ASPHALT ROOFING®
MANUFACTURERS ASSOCIATION

Summer Committee Meetings

August 20 - 22, 2018

Read Ahead Materials

ARMA Summer Committee Meetings
Sheraton Tampa Riverwalk Hotel
200 N Ashley Drive, Tampa, FL 33602
August 20 – 22, 2018

ASPHALT ROOFING™
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To: ARMA Members and Staff

From: Reed Hitchcock, Executive Vice President

Re: Antitrust Compliance - Quick Reference

The Asphalt Roofing Manufacturers Association ("**ARMA**" or "**Association**") has in effect an Antitrust Compliance Policy ("Policy"). The Policy is intended for the guidance of ARMA member company representatives, officers, directors and staff, when engaged in any activity conducted in the name of, or on behalf of, ARMA. All such persons are expected to be familiar with the Policy and to follow it both in letter and spirit.

The following cautionary statements are taken from the full Policy and are intended to be used as a quick reference tool. This document is not a substitute for the full Policy, which is available from the Association's office and with which all are expected to be conversant. At all Association meetings and events, including informal gatherings before, during or following such meetings and events, **ARMA** members, their representatives and guests will not discuss any of the following competitively sensitive topics:

1. Current or future prices, price levels, costs or profit margins.
2. What is a fair or rational profit level.
3. Actions which could lead to standardizing or stabilizing prices.
4. Pricing or bidding methodologies or procedures.
5. Pricing practices or strategies, including methods, timing or implementation of price changes.
6. Whether or how prices, warranties or other terms of sale are advertised.
7. Cash or any other discounts, rebates, service charges or other terms and conditions of sale.
8. Credit terms.
9. Product warranty terms.
10. Actual, planned or projected production, production capacity or capacity utilization.
11. Projected demand.
12. Confidential company plans for new products.
13. Dividing or allocating geographic or product markets or customers.
14. Whether or on what terms to do business with a supplier, competitor or customer.
15. Whether or on what terms to solicit other companies' employees for employment.
16. The business practices of individual firms.
17. The validity of any patent or the terms of any patent license.
18. Ongoing litigation, unless being reported upon by ARMA's General Counsel or discussed appropriately at ARMA's Counsel Forum.

We hope the above rules will be helpful as you participate in ARMA meetings and other activities. If you have any questions about antitrust compliance, do not hesitate to contact ARMA's General Counsel:

C. Michael Deese
ARMA General Counsel
Howe & Hutton, Ltd.
Tel: (202) 466-7252 x103
Email: cmd@howehutton.com

ARMA 2018 Summer Committee Meetings Schedule of Events

August 20-22, 2018
Sheraton Tampa Riverwalk Hotel
200 N Ashley Drive, Tampa, FL 33602

Monday, August 20

Time	Session or Event
1:00pm – 4:00pm	**Communications, Marketing, and Education Committee Working Session** **Riverview Room**
12:00pm – 5:00pm	**Technical Affairs Committee** **Bayshore East**

Tuesday, August 21

Time	Session or Event
7:00am – 8:00am	**ARMA Breakfast - Riverview Room**
8:00am – 2:30pm	**General Business Session** **Bayshore Ballroom**
12:00pm – 12:45pm	**ARMA Lunch - Riverview Room**
2:00pm – 4:30pm	**PRI Tour** **6412 Badger Drive, Tampa FL 33610**
4:30pm – 6:00pm	**ARMA Reception at PRI** **Rooftop 220 Restaurant** **220 W 7th Avenue, Tampa, FL 33602**

Wednesday, August 22

Time	Session or Event
7:30am – 8:30am	**ARMA Breakfast – Riverview Room**
8:30am – 4:00pm	**Health, Safety, and Environment Committee Session** **Bayshore East**
8:30am – 12:00pm	**Codes Steering Group** **Bayshore West**
12:00pm – 1:00pm	**ARMA Lunch – Riverview Room**

Asphalt Roofing Manufacturers Association
Communications, Marketing, and Education Committee
(CMEC) Agenda

Monday, August 20, 2018 - Riverview Room

Communications, Marketing, and Education Committee
Chair: Sara Jonas, SOPREMA

Time	Discussion	Back-up Materials
1:00pm (5 minutes)	Call to Order • Review of Antitrust Policy • Review of Meeting Agenda • Review and Approval of Previous Meeting Minutes	- July 9 Meeting Minutes -ARMA Antitrust Quick Reference
1:05pm (25 minutes)	Overview of 2018 Projects and Activities • Key Successes So Far This Year • Additional Initiatives: Metal Roofing Alliance	- July Activity Report
1:30pm (20 minutes)	Heidi Ellsworth, editor of *Roofers Coffee Shop*	
1:50pm (25 minutes)	ARMA Awards Program Launch • Media Outreach Plan	
2:15pm (15 minutes)	Networking Break	

2:30pm (45 minutes)	Research and Analysis Report
	• Digital Update
	  o Audience Survey Data
	  o Asphaltroofing.org Analytics Review
	• Industry Research
	  o IRE Research
	• Recommendations/Next Steps	

3:15pm (30 minutes)	Upcoming 2019 Strategy – Brainstorming	
3:45pm (15 minutes)	Other Business / New Business	
4:00pm	CMEC Adjournment	
4:00pm (60 minutes)	CMEC to Join TAC Meeting – Bayshore East Room • ASTM Wind Resistant Test • Updates on technology/marcom issues	
5:00pm	Adjournment	

ARMA 2018 Summer Committee Meetings
Technical Affairs Committee Working Session
Monday, August 20, 2018

Technical Affairs Committee
Co-Chair: Jean-Francois Cote, SOPREMA, Inc.
Co-Chair: Sid Dinwiddie, PABCO Roofing Products

Time	Session	Back-up Materials
1:00PM (10 minutes)	**Introduction and Opening Remarks** -Call to Order and Introductions -Review of Antitrust Policy -Review of Meeting Agenda -Approval of Minutes (TBD)	Antitrust Quick Reference Minutes
1:10pm (60 minutes)	**ARMA-Sustainability Task Force** Chair: Jean Francois Cote - Anna Lasso UL E, working session on PCR	
2:10 pm (50 minutes)	**ARMA Meeting Education Task Force** Chair: Michelle Benatti John Casola Roofing Asphalt Characterization	
3:00 PM (15 Minutes)	**Break**	
3:15PM (10 minutes)	**ARMA Asphalt Shingle Recycling Task Force** Chair: Marty Grohman	
3:25 PM (20 minutes)	**Ventilation Task Force** Chair: Paul Scelsi Research proposal	Research proposal
3:45pm (15 minutes)	**ARMA Technical Review Task Force (Publication Review)** Chair: Lynn Picone -Technical Bulletins	
4:00PM (60 minutes)	TAC & CMEC Joint Meeting	
5:00PM	Adjournment	

NOTE: The CRTF will have a task force meeting at 12:00 PM prior to the start of the TAC meeting.

