



Designation: E3223/E3223M – 20

# Standard Guide for Specifying and Testing Field-Constructed Exterior Building Wall System Mockups in New Construction<sup>1</sup>

This standard is issued under the fixed designation E3223/E3223M; 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 ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

## 1. Scope

1.1 This guide provides information to assist in the specification, design, and performance testing of field-constructed exterior wall assemblies (“mockups”) for construction projects. This includes testing procedures appropriate to evaluate the component and assembly performance for water penetration resistance, air leakage resistance, and other test methods that may be applied as part of the quality assurance (QA) program for the installed systems.

1.2 This guide is intended to be applied to exterior wall mockups that include components, systems, and assemblies including, but not limited to, curtain walls, windows, doors, masonry walls, precast concrete, cast-in-place concrete, exterior insulation and finish system (EIFS), roofing interfaces, stucco, wood siding, metal panels, sealants, appurtenances, penetrations, louvers, and combinations thereof. Such mockups are expected to include the intersection between wall systems.

1.3 This guide is not intended to provide a comprehensive list of potential testing that may be applicable to field-constructed mockups. Additional tests may be applicable to mockups for specific projects.

1.4 This guide is not intended to address all possible project delivery methods and as such the requirements listed herein must be evaluated by the specifier for appropriateness with the delivery method.

1.5 The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system are not necessarily exact equivalents; therefore, to ensure conformance with the standard, each system shall be used independently of the other, and values from the two systems shall not be combined.

1.6 *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*

*appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.7 *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:*<sup>2</sup>

- C724 Test Method for Acid Resistance of Ceramic Decorations on Architectural-Type Glass
- C794 Test Method for Adhesion-in-Peel of Elastomeric Joint Sealants
- C1193 Guide for Use of Joint Sealants
- 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/C1652M Test Method for Measuring Optical Distortion in Flat Glass Products Using Digital Photography of Grids
- C1715/C1715M Test Method for Evaluation of Water Leakage Performance of Masonry Wall Drainage Systems
- D4541 Test Method for Pull-Off Strength of Coatings Using Portable Adhesion Testers
- D7234 Test Method for Pull-Off Adhesion Strength of Coatings on Concrete Using Portable Pull-Off Adhesion Testers
- E283 Test Method for Determining Rate of Air Leakage Through Exterior Windows, Skylights, Curtain Walls, and Doors Under Specified Pressure Differences Across the Specimen
- E330 Test Method for Structural Performance of Exterior Windows, Doors, Skylights and Curtain Walls by Uniform Static Air Pressure Difference

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<sup>2</sup> For referenced ASTM standards, visit the ASTM website, [www.astm.org](http://www.astm.org), or contact ASTM Customer Service at [service@astm.org](mailto:service@astm.org). For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

- E331** Test Method for Water Penetration of Exterior Windows, Skylights, Doors, and Curtain Walls by Uniform Static Air Pressure Difference
- E488/E488M** Test Methods for Strength of Anchors in Concrete Elements
- E576** Test Method for Frost/Dew Point of Sealed Insulating Glass Units in the Vertical Position
- E631** Terminology of Building Constructions
- E783** Test Method for Field Measurement of Air Leakage Through Installed Exterior Windows and Doors
- 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
- 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
- E1233/E1233M** Test Method for Structural Performance of Exterior Windows, Doors, Skylights, and Curtain Walls by Cyclic Air Pressure Differential
- E2359/E2359M** Test Method for Field Pull Testing of an In-Place Exterior Insulation and Finish System Clad Wall Assembly
- E2813** Practice for Building Enclosure Commissioning
- 2.2 *AAMA Standards:*<sup>3</sup>
- AAMA 501.1** Standard Test Method for Water Penetration of Windows, Curtainwalls 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 502** Voluntary Specification for Field Testing of Newly Installed Fenestration Products
- AAMA 503** Specification for Field Testing of Newly Installed Storefronts, Curtain Walls and Sloped Glazing Systems
- AAMA 508** Voluntary Test Method and Specification for Pressure Equalized Rain Screen Wall Cladding Systems
- AAMA 509** Voluntary Test and Classification Method for Drained and Back Ventilated Rain Screen Wall Cladding Systems
- AAMA/WDMA/CSA 101/I.S.2/A440** North American Fenestration Standard/Specification for windows, doors, and skylights
- 2.3 *Other Standards:*
- ASCE/SEI 7** Minimum Design Loads and Associated Criteria for Buildings and Other Structures<sup>4</sup>
- ISO/IEC 17025** General requirements for the competence of

