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Standard Practice for Building Enclosure Commissioning[1]

This standard is issued under the fixed designation E2813; 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 (ε) indicates an editorial change since the last revision or reapproval.

~~ε[1] NOTE—Editorial changes were made throughout in April 2015.~~

INTRODUCTION

Building Enclosure Commissioning (BECx) is a process that begins with the establishment of the Owner's Project Requirements (OPR) and endeavors to ~~ensure~~confirm that the exterior enclosure and those elements intended to provide environmental separation within a building or structure meet or exceed the expectations of the Owner as ~~defined in the OPR.~~ described in the OPR, and as defined by the contract documents. A fundamental understanding of the most current published edition of ~~ASHRAE~~ANSI/ASHRAE/IES Standard 202, Commissioning Process for Buildings and Systems and ASTM E2947, Standard Guide for Building Enclosure Commissioning is recommended for optimal use and application of this practice.

1. Scope

1.1 This practice is intended to serve as a concise, authoritative, and technically sound practice for Building Enclosure Commissioning (BECx) that establishes two levels of BECx: *Fundamental* and *Enhanced* (refer also to Section 4).

1.2 The BECx process as defined in this practice includes the following phases and sub-phases:
1.2.1 Pre-design,
1.2.2 Design,
1.2.2.1 Schematic Design,
1.2.2.2 Design Development,
1.2.2.3 Construction Documentation,
1.2.3 ~~Pre-Construction,~~Bidding and Negotiation Phase,
1.2.4 Construction, ~~and~~
1.2.4.1 Pre-Construction,
1.2.4.2 Construction Administration, and
1.2.5 Occupancy and Operations.

1.3 This practice includes a mandatory OPR Development Guideline (Annex A1) and requires the development of an OPR for both Fundamental and Enhanced BECx that addresses, at a minimum, the performance attributes and metrics included in Annex A1 of this practice.

1.4 This practice includes mandatory BECx Performance Testing Requirements (Annex A2) approved for use with this practice to evaluate the performance and durability of enclosure materials, components, systems, and assemblies.

1.5 This practice mandates ~~independent, third-party~~ independent design ~~peer~~ review during the Design Phase of both Fundamental and Enhanced BECx.

1.6 This practice recognizes that the OPR for exterior enclosure performance and environmental separation may exceed the baseline requirements of applicable building codes and standards and provides guidance for the development of an OPR based on the following attributes as defined in Annex A1 of this practice:
1.6.1 Energy,
1.6.2 Environment,

[1] This practice is under the jurisdiction of ASTM Committee E06 on Performance of Buildings and is the direct responsibility of Subcommittee E06.55 on Performance of Building Enclosures.

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1.6.3 Safety,
1.6.4 Security,
1.6.5 Durability,
1.6.6 Sustainability, and
1.6.7 Operation.

1.7 The terms "building enclosure" and "enclosure" as they appear in this practice refer collectively to all materials, components, systems, and assemblies intended to provide shelter and environmental separation between interior and exterior, or between two or more environmentally distinct interior spaces in a building or structure.

1.8 This practice establishes that the Building Enclosure Commissioning Provider (BECxP) refers specifically to the individual retained by the Owner to develop, manage, and be in responsible charge of the BECx process, including individual members and technical specialists that may comprise the BECx ~~team~~group (see 4.2).

1.9 The role and responsibilities of the BECxP as defined by this practice are not intended to supersede or otherwise replace the contractual obligations reserved specifically for the parties responsible for the design and construction of a building or structure, nor the duties that may otherwise be assigned to those parties by applicable regulatory or statutory law.

1.10 This practice is not intended to warrant or otherwise guarantee the as-built or in-service durability, or both, and performance of enclosure materials, components, systems, and assemblies.

1.11 The values stated in SI units are to be regarded as standard. The values given in parentheses are mathematical conversions to inch-pound units that are provided for information only and are not considered standard.

1.12 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate ~~safety~~ safety, health, and ~~health~~environmental practices and determine the applicability of regulatory limitations prior to use.*

1.13 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

C423 Test Method for Sound Absorption and Sound Absorption Coefficients by the Reverberation Room Method
C510 Test Method for Staining and Color Change of Single- or Multicomponent Joint Sealants
C522 Test Method for Airflow Resistance of Acoustical Materials
C724 Test Method for Acid Resistance of Ceramic Decorations on Architectural-Type Glass
C732 Test Method for Aging Effects of Artificial Weathering on Latex Sealants
C794 Test Method for Adhesion-in-Peel of Elastomeric Joint Sealants
C1060 Practice for Thermographic Inspection of Insulation Installations in Envelope Cavities of Frame Buildings
C1087 Test Method for Determining Compatibility of Liquid-Applied Sealants with Accessories Used in Structural Glazing Systems
C1153 Practice for Location of Wet Insulation in Roofing Systems Using Infrared Imaging
~~C1193~~C1193-11a Guide for Use of Joint Sealants
C1246 Test Method for Effects of Heat Aging on Weight Loss, Cracking, and Chalking of Elastomeric Sealants After Cure
C1258 Test Method for Elevated Temperature and Humidity Resistance of Vapor Retarders for Insulation
C1279 Test Method for Non-Destructive Photoelastic Measurement of Edge and Surface Stresses in Annealed, Heat-Strengthened, and Fully Tempered Flat Glass
C1294 Test Method for Compatibility of Insulating Glass Edge Sealants with Liquid-Applied Glazing Materials
C1371 Test Method for Determination of Emittance of Materials Near Room Temperature Using Portable Emissometers
C1522 Test Method for Extensibility After Heat Aging of Cold Liquid-Applied Elastomeric Waterproofing Membranes
C1549 Test Method for Determination of Solar Reflectance Near Ambient Temperature Using a Portable Solar Reflectometer
C1601 Test Method for Field Determination of Water Penetration of Masonry Wall Surfaces
C1651 Test Method for Measurement of Roll Wave Optical Distortion in Heat-Treated Flat Glass
~~C1652~~C1652/C1652M Test Method for Measuring Optical Distortion in Flat Glass Products Using Digital Photography of Grids
D2203 Test Method for Staining from Sealants
D4541 Test Method for Pull-Off Strength of Coatings Using Portable Adhesion Testers
D5957 Guide for Flood Testing Horizontal Waterproofing Installations
E90 Test Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions and Elements

