Exterior Enclosure Technical Requirements For the Commissioning Process

This Guideline is for Use with ASHRAE Guideline 0-2005: The Commissioning Process
NIBS Guideline 3-2006

Exterior Enclosure 
Technical Requirements 
For the Commissioning Process 

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ASHRAE Guideline 0-2005: 
The Commissioning Process 

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Project Committee for NIBS Guideline 3

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Exterior Enclosure Technical Requirements for The Commissioning Process

FOREWORD

The Commissioning Process is a quality-oriented process for achieving, verifying, and documenting that the performance of facilities, systems, and assemblies meets defined objectives and criteria. The Commissioning Process assumes that owners, programmers, designers, contractors, commissioning team members, and operations and maintenance entities are fully accountable for the quality of their work. The Commissioning Team uses methods and tools to verify that the project is achieving the Owner's Project Requirements throughout the delivery of the project.

The Commissioning Process begins at project inception (during the Pre-Design Phase) and continues for the life of the facility (through the Occupancy and Operations Phase). The Commissioning Process includes specific tasks to be conducted during each phase in order to verify that design, construction, and training meet the Owner's Project Requirements.

The Commissioning Process is outlined in ASHRAE Guideline 0-2005: The Commissioning Process. This Guideline, along with other Technical Support guidelines to Guideline 0-2005 provides specific information related to the building exterior enclosure.

This Guideline focuses upon the implementation of this process to building exterior enclosure systems and describes the specific tasks necessary to that implementation. It can be applied to both new construction and renovation projects.

The Commissioning Process does not impinge upon the competency, authority or responsibility of licensed professionals nor upon the obligations between Owners, Design Professionals or Contractors contained in contract forms or project-specific contracts.

The Commissioning Process structures the design and construction process to increase quality. It does not require the Owner to employ a specific outside expert as the Commissioning Authority and nothing would prevent the Owner from selecting the project design or construction firm to do commissioning, if the Commissioning Authority is properly qualified and is sufficiently independent by being positioned outside the specific project team within the firm.

For a given project, the commissioning role might be performed by a number of players - owner, Program Manager, Construction Manager (CM), third party commissioning authority hired by the owner, LEED-required commissioning authority, general contractor, the MEP contractor, etc. For a project, each player will have a mixed set of characteristics including independence, expertise, and project-related knowledge. Whoever hires the Commissioning Authority (CxA) is doing so in order to provide the project with an independent set of eyes that verify and assure the required performance of the building. This required performance should be defined and found in the project documents and specifications.

The level of effort of the Commissioning Process and size of the Commissioning Team for a given building can be strongly influenced by such factors as the owner's preferred level of building quality, the level of risk the owner will accept, as well as building size, type and complexity.
Thus, it is difficult to develop general estimates of the level of effort required by the Commissioning Authority and other members of the Commissioning Team.

**Reading and Using Guideline 3-2006**

This guideline is process-oriented to address any performance objectives required by an owner for the exterior enclosure including the control of heat flow, air flow, noise, fire, light, infrared, ultraviolet, rain penetration, moisture, structural performance, durability, security, reliability, aesthetics, value, constructability, maintainability, and sustainability. The commissioning objectives for a building's exterior enclosure can vary tremendously by type of owner, type and size of building, and the owner's project objectives across the large list of objects just mentioned, plus others.

Thus, this is not a one-size-fits-all "how to" document on avoiding leaky envelopes. The annexes to this guideline provide examples of approaches and solutions to a range of specific circumstances during design, construction, testing, and O&M.

We urge building owners to:

- Use this guideline, and related GL-0 and GL-1, from the outset of a project's life cycle.
- Use these guidelines to help determine a balance among the functional, quality, risk and cost objectives for the building project.
- Indicate in the Requests for Proposals to the design team, construction manager, and commissioning authority for the project that these guidelines and annexes be used as guidance in accomplishing the work for the project.

**Development of Guideline 3-2006 and Related Guidelines**

Development of guidelines for HVAC&R commissioning began formally in 1982 when the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) formed a committee to document best practices to achieve facilities that performed according to the owner's project requirements.

(a) ASHRAE published its original commissioning guideline in 1989, and an updated version in 1996.

(b) In 2005 ASHRAE Guideline 0 "The Commissioning Process" was published to address the overall quality-based process without reference to a specific discipline or building system. Guideline 0-2005 is an ASHRAE publication that was developed as a result of joint program between ASHRAE and NIBS. To promote one uniform commissioning guideline involving a range of disciplines and building systems the ASHRAE Guideline 0 committee developed the guideline through a multi-discipline committee and with industry review through NIBS.

(c) "ASHRAE Guideline 1-200X "HVAC&R Technical Requirements for The Commissioning Process" replaces ASHRAE Guideline 1-1996. The commissioning process requirements have been placed into Guideline 0-2005. Guideline 1-200X, in support of Guideline 0-2005, incorporates specific requirements for projects to verify that HVAC&R systems work from the day the project is turned over to the owner while meeting the requirements of owners, occupants, users of processes, and facility operating-
maintenance-service organizations at a high level of satisfaction and where overall cost to deliver the project was reduced.

(d) Development of this NIBS Guideline 3-2006, which provides specific guidance on technical requirements for commissioning of the building exterior enclosure, began formally in early 2004 when NIBS formed a committee to document best practices to achieve exterior enclosure systems that performed according to and meet the Owner's Project Requirements.

Guideline 3-2006 incorporates committee experience on projects where the building exterior enclosure systems and assemblies have met the requirements of owners, occupants, users of processes, and facility operating-maintenance-service organizations at a high level of satisfaction. Guideline 3-2006 has also benefited from committee experience on projects where the building exterior enclosure systems and assemblies have fallen short of owner/occupant expectations at various stages of design, construction, and post-occupancy performance. In that regard, Guideline 3-2006 endeavors to provide a holistic, technically sound and verifiable approach to this process that is both respectful of the contractual obligations between Owners, Design Professionals and Contractors and mindful of the collective obligation of those parties to develop a project that achieves the Owner's Project Requirements throughout the delivery of the project.

Guidelines 0, 1 and 3 are integral parts of the National Institute of Building Sciences (NIBS) Whole Building Commissioning guideline series. The relationship of these guidelines to other technical commissioning guidelines is shown in Figure F-1.

Approach

Emphasis is placed upon documentation of the Owner's Project Requirements (OPR) at the inception of a project and the proper transfer of this information from one party to the next throughout the life of a project. The Commissioning Process has been structured to coincide with the phases of a generic project with Pre-Design, Design, Construction, and Occupancy and Operations phases. If circumstances require owners to adopt the Commissioning Process during the Design or Construction Phase of a project, such later implementation must capture the information that would have been developed had the Commissioning Process begun at project inception. Beginning the Commissioning Process at project inception will help to achieve maximum benefits and minimize cost.

Due to the integration and interdependency of facility systems, a performance deficiency in one system can result in less than optimal performance by other systems. Although Guideline 3 focuses upon building exterior enclosure systems, a successful whole building commissioning process will carefully validate interfaces and possible interferences between all building systems. Even if building exterior enclosure is the only intended focus of the process, coordination among disciplines is essential for success.
NIBS Guideline 3-2006

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We urge building owners to:

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- Use these guidelines to help determine a balance among the functional, quality, risk and cost objectives for the building project.

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(d) Development of this NIBS Guideline 3-2006, which provides specific guidance on technical requirements for commissioning of the building exterior enclosure, began formally in early 2004 when NIBS formed a committee to document best practices to achieve exterior enclosure systems that performed according to and meet the Owner’s Project Requirements.

Guideline 3-2006 incorporates committee experience on projects where the building exterior enclosure systems and assemblies have met the requirements of owners, occupants, users of processes, and facility operating-maintenance-service organizations at a high level of satisfaction. Guideline 3-2006 has also benefited from committee experience on projects where the building exterior enclosure systems and assemblies have fallen short of owner/occupant expectations at various stages of design, construction, and post-occupancy performance. In that regard, Guideline 3-2006 endeavors to provide a holistic, technically sound and verifiable approach to this process that is both respectful of the contractual obligations between Owners, Design Professionals and Contractors and mindful of the collective obligation of those parties to develop a project that achieves the Owner’s Project Requirements throughout the delivery of the project.

Guidelines 0, 1 and 3 are integral parts of the National Institute of Building Sciences (NIBS) Whole Building Commissioning guideline series. The relationship of these guidelines to other technical commissioning guidelines is shown in Figure F-1.

Approach

Emphasis is placed upon documentation of the Owner’s Project Requirements (OPR) at the inception of a project and the proper transfer of this information from one party to the next throughout the life of a project. The Commissioning Process has been structured to coincide with the phases of a generic project with Pre-Design, Design, Construction, and Occupancy and Operations phases. If circumstances require owners to adopt the Commissioning Process during the Design or Construction Phase of a project, such later implementation must capture the information that would have been developed had the Commissioning Process begun at project inception. Beginning the Commissioning Process at project inception will help to achieve maximum benefits and minimize cost.