ASPHALT ROOFING MANUFACTURERS ASSOCIATION

ARMA Cool Roof Task Force Teleconference
Monday August 20th, 2018 12:00-1:00 PM
Room: Bayshore East

Topic	**Back-up Materials**
Call to Order • Roll Call • Antitrust Reminder • Agenda Review • Approval of Minutes	• -Antitrust Quick Reference • -Minutes 8-3-2018
Discussion CRRC • SRI Concept • Finalize Retesting Strategic Direction	
New / Other Business	
Action Item Review	
Adjournment	

ARMA 2018 Summer Committee Meetings
General Business Agenda
Tuesday, August 21, 2018
Room: Bayshore Ballroom

Time	Session
7:00am (1 hour)	Breakfast – Riverview Room
8:00am (15 minutes)	**Introduction and Opening Remarks** Call to Order and Introductions Review of Antitrust Policy
8:30am (60 minutes)	Bob Zemantic Jr, Engineering Standards – Loss Prevention Data Sheets
9:30am (60 minutes)	Florida Building Code Roofing Panel Discussion Mike Silvers & Brian Swope of the Florida Roofing and Sheet Metal Contractors Association
10:30am (15 minutes)	Break – Bayshore Foyer
10:45am (45 minutes)	Dr. Murray Morrison, IBHS
11:30am (30 minutes)	Darrel Higgs, DPH Consulting
12:00pm (60 minutes)	Lunch - Riverview Room
1:00pm (30 minutes)	Michael Fischer – Monroe County, Florida
1:30pm (60 minutes)	Payam Bozorgchami, California Energy Commission
2:30pm	Adjourn
3:00pm	Meet at Hotel Lobby for PRI Tour Bus
3:20pm (30 minutes)	Bus Departs to PRI
4:00pm (60 minutes)	**PRI TOUR** 6412 Badger Drive, Tampa FL 33610
6:00pm (120 minutes)	**PRI Reception** Rooftop 220 220 W 7th Avenue, Tampa, FL 33602
8:00pm	**Return to Hotel From Reception**

ARMA 2018 Summer Committee Meetings
Codes Steering Group - Working Meeting Agenda
Wednesday, August 22, 2018 - Room: Bayshore West

Codes Steering Group
Chair: Aaron Phillips, TAMKO Building Products, Inc.
TRG Chair: Greg Keeler, Owens Corning

Time	Discussion Topic	Back-up Materials
8:30 (10 minutes)	**Call to Order** • Self-Introductions • Antitrust Reminder • Agenda Review • Approval of Past Meeting Minutes	-Antitrust Quick Reference
8:40 AM (50 minutes)	**Stakeholder Discussion** • IBHS • FRSA • RICOWI • FM Approvals	
9:30 AM (30 minutes)	**State and Local Code Activity** • Florida Building Commission • Monroe County • LA County • Denver Green Roof Ordinance • State and Local Adoption Process	
10:00 AM (10 minutes)	**Break**	
10:10 AM (25 minutes)	**Codes and Standards Update** • ICC Code Development • ASHRAE • California Energy Commission • UL 2218	
10:35 AM (65 minutes)	**Task Force & Technical Resource Group (TRG) Activities** Cool Roof Task Force (CRRC and ENERGY STAR) ASTM D 7158 Texas Department of Insurance Miami Dade	
11:40 AM (5 minutes)	**New / Other Business**	
11:45 AM (5 minutes)	**Action Item Review**	
12:00pm	**Adjournment**	

ARMA 2018 Summer Committee Meetings
Health, Safety, and Environment Committee Agenda
Wednesday, August 22, 2018 - Room: Bayshore East

Health, Safety, and Environment Committee Meeting

Chair: Devlin Whiteside, Owens Corning
Vice-Chair: Bob Hockman, TAMKO

Time	Session	Back-up Materials
7:30am (45 minutes)	Breakfast	
8:15am (15 minutes)	**Introduction and Opening Remarks** -Call to Order -Review of Antitrust Policy -Housekeeping -Review of Meeting Agenda -Introductory Activity	-Antitrust Quick Reference -HSE Committee Meeting Agenda
8:30am (30 minutes)	**Regulatory Update** -Led by: Art Sampson, ARMA Regulatory Counsel	
9:00am (30 minutes)	**HSE Committee 2018 Discussion** -Led by: Bob Hockman, TAMKO Discuss current HSE ARMA projects, upcoming projects, and project suggestions.	
9:30am (30 minutes)	Break	
10:00 am (60 minutes)	Doug Green – Venable – Discussion on TSCA Regulatory Requirements that Could Affect Roofing Manufacturing Activities and How to Respond.	
11:00 am (60 minutes)	Tia Jeter – SCS Engineers - Air Permitting and the Strategic Use of Air Modeling	
12:00 pm	Lunch	
1:00pm (60 minutes)	Discussion Silica and Silica Testing - Reviewing reports and strategy	
2:00pm (30 minute)	Networking Break	
2:30pm (30 minutes)	Harry Dietz, Director of enterprise risk management - NRCA Discussion on NRCA EH&S Activities and Training	
3:00pm (30 minutes)	Mark Klein, GAF -- OSHA “Dry Sweeping” Prohibition & Regulatory Requirements - Open discussion with Committee	
3:30 pm (30 minutes)	New Business Led by Bob Hockman, TAMKO	
4:00pm	Adjournment	

Thank You Sponsors!

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ARMA Communications, Marketing, and Education Committee

Asphalt Roofing Manufacturers Association
Communications, Marketing and Education Committee Monthly Report
July 1-31, 2018

MONTHLY SUMMARY

This month, the latest ARMA article, a feature on the 2018 QARC Bronze winner (The Museum of the American Revolution), was drafted for *Roofing Contractor Magazine.* In addition to developing media content, Kellen continues to earn media coverage on ARMA topics such as the Q2 asphalt product shipment report and ARMA's three-tab shingles eBook. To date, **61** media placements totaling over **1,818,000** media impressions have been secured. As media follow up continues, additional media placements and opportunities are expected.

The ARMA homepage survey has garnered 79 responses to date and shows the majority of homepage visitors are homeowners seeking information about asphalt shingles. Kellen plans to keep the survey open indefinitely and will share data highlights and insights in greater depth at the Tampa meeting.

MEDIA DEVELOPMENT

ARMA continues to earn media attention and reach key audience members such as roofing contractors, roofing business owners, material suppliers and buyers, building industry executives among several others. A total of 11 media placements were earned this month, totaling over 277,000 media impressions. In addition to media placements, several article opportunities are being discussed with prominent roofing and construction trade publications. Click here to view the print media placements.

Media Placements

Online

- ***Construction Specifier*** – Shared ARMA's latest whiteboard video on attic ventilation, helping push the video the nearly 3,000 views. This publication reaches 15,000 construction professionals.

- ***Construction Specifier e-Newsletter*** – Included ARMA's whiteboard video on attic ventilation in its e-newsletter, which is circulated to more than 30,000 subscribed construction professionals.

- ***Hardware + Building Supply Dealer (HBSDealer) –*** Shared the news on ARMA's first ever quarterly asphalt roofing shipment report to its 45,627 active users. The editor specified to ARMA that future reports were of great interest to the publication, as well.

- ***HBSDealer e-Newsletter*** – Included its article on ARMA's Q2 shipment report in its email newsletter, reaching over 30,000 building and construction professionals and executives.

- ***Roofers Coffee Shop*** – Featured ARMA and its roofing resources, reaching 10,000 roofing professionals.

- ***Roofers Coffee Shop*** – Published ARMA's Q2 asphalt roofing shipment report to over 10,000 roofing professionals.

- ***Roofing Contractor* –** Shared the Q2 shipment report online. In light of the *IRE Roofing Contractors' Survey* identifying this publication as a main source of information for the roofing contractor audience, ARMA has actively targeted this publication with news and opportunities. This publication reaches 38,000 roofing professionals a month.

- ***Roofing Magazine* –** Posted the staff-written article on the 2018 QARC Silver Award winner (Topsail Residence) as well as shared drone video footage of the project provided by ARMA. This publication reaches over 15,000 online.

Print

- ***Roofing Contractor* –** Helped announce the winners of the 2018 ARMA Accident Prevention Contest in the magazine's "association news" section. The print edition of *Roofing Contractor* reaches 25,000 roofing professionals.

- ***Roofing Magazine* –** Published the feature article on the 2018 QARC Silver Award winner (Topsail Residence) in its July/August edition, reaching over 38,500 roofing contractors and professionals.

- ***Western Roofing Magazine* –** Shared the news on ARMA's latest available e-book dedicated to the installation of three-tab asphalt shingles. The publication reaches over 20,000 roofing professionals from the western United States.