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the ~~standard's~~standard's Document Summary page on the ASTM website.

E283 Test Method for Determining Rate of Air Leakage Through Exterior Windows, Curtain Walls, and Doors Under Specified Pressure Differences Across the Specimen
~~E330~~E330/E330M Test Method for Structural Performance of Exterior Windows, Doors, Skylights and Curtain Walls by Uniform Static Air Pressure Difference
E331 Test Method for Water Penetration of Exterior Windows, Skylights, Doors, and Curtain Walls by Uniform Static Air Pressure Difference
E336 Test Method for Measurement of Airborne Sound Attenuation between Rooms in Buildings
~~E488~~E488/E488M Test Methods for Strength of Anchors in Concrete Elements
E492 Test Method for Laboratory Measurement of Impact Sound Transmission Through Floor-Ceiling Assemblies Using the Tapping Machine
~~E514~~E514/E514M Test Method for Water Penetration and Leakage Through Masonry
E576 Test Method for Frost/Dew Point of Sealed Insulating Glass Units in the Vertical Position
E596 Test Method for Laboratory Measurement of Noise Reduction of Sound-Isolating Enclosures
E631 Terminology of Building Constructions
E779 Test Method for Determining Air Leakage Rate by Fan Pressurization
E783 Test Method for Field Measurement of Air Leakage Through Installed Exterior Windows and Doors
E795 Practices for Mounting Test Specimens During Sound Absorption Tests
E903 Test Method for Solar Absorptance, Reflectance, and Transmittance of Materials Using Integrating Spheres
E966 Guide for Field Measurements of Airborne Sound Attenuation of Building Facades and Facade Elements
E997 Test Method for Evaluating Glass Breakage Probability Under the Influence of Uniform Static Loads by Proof Load Testing
E1007 Test Method for Field Measurement of Tapping Machine Impact Sound Transmission Through Floor-Ceiling Assemblies and Associated Support Structures
E1014 Guide for Measurement of Outdoor A-Weighted Sound Levels
E1050 Test Method for Impedance and Absorption of Acoustical Materials Using a Tube, Two Microphones and a Digital Frequency Analysis System
E1105 Test Method for Field Determination of Water Penetration of Installed Exterior Windows, Skylights, Doors, and Curtain Walls, by Uniform or Cyclic Static Air Pressure Difference
E1186 Practices for Air Leakage Site Detection in Building Envelopes and Air Barrier Systems
E1425 Practice for Determining the Acoustical Performance of Windows, Doors, Skylight, and Glazed Wall Systems
E1503 Test Method for Conducting Outdoor Sound Measurements Using a Digital Statistical Sound Analysis System
E1827 Test Methods for Determining Airtightness of Buildings Using an Orifice Blower Door
E1886 Test Method for Performance of Exterior Windows, Curtain Walls, Doors, and Impact Protective Systems Impacted by Missile(s) and Exposed to Cyclic Pressure Differentials
E1980 Practice for Calculating Solar Reflectance Index of Horizontal and Low-Sloped Opaque Surfaces
E1996 Specification for Performance of Exterior Windows, Curtain Walls, Doors, and Impact Protective Systems Impacted by Windborne Debris in Hurricanes
E2099 Practice for the Specification and Evaluation of Pre-Construction Laboratory Mockups of Exterior Wall Systems
E2178 Test Method for Air Permeance of Building Materials
E2179 Test Method for Laboratory Measurement of the Effectiveness of Floor Coverings in Reducing Impact Sound Transmission Through Concrete Floors
E2249 Test Method for Laboratory Measurement of Airborne Transmission Loss of Building Partitions and Elements Using Sound Intensity
E2264 Practice for Determining the Effects of Temperature Cycling on Fenestration Products
E2268 Test Method for Water Penetration of Exterior Windows, Skylights, and Doors by Rapid Pulsed Air Pressure Difference
E2319 Test Method for Determining Air Flow Through the Face and Sides of Exterior Windows, Curtain Walls, and Doors Under Specified Pressure Differences Across the Specimen
E2353 Test Methods for Performance of Glazing in Permanent Railing Systems, Guards, and Balustrades
E2357 Test Method for Determining Air Leakage Rate of Air Barrier Assemblies
~~E2359~~E2359/E2359M Test Method for Field Pull Testing of an In-Place Exterior Insulation and Finish System Clad Wall Assembly
~~E2570~~E2570/E2570M Test Methods for Evaluating Water-Resistive Barrier (WRB) Coatings Used under Exterior Insulation and Finish Systems (EIFS) or EIFS with Drainage
E2649 Test Method for Determining Argon Concentration in Sealed Insulating Glass Units Using Spark Emission Spectroscopy
E2947 Guide for Building Enclosure Commissioning
F1233 Test Method for Security Glazing Materials And Systems
~~F1642~~F1642/F1642M Test Method for Glazing and Glazing Systems Subject to Airblast Loadings
F1869 Test Method for Measuring Moisture Vapor Emission Rate of Concrete Subfloor Using Anhydrous Calcium Chloride