Due to the integration and interdependency of facility systems, a performance deficiency in one system can result in less than optimal performance by other systems. Although Guideline 3 focuses upon building exterior enclosure systems, a successful whole building commissioning process will carefully validate interfaces and possible interferences between all building systems. Even if building exterior enclosure is the only intended focus of the process, coordination among disciplines is essential for success.
Annexes are included to assist in further understanding the implementation of the Commissioning Process to building exterior enclosure systems. The Annexes are based upon specific project experience, with details based upon current best practice. The Annexes illustrate application of the Commissioning Process to a variety of Building Exterior Enclosure systems and equipment. The Annexes should be viewed as examples of how to develop and define ongoing communications, Owner's Project Requirements, Basis of Design, and Commissioning Plan documents, verification, testing requirements, and training.
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1 PURPOSE

1.1 The purpose of this guideline is to describe the technical requirements for the application of the Commissioning Process described in ASHRAE Guideline 0-2005 that will verify that the building exterior enclosure systems achieve the Owner's Project Requirements (OPR).

2 SCOPE

2.1 Extent. The procedures, methods, and documentation requirements in this guideline describe the application of the Commissioning Process to building exterior enclosure systems for each project delivery phase from pre-design through owner occupancy and operation.

2.2 ASHRAE Guideline 0-2005. This guideline supports the Commissioning Process activities described in ASHRAE Guideline 0-2005 The Commissioning Process. This guideline has been developed as a joint program between ASHRAE and NIBS. The guideline includes requirements for:

(a) Exterior enclosure systems to fully support the Commissioning Process activities,
(b) Verification during each phase of the commissioning process,
(c) Acceptance during each phase,
(d) Documentation during each phase,
(e) A Systems Manual, and training for operations and maintenance personnel and occupants.

2.3 Primary focus on New Buildings. The procedures, methods, and documentation requirements apply to new construction and to on-going commissioning process activities or requirements of buildings and facilities, or portions thereof. They also can be applied to rehab, retro-commissioning, or re-commissioning projects.

3 UTILIZATION

3.1 The application of this guideline will depend upon the Owner's Project Requirements and how the project will be designed, built, and operated. This guideline is supplemental to the Commissioning Process detailed in ASHRAE Guideline 0-2005. This guideline must be used in conjunction with ASHRAE Guideline 0-2005; it is not intended for use as a stand-alone document.

3.2 This guideline describes specific details required to properly implement the Commissioning Process relative to building exterior enclosure systems. This includes documentation, performance criteria, test procedures, and checklists. Throughout this guideline citations are made to standards, guidelines, codes and industry references. These should be considered as the minimum requirement for the referenced citation within this guideline. In all cases where the owner has more stringent requirements, these should replace the benchmark for verifying the requirement.
4 DEFINITIONS

4.1 Terms used in this document that refer to the underlying commissioning process are not redefined herein. For such definitions refer to ASHRAE Guideline 0-2005, Section 4, Definitions.

4.2 The following definitions are specific to the implementation of the commissioning process to building exterior enclosure systems.

**Beneficial Use:** When the project, or a portion of the project, is so nearly complete that the owner may use the project for its intended purpose. (See also “Substantial Completion”).

**Pre-Design Phase:** Pre-Design is a preparatory phase of the project delivery process in which the Owner’s Project Requirements are developed and defined. See Part 5 of this Guideline.

**Design Phase:** During the Design Phase of the project delivery process the Owner’s Project Requirements are translated into construction documents. See Part 6 of this Guideline.

**Design Sub-Phases:** The Design Phase is typically broken into three sub-phases; with each being about 1/3 of the total design phase. These sub-phases have a variety of names but for this document the following terms will be used. Schematic Design, Design Development and Construction Documentation.

**Schematic Design:** (Also referred to as “35% Design.”) A phase of building design that produces documents that establish the conceptual design of a project, illustrating the scale and relationship of the Project components including preliminary selections of major building systems and construction materials.

**Design Development:** (Also referred to as “65% Design”). A phase of building design that produces documents that illustrate and describe the refinement of the design of a Project, establishing the scope, relationships, forms, size and appearance of the Project and identifying major materials and systems and establishing their quality levels.

**Construction Documentation:** (Also referred to as “100% Design”) A phase of building design that produces documents that (1) set forth in detail the requirements for the construction of a Project and (2) establish in detail the quality of materials and systems required for the Project. Final Construction Documents are prepared as required to solicit, procure and construct the project and include drawings, specifications, contract forms and conditions, bidding requirements and resource documents.

**Construction Phase:** See Part 7 of this Guideline and ASHRAE Guideline 0-2005 (Section 7.2)

**Exterior Enclosure:** the exterior enclosure of a building includes all systems separating the interior environment from the exterior, including exterior walls, fenestration, and roofing and roof openings, below grade perimeter walls and the slab-on-grade or crawlspace.
Completion:

Final Completion: The date when the contractor has completed the contract requirements, the A/E has inspected to determine completion, the owner has made final payment to the contractor, and the contractor has accepted final payment. (See also "Substantial Completion").

Substantial Completion: The date established by the A/E when the project, or a portion of the project, is so nearly complete that the owner may use the project for its intended purpose. (See also "Final Completion").

Guideline: A document that identifies a procedure for the design, testing, application, or evaluation of a specific product, concept or practice. A guideline is not definitive, but encompasses areas where there may be a variety of approaches, none of which needs necessarily to be precisely correct. Guidelines are developed under due process procedures similar, but not identical, to those used for standards. (Source: ASHRAE 2005 Project Committee Manual of Practice (PC MOP))

Standard: a document that defines test methods for rating purposes, properties, processes, dimensions, materials, relationships, procedures, concepts, or nomenclature. Adherence to due process in its development and achievement of consensus are conditions of approval.

Rating standard: a standard which sets forth a method of interpreting the results of tests of individual units, at specified conditions, in relation to a product manufactured in quantity. (Also see testing standard.)

Testing standard: a standard setting forth methods for measuring capacity, durability, performance, or other characteristics of a specific material, component or system, together with a specification of instrumentation, procedure and calculations. (Also see rating standard.) (Source: ASHRAE 2005 PC MOP)

5 PRE-DESIGN PHASE

5.1 Introduction

5.1.1 Pre-Design Commissioning Overview for Exterior Enclosure System. Pre-Design is a preparatory phase of the project delivery process in which the Owner's Project Requirements are developed and defined. General information about the overall project is gathered, including: (a) Program requirements (e.g., facility interior conditions), (b) Community context (e.g., reflectance limits on glazing), (c) codes, regulations, standards, and guidelines, (d) Site and climate (e.g., outdoor air design conditions), (e) Facility functions, (f) Construction budget, (g) Building delivery schedule, (h) Training requirements, (i) Documentation requirements, and (j) Operational and maintenance budgets.

Information for the Exterior enclosure system is gathered as part of this process, using a structure such as that presented in Section 5.2.2, which covers the exterior enclosure portion of the Owner's Program Requirements.
5.1.2 Objectives. Pre-Design Phase Commissioning Process objectives relative to building exterior enclosure systems include the following:

(a) Developing the Owner’s Project Requirements (OPR),
(b) Identifying a scope and budget for the Commissioning Process,
(c) Developing the initial Commissioning Plan,
(d) Acceptance of Pre-Design Phase Commissioning Process activities.
(e) Developing checklists for programming submittals and for the design phase checklists.

5.2 Activities for Pre-Design Commissioning Process. Commissioning activities in the Pre-Design phase should begin with the members of the commissioning team participating in a Project Phase Kickoff Meeting held at the outset of this Phase that will include an identification of objectives for the phase. See section 5.2.8 below. This first activity of this Pre-Design phase is in addition to the commissioning activities listed in ASHRAE Guideline 0-2005 (Section 5.2).

5.2.1 Commissioning Team Members and Responsibilities. Annex F lists the roles and responsibilities of the essential members of the Commissioning Team relative to building exterior enclosure systems during the Pre-Design Phase, including those members detailed in ASHRAE Guideline 0-2005, Section 5.2.1.3. Annex F also lists additional members for inclusion on the Commissioning Team during the Pre-Design Phase if they are known or present.

5.2.2 Owner’s Project Requirements (OPR) Document

5.2.2.1 This document provides the basic requirements from which all design, construction, acceptance, and operation decisions are made. Objectives and functional requirements of building exterior enclosure systems to be included:

(a) Owner’s Vision – Document the owner’s vision for the building exterior enclosure as it relates to the building’s function, image, service life, expansion strategy, etc.

(b) Project budget and schedule – Develop a description of the Owner’s approach to allocating resources for the building exterior enclosure systems. This would entail a narrative of the relative importance of durability expectations and service life of systems and components, capital investment, life of systems, operating costs, maintenance costs, and use of life cycle costing for selection of the systems. Relative to schedule, sufficient time must be allocated for design, construction, proper startup, testing, and operational/seasonal tuning of building exterior enclosure systems.

(c) Owner directives – Document any pre-defined owner directives regarding what exterior enclosure systems, materials, and components will be required. For example this could be “exterior skin of limestone only,” or “EIFS exterior skin,” or “only curtain wall.” It is critical when directives are given, that the owner’s intent be well understood. For example, if
an owner states "only a specific manufacturer or type of system shall be used," it is important to understand that this directive is based upon the owner's "need to simplify maintenance due to the use of that manufacturer on the owner's other 20 facilities."

(d) Occupant requirements – Develop and document an understanding of the impact of the building exterior enclosure on:

1. Thermal comfort, including such items as operative temperature, mean radiant temperature (MRT), effective temperature, controlled and uncontrolled air movement, relative humidity.

2. Visual comfort (views to the outside, access to daylight, luminance of surfaces in the space, control of glare, etc.),

3. Indoor air quality.

4. Acoustics

5. Special indoor environmental requirements (museums, archival facilities, rare book libraries, hospitals, laboratories, research facilities, etc.)

