Using ASTM E2128 – Standard Guide for Evaluating Leakage of Building Walls

Robert Kudder, PhD, S.E., FASTM

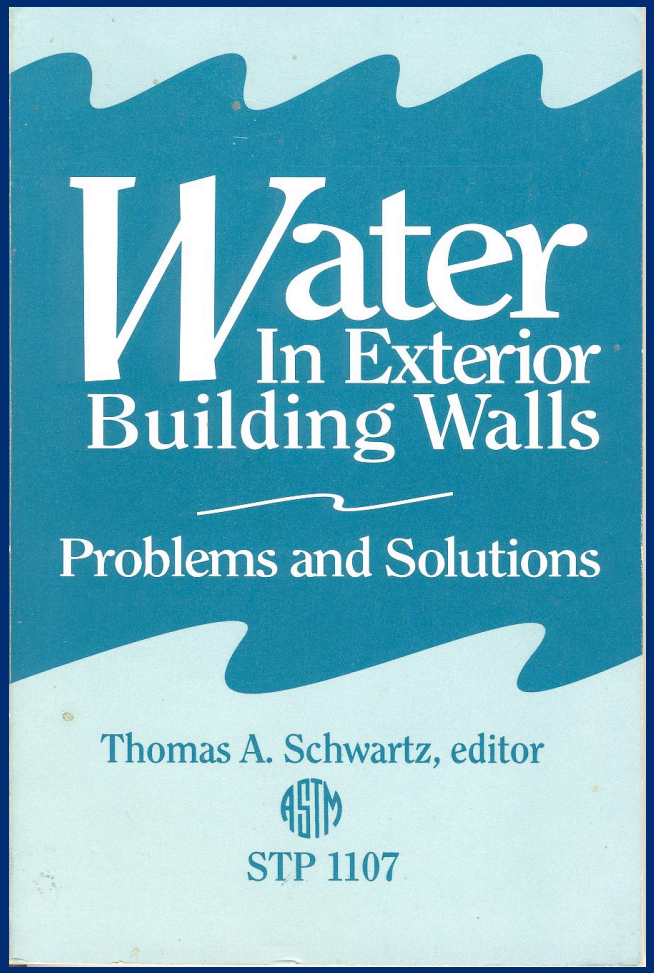
Raths, Raths & Johnson, Inc

BEC Detroit, October 14, 2014

Background

- 1986 Alan Yorkdale and James Gross gathered professionals together to form a new Subcommittee to deal comprehensively with building walls as systems
- Complement material and subsystem specific standards, incorporating existing standards as appropriate
- 15 wall properties; Water resistance > Leakage

ASTM Symposium 1990



- Chaired by Tom Schwartz
- Many papers with diverse and considered approaches to evaluations
- Many authors became active in E06.55
- Many Symposia have followed