F2170 Test Method for Determining Relative Humidity in Concrete Floor Slabs Using in situ Probes
F2420 Test Method for Determining Relative Humidity on the Surface of Concrete Floor Slabs Using Relative Humidity Probe Measurement and Insulated Hood (Withdrawn 2014)[3]

~~2.2 *ASHRAE Guidelines:*~~[5]
~~ASHRAE 90.1 Map of Climate Zones~~
~~ASHRAE Standard 202 Commissioning Process for Buildings and Systems~~

2.2 *AAMA Standards:*[4]
AAMA 501.1 Standard Test Method for Water Penetration of Windows, Curtain ~~Walls,~~Walls and Doors Using Dynamic Pressure
AAMA 501.2 Quality Assurance and Diagnostic Water Leakage Field Check of Installed Storefronts, Curtain Walls, and Sloped Glazing Systems
AAMA 501.4 Recommended Static Test Method for Evaluating Window Wall, Curtain Wall and Storefront Systems Subjected to Seismic and Wind-Induced ~~Interstory Drifts~~Inter-Story Drift
AAMA 501.5 Test Method for Thermal Cycling of Exterior Walls
AAMA 508-07 Voluntary Test Method and ~~Specifications~~Specification for Pressure Equalized Rain Screen Wall Cladding Systems
AAMA 1503 Voluntary Test Method for Thermal Transmittance and Condensation Resistance of Windows, Doors, and Glazed Wall Sections
AAMA 1801 Voluntary Specification for the Acoustical Rating of Exterior Windows, Doors, Skylights and Glazed Wall Sections

2.3 *ANSI Standards:*[5]
~~ANSI~~ANSI/ASA S12.8 Methods for Determination of Insertion Loss of Outdoor Noise Barriers
~~ANSI~~ANSI/ASA S12.60 Acoustical Performance Criteria, Design Requirements, and Guidelines for Schools
ANSI/ASHRAE/IES 90.1 Energy Standard for Buildings Except Low-Rise Residential Buildings (Map of Climate Zones)
~~ANSI-ASHRAE~~ ANSI/ASHRAE/IES Standard 101 Application of Infrared Sensing Devices to the Assessment of Building Heat Loss Characteristics
ANSI/ASHRAE/IES Standard 202 Commissioning Process for Buildings and Systems

2.4 *CAN/CGSB ~~Standards:~~Standard:*[6]
CAN/CGSB 149-GP-2MP Manual for Thermographic Analysis of Building ~~Envelopes~~Enclosures

2.5 *CEN ~~Standards:~~Standard:*[7]
CEN 1063 ~~Testing and Classification of Resistance Against Bullet Attack~~Glass in building - Security glazing - Testing and classification of resistance against bullet attack

2.6 *CSA ~~Standards:~~Standard:*[8]
CSA-A123.21 Standard Test Method for the Dynamic Wind Uplift Resistance of ~~Membrane Roofing~~ Membrane-Roofing Systems

2.7 *CSI ~~Standards:~~Standard:*[9]
Project Resource Manual and Manual of Practice

2.8 *GANA Test Methods:*[10]
GANA LD 100-06 Standard Test Method for Ball Drop Impact of Laminated Architectural Flat Glass
GANA TD 101-04 Standard Test Method for Center-Punch Fragmentation of Fully-Tempered Flat Glass
GANA LD 101-08 Standard Specification for Ball Drop Impact Resistance of Laminated Architectural Flat Glazing

2.9 *GSA ~~Standards:~~Standard:*[11]
~~GSA TS-01~~GSA-TS01 Standard Test Method for Glazing and Window Systems Subject to Dynamic Overpressure Loadings

2.10 *ICC ~~Publications:~~Publication:*[12]
International Building Code

[3] The last approved version of this historical standard is referenced on www.astm.org.
[4] Available from American Architectural Manufacturers Association (AAMA), 1827 Walden Office Square, Suite 550, Schaumburg, Illinois 60173-4268, http://www.aamanet.org.
[5] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.
[6] Available from Canadian General Standards Board ~~(CAN/CGSB),~~ (CGSB), 11 Laurier St., Phase III, Place du Portage, Gatineau, Quebec K1A 0S5, Canada, http://www.tpsgc-pwgsc.gc.ca/ongc-cgsb/index-eng.html.
[7] Available from European Committee for Standardization (CEN), Avenue Marnix 17, B-1000, Brussels, Belgium, http://www.cen.eu.
[8] Available from Canadian Standards Association (CSA), ~~5060 Spectrum Way, Mississauga, ON L4W 5N6, Canada, http://www.csa.ca.~~178 Rexdale Blvd., Toronto, ON M9W 1R3, Canada, http://www.csagroup.org.
[9] Available from Construction Specifications Institute (CSI), 110 ~~South~~S. Union Street, Suite 100, Alexandria VA 22314, ~~http://www.csinet.org.~~ http://www.csiresources.org.
[10] Available from Glass Association of North America (GANA), 800 SW Jackson ~~St.~~St., Suite 1500, Topeka, KS 66612-1200, ~~http://www.glasswebsite.org.~~ http://www.glasswebsite.com.
[11] Available from U.S. General Services Administration (GSA), ~~One Constitution Square, 1275 First Street, NE, Washington, DC 20417,~~1800 F Street, NW, Washington, DC 20405, http://www.gsa.gov.
[12] Available from International Code Council (ICC), 500 New Jersey Ave., NW, 6th Floor, Washington, DC 20001, http://www.iccsafe.org.