Media Opportunities

- *Construction Specifier* – Plans to publish a bylined article highlighting the benefits of asphalt roofing on steep-slope roofing systems. The piece features several QARC award winners (December edition).

- *Roofing Contractor* – Plans to publish a feature article on the Museum of the American Revolution (QARC Bronze Winner) in its September issue. This opportunity was secured as a result of outreach performed by ARMA and the relationship developed with the editor at IRE.

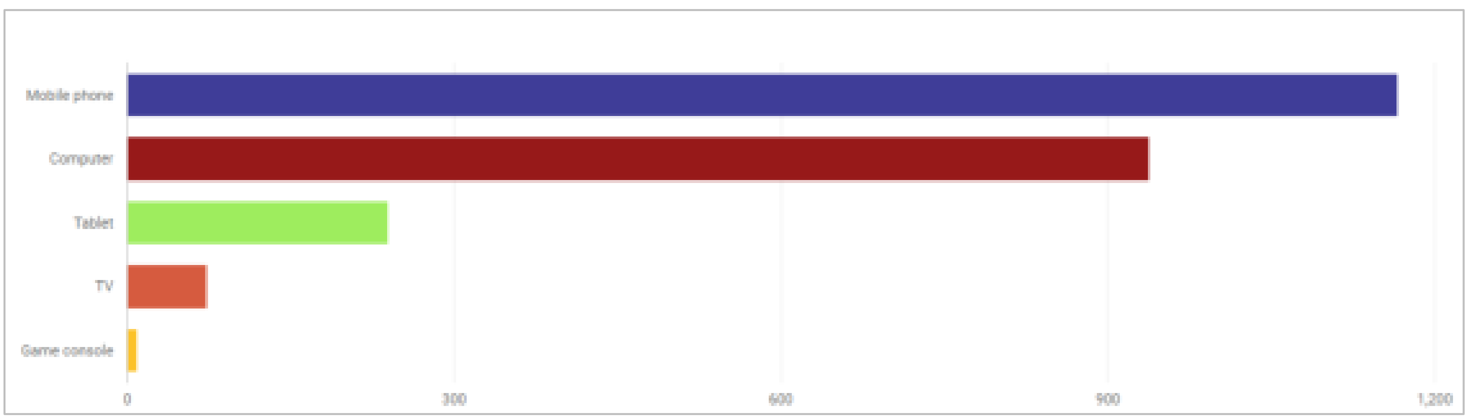
- *Western Roofing Magazine* – Plans to publish a bylined article on the West Loch Senior Village (QARC Honorable Mention) in one of its upcoming issues.

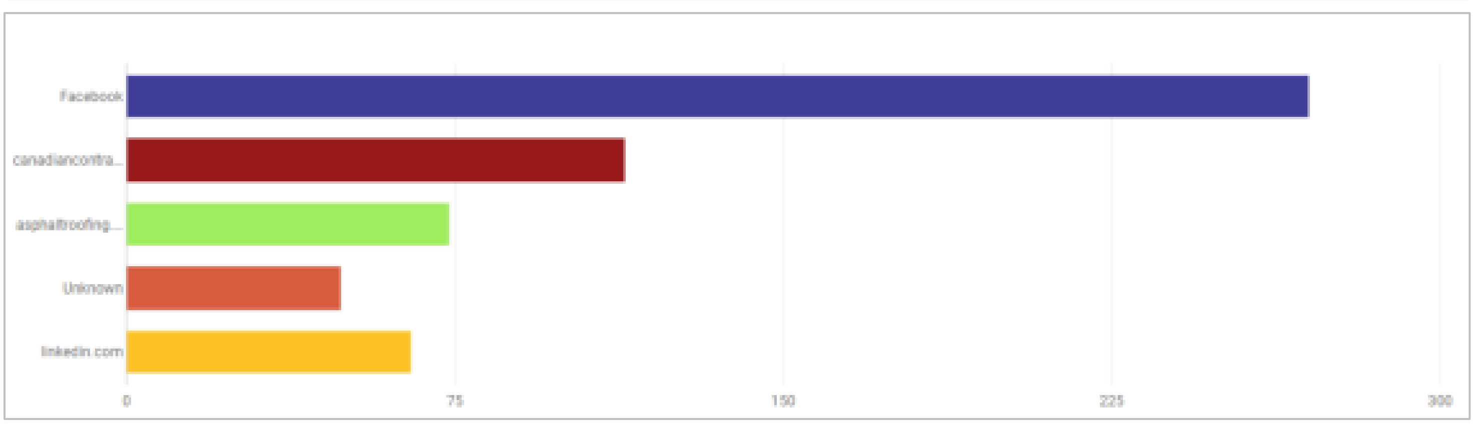
Media Monitoring

Kellen continues to monitor for articles regarding the proposed ban on asphalt shingles in Monroe County, Florida. This month, **no new articles** were published on the topic. Kellen will continue to proactively monitor and report relevant updates to the CMEC.

COLLATERAL MATERIAL

ARMA's latest video on attic ventilation continues to grow with our target audiences, amassing 2,700 views and 16 likes. Now that ARMA's latest video has been established and promoted for four months, reliable viewing trend data is developing and suggesting where further promotion would be most effective. According to YouTube's metrics, mobile viewing is by far the most popular method of viewing ARMA's attic ventilation video. In addition, Facebook is the most popular external referral, followed by *Canadian Contractor* (media placement) and the ARMA website. Kellen will use this data to further video promotion on the most effective channels as detailed by YouTube.





Video Title	*Your Guide to Algae Discoloration*	*6 Steps to Enhancing the Service Life of Your Roof System*	*How Cool Roofs Contribute to Energy Efficiency in Commercial Buildings*	*How Does Proper Attic Ventilation Protect my Roof?*
Release Date	October 2016	January 2017	October 2017	April 2018
Views	**2,420 (64 new views)**	**832 (40 new views)**	**576 views (70 new views)**	**2,496 (699 new views)**

The ARMA Awards Program Rebrand

A media outreach and promotion plan for launching the new ARMA Awards Program is currently under internal review. The plan includes several promotional vehicles such as earned media, social media and paid advertising. The plan will be shared with the CMEC for their review in mid-August.

ARMA Bookstore

ARMA is interested in converting the *Quality Control Guidelines for the Application of Asphalt Shingle Roof Systems* publication into an eBook. Following technical review by the ARMA Technical Affairs Committee, the publication was sent to NRCA for their input and feedback. The publication was created jointly with NRCA. Follow up is ongoing.

2018 Book Sales to Date:

Title	5/31 – 6/27 eBook Copies	2018 Total eBook Copies	5/31 – 6/27 POD Copies	2018 Total POD Copies	Total Copies	ARMA's Revenue
Good Applications Guide: Installing Laminated Shingles	1	4	1	3	7	$28.65
Good Applications Guide: Installing Three-Tab Shingles	2	7	0	1	8	$27.60

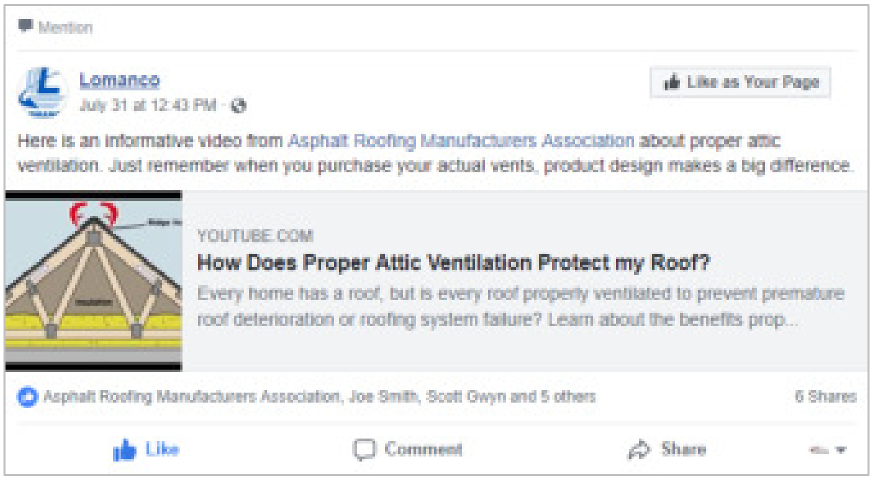
Residential Asphalt Roofing Manual	7	40	5	25	65	$633.57
Modified Bitumen Design Guide for Building Owners	1	2	0	2	4	$31.57

SOCIAL MEDIA

ARMA's Facebook page has grown to **124** likes (5 more than June), consisting of member companies, roofing contractors, media outlets and other roofing organizations. ARMA's Facebook page reached a total of **306** individuals and **30** total engagements (likes, link clicks, shares, comments).