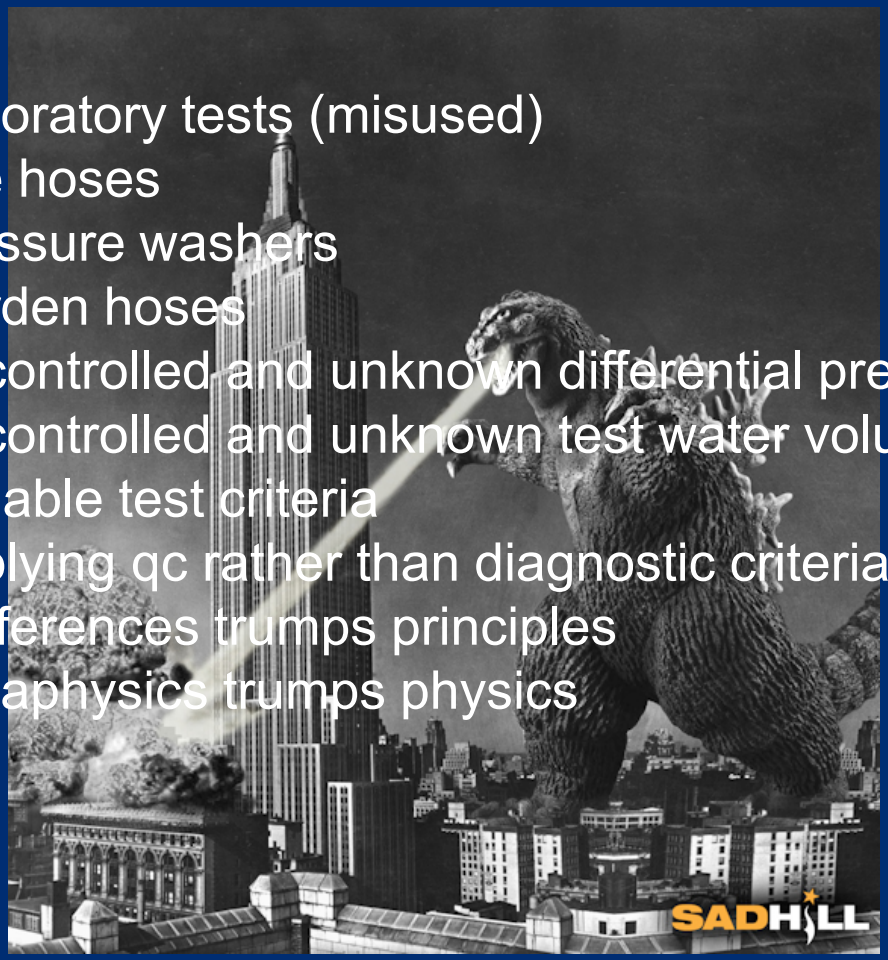
E06.55.15 – Water Penetration

Leakage -> Dispute -> Resolution
Conflicting evaluations

(assumed)

Evaluation -> Testing

- Laboratory tests (misused)
- Fire hoses
- Pressure washers
- Garden hoses
- Uncontrolled and unknown differential pressure
- Uncontrolled and unknown test water volume
- Variable test criteria
- Applying qc rather than diagnostic criteria
- Preferences trumps principles
- Metaphysics trumps physics



Test and it will fail

Resolution

- Need a protocol which a competent professional can hold himself accountable to and also hold an opposing professional accountable to
- The most expedient, efficient and just resolution of a dispute results when competent and accountable professionals are involved
- An inexperienced, incompetent, self-promoting consultant operating outside the guidelines of scientific principles hinders dispute resolution

Designation: E2128 – 12

Standard Guide for Evaluating Water Leakage of Building Walls[1]

This standard is issued under the fixed designation E2128; 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.

1. Scope

1.1 This guide describes methods for determining and evaluating causes of water leakage of exterior walls. For this purpose, water penetration is considered leakage, and therefore problematic, if it exceeds the planned resistance or temporary retention and drainage capacity of the wall, is causing or is likely to cause premature deterioration of a building or its contents, or is adversely affecting the performance of other components. A wall is considered a system including its exterior and interior finishes, fenestration, structural components, and components for maintaining the building interior environment.

1.2 Investigative techniques discussed may be intrusive, disruptive, or destructive. It is the responsibility of the investigator to establish the limitations of use, to anticipate and advise of the destructive nature of some procedures, and to plan for patching and selective reconstruction as necessary.

1.3 *This practice does not purport to address all of the safety concerns, if any, associated with its use. Establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use. Awareness of safety and familiarity with safe procedures are particularly important for above-ground operations on the exterior of a building and destructive investigative procedures which typically are associated with the work described in this guide.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

C1601 Test Method for Field Determination of Water Penetration of Masonry Wall Surfaces

C1715 Test Method for Evaluation of Water Leakage Performance of Masonry Wall Drainage Systems

E331 Test Method for Water Penetration of Exterior Windows, Skylights, Doors, and Curtain Walls by Uniform Static Air Pressure Difference

E547 Test Method for Water Penetration of Exterior Windows, Skylights, Doors, and Curtain Walls by Cyclic Static Air Pressure Difference

E631 Terminology of Building Constructions

E860 Practice for Examining And Preparing Items That Are Or May Become Involved In Criminal or Civil Litigation

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

E1188 Practice for Collection and Preservation of Information and Physical Items by a Technical Investigator

2.2 *AAMA Standards:*[3]

AAMA 501.2 Quality Assurance and Diagnostic Water Leakage Field Check of Installed Storefronts, Curtain Walls and Sloped Glazing Systems

AAMA 511 Voluntary Guideline for Forensic Water Penetration Testing of Fenestration Products, Article 4.2.1.3.1 Optional Sill Dam Test (This test method previously appeared in AAMA 502.)

3. Terminology

3.1 *Defintions*—Refer to Terminology E631.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *incidental water*—unplanned water infiltration that penetrates beyond the primary barrier and the flashing or secondary barrier system, of such limited volume that it can escape or evaporate without causing adverse consequences.

3.2.2 *water absorption*—a process in which a material takes in water through its pores and interstices and retains it wholly without transmission.

3.2.3 *water infiltration*—a process in which water passes through a material or between materials in a system and reaches a space that is not directly or intentionally exposed to the water source.