6. Level of occupant control (operable windows, etc)

7. Access

8. Life safety.

(e) System Performance requirements – Develop and document an understanding of the impact of the building exterior enclosure on:

1. Heat flow control

2. Air flow control

3. Water vapor flow control

4. Rain penetration control

5. Light, infrared, ultraviolet, and other radiation control

6. Noise, vibration control

7. Fire control

8. Structural performance (snow, wind, seismic, blast, impact, ballistic, etc)

9. Durability

10. Aesthetics/Value

11. Constructability

12. Maintainability

13. Sustainability

(f) Systems integration requirements – A discussion of requirement to integrate the building exterior enclosure systems with other systems, such as fire, life safety, structural, daylighting control, mechanical ventilation, natural ventilation, heating and cooling, and security, over and
above code requirements. The owner's interest in integrating renewable energy technologies such as wind, solar and photovoltaics should be determined. The owner's interest in advanced technologies should also be determined, for example (a) active façade systems that work to take advantage of solar radiation, or to shade solar heat and prevent glare, and (b) taking advantage controlled natural ventilation and thermal mass storage to obtain free nighttime cooling.

(g) Site information – The Commissioning Authority (CxA) and Commissioning Team should verify that the design team has developed a topographical survey that identifies above-grade features and contours of the site, below-grade utilities, as well as a geotechnical report about the below-grade strata, to identify proper foundation depths and design. The Commissioning Authority should verify that the design team has:

1. Determined the below-grade water table and has had the water sampled for pollutants or chemicals that can affect either the building exterior enclosure materials or the indoor environmental quality.

2. Evaluated the outside air for wind or rain-borne pollutants that can affect building materials or the quality of ventilation air.

3. If appropriate, discussed mitigation methods for brownfields and reviewed requirements for special treatment of outside air.

(h) Restrictions and limitations – Identify and document specific pre-existing or new restrictions and limitations on the building exterior enclosure systems. For example, if a facility is being added to a campus and for design consistency only exterior enclosure systems with a certain color and pattern of face brick can be considered.

(i) Training requirements – Document (1) the current level of knowledge of the owner's personnel relative to the building exterior enclosure and (2) appropriate levels of training on new building exterior enclosure technologies. This is important to enable the design of building exterior enclosure systems to be within the Owner's current or future (with additional training) capabilities. Document training involved in event of turnover of key personnel.

(j) Warranty requirements – Develop a listing of the requirements for warranties on the building exterior enclosure systems and components, including start of the warranty period, and conditions.1

(k) Quality requirements of systems, materials and construction – Describe the level of quality, in concurrence with the life cycle cost approach, of the building exterior enclosure materials, including the durability and time expectancy between failures/replacement. Document

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1 For examples of warranty considerations, see (1) "Elements of Roofing, A guide For Building Owners," Section 2E, Roof System Warranties, National Roofing Contractors Association, 2000, pp. 51-51. (www.nrca.net)
the general expectations of the Owner for the quality of construction (e.g., industry average, above average, or best workmanship). Indicate measurable performance criteria when possible.

(i) Statistical and quality tools – Identify the owner’s approach and preferences for sampling frequency to be used for quality control of the various systems, materials and components during the design and construction phases.

(m) Benchmarking requirements – Develop a listing of targets or benchmarks for future comparison and optimization of the building exterior enclosure systems. This includes peak load targets, energy usage impacts, sub-system efficiency targets, performance information, and capabilities of the building exterior enclosure systems and components.

(n) Operation and maintenance – Develop a narrative of how the building exterior enclosure systems are to be operated and maintained, including how the operation and maintenance personnel approach resolution of problems (fix upon fail, use manufacturer’s recommendations, or owner internal frequencies), and the source (in-house or contracted) and expected level (current, new, additional) of manpower for the operations and maintenance staff, and known frequencies of maintenance items. Include a summary of the assumptions for accessibility to building exterior enclosure systems (e.g., for cleaning of windows, etc.). Further, list special requirements for maintenance and access (e.g., test equipment, permanent ladders, catwalks, and scaffolds and lifts for cleaning, etc.). Include the Owner’s concern for safety of staff (e.g., no staff on ladders).

(o) Allowable range of operation – Document the differential range that will be allowed in the operation of the building exterior enclosure systems. For example, number of days per year that the owner is willing to accept condensation, temperature in the space shall not vary more than +/- x deg, when windows are closed, and not more than +/- y deg when operable windows are open, relative humidity range, winter and summer, and allowable drift. Allowable variability or expected stability of relative humidity conditions inside the building during summer and winter affects the design of exterior enclosure assemblies.

(p) Applicable codes and standards – Detail the known building exterior enclosure codes and standards that will be followed for the project, including the year of publication, the specific option to be used, and how the code requirements will impact the selection and design of the exterior enclosure. Also include a narrative on the Owner’s approach to codes, standards, guidelines, and best practices (e.g., exceed Standard 90.1 by 10%, or achieve a comfort satisfaction of 90% using the criteria and procedures in the latest version of ASHRAE Standard 55-2004. Energy codes may affect allowable glazing percentages and skylights and therefore impact or limit elements in the design of the classification and its proximity to other buildings. Design options on some buildings may be constrained by historic district zoning or other community requirements. See Annex U for standards (and test methods)
applicable to specific exterior enclosure systems, sub-systems, materials, and components.

(q) Insurance requirements – Develop a list of insurance requirements, including FM requirements, and any special insurance requirements or exclusions that would impact design, construction or operation of the exterior enclosure.

(r) Owner safety requirements – Develop a list of special owner safety requirements.

(s) Constructability – Develop a narrative on any known site restrictions that would limit the size of exterior enclosure components that could be transported to the site (e.g., the only access road has a low bridge) or installed at the site (e.g., the use of high cranes or helicopters is prohibited).

(t) Project documentation requirements – Develop a narrative of what level of detail or type of documentation is desired by the owner for whatever exterior enclosure system will be selected, so that the system can be properly designed, installed, tested, operated, and troubleshooting to maintain building exterior enclosure systems for the life of the facility. Identify the owner’s desired format(s) for the documentation, either electronic or paper, and any specific features.

5.2.3 Identify the Scope and Budget for the Commissioning Process. The preliminary estimates of Cx scope and budget developed early on during the Pre-Design Phase are important tools that permit the Owner to balance quality objectives for the building against with costs of achieving those desired levels of quality. Identifying this balance between desired quality and cost to achieve at this early point in the process will provide a solid basis for subsequent decision making by the entire building delivery team. Also, the tradeoffs between quality and cost will likely be revisited and refined numerous times during subsequent phase of building delivery, using this early set of estimates as a starting point. Refer to ASHRAE Guideline 0-2005, Section 5.2.3 for additional detail.

5.2.3.1 Cx Scope. This should include a listing of the administrative tasks, the quality assurance tasks, the building exterior enclosure components and systems that are the focus of the Commissioning Process. The Cx Scope in addition, interfaces among systems are extremely important, and need to be carefully addressed. The Exterior Enclosure systems and the interfaces among them may include

(a) Foundations (excluding structural)
   1. Standard
   2. Special
   3. Slab-on-Grade – vapor barriers, air barriers, etc.

(b) Basement construction (excluding structural)
   1. Excavation
   2. Basement Walls – waterproofing, drainage, etc.
3. Crawlspace with coverings

(c) Superstructure (only as it functions as part of exterior enclosure systems)
   1. Floor Construction
   2. Roof Construction
   3. Sunshades (on walls, etc)
   4. Connections to existing adjacent structures.

(d) Exterior Enclosure (vertical, above grade)
   1. Exterior Walls – masonry, stone, metal panel, stucco, EIFS, curtainwall, parapets, sheet metal, etc.
   2. Exterior Windows
   3. Exterior Doors
   4. Connections to Existing Buildings
   5. Louvers and vents
   6. Grilles and sunscreens

(e) Roofing
   1. Roof System, including parapet
   2. Roof Openings, including skylights, pipe chases, ducts, etc.

5.2.3.2 Cx Budget. At the Pre-design phase, the Cx budget should include preliminary estimates of the costs to accomplish all Commissioning Process activities including but not limited to:

(a) The activities of the commissioning team during all building delivery phases

(b) Project-specific, pre-construction laboratory mock-up testing of building exterior enclosure materials, components, systems and assemblies.

(c) Field QA testing of building exterior enclosure materials, components, systems, and assemblies during initial installation, and at various stages throughout construction.

5.2.4 Commissioning Plan

5.2.4.1 Refer to ASHRAE Guideline 0-2005, Section 5.2.4, for specific requirements for the Commissioning Plan and for formatting guidance.

5.2.4.2 The roles and responsibilities relative to building exterior enclosure systems for the Commissioning Team members detailed in Section 5.2.1 should be included in the Commissioning Plan. The format of the Design and Construction Checklists needs to be defined at this time for expansion and completion during the Design and Construction Phases.
5.2.4.3 The format of the Design and Construction Checklists needs to be defined at this time for expansion and completion during the subsequent project phases.

5.2.4.4 The communication processes should be defined for reviewing designs, resolving issues, and obtaining documentation among the Commissioning Team members. Contact information should be included for the Commissioning Team members and other key project participants.

5.2.5 **Establish Issues Log Procedures.** Issues logs should be defined and formatted at this time, and issues logs should be maintained throughout the project starting with this phase. See ASHRAE Guideline 0-2005, Section 5.2.5, for formatting, frequency, and reporting of the Issues Logs.

