CRA COLORADO ROOFING ASSOCIATION

Denver, CO – Wednesday, December 18, 2013

NRCA Update on Technical Issues

presented by

Mark S. Graham
Associate Executive Director, Technical Services
National Roofing Contractors Association

NRCA

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Topics

- Asphalt update
- Moisture in concrete roof decks
- New LTTR values
- Asphalt shingle issues
- ANSI/SPRI ES-1
- Etc.
- Questions

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Asphalt update

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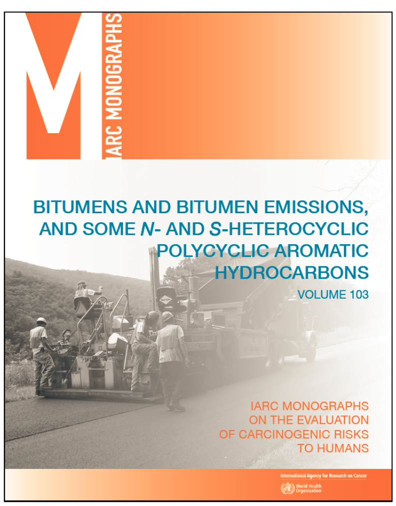
Asphalt



IARC Monograph – 103:

- Group 2A –Probably carcinogenic to humans
- Pgs. 160 – 165 specific to "Roofing workers exposed to bitumens"

No new regulation (yet)

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Some terminology…

Flash point (FP): the lowest temperature at which asphalt vapors above a volatile combustible substance can ignite in air when exposed to an ignition source; tested using ASTM D92.

Equiviscous temperature (EVT): the temperature at which asphalt attains proper viscosity (flow rate) for built-up membrane application; tested using ASTM D4402 – 125 cP (mop application) and 75 cP (mechanical spreader application).

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Some more terminology…

EVT application range: the recommended bitumen application range. The range is approximately 25 F above or below the EVT, thus giving a range of approximately 50 F. The EVT is measured in the mop cart pr mechanical spreader just prior to application of bitumen to the substrate.

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NRCA recommends…

"…NRCA recommends designers specify asphalt with a sufficiently high enough FP temperature top provide a minimum 125-degree differential between an asphalt's EVT and FP temperature to allow for proper application of built-up membranes."

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NRCA asphalt testing -- 1989

- 26 asphalt samples
- EVTs:
  - Type III (mop) 375 – 450 F
  - Type III (spreader) 400 – 500 F
  - Type IV (mop) 395 – 475 F
  - Type IV (spreader) 425 – 505 F
- FPs:
  - Not reported

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NRCA asphalt testing -- 2000

- 19 asphalt lots sampled
- EVTs:
  - Type III (mop) 390 – 440 F
  - Type III (spreader) 415 – 470 F
- FPs: 585 – 640 F
- ASTM D312 compliance:
  - 10 of 19 did not comply

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NRCA asphalt testing – 2013 (to date)

- 11 asphalt lots sampled
- EVTs:
  - Type III (mop) 424 – 462 F
  - Type III (spreader) 452 – 486 F
  - Type IV (mop) 455 – 482 F
  - Type IV (spreader) 480 – 506 F
- FPs: 615 – 660 F
- ASTM D312 compliance:
  - 8 of 11 do not comply

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Are asphalts currently installable?

- Comply with MSDS
- Comply with manufacturers' installation instructions
- Comply with NRCA's guidelines

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Moisture in concrete roof decks

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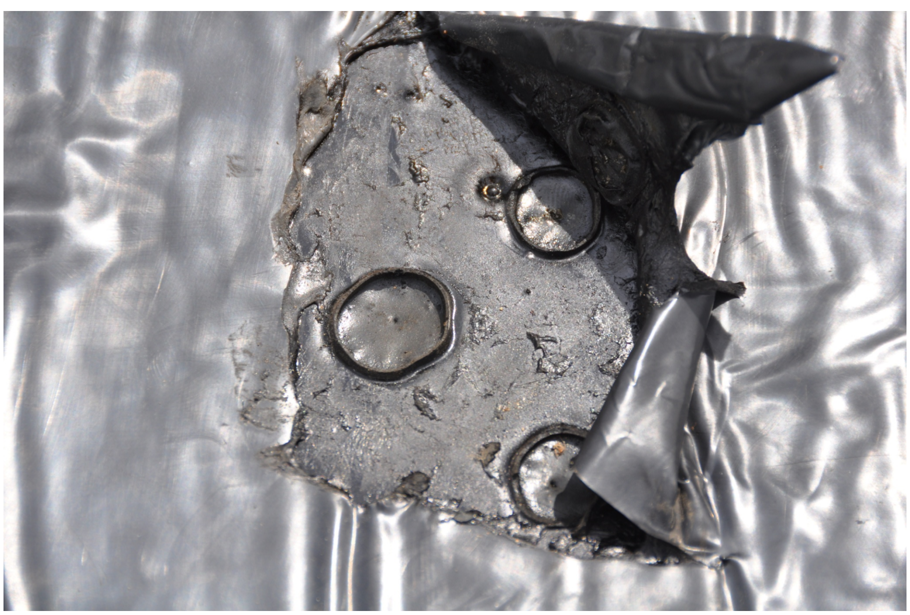

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Some terminology

- **Structural concrete (normal weight)**
  - 150 lbs/ft^3
- **Lightweight structural concrete**
  - 85–120 lbs/ft^3
- **Lightweight insulating concrete**
  - 20-40 lbs/ft^3

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Some terminology

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- ~~**Lightweight insulating concrete**~~
  - ~~20-40 lbs/ft^3~~

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Concrete mix design

- Aggregate:
  - Large aggregate
  - Fine (small) aggregate
- Portland cement
- Water
- Admixtures:
  - Fly ash
  - Air entrainment
  - Curing compounds
  - Etc.

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Concrete Aggregates

60-80% of Concrete Mix Design

- Normal-weight aggregates (stone):
  - Dense
  - Absorb about 2% by weight
- Light-weight aggregates (expanded shale):
  - Porous
  - Absorbs from 5 - 25% by weight

Lightweight structural concrete inherently contains more moisture

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An up-close look

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Uses for lightweight structural concrete

- Cast-in-place roof decks (removable forms)
- Composite roof decks (metal form deck stays in-place)
- Deck topping (e.g., topping over precast concrete)

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What is the appeal?

Water Tower Place (1975)
Chicago, IL
859 feet tall

- Reduced weight:
  - Transportation
  - Pumping
  - Placement
  - In-place (Dead load)
- Similar strength
- Similar workability:
  - Begin finishing earlier
- Sustainability credit:
  - LEED

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Reported roofing-related problems

- Moisture within the roof system
- Loss of adhesion
- Insulation facer delamination
- Adhesive curing issues
- Mold growth
- Fastener/metal corrosion
- R-value loss

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When is it OK to roof?