3.2.4 *water leakage*—water that is uncontrolled; exceeds the resistance, retention, or discharge capacity of the system; or causes subsequent damage or premature deterioration.

[1] This guide is under the jurisdiction of ASTM Committee E06 on Performance of Buildings and is the direct responsibility of Subcommittee E06.55 on Exterior Building Wall Systems.

Current edition approved Jan. 1, 2012. Published January 2012. Originally approved in 2001. Last previous edition approved in 2009 as E2128 – 01a (2009). DOI: 10.1520/E2128-12.

[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 Document Summary page on the ASTM website.

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

“Leakage”

~~Standard Guide to Determine If a Building Leaks~~

~~Standard Guide to Prevent Building Leaks~~

- 4.2 This guide is not intended as a design guide or as a guide specification…
- 5.2 The protocol in this guide is not based on conventional hypothesis testing and quantitative random sampling. The starting premise for the application of this guide is that the building is suspected or known to leak. The objective of this guide is to …address the question of why, how and to what extent a building leaks.
- 5.4 The recommended sampling method for the application of this guide is to consider the spectrum of wall conditions…

Sampling

Journal of ASTM International, Vol. 4, No. 9
Paper ID JAI100815
Available online at www.astm.org

Lonnie L. Haughton[1] *and Colin R. Murphy*[2]

Qualitative Sampling of the Building Envelope for Water Leakage

ABSTRACT: Industry standards for intrusive water leakage evaluations of the building envelope are promulgated by ASTM E 2128, "Standard Guide for Evaluating Water Leakage of Building Walls," which lays out a purposeful step-by-step methodology by which information is accumulated and succeeding sampling locations are identified by a skilled professional; however, some laypersons have criticized building envelope survey findings that are not derived statistically from random sampling. This paper notes that there are relatively few building envelope investigations for which statistical random sampling, in and of itself, is a legitimate or practical methodology for achieving a comprehensive understanding of the sources and mechanisms of water leakage and, therefore, the use of quantitative (i.e., statistical) survey protocols to evaluate the validity of purposeful qualitative sampling of the building envelope is not appropriate. Further, this paper demonstrates that a building envelope evaluation that has been carried out in conformance with ASTM E 2128 satisfies current rules of evidence that require an expert's sampling methodology and analysis to be based upon "scientifically valid" principles. In addition, this paper identifies fundamental assumptions that guide the initial steps of most water leakage evaluations, proposes basic categories for prioritizing the sampling, and discusses the potentially complementary roles of limited surveys by plaintiff and defense experts.

KEYWORDS: qualitative sampling, qualitative survey, purposive sampling, inductive analysis, random sampling, building envelope, ASTM E 2128, substantive significance, rules of evidence

Footnote #4

“Leakage”

- *3.2 Definition of terms specific to This Standard:*
- *3.2.1 incidental water*
- *3.2.2 water absorption*
- *3.2.3 water infiltration*
- *3.2.4 water leakage*
- *3.2.4 water penetration*
- *3.2.6 water permeation*

“Leakage”

- 1.1 …water penetration is considered leakage, and therefore problematic, if it exceeds the planned resistance or temporary retention and drainage capacity of the wall, is causing or is likely to cause premature deterioration of a building or its contents, or is adversely affecting the performance of other components. …

“Walls”

- 1.1 … A wall is considered a system including its exterior and interior finishes, fenestration, structural components, and components for maintaining the building interior environment.
- 5.1 … systematic approach to evaluating wall leaks and is applicable to any wall system or material. It differs from other approaches which are material specific or component specific…

“Evaluating”

- 5.3 … The evaluation of water leakage of building walls is a cognitive process in which technically valid conclusions are reached by the application of knowledge, experience and a rational methodology to determine the following:
- 5.3.1 The intrinsic properties of the wall
- 5.3.2 The cause(s) and mechanism(s) of leakage
- 5.3.3 The applicability of findings to similar un-inspected or un-tested locations on the building

“Guide”

- NOT a “specification” or “practice”
- Emphasis is on scientific principles: systematic, comprehensive, rational, justifiable, repeatable, verifiable, properly reported
- Strength from adaptability and flexibility
- 4.1.2 …It is the responsibility of the professional using this guide to determine the activities and sequence necessary to properly perform an appropriate leakage evaluation of a particular building.