testing and calibration laboratories<sup>5</sup>

### 3. Terminology

3.1 *Definitions*—For definitions of general terms related to building construction used in this guide, refer to Terminology **E631**.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *complete wall assembly mockup, n*—mockup assembly that is adequately complete to simulate accurately the conditions and properties of the wall being evaluated by the specifier.

3.2.2 *detailing mockup, n*—mockup specimen used to evaluate detailing of wall system components but not performance.

3.2.2.1 *Discussion*—This type of mockup is intended to serve as a full-scale, three-dimensional model and training tool illustrating the proper assembly of the exterior wall systems as required in the approved project documents for a given building or structure.

3.2.3 *integrated mockup, n*—mockup specimen built on the building structure.

3.2.3.1 *Discussion*—If properly installed and validated through testing, it may be integrated into the completed construction if testing does not cause visible or unseen damage. It may also be known as an “on-structure mockup.”

3.2.4 *layered mockup, n*—mockup specimen of components or subsystems with portions of the exterior cladding partially or fully omitted so that they do not entirely conceal the underlying layers of the wall assembly.

3.2.4.1 *Discussion*—A critical component or subsystem, which is covered up and concealed by subsequent work (such as flashing), is difficult to inspect and receive potential corrective measures. A layered mockup of the component or subsystem provides an opportunity for the project team to review the standard of installation of the critical component or subsystem and, if required, develop and test corrective measures.

3.2.5 *off-structure mockup, n*—mockup specimen built separate from the building structure and typically, but not necessarily, constructed on the building site; may also be known as a “remote mockup” or a “standalone mockup.”

3.2.6 *owner’s designated representative, n*—party whom the owner has authorized to accept or reject work.

3.2.7 *reduced scale mockup, n*—mockup that includes the same components as will be used on the building but that does not have a consistent scale as to the sizes of individual features.

3.2.7.1 *Discussion*—Note that the size of the components could potentially affect the performance of those components during testing.

3.2.8 *specifier, n*—party responsible for defining the exterior wall system; typically, but not necessarily, the specifier is the designer of record.

<sup>3</sup> Available from American Architectural Manufacturers Association (AAMA), 1827 Walden Office Square, Suite 550, Schaumburg, IL 60173-4268, <http://www.aamanet.org>.

<sup>4</sup> Available from American Society of Civil Engineers (ASCE), 1801 Alexander Bell Dr., Reston, VA 20191, <http://www.asce.org>.

<sup>5</sup> Available from International Organization for Standardization (ISO), ISO Central Secretariat, BIBC II, Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland, <http://www.iso.org>.

3.2.9 *testing/inspection agency, n*—agency selected to verify compliance of the mockup with contract requirements or conduct the specified testing, or both.

3.2.10 *visual mockup, n*—mockup specimen used to assess color, shape, and texture of exposed building components, but not constructability or performance.

#### 4. Significance and Use

4.1 This guide is intended to assist the construction team in evaluating the constructability, functionality, sequence of construction, interference, tolerances, component performance, and assembled system performance of the exterior wall systems.

4.2 This guide does not establish specific roles for the parties involved during construction or the contractual obligations of those parties. The role of each party within any specific project should be established and documented before the start of the project.

4.3 This guide is intended for use when specifying construction mockups that are either integrated mockups or off-structure mockups.