2.11 *ISO ~~Publications:~~Publication:*[13]
ISO 9000
~~2.13 *NIJ Standards:*[15]~~
~~NIJ Std. 0108.01 Ballistic Resistant Protective Materials~~
2.12 *NFRC Standards:*[14]
NFRC 100 Procedure for Determining Fenestration Product U-Factors
NFRC 200 Procedure for Determining Fenestration Product Solar Heat Gain Coefficient and Visible Transmittance at Normal Incidence
NFRC 300 Test Method for Determining the Solar Optical Properties of Glazing Materials and Systems
2.13 *NIJ Standard:*[15]
NIJ Std. 0108.01 Ballistic Resistant Protective Materials
2.14 *State Department (SD) Ballistic ~~Standards:~~Standard:*[16]
SD-STD-01.01 Forced Entry and Ballistic Resistance of Structural Systems
2.15 *UL ~~Standards:~~Standard:*[17]
UL 752 Standard of Safety for Bullet-Resisting Equipment

3. Terminology

3.1 *Definitions*—Refer to the most current edition of the following:[18]
3.1.1 ~~ASHRAE~~ANSI/ASHRAE/IES Standard 202, Section 3, Definitions
3.1.2 Guide E2947
3.1.3 Terminology E631
3.1.4 AIA Architect's Handbook of Professional Practice
3.1.5 CSI Project Resource Manual and Manual of Practice

3.2 *Acronyms:*
3.2.1 *AAMA*—American Architectural Manufacturers Association
3.2.2 *A/E*—Architect/Engineer
3.2.3 *AIA*—American Institute of Architects
3.2.4 *ANSI*—American National Standards Institute
3.2.5 *AOR*—Architect-of-Record
3.2.6 *ASCE*—American Society of Civil Engineers
3.2.7 *ASHRAE*—American Society of Heating, Refrigerating and Air Conditioning Engineers
3.2.8 *BCA*—Building Commissioning Association
3.2.9 *BECx*—Building Enclosure Commissioning
3.2.10 *BECxG*—Building Enclosure Commissioning Group
3.2.11 *BECxP*—Building Enclosure Commissioning Provider (aka "Agent" or "Authority")
3.2.12 ~~*BECxT—*~~*BOD*—Building Enclosure ~~Commissioning Team~~Basis-of-Design
~~3.2.11 *BOD*—Basis-of-Design~~
3.2.13 *CAN/CGSB*—Canadian General Standards Board
3.2.14 *CSA*—Canadian Standards Association
3.2.15 *CSI*—Construction Specifications Institute
3.2.16 *Cx*—Commissioning
~~3.2.16 *CxA*—Commissioning Agent (or "Authority")~~
3.2.17 *CxP*—Commissioning Provider
3.2.18 *EIS*—Energy Information System

[13] Available from ~~National Institute of Justice (NIJ), 810 7th St., NW, Washington, DC 20531, http://nij.gov.~~International Organization for Standardization (ISO), ISO Central Secretariat, BIBC II, Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland, http://www.iso.org.
[15] Available from National Institute of Justice (NIJ), 810 7th St., NW, Washington, DC 20531, http://nij.gov.
[14] Available from National Fenestration Rating Council (NFRC), 6305 Ivy ~~Lane,~~Ln., Suite 140, Greenbelt, MD 20770, http://www.nfrc.org.
[16] Available from U.S. Government ~~Printing Office Superintendent of Documents,~~ Publishing Office (GPO), 732 N. Capitol St., NW, ~~Mail Stop: SDE,~~ Washington, DC ~~20401, http://www.access.gpo.gov.~~20401-0001, http://www.gpo.gov.
[17] Available from Underwriters Laboratories (UL), 2600 N.W. Lake Rd., Camas, WA 98607-8542, http://www.ul.com.
[18] Selection, interpretation, application, and use of the terminology contained in these documents shall be at the sole discretion of the BECxP. Reconciliation of conflicts in terminology or the definition of terms that may exist among or between these documents shall be the sole responsibility of the BECxP, subject to review and final approval by the AOR and Owner.