Systematic Approach

- 5.1.1 *Sequence of Activities –*
- *5.1.1.1 Review of project documents*
- *5.1.1.2 Evaluation of design concept*
- *5.1.1.3 Determination of service history*
- *5.1.1.4 Inspection*
- *5.1.1.5 Investigative testing*
- *5.1.1.6 Analysis*
- *5.1.1.7 Report*

Systematic Approach

- 5.1 … The sequence of activities is intended to lead to an accumulation of information in an orderly and efficient manner, so that each step enhances and supplements the information gathered in the preceding step.
- 5.1.2 The first four activities … intentionally precede *10. Investigative Testing* because they facilitate a rational determination of the spectrum of conditions and are the basis for a rational selection of investigative test locations and procedure.

Review Project Documents

- Available, accessible, complete OR missing and incomplete
- Design, bid, contract, referenced codes and standards, submittals, mock-up, RFI, CO, CCD, meeting minutes, qa reports, progress photos, correspondence, repairs/modifications
- Local practices (undocumented influence)
- Missing documents burden the inspection process

Design Intent

- Is there one?
  - Do the documents reveal an intended water resistance mechanism in a consistent way?
  - Burden on the evaluator to understand design concepts
- Performance criteria: original, contemporary
- Exposure: design, adequacy
- Achieved: consistent, complete, constructible

Service History

- Information gathering
  - Patterns of leakage and damage
  - Judge findings
- Symptoms of leaks
  - Usual suspects

Usual Suspects

- Wall/ceiling
- Wall/floor
- Window, door, vent, louver
- Wall/low roof
- Balcony
- Service penetrations
- Handrails
- Roof termination
- Setbacks
- Corners and edges
- Transitions
- Field
- Within fenestration
  - Mullions
  - Sill/Jamb
  - Splices
  - Gaskets/glazing
  - Interfaces
  - Curbs/slab edge