5.2.6 **Prepare Issues Report.** See ASHRAE Guideline 0-2005, Section 5.2.6, for timing and frequency of preparing Issues Reports.

5.2.7 **Prepare Commissioning Process Progress Report.** See ASHRAE Guideline 0-2005, Section 5.2.7, for timing and frequency of preparing Commissioning Process Progress Reports.

5.2.8 **Participate in Key Project Review Meetings**

5.2.8.1 **Participate in Pre-Design Phase Objectives Meeting.** A key objective of this meeting is to identify objectives for this phase. The Commissioning team will use this information as a resource in developing the Owner's Project Requirements in Section 5.2.2 above.

5.2.8.2 **Participate in Final Pre-Design Phase Project Objectives Meeting.** A key objective of this meeting is to review the products of the pre-design phase to determine if all objectives identified in the Pre-Design Phase Kickoff Meeting have been achieved. The results of this review shall be documented by the Commissioning team and any unresolved issues shall be identified as input the identification of objectives for the next phase of the project.

5.3 **Pre-Design Phase Acceptance Requirements.** See ASHRAE Guideline 0-2005, Section 5.3, Pre-Design Phase Acceptance Requirements.

5.4 **Pre-Design Phase Documentation.** See ASHRAE Guideline 0-2005, Section 5.4 for documentation listings.

5.5 **Pre-Design Phase Identification of Training Requirements.** See ASHRAE Guideline 0-2005, Sections 5.5 and 5.2.2.4(h), for training identification procedures.

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2 See Table F-1, Annex F, for a list of Commissioning Team members, and examples A*, B*, C* etc for example Commissioning Teams for several building types and sizes.
5.6 **Milestones.** During the Pre-Design Phase it is critical to document the key milestones relative to the building exterior enclosure systems. These milestones are listed in Annex B.

6 **DESIGN PHASE**

6.1 Introduction

6.1.1 **Design Phases.** During the Design Phase of the project delivery process the Owner’s Project Requirements (OPR) are translated into a design intent and represented in construction documents. The Design Phase is typically broken into three sub-phases, with each being about 1/3 of the total design phase. These sub-phases have a variety of names but for this document the following terms will be used: Schematic Design, Design Development and Construction Documentation.

(a) **Schematic Design.** Early in Schematic Design phase, rough concepts of building massing, internal layout, appearance and materials are developed and tested against the OPR to arrive at a solution that best fulfills all criteria. Analysis of conceptual solutions should include impact of inter-related systems. Refer to Annex R. It may become apparent that it is not possible to meet all criteria because of cost, technical difficulty, Owner changes, etc. As the Schematic Design solution is developed and finalized, the Commissioning Team should record all changes to the OPR and why they were made. During this phase, a document called the Basis of Design (BOD) is created that clearly conveys the assumptions made in developing a design solution that fulfills the intent and criteria in the Owner’s Project Requirements document. During schematic design, the OPR is evaluated and updated to balance scope, budget and quality. Narrative descriptions of building exterior enclosure systems (e.g., roof, exterior walls, floors, windows, skylights, atria, thermal mass, etc.) are developed and included in the Basis of Design, and the Commissioning Plan is expanded to include more details of Construction Phase and Occupancy and Operations Phase activities.

(b) **Design Development.** In this phase more detailed drawings, typically large-scale wall sections, elevations and plan details, and preliminary specifications for the exterior enclosure systems are developed in support of the solution represented in the BOD. Commissioning procedures are established by the Commissioning Team for incorporation into the Construction Documents. The Commissioning Authority (CxA) should verify that the Design Team agrees upon these procedures. The OPR and BOD are updated to reflect ongoing decisions, and the Design Development Documents are verified against them.

(c) **Construction Documentation.** The Construction Documents indicate the scope of Work, the required level of quality and all other administrative and procedural requirements of the Contractor. Construction Documents must also include requirements for the Contractor to implement Commissioning Activities. Ideally, all significant decisions were made during the Design Development phase, but the OPR and BOD should be updated if changes have been made.

6.1.2 **Objectives of the Design Phase Commissioning Process.** See ASHRAE Guideline 0-2005, Section 6.1.2, Items (a) through (h) for general Design Phase
Commissioning Process objectives. Commissioning Process objectives specific to the Exterior Enclosure include:

(a) Verifying that each exterior enclosure system documented in the Basis of Design fulfills the requirements within the Owner's Project Requirements document and that the various enclosure systems are coordinated with each other and with other related systems.

(b) Developing Commissioning Process requirements for inclusion in the Construction Documents such as submittals, periodic inspections, laboratory testing, field-testing, mock-ups of exterior assemblies, and documentation.

(c) Developing Construction Checklists for each exterior system.

(d) Performing commissioning-focused design review to check proposed design solutions against the OPR. Reviews should also focus on inter-disciplinary coordination.

6.2 Activities of the Design-Phase Commissioning Process.

6.2.1 Commissioning Team Responsibilities during the Design-Phase Commissioning Process. In addition to those detailed in ASHRAE Guideline 0-2005 (Section 6.2.1.3), Annex F lists the roles and responsibilities of the essential members of the Commissioning Team relative to building exterior enclosure systems during the Design Phase. Also, if known or present, additional members of the Commissioning Team during the Design Phase are listed in Annex F. Basis of Design Documentation

6.2.2 Basis of Design Documentation

6.2.2.1 Schematic Design Phase. The BOD is developed during the Schematic Design Phase and should include the following as a minimum:

(a) A description of each system option considered, such as type of building exterior enclosure systems, sub-systems, materials and components, and the interaction of the building exterior enclosure system with the heating, cooling, mechanical and natural ventilation, lighting, building interior, and other systems. Describe how the designer intends to meet the building exterior enclosure-related Owner's Project Requirements. For appropriate exterior enclosure systems or components, provide an outline sequence of operations, e.g.:

1. Automatically controlled shading devices,

2. Operation of sensing devices that provide feedback to occupants about daylighting, security, natural ventilation, or glare control elements of the building exterior enclosure system.

(b) The reasoning for the selection of the final building exterior enclosure system. This should be a short statement for each sub-system or element (roof, exterior walls, windows, skylights, floors, shading devices, etc.) including supporting information describing fulfillment of criteria in the OPR. Refer to Annex J for Owner's Project Requirements, includ-
6.2.3.1 During the following Design Phases, the Commissioning Plan is added to or updated as applicable to the examination of alternative building exterior enclosure systems, the selection of preferred systems from the alternatives, and the design of the selected systems:

(a) Schematic Design. In this phase, various enclosure system options have been evaluated and are presented to the owner for selection. Each exterior enclosure system has specific tests and tools available for qualitative analysis of performance, with varying degrees of certainty. The Commissioning Plan helps the owner understand the requirements and risks associated with each enclosure system in delivering the anticipated level of performance and the cost and schedule impact of the Commissioning activities. For example, a custom glass curtain wall system will likely require construction of a full size mock-up at an off-site laboratory with extensive testing procedures. The testing will be expensive and could add months to the schedule for the enclosure, but it might result in the highest probability of successful in-place performance. On the other hand, brick veneer can be erected over CMU back up without the need for extensive testing, but the performance of the interface with other systems such as windows may be less predictable. At the completion of Schematic Design, exterior enclosure systems have been generally selected, and the broad concept of their associated commissioning plans have become part of the BOD.

(b) Design Development and Construction Document Phases. During these two phases, the Design Team develops and refines the exterior enclosure system designs and coordinates them with other systems. The Commissioning Plan identifies (1) the types of tests, (2) test requirements, and (3) items to be included in the construction inspection checklists. The Commissioning Plan lays out the sequence of tests and inspections. At the end of each sub-phase, the Commissioning Team coordinates the Commissioning Plan against the Owner’s Project Requirements (OPR) and validates performance parameters for each exterior enclosure system.

6.2.4 Commissioning Process Requirements for the Construction Documents Phase. See ASHRAE Guideline 0-2005, Section 6.2.4, for instructions to include Commissioning Process Requirements in the Construction Documents. Requirements specific to the Exterior Enclosure include:

(e) Systems to be documented and tested. See Annex U for applicable test methods. (Add statistical verification and tools including frequency, location, etc.)

(f) A Schedule of building exterior enclosure-related Commissioning Process activities for (a) the Construction Phase and (b) the Occupancy and Operations Phase. The schedule should identify critical times for witnessing testing activities, building exterior enclosure systems and equipment accessibility for maintenance and commissioning, completion of Construction Checklists, and activities relative to substantial completion/project closeout.

(g) Integrate specific component performance documentation requirements and use of Construction Checklists into the relevant building exterior enclosure specification sections (and others as appropriate), with appropriate cross-references.
(h) Integrate building exterior enclosure Commissioning Process activities into the relevant building exterior enclosure specification Sections as required. See ASHRAE Guideline 0-2005, Section 6.2.4, for requirements. A guide specification section template for technical requirements of building exterior enclosure is provided in Annex L of this Guideline 3.

6.2.5 **Construction Checklists.** Annex M contains sample formats for typical building exterior enclosure Construction Checklists.

6.2.5.1 Construction Checklists for exterior enclosure should focus on verification of construction in the field except for projects such as unitized curtain walls, which have substantial in-plant manufacturing and the manufacturer's own installation checklist. Otherwise, use Commissioning Authority (CxA) Checklists to verify that delivered materials conform to specifications, that substrates and supporting structures have been inspected and approved for overlying construction, and that all components of the assembly are being properly completed.