3.2.19 *EMCS*—Energy Management and Control System

3.2.20 *EOR*—Engineer-of-Record

3.2.21 *GANA*—Glass Association of North America

3.2.22 *GSA*—United States General Services Administration

3.2.23 *HVAC*—Heating, Ventilation, and Air Conditioning

3.2.24 *IAQ*—Indoor Air Quality

3.2.25 *IEQ*—Indoor Environmental Quality

3.2.26 *LEED*—Leadership in Energy and Environmental Design (trademark[19])

3.2.27 *NASFA*—National Association of State Facilities Administrators

3.2.28 *NEBB*—National Environmental Balancing Bureau

3.2.29 *NIBS*—National Institute of Building Sciences

3.2.30 *NFRC*—National Fenestration Rating Council

3.2.31 *O&M*—Operations and Maintenance

3.2.32 *OPR*—Building Enclosure Owner's Project Requirements

3.2.33 *RCx*—Retro-Commissioning

3.2.34 *ReCx*—Re-Commissioning

3.2.35 *RFI*—Request For Information

~~3.2.36 *RFP*—Request For Proposals~~

~~3.2.37 *RFQ*—Request For Qualifications~~

~~3.2.38 *TAB*—Testing, Adjusting, and Balancing~~

3.2.36 *USDHS (or DHS)*—U.S. Department of Homeland Security

3.2.37 *USDOD (or DOD)*—U.S. Department of Defense

3.2.38 *USDOE (or DOE)*—U.S. Department of Energy

3.2.39 *USDOS (or DOS)*—U.S. Department of State

3.2.40 *USGBC*—U.S. Green Building Council

3.2.41 *VA*—U.S. Department of Veterans Affairs

4. Summary of Practice

4.1 This practice establishes two levels of BECx: *Fundamental and Enhanced*.

4.1.1 *Fundamental BECx*—Architecture or engineering-related technical services, or both, performed on behalf of the Owner by the BECxP and associated group members and summarized as follows:

4.1.1.1 BECxP engagement during the *Design Phase* of the BECx process, but no later than commencement of the Design Development sub-phase;[20]

4.1.1.2 Review and documentation of the preliminary OPR developed during the Pre-Design Phase of the BECx process;[21]

4.1.1.3 Identification of the scope and recommended budget for the BECx process and development of a preliminary BECx Plan;[22]

4.1.1.4 Technical assistance and documentation during the development of the BOD, contract documents, project-specific BECx specification section, and final OPR during the Design Phase of the BECx process, including completion of a minimum of one ~~independent, third-party~~ independent design ~~peer~~ review of enclosure-related construction document drawings and specifications in a manner that will allow for timely review and consideration by the AOR prior to solicitation and contract award. The project-specific BECx specification section establishes the roles and responsibilities of the contractor and individual members of the construction team in the context of the BECx process, including a summary of required pre-construction laboratory and field performance test standards and methodology for enclosure-related materials, components, systems, and assemblies ~~adopted from~~required by Annex A2 of this practice and further defined by the AOR in the ~~approved contract document drawings and specifications;~~construction documents;

[19] LEED is a trademark held by the U.S. Green Building Council.

[20] Typically characterized by the AOR as "50 %" completion of the Construction Documents, subject to review and concurrence by the Owner and BECxP.

[21] Including retroactive development of a written OPR in circumstances where a formal OPR may not exist or otherwise was not fully developed during the Pre-Design Phase of the BECx process as defined by ~~ASHRAE~~ANSI/ASHRAE/IES Standard 202 and Guide E2947.

[22] The BECx Plan shall be as defined by ~~ASHRAE~~ANSI/ASHRAE/IES Standard 202 and Guide E2947.

4.1.1.5 ~~Development of~~ Document a final BECx Plan that includes an outline of the BECx process, BECx roles and responsibilities of the ~~BECxP and~~ BECxP, individual members of the BECx ~~team,~~group,[23] the Design Team, the Construction Team, and the methodology established to verify and document compliance of the as-built construction with the requirements of the approved contract documents. The BECx Plan shall be developed to align with the requirements of the BECx section of the project ~~specifications, and;~~specifications;

4.1.1.6 Direct and substantive participation[24] by the BECxP during the ~~Pre-Construction, Construction,~~ Bidding and Negotiation, Pre-Construction, Construction Administration, and Occupancy & Operations phases of the BECx process, including pre-construction laboratory and field performance testing as required in Annex A2 for *Fundamental BECx*.

4.1.2 *Enhanced BECx*—Architecture or engineering-related technical services, or both, performed on behalf of the Owner by the BECxP and associated BECx group members in accordance with the requirements of *Fundamental BECx*, but with the following additional requirements:

4.1.2.1 BECxP engagement during the *Pre-Design Phase* of the BECx process, but no later than commencement of the Schematic Design sub-phase;

4.1.2.2 Technical assistance and documentation during the development of the preliminary OPR;

4.1.2.3 Technical assistance and documentation during the development of the BOD, contract documents, including the project-specific BECx specification section, and final OPR during the Design Phase of the BECx process, including completion of a minimum of three ~~independent, third-party~~ independent design ~~peer~~ reviews[22] of enclosure-related construction document drawings and specifications in a manner that will allow for timely review and consideration by the AOR prior to solicitation and contract award, and;

4.1.2.4 Direct and substantive participation[25] (see 4.2) by the BECxP and BECxG during the ~~Pre-Construction, Construction,~~ Bidding and Negotiation, Pre-Construction, Construction Administration, and Occupancy and Operations phases of the BECx process, including pre-construction laboratory and field performance testing as required in Annex A2 for *Enhanced BECx*.