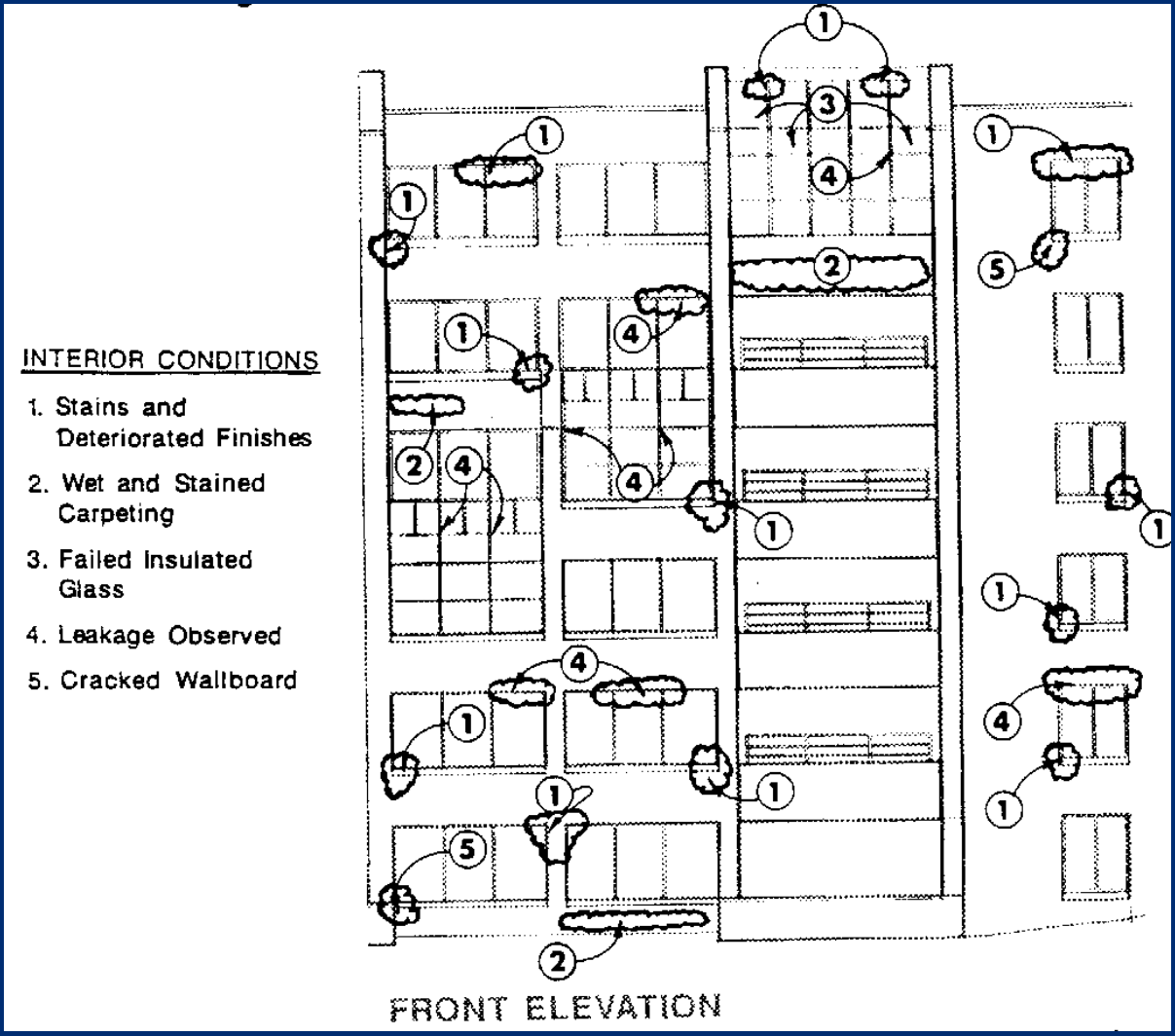
Service History

- Information gathering
  - Patterns of leakage and damage
  - Judge findings
- Symptoms of leaks
  - Usual suspects
- Interviews
  - Observations: origination, path, accumulation
  - Conditions (interior and exterior)
  - Related features

Service History

- Maintenance and repair records
  - Correct or exacerbate leakage
  - Distinguish repairs from original construction
- Weather records
- Correlation
  - Events/conditions
  - Building features
- Interpretation