Historical guidelines

- After 28 days
- Application of hot bitumen
- Plastic film test
  - ASTM D4263, "Standard Test Method for Indicating Moisture in Concrete by the Plastic Sheet Method"

These are not appropriate for current generations of concrete mixes

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Flooring industry

ASTM Committee F06—Resilient Floor Coverings

- ASTM F1869, "Standard Test Method for Measuring Vapor Emission Rate of Concrete Subfloor Using Anhydrous Calcium Chloride"
- ASTM F2170, "Standard Test Method for Determining Humidity in Concrete Floor Slabs Using In-situ Probes"

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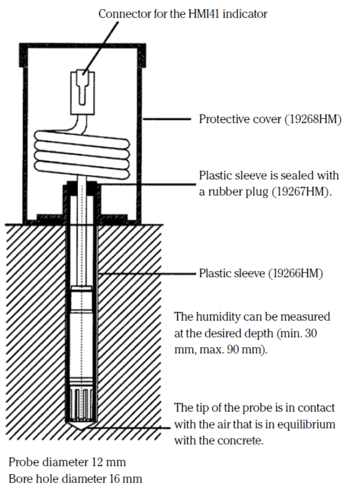
ASTM F2170 apparatus

Measure relative humidity (RH %) and temperature



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Trial ASTM F2170 tests

Existing lightweight structural concrete roof decks

	Roof 1	Roof 2	Roof 3
Roof age (yrs)	4	7	7
Area (ft^2)	13,200	23,840	14,760
Thickness (in.)	6.5	7.5	7.3
No. of readings	13	10	8
High reading	99% RH	99% RH	99% RH
Low reading	63% RH	96% RH	84% RH
Median reading	97% RH	99% RH	99% RH
Mean reading	89% RH	99% RH	95% RH

Values of 65-85% RH are considered acceptable in the flooring industry depending upon the specific floor covering type.

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Concrete Floors and Moisture, 2nd Edition

Howard M. Kanare, CTL Group

75% internal RH can be achieved:

- Normal weight structural concrete
  - Less than 90 days
- Lightweight structural concrete
  - Almost 6 months

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Conclusions

- Concrete roof decks – normal weight and light-weight structural – present challenging moisture-related considerations.
- Further complicated by the use of admixtures and method of finishing.
- NRCA does not support the 28-day drying period or the plastic sheet test

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Conclusions - continued

- Roofing contractors can only visually assess the dryness of the concrete's top surface
- Roofing contractors cannot readily assess any remaining free moisture within concrete or its likely release

Roofing contractors are not privy to and may not be knowledgeable about the information necessary to make "…when to roof…" decisions

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Additional information

***Professional Roofing*, Feb. 2010**

Tech Today

Moisture in concrete roof decks

Concrete's curing and drying rates can affect roof systems

by Mark S. Graham

Lately, NRCA has experienced an increase in reports of moisture-related problems with low-slope membrane roof systems applied to newly poured, normal-weight or lightweight structural concrete roof decks.

In the reported instances, significant amounts of water have been found within roof systems within several months to up to three years after construction. In most of the situations reported, it was determined the roof membrane was watertight and not the source of moisture infiltration. Nevertheless, NRCA has some recommendations for avoiding such problems.

Concrete decks

When mixed, poured and formed, normal-weight and lightweight structural concrete contain significant amounts of water. As concrete cures and hardens, it consumes large amounts of this water through hydration and evaporation. For example, a 4-inch-thick concrete slab will release about 1 quart of water for each square foot of surface area.

Historically, the roofing industry has used a minimum 28-day period as a guideline for applying roofing materials over newly poured concrete roof decks. The 28-day period coincides with the curing time of concrete before it is tested for design compression strength. There is little correlation between this 28-day period and concrete's true "dryness."

In some instances, a plastic sheet test has been used to determine concrete's dryness. With this test, a plastic sheet (4-mil-thick polyethylene) is taped to the concrete surface and the plastic sheet's underside is monitored for the presence of condensation.

Up to the publication of *The NRCA Roofing and Waterproofing Manual, Fourth Edition* in 1996, NRCA recommended the plastic sheet test as a method for determining a concrete surface's dryness.

However, with the publication of *The NRCA Roofing and Waterproofing Manual, Fifth Edition* in 2001 and continuing with the publication of The NRCA Roofing Manual this year, NRCA no longer considers the plastic sheet test a viable assessment of concrete's dryness.

Similar to the roofing industry, the concrete industry has seen significant advances in technology regarding concrete mix design, placement and curing.

For example, the use of concrete additives in concrete mix designs and curing compounds during concrete placement greatly can accelerate or retard concrete's curing and release of free moisture. Similarly, weather conditions, covering newly poured concrete, timing of concrete form removal, and temporary heating or ventilating of a building's interior after concrete placement can affect the rate of concrete's upward or downward release of free moisture.

For these reasons, NRCA no longer supports the 28-day drying period or plastic sheet test.

NRCA's recommendations

NRCA considers the decision of when it is appropriate to cover a newly poured concrete substrate to be beyond roofing contractors' control. Because of the numerous variables associated with concrete mix design, placement, curing and drying, roofing contractors are not privy to and may not be knowledgeable of the information necessary to make such a decision.

Also, though a roofing contractor can assess the dryness of concrete's topmost surface, he or she cannot readily assess any remaining free moisture within the concrete and its likely direction of release.

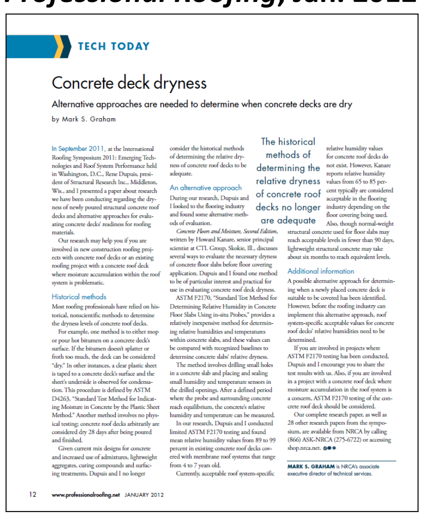
NRCA recommends the decision of when a newly poured concrete substrate is ready to be covered with a new roof system be made with the project or roof system designer, roof system manufacturer and roofing contractor. It also would be useful for designers to consult structural engineers, general contractors, concrete suppliers and concrete placement contractors who likely have more knowledge of concrete's curing and moisture-release rates.

Additional information regarding concrete roof decks is contained in *The NRCA Roofing Manual: Membrane Roof Systems—2007.*

Mark S. Graham is NRCA's associate executive director of technical services.

ProfessionalRoofing February 2010 23

***Professional Roofing*, Jan. 2012**



TECH TODAY

Concrete deck dryness

Alternative approaches are needed to determine when concrete decks are dry

by Mark S. Graham

In September 2011, at the International Roofing Symposium 2011: Emerging Technologies and Roof System Performance held in Washington, D.C., Rene Dupuis, president of Structural Research Inc., Middleton, Wis., and I presented a paper about research we have been conducting regarding the dryness of newly poured structural concrete roof decks and alternative approaches for evaluating concrete decks' readiness for roofing materials.

Our research may help you if you are involved in new construction roofing projects with concrete roof decks or an existing roofing project with a concrete roof deck where moisture accumulation within the roof system is problematic.

Historical methods

Most roofing professionals have relied on historical, nonscientific methods to determine the dryness levels of concrete roof decks.

For example, one method is to either mop or pour hot bitumen on a concrete deck's surface. If the bitumen doesn't splatter or froth too much, the deck can be considered "dry." In other instances, a clear plastic sheet is taped to a concrete deck's surface and the sheet's underside is observed for condensation. This procedure is defined by ASTM D4263, "Standard Test Method for Indicating Moisture in Concrete by the Plastic Sheet Method." Another method involves no physical testing; concrete roof decks arbitrarily are considered dry 28 days after being poured and finished.

Given current mix designs for concrete and increased use of admixtures, lightweight aggregates, curing compounds and surfacing treatments, Dupuis and I no longer consider the historical methods of determining the relative dryness of concrete roof decks to be adequate.

An alternative approach

During our research, Dupuis and I looked to the flooring industry and found some alternative methods of evaluation.

Concrete Floors and Moisture, Second Edition, written by Howard Kanare, senior principal scientist at CTL Group, Skokie, Ill., discusses several ways to evaluate the necessary dryness of concrete floor slabs before floor covering application. Dupuis and I found one method to be of particular interest and practical for use in evaluating concrete roof deck dryness.