6.2.5.2 Attachment of important typical approved shop drawings to Checklists can help in verification of a large percentage of the constructed work.

6.2.6 **Systems Manual.** See ASHRAE Guideline 0-2005, Section 6.2.6 for Systems Manual requirements. Because many exterior enclosure systems are assemblies of many materials by many installers, versus a manufactured system with one installer, accurate record keeping of as-built conditions are extremely important.

6.2.6.1 **Applications:** A Systems Manual is developed for each major building exterior enclosure system; these typically include (but are not limited to):

(a) Roof/Garden Roof
(b) Skylights/sloped glazing
(c) Atria
(d) Exterior walls
(e) Windows
(f) Doors
(g) Sealants and expansion joints
(h) Control joints
(i) Flashings
(j) Shading devices
(k) Curtain walls or window walls
(l) Plaza decks
(m) Planters
(n) Below-grade construction
(o) Balconies and railings
(p) Floors
(q) Other special building exterior enclosure systems, equipment and controls.

6.2.6.2 **Example Systems Manual:** Annex O presents an example of a building exterior enclosure Systems Manual format and suggested contents for a typical facility.

6.2.7 **Training Requirements**

6.2.7.1 General requirements for development of training requirements during the Design Phase are outlined in ASHRAE Guideline 0-2005 (Section 6.2.7). In general, building exterior enclosure training will address a range of knowledge sets and should be provided through a variety of formats tailored to the needs and capabilities of the owner's operating personnel as expressed in the OPR. The building exterior enclosure training should cover overall systems as well as individual components and assemblies.

Most exterior enclosure systems do not include complex operations. Moving parts, if present at all may be limited to doors, operable windows and similar systems. For such buildings, training will be concentrate on maintenance of the exterior enclosure. For more complex systems, such as sophisticated security systems integrated with power-operated doors or automated building ventilation systems, training will need to be expanded to cover intended sequence of operations and coordination with other building systems.

Annex P of this Guideline provides building exterior enclosure-specific recommendations for the training program and Training Manual.

6.2.8 **Commissioning-Focused Review of Design Documents**

6.2.8.1 The process for accomplishing design reviews for verifying achievement of the Owner's Project Requirements is contained in ASHRAE Guideline 0-2005 (Section 6.2.8). Specific to building exterior enclosure systems, the following guidance is provided for the **four-step review process**, as defined in ASHRAE Guideline 0-2005 (Section 6.2.8.2). The OPR is updated and refined as appropriate as a part of this process.

(a) **General Quality Review.** A general quality review for building exterior enclosure systems should focus on completeness, organization and readability of drawings and specifications with attention to details, schedules, controls, phasing, legends, etc.

(b) **Coordination Review.** Key system elements and random samples (10-20%) of other portions of the building exterior enclosure systems are reviewed to evaluate the coordination accomplished within and among disciplines. This includes reviewing for interfaces among disciplines (e.g., daylighting control sensor locations relative to transparent and translucent portions of the exterior enclosure) and checking the design against the Owner's Project Requirements (e.g., is an acceptable interior glass surface temperature likely to be achieved). The in-
tent of this review is to determine if there are systematic errors, not to fully check the drawings. The responsibility for complete checking of the drawings for coordination and accuracy remains with the Design Team. See Annex R for a list of inter-relationships.

(c) Building Exterior Enclosure System-Specific Review. The Commissioning Authority should verify that, within the areas selected for review, the design complies with the Owner's Project Requirements. The intent of this review is to determine if there are systematic errors for exterior enclosure materials and interface coordination, not to fully check the drawings. The responsibility for complete checking of the drawings for coordination, appropriateness, and accuracy remains with the Design Team.

(d) Building Exterior Enclosure Specification Review. The Commissioning Authority should verify that a review of the specifications is performed to determine completeness and applicability to the project. A review of 10-20% of the building exterior enclosure specification is performed in detail for verification of compliance with the Owner's Project Requirements. Items checked include applicability of the section to the project, Commissioning Process requirements, submittal requirements, applicability of sub-systems and materials, training requirements, coordination with other sections, and coordination with the drawings.

6.2.8.2 Schematic Design Documents. Review approximately 20% of the BOD to verify that it provides an acceptable design solution to fulfill the OPR requirements, both for (1) exterior enclosure requirements and (2) requirements for integrating the exterior enclosure with other building systems.

6.2.8.3 Design Development Documents. Review approximately 20% of the systems documented to verify that the design solutions are in conformance with the BOD and will fulfill the requirement of the OPR. Review the documented solutions for coordination of integrated systems required for performance.

6.2.8.4 Construction Documents

(a) Review approximately 20% of the systems documented to verify that the design solutions are in conformance with the BOD and will fulfill the requirement of the OPR.

(b) Review specifications for inclusion of Commissioning Process requirements, including submittal requirements, training requirements, requirements for Systems Manual, testing requirements, inspection requirements, mock-ups, performance requirements, contractors quality assurance requirements, etc.

(c) Use and wear during construction. Components of the Exterior Enclosure systems can be subject to use and wear during the construction phase. Thus, the Owner should consider, prior to the beginning of construction, the extent to which the Owner Contractor Agreement specifies that the Exterior Enclosure system perform at the level of "new" equipment at the time of substantial completion. Once the owner makes a decision about this, these concerns should then be addressed.
during the design phase by the design team, and the Commissioning Authority should verify that this has been done. See also Section 8.1.1.1 below.

6.2.9 Objectives Reviews. Phase Commissioning activities in each of the design phases – Schematic Design, Design Development, and Construction Documents - should begin and end with the members of the updated commissioning team participating in a Project Review meeting to address objectives and issues. These activities are in addition to the commissioning activities listed in ASHRAE Guideline 0-2005 (Section 6.2) and to those listed below in this Guideline 3-2006 (Section 6.2.1).

6.2.9.1 Objectives Review at Beginning of Each Design Phase. Commissioning activities in each of the design phases – Schematic Design, Design Development, and Construction Documents - should begin with the members of the updated commissioning team participating in a Project Review meeting to address objectives for the current phase.

6.2.9.2 Objectives Review at End of Each Design Phase. Commissioning activities in each of the design phases – Schematic Design, Design Development, and Construction Documents - should end with the members of the updated commissioning team participating in a Project Review meeting to address whether the objectives for the current phase have been met by the design products produced during the phase. Outstanding issues should be documented, and the resulting issues list becomes a resource for beginning the subsequent design phase.

6.3 Design Phase Acceptance Requirements. Refer to ASHRAE Guideline 0-2005 (Section 6.3) for Design Phase acceptance requirements and customize these general requirements for each sub-phase of design (Schematic Design, Design Development, and Construction Documents).

6.4 Design Phase Documentation Requirements. Refer to ASHRAE Guideline 0-2005 (Section 6.4) for Design Phase documentation requirements and customize these general requirements for each sub-phase phase of design (Schematic Design, Design Development, and Construction Documents).

6.5 Design Phase Training Requirements. Refer to ASHRAE Guideline 0-2005 (Section 6.5) for Design Phase Training Requirements.
7 CONSTRUCTION PHASE

7.1 Introduction

7.1.1 Commissioning Process activities described in this section to be performed by the various members of the Construction-Phase Commissioning Team are described in ASHRAE Guideline 0-2005 (Section 7.2). Additional requirements pertaining to building exterior enclosure may include but are not limited to:

(a) Assistance with detail development during the construction phase for elements not addressed or co-ordinated during the design phase.

(b) Additional field-testing. The Commissioning Team may confer with the Design Team/ Contractor about the possible need for detail alterations if failures occur during either the Laboratory mock up or the field air and water leakage tests performed during the construction phase.

(c) Field review of aesthetic and functional mock-up(s) and review of both the unique interface conditions and the general interface conditions to verify that they meet the design intent and will provide the level of water and air tightness of the exterior enclosure as specified in the OPR. Mock-ups construction and testing should be scheduled with adequate time allowed for the remediation of unforeseen issues by way of iterative repair submittals and testing prior to actual construction.

(d) Thorough review of submittals including: Shop Drawing(s), mockups, sample constructions, project schedule and sequencing, and all building exterior enclosure components allowing for revisions as necessary to provide the level of water and air tightness in the exterior enclosure as specified in the OPR.

(e) Review of the Contractor’s and Subcontractors’ site-specific quality plans for the building exterior enclosure.

7.2 Construction-Phase Commissioning Process Activities

7.2.1 Construction-Phase Commissioning Process Responsibilities

7.2.1.1 Construction Phase Commissioning Process Responsibilities. These responsibilities for building exterior enclosure systems are to be applied as described in ASHRAE Guideline 0-2005 (Section 7.2.1).

7.2.1.2 Essential Commissioning Team members. The essential members during the Construction Phase are listed in ASHRAE Guideline 0-2005 (Section 7.2.1.4). In addition, Annex F to this Exterior Enclosure guideline contains a recommended list of new members who should participate in the exterior enclosure Commissioning team. In addition, specialists with knowledge of specific exterior enclosure systems may be utilized as resources to the team are also listed in Annex F.

7.2.2 Pre-bid Conference. ASHRAE Guideline 0-2005 (Section 7.2.2). The pre-bid conference should include, the program manager, the construction manager, the general contractor, consultants on exterior enclosure elements, manufacturers of exterior enclosure systems, the mechanical engineer, the Architect of Record, Code
Consultant, the Owner and/or the Owner’s representatives as well as the complete Commissioning Team, general contractors, and subcontractors including all consultants and building exterior enclosure specialists to discuss design intent, construction sequencing, constructability, and other issues pertaining to the coordination and construction of the building exterior enclosure.