4.4 This guide is intended to aid the specifier in the development of a QA mockup program for assessing the performance of exterior walls. It is not intended to provide a comprehensive list of applicable test methods for QA testing available or applicable to a mockup program.

4.5 This guide does not address preconstruction laboratory testing of a wall system.

4.6 This guide is intended to address technical issues with the performance of the wall system and the interconnection of the various components and systems. A mockup may or may not be used as an aesthetic mockup; however, this guide is not intended to address aesthetic issues with the wall system.

4.7 This guide is not intended to provide guidance for construction observation services. However, the mockup may be useful to inform inspectors of the intended construction, sequence, materials, and interface conditions encountered on the project and serve as a standard of quality to which the remainder of construction can be compared.

#### 5. Scope of Mockups

5.1 The overall scope of a mockup program will vary between projects and should be clearly specified to achieve the objectives set forth by the design team, the owner or developer, and the overall project sequence.

5.2 The number of mockups for a specific project varies and is dependent on the number, complexity, and uniqueness of wall systems specified for the project.

5.3 Visual mockups are primarily used to allow the designer of record to approve or reject the appearance of the building components. They often omit hidden components of the wall assembly and, in some cases, use components that are not directly consistent with the design to convey the aesthetic qualities. In these cases, visual mockups should not be used to verify performance or constructability.

5.4 A complete wall assembly mockup represents a more comprehensive mockup scope option. The complete wall assembly mockup can be either an integrated mockup or an off-structure mockup. In some cases, a cladding could be omitted if it is solely aesthetic and not part of the weather resistance of the wall. If a cladding is omitted, any related anchorage or fastening penetrations should still be installed to assess their impact on the air and water barrier. A complete wall assembly mockup can satisfy many objectives of a mockup program, but concealed conditions will not be accessible for training or serve as an easily observed standard of workmanship.

5.5 While a complete wall assembly mockup can be specified to be off site, off structure, or integrated into the construction, a detailing or layered mockup is typically constructed on site for demonstration and instructional purposes but is not incorporated into the finished work on the project as an integrated mockup.

5.6 Complete wall assembly mockups often represent the typical detail conditions in the wall system; however, atypical conditions can also be included to evaluate specific materials, details, or interfaces.

5.7 Reduced-scale and detailing mockups are typically more limited in size and scope than full-size mockups. As a result, they can help evaluate a greater range of specific details and configuration of the components in the assembly. An example of a typical detailing mockup might be the intersection of the flashing, moisture barrier, air barrier, and window frame. It is important that detailing mockups remain consistent with the project documents.

#### 6. Design

6.1 The primary objective of a mockup program is to evaluate the constructability and performance of a representative building assembly at the beginning or during the construction process (or both) when further modification and refinement of exterior wall assemblies and details can still be accomplished with minimal impact on the schedule and cost of the work. The mockup program may include:

6.1.1 *Evaluation of Details*—A mockup can include typical wall conditions as well as unique wall conditions. Complex details, particularly interfacing details in which several subsystems should be integrated and made weathertight, are difficult to conceptualize, draw, and communicate to the trades. A mockup provides the opportunity to verify that all the requirements for a detail have been properly addressed in the design and are understood by the trades.

6.1.2 *Coordination of Trades*—Proper implementation of waterproofing and weather-resisting details often require coordination of several different trades. A mockup can provide an opportunity for each of the trades involved to understand their individual roles and integration with other trades in the sequence of construction required to achieve the desired result.

6.1.3 *Identification of Conflicts*—Even with care and modern analytical tools, constructability problems might not be identified in the design process. A mockup provides the opportunity to identify and respond to problems such as

conflicts and physical interference between subsystems, difficulties in accessing a work area because of preceding work, unforeseen compatibility or adhesion issues, and gaps or omissions in the interfacing between subsystems.

**6.1.4 Establishment of Acceptable Standards for Workmanship**—Several different crews may be working simultaneously on the same item of work. A mockup that remains undisturbed and accessible for the entire project can serve as a standard or benchmark for the work so that all crews are held to an agreed-upon and demonstrated standard for workmanship. Mockups can also help resolve disputes, clarify intent, and be used for training.