ASTM F2170, "Standard Test Method for Determining Relative Humidity in Concrete Floor Slabs Using in-situ Probes," provides a relatively inexpensive method for determining relative humidities and temperatures within concrete slabs, and these values can be compared with recognized baselines to determine concrete slabs' relative dryness.

The method involves drilling small holes in a concrete slab and placing and sealing small humidity and temperature sensors in the drilled openings. After a defined period where the probe and surrounding concrete reach equilibrium, the concrete's relative humidity and temperature can be measured.

In our research, Dupuis and I conducted limited ASTM F2170 testing and found mean relative humidity values from 89 to 99 percent in existing concrete roof decks covered with membrane roof systems that range from 4 to 7 years old.

Currently, acceptable roof system-specific relative humidity values for concrete roof decks do not exist. However, Kanare reports relative humidity values from 65 to 85 percent typically are considered acceptable in the flooring industry depending on the floor covering being used. Also, though normal-weight structural concrete used for floor slabs may reach acceptable levels in fewer than 90 days, lightweight structural concrete may take about six months to reach equivalent levels.

The historical methods of determining the relative dryness of concrete roof decks no longer are adequate

Additional information

A possible alternative approach for determining when a newly placed concrete deck is suitable to be covered has been identified. However, before the roofing industry can implement this alternative approach, roof system-specific acceptable values for concrete roof decks' relative humidities need to be determined.

If you are involved in projects where ASTM F2170 testing has been conducted, Dupuis and I encourage you to share the test results with us. Also, if you are involved in a project with a concrete roof deck where moisture accumulation in the roof system is a concern, ASTM F2170 testing of the concrete roof deck should be considered.

Our complete research paper, as well as 28 other research papers from the symposium, are available from NRCA by calling (866) ASK-NRCA (275-6722) or accessing shop.nrca.net.

MARK S. GRAHAM is NRCA's associate executive director of technical services.

12 www.professionalroofing.net JANUARY 2012

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Recommendations

Normal weight structural concrete

In new construction:

- Designer should specify "…when to roof…" criteria
  - Consult with CM/GC, concrete supplier and placement contractor, and roof system manufacturer

In reroofing:

- If evidence of moisture-related problems associated with the deck, treat the deck as lightweight structural concrete

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Recommendations – cont.

Lightweight structural concrete

In new construction:

- NRCA recommends lightweight structural concrete not be used for roof deck construction.
- If lightweight structural concrete is used, the Designer should specifically identify concrete drying parameters/when to apply roofing

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Recommendations – cont.

Existing concrete roof decks (known to be lightweight structural concrete or where moisture-related problems are evident):

- Above-deck venting design (e.g., venting base sheet)
- Adhered vapor retarder (e.g., two-part epoxy 12-15 mils)

Adhered or loosely-laid, ballasted roof systems

NRCA Industry Issue Update, August 2013

INDUSTRY ISSUE UPDATE

NRCA Member Benefit

Moisture in Lightweight Structural Concrete Roof Decks

Concrete Moisture Presents Challenges for Roofing Contractors

NRCA's Technical Services Section is receiving an increasing number of inquiries relating to the application of roof systems over concrete roof decks. These inquiries can be separated into two general questions: When is a concrete roof deck dry enough to apply a roof covering? And why is a roof system applied over a concrete roof deck showing signs of moisture infiltration when the roof covering isn't leaking?

CONCRETE BASICS

There are three general types of concrete: normal-weight structural concrete, lightweight structural concrete and lightweight insulating concrete.

Normal-weight structural concrete is what most people think of as concrete; it has a density of about 150 pounds per cubic foot (pcf). Lightweight structural concrete has structural load-carrying capabilities similar to normal-weight structural concretes; it has a density in the range of 85 to 120 pcf. Lightweight insulating concrete, which many roofing professionals are familiar with as an insulating, slope-to-drain deck topping, typically has a density in the range from 20 to 40 pcf.

Structural concrete—normal-weight structural concrete and lightweight structural concrete—is produced by mixing large and small aggregates, Portland cement, water and, in some instances, admixtures such as fly ash or various chemical additives. Admixtures can add entrained air to the concrete, accelerate concrete's curing, retain concrete's excess moisture and/or lengthen concrete's finishing time. Use of admixtures typically is not visually identifiable in the field; microscopic analysis usually is needed for post-application identification of admixtures.

The primary difference in the composition of normal-weight structural concrete and lightweight structural concrete is the large aggregates' type. Normal-weight structural concrete contains normal-weight aggregates such as stone or crushed gravel, which are dense and typically will absorb no more moisture than about 2 percent by weight. Lightweight structural concrete uses lightweight, porous aggregates such as expanded shale, which will absorb about 5 to 25 percent moisture by weight. Lightweight aggregate needs to be saturated with moisture—it's often stored in ponds—before mixing. As a result, lightweight structural concrete inherently contains much more water than normal-weight structural concrete.

Lightweight structural concrete is used in roofing-related applications for cast-in-place concrete roof decks using removable forms; composite roof decks where a metal form deck remains in place; and as a deck topping material, such as a concrete topping surface over precast concrete planks or tees.

Once poured, lightweight structural concrete typically cannot be easily distinguished from normal-weight structural concrete. Visual identification is possible using magnification, typically a microscope used by a trained technician.

> Lightweight structural concrete inherently contains much more water than normal-weight structural concrete

REPORTED PROBLEMS

The problems reported to NRCA associated with lightweight structural concrete roof decks include the following:

- *Moisture accumulation.* Excessive moisture from a concrete deck can be pressure-differential driven into and condensed within a roof system.
- *Adhesion loss.* The presence of moisture can result in deterioration of moisture-sensitive roofing materials and adhesive bond loss between adhered material layers.
- *Adhesive issues with water-based and low-volatile organic compounds.* Excessive moisture can affect adhesive curing and drying rates. Also, moisture can result in adhesive "rewetting," resulting in bond strength loss.
- *Metal and fastener corrosion.* Excessive moisture can contribute to and accelerate metal components' corrosion, including fastener corrosion.
- *Insulation R-value loss.* The accumulation and presence of moisture in most insulation products will result in reduced thermal performance (lower effective R-value).
- *Microbial growth.* The presence of prolonged high-moisture

NRLRC's Contract Provisions, Vol. III

"Roofing Contractor's commencement of the roof installation indicates only that the Roofing Contractor has visually inspected the surface of the roof deck for visible defects and has accepted the surface of the roof deck. Roofing Contractor is not responsible for the construction, structural sufficiency, durability, fastening, moisture content, suitability, or physical properties of the roof deck or other trades' work or design. Roofing Contractor is not responsible to test or assess moisture content of the deck or substrate."

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New LTTR values

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Some terminology

R-value: See "thermal resistance (R)"

thermal resistance: The quantity determined by the temperature difference at steady state between two defined surfaces or a material or construction that induces a unit heat flow rate through a unit area. In English (inch·pound) units, it is expressed as $F \cdot ft^2 \cdot hr/Btu$.

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About thermal resistance (R)

- A thermal resistance (R) value applies to a specific thickness of material or construction.
- The thermal resistance (R) of a material is the reciprocal of the thermal conductance (C) of the same material (i.e., R = 1/C).
- Thermal resistance (R) values can be added, subtracted, multiplied and divided by mathematically appropriate methods.