7.2.3 Coordinate Owner’s Representatives Participation. ASHRAE Guideline 0-2005 (Section 7.2.3), and including but not limited to the individuals listed in Annex F, to be involved in the following Participation Activities. Submittal reviews - particularly for product substitutions, including product evaluation by life cycle costing (LCC).

(a) Aesthetic and functional review(s) of mock up shop drawings, and accompanying submittals for all laboratory testing and field testing

(b) Periodic construction monitoring – quality assurance, particularly increased during critical events, such as roof transition and roof termination installation, initial installation of sealants, and the specific project interfacing conditions, such as below grade waterproofing, and the differing material interfaces, e.g., masonry, metal panels, EIFS, stucco, stone, GFRC, windows, curtain wall, fenestration expansion joints, plaza deck waterproofing, green roofs.

(c) Inspection, testing and witnessing; including field-testing specific to the project and detailed documentation.

(d) Establishment of a training program for the Owner’s personnel for O & M of the building exterior enclosure.

7.2.4 Update Owner’s Project Requirements. Refer to ASHRAE Guideline 0-2005 (Section 7.2.4) for details.

7.2.5 Update the Commissioning Plan. Refer to ASHRAE Guideline 0-2005 (Section 7.2.5) for details.

7.2.6 Conduct Pre-Construction Commissioning Process Meeting

7.2.6.1 Special issues relative to sequencing and early installation of equipment located in limited access areas such as sub grade basements or roofing or that may require coordination between multiple sub-contractors should be discussed.

7.2.6.2 Additional meetings prior to construction should be held with the architect, commissioning authority, owner, contractor to review and discuss issues with each subcontractor for the building exterior enclosure.

7.2.6.3 Pre-Construction Conference. ASHRAE Guideline 0-2005 (Section 7.2.2). The pre-bid conference should include, the program manager, the construction manager, the general contractor, consultants on exterior enclosure elements, manufacturers of exterior enclosure systems, the mechanical engineer, the Architect of Record, Code Consultant, the Owner and/or the Owner’s representatives as well as the complete Commissioning Team, general contractors, and subcontractors including all consultants and building exterior enclosure specialists to discuss design intent, construction sequencing, constructability, issues, and other issues pertaining
to both the co-ordination and construction of the building exterior enclosure. Enclosure contractors are responsible for quality control including but not limited:

(a) Submittals including a site-specific quality plan.

(b) Aesthetic and functional review(s) of mock up shop drawings, and accompanying submittals for all laboratory testing and field testing.

(c) Periodic construction monitoring – for quality control, particularly increased during critical events, such as roof transition and roof termination installation, initial installation of sealants, and the specific project interfacing conditions, such as below grade waterproofing, and the differing material interfaces, e.g., masonry, metal panels, EIFS, stucco, stone, GFRC, windows, curtain wall, fenestration expansion joints, plaza deck waterproofing, green roofs.

(d) Inspection, and testing including field-testing specific to the project and detailed documentation.

(e) Establishment of a training program for the Owner’s personnel for O & M of the building exterior enclosure.

7.2.7 Verify Submittals. Drawings and specifications should be reviewed for the following:

7.2.7.1 Review shop drawings. These should be reviewed for building exterior enclosure issues that impact the constructability, operability, maintainability, and sustainability of the individual material installation instructions from the manufacturer, operation, maintenance, and replacement, including but not limited to:

(a) Review of interface conditions, tolerances, sequence of installation, material compatibility.

(b) Building Enclosure Construction process – Review and integrate shop drawings for interfacing materials.

7.2.7.2 Review Product submittals. These should be reviewed for the following:

(a) Meeting the project specifications /OPR.

(b) Compatibility with adjacent building exterior enclosure components evaluate that the Durability meets intended life of exterior enclosure system or that the product can be removed and replaced as part of scheduled maintenance during the service life of the specific building exterior enclosure assembly.

7.2.7.3 Review Project Schedule. This should be reviewed for the following: Schedule of submittals, laboratory testing, sample construction, mock up testing, field testing, training for O&M, inspection by JHA or Code Authority.

7.2.8 Schedule Commissioning Process Activities. In addition to the items in included in ASHRAE Guideline 0-2005 (Section 7.2), Commissioning Process Activities should include the following scheduled activities:
(a) Submittals, including, but not limited to, systems, materials, equipment, MEP and Building exterior enclosure coordination drawings, and the individual manufacturer's installation drawings, schematics and instructions.

(b) QC -- testing inspection, including developing a testing inspection matrix.

(c) QA inspections and testing by third parties, JHA.

(d) Functional tests for installed wall assemblies.

(e) Document start date, duration, description, and entity responsible for completion on the commissioning process schedule.

7.2.9 Verify and Document field quality control and quality assurance procedures.

7.2.9.1 Verify QC/QA Requirements. The following requirements apply to all building exterior enclosure systems and features that are to be commissioned when referenced below.

(a) Field Testing -- type, location, frequency

(b) Manufacturers performance testing performed at factory or at an approved third party laboratory with testing per recognized standards (ASTM, ASHRAE, etc.).

(c) Submittal of shop drawings for each exterior enclosure system and each sample construction.

(d) Laboratory Testing for custom systems or for standard systems that are 'modified' for use in the project

(e) Sample construction-constructed in the field to demonstrate workmanship.

(f) Formal mock-up testing submittal/ Mock up testing.

(g) Field testing- delineating the exterior enclosure systems to be tested such as, flashings, end dams, weeps, - masonry flashings at base and shelf angles, EIFS flashings, window head and sill; louvers; doors; parapets, thru wall flashing; all penetrations of walls- including below grade, above grade, and roof; roof penetrations.

(h) Inspection---develop a site specific plan for the project that clearly summarizes the type of testing, who is to perform, when will testing be performed, what is the criteria for acceptance, how is the testing to be documented, who will receive the documentation of these inspections.

(i) Preconstruction and Pre-installation Meeting -- include the A/E, the CM, GC, and the subcontractor(s), manufacturers, building enclosure consultants, for the building exterior enclosure.

7.2.9.2 Participants required for testing. These may include, in addition to the participants listed in Guideline 0:

(a) Other subcontractors, manufacturers, and specialists consultants with knowledge of specific systems and equipment that interface with the building exterior enclosure systems.
(b) Verify integrated performance of all components and control system components, including all interlocks and interactions with other equipment and systems.

7.2.9.3 **Test Verification Procedures.** The Commissioning Team will develop a range of test verification procedures—both QC and QA. These procedures include:

(a) Component test procedures: Component test procedures verify the performance of components under a full range of actions, responses to inputs, and loads. (QC)

(b) System/assembly test procedures: System/assembly test procedures verify the performance of subsystems, systems and assemblies under a full range of operating conditions (both normal and emergency), responses to inputs, and loads. (QC)

(c) Intersystem test procedures: Intersystem test procedures verify the interactions between systems and assemblies. (QA)

(d) Owner’s Project Requirements test procedures: Owner’s Project Requirements test procedures verify that the various systems and assemblies that comprise the exterior enclosure deliver the intended Owner’s Project Requirements at the point of use (QA)

7.2.9.4 **Random Sampling.** The Commissioning Process should use random sampling (based upon a known probability distribution of expected values, an assumed statistical distribution, or random sampling based upon best judgment) for verification of each test determined to be related to the Owner’s Project Requirements. In developing the test procedures, special attention must be paid to issues of personnel safety, equipment/assembly protection, and manufacturer’s recommendations to protect the validity of warranties.

7.2.10 **Develop Test Data Records.** In addition to the items listed in ASHRAE Guideline 0-2005, Section 7.2.10, the following building exterior enclosure related items should be included:

(a) Existing conditions, of structures and building elements for horizontal or vertical expansion.

(b) Environment conditions, e.g. ambient temperature, humidity, time-of-day, solar conditions, wild, rain.

7.2.11 **Commissioning Team Meetings.** In addition to the items listed in ASHRAE Guideline 0-2005, Section 7.2.11, the following building exterior enclosure related items should be included:

(a) Commissioning Team meetings are required to specifically address exterior enclosure related issues. These meetings should be organized and conducted in accordance with the recommendations guidelines established in ASHRAE Guideline 0-2005. The meetings may or may not be conducted within a regularly scheduled commissioning meeting. Attendees should include all parties and disciplines affected by the subjects under consideration. Examples of such meetings may involve:
(b) Building exterior enclosure installation and testing – Below grade waterproofing thru the roof.

(c) HVAC & Equipment coordination within the building exterior enclosure discipline and with other disciplines such as structural, HVAC, fire protection.

(d) Review of verification or functional test procedures.

(e) Review of non-conformances.

7.2.12 Accomplish Periodic Site Visits. In addition to the items listed in ASHRAE Guideline 0-2005, Section 7.2.12, the following building exterior enclosure related items should be included:

(a) These visits by members of the Commissioning Team are to Verify Compliance with the Construction Documents and the Owner's Project Requirements. This is quality assurance.

(b) Coordination of the timing of these building exterior enclosure system visits should involve the contractors, manufacturers, and consultants in relation to the project schedule. It is important that some progress be accomplished on the various areas so that a site visit would be beneficial to observe testing.

(c) Verify that Construction Checklists are being continuously used in a timely fashion, and properly signed off by construction and design team members.