**6.1.5 Performance Verification**—Field preconstruction qualification testing may be required to be performed on a mockup. If so, the project documents should define the portion of the wall system to test, the approximated construction intervals for which the testing is to occur, the parties to be in attendance, and the test methods and the performance requirements of the specified testing. Where possible, tests of a mockup should be performed in advance of release of materials and actual construction providing an opportunity to respond to issues identified during the tests in a timely manner.

**6.1.6 In-Service Operation, Repair, and Maintenance**—Components and systems included in a mockup should accurately reflect the construction of the wall system in service so that considerations for the operation, removal, or replacement of components (such as damaged glass or failed sealants) may be reviewed. Maintenance of renewable items should be considered in the design of a mockup, and the viability of the required maintenance procedures should be verified after the mockup is constructed.

**6.2** Specific design criteria for the construction, evaluation, and testing of the mockups should be included in the project documents.

**6.3** The project documents produced should include enough information to describe the materials, details, and performance testing requirements of the mockups. This should include:

- 6.3.1 Types of mockups,
- 6.3.2 Mockup size and dimensions (including drawings depicting mockups as necessary),
- 6.3.3 Number and location of mockups,
- 6.3.4 Test protocol for each mockup,
- 6.3.5 Performance requirements and any pass/fail criteria,
- 6.3.6 Requirements for notification of parties before testing,
- 6.3.7 Schedule for performing mockup construction and testing, and
- 6.3.8 Clarification of roles and responsibilities.

**6.4** Project documents should include the requirements for mockup shop drawing submittals and related technical information, illustrating the design and intended construction of the mockups. For each trade, shop drawings and submittals for the mockups should be required by the project documents to be reviewed and approved before starting the construction of the mockups.

**6.5** The specification of mockups for testing during the construction of a building can have an impact on both the construction schedule and cost depending on the extent of

testing performed. These issues should be discussed during the design development phase of the project.

**6.6** The extent of testing specified should be based on a variety of factors such as: the success of previously constructed projects of similar wall design with similar weather exposure, the complexity of the design, the extent of problems experienced on previous projects of similar construction, the sensitivity of the completed construction to water penetration and air leakage, the extent of fenestration, the relevancy of previously completed laboratory testing, and the owner's project requirements. These factors should be discussed in the development of the scope of testing and included in the project documents.

**6.7** The performance requirements of the mockups should be consistent with the construction proposed for the building wall systems.

**6.8** The number of in-situ field tests to be performed on exterior wall integrated mockups of the building and guidance regarding locations for the testing should be provided in the project documents.

**6.9** The necessary pass/fail criteria and subsequent approvals required on the mockups should be defined, as well as who will provide those approvals, including the consequences and follow-up actions required after failures.

**6.10** The schedule for completion of the mockups should be indicated at specific stages of the project. Integrated mockups are typically installed before installing other portions of the wall system. For off-structure mockups, the timeframe is not tied directly to the progress of the building structure; however, mockups should be completed early enough to provide time for modifications as necessary before the start of constructing the exterior walls on the building.

**6.11** When there are stages at which the contractor should provide notification to allow for the inspection of a partially completed mockup, those stages and the notification requirements should be defined in the project documents. Construction of a mockup should not continue until the mockup is reviewed. The extent of the review will vary depending on the mockup type being specified. For example, mockups that have portions of the systems covered by subsequent layers of material will require multiple visits during construction versus mockups in which the layers remain exposed.

**6.12** The project documents should identify who should be present at meetings to review mockup construction.

**6.13** "Pretesting" and subsequent modification of mockups should be prohibited unless the modifications are reviewed by the owner's designated representative and the resulting corrective work is documented so that it can be implemented on similar systems on the rest of the project.