4.2 This practice establishes that the BECxP shall assemble a ~~team (BECxT)~~group (BECxG) that, at a minimum, demonstrates a level of proficiency in the core competencies listed below that ~~meet~~meets or ~~exceed~~exceeds the requirements of building codes, standards, guidelines, and regulations applicable to or otherwise voluntarily adopted by the Owner to govern enclosure-related design, construction, ~~integration, and performance.~~and performance. Determination of the qualification of the BECxP and BECxG will be at the discretion of the Owner:

4.2.1 ~~*BECxT*~~*BECxG Core Competencies:*

4.2.1.1 *Building and Materials Science,* including, at a minimum, demonstrated knowledge of the:

(1) Principles associated with heat transfer via conduction, convection, radiation, and air infiltration/exfiltration;

(2) Principles associated with moisture storage and transport via gravity, diffusion, convection, capillary action, absorbed flow, and osmosis; and

(3) Characteristics and behavior of enclosure-related materials, components, systems, and assemblies when specified for a given application, geographic region, location, exposure, or climate, and corresponding influence on workability, durability, serviceability, performance, and anticipated service-life.

(4) Principles of structural loading and structural capacity of enclosure-related materials, components, systems, and assemblies for specified loads including: wind, earthquake, projectile, differential volume change, and kinetic energy and differential pressure conditions.

4.2.1.2 *Procurement and Project Delivery,* including, at a minimum, demonstrated knowledge of the:

(1) Influence of the project delivery method[26] selected by the Owner on the scope, adaptation, implementation, and cost of the BECx process as defined in this practice;

(2) Influence of the number and type of contracts[27] established between the Owner and the design and construction teams on the role and responsibilities of the BECxP and individual members of the BECx ~~team;~~group;

(3) Influence of design and construction scheduling, phasing, and sequencing of the work on the scope, adaptation, implementation, and cost of the BECx process as defined in this practice;

(4) Influence of the experience, qualifications, technical depth, and commitment of the design and construction teams to the BECx process on the role and responsibilities of the BECxP, the range and technical depth required of the BECx ~~team,~~group, and the anticipated scope and cost of the BECx process.

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[23] Though it is recognized that all parties participating in the design and construction of the building are part of the BECx process, for the purposes of this practice, the BECx group (BECxG) is defined as the group of individuals, working under direct supervision of the BECxP. This group may be comprised of a single person or may include multiple subject matter specialists and administrative staff. It is the responsibility of the BECxP to perform each required task or to delegate the appropriate task to the appropriate Group member.

[24] As outlined in ~~ASHRAE~~ANSI/ASHRAE/IES Standard 202 and Guide E2947, unless otherwise defined in this practice.

[25] As defined in ~~ASHRAE~~ANSI/ASHRAE/IES Standard 202 and Guide E2947.

[26] Including, but not limited to: Design-Build; Design-Bid-Build; Design-Negotiate-Build; Construction Management, and; Owner-Build as defined by CSI Project Resource Manual and Manual of Practice.

[27] Including, but not limited to Single-Prime Contract and Multiple-Prime Contracts, with basis-of-payment provisions that may include: Stipulated/Lump Sum; Cost-Plus Fee; Fixed Fee, and; Guaranteed Maximum Price, with penalties, bonuses, and incentives for early completion of the work and liquidated damages for any delays in substantial or final completion of the project.

4.2.1.3 *Contract Documents and Construction Administration,* including, at a minimum, demonstrated knowledge of the:

(1) Interrelationship and commonly understood hierarchy that exists between Procurement Documents, Contract Documents, Contract Drawings and Specifications[28] developed during the Design Phase of the BECx process, as well as submittals and legally binding Instruments of Change[28] issued during the Pre-Construction (Procurement) and Construction Phases of the BECx process, including but not limited to: Addenda; Submittals; Architect's Supplemental Instructions and Field Directives; Construction Change Directives, and; Change Orders;

(2) Influence of enclosure-related design, detailing, and integration[29] on total building performance, including at a minimum consideration of the performance attributes listed in 1.5 and Annex A1 of this practice;

(3) Influence of product selection, allowable construction tolerances, and dimensional requirements to accommodate environmental and service loads on detailing at interface conditions between enclosure-related materials, components, systems, and assemblies, and; the corresponding influence on sequencing, phasing, and coordination of trades during the Construction Phase of the BECx process;

(4) Importance of material compatibility and continuity of primary heat, air, and moisture control layers throughout the building enclosure on total building performance and the appropriate mitigation of risks associated with improperly managed heat, air, and moisture transport across the building enclosure;

(5) Importance of the timely preparation and distribution of subject-direct, technically sound, and actionable documentation and feedback to the Owner, design, and construction teams throughout the Construction Phase of the BECx process.

4.2.1.4 *Performance Test Standards and Methodology,* including, at a minimum, demonstrated knowledge of the:

(1) Pre-construction laboratory and field-applied test standards and methodology referenced in this practice (see Annex A2) and their intended use and application[30] in evaluating the durability, performance, constructability, and anticipated service-life of enclosure-related materials, components, systems, and assemblies;

(2) Importance of establishing appropriate and quantifiable thresholds of performance and clear and unambiguous definitions of failure[31] for enclosure-related materials, components, systems, and ~~assemblies to validate the OPR and BOD, and to~~ to allow for proper enforcement of the contract documents;

(3) Influence of modifications to the intended use and application of pre-construction laboratory and field test standards and methodology on the appropriate interpretation of test results and their relevance to the requirements of the contract documents;

(4) Importance of ~~ensuring~~confirming the timely, clear, and unambiguous translation of all modifications to the design, construction, and integration of enclosure-related materials, components, systems, and assemblies arising from pre-construction laboratory testing to the field during the Construction Phase of the BECx process;

(5) Importance of recognizing the distinction between errors and omissions in architectural or product design, or both, versus defective installation or workmanship, or both, when interpreting field test results, and; the techniques available during the development and implementation of field testing protocols that will minimize the risk for confusion and misinterpretation relative to the requirements of the contract documents;

(6) Distinction between test standards and methodologies "recognized in the industry" or otherwise developed by industry or trade associations versus test standards developed by independent standards-writing organizations and the impact, if any, on the enforcement of the contract documents when both are included in the project specifications.

