What should a contractor do to manage risk?
Objectives:

1. Building Envelope–Import of Field Water Testing
2. Field Mock Ups– importance / impact
3. Commissioning of the Building Envelope
4. Resources for Commissioning of the Exterior Envelope
Cladding
Brick veneer on steel studs/steel frame
Precast
What is building commissioning?

- ASHRAE definition; **Commissioning is the process of ensuring that systems are designed, installed, functionally tested, and capable of being operated and maintained to perform in conformity with the design intent.**
What is the goal of Total Building Commissioning?

- To deliver a facility that operates as it was intended.
- To provide a facility that meets the needs of the building owner and occupants.
- To provide appropriate training for facility operators on the operation and maintenance of the building systems.
The commissioning process can be applied in a variety of approaches focusing on building systems/assemblies and can be customized to suit project needs. But regardless of commissioning approach and system focus, it always requires clear definition of performance expectations, rigor in planning and execution, and thorough project testing, operational training, and documentation.
RATING SYSTEM

- LEED for New Construction
- LEED for Core & Shell
- LEED for Schools
- LEED for Healthcare*
- LEED for Retail*
- LEED for Commercial Interiors
- LEED for Retail Interiors*
- LEED for Existing Buildings
- LEED for Existing Schools*

REFERENCE GUIDE

- GREEN BUILDING DESIGN & CONSTRUCTION
  2009 Edition

- GREEN INTERIOR DESIGN & CONSTRUCTION
  2009 Edition

- GREEN BUILDING OPERATIONS & MAINTENANCE
  2009 Edition

* These rating systems are under development or in pilot. Once they are available, supplements will be sold for the new LEED 2009 Reference Guides.
Commissioned Systems

Commissioning process activities must be completed for the following energy-related systems, at a minimum:

- Heating, ventilating, air conditioning and refrigeration (HVAC&R) systems (mechanical and passive) and
- associated controls
- Lighting and daylighting controls
- Domestic hot water systems
- Renewable energy systems (e.g., wind, solar)
EA Credit 3: Enhanced Commissioning

- Intent
- To begin the commissioning process early in the design process and execute additional activities after systems performance verification is completed.
Requirements

Implement, or have a contract in place to implement, the following additional commissioning process activities in addition to the requirements of EA Prerequisite 1: Fundamental Commissioning of Building Energy Systems and in accordance with the LEED Reference Guide for Green Building Design and Construction, 2009 Edition:
Prior to the start of the construction documents phase, designate an independent commissioning authority (CxA) to lead, review and oversee the completion of all commissioning process activities.

- The CxA must have documented commissioning authority experience in at least 2 building projects.
- The individual serving as the CxA:
  - Must be independent of the work of design and construction.
  - Must not be an employee of the design firm, though he or she may be contracted through them.
  - Must not be an employee of, or contracted through, a contractor or construction manager holding construction contracts.
  - May be a qualified employee or consultant of the owner.
- The CxA must report results, findings and recommendations directly to the owner.
The CxA must conduct, at a minimum, 1 commissioning design review of the owner’s project requirements basis of design, and design documents prior to the mid-construction documents phase and back-check the review comments in the subsequent design submission.

n The CxA must review contractor submittals applicable to systems being commissioned for compliance with the owner’s project requirements and basis of design. This review must be concurrent with the review of the architect or engineer of record and submitted to the design team and the owner.

n The CxA or other project team members must develop a systems manual that gives future operating staff the information needed to understand and optimally operate the commissioned systems.

n The CxA or other project team members must verify that the requirements for training operating personnel and building occupants have been completed.

n The CxA must be involved in reviewing the operation of the building with operations and maintenance (O&M) staff and occupants within 10 months after
Why do buildings have issues?

The Three primary categories of causation for buildings with issues

- Design
- Construction
- Operation and Maintenance
The Devil is in the Details

- **Design**–
  - Eliminate Detailia Absentia
  - Eliminate Detailia Dementia
- **Construction**
  - Eliminate Installation Absentia
  - Eliminate Installation Dementia
- **Operation and Maintenance**
  - Provide a roadmap for operational budgets, periodic inspections and documentation of the building envelope performance
Keys to a high performance building envelope

