermal Mass		P	D			P	D		P	P		P	P		P	*		P							P		P	P		P		P	D	P	P	P	P		B	
IV.c	Structure Outside of Thermal Envelope		D										P					*			P	P	P	P							D	P	D	P	D			P			
IV.d	Reduce Heat Gain																		*																						
V	**Light, Solar, other Radiation Control**																																								
V.a	Daylighting			P									D			D	D	D			*	D	D	P				P	P					P			P		P		
V.b	Shading			P									D				D	D	P		D	*	D												P		P	P			
V.c	Glare Control																D	D			D	D	*																		
	UV Control																																								
V.d	Photovoltaic Generation			P														P	P		P	P	P	*																	
V.e	Radio/Electromagnetic Control				P														D						*			P	P				P	P	P						
V.f	Green Roof		D	P	P		D									P	P									*		P			P		P	P				P		P	P
VI	**Noise and Vibration Control**																																								
VI.a	Acoustic Isolation		P	D	P						P	D	D			D	D	P			P							*	P					P	P		P	P		P	
VI.b	Vibration Control										P	D	D				D	D										P	*					P	P		P	P		P	
VII	**Fire Control**																																								
VII.a	Passive Fire Protection				P							P	P			P	P	D	P							P					*		D	P	P		P	P	P		
VII.b	Active Fire Protection																	P													P	*	P	P	P	P					
VII.d	Catastrophic Fire Protection		P	P	P							P				P			P							P					D	P	*	P	P	P	P	P		P	
IX	**Structural Performance**																																								
IX.a	General Structural Performance											E					E	E								E			P		P		P	*			P			P	
IX.b	Seismic Resistance											E					E	E								E			P		P		P	*			P			P	
IX.c	Blast Resistance										E	P					PP	E			E					P								P	*	P	P	P		P	
IX.d	Forced Entry Resistance			E	P							P						P			E													P	P	*	P				
IX.e	Hurricane/High Wind Loads		P	P			P										PP	P																			*	P	P	P	
IX.f	Stiffness of Structure				P							P					PP	P															P	D	D	P	D	*	D	D	
IX.g	High-Rise Buildings			E									P					P			P	P	P	P							P	P	P	P	P	P	P	P	*	P	
IX.h	Geotechnical Bearing Capacity										D	D		D			D	P								E								D	P	P	P	P	D	*	
X	**Durability**																																								
X.a	Extended Life Span		D				P			D			P													P					D	P		D	P	P	P	D		P	*
X.b	High Reliability		D				P			D			P																		D	D	D	D	P	P	P	D		P	
X.c	Microbial Growth Resistance		D	P			D	P		D		P	P																								P				

ANNEX R – INTEGRATION REQUIREMENTS

2nd – Between EE and Other Building Systems

	Material/System Type or Criteria D = Direct Interrelationship P = Possible Interrelationship	Issues & Opportunities											
		Exterior Enclosure	Daylighting Integration Across Systems	Interiors	Ventilation	Value	Control System/ Building Automation	Fire Protection	Structural	Acoustical	HVAC	Electrical	Energy Savings
II	**Air flow Control**												
II.a	Air Barrier	EX-5		I.3	V2				S6,7		H.3		
II.c	Natural Ventilation	EX-7		I.5	V4		C2,4		S.8.		.	EI.13	En.4
II.b	Biological/Chemical Isolation	EX-6		I.4	V3				S.2.		H.4	.	
III	**Water Vapor Flow Control**												
III.a	Vapor Retarder	EX-8,9		I.3					S7,9		H.5		
III.b	Self-Drying Assemblies	EX-10							S10		H.5.		
IV	**Rain Penetration/Water Control**												
IV.a	Drainable/Rain Screen Systems	Ex.11-13							S11		H.6.		
IV.b	Thin Barrier Systems	Ex.13-14		I,6					S12				
IV.c	Massive Barrier Systems	Ex.15,16	D.3						S.10,13		H1,7	E.2	En5,6
IV.d	Double Facades	Ex.17	D.5		V5		C.3		S.14		H1,2,6,8		En.7
IV.e	High Below-grade Watertable	Ex.18,18a		I.7					S15,16		H.9	EI.3, EI.4	
I	**Heat Flow Control**												
I.a	Increased enclosure insulation	EX-1	D.2								H1-2	EI.1	En.1,5
I.b	Thermal Mass	EX-4	D.1	I.1	V1				S3,4		H1,2	EI.1	En.1
I.c	Structure Outside of Thermal	EX-3		I.2				F.1	S1, 5, 23				En.2
I.d	Reflective Solar Barrier	EX-2									H1,2	EI.1	En.3
V	**Light, Solar and other Radiation**												
V.a	Daylighting	Ex19,20	D.1	I.8,9,10			C.1		S17,18		H.5,10,11	EI.5	En.8
V.b	Shading	Ex.21		I.11			C.4		S.18		H.12.	EI.5,13	
V.c	Glare Control	Ex.22.											
V.d	Photovoltaic Generation	Ex.23.										EI.6, EI.7	
V.e	Radio Frequency/Electromag-netic	Ex24,25									H13,14		
V.f	Green Roof	Ex26,27							S.19		H1,2	EI.1	
VI	**Noise and Vibration Control**												
VI.a	Acoustic Isolation	Ex28-30							S.3.		H15,16	EI.8.	
VI.b	Vibration Control	Ex28-29							S20,21		H15,16	EI.8	
VII	**Fire Control**												
VII.a	Passive Fire Protection	Ex31-32							S.22.		H.19		
VII.b	Active Fire Protection	.		I.12				F.2			H.19	EI.9.	
VII.d	Catastrophic Fire Protection	Ex31-33						F.3	S.24		H.18,19	EI.10	
IX	**Structural Performance**												
IX.a	Seismic Resistance	Ex.34.							S.30				
IX.a	Seismic Resistance	Ex.34.							S.30				
IX.b	Blast Resistance	Ex 35-37							S25-27		H20,21	EI10,11	
IX.c	Forced Entry Resistance	Ex39-41							S.3,27		H20,22	EI.10,11.	
IX.d	Hurricane/High Wind Loads	Ex42-44							S.28		H.23..	EI.10,12.	
IX.e	Stiffness of Structure												
IX.f	High-Rise Buildings												
IX.g	Geotechnical Bearing Capacity												
X	**Durability**												
X.a	Extended Life Span	Ex.45.							S.29				
X.b	High Reliability										H.10,18		
X.c	Microbial Growth Resistance												