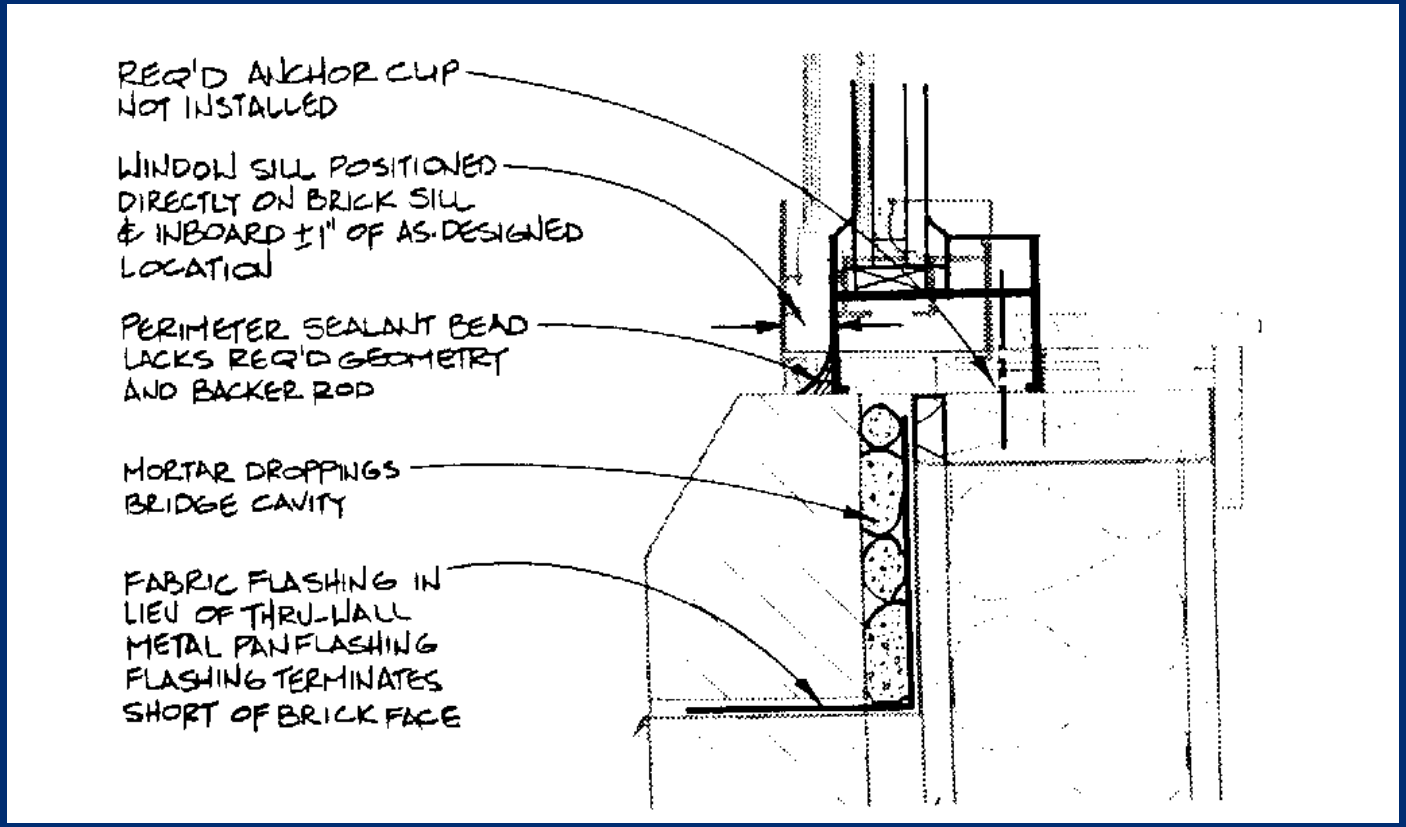
Correlation with Building Features



Inspection

- As-built condition (verify *or* document)
- Current conditions
  - Concealed configuration (flashing)
  - Concealed damage
  - Water paths: drips, stains, daylight
  - Components: gaskets, seals, coatings
  - Wear and tear
- Scope: typical/atypical, performing/non-performing; scope of findings

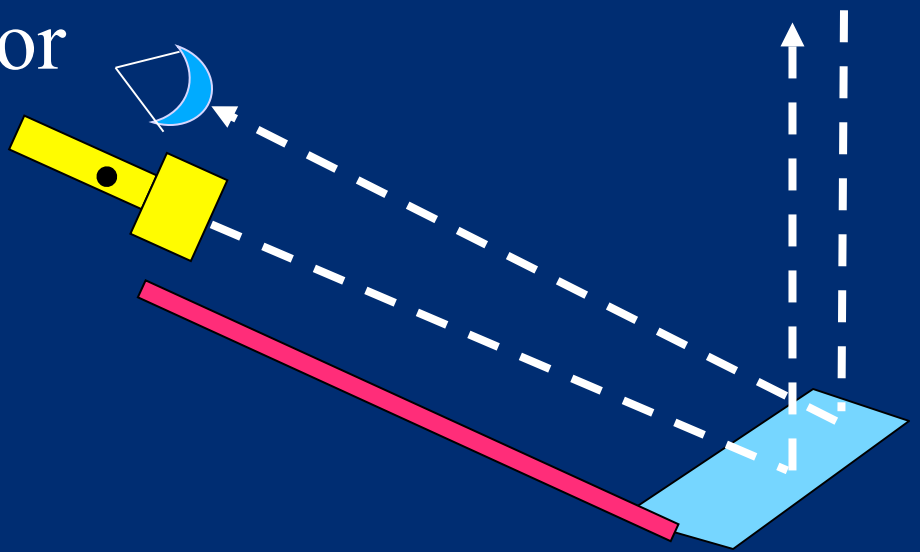
Verification



Half-tone composite drawing of all available information used as
A field recording drawing for actual conditions

Inspection Tools

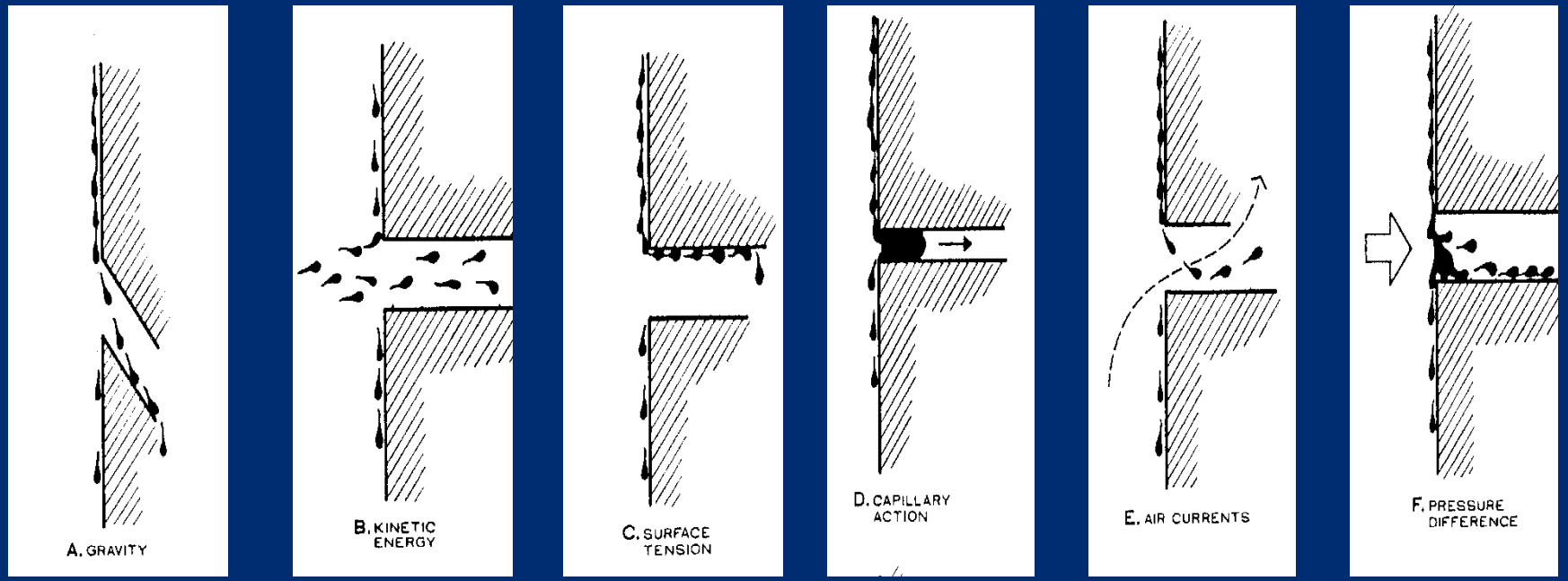
- Openings
- Digital camera
- Fiber-optic borescope/camera
- Smoke generator
- Flashlight and mirror