- Design—Plans and Specifications—details for the interfacing building envelope materials, performance requirements, responsibility for QC/QA, site specific quality plan submittal
- Peer review of the building envelope during design
- Preconstruction Prequalification of contractors, materials and specialty subcontractors
- Building Envelope Co Ordination Program—interfacing materials/subcontractor submittals, field testing of mock ups, first work, foreman qualification,
- Construction QC/QA—performed by CM, GC, and subs
  --Field inspection, testing, and documentation of the building envelope sequential installation
The road to zero water infiltration

- Specifications –
  - 01 40 00 Quality – provide requirements and delineate responsible individuals for specific inspections, testing, and documentation
  - 01 43 39 – Mock ups
  - 03 00 00 Concrete – call out trial batches, submittal of seasonal concrete mixes, tolerances
  - 04 00 00 Masonry – call out standardized field testing and performance requirements
  - 07 00 00 Thermal and Moisture Protection
  - 08 00 00 Openings
Building Enclosure Coordination Program

A single component of the Site Specific Quality Program
BECP –

- Who is responsible for its implementation on site
- What are the key components of the program
- How are the activities of the BECP accomplished
- Does the BECP need jobsite leadership
- Does BECP work on both Hard Bid and Construction Management projects
- What are the roles of the Project Director, Project Manager, Project Superintendents, Project engineers, Subcontractors, suppliers, manufacturers
- What must be done and by whom
---Third Party Peer Review---

- Architectural
- Structural
- Mechanical, Electrical, Plumbing
- Code and Permit
- Sustainability, Energy
- Building Enclosure
Building Envelope Field Mock Ups

- Below concrete slab on grade vapor retarder
- Waterproofing
- Building envelope
- Roofing
- Penetrations – wall/roof – below grade, above grade
01 43 00 Quality Assurance

- 01 43 13 Manufacturer Qualifications
- 01 43 16 Supplier Qualifications
- 01 43 19 Fabricator Qualifications
- 01 43 23 Installer Qualifications
- 01 43 26 Testing and Inspecting Agency Qualifications
- 01 43 29 Code–Required Special Inspector Qualifications
- 01 43 33 Manufacturer’s Field Services
- 01 43 36 Field Samples
- 01 43 39 Mockups
Standardized Field Testing of the Building Envelope – with stipulated performance requirements

- Concrete – cast in place, precast, GFRC
- Steel – panels
- Masonry – stone, brick, CMU
- Windows, Curtainwall, Storefront, skylights
- EIFS, Stucco,
- Roofing –
- Penetrations thru slabs, walls, soffits, roofs,
Tolerance issues

- Rebar and tendon placement
- Anchor bolt placement
- Weld plate placement
- Floor flatness
- Concrete slab edge location
- Stairs
- Masonry – brick, stone
- Wall Finish– Painting/ Coatings/ Plaster
- Steel Stud framing

- Gypsum Sheathing– exterior Installation
- Mechanical and Electrical inserts
- Curtain Wall Installation
- Elevator Tolerances
Delay in completing the building enclosure
Delay in subcontractors schedules
Extended field overhead
Delay in date of owner move in
Non performing building enclosure and impacts to interior finishes
Erosion of project profitability – claims
Damage to reputation
Site Mock-ups

- **Section 01 43 39** 1.1 The Contractor shall direct all the appropriate subcontractors in the construction of all site mock-ups for review by the Owner and Architect/Engineer (A/E) as required by the Construction Documents.
- 1.2 The mock-up(s) when approved by the A/E and Owner shall become the site reference for quality of the incorporated features of materials and workmanship.
- 1.3 The mock-up shall not be part of the work and shall remain in place until Substantial Completion, or otherwise directed by the Owner.
Building Enclosure - mock up
NON-STANDARD WATER PENETRATION TESTING

AAMA Calibrated Spray Nozzle:

- Adapted From AAMA 501.2–03 “Quality Assurance & Diagnostic Water Leakage Field Check Of Installed Storefronts, Curtain Walls, And Sloped Glazing Systems
- Delivers Constant Water Spray At A Set Pressure
- Light & Portable
- Useful For Testing Small Areas To Assess Specific Leak Points
- Provides No Quantitative Data
FIELD PERFORMANCE TESTING – BRICK
CONSTRUCTION INFLUENCE ON TESTING
In this case, water travel beyond the sill extrusion is defined as “water penetration”.
STANDARDIZED WATER PENETRATION TESTING

Typical E1105 Field Test Set-Up
Interior Pressure Chamber
STANDARDIZED WATER PENETRATION TESTING