ANNEX R – INTEGRATION REQUIREMENTS

3rd – Lists of Issues and Actions

R.1 Air Flow Control

R.1.1 Air Barriers

AB.1 Air Barrier: Air barriers are an extremely important component in the control of the separation of the internal and external air masses, with resulting impacts on durability, indoor air quality, and energy consumption. Air barrier detailing must be complete around the full perimeter of exterior enclosure and across all systems.

The Commissioning Authority should verify the following:

- Design Phase: Design Phase: The Design Team has selected systems with appropriate air barriers and permeance for each component of the enclosure, and has detailed continuity of air barrier across joints between the air barriers.
- Construction Phase: Test air leakage through exterior systems.

AB.2 Air Barrier Penetrations: Numerous penetrations are likely through the air barrier, including MEP systems, anchorage devices for cladding, or electrical outlets and other penetrations of interior faces of exterior walls.

The Commissioning Authority should verify the following:

- Design Phase: That the Design Team has reviewed the extent of penetrations and provided detailing, including:
  - Sleeves with integral flanges at mechanical penetrations,
  - Means of sealing at electrical conduit and plumbing piping penetrations.

  In addition, That the Design Team has evaluated the type of anchorage and substrate to which the anchors are being installed to or through to determine likelihood for future voids to be created in the air barrier due to future actions of the wall, such as movement due to thermal cycling.
- Construction Phase: Verify that sealing of penetrations are properly installed. Periodically inspect penetrations for proper sealing and integration with the air barrier.

ANNEX U – TESTING PROCEDURES

- Annex U: Exterior Enclosure Testing Procedures
  - Sub-Annex Ua: Laboratory Testing
    - Sub-Annex Ua1: Laboratory Testing Case Study Example
  - Sub-Annex Ub: Field Testing
    - Sub-Annex Ub1: Field Testing Case Study Example
    - Sub-Annex Ub2: Recommended Practice for Incremental Field Air and Water Testing
  - Sub-Annex Uc: Resources for Testing
    - Sub-Annex Uc1: Reference Standards for Field Testing
    - Sub-Annex Uc2: Technical information
    - Sub-Annex Uc3: Testing Resources by wall Assembly

ANNEX U – LAB TESTING CASE STUDY

Project: Children's Hospital of Wisconsin Administration Building

Case Study By Wagdy Anis AIA, LEED-AP, Member ASHRAE
Shepley Bulfinch Richardson and Abbott
Architecture - Planning - Interior Design
http://www.sbra.com

Order of tests performed:

1. Preload.
2. Air infiltration static method. (Including chamber calibration.)
3. Water penetration static method.
4. Water penetration dynamic method. (Including engine calibration.)
5. Uniform and concentrated load deflection test at design wind load and window washing scaffold tie-back anchor at design conditions.
6. Interstory differential movement, vertical and horizontal displacement test --- six (6) cycles. Test method is usually developed in conjunction with the testing laboratory, Architect and Project Structural Engineer to ensure test is a reasonable replica of what can be anticipated on the structure. Test specimen is then left in maximum open horizontal joint condition at conclusion of testing for the continuation of test.
7. Condensation resistance AAMA 1503.2 with each of both test conditions maintained for 24 hours after equilibrium has been maintained.
8. Thermal cycle. (Six (6) cycles).
9. Structural test at 1.5 times design load. Depending upon the design of the system.
10. Interstory differential horizontal/seismic test to verify connection and panel joint design satisfies requirements of ASCE 7 Section 9.5.2.2.4.3, six (6) cycles. At conclusion of test, wall shall be structurally intact and sound.
11. In event structural silicone is employed to provide structural bond, apply 30 PSF negative load for one minute and inspect work for loss of silicone adhesive bond under load.
12. Perform supplemental test as directed by removing sealant at locations, as determined by the architect, and retesting for water penetration to verify sufficiency of internal drainage systems.

ANNEX U – LAB TESTING CASE STUDY

Figure 1. Lab mockup during ASTM E283 air infiltration test

ANNEX U – LAB TESTING CASE STUDY

Figure 2 Dynamic Water test

ANNEX U – LAB TESTING CASE STUDY

Figure 3. Strain gauges for measuring inter-story drift

ANNEX U – FIELD TESTING CASE STUDY

A chamber is created using polyethylene and a simple wood frame (Figure 2), a smoke device is released, or generated using theatrical foggers, while air from a fan depressurizes or pressurizes depending on the configuration.

ANNEX U – TESTING PROCEDURES

Sub-Annex Ub2: Recommended Practice for Incremental Field Air and Water Testing

Ub2-1 Recommended Practice for the Incremental Inspection and Field Air and Water Testing of Exterior Enclosure Elements

Ub2-1.1 ***Incremental field air and water inspection and testing of subassemblies.*** The incremental field air and water testing of subassemblies of all building exterior enclosure elements should be a standardized practice on projects of all sizes. The 'Incremental' concept signifies testing of critical air and water management enclosure components, such as air barriers, window and door air and water seals, flashings, etc. while those components are still visible and before those components are buried or covered up by other construction in a completed assembly, so that repairs can be done effectively and inexpensively.

Ub2-1.1.1 During team selection, a criterion in the owner's selection of the architect should include the architect's track record in specifying the incremental and final field water testing of the full range of exterior enclosure elements. Likewise, a criterion in the owner's selection of the General Contractor or Construction Manager should include their track record in designing and successfully carrying out incremental field water testing of all building exterior enclosure elements.

Ub2-1.1.2 During design, Owners should be informed that water leakage can be a source of significant problems downstream, and that incremental field water testing is a practical, low-tech, and low cost means of identifying and avoiding such leaks. Owners should be made aware that eliminating such testing as a result of value engineering or other cost cutting measures during construction could result in significant costs and potential health hazards later during building operations. Air leakage can result in condensation, mold, rust, decay, indoor air quality problems, premature failure of enclosure assemblies, and is a major source of energy loss.

Ub2-1.1.3 Construction documents for the building exterior enclosure should include specific provisions for planning and accomplishing the incremental field water testing being recommended in Section U.2-1 of this Annex.

Ub2-1.1.4 The scope of air barrier and building assembly testing for air leakage and air barrier continuity should be discussed with the Owner, and included in the specifications. A list of such inspections and testing is included herein.

Coordination is required between subcontractors to provide continuity of an air barrier system and achieve an airtight building enclosure; the interconnections between materials and assemblies of materials and the penetrations should be a focus. Determining who is responsible for the interface joint between the different air barrier system assemblies, where one trade stops and the other starts, and the trade responsible for the joint between the two is vital. Determining who is responsible for sealing penetrations should be established. Sequencing construction operations so that the joints are accessible and constructible is an important milestone discussion in a commissioning process

Ub2-1.1.5 Each manufacturer should provide specific instructions for the incremental field water testing of subassemblies within the installation instructions for its exterior enclosure products.

ANNEX U – FIELD TESTING CASE STUDY

Chamber depressurization using detection liquids utilizes a device nicknamed the “bubble gun” (Figure 3). A bubble solution is spread on the suspected penetration or joint, such as a brick tie fastened to a wall. The plastic dome of the device is placed over the area and depressurized to 500 Pa (2.0” w.g.). Bubbles form if there is an air leak.

ANNEX Z – Tools and Resources

- Lists of resources and tools available for Cx EE

For more information on Guideline 3-2006, please contact:

Earle Kennett

ekennett@nibs.org