ARMA Technical Committee
Kansas City, MO
March 8, 2016

NRCA technical issues

presented by

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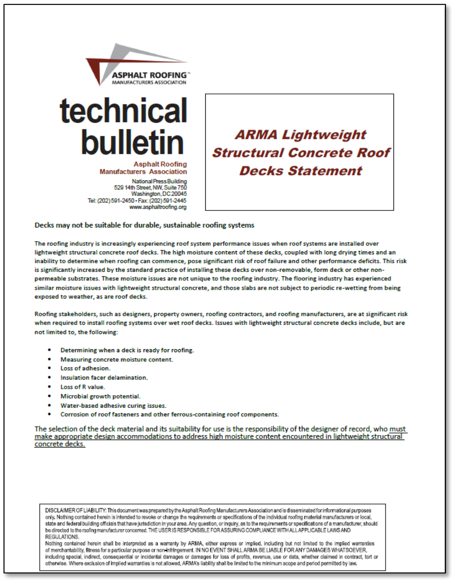
Vice President, Technical Services
National Roofing Contractors Association

Moisture in concrete roof decks



technical bulletin

Asphalt Roofing Manufacturers Association

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www.asphaltroofing.org

ARMA Lightweight Structural Concrete Roof Decks Statement

Decks may not be suitable for durable, sustainable roofing systems

The roofing industry is increasingly experiencing roof system performance issues when roof systems are installed over lightweight structural concrete roof decks. The high moisture content of these decks, coupled with long drying times and an inability to determine when roofing can commence, pose significant risk of roof failure and other performance deficits. This risk is significantly increased by the standard practice of installing these decks over non-removable, form deck or other non-permeable substrates. These moisture issues are not unique to the roofing industry. The flooring industry has experienced similar moisture issues with lightweight structural concrete, and those slabs are not subject to periodic re-wetting from being exposed to weather, as are roof decks.

Roofing stakeholders, such as designers, property owners, roofing contractors, and roofing manufacturers, are at significant risk when required to install roofing systems over wet roof decks. Issues with lightweight structural concrete decks include, but are not limited to, the following:

- Determining when a deck is ready for roofing.
- Measuring concrete moisture content.
- Loss of adhesion.
- Insulation facer delamination.
- Loss of R value.
- Microbial growth potential.
- Water-based adhesive curing issues.
- Corrosion of roof fasteners and other ferrous-containing roof components.

The selection of the deck material and its suitability for use is the responsibility of the designer of record, who must make appropriate design accommodations to address high moisture content encountered in lightweight structural concrete decks.

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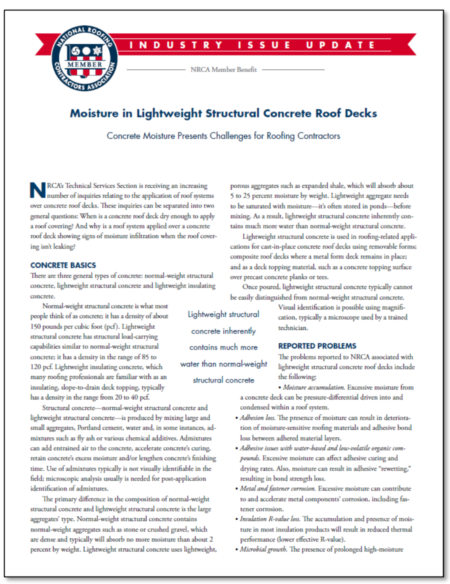
ARMA Technical Bulletin:

- "…over non-removable, form deck or other non-permeable substrates…"
- "…the responsibility of the designer of record…"
- "…who must make appropriate design accommodations to address high moisture content encountered in lightweight structural concrete decks."