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Thermal resistance (R)

ASTM C518, " Standard Test Method for Steady-state Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus"

-- Originally published in 1963
Current edition is 2010

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Theory of foam aging

ASTM C1303, Appendix X3-Theory of Foam Aging

- R-value of most foam insulations is affected by the gas mixture in the foam
  - R-value of most blowing agents is greater than that of air.
  - R-value of foam insulation is greater when there is more blowing agent and less air

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Theory of foam aging -- continued

ASTM C1303, Appendix X3-Theory of Foam Aging

- For rigid, closed-cell foams, diffusion plays a role:
  - Air diffuses into cells
  - Blowing agent diffuses out of cells or partially dissolves into the polymer matrix
- Diffusion rate depends upon:
  - Type of polymer
  - Type of gas
  - Foam structure
  - Temperature
  - Pressure

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Long-term thermal resistance (LTTR)

R-value: same

thermal resistance: same

long-term: for the purpose of the Prescriptive Method, long term refers to five years

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Long-term thermal resistance (LTTR)

- ASTM C1303, "Standard Test Method for Predicting Long-Term Thermal Resistance of Closed-Cell Foam Insulation"
- CAN/ULC-S770, "Standard Test Method for Determination of Long-Term Thermal Resistance of Closed-Cell Thermal Insulating Foams

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PIMA Quality Mark^{cm} program

- Established in 2003
- Implemented on January 1, 2004
- Report LTTR values based upon CAN/ULC-S770-03
- Third-party administration by FM Global

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Insulation thickness	LTTR
1.0 inch (25 mm)	6.0
1.5 inches (38 mm)	9.0
1.7 inches (43 mm)	10.3
1.8 inches (46 mm)	10.9
2.0 inches (51 mm)	12.1
2.5 inches (64 mm)	15.3
2.7 inches (69 mm)	16.6
3.0 inches (76 mm)	18.5
3.3 inches (84 mm)	20.4
3.5 inches (89 mm)	21.7
4.0 inches (102 mm)	25.0

"Tech today," *Professional Roofing,* November 2002

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Revision of PIMA Quality Mark^cm program

- Report LTTR values based upon:
  - ASTM C1303-11
  - CAN/ULC-S770-09
- Effective date of January 1, 2014

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New minimum LTTR values

PIMA Quality Mark^{cm} program (minimum values)

Revised LTTR values		
Thickness (inches)	**New LTTR values per inch thickness**	**New LTTR values per thickness**
1	5.6	5.6
2	5.7	11.4
3	5.8	17.4
4	5.9	23.6

"Tech today," *Professional Roofing,* August 2013

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Comparing existing vs. new LTTR values

Thickness	LTTR (2004 – 2013)	New LTTR (2014 –)
1 inch	6.0	5.6
1.5 inches	9.0	8.6
2 inches	12.1	11.4
3 inches	18.5	17.4
4 inches	25.0	23.6

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Some concerns

Design/bid/construction scenarios:

- Projects designed in 2013, but will be constructed in 2014
- Projects bid in 2013, but will be constructed in 2014
- Projects designed and bid in 2014 using outdated LTTR values

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NRCA recommends designers specify polyisocyanurate insulation by thickness – not R-value or LTTR.

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Some words of caution…

Do not use the terms "R-value" and "LTTR" interchangeably.

Some additional cautions…

- Is the "long-term" in LTTR really long term in the context of a roof system service life?
- LTTR may not appropriate for use for vapor retarder design.
- LTTR may not be appropriate for use for building energy calculations.

NRCA has not endorsed the LTTR concept

"Although the LTTR method of R-value determination and reporting may be appropriate for laboratory analysis, research comparison and procurement purposes, NRCA does not consider LTTR to be appropriate for design and in-service purposes…"

--The NRCA Roofing Manual: Membrane Roof Systems-2011

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NRCA's recommended design R-values

The NRCA Roofing Manual: Membrane Roof System-2011

Polyisocyanurate			
Thickness, in.	LTTR	NRCA Recommended Design R-values	
		Heating Conditions	Cooling Conditions
1.0	6.0	5.0	5.6
1.25	7.5	6.3	7.0
1.5	9.0	7.5	8.4
1.75	10.5	8.8	9.8
2.0	12.1	10.0	11.2
2.3	14.0	11.5	12.9
2.5	15.3	12.5	14.0
2.8	17.2	14.0	15.7
3.0	18.5	15.0	16.8
3.25	20.1	16.3	18.2
3.5	21.7	17.5	19.6
3.75	23.4	18.8	21.0
4.0	25.0	20.0	22.4

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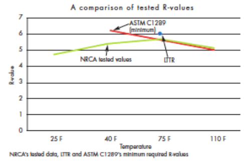
Tech Today

R-value concerns

R-values are found to be below LTTR

by Mark S. Graham



NRCA's tested data, LTTR and ASTM C1289's minimum required R-values

"Tech today," *Professional Roofing*, May 2010

NRCA 2009 R-value testing:

- 15 samples of new 2-inch polyiso. were testing according to ASTM C518
- Tested R-values at 75 F were lower than LTTR
- R-value of polyiso. is temperature sensitive
- R-values at 25 F, 40 F and 110 F are lower than R-value at laboratory conditions

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BSC Information Sheet 502

Understanding the Temperature Dependence of R-values for Polyisocyanurate Roof Insulation

BCS Info. Sheet 502:

- Replicated NRCA's 2009 R-value testing
- Similar results
- Suggests a "climate-based" R-value approach
- Suggests use of a hybrid insulation approach

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In review…

- New LTTR values as of January 1, 2014
- Implementation concerns
- LTTR may not be appropriate for design purposes
- NRCA is maintaining it's longstanding design R-value recommendation

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Asphalt shingles

- ASTM D225 (organic shingles)

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Asphalt shingles

- ~~ASTM D225 (organic shingles)~~
- ASTM D3462 (fiberglass shingles)
- ICC-ES AC 438 (alternative asphalt shingles)

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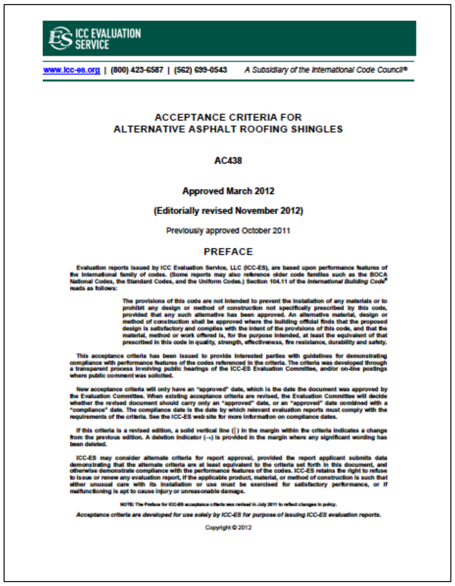
ICC-ES AC438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ACCEPTANCE CRITERIA FOR
ALTERNATIVE ASPHALT ROOFING SHINGLES

AC438

Approved March 2012

(Editorially revised November 2012)

Previously approved October 2011

PREFACE

Evaluation reports issued by ICC Evaluation Service, LLC (ICC-ES), are based upon performance features of the International family of codes. (Some reports may also reference older code families such as the BOCA National Codes, the Standard Codes, and the Uniform Codes.) Section 104.11 of the *International Building Code®* reads as follows:

> The provisions of this code are not intended to prevent the installation of any materials or to prohibit any design or method of construction not specifically prescribed by this code, provided that any such alternative has been approved. An alternative material, design or method of construction shall be approved where the building official finds that the proposed design is satisfactory and complies with the intent of the provisions of this code, and that the material, method or work offered is, for the purpose intended, at least the equivalent of that prescribed in this code in quality, strength, effectiveness, fire resistance, durability and safety.

This acceptance criteria has been issued to provide interested parties with guidelines for demonstrating compliance with performance features of the codes referenced in the criteria. The criteria was developed through a transparent process involving public hearings of the ICC-ES Evaluation Committee, and/or on-line postings where public comment was solicited.