Typical E1105 Field Test Set-Up
Exterior Pressure Chamber
STANDARDIZED WATER PENETRATION TESTING

Surface Area Per Tube = 0.76 in.$^2$

Surface Area Per Chamber = 1,728 in.$^2$

2,274 Rilem Tube Tests = 1 C1601 Chamber Test
In Surface Area Tested
NON-STANDARD WATER PENETRATION TESTING

Non–Standardized Methods:

- AAMA Spray Nozzle
- E1105 Spray Rack
- Cavity Drainage
- Water Ponding

Test

Typical Reasons For Use:

- Track Specific Water Leakage Paths
- Assess Specific Components
- Assess Material Interfaces & Laps
- Qualitative Evaluation Of Repairs
- Quantitative Data Not Required
Water Ponding:

- Basic Water Application To Test Specific Laps Or Joints
- Plumber’s Putty Used to Hold Water On Joints
- Used for Membrane Flashings, Sheet Metal Flashings & Window Components
- No Quantitative Data Gathered
NON-STANDARD WATER PENETRATION TESTING

Water Ponding:
ASHRAE/NIBS Guideline 03–06

- Exterior Enclosure Technical Requirements for the Commissioning Process
- National Institute of Building Science (NIBS) thru Building Envelope and Thermal Energy Council (BETEC) is updating Guideline 03
References

Tolerance Reference Documents


The Building Commissioning Guide, U.S. General Services Administration, 2005
NIBS GUIDELINE 3- 2006

- Downloadable free from the NIBS WBDG web site -- http://www.wbdg.org/ccb/NIBS/nibs_g13.pdf
Moisture Control in Buildings: The Key Factor in Mold Prevention
2nd Edition

Heinz R. Trechsel
Mark T. Bomberg
Editors

Quality Management in Design and Construction of the Building Envelope

25
Standard Specifications for Tolerances for Concrete Construction and Materials (ACI 117-90)

Reported by ACI Committee 117

W. Robert Little
Chairman

This specification provides standard tolerances for concrete construction. This document is intended to be used as the reference document for establishing tolerances for concrete construction by specification writers and ACI committees writing standards.

Keywords: bending (flexing); column; building code; concrete construction; concrete; electrical; form; formwork (construction); masonry; mass concrete; prestressed concrete; precast concrete; reinforcing steel; specifications; splicing; standards; tolerances (mechanical).

FOREWORD

1. This foreword is included for explanatory purposes only; it is not a part of Standard Specification 117.

2. Standard Specification 117 is a Reference Standard which the Architect/Engineer may cite in the Project Specifications for any construction project, together with supplementary requirements for the specific project.

This standard is not intended to apply to special structures not cited in the standard such as nuclear reactors and containment vessels, buses and silos, and prestressed circular structures. It is also not intended to apply to the specialized construction procedure of shotcrete.

3. Standard Specification 117 addresses each of the Three-Part Section Format of the Construction Specifications Institute; organized by structural elements, structural components and types of structures; the numbering system reflects this organization. The language is imperative and terse to preclude an alternative.

4. A Specification Checklist is included as a preface to, but not forming a part of, Standard Specification 117. The purpose of this Specification Checklist is to assist the Architect/Engineer in properly choosing and specifying the necessary mandatory and optional requirements for the Project Specification.

INTRODUCTION

This commentary pertains to “Standard Specifications for Tolerances for Concrete Construction and Materials (ACI 117).” The purpose of the report is to provide graphic and written interpretations for the specification and its application. No structure is exactly level, plumb, straight, and true. Fortunately, such perfection is not necessary. Tolerances are a means to establish permissible variation in dimension and location, giving both the designer and the contractor parameters within which the work is to be performed. They are the means by which the designer conveys to the contractor the performance expectations upon which the design is based or the use of the project requires. Such specified tolerances should reflect design assumptions and project needs, being neither overly restrictive nor lenient. Neatness rather than dimensionality should be the basis of selecting tolerances.

As the title “Standard Specifications for Tolerances for Concrete Construction and Materials (ACI 117)” implies, ACI Committee Reports, Guides, Standard Practices, and Commentaries are intended for guidance in planning, designing, executing, or inspecting construction and in preparing specifications. Reference to this document shall not be made in the Project Documents. If items found in these documents are desired to be a part of the Project Documents, they shall be phrased in mandatory language and incorporated in the Project Documents.