Investigative Testing

- Objectives
  - Recreate leaks, not create leaks
  - Trace concealed paths
  - Correlate behavior during test with observed behavior and damage during service
  - Verify hypotheses
- Exercise all transport mechanisms
- Isolate features for diagnosis
- Locations and sequence of testing

Transport Mechanisms



AAMA – Aluminum Curtain Wall Design Manual

Analysis

- Diagnosis and evaluation is NOT standard pass/fail program
- Known or suspected non-performing wall
- What E2128 is for
  - Establish a standard for accountability
  - Allow flexibility for a rational approach by a knowledgeable professional
  - Intrinsic properties vs anomalies
  - Patterns and commonalities
  - Correlation with known performance
  - Relevance to overall performance
- Reporting – complete, rational, repeatable

ASTM C1601

Calibrated Nozzle AAMA 501.2

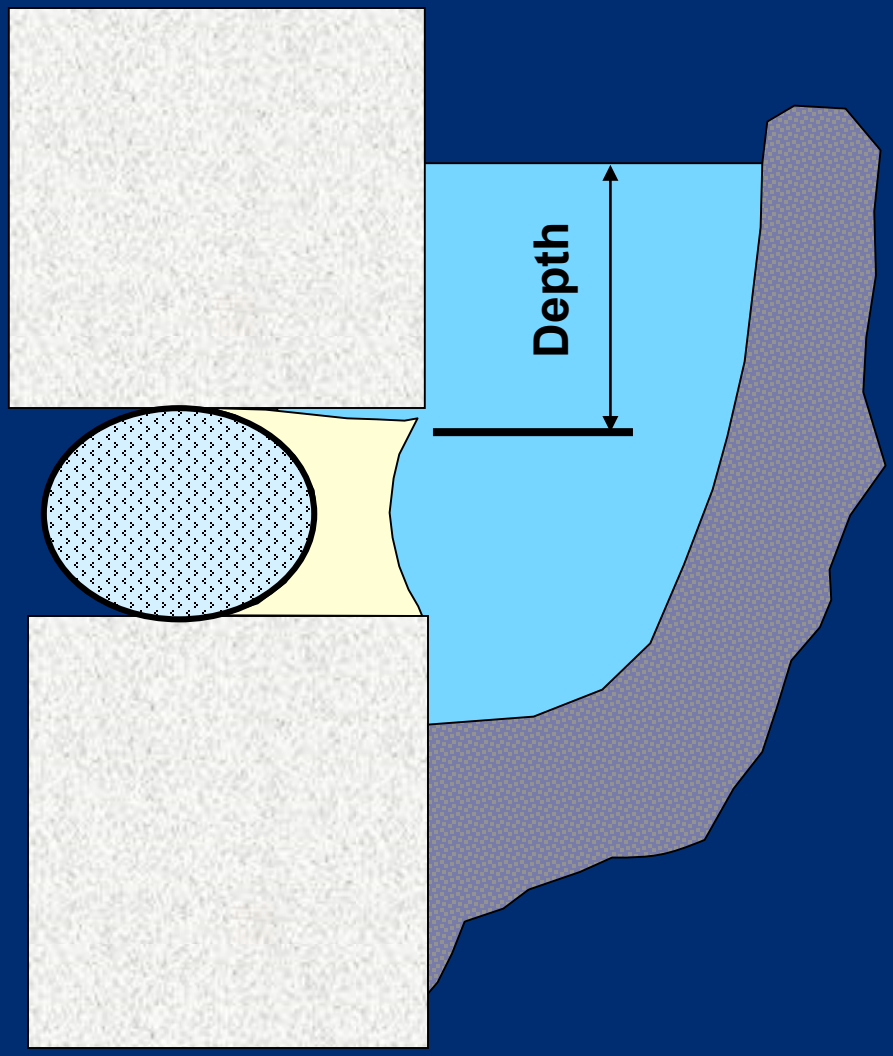
“Trickle”