New acceptance criteria will only have an "approved" date, which is the date the document was approved by the Evaluation Committee. When existing acceptance criteria are revised, the Evaluation Committee will decide whether the revised document should carry only an "approved" date, or an "approved" date combined with a "compliance" date. The compliance date is the date by which relevant evaluation reports must comply with the requirements of the criteria. See the ICC-ES web site for more information on compliance dates.

If this criteria is a revised edition, a solid vertical line (|) in the margin within the criteria indicates a change from the previous edition. A deletion indicator (→) is provided in the margin where any significant wording has been deleted.

ICC-ES may consider alternate criteria for report approval, provided the report applicant submits data demonstrating that the alternate criteria are at least equivalent to the criteria set forth in this document, and otherwise demonstrate compliance with the performance features of the codes. ICC-ES retains the right to refuse to issue or renew any evaluation report, if the applicable product, material, or method of construction is such that either unusual care with its installation or use must be exercised for satisfactory performance, or if malfunctioning is apt to cause injury or unreasonable damage.

NOTE: The Preface for ICC-ES acceptance criteria was revised in July 2011 to reflect changes in policy.

Acceptance criteria are developed for use solely by ICC-ES for purpose of issuing ICC-ES evaluation reports.

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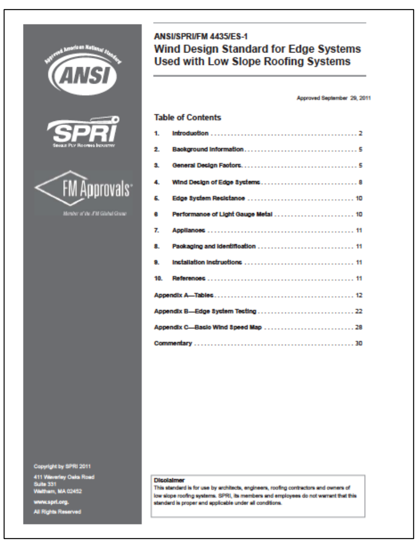
- Alternative acceptance
- No weight/mass testing
- No tear strength testing
- ASTM E108 Class C
- ASTM D7158 Class D
- Weather resistance
    - Break strength
- Temperature cycling
- Wind-driven rain

ANSI/SPRI ES-1

ANSI/SPRI/FM 4435/ES-1, 2011 Edition


ANSI/SPRI/FM 4435/ES-1
Wind Design Standard for Edge Systems Used with Low Slope Roofing Systems

Approved September 29, 2011

Table of Contents

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Suite 331
Waltham, MA 02452
www.spri.org.

Disclaimer
This standard is for use by architects, engineers, roofing contractors and owners of low slope roofing systems. SPRI, its members and employees do not warrant that this standard is proper and applicable under all conditions.

- Design wind loads
- Tested resistance:
  - RE-1
  - RE-2
  - RE-3
- Prescriptive requirements
- Appendixes
- Commentary

Sec. 1504-Performance Requirements

International Building Code, 2012 Edition

1504.5 Edge securement for low-slope roofs. Low-slope built-up, modified bitumen and single-ply roof system metal edge securement, except gutters, shall be designed and installed for wind loads in accordance with Chapter 16 and tested for resistance in accordance with Test Methods RE-1, RE-2 and RE-3 of ANSI/SPRI ES-1, except V_{ult} wind speed shall be determined from Figure 1609A, 1609B, or 1609C as applicable.

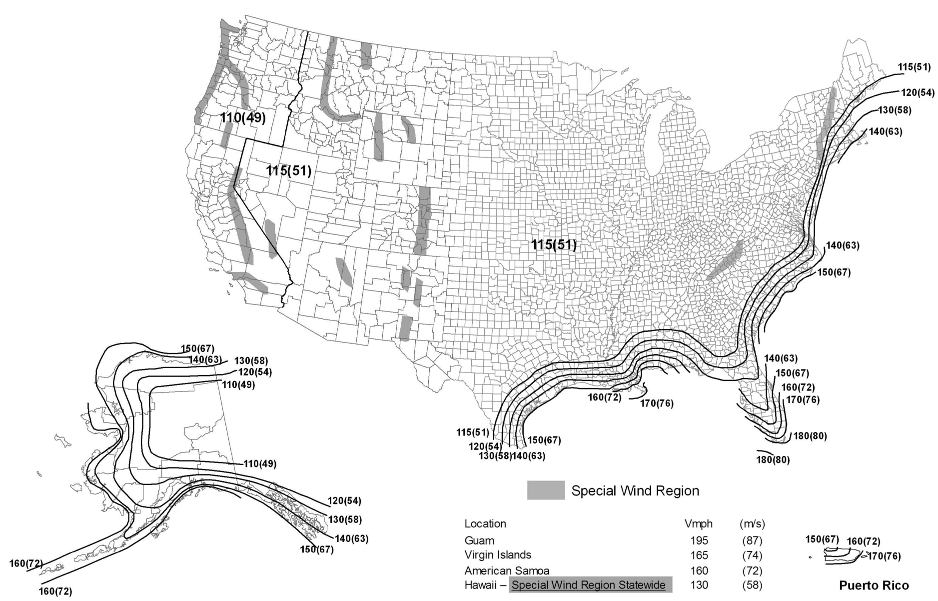

Fig. 1607A--V_{ult} for Risk Category II Buildings

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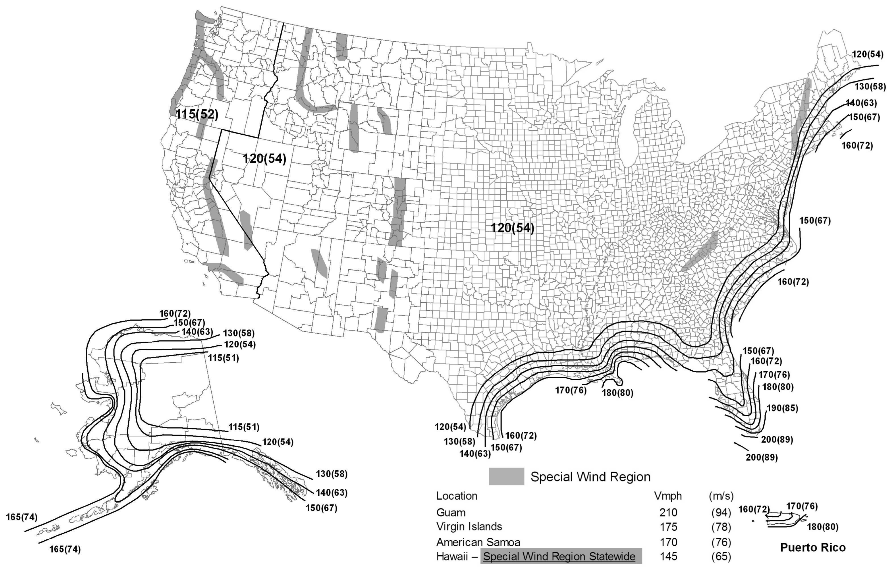