7.2.13 Test Execution. In addition to the items listed in ASHRAE Guideline 0-2005, Section 7.2.13, the following building exterior enclosure related items should be included.

7.2.13.1 Observation. The Commissioning Authority is to verify that tests were performed.

7.2.13.2 Test results. The Commissioning Authority (CxA) is to re-verify that the test standards and performance criteria adapted by the testing agency prior to and during testing are consistent with the criteria established in the contract documents for the project and appropriate for the building enclosure material, component, system or assembly to be tested. The Commissioning Authority will further document whether a test passed or failed, and any remedial action that was completed during the test, and the applicability of said remedial action to similar building enclosure systems or assemblies that may exist at other locations throughout the project. The number of tests completed is to be noted, together with a list of names and contact information for all witnesses to each test. The Commissioning Authority is to provide commentary, as appropriate, on the anticipated long-term durability of all remedial action taken as a result of testing, the parties responsible for the development and implementation of said remedial action, and will verify that said remedial action has been properly executed on a building-wide basis where applicable.


7.2.15 Construction Phase Commissioning Process Report. See ASHRAE Guideline 0-2005, Section 7.2.15, plus the material listed below. This should include an evaluation of the Commissioning Process used and changes that will improve the
delivered project. This should include scheduling and the to date status of submittals, lab testing, mock ups, and field testing. This is essential to insure that issues, benefits and recommendations are captured in a written document while all team members are available and information is fresh. It forms the basis for the Final Commissioning Process Report developed during the Occupancy and Operations Phase.

(a) A draft Construction Phase Commissioning Process Report should be submitted for Owner review. Submittal of the draft report to other Commissioning Team members is appropriate.

(b) The final Construction Phase Commissioning Process Report should incorporate review comments from all construction team members including the Owner.

7.2.16 Verify Systems Manuals Update. Verify that the Systems Manual is updated to incorporate materials generated during the Construction Phase, per ASHRAE Guideline 0-2005, Section 7.2.16. Verify that the Systems Manual includes an overview of all enclosure types and systems. The purpose and general overview of each enclosure type and location used should be included in the Systems Manual general description section to meet the knowledge needs of the EOM staff, occupants, and owners. In addition, add the following items to the systems Manual:

(a) Maintenance needs—periodic inspection of the skin and roof
(b) Operating parameters—periodic inspection of the roof and skin
(c) Replacement schedule – based upon the service life of the enclosure system and its individual material components.

7.2.17 Update Basis of Design. See ASHRAE Guideline 0-2005, Section 7.2.17.

7.3 Construction Phase Acceptance Requirements. See ASHRAE Guideline 0-2005, Section 7.3.

7.4 Construction Phase Documentation Requirements. See ASHRAE Guideline 0-2005, Section 7.4.

7.5 Construction Phase Training Requirements. See ASHRAE Guideline 0-2005, Section 7.5.

8 OCCUPANCY AND OPERATIONS PHASE

8.1 Introduction. See ASHRAE Guideline 0-2005, Sections 8.1.1 through 8.1.6, plus the additional sections 8.1.7 through 8.1.9 below. For clarity, Section 8.1.1 from Guideline 0-2005 is repeated below, and two subsections are added to address exterior enclosure topics. See also Annex B, Flow Diagram, Occupancy and Operations Phase.

8.1.1 The Occupancy and Operations Phase of the Commissioning Process begins at substantial completion. As a minimum, the Commissioning Process activities begun at this point should continue through the end of the contractual warranty/correction period and ideally continue throughout the life of the facility. During the Occupancy
and Operations Phase, the on-going operation, maintenance, and modification of the facility systems and assemblies, and their associated documentation, are verified against the updated Owner's Project Requirements." (Guideline 0-2005, Section 8.1.1).

8.1.1.1 **Use and Wear during Construction.** Components of the Exterior Enclosure systems can be subject to use and wear during the construction phase. Thus, the Owner should consider, prior to the beginning of construction, the extent to which the Owner Contractor Agreement specifies that the Exterior Enclosure system perform at the level of "new" equipment at the time of substantial completion. Once the owner makes a decision about this, then these concerns should then be addressed during the design phase by the design team, and the Commissioning Authority should verify that this has been done.

8.1.1.2 **Variation in Service Life.** The service life of exterior enclosure components can vary, often substantially. The Owner's Project Requirements (OPR) should address the functional performance and inter-relationship of these components to verify that an adequately functioning Exterior Enclosure system is provided over the expected service life of the exterior enclosure system.

8.1.1.3 **Constant Commissioning.** A program of constant commissioning is recommended for the exterior enclosure systems in order to maintain the required level of performance is maintained by monitoring the acceptable performance of key components and assemblies.

8.1.2 **Preparation for the submittal of the Substantial Completion Document.** The Commissioning Authority and the Commissioning Team should be actively involved in the initial portion of the Owner Occupancy and Operations Phase of a project. At this phase, the Commissioning Authority's involvement is primarily to verify the accuracy of the documentation record and manuals relative to the performance of the completed exterior enclosure including:

(a) Operations and Maintenance Manuals
(b) Manufacturers Conformance Records
(c) Functional Performance Test Records
(d) Record Drawings
(e) Systems Manual
(f) Commissioning Report
(g) Documentation Review
(h) Exterior Envelope Preventative Maintenance Program including cyclical verification of Exterior Enclosure components to the original manufacturer's maintenance recommendations and performance specifications with consideration for warranty enforcement.

(i) Additional documentation and verification as specified in Owner's Project Requirements.
8.1.3 **Documentation Requirements for Substantial Completion.** At the time of Substantial Completion, when the Occupancy and Operations Phase begins, the Exterior Enclosure systems should be cleaned and in a condition equal to a "new" installation that meet the Owners Project Requirements for appearance, performance, and all operational training and manuals. When applying for Significant Completion or Beneficial Use, the Contractor should document that all requirements of the contract are complete and acceptable. The Commissioning Authority should verify that the functional verification includes the following minimum Contract level compliance:

(a) Documentation of non-conforming performance levels of Exterior Enclosure systems, components, and controls.

(b) Organization of corrective action and coordinate schedule for completion.

(c) Organization of seasonal testing of Exterior Enclosure systems and assemblies to the level directed by the owner

(d) Documentation of any accepted reduction(s) in owner project requirement(s).

(e) Creation of a lifecycle impact statement based on the analysis of non-conforming Exterior Enclosure conditions to the functionality of the entire facility.

(f) Development of Re-commissioning or Constant Commissioning cycles as directed by the owner.

8.1.4 **Schedule of Services following Final Acceptance.** The Commissioning Authority should verify that the Contractor provides the Owner with a project specific schedule of services available following Final Acceptance. These may include:

(a) OEM training update

(b) Seasonal performance levels analysis based on design parameters

(c) Lifecycle verification test results

(d) Design liability resolution

(e) Post-construction design evaluation

(f) Site visits and verification programs provided by manufacturer's representatives, vendors and sub-contractors.

(g) Update Construction Record Documents

(h) Design analysis and Impact statement for proposed modifications.

(i) Notification of OEM Service Bulletins

(j) Orphan Equipment List with Cross Reference to replacements

8.1.5 **Retro-Commissioning.** The activities described below assume that the Commissioning Process has progressed through the activities defined for the Pre-Design, Design, and Construction Phases. A Commissioning Process that begins during the Occupancy and Operations Phase is termed "Retro-Commissioning" and is substantially different from the process described herein. The Retro-Commissioning Process is not within the scope of this Guideline.
8.2 Occupancy and Operations Phase Commissioning Process Activities for Exterior Enclosure Systems

8.2.1 Occupancy and Operations Phase Commissioning Process Responsibilities are based on Owners Project Requirements. See ASHRAE Guideline 0-2005, Section 8.2.1, plus the additional items (a) through (g) listed below.

(a) Verification of Pre-Design Cost Benefit Analysis to actual performance of completed processes accepted by the owner

(b) Sustainability analysis verification.

(c) IAQ performance using relevant ASHRAE standards.

(d) Guarantee/Warranty enforcement matrix.

(e) Comfort performance verification using ASHRAE Standard 55-2004, or owner’s requirements when they are more stringent for all types of space uses, based on the Owners Project Requirements.

(f) Conformance to Standards and Codes references in Construction Documents and Systems Manual.

(g) Documentation that the completed process meets the Level of Quality established in the Owners Project Requirements.

8.2.2 Call-back of Contractors. See ASHRAE Guideline 0-2005, Section 8.2.2.

8.2.3 Performance Verification. See ASHRAE Guideline 0-2005, Section 8.2.3. In addition, the Commissioning Authority should ascertain that the performance verification being conducted for the exterior enclosure systems meet the Owners Project Requirements as updated during the construction.

8.2.4 Training. See ASHRAE Guideline 0-2005, Section 8.2.4, and Section 8.5 below in this guideline for the Exterior Enclosure.

8.2.5 Final Project Commissioning Process Report. See ASHRAE Guideline 0-2005, Section 8.2.5.

8.2.6 Final Project Systems Manual. See ASHRAE Guideline 0-2005, Section 8.2.6.

8.2.6.1 Migration of Performance Levels. All types of Exterior Enclosure systems will migrate from performance levels established at the time of Final Acceptance. Materials used in Construction have varied lifecycles and Preventative Maintenance requirements. The Commissioning Documentation will benchmark performance providing the method to monitor and maintain the Owners Project Requirements through the lifecycle of the work. The information is useful in developing a program to optimize system performance. The information is useful in establishing a budget plan focusing on value. Benchmark information for components in the Systems Manual should include:

(a) Energy Consumption based on real-time monitoring

(b) Service records of Envelope components
(c) Warranty/Guarantee Performance Ranges
(d) Service call statistics and IAQ issues
(e) Maintenance and history of instances when the Exterior Enclosure was subjected to conditions beyond the minimum level required in the Owner’s Project Requirements.
(f) Variations in the use of space or design population from that supported by the original design.