Useful when surface tension is the operative transport mechanism; not a standard ASTM or AAMA test method.

“Trough”

Not a standard ASTM or AAMA test; putty, modeling clay, Duxseal or Dow Dilatant Putty.

“Trough”



1 inch head = 5.2 psf

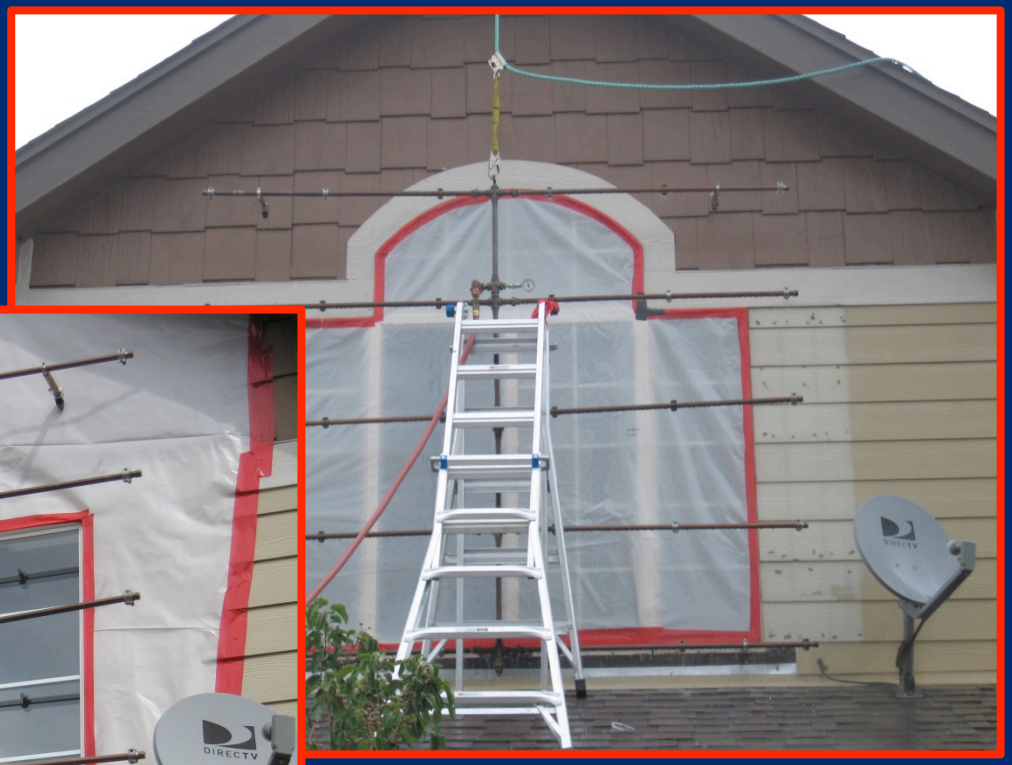
AAMA 511 4.2.3.1 Sill Flood

E1105 – Exterior Chamber

E1105 – Interior Chamber

Spray Rack

Masking



Summary

- Systematic and comprehensive protocol
- Find out how the wall is actually build
- Find out what the wall is actually doing
- Don’t rush into testing
- Select a protocol and methodology which addresses the issues, not to demonstrate the obvious
- Recreate the non-performance problem, don’t create a problem where none exists
- Verify findings and understand anomalies
- Address all relevant transport mechanisms

Going Forward

- A well-thought-out and executed evaluation protocol is worth a thousand expert opinions
- It is not the test method, it is the evaluation protocol
- ***Before*** E2128, the distinction between a rational and defendable leakage evaluation and an incompetent speculative evaluation was just a matter of opinion
- ***After*** E2128, the difference is a matter of accord with a peer-reviewed consensus protocol with flexibility and accountability
- Refine Appendices