Fig. 1607B--V_{ult} for Risk Category III and IV Buildings

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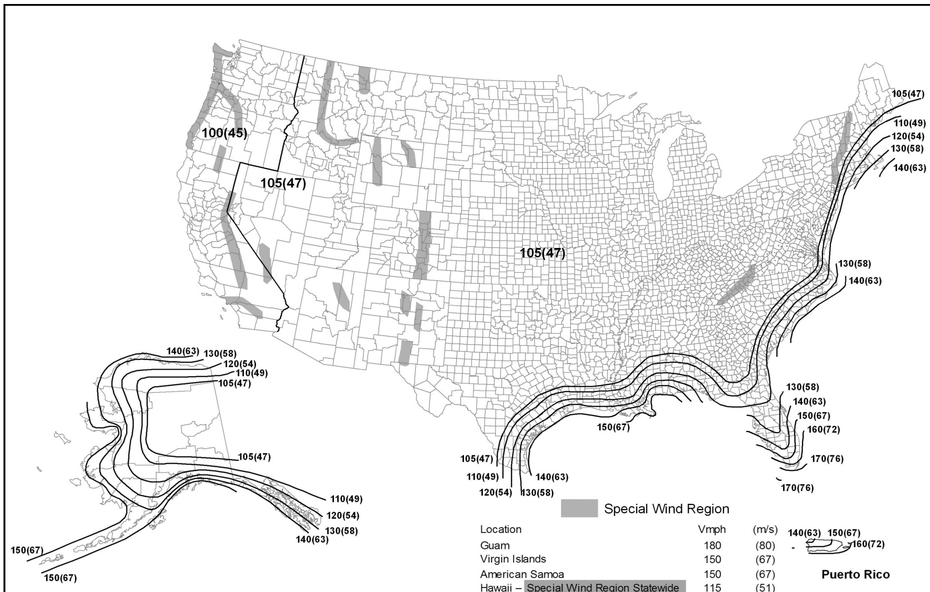

Fig. 1607C--V_{ult} for Risk Category I Buildings

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Design wind loads

ANSI/SPRI FM 4435/ES-1, 2011 Edition

4.2 Wind Load Determination

The following factors apply when determining the wind load of a roof edge system: wind speed, building height, exposure factor, topography, importance factor, corner and perimeter regions, and edge condition. See Commentary and Section 3 for further information.

This document includes an edge system design factor (safety factor) of 2.0.

4.2.1 General Wind Load Design Equation

The roof edge design pressure, P, shall be calculated using the equation shown below:

$$P = 2.0 \times q_{fz} \times GC_p \times I \qquad \text{Equation (1)}$$

where:

P = Roof Edge Design Pressure, psf (kPa)

2.0 = Design Factor

q_{fz} = Field of roof pressure at height z in feet

GC_p = External Pressure Coefficient from Table 2

I = Importance Factor from Table A1

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Design wind loads

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Table 1

Exposure Categories

Wind Exposure Categories	
B	Surface Roughness B: Urban and Suburban areas, wooded areas, or other terrain with numerous closely spaced obstructions having the size of single-family dwellings or larger. This applies where the ground surface roughness condition prevails in the upwind direction for a distance of at least 2600 ft. (792 m) or 20 times the height of the building, whichever is greater. **Exception:** For buildings whose mean roof height is less than or equal to 30 ft. (9.1 m), the upwind distance may be reduced to 1500 ft. (457 m)
C	Surface Roughness C: Open terrain with scattered obstructions having heights generally less than 30 ft. (9.1 m). This category includes flat open country, grasslands, and all water surfaces in hurricane prone regions. Exposure C shall apply for all cases where exposures B or D do not apply.
D	Surface Roughness D: Flat, unobstructed areas and water surfaces outside hurricane prone regions. This category includes smooth mud flats, salt flats, and unbroken ice. This shall apply where the ground surface roughness, as defined by surface roughness D, prevails in the upwind direction for a distance at least 5000 ft. (1524 m) or 20 times the building height, whichever is greater. Exposure D shall extend into downwind areas of Surface Roughness B or C for a distance of 600ft (200 m) or 20 times the height of the building, whichever is greater.

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Design wind loads

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Table A3
Field of Roof Pressure q_{fz} psf (kPa)—Exposure C
Enclosed Building[1]

Building Height ft. (m)	Exposure C, Occupancy Category II (I=1.0) Wind Speed, 3 Second Gust, mph (m/sec)									
	85 (38.1)	90 (40.3)	100 (44.8)	110 (49.3)	120 (53.8)	130 (58.2)	140 (62.7)	150 (67.2)	160 (71.7)	170 (76.2)
0 ≤ 15 (0–4.6)	-18.6 -(0.89)	-20.8 -(1.00)	-25.7 -(1.23)	-31.1 -(1.49)	-37.0 -(1.77)	-43.4 -(2.08)	-50.3 -(2.41)	-57.8 -(2.77)	-65.7 -(3.15)	-74.2 -(3.55)
> 15 ≤ 20 (4.6–6.1)	-19.6 -(0.94)	-22.0 -(1.05)	-27.2 -(1.30)	-32.9 -(1.58)	-39.1 -(1.87)	-45.9 -(2.20)	-53.3 -(2.55)	-61.2 -(2.93)	-69.6 -(3.33)	-78.6 -(3.76)
> 20 ≤ 25 (6.1–7.6)	-20.5 -(0.98)	-23.0 -(1.10)	-28.4 -(1.36)	-34.4 -(1.65)	-40.9 -(1.96)	-48.0 -(2.30)	-55.7 -(2.66)	-63.9 -(3.06)	-72.7 -(3.48)	-82.1 -(3.93)
> 25 ≤ 30 (7.6–9.1)	-21.4 -(1.02)	-24.0 -(1.15)	-29.6 -(1.42)	-35.8 -(1.72)	-42.6 -(2.04)	-50.0 -(2.40)	-58.0 -(2.78)	-66.6 -(3.19)	-75.8 -(3.63)	-85.6 -(4.10)
> 30 ≤ 40 (9.1–12.2)	-22.7 -(1.09)	-25.4 -(1.22)	-31.4 -(1.50)	-38.0 -(1.82)	-45.2 -(2.17)	-53.1 -(2.54)	-61.6 -(2.95)	-70.7 -(3.38)	-80.4 -(3.85)	-90.8 -(4.35)

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Design wind loads

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Table 2
External Pressure Coefficient[1] **(GC_p)**
Enclosed Building[2]

Type of Loading	Edge Location	Roof Height 60 ft. (18.3 m) or less z ≤ 60 ft. (18.3 m)	Roof Height over 60 ft. (18.3 m) z > 60 ft. (18.3 m)
Horizontal (acting outward from the building edge)	Perimeter	-0.97[3]	-0.68
	Corner	-1.21[3]	-1.25
Vertical (acting upward at the building edge)	Perimeter	-1.68	-1.57
	Corner	-2.53	-2.14

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Design wind loads

ANSI/SPRI FM 4435/ES-1, 2011 Edition

$P = 2.0 \times q_{fz} \times GC_p \times I$

$= 2.0 \times (-42.6 \text{ psf}) \times GC_p \times 1.0$

For horizontal loads:

Perimeter (GCp = -0.97):	82.6 psf
Corner (GCp = -1.21):	103.1 psf

For vertical loads:

Perimeter (GCp = -1.68):	143.1 psf
Corner (GCp = -2.53):	215.6 psf

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Design wind load pressures

International Building Code, 2012 Edition

SECTION 1603

CONSTRUCTION DOCUMENTS

1603.1 General. *Construction documents* shall show the size, section and relative locations of structural members with floor levels, column centers and offsets dimensioned. The design loads and other information pertinent to the structural design required by Sections 1603.1.1 through 1603.1.9 shall be indicated on the *construction documents.*

[continued…]

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1603.1.4 Wind design data. The following information related to wind loads shall be shown, regardless of whether wind loads govern the design of the lateral force resisting system of the structure:

1. Ultimate design wind speed, V_{ult}, *(3-second gust),* miles per hour (km/hr) and nominal design wind speed, V_{asd}, as determined in accordance with Section 1609.3.1.
2. *Risk category.*
3. Wind exposure. Where more than one wind exposure is utilized, the wind exposure and applicable wind direction shall be indicated.
4. The applicable internal pressure coefficient.
5. Components and cladding. The design wind pressures in terms of psf (kN/m^2) to be used for the design of exterior component and cladding materials not specifically designed by the *registered design professional.*

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1603.1.4 Wind design data. The following information related to wind loads shall be shown, regardless of whether wind loads govern the design of the lateral force resisting system of the structure:

1. Ultimate design wind speed, V_{ult}, *(3-second gust),* miles per hour (km/hr) and nominal design wind speed, V_{asd}, as determined in accordance with Section 1609.3.1.
2. *Risk category.*
3. Wind exposure. Where more than one wind exposure is utilized, the wind exposure and applicable wind direction shall be indicated.
4. The applicable internal pressure coefficient.
5. Components and cladding. The design wind pressures in terms of psf (kN/m^2) to be used for the design of exterior component and cladding materials not specifically designed by the *registered design professional.*

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Design wind loads

ANSI/SPRI FM 4435/ES-1, 2011 Edition

The Designer is required by the Code to include the design wind loads in the Construction Documents.