Commentary on Standard Specifications for Tolerances for Concrete Construction and Materials (ACI 117-90)

Reported by ACI Committee 117

W. Robert Little
Chairman

This report is a commentary on the Standard Specifications for Tolerances for Concrete Construction and Materials. It is intended to be used with ACI 117 for clarity of interpretation and strength in the use of the committees regarding the application of the tolerances set forth therein.

Keywords: bending (flexing); column; building code; concrete construction; concrete; electrical; form; formwork (construction); masonry; mass concrete; prestressed concrete; precast concrete; reinforcing steel; specifications; splicing; standards; tolerances (mechanical).

INTRODUCTION

This commentary pertains to “Standard Specifications for Tolerances for Concrete Construction and Materials (ACI 117).” The purpose of the report is to provide graphic and written interpretations for the specification and its application. No structure is exactly level, plumb, straight, and true. Fortunately, such perfection is not necessary. Tolerances are a means to establish permissible variation in dimension and location, giving both the designer and the contractor parameters within which the work is to be performed. They are the means by which the designer conveys to the contractor the performance expectations upon which the design is based or the use of the project requires. Such specified tolerances should reflect design assumptions and project needs, being neither overly restrictive nor lenient. Neatness rather than dimensionality should be the basis of selecting tolerances.

As the title “Standard Specifications for Tolerances for Concrete Construction and Materials (ACI 117)” implies, ACI Committee Reports, Guides, Standard Practices, and Commentaries are intended for guidance in planning, designing, executing, or inspecting construction and in preparing specifications. Reference to this document shall not be made in the Project Documents. If items found in these documents are desired to be a part of the Project Documents, they shall be phrased in mandatory language and incorporated in the Project Documents.

Relationship of all components

The required degree of accuracy of individual parts can be influenced by adjacent units and materials, joint and connection details, and the possibility of the accumulation of tolerances in critical dimensions.
Standard Specification for
Application and Finishing of Gypsum Board

This standard is issued under the fixed designation C 840; the number immediately following the designation indicates the year of
original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A
superscript epsilon (e) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope

1.1 This specification covers the minimum requirements for the methods of application and finishing of gypsum board, including related items and accessories.

1.2 Details of construction for a specific assembly to achieve the required fire resistance shall be obtained from reports of fire-resistance tests, engineering evaluations, or
listings from recognized fire testing laboratories.

1.3 When this specification is supplemented (see
1.4 The values stated in inch-pound units are to be regarded as
the standard. The SI (metric) values given in parentheses are
approximate and are provided for information purposes only.
1.6 The text of this specification references notes and
footnotes which provide explanatory material. These notes and
footnotes (excluding those in tables and figures) shall not be
considered as requirements of the specification.
1.7 The following precautionary caveat pertains only to

Designation: C 926 – 98a

Standard Specification for
Application of Portland Cement-Based Plaster

This standard is issued under the fixed designation C 926; the number immediately following the designation indicates the year of
original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A
superscript epsilon (e) indicates an editorial change since the last revision or reapproval.

1. This specification covers the requirements for the appli-
ded full-thickness portland cement-based plaster for
(succo) and interior work.

2. The values stated in inch-pound units are to be regarded as
the standard. The SI (metric) values given in parentheses are
approximate and are provided for information purposes only.
3. General information will be found in Annex A1. Designa-

4. The text of this specification references notes and
footnotes which provide explanatory material. These notes and
footnotes (excluding those in tables and figures) shall not be
considered as requirements of the specification.
5. The following precautionary caveat pertains only to

Designations:

C 631 Specification for Bonding Compounds for Interior
Plastering
C 897 Specification for Aggregate for Job-Mixed Portland
Cement-Based Plasters
C 932 Specification for Surface-Applied Bonding Agent for
Exterior Plastering
C 1063 Specification for Installation of Lathing and Furring
to Receive Interior and Exterior Portland Cement-Based
Plaster
C 1116 Specification for Fiber-Reinforced Concrete and
Shotcrete
C 1328 Specification for Plastic (Succo) Cement
E 90 Test Method for Laboratory Measurement of
Airborne-Sound Transmission Loss of Building Partitions
Curtain Wall
HANDBOOK OF CONSTRUCTION TOLERANCES

DAVID KENT BALLAST, AIA
William R Nash, P.E.
Whitlock, Dalrymple Poston & Associates

bnash@wdpa.com