5. Procedure

5.1 This practice establishes that the BECx process shall be as outlined in ~~ASHRAE~~ANSI/ASHRAE/IES Standard 202 and Guide E2947 and include, at a minimum, the following:

5.1.1 *Pre-Design Phase:*[32]

5.1.1.1 Attend a project planning conference ("Kick-Off Meeting");

5.1.1.2 Review the functional and programmatic requirements for the project established by the Owner and AOR;

5.1.1.3 Review and discuss factors influencing enclosure design, construction, long-term durability, serviceability, and performance with the Owner and AOR (if retained), including at a minimum (see also Annex A1):

(1) Anticipated construction type, importance factor, and occupancy/use classification;

(2) Geographic location and climate;

(3) Site orientation, massing, and options for enclosure material selection, integration, and relative distribution at each building exposure that will consider:

(a) Identification and apportionment of initial enclosure costs;

(b) Occupant comfort, productivity, and rate of return on initial investment;

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[28] As defined by the Construction Specifications Institute (CSI).

[29] Including, but not limited to integration with base building structural and environmental control systems.

[30] Including the limitations associated with each test standard.

[31] Including remedial action required in the event of failure and the nature and extent of re-testing necessary to ~~verify~~evaluate compliance of the repair(s) with the requirements of the contract documents.

[32] The *Pre-Design Phase* is the BECxP *minimum point-of-engagement* required to qualify as *Enhanced* BECx under this practice. Refer to ~~ASHRAE~~ANSI/ASHRAE/IES Standard 202 and Guide E2947 for additional steps associated with this phase of the BECx process.

(c) Enclosure long-term durability and performance;
(d) Costs associated with routine maintenance and energy use;
(e) Sustainable design objectives with long-term durability and performance;
(f) Optimize acoustical requirements; and
(g) Safety and security requirements.

(4) Consideration of exemplars that may exist in the same region or climate for which actual as-built enclosure performance can be quantifiably evaluated.

5.1.1.4 Provide technical assistance to the Owner during the development of a written OPR for enclosure materials, components, systems, and assemblies in accordance with Annex A1 of this practice,[33] including at a minimum an evaluation of the interrelationship between the following performance attributes and the relative influence of each on ~~enclosure durability,~~ enclosure, performance, and total cost of ownership:

(1) Energy
(2) Environment
(3) Safety
(4) Security
(5) Durability
(6) Sustainability
(7) Operation

5.1.1.5 Provide a summary of the preliminary BECx Plan scope and budget to the Owner.

5.1.2 *Design Phase:*[34]

5.1.2.1 Review and document the OPR[35] and preliminary BECx Plan developed during the Pre-Design phase of the BECx process;

5.1.2.2 Review and provide technical assistance during the development of the preliminary enclosure BOD;[25]

5.1.2.3 Provide or otherwise coordinate the completion of an ~~independent, third-party~~ independent design ~~peer~~ review of enclosure-related construction document drawings and specifications based on the following sub-phases of the design process:[25]

(1) Schematic Design[36]
(2) Design Development[36]
(3) Construction Documents[37]

5.1.2.4 Update, refine, and document the OPR, enclosure BOD, and BECx Plan at the conclusion of each sub-phase of the design process;

5.1.2.5 Establish appropriate and quantifiable enclosure-related performance metrics, test standards, and test methodology in accordance with Annex A2 for incorporation into the contract documents,[22] including:

(1) Preconstruction laboratory mockups;
(2) Field-constructed "off-structure" mockups;
(3) Field-constructed "on-structure," first-installation mockups;
(4) Field testing at milestone intervals during construction;
(5) Post-occupancy evaluation and performance testing.

5.1.2.6 Provide a formal, written response to the position(s) taken by the AOR and other contracted parties to the project in response to ~~BECxP~~BECxP/BECxG comments and recommendations, including ~~BECxP~~BECxP/BECxG recommendations not accepted by the AOR and a summary discussion of the relative advantages, disadvantages, and potential risks associated with each of those decisions on building enclosure durability, performance, and total cost of ownership.[38]

5.1.2.7 ~~Document~~ Confirm documentation of the Design Phase OPR, enclosure BOD, and BECx Plan for review and approval by the Owner.

5.1.3 ~~*Pre-Construction*~~ *Bidding and Negotiation Phase:*

5.1.3.1 Attend a Pre-Bid Conference to review the BECx specification with prospective bidders;

5.1.3.2 Review and assist ~~with the~~ by providing Owner requested evaluation of enclosure-related bidder requests for information or clarification and assist the AOR and Owner with the development of Addenda as appropriate;

5.1.3.3 Review and assist with the evaluation of enclosure-related contractor/subcontractor bids, including at a minimum:

(1) Scheduling, phasing, and coordination of trades;
(2) Quality Assurance (QA) and Quality Control (QC) programs;
(3) Qualifications and Exclusions; and

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[33] Refer also to Guide E2947 for additional information regarding development of the OPR document.