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Tested resistance

ANSI/SPRI FM 4435/ES-1, 2011 Edition

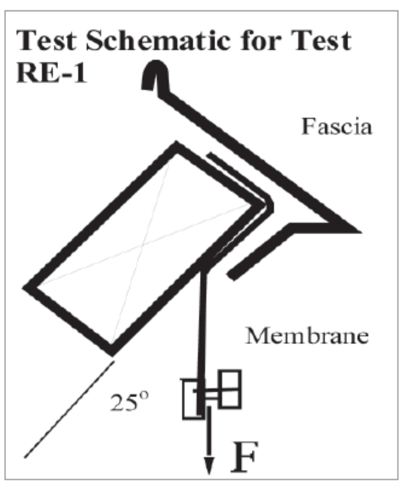

Figure RE1.1

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Tested resistance

ANSI/SPRI FM 4435/ES-1, 2011 Edition

Fascia Blow-Off Test Set Schematic

(Force at Failure x Face Area = Blowoff Resistnace)

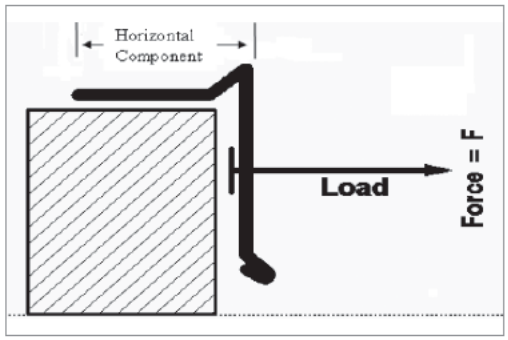

Figure RE2.1

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Tested resistance

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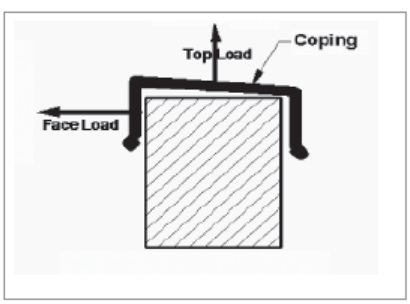

Figure RE3.1
RE3 Test—Face Leg Pull

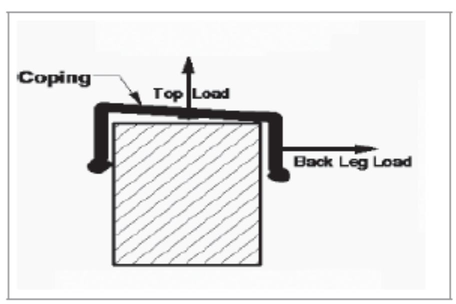

Figure RE3.2
RE3 Test—Back Leg Pull

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NRCA's shop-fabricated edge metal testing

www.nrca.net

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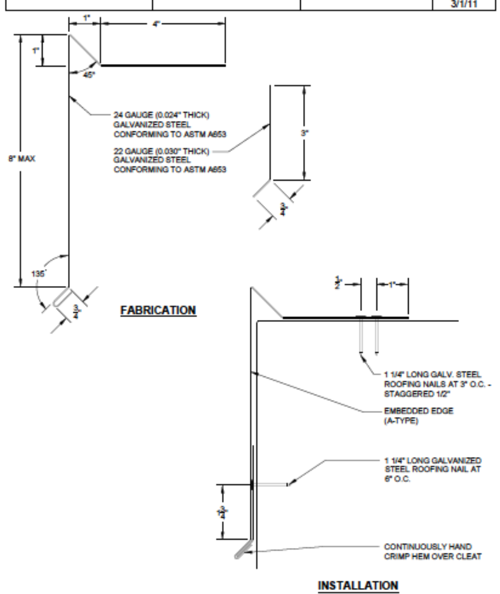
THE NRCA ROOFING MANUAL CONSTRUCTION DETAILS SM-14, SM-15	EMBEDDED EDGE (A-TYPE) • 24 GA. GALVANIZED STEEL • 22 GA. GALVANIZED STEEL CLEAT • CONTINUOUS FRONT FACE CLEAT	ANSI/SPRI ES-1 TESTED RESISTANCE 210 LBS./SQ. FT.	UL-25 3/1/11



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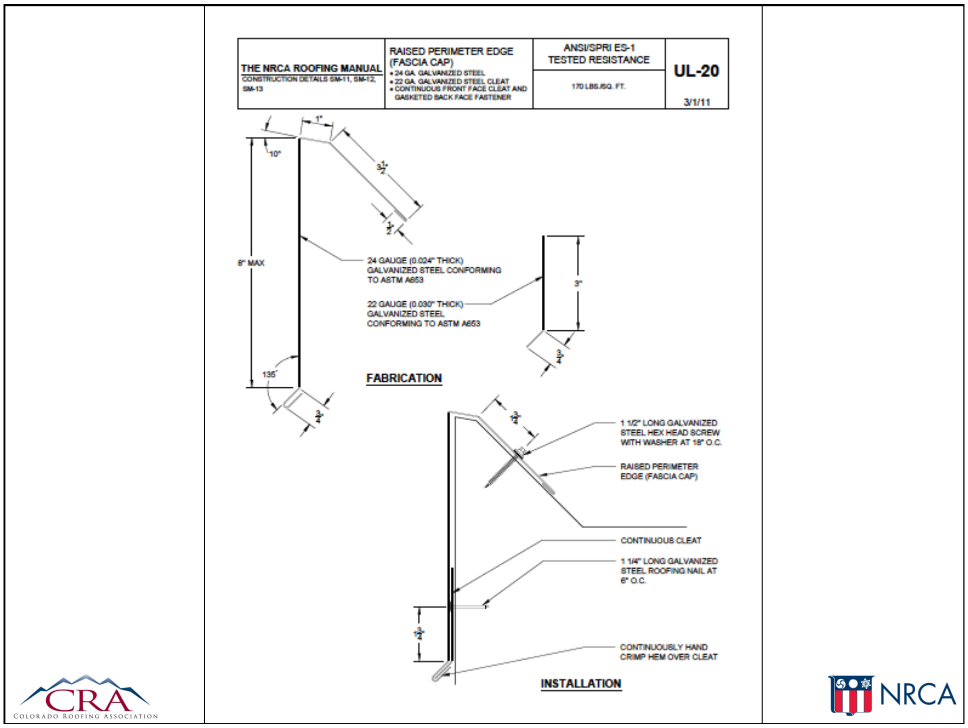
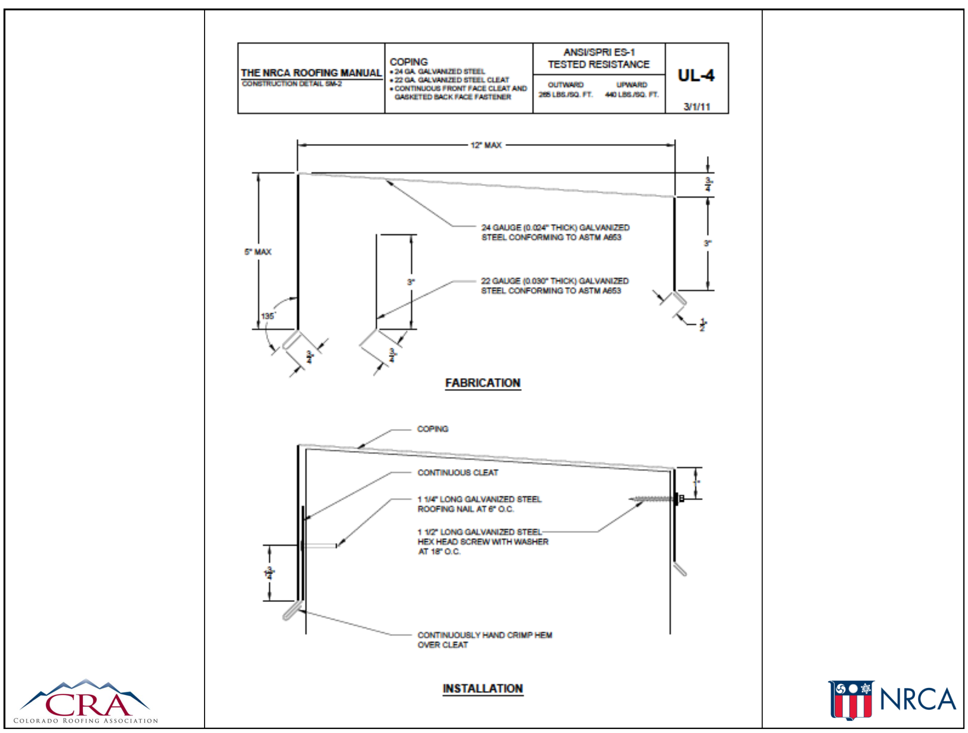