**6.14** Unless otherwise agreed upon by the design professional, owner's representative, and the contractor, an independent third-party testing/inspection agency should be required to perform specified performance testing of the mockups and report the results.

6.15 Procedures for documenting modifications to a mockup and noting corrections to be made in the final construction should be listed in the project documents.

6.16 Mockups constructed before or during construction should be constantly updated (where possible) to reflect modifications to the exterior walls that are generated during the construction period.

## **7. Construction**

7.1 The project documents should include specific requirements for the responsibilities of all stakeholders and their roles in the construction and testing of the mockups.

7.2 Mockups to be tested should be installed as required by the project documents.

7.3 A mockup should be installed by the same subcontractors (and if possible, the same personnel) who will construct the related exterior wall systems on the project. It is important that mockups be installed under the supervision of the contractor's designated representative and reviewed by the quality control personnel who will be responsible for the work on the remainder of the project.

7.4 In projects with performance-based specifications, the contractor and subcontractors should be responsible for modifications to the wall system to meet the performance requirements of the project. All modifications made to a mockup should be documented in writing by the contractor and subcontractors and the testing/inspection agency. The project documents should make it clear that the contractor cannot make modifications to the approved design on his/her own without the knowledge of other parties.

7.5 All modifications that could affect the performance of a mockup should be evaluated by the designer of record and the owner's designated representative to determine if post-modification testing is necessary. If retesting is required, the modification/retesting process should be repeated until the mockup passes all the specified testing.

## **8. Testing/Inspection Agency**

8.1 Provisions should be included in the project documents that outline the qualifications, accreditations, and responsibilities of the testing/inspection agency. Guidance to the specifier regarding the importance of testing/inspection agency accreditation is included in the appendix.

8.2 The testing/inspection agency should verify that mockups conform to the project documents and record, in writing, variations and nonconformances of the as-built wall system from the requirements of the project documents. It is important that variations between the as-built wall system in a mockup and the project documents be identified by the testing/inspection agency and understood by the project team.

8.3 After review of the contract documents, the testing/inspection agency should develop a test plan that includes the reference test methods, the pass/failure criteria for each test, and the proposed sequence of testing. The test plan should be reviewed by the designer of record and the owner's designated representative before the start of testing.

8.4 The testing/inspection agency should perform the testing in accordance with the specified test procedures or report any deviations from the test procedure.

8.5 The testing/inspection agency should prepare a written report presenting the results of the testing that states the location of deficiencies, observations, and failures and whether the specimen meets or fails to meet the specified requirements of the project. The report should also include any additional information required by the specified test procedures.

8.6 The testing/inspection agencies should be independent third parties reporting directly to the owner and be qualified professionals (credentialed where required).

## **9. Factors in Selection of Field Testing for Mockups**

9.1 The testing to be performed on exterior wall system mockups should be defined by the specifier in the project documents.

9.2 The assembly and testing of field-constructed mockups are valuable tools in the evaluation of wall system detailing and performance. The tests can be performed to evaluate the impact of field conditions (that is, proximity of the wall system to the building structural elements) and form a part of the QA program for the construction of the building. Field tests should be selected based on the owner's project requirements for the performance of the building.

9.3 Certain tests are typically performed in a laboratory rather than in the field, including, but not limited to, structural testing, thermal testing, acoustical testing, fire testing, missile or windborne debris impact testing, and seismic and wind-induced inter-story drift testing. Laboratory mockup testing is not part of this guide; however, similar tests for acoustical, structural, and thermal performance can be conducted on field-constructed mockups when the performance of a particular system or component is in question. Field versions of laboratory test methods should be vetted before inclusion in the contract documents to prevent conflicts during construction regarding the appropriateness of the methods. Field-constructed mockups should incorporate remedies developed to address deficiencies identified during laboratory testing, if any.

9.4 The performance requirements such as the test pressure and the pass/fail criteria for each of the test procedures should be specified in the project documents.