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 concrete; 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

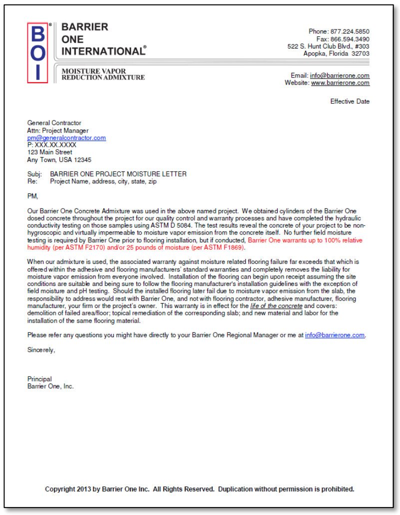
The problems reported to NRCA associated with lightweight structural concrete roof decks include the following:

- *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

NRCA *"Industry Issue Update,"* August 2013:

- Reported problems
- Deck dryness tests:
  - Conventional dryness tests are not reliable
  - Suggested using ASTM F2170
- NRCA recommendations:
  - Contractors should not determine deck dryness
  - Don't use lightweight structural concrete
  - Remedial repair suggestions

Barrier One



BARRIER ONE INTERNATIONAL®
MOISTURE VAPOR REDUCTION ADMIXTURE

Phone: 877.224.5850
Fax: 866.594.3490
522 S. Hunt Club Blvd., #303
Apopka, Florida 32703

Email: info@barrierone.com
Website: www.barrierone.com

Effective Date

General Contractor
Attn: Project Manager
pm@generalcontractor.com
P: XXX.XX.XXXX
123 Main Street
Any Town, USA 12345

Subj: BARRIER ONE PROJECT MOISTURE LETTER
Re: Project Name, address, city, state, zip

PM,

Our Barrier One Concrete Admixture was used in the above named project. We obtained cylinders of the Barrier One dosed concrete throughout the project for our quality control and warranty processes and have completed the hydraulic conductivity testing on those samples using ASTM D 5084. The test results reveal the concrete of your project to be non-hygroscopic and virtually impermeable to moisture vapor emission from the concrete itself. No further field moisture testing is required by Barrier One prior to flooring installation, but if conducted, Barrier One warrants up to 100% relative humidity (per ASTM F2170) and/or 25 pounds of moisture (per ASTM F1869).

When our admixture is used, the associated warranty against moisture related flooring failure far exceeds that which is offered within the adhesive and flooring manufacturers' standard warranties and completely removes the liability for moisture vapor emission from everyone involved. Installation of the flooring can begin upon receipt assuming the site conditions are suitable and being sure to follow the flooring manufacturer's installation guidelines with the exception of field moisture and pH testing. Should the installed flooring later fail due to moisture vapor emission from the slab, the responsibility to address would rest with Barrier One, and not with flooring contractor, adhesive manufacturer, flooring manufacturer, your firm or the project's owner. This warranty is in effect for the *life of the concrete* and covers: demolition of failed area/floor; topical remediation of the corresponding slab; and new material and labor for the installation of the same flooring material.

Please refer any questions you might have directly to your Barrier One Regional Manager or me at info@barrierone.com.

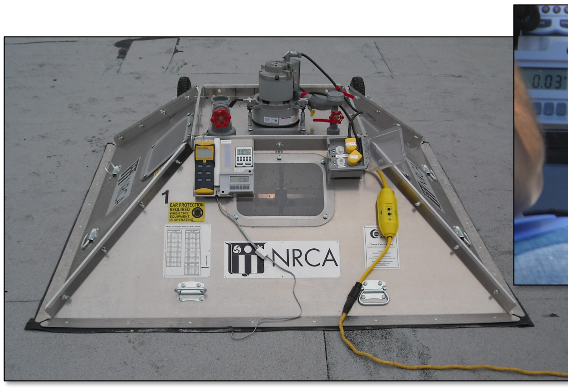
Sincerely,

Principal
Barrier One, Inc.

"…moisture vapor reduction admixture (water-based concrete admixture). A nano scale, chemical formation of micro calcium silicate hydrate molecules that blocks moisture vapor transmission through the capillary system of cementitious structural concrete."

Field uplift testing

- ASTM E907, "Standard Test Method for Field Testing Uplift Resistance for Adhered membrane Roofing Systems"
- FM 1-52, "Field Verification of Roof Wind Uplift Resistance"



INDUSTRY ISSUE UPDATE

NRCA Member Benefit

Field-uplift testing

ASTM E907 and FM 1-52 tests continue to be problematic

June 2015

NRCA continues to receive a significant number of reports from roofing contractors, manufacturers and designers regarding the use of and problems associated with field-uplift tests as post-installation quality assurance measures for membrane roof systems. NRCA has addressed these testing issues a number of times during the years. Following is a summary of NRCA's previous discussions, as well as updated information and recommendations.

ASTM E907/FM 1-52

There are two recognized field test methods for determining adhered membrane roof systems' uplift resistances: ASTM E907, "Standard Test Method for Field Testing Uplift Resistance of Adhered Membrane Roofing Systems," and FM Global Loss Prevention Data Sheet 1-52 (FM 1-52), "Field Verification of Roof Wind Uplift Resistance."

An example of a test chamber used for negative-pressure uplift testing

Both test methods are similar and provide for affixing a 5- by 5-foot dome-like chamber to a roof surface's topside and applying a defined negative (uplift) pressure inside the chamber to the roof system's exterior-side surface using a vacuum pump (see photo). During the test, membrane surface deflection inside the chamber is visually monitored and measured to determine whether a roof system passes or is "suspect."

Using ASTM E907, a roof system is considered to be suspect if the deflection measured during the test is 25 mm (about 1 inch) or greater. During FM 1-52 testing, a roof system is suspect if the measured deflection is between $\frac{1}{4}$ of an inch and $\frac{15}{16}$ of an inch depending on the maximum test pressure; 1 inch where a thin topping board (cover board) is used; or 2 inches where a thin cover board or flexible, mechanically attached insulation is used.

If an ASTM E907 or FM 1-52 test yields a suspect result, a test cut should be taken in the test area to determine whether failure has occurred and the specific failure mode.

ASTM E907 and FM 1-52 differ notably in their test cycles and maximum test pressures for determining roof system deflections and whether a roof system passes or is suspect. ASTM E907 testing is conducted in 15-pounds per square foot (psf) pressure intervals up to the calculated design wind (uplift) pressure for the specific roof system being evaluated. FM 1-52 testing is conducted using an initial 15-pounds psf pressure followed by 7.5-pound psf increments up to a maximum test pressure of 1.25 times the design uplift pressure for the specific roof system being evaluated.

Considering maximum test loading and allowable test deflections in combination, FM 1-52 requires 25 percent higher test loads, yet only allows as little as $\frac{1}{4}$ the test deflection of ASTM E907. That said, FM 1-52 is a significantly more stringent test than ASTM E907.

ASTM E907 originally was published as a recognized consensus standard in 1983, and it was revised in 1996. In 2013, ASTM withdrew ASTM E907 because a consensus could not be reached regarding necessary revisions—most significantly, defining the test method's precision and bias (accuracy). ASTM E907-96 still is available for use and can be obtained directly from ASTM's website, www.astm.org.

FM 1-52 is an FM Global-promulgated evaluation method and not a recognized industry-consensus test standard. FM 1-52's scope indicates it only is intended to confirm acceptable wind-uplift resistance on completed roof systems in hurricane-prone regions, where a partial blow-off has occurred or where inferior roof system construction is suspected or known to be present.

FM 1-52 originally was published by FM Global in October 1970. The negative-pressure uplift test was added in August 1980 and has been revised several times. The current edition is dated July 2012 and includes an option for "visual construction observation (VCO)" as an alternative to negative-pressure uplift testing. VCO provides for full-time, third-party monitoring of a roof system application to verify roof system installation in accordance with contract documents.

NRCA "Industry Issue Update," June 2015

NRCA's experience:

- Most tests not conducted in accordance with ASTM E907 or FM 1-52.
- No correlation between field test vs. lab. results/classifications
- NRCA survey: 55% passing

The latest…

Designers specifying roof systems designs that have not been FM tested/classified, but require the contractor to pass FM 1-52 to receive payment

NRCA recommendations

- Consider avoiding projects where field-uplift testing is indicated in the contract documents as a basis for acceptance of roofing work
- Add proposal/contract language (see Industry Issue Update).

Wind design for roof assemblies

Specifying a wind warrantee, in itself, is not proper wind design

Proper wind design

- Determine wind loads
  - IBC Ch. 16-Structural Design
  - ASCE 7-10, "Minimum Design Loads for Buildings and Other Structures"
- Design for resistance
  - FM 4474
  - UL 580 or UL 1897

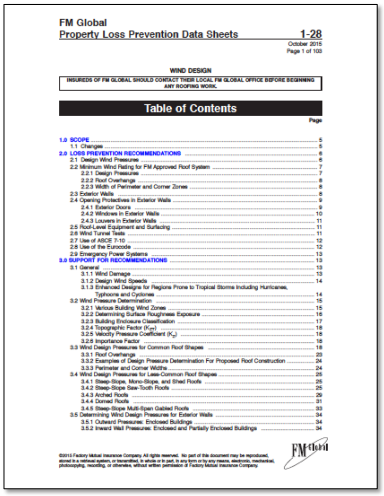
IBC requires (Sec. 1603) design wind loads to be shown in the Construction Documents

Design wind load determination

www.roofwinddesigner.com

FM 1-28 has been updated

www.fmglobaldatasheets.com


FM Global
Property Loss Prevention Data Sheets 1-28
WIND DESIGN
Table of Contents

- October 2015 update
- Based upon ASCE 7-05 with enhancements
- Reformatted
- Be cautious of FM-insured projects
- See *Professional Roofing*, March 2016

Professional Roofing, March 2016


TECH TODAY
A new consideration
FM 1-28 has been updated, further complicating wind designs
by Mark S. Graham

- Use RoofNav's ratings calculator
- Apply a 2.0 safety factor
- Roof overhang factors (Table 7)
- Windborne debris separation distances
- Roof-mounted equipment (ASCE 7-10)
- Tornado-resistant design (Appendix)

Comparing FM 1-28 to ASCE 7-05 and ASCE 7-10

Example: A manufacturing building located in New Orleans, LA. The building is an enclosed structure with a low-slope roof system and a roof height of 33 ft. The building is located in an area that is categorized as Exposure Category C.

Document	Basic wind speed (mph)	Design wind pressure (psf)		
		Zone 1 (Field)	Zone 2 (Perimeter)	Zone 3 (Corner)
FM 1-28 (without SF)	v = 120	43	72	108
FM 1-28 (w/ 2.0 SF)		86	144	216
ASCE 7-05 (without SF)	v = 120	38	63	95
ASCE 7-05 (w/ 2.0 SF)		76	126	190
ASCE 7-10 Strength design	v_{ULT} = 150	59	99	148
ASCE 7-10 ASD (without SF)	v_{ASD} = 116	35	59	89
ASCE 7-10 ASD (w/ 2.0 SF)		71	118	178

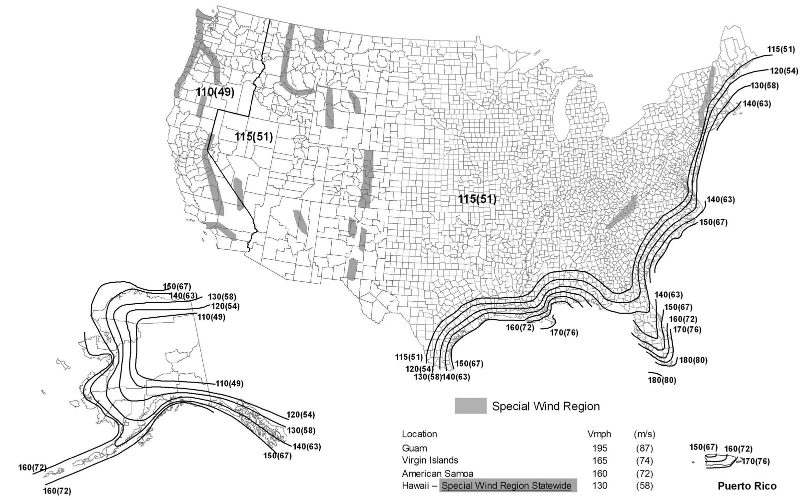
ASCE 7-16 (public review draft)

- Revised basic wind speed map
- Changes (and new) pressure coefficients
- Revised perimeter and corner zones

Expect higher field, perimeter and corner uplift pressures

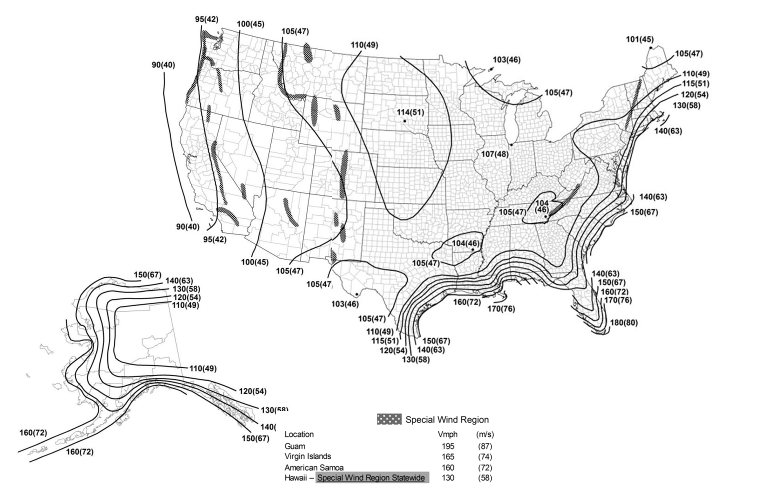
ASCE 7-10 basic wind speed map

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



ASCE 7-16 (draft) basic wind speed map

Risk Category II Buildings



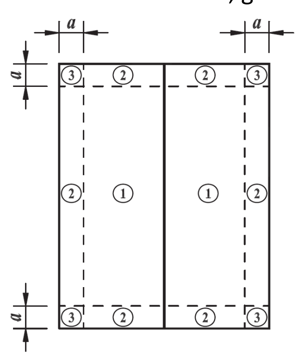
GC_p pressure coefficients

h ≤ 60 ft., gable roofs ≤ 7 degrees

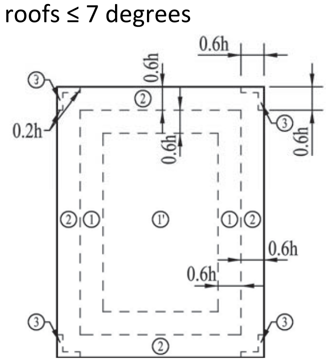
Zone	ASCE 7-10	ASCE 7-16 (draft)
1'	--	-0.9
1	-1.0	-1.7
2 (perimeter)	-1.8	-2.3
3 (corners)	-2.8	-3.2

Zones

h ≤ 60 ft., gable roofs ≤ 7 degrees



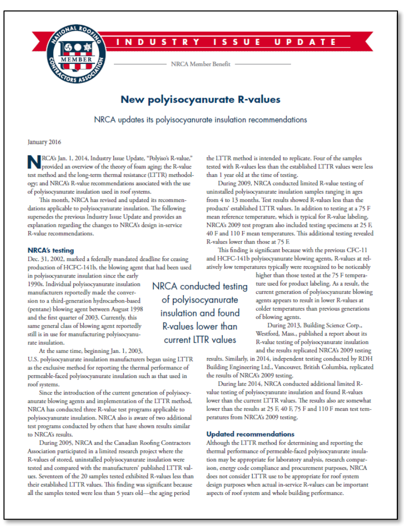
ASCE 7-10



ASCE 7-16 (draft)

Proper wind design is oftentimes avoided…
and it's only going to get more complicated

NRCA's revised polyiso. R-value recommendation



INDUSTRY ISSUE UPDATE

NRCA Member Benefit

New polyisocyanurate R-values

NRCA updates its polyisocyanurate insulation recommendations

January 2016

NRCA's Jan. 1, 2014, Industry Issue Update, "Polyiso's R-value," provided an overview of the theory of foam aging; the R-value test method and the long-term thermal resistance (LTTR) methodology; and NRCA's R-value recommendations associated with the use of polyisocyanurate insulation used in roof systems.

This month, NRCA has revised and updated its recommendations applicable to polyisocyanurate insulation. The following supersedes the previous Industry Issue Update and provides an explanation regarding the changes to NRCA's design in-service R-value recommendations.

NRCA's testing

Dec. 31, 2002, marked a federally mandated deadline for ceasing production of HCFC-141b, the blowing agent that had been used in polyisocyanurate insulation since the early 1990s. Individual polyisocyanurate insulation manufacturers reportedly made the conversion to a third-generation hydrocarbon-based (pentane) blowing agent between August 1998 and the first quarter of 2003. Currently, this same general class of blowing agent reportedly still is in use for manufacturing polyisocyanurate insulation.

At the same time, beginning Jan. 1, 2003, U.S. polyisocyanurate insulation manufacturers began using LTTR as the exclusive method for reporting the thermal performance of permeable-faced polyisocyanurate insulation such as that used in roof systems.

Since the introduction of the current generation of polyisocyanurate blowing agents and implementation of the LTTR method, NRCA has conducted three R-value test programs applicable to polyisocyanurate insulation. NRCA also is aware of two additional test programs conducted by others that have shown results similar to NRCA's results.

During 2005, NRCA and the Canadian Roofing Contractors Association participated in a limited research project where the R-values of stored, uninstalled polyisocyanurate insulation were tested and compared with the manufacturers' published LTTR values. Seventeen of the 20 samples tested exhibited R-values less than their established LTTR values. This finding was significant because all the samples tested were less than 5 years old—the aging period the LTTR method is intended to replicate. Four of the samples tested with R-values less than the established LTTR values were less than 1 year old at the time of testing.

During 2009, NRCA conducted limited R-value testing of uninstalled polyisocyanurate insulation samples ranging in ages from 4 to 13 months. Test results showed R-values less than the products' established LTTR values. In addition to testing at a 75 F mean reference temperature, which is typical for R-value labeling, NRCA's 2009 test program also included testing specimens at 25 F, 40 F and 110 F mean temperatures. This additional testing revealed R-values lower than those at 75 F.

This finding is significant because with the previous CFC-11 and HCFC-141b polyisocyanurate blowing agents, R-values at relatively low temperatures typically were recognized to be noticeably higher than those tested at the 75 F temperature used for product labeling. As a result, the current generation of polyisocyanurate blowing agents appears to result in lower R-values at colder temperatures than previous generations of blowing agents.

NRCA conducted testing of polyisocyanurate insulation and found R-values lower than current LTTR values

During 2013, Building Science Corp., Westford, Mass., published a report about its R-value testing of polyisocyanurate insulation and the results replicated NRCA's 2009 testing results. Similarly, in 2014, independent testing conducted by RDH Building Engineering Ltd., Vancouver, British Columbia, replicated the results of NRCA's 2009 testing.

During late 2014, NRCA conducted additional limited R-value testing of polyisocyanurate insulation and found R-values lower than the current LTTR values. The results also are somewhat lower than the results at 25 F, 40 F, 75 F and 110 F mean test temperatures from NRCA's 2009 testing.

Updated recommendations

Although the LTTR method for determining and reporting the thermal performance of permeable-faced polyisocyanurate insulation may be appropriate for laboratory analysis, research comparison, energy code compliance and procurement purposes, NRCA does not consider LTTR use to be appropriate for roof system design purposes when actual in-service R-values can be important aspects of roof system and whole building performance.

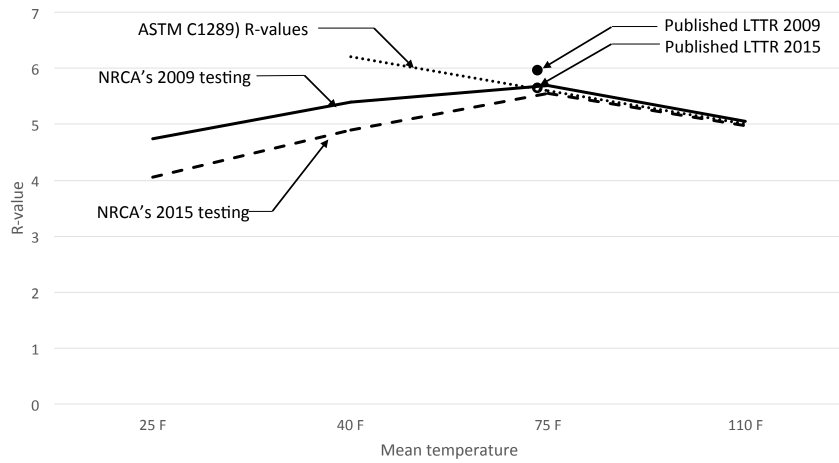
NRCA recommends designers:

- Use an in-serve design R-value of 5.0 per inch thickness for polyiso.
- Specify insulation by its thickness, not its R-value

NRCA's recommendation is based upon our own testing, and confirming replicate testing by:

- Building Science Corp.
- RDH Building Engineering, Ltd.

NRCA's R-value testing



Modified bitumen sheet testing

Purpose

NRCA's MB sheet testing

Analyze critical physical properties of popular MB sheet products and compare results to applicable ASTM product standards and past test results

Modified bitumen sheet testing

ASTM D5147-Test methods for MB sheet materials

Low-temperature flexibility test:
- 1" diameter mandrel
- 180° bend
- Visually observe cracking

Granule loss test:
- Weigh specimen
- 50 scrub cycles
- Re-weigh specimen
- Calculate difference

NRCA's 2011 MB testing

Polymer-modified bitumen test results

Product (manufacturer and product)	Low-temperature flexibility		Granule embedment (as received)
	As received	Heat aged (90 days at 158 F)	
SBS products			
1-1	-5	+5	0.8
1-2	-15	-10	1.0
2-1	+5	+20	1.4
2-2	-20	-15	1.8
2-3	-5	+20	3.2
2-4	+10	+15	1.2
3-1	+30	+45	0.3
3-2	-5	0	0.3
3-3	+25	+40	1.5
4-1	-5	+5	1.1
5-1	+5	+10	0.5
6-1	-5	-5	0.7
6-2	+10	+20	1.7
APP products			
1-3	+30	+15	1.5
3-4	+35	+20	0.4
7-1	+15	+15	1.6

Summary of results

NRCA's 2011 MB testing

- 9 of 13 SBS products did not comply with ASTM's low-temp. flex requirement (0 F max.)
- 1 of 3 APP products did not comply with ASTM's low-temp. flex requirement (32 F max.)
- 1 of 16 products did not comply with ASTM's granule loss requirement (2 grams max.)

NRCA's 2015 MB testing

Polymer-modified bitumen test results

Sample (manufacturers and product)	Low-temperature flexibility (F)		Granule embedment as received (grams)
	As received	Heat aged (90 days at 158 F)	
SBS products			
1-A	-25	-25	0.9
2-A	-20	-15	1.6
2-B	0	15	0.7
2-C	-35	-15	1.3
3-A	10	20	1.8
4-A	-30	-30	1.1
4-B	-15	-5	0.8
5-A	-5	0	0.6
5-B	10	10	0.7
6-A	-20	-15	1.1
9-A	-30	-15	0.6
ASTM International's maximum allowable values	0	0	2
APP products			
3-B	20	20	0.7
8-A	20	35	3.4
ASTM International's maximum allowable values	32	32	2

Summary of results

NRCA's 2015 MB testing

- 3 of 11 SBS products did not comply with ASTM's low-temp. flex requirement (0 F max.)
- 1 of 2 APP products did not comply with ASTM's low-temp. flex requirement (32 F max.)
- 1 of 13 products did not comply with ASTM's granule loss requirement (2 grams max.)