THE NRCA ROOFING MANUAL
CONSTRUCTION DETAILS SM-11, SM-12, SM-13
RAISED PERIMETER EDGE (FASCIA CAP)
• 24 GA. GALVANIZED STEEL
• 22 GA. GALVANIZED STEEL CLEAT
• CONTINUOUS FRONT FACE CLEAT AND GASKETED BACK FACE FASTENER
ANSI/SPRI ES-1 TESTED RESISTANCE
170 LBS./SQ. FT.
UL-20
3/1/11
24 GAUGE (0.024" THICK) GALVANIZED STEEL CONFORMING TO ASTM A653
22 GAUGE (0.030" THICK) GALVANIZED STEEL CONFORMING TO ASTM A653
8" MAX
FABRICATION
1 1/2" LONG GALVANIZED STEEL HEX HEAD SCREW WITH WASHER AT 18" O.C.
RAISED PERIMETER EDGE (FASCIA CAP)
CONTINUOUS CLEAT
1 1/4" LONG GALVANIZED STEEL ROOFING NAIL AT 6" O.C.
CONTINUOUSLY HAND CRIMP HEM OVER CLEAT
INSTALLATION
CRA
COLORADO ROOFING ASSOCIATION
NRCA


THE NRCA ROOFING MANUAL
CONSTRUCTION DETAIL SM-2
COPING
• 24 GA. GALVANIZED STEEL
• 22 GA. GALVANIZED STEEL CLEAT
• CONTINUOUS FRONT FACE CLEAT AND GASKETED BACK FACE FASTENER
ANSI/SPRI ES-1 TESTED RESISTANCE
OUTWARD 265 LBS./SQ. FT.
UPWARD 440 LBS./SQ. FT.
UL-4
3/1/11
12" MAX
24 GAUGE (0.024" THICK) GALVANIZED STEEL CONFORMING TO ASTM A653
22 GAUGE (0.030" THICK) GALVANIZED STEEL CONFORMING TO ASTM A653
5" MAX
FABRICATION
COPING
CONTINUOUS CLEAT
1 1/4" LONG GALVANIZED STEEL ROOFING NAIL AT 6" O.C.
1 1/2" LONG GALVANIZED STEEL HEX HEAD SCREW WITH WASHER AT 18" O.C.
CONTINUOUSLY HAND CRIMP HEM OVER CLEAT
INSTALLATION
CRA
COLORADO ROOFING ASSOCIATION
NRCA

NRCA's shop-fabricated edge metal testing

- NRCA has third-party certifications:
  - UL
  - Intertek Testing Services, N.A.
  - FM Approvals
- Contractors included in NRCA's third-party certification program are listed on NRCA's website: www.nrca.net
- If interested, contact me for more information.

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Colorado contractors

Included in NRCA's UL ANSI/SPRI ES-1 certification

Central States Roofing Co., Inc.

Colorado Springs, CO

Douglas Colony Group

Commerce City, CO

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In review…

ANSI/SPRI/FM 4435 ES-1

- Code requirement
- Design wind loads
- Loads should be in Contract Documents
- RE-1, RE-2 & RE-3 testing
- NRCA's UL, ITS and FM third-party certification programs provide a means of compliance for contractor-fabricated edge metal

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Consultants' roles

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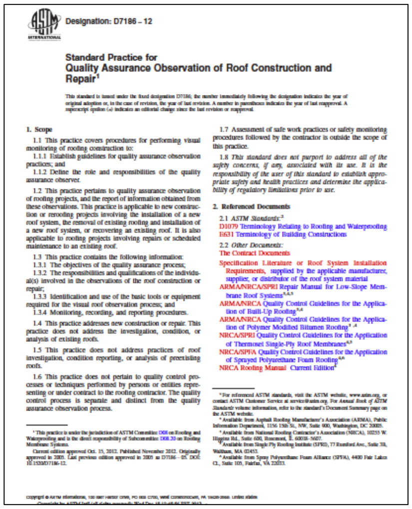
ASTM D7186-12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Standard Practice for
Quality Assurance Observation of Roof Construction and Repair[1]

"Standard Practice for Quality Assurance Observation of Roof Construction and Repair"

- Observe and report
- Reporting procedures
- QAO shall have insurance
- QAO shall provide nad maintain PPE and fall protection equipment, if required by regulating authorities

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RCI

- Member
- Registered Roof Observer (RRO)
- Registered Roof Consultant (RRC)
- Registered Waterproofing Consultant (RWC)
- Registered Exterior Wall Consultants (REWC)
- Registered Building Envelope Consultant (RBEC)

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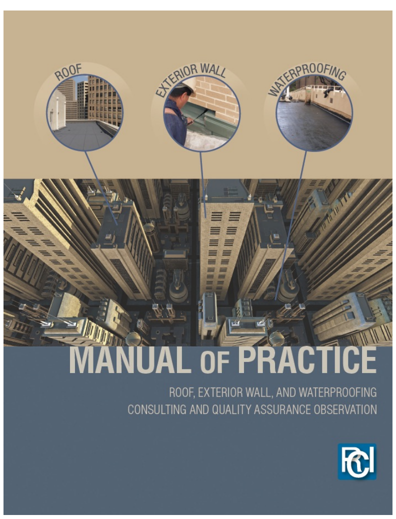
RCI



Manual of Practice:

- Sec. 1: Introduction
- Sec. 2: Recommended practices for consulting
- Sec. 3: Recommended practices for QAO
- Sec. 4: Specialized areas of practice
- Appendixes

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Questions?

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