9.5 The field testing of a mockup for water penetration and air leakage may be performed without project-specific laboratory testing. This may be performed on projects for which the wall system to be installed is a standard wall system and the manufacturer provides results from previous performance testing on similar materials, systems, or assemblies.

9.6 In many cases, the primary surface that performs air, water, and vapor management is concealed within the system or behind other cladding elements. In some cases, it may be appropriate to adapt existing test methods to test these transitions and concealed conditions to provide a more accurate evaluation of their performance and locate possible defects in the overall assembly. However, test standards that are intended

only for the exposed conditions shall be carefully adapted to account for the fact that many of these concealed conditions would not ordinarily be exposed to such rigorous test conditions. The specifier should recognize that there are conditions in which testing of a fenestration perimeter with or without the adjacent cladding or screen sealants may be appropriate.

9.7 Where test methods are adapted by the construction documents to test the interface elements, or to test enclosure elements differing from those intended by the test standards, the construction documents shall resolve any conflicts in test methods and failure criteria.

## 10. Factors in Selection of Mockup Specimen

10.1 *Selection of Mockup Specimen*—The specifier should determine the number and type of mockup specimens to test. The type and number of tests should be defined in the construction bid documents to avoid changes to the contract during construction. The mockup specimen may be a hybrid of mockup types.

10.2 *Execution of the Mockup*—A mockup specimen should be selected and specified according to the objectives of the process and the sequencing of the overall project. A mockup can be specified as either an off-structure or as an integrated mockup, each with its advantages and disadvantages.

10.2.1 *Off-Structure Mockup*—A field mockup can be constructed separately from the actual project. This is typically specified to be constructed on site. However, in special circumstances, often when the site does not allow for on-site construction, the off-structure mockup can be built at an off-site location. In these cases, some of the advantages listed in 10.2.1.1 are diminished. The substrates and the subsystems included in an off-structure mockup should be clearly specified.

### 10.2.1.1 *Advantages of an Off-structure Mockup:*

(1) Off-structure mockup construction is not tied directly to the progress of construction of the building. The off-structure mockup can be constructed early in the project, such as when foundation work is being performed. As a result, lessons learned from the mockup early in the project can more easily be incorporated into project documents (through shop drawings) and the built systems. An off-structure mockup can be used for qualification and quality control testing before work on the actual project begins. Most laboratory tests of project-specific assemblies are off-structure mockups of this type. Off-structure test protocols can also include potentially damaging tests that should not be performed on integrated mockups (if safety and sequencing issues are considered).

(2) If implemented on the construction site, an off-structure mockup that remains undisturbed and accessible for the entire construction project can serve as a sample or benchmark for detailing interfacing of trades and workmanship. Most site-built sample walls are mockups of this type.

(3) An off-structure mockup can integrate a variety of conditions that are widely separated from each other on the building.

(4) Off-structure mockups are freestanding and provide more flexibility for the kinds of test chamber construction needed for certain types of performance testing. It is often

useful to identify the testing setup requirements such as pressurization chambers and interface conditions with a mockup in the project documents.

(5) Off-structure mockups provide a significant advantage when opaque wall and whole mockup air infiltration/exfiltration testing is required.

### 10.2.1.2 *Disadvantages of an Off-structure Mockup:*

(1) The selection of trade contractors responsible for construction of an off-structure mockup may not be entirely established early in the project. Some materials and assemblies, such as windows, may have significant lead times for delivery. Additionally, the schedule may be impacted by construction factors such as material cure time and construction sequencing. Such issues should be considered before the specification of a schedule for the construction of an off-structure mockup.

(2) Consideration should be given to the possible costs associated with the following: engineering, testing setup charges, minimum order quantities, mobilization, coordination of trades, fabrication and delivery of specialty items (for all subsystems involved in the mockup), preceding out of sequence with the on-site work, and removal of the mockup from the site.

10.3 *Integrated Mockup*—A mockup can be implemented on the actual construction project, and the components of the mockup can eventually be integrated into the finished work. One or more areas can be selected for completion early in the project.