[34] The *Design Phase* is the BECxP *minimum point-of-engagement* required to qualify as *Fundamental* BECx under this practice. Refer to ~~ASHRAE~~ANSI/ASHRAE/IES Standard 202 and Guide E2947 for additional steps associated with this phase of the BECx process.

[35] Including retro-active development of a written OPR document based on input provided by the Owner in circumstances where a formal written OPR may not exist but is required to qualify as Fundamental BECx under this practice.

[36] Required to qualify for *Enhanced* BECx under this practice (optional for *Fundamental* BECx).

[37] Required to qualify for both *Fundamental* and *Enhanced* BECx.

[38] Documentation shall be provided as part of the updated OPR.

(4) Substitutions and "Value Engineering" options.

5.1.3.4 ~~Document~~ Confirm documentation of the Pre-Construction Phase OPR, enclosure BOD, and BECx Plan for review and approval by the Owner.

5.1.4 *Construction Phase:*[39]

5.1.4.1 Technical assistance during the review of enclosure-related shop drawings and technical submittals for compliance with the contract documents;

5.1.4.2 ~~Direct and substantive~~ Substantive participation[25] in a Pre-Construction Meeting and Pre-Installation Meetings with the GC, CM, and enclosure-related subcontractors and trades[40] to review and document, at a minimum:

(1) Final approved OPR, enclosure BOD, and BECx Plan;

(2) Status of all outstanding shop drawings and technical submittals;

(3) Schedule, phasing, and coordination of enclosure-related subcontractors and trades;[41]

(4) GC, CM, subcontractor, and enclosure-related trade ~~QA, QC,~~ QA and ~~safety~~QC programs;[42]

(5) Subcontractor qualifications, exclusions, and conditions associated with the construction of a fully integrated building enclosure that may influence product, material, or installation warranties;

(6) Test standards and methodologies, performance thresholds, appropriate interpretation of test results, and definitions of failure required in the contract documents;[43]

(7) On-site construction observation and documentation protocol established for the timely identification and remediation of hidden/concealed or otherwise unanticipated conditions in the field, enclosure-related product or installation defects, and non-conforming work;

(8) Modification or refinement of enclosure-related detailing, fabrication, installation requirements, or sequencing and coordination of trades, or a combination thereof, arising from pre-construction mock-up assembly and testing.

5.1.4.3 ~~Direct and substantive~~ Substantive participation[25] during in-plant QA and QC reviews including, at a minimum, review and documentation of the methodology of:

(1) Industry standard quality control criteria that may be applicable to the procurement or manufacture, or both, of the materials, components, systems, and assemblies specified for the project;[44]

(2) Methodology established to identify, track, and remediate, at milestone intervals during production, ~~all~~ defective and nonconforming work;

(3) Product or project-specific in-house technical training programs;

(4) In-house performance testing capabilities available for application to completed components and assemblies at milestone intervals during production.

5.1.4.4 On-site construction observation and documentation, including:

(1) Periodic observation, evaluation, and documentation of enclosure-related work in progress at representative locations on the project for compliance with the contract documents;[45]

(2) Development and distribution of field observation reports, field test reports, and related documentation as required for timely and effective review and remedial action by the GC, CM, and appropriate subcontractors and trades;[46]

(3) Coordination of and attendance at regularly scheduled BECx meetings with the GC, CM, and appropriate subcontractors and trades;

(4) Review and documentation of enclosure-related field performance testing at milestone intervals throughout construction[47] for compliance with the requirements of the contract documents,[48] including at a minimum:

(a) Review and documentation of the design and construction of all field-constructed test chambers and verification of current calibration[49] of all test equipment as required by the governing industry standard for the test method specified;

(b) Review and clarification of test procedures and methodology, performance thresholds, and definition(s) of "non-compliance" or "failure" as required in the contract documents.

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[39] Reference ~~ASHRAE~~ANSI/ASHRAE/IES Standard 202 and Guide E2947 for additional information.

[40] Including, but not limited to, meetings in preparation for pre-construction laboratory or field-constructed, or both, mock-ups, "first installation" mock-ups, and actual construction in the field.

[41] Including, but not limited to, review and coordination of approved shop drawings for accuracy, completeness, and coordination with adjacent trades at enclosure interface conditions.

[42] Including, but not limited to, in-plant performance testing capabilities during production and milestone evaluation forms, checklists, and similar documentation intended to support both off-site fabrication and on-site field quality control programs.

[43] Including anticipated schedule for field testing and required coordination of trades to fully complete the work at each test specimen prior to testing.

[44] Examples include inspection or quality control criteria, or both, established by AAMA, the Portland Cement Association, and similar organizations that are in compliance with ISO 9000 and may be already required contractually or otherwise have been adopted for use by the supplier/manufacturer to which this practice is applied.

[45] The number and frequency of site visits required will vary based upon the complexity of the project and nature/extent of the work-in-progress and shall be determined at the sole discretion of the BECxP, subject to review and approval by the Owner.

[46] The BECxP shall develop, periodically update, and maintain a summary ~~"log" of~~ issues and ~~concerns~~ resolutions log including items identified during the Construction Phase of the BECx process, and the actions taken by the construction team to address or otherwise remediate missing or non-conforming work.

[47] Refer to Annex A1 and the appropriate Appendix section for detailed information regarding recommended test standards and methodology.

[48] Including coordination with GC/CM project schedule and required sequencing, and coordination of trades.

[49] Includes both project-specific calibration in the field before testing and confirmation of any annual equipment calibration that may be required by appropriate/applicable industry or trade standards.