Recommendations

NRCA's 2011 and 2015 MB testing

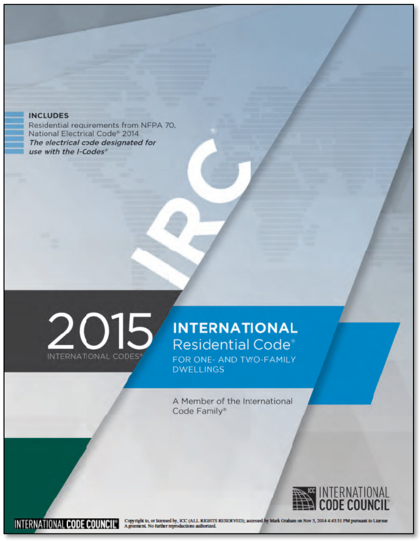
Seek third-party certifications of compliance with the applicable ASTM product standard:

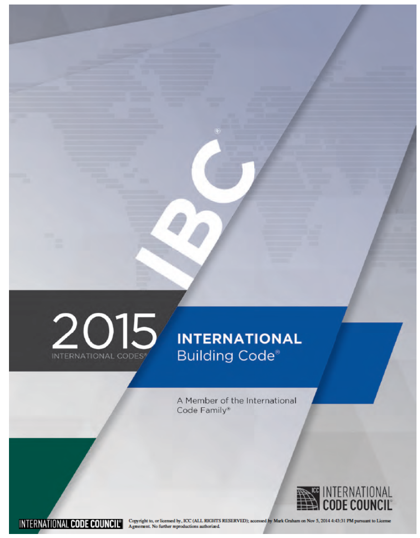
- – UL product certification
- – ICC-ES evaluation report
- – Miami-Dade County product approval

Attic ventilation

Attic ventilation

Code Requirements





Attic ventilation

IRC 2015:

- 1:150 ratio
- 1:300 ration permitted:
  - In Climate Zones 6, 7 and 8 with a Class I or II vapor retarder, and
  - 40% ≤ 50% of ventilation within 3 feet of the ridge
  - Unvented attic option

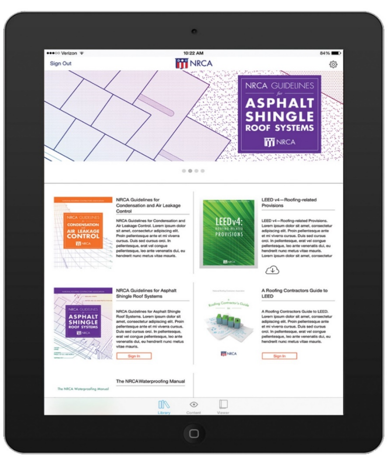
IBC 2015:

- 1:150 ratio
- 1:300 ration permitted:
  - In Climate Zones 6, 7 and 8 with a Class I or II vapor retarder, and
  - 40% ≤ 50% of ventilation within 3 feet of the ridge
  - Unvented attic option

Attic ventilation requirements are finally consistent in IBC 2015 and IRC 2015

The NRCA Roofing Manual

NRCA App



- NRCA App available on the Apple Store and Google Play Store for tablets
- iPhone App also available
- Register within App as being an NRCA member
- The NRCA Roofing Manual is viewable to NRCA members
- Favorite and send pages features

Manual online

www.nrca.net

- Available to all NRCA member registered users (multiple users per member company)
- “Members only” section, click on “My account”, the “Electronic file”
- View, download and print

Questions

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