### 10.3.1 *Advantages of an Integrated Mockup:*

10.3.1.1 A simulation of structural support and substrate conditions does not have to be designed and built separately from the project.

10.3.1.2 Materials installed remain in service for the actual project. Only limited materials and labor are consumed specifically and exclusively for the mockup process.

10.3.1.3 An integrated mockup can provide most of the benefits of a mockup program at potentially less cost than an off-structure mockup.

### 10.3.2 *Disadvantages of an Integrated Mockup:*

10.3.2.1 The integrated mockup area may be covered or concealed by subsequent phases of the work and, therefore, not be available as a benchmark.

10.3.2.2 Construction progress may be interrupted for refinements, adjustments, and testing of an integrated mockup.

10.3.2.3 Since an integrated mockup is built after the beginning of construction, it may be difficult and costly to change details, shop drawings, and manufacturing in response to problems identified by the lessons learned from the mockup. This is, however, preferable to identifying problems after construction has progressed.

10.3.2.4 Some testing cannot be performed until the work of all trades is complete. At that point, many of the trades are often well into construction on the remainder of the building.

10.3.2.5 Air infiltration performance may not be reliably tested in an integrated mockup because of the inability to isolate properly the portions of the integrated mockup from surrounding conditions.

## 11. Reports

11.1 The review of a mockup should be performed and reported on by the owner's designated representative. The owner's designated representative should provide written reports on each mockup to the project team. Each report should provide a general description of the mockup, a list of the specified testing, and an outline of the performance requirements.

11.1.1 The reports should indicate conformance or nonconformance with the project documents for the project. If a mockup, or a portion thereof, is found to be noncompliant because of performance failures documented during testing or installation, then the report should clearly state the specified performance and the specific noncompliance with the requirements. The report should include documentation of all remedial action as discussed and agreed upon by the contractor and subcontractor.

11.1.2 If remedial action is taken, the report should include the results of testing of the remediated mockup and whether the remediated mockup meets the project performance requirements.

11.2 Generally, the standardized test methods referenced by this guide provide reporting requirements for the testing. These requirements should be reviewed by the specifier and additional requirements added as necessary before competitive bidding of the project to address project-specific performance objectives established for a given building or structure.

## 12. Keywords

12.1 mockup; quality assurance; testing

## APPENDIX

### (Nonmandatory Information)

#### X1. MOCKUP TESTING METHODS

X1.1 *Introduction*—Table X1.1 provides information on test methods that may be used to verify the performance of mockup materials, assemblies, or systems. This table is largely based on the tests included in the enhanced field mockup testing category of Table A2.1 of Practice E2813. This table is intended to provide initial guidance to a specifier in selecting test methods that have been found to be appropriate for use on mockups. This list is not all-inclusive and not all tests listed will be relevant to all mockups. Often, performance verification testing standards are not developed with the intent of testing mockup panels. Some test methods are intended to be performed in a laboratory but can be adapted for use on field mockups with appropriate modifications. Many tests are not intended for testing interfaces with adjacent wall systems. However, if a specifier chooses to adapt a test method to test the interfaces of the mockup, those adaptations as well as the resolution of all conflicts between the test methods and the criteria contained therein should be clearly stated in the project

documents. Exterior building walls usually consist of a combination of various subsystems and a variety of materials. Some of the tests discussed in this appendix are intended for a specific subsystem or material, and some can be applied to several subsystems simultaneously or to the entire wall. The specifier should be clear and specific about which specified tests apply to which subsystem or combination of subsystems. In addition, performance verification of the interface between subsystems is a critical objective of mockup testing and should be addressed in the overall mockup testing program. A general discussion of wall test methods applicable to mockups and guidance for adaptation of test methods where practical is provided in Table X1.1. The specifier is encouraged to carefully review the individual tests and require qualified and appropriately accredited testing agencies to perform the tests specified. Accreditation in accordance with ISO/IEC 17025 or other appropriate accreditation bodies should be used as the basis for determining competence of the testing agency.