8.2.7 Constant Commissioning Process. See ASHRAE Guideline 0-2005, Section 8.2.8, plus Section 8.6 below in this Guideline for the Exterior Enclosure.

8.3 Acceptance Requirements, Occupancy and Operations Phase. See ASHRAE Guideline 0-2005, Section 8.3.

8.4 Documentation Requirements, Occupancy and Operations Phase. See ASHRAE Guideline 0-2005, Section 8.4, including 8.4.1 and 8.4.2. In addition, the following section applies.

8.4.1 Owner Request for Recommissioning and Constant Commissioning requirements. This activity provides the greatest value when initiated at the pre-Design phase.

8.4.1.1 Owner established requirements for:
(a) Measurement and Verification Criteria
(b) Recording Performance verification and level of Organization
(c) Preventative Maintenance and Warranty Requirements
(d) Continuous or Recommissioning cycles
(e) Record Documentation and Impact analysis.
(f) History and Life-Cycle Documentation
(g) Level of Quality established in the Owners Project Requirements.

8.5 Training Requirements, Occupancy and Operations Phase. See ASHRAE Guideline 0-2005, Sections 8.2.4, and 8.5, plus section 8.2.4, above in this guideline. In addition, the following sections apply.

8.5.1 Whenever possible O&M training should begin during the design phase and continue in the construction phase thus helping to reduce logistic hindrances in performing the O&M. Acceptance of the training and documentation deliverables must be in place and approved at the time significant completion is requested by the Contractor. The turn over of equipment to the owner may be phased based on size of the work and Owner Project Requirements to generate income from beneficial use. In such cases the Commissioning Process should monitor correct applications of O&M and manufacturers requirements by both the contractor’s personnel and the Owner’s. This requires a clear assignment of responsibility and a well-organized turnover schedule.
8.5.2 The Commissioning Authority should ensure that, at the start of the Construction Phase, the A&E has a preliminary O&M guide prepared for review under the Commissioning Process in parallel with the submittal schedule. At a minimum, the O&M guide should I cover:

(a) Simple and generic instructions so it can be easily updated as equipment is delivered including on site storage requirements

(b) Available in time to guide proper operation of the equipment during functional testing and verification

(c) Easy to use and written at a level where it is clearly understood by the O&M Personnel or the contractor conducting the function and verification testing

(d) Identifies the location of information and procedures provided by the equipment manufacture for correct start-up and performance verification.

8.5.3 Update Training Organization and Documentation. In addition, during the Occupancy and Operations Phase, the Commissioning Authority should update the training organization and documentation consistent with the level established in the Owners Project Requirements, commensurate with level of complexity of the exterior enclosure. All training services should be organized into a matrix that cross-references training requirements and responsibilities for each member of the Owner’s Staff.

8.5.3.1 Training for Seasonal weather cycles. Variable weather conditions impact the Exterior Enclosure systems and components. Proper response requires trained maintenance personnel, proper Preventative Maintenance practices, and budget-sensitive life cycle replacement. The Commissioning Process provides the Owner with an organized training program to accomplish these objectives. At a minimum, this training program should define:

(a) The responsibilities of each O&M job position. This should include development of a training matrix based on individual responsibility. The facility manager is responsible for designating personnel, roles and training

(b) The certification of training comprehension for each job position. The key here is that employee signs something that says he is competent to do ‘x”, which is in essence an acceptance of responsibility.

(c) A method of updating operating personnel to changes in the operating programs or performance of exterior enclosure systems, components, and controls.

(d) The organization of the repair/modification/decommissioning of essential exterior enclosure systems, components, and controls through formal training and impact analysis of the changes.

8.5.3.2 Non-conforming Conditions. If the Owner has accepted non-conforming conditions, then the Commissioning Authority should verify that modifications to the training matrix are made in order to address the non-conforming conditions. The modified training should use impact statements to identify components affected by the non-conforming condition and the
estimated impacts on the O&M Budget for the Facility. The review should include:
(a) Cost impact
(b) Sustainability impact
(c) Life cycle impact
(d) Impact on the Owners Project Requirements.

8.5.4 Training for Post-Occupancy Performance Verification. At Significant Completion the Commissioning Process assures that all deliverables are organized complete and available to the owner. Then during the period of beneficial use, the Owner is responsible for proper O&M of the facility. The period of beneficial use, and the entire construction phase both end at the time of the Owner’s acceptance.

The O&M for the facility is based on training and procedures developed and refined to a site-specific level. The Commissioning Process will assure that the O&M Manual(s) delivered at Significant Completion is a clear, concise, complete and correct program of O&M for the work, meeting the level of the Owner’s Project Requirements. As a minimum the O&M Manuals and Training will organize the operating and warranty requirements of the following source records of the work:

(a) O&M document directory of an index or table of contents
(b) Emergency Operating Procedures and capabilities
(c) Operating Manual meeting the Owner’s Project Requirements
(d) Annotation of Changes in Operating Procedures to optimize performance
(e) Maintenance Manual, Warranty information, and verified equipment performance data to the Owner’s Project Requirements
(f) Changes in Maintenance Procedures, Performance verification log forms, and Modifications and Repair documentation
(g) Equipment Test Reports and Service Bulletins
(h) Non-conformance reports with corrective action and impact statement documentation
(i) Construction record as-built, guides and schedules.

8.5.5 Training during Occupancy and Operations Phase. This training should be at the level defined in the Owners Project Requirements as implemented at the time of Significant Completion. As a minimum the Occupancy and Operations Phase Training sequence should contain:

(a) Role and responsibilities Matrix based on information contained in the O&M manuals
(b) Means of determining level of comprehension for Owner’s personnel following the training sequence.
(c) Methods of cross training and tracking comprehension of impact following repair, modification, or performance changes in any O&M phase of the Exterior Enclosure elements
(d) A short narrative in layman's terms, extracted from the BoD, of the essential exterior enclosure design characteristics used by the A&E to achieve the Owners Project Requirements relative to the exterior enclosure during:

1. Planning
2. Design Development
3. Construction Records submittals, substitutions, changes, and acceptance of work not meeting the Owners Project Requirements
4. Significant Construction events.

8.6 **Constant Commissioning.** See ASHRAE Guideline 0-2005, Section 8.2.8, and section 8.2.8 above, plus the material below.

8.6.1 The Constant Commissioning Process has the following key activities.

(a) Maintaining the Owner's Project Requirements to reflect changes in use and operation of the facility.

(b) Maintaining the Basis of Design to reflect changes in systems and assemblies due to renovations or in response to changes in the Owner's Project Requirements.

(c) Periodic evaluation of achieving the current Owner's Project Requirements and against previous benchmarks by appropriate tests.

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

(e) On-going training of operations and maintenance personnel and occupants on current Owner's Project Requirements and Basis of Design, and changes in systems and assemblies.

8.6.2 Whole Building Commissioning Performance verification data provides a benchmark of the building's performance at a given point in time, including the performance of the building exterior enclosure system.
Annex B: Flow Diagram of Building Development and Commissioning Processes

Commentary

This annex is intended to provide a detailed description of the commissioning (Cx) process and how it relates to the overall building development process. While the intent has been to describe the commissioning process for the building exterior enclosure, the flow diagrams contained on the following pages are probably sufficiently general to be used to describe commissioning and building development processes for all major building systems.

This annex is a major expansion of a less detailed flow diagram that is listed in Appendix B of ASHRAE Guideline 0-2005. Several key additions have been made in this newer Annex B to NIBS Guideline 3-2006:

- First, this annex shows two parallel related flow diagrams, with major activities of the building development process on the left and key commissioning activities on the right,
- Second, the building design phases have been disaggregated into 3 sub phases – Schematic Design, Design Development, and Construction Documents.
- Third, most boxes within the right-hand Cx flow diagram have section numbers that link them to specific sections within the body of Guideline 3, in an effort to provide consistency between the text of the guideline and the sequences shown in the flow diagrams shown within this annex.

The reader is cautioned not to conclude from this annex that all boxes identified in as Cx activities are unique to the Cx process. Indeed, some of these activities have been included in traditional quality control procedures for some time. Unfortunately, most buildings have benefited from little or no quality control activity. Some buildings, have been blessed with more extensive quality control activities. For example, several members of the Guideline 3-2006 committee have indicated that their firms routinely accomplish a decent subset of the activities listed in this annex as a part of their normal design and construction services. However, the Cx process listed in this annex is much more comprehensive than traditional quality control services.

The reader is also cautioned not to conclude that it is sufficient to simply follow the Cx process outlined in this annex. It is also critical that the building development team have in depth expertise and experience about how building exterior enclosures are properly constructed, operated, and maintained. Following the process is not a substitute for solid expertise about the exterior enclosure.

Credits

This annex has been developed by Joseph Deringer, starting from the Guideline 0-2005 flow diagram, and with substantial input from many members of the Guideline 3-2006 committee.

Five pages of Flow Diagrams begin on the following page.