Similar to the other ongoing purges happening on Instagram, Twitter and especially Facebook, the ARMA LinkedIn page was recently shut down by LinkedIn. ARMA is currently working to rebuild the company page and rebuild the LinkedIn follower base, which will be done through paid social media advertising and email outreach.

Below is a snapshot of Social Media Engagement this month based on our ARMA releases and marketing materials shared by our member companies, contractors and the trade publications.



July Social Media Posts:

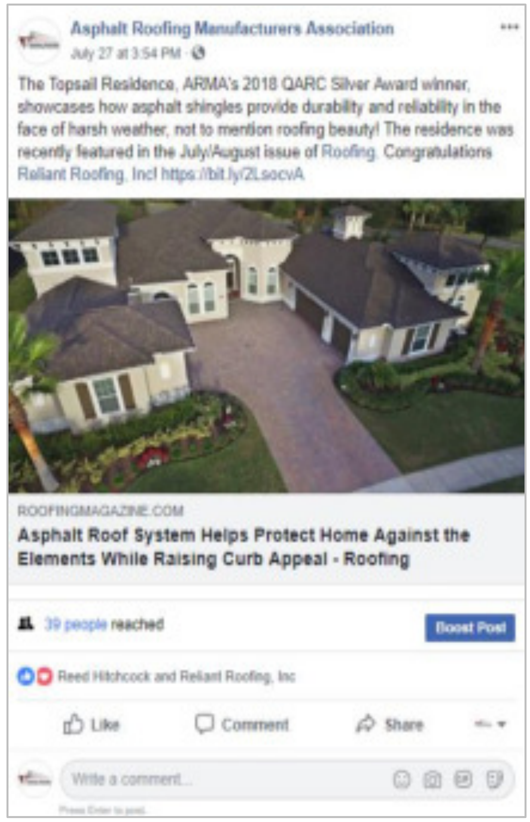
- Have you noticed dark streaks on your asphalt shingle roof this summer? Visit ARMA's YouTube channel to learn what algae discoloration is and effective strategies for addressing it. https://bit.ly/2oI5fFe **(Facebook: 49 people reached, one share, one like).**

- ARMA will officially begin releasing a quarterly report on asphalt roofing product shipments. Our first report, recently featured in HBSDealer, shares data from the second quarter of 2018. Take a look today! https://bit.ly/2LNOLHO **(Facebook: 93 people reached, two shares, five likes).**

- The Topsail Residence, ARMA's 2018 QARC Silver Award winner, showcases how asphalt shingles provide durability and reliability in the face of harsh weather, not to mention roofing beauty! The residence was recently featured in the July/August issue of Roofing.

Congratulations Reliant Roofing, Inc! https://bit.ly/2LsocvA **(Facebook: 39 people reached, two likes)**

Top Performing Posts



July Engagement Totals:

facebook

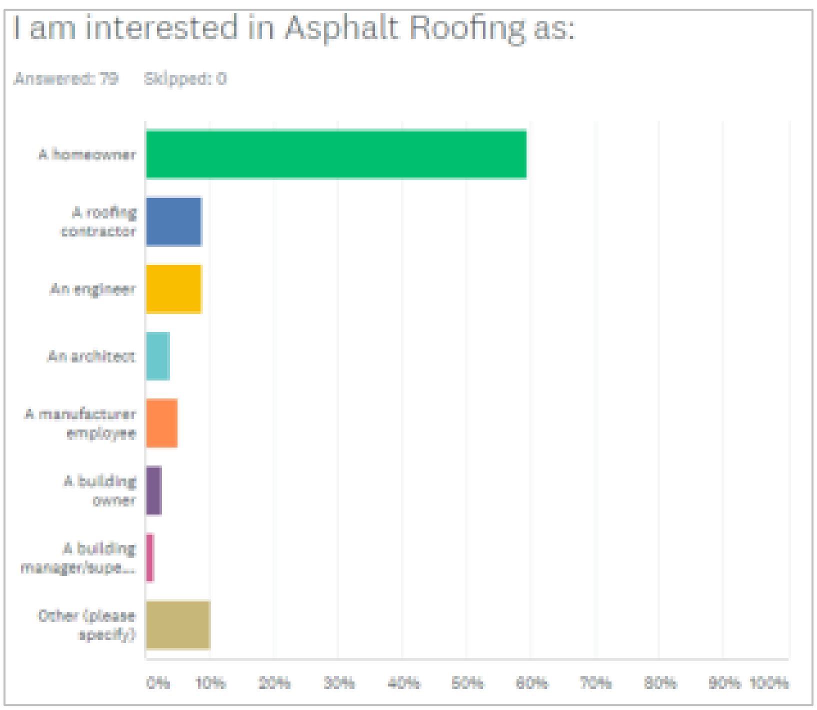
Reach: 306 individuals reached
Engagement: 30 total (likes, comments, shares, clicks).

ARMA Website

Progress continues to be made toward completing the ARMA website's Google indexing report. To date, only 218 links are awaiting indexing (1,243 at its max). As a result, the website's traffic continues to reach previously established levels (280 – 330 visitors a day), this is only expected to continue increasing as the indexing process nears completion.

The ARMA homepage survey has now been active for over a month and has collected 79 responses to date. The Kellen team will keep the survey open indefinitely as it continues to collect meaningful data. The survey can always be removed or expanded to different areas of the website at a later date. So far, the data show a majority of visitors are homeowners seeking information about asphalt shingles; and technical publications, news articles and videos are the best vehicles for conveying roofing information.

	VERY IMPORTANT	SOMEWHAT IMPORTANT	NEUTRAL	NOT VERY IMPORTANT	NOT IMPORTANT AT ALL	TOTAL
Videos	59.09% 13	13.64% 3	18.18% 4	4.55% 1	4.55% 1	22
ARMA's Technical Publications	63.64% 14	22.73% 5	13.64% 3	0.00% 0	0.00% 0	22
News Articles	54.55% 12	22.73% 5	22.73% 5	0.00% 0	0.00% 0	22
Blogs	45.00% 9	10.00% 2	40.00% 8	0.00% 0	5.00% 1	20
Facebook	28.57% 6	9.52% 2	33.33% 7	14.29% 3	14.29% 3	21
Twitter	23.81% 5	4.76% 1	42.86% 9	9.52% 2	19.05% 4	21
LinkedIn	28.57% 6	14.29% 3	28.57% 6	4.76% 1	23.81% 5	21
Tradeshows	30.00% 6	10.00% 2	30.00% 6	10.00% 2	20.00% 4	20



June 1 - 30	July 1 - 31	% Change – June to July
Sessions	**Sessions**	**Sessions**
7,274	7,915	8.81%
Users	**Users**	**Users**
6,426	7,039	9.54%
Page Views	**Page Views**	**Page Views**
13,082	14,095	7.74%
Pages / Sessions	**Pages / Sessions**	**Pages / Sessions**
1:80	1.78	-0.98%
Avg. Session Duration	**Avg. Session Duration**	**Avg. Session Duration**
00:01:27	00:01:28	1.63%

MOBILE

June 1 - 30	July 1 - 31	% Change – June to July
Mobile Sessions	**Mobile Sessions**	**Mobile Sessions**
2,411	2,793	15.84%
Mobile Users	**Mobile Users**	**Mobile Users**
2,088	2,406	15.23%
Mobile Bounce Rate	**Mobile Bounce Rate**	**Mobile Bounce Rate**
77.60%	78.73%	1.46%
Mobile Pages Per Session	**Mobile Pages Per Session**	**Mobile Pages Per Session**
1.45	1.37	-5.27
Mobile Avg. Session Duration	**Mobile Avg. Session Duration**	**Mobile Avg. Session Duration**
00:01:01	00:00:57	-7.56%

WEBSITE TRAFFIC SOURCES

June 1 - 30	July 1 - 31	% Change – June to July
Search Traffic	**Search Traffic**	**Search Traffic**
5,123	6,085	18.78%
Referrals From Websites	**Referrals From Websites**	**Referrals From Websites**
659	583	-11.53%
Direct Visits	**Direct Visits**	**Direct Visits**
1,314	1,166	-11.26%
Social	**Social**	**Social**
178	79	-55.62%

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ARMA Codes Steering Group

Attendance

Mark Harner	CertainTeed Corporation
Kermit Stahl	CertainTeed Corporation
Marty Ward	GAF
Don Shaw	IKO
John Kouba	Malarkey Roofing
Greg Keeler	Owens Corning
Sid Dinwiddie	PABCO
Aaron Phillips	TAMKO Building Products, Inc.
Jay Crandall	ARES Consulting
Tim McQuillen	ARMA Staff

Call to Order

McQuillen call the meeting to order at approximately 2:33 PM in which he read the roll call and gave the ARMA antitrust reminder.

Discussion on ASTM D 7158

Jay Crandall provided a quick review as it related to changes in wind speeds from ASCE 7-10 versus ASCE 7-16. He reported that the wind speeds in the two documents are similar and in ASCE 7-16 it is actually down on the West Coast by about 10 mph. Crandall offered to insert a table into the document that would incorporate cells to include building height, wind speed and exposure; the body of the table would indicate the class required. Discussion followed on the proposed revision types; tables versus language on ratings/class and labeling as well following the standard as in its current form. A decision was not made during the discussion to allow more time for participants to think about which approach to incorporate into the ballot.

Crandall discussed a new factor in ASCE 7-16, namely, "K_e" which is an elevation factor; he noted that in Denver, CO it could result in a 15% reduction in wind load. He went on to explain that this could be cited as a factor of safety in appendix X and that language could be added to reflect 1.0 as the elevation value in which the document would reflect a conservative approach.

Crandall discussed page 13 of the document on table deflection and the need to verify if the values needed to be updated, as well the need for further clarification in section 12.1 topographic factors. Discussion on section X1.3 revolved around the change in text and the velocity pressure equation. There was discussion on the two letter subscript of Kzt and whether an editorial suggestion could be made at ASTM.

Discussion focused on the 3 approaches that could be taken in balloting the document: changes to the document specific to only ASCE 7-16, group of changes to improve clarity and correct mistakes, and to improve the appendix. It was determined to have Crandall provide a document highlighting only the essential items that needed to be updated to incorporate ASCE 7-16 into the standard.

New/Other Business and Action Item Review

No new business was brought forth. McQuillen stated the meeting's action items: Crandall to provide a revised document highlighting only the essential items relevant to changes in the standard to incorporate ASCE 7-16. McQuillen to distribute the revised document to the task force for review and comments with a request to have edits back by the end of the week.

Adjournment

The meeting adjourned at 3:32 PM.

Attendance

Paul Casseri	Atlas Roofing
Mark Harner	CertainTeed Corporation
Marty Ward	GAF
Brendan Dineen	Malarkey Roofing
Greg Keeler	Owens Corning
Jason Simmons	PRI Construction Materials Technologies, LLC
Aaron Phillips	TAMKO Building Products, Inc.
Tim McQuillen	ARMA Staff

Call to Order
The meeting started at approximately 11:02 AM with McQuillen reading the roll call and giving the antitrust reminder. McQuillen provided an overview of the agenda.

Discussion
McQuillen gave a summary of the discussion that took place at the July 11th meeting at Miami Dade, including who attended the meeting from Miami Dade and ARMA. McQuillen placed on the screen for the participants to view the ARMA Miami Dade TRG-TAS and RAS excel spreadsheet.

McQuillen reviewed the spreadsheet and the talking points that were discussed at the July 11th meeting. Under TAS 103, section 19, McQuillen reported that Greg Keeler had testing in place at a Florida Weathering farm to look at real underlayment temperatures. Mr. Keeler reported that the test included the darkest color underlayment placed on the weathering farm. Upon completion of summer months' temperature measurements, Keeler will share the test data with the group and Miami Dade.

McQuillen reported with respect to section 19.7 that there was agreement with Miami Dade that additional language would be useful to clarify passing and failing results as it related to wrinkles in the underlayment. Jason Simmons agreed to draft language on the topic to share with the group.

McQuillen reviewed the ARMA request to include ICC ES Acceptance Criteria, (AC 152)-Adhesive Attachment of Concrete or Clay Roofing Tiles. Miami Dade was agreeable to include the additional test, but unwilling to lower the psi requirement from 15 to 10. Mr. Keeler proposed to work with Mr. Simmons to set up a Design of Experiment (DOE) to provide justification for lowering the psi requirement.

McQuillen provided a quick overview of TAS 104 and stated that most of the requested changes were identical to TAS 103. Mr. Harner confirmed that the Water Vapor Transmission test was not identical and the procedure needed to be identified in TAS 104.

McQuillen reported on the discussion pertaining to TAS 107 and the request to add a table to account for buildings greater than 33 feet in height. The discussion focused on using ASTM D 7158 as the design basis to create the table versus a larger scale test that Miami Dade has used in the past at FIU that included hip and ridge shingles.

McQuillen reviewed the request in changes in the HVHZ section of code, pertaining to the alignment of the fire classification with the FBC section. Miami Dade provided no comment in favor of or opposed to this request.

McQuillen reported that he only received one comment on TAS 114 and a couple of comments on the review of RAS 128. Participants on the call stated that they did not have an opportunity to review the documents.

New/Other Business

McQuillen reported that SPRI had invited ARMA to a meeting with Miami Dade to be scheduled in early September. Other participants in the meeting would include representatives from SPRI and PIMA. The purpose of the meeting will be to discuss the processes involved in renewing and revising NOAs.

Action Item review

McQuillen to send out a meeting invite for the August 29th meeting in Miami Dade. McQuillen to send out a doodle poll to the TRG to schedule another conference call prior to the August 29th meeting. McQuillen to send out the spreadsheet for all TRG participants to review and edit. Greg Keeler and Jason Simmons to create a DOE as pertains to AC 152 conditions of Acceptance. Jason Simmons to draft language pertaining to the conditions of Acceptance under section 19.7 of TAS 103.

Adjournment

The meeting was adjourned at 11:47 AM.

Attendance

Kermit Stahl	CertainTeed Corporation
Marty Ward	GAF
Don Shaw	IKO
Brendan Dineen	Malarkey Roofing
Eileen Dutton	Malarkey Roofing
Greg Keeler	Owens Corning
Aaron Phillips	TAMKO Building Products, Inc.
Jonathon McBride	Specialty Granules LLC
Tim McQuillen	ARMA Director of Technical Services
Reed Hitchcock	ARMA Executive Vice President

Call to Order

Tim McQuillen called the meeting to order at 1:02pm ET. McQuillen read the roll call and reminded all that the meeting would be subject to ARMA's Antitrust Compliance Policy. Motion was made by Marty Ward/Don Shaw to approve the minutes of the May 10, 2018 meeting. The motion passed unanimously.

Discussion Denver Green Roof/Cool Roof Draft

McQuillen placed on the screen a copy of the draft proposal for the participants to view. McQuillen reviewed the written comments provided by the CRTF member so that all participating could see comments and questions. Discussion by the participants focused on table X and the different requirements based on different product types in which it was suggested that the current draft is picking winners and losers. Questions that came up during the discussion included: whether the SRI minimum values were in addition to solar reflectance or an option in lieu of SR values; what is low slope concrete roofs; do cool roofs meet the objective of the regulation; storm water drainage; urban heat island mitigation and aesthetics.

McQuillen reminded the task force that comments on the draft proposal were due back by August 10th. The group discussed whether ARMA should try to discredit the document as being unworkable and not enforceable, whether making cool roofs a mandate is a good idea and whether in its comments ARMA should list potential unintended consequences, including reflection into higher adjacent buildings.

McQuillen asked for a volunteer to create a first draft of the ARMA letter. Marty Ward volunteered to create a first draft to share with the CRTF.

Adjournment:

There being no further business to come before the group, the meeting was adjourned by general consensus at 1:46 pm ET.

SECTION 1504
PERFORMANCE REQUIREMENTS

1504.1 Wind resistance of roofs. Roof decks and roof coverings shall be designed for wind loads in accordance with Chapter 16 and Sections 1504.2, 1504.3 and 1504.4.

1504.1.1 Wind resistance of asphalt shingles. Asphalt shingles shall be tested in accordance with ASTM D7158. Asphalt shingles shall meet the classification requirements of Table 1504.1.1 for the appropriate maximum basic wind speed. Asphalt shingle packaging shall bear a label to indicate compliance with ASTM D7158 and the required classification in Table 1504.1.1.

Exception: Asphalt shingles not included in the scope of ASTM D7158 shall be tested and labeled in accordance with ASTM D3161. Asphalt shingle packaging shall bear a label to indicate compliance with ASTM D3161 and the required classification in Table 1504.1.1.

1504.2 Wind resistance of clay and concrete tile. Wind loads on clay and concrete tile roof coverings shall be in accordance with Section 1609.5.

1504.2.1 Testing. Testing of concrete and clay roof tiles shall be in accordance with Sections 1504.2.1.1 and 1504.2.1.2.

1504.2.1.1 Overturning resistance. Concrete and clay roof tiles shall be tested to determine their resistance to overturning due to wind in accordance with Chapter 15 and either SBCCI SSTD 11 or ASTM C1568.

1504.2.1.2 Wind tunnel testing. Where concrete and clay roof tiles do not satisfy the limitations in Chapter 16 for rigid tile, a wind tunnel test shall be used to determine the wind characteristics of the concrete or clay tile roof covering in accordance with SBCCI SSTD 11 and Chapter 15.

1504.3 Wind resistance of nonballasted roofs. Roof coverings installed on roofs in accordance with Section 1507 that are mechanically attached or adhered to the roof deck shall be designed to resist the design wind load pressures for components and cladding in accordance with Section 1609.5.2. The wind load on the roof covering shall be permitted to be determined using allowable stress design.

1504.3.1 Other roof systems. Built-up, modified bitumen, fully adhered or mechanically attached single-ply roof systems, metal panel roof systems applied to a solid or closely fitted deck and other types of membrane roof coverings shall be tested in accordance with FM 4474, UL 580 or UL 1897.

1504.3.2 Structural metal panel roof systems. Where the metal roof panel functions as the roof deck and roof covering and it provides both weather protection and support for loads, the structural metal panel roof system shall comply with this section. Structural standing-seam metal panel roof systems shall be tested in accordance with ASTM E1592 or FM 4474. Structural through-fastened metal panel roof systems shall be tested in accordance with ASTM E1592, FM 4474 or UL 580.

Exceptions:

1. Metal roofs constructed of cold-formed steel shall be permitted to be designed and tested in accordance with the applicable referenced structural design standard in Section 2210.1.
2. Metal roofs constructed of aluminum shall be permitted to be designed and tested in accordance with the applicable referenced structural design standard in Section 2002.1.

1504.3.3 Metal roof shingles. Metal roof shingles applied to a solid or closely fitted deck shall be tested in accordance with ASTM D3161, FM 4474, UL 580 or UL 1897. Metal roof shingles tested in accordance with ASTM D3161 shall meet the classification requirements of Table 1504.1.1 for the appropriate maximum basic wind speed and the metal shingle packaging shall bear a label to indicate compliance with ASTM D3161 and the required classification in Table 1504.1.1.

1504.4 Ballasted low-slope roof systems. Ballasted low-slope (roof slope < 2:12) single-ply roof system coverings installed in accordance with Sections 1507.12 and 1507.13 shall be designed in accordance with Section 1504.8 and ANSI/SPRI RP-4.

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,

TABLE 1504.1.1
CLASSIFICATION OF STEEP SLOPE ROOF SHINGLES TESTED IN ACCORDANCE WITH ASTM D316 OR D71581

MAXIMUM BASIC WIND SPEED, *V*, FROM FIGURES 1609.3(1)-(8) OR ASCE 7 (mph)	MAXIMUM ALLOWABLE STRESS DESIGN WIND SPEED, V_{asd}, FROM TABLE 1609.3.1 (mph)	ASTM D7158[a] CLASSIFICATION	ASTM D3161 CLASSIFICATION
110	85	D, G or H	A, D or F
116	90	D, G or H	A, D or F
129	100	G or H	A, D or F
142	110	G or H	F
155	120	G or H	F
168	130	H	F
181	140	H	F
194	150	H	F

For SI: 1 foot = 304.8 mm; 1 mph = 0.447 m/s.

a. The standard calculations contained in ASTM D7158 assume Exposure Category B or C and building height of 60 feet or less. Additional calculations are required for conditions outside of these assumptions.

RE-2 and RE-3 of ANSI/SPRI ES-1, except basic design wind speed, *V*, shall be determined from Figures 1609.3(1) through 1609.3(8) as applicable.

1504.6 Physical properties. Roof coverings installed on low-slope roofs (roof slope < 2:12) in accordance with Section 1507 shall demonstrate physical integrity over the working life of the roof based on 2,000 hours of exposure to accelerated weathering tests conducted in accordance with ASTM G152, ASTM G154 or ASTM G155. Those roof coverings that are subject to cyclical flexural response due to wind loads shall not demonstrate any significant loss of tensile strength for unreinforced membranes or breaking strength for reinforced membranes when tested as herein required.

1504.7 Impact resistance. Roof coverings installed on low-slope roofs (roof slope < 2:12) in accordance with Section 1507 shall resist impact damage based on the results of tests conducted in accordance with ASTM D3746, ASTM D4272 or the "Resistance to Foot Traffic Test" in Section 5.5 of FM 4470.

1504.8 Surfacing and ballast materials in hurricane-prone regions. For a building located in a hurricane-prone region as defined in Section 202, or on any other building with a mean roof height exceeding that permitted by Table 1504.8 based on the exposure category and basic wind speed at the site, the following materials shall not be used on the roof:

1. Aggregate used as surfacing for roof coverings.
2. Aggregate, gravel or stone used as ballast.

TABLE 1504.8
MAXIMUM ALLOWABLE MEAN ROOF HEIGHT PERMITTED FOR BUILDINGS WITH AGGREGATE ON THE ROOF IN AREAS OUTSIDE A HURRICANE-PRONE REGION

NOMINAL DESIGN WIND SPEED, V_{asd} (mph)[b, d]	MAXIMUM MEAN ROOF HEIGHT (ft)[a, c]		
	Exposure category		
	B	C	D
85	170	60	30
90	110	35	15
95	75	20	NP
100	55	15	NP
105	40	NP	NP
110	30	NP	NP
115	20	NP	NP
120	15	NP	NP
Greater than 120	NP	NP	NP

For SI: 1 foot = 304.8 mm; 1 mile per hour = 0.447 m/s.

a. Mean roof height as defined in ASCE 7.

b. For intermediate values of V_{asd}, the height associated with the next higher value of V_{asd} shall be used, or direct interpolation is permitted.

c. NP = gravel and stone not permitted for any roof height.

d. V_{asd} shall be determined in accordance with Section 1609.3.1.

SECTION 1505
FIRE CLASSIFICATION

[BF] 1505.1 General. Roof assemblies shall be divided into the classes defined in this section. Class A, B and C roof assemblies and roof coverings required to be listed by this section shall be tested in accordance with ASTM E108 or UL 790. In addition, *fire-retardant-treated wood* roof coverings shall be tested in accordance with ASTM D2898. The minimum roof coverings installed on buildings shall comply with Table 1505.1 based on the type of construction of the building.

Exception: Skylights and sloped glazing that comply with Chapter 24 or Section 2610.

[BF] 1505.2 Class A roof assemblies. Class A roof assemblies are those that are effective against severe fire test exposure. Class A roof assemblies and roof coverings shall be *listed* and identified as Class A by an *approved* testing agency. Class A roof assemblies shall be permitted for use in buildings or structures of all types of construction.

Exceptions:

1. Class A roof assemblies include those with coverings of brick, masonry or an exposed concrete roof deck.
2. Class A roof assemblies also include ferrous or copper shingles or sheets, metal sheets and shingles, clay or concrete roof tile or slate installed on noncombustible decks or ferrous, copper or metal sheets installed without a roof deck on noncombustible framing.
3. Class A roof assemblies include minimum 16 ounce per square foot (0.0416 kg/m^2) copper sheets installed over combustible decks.
4. Class A roof assemblies include slate installed over ASTM D226, Type II underlayment over combustible decks.

TABLE 1505.1[a, b]
MINIMUM ROOF COVERING CLASSIFICATION FOR TYPES OF CONSTRUCTION

IA	IB	IIA	IIB	IIIA	IIIB	IV	VA	VB
B	B	B	C[c]	B	C[c]	B	B	C[c]

For SI: 1 foot = 304.8 mm, 1 square foot = 0.0929 m^2.

a. Unless otherwise required in accordance with the *International Wildland-Urban Interface Code* or due to the location of the building within a fire district in accordance with Appendix D.

b. Nonclassified roof coverings shall be permitted on buildings of Group R-3 and Group U occupancies, where there is a minimum fire-separation distance of 6 feet measured from the leading edge of the roof.

c. Buildings that are not more than two stories above grade plane and having not more than 6,000 square feet of projected roof area and where there is a minimum 10-foot fire-separation distance from the leading edge of the roof to a lot line on all sides of the building, except for street fronts or public ways, shall be permitted to have roofs of No. 1 cedar or redwood shakes and No. 1 shingles constructed in accordance with Section 1505.7.

[BF] 1505.3 Class B roof assemblies. Class B roof assemblies are those that are effective against moderate fire-test exposure. Class B roof assemblies and roof coverings shall be *listed* and identified as Class B by an *approved* testing agency.

[BF] 1505.4 Class C roof assemblies. Class C roof assemblies are those that are effective against light fire-test exposure. Class C roof assemblies and roof coverings shall be *listed* and identified as Class C by an *approved* testing agency.

[BF] 1505.5 Nonclassified roofing. Nonclassified roofing is *approved* material that is not *listed* as a Class A, B or C roof covering.

[BF] 1505.6 Fire-retardant-treated wood shingles and shakes. *Fire-retardant-treated wood* shakes and shingles shall be treated by impregnation with chemicals by the full-cell vacuum-pressure process, in accordance with AWPA C1. Each bundle shall be marked to identify the manufactured unit and the manufacturer, and shall be *labeled* to identify the classification of the material in accordance with the testing required in Section 1505.1, the treating company and the quality control agency.

[BF] 1505.7 Special purpose roofs. Special purpose wood shingle or wood shake roofing shall conform to the grading and application requirements of Section 1507.8 or 1507.9. In addition, an underlayment of $^5/_8$-inch (15.9 mm) Type X water-resistant gypsum backing board or gypsum sheathing shall be placed under minimum nominal $^1/_2$-inch-thick (12.7 mm) wood structural panel solid sheathing or 1-inch (25 mm) nominal spaced sheathing.

[BF] 1505.8 Building-integrated photovoltaic products. *Building-integrated photovoltaic products* installed as the roof covering shall be tested, *listed* and *labeled* for fire classification in accordance with Section 1505.1.

[BF] 1505.9 Rooftop mounted photovoltaic panel systems. Rooftop rack-mounted *photovoltaic panel systems* shall be tested, *listed* and identified with a fire classification in accordance with UL 1703 and UL 2703. The fire classification shall comply with Table 1505.1 based on the type of construction of the building.

[BF] 1505.10 Roof gardens and landscaped roofs. Roof gardens and landscaped roofs shall comply with Section 1505.1 and 1507.16 and shall be installed in accordance with ANSI/SPRI VF-1.

SECTION 1506
MATERIALS

1506.1 Scope. The requirements set forth in this section shall apply to the application of roof-covering materials specified herein. Roof coverings shall be applied in accordance with this chapter and the manufacturer's installation instructions. Installation of roof coverings shall comply with the applicable provisions of Section 1507.

1506.2 Material specifications and physical characteristics. Roof-covering materials shall conform to the applicable standards listed in this chapter.

1506.3 Product identification. Roof-covering materials shall be delivered in packages bearing the manufacturer's identifying marks and *approved* testing agency labels required in accordance with Section 1505. Bulk shipments of materials shall be accompanied with the same information issued in the form of a certificate or on a bill of lading by the manufacturer.

SECTION 1507
REQUIREMENTS FOR ROOF COVERINGS

1507.1 Scope. Roof coverings shall be applied in accordance with the applicable provisions of this section and the manufacturer's installation instructions.

1507.1.1 Underlayment. Underlayment for asphalt shingles, clay and concrete tile, metal roof shingles, mineral-surfaced roll roofing, slate and slate-type shingles, wood shingles, wood shakes, metal roof panels and photovoltaic shingles shall conform to the applicable standards listed in this chapter. Underlayment materials required to comply with ASTM D226, D1970, D4869 and D6757 shall bear a label indicating compliance with the standard designation and, if applicable, type classification indicated in Table 1507.1.1(1). Underlayment shall be applied in accordance with Table 1507.1.1(2). Underlayment shall be attached in accordance with Table 1507.1.1(3).

Exceptions:

1. As an alternative, self-adhering polymer modified bitumen underlayment complying with ASTM D1970 and installed in accordance with the manufacturer's installation instructions for the deck material, roof ventilation configuration and climate exposure for the roof covering to be installed shall be permitted.
2. As an alternative, a minimum 4-inch-wide (102 mm) strip of self-adhering polymer modified bitumen membrane complying with ASTM D1970 and installed in accordance with the manufacturer's installation instructions for the deck material shall be applied over all joints in the roof decking. An approved underlayment for the applicable roof covering for design wind speeds less than 120 mph (54 m/s) shall be applied over the 4-inch-wide (102 mm) membrane strips.
3. As an alternative, two layers of underlayment complying with ASTM D226 Type II or ASTM D4869 Type IV shall be permitted to be installed as follows: Apply a 19-inch (483 mm) strip of underlayment parallel with the eave. Starting at the eave, apply 36-inch-wide (914 mm) strips of underlayment felt, overlapping successive sheets 19 inches (483 mm). The underlayment shall be attached with corrosion-resistant fasteners in a grid pattern of 12 inches (305 mm) between side laps with a 6-inch (152 mm) spacing at side and end laps. End laps shall

ARMA Cool Roof Task Force Teleconference
Monday August 20th, 2018 12:00-1:00 PM
Bayshore Ballroom
Sheraton, Tampa Riverwalk Hotel

Topic	Back-up Materials
Call to Order • Roll Call • Antitrust Reminder • Agenda Review • Approval of Minutes	• -Antitrust Quick Reference • -Minutes 8-3-2018
Discussion CRRC • SRI Concept • Finalize Retesting Strategic Direction	
New / Other Business	
Action Item Review	
Adjournment	

BYLAWS
OF
COOL ROOF RATING COUNCIL, INC.

Effective August 1, 2003 by vote of Membership
Amended October 23, 2003 by vote of Board of Directors
Amended by vote of Membership February 13, 2006
Amended by vote of Membership June 8, 2007
Amended by vote of Membership June 11, 2008
Amended by vote of Membership June 13, 2013
Amended by vote of Membership June 19, 2014
Amended by vote of Membership March 13, 2015
Amended by vote of Membership June 14, 2017
Amended by vote of Membership May 18, 2018

ARTICLE 1: PRINCIPAL OFFICE AND RESIDENT AGENT

Section 1. Principal Office

The principal office of the Cool Roof Rating Council, Inc., a non-profit corporation incorporated under the laws of the State of Maryland (hereinafter, the "Corporation"), shall be in the State of Maryland. The Corporation may have such other office or offices at such suitable place or places within or without the State of Maryland as may be designated from time to time by the Board of Directors of the Corporation.

Section 2. Resident Agent

The Corporation shall have and continuously maintain in service a resident agent in the State of Maryland, who shall be an individual resident of the State of Maryland or a Maryland corporation, whether for-profit or not-for-profit.

ARTICLE 2: PURPOSES

It is not uncommon for the temperature in cities to be several degrees higher than the surrounding countryside, which is subject to the same climatological conditions. This Urban Heat Island Effect increases the usage of energy to cool our cities and contributes to increased air pollution. The use of more reflective building surfaces, coupled with other measures, could appreciably reduce this effect. In furtherance of this goal, the purposes of the Corporation are: to implement and communicate fair, accurate, and credible radiative energy performance rating systems for roof surfaces; to support research into energy-related radiative properties of roofing surfaces, including durability of those properties and durability of the affected roof system(s); and to provide education and objective support to parties interested in understanding and comparing various roofing options.

The Corporation shall have and exercise all powers necessary and convenient to effect the educational purposes for which the organization is organized, subject to the limitations specified in the Corporation's Articles of Incorporation.

ARTICLE 3: MEMBERS

Section 1. Membership Eligibility

Membership shall be open to individuals and organizations with an interest in the use, production, promotion, performance and development of technology related to cool roofing products and energy performance of roof surfaces. The members may include corporations, partnerships, sole proprietorships, associations, individuals, universities, government and non-governmental agencies.

Section 2. Member Classes.

The Corporation shall have two classes of membership. The designation of such classes shall be as follows:

(a) Manufacturing members, distributors, suppliers and their trade associations; and

(b) Other - Roofing contractors, consultants, not-for-profits, government agencies, educational institutions, air quality control boards, code bodies, energy suppliers, individuals, and other trade associations.

Section 3. Member Voting Rights.

Each member shall be entitled to one vote on all matters brought before the membership, except that a member and its employees and subsidiaries (if any and despite whether they have independently become members of the Corporation) shall only be entitled to one collective vote. However, multiple members that are direct or indirect subsidiaries of another member company are each entitled to a vote, provided that the parent company member does not also vote. Each member shall designate, in writing, one representative who shall exercise the member's vote. Such designation may be changed by submitting a letter delivered to the Secretary of the Corporation.

Section 4. Application for membership

Those individuals or organizations seeking membership in the Corporation shall apply to the Corporation in writing, which application shall state the name, location and nature of business or interest of the applicant. The application shall contain an agreement that if admitted to membership, the applicant will observe all provisions of the Corporation's Articles of Incorporation and its Bylaws, and will pay all applicable dues and assessments.

Section 5. Membership Selection

The Board of Directors is responsible for reviewing and approving/denying membership applications. The Board of Directors may decide to delegate this authority to the Executive Committee. Applications that received a denied vote from the Executive Committee for any other reason than incomplete paperwork requiring a resubmission of an application will automatically be reviewed by the full Board of Directors.

Section 6. Termination of Membership

Any member may be removed from membership for cause by an affirmative two-thirds vote of all the members present at a meeting at which a quorum is present. Notice of such proposed action shall be set forth in the notice of the meeting in accordance with Section 4 of Article 4 of the Bylaws. Membership shall terminate automatically, without the necessity for any such action, in the event a member is in default of payment of dues for a period of six months or longer.

Section 7. Resignation

Any member may resign by delivering a written letter of resignation to the Corporation. Such resignation shall be effective upon receipt. No member so resigning shall be entitled to any refund of dues or other amounts paid.

ARTICLE 4: MEMBER MEETINGS AND REPORTS

Section 1. Annual Meeting

The annual meeting of the members shall be held at such time and place as designated by the Board of Directors for the purpose of transaction of business as may come before the meeting.

Section 2. Special Meetings

Special meetings of the members may be called by the Chairman of the Board or the Secretary at the request of at least 15% of the members entitled to vote at such meeting. The Board of Directors shall designate the time and place of the special meeting.

Section 3. Voting.

Members may vote in person through their designated representative, by proxy executed in writing by their designated representative, or by ballot, subject to Article 3, Section 3. No proxy shall be valid for a period greater than 11 months, unless otherwise provided in the proxy. A proxy executed by or on behalf of a member shall be deemed valid unless challenged at or prior to its exercise. Voting on all matters, including the election of the Board of Directors, may be conducted by mail, facsimile, or by electronic transmission. In the event of a tied vote in the election of the Board of Directors that results in one or more Board of Director seats being unfilled, a tiebreaker election will be held to resolve the tie. The tiebreaker election will be conducted immediately if a quorum of members is present, or otherwise within 45 days of the initial vote. The tiebreaker election will be conducted to select from among the candidates that tied in the initial election, and will be subject to the same provisions as described by these bylaws. All eligible members may vote in the tiebreaker election, regardless if they voted or not in the original election.

Section 4. Notice of Meetings.

Notice of meetings, stating the place, day and time shall be sent by mail, e-mail, telegram or telephone no less than 30 days before the date of such meeting. In case of a special meeting, or when required by statute or these Bylaws, the purpose for which the meeting is called shall be stated in the notice. The notice shall be deemed delivered when e-mail delivery confirmation has been received or when deposited in the United States Mail, addressed to the member at the address or e-mail address as it appears on the records of the Corporation, with postage thereon paid.

Section 5. Quorum

The presence in person or by proxy of twenty percent of the members entitled to vote shall constitute a quorum for the purpose of considering the business of the meeting. If a quorum is not present at any meeting of members, a majority of the members present may adjourn the meeting at any time without further notice. At any adjourned meeting at which a quorum shall be present, any business may be transacted which might have been transacted at the original meeting. Withdrawal of members from any meeting shall not cause failure of a duly constituted quorum at that meeting.

Section 6. Informal Action by Members

Any action of the members may be taken without a meeting if consent in writing or by electronic transmission setting forth the action taken is given by all members and filed with the minutes of the Corporation.

Section 7. Telephone Conference.

Members may participate in a meeting of the members by means of conference telephone or similar communications equipment by means of which all persons participating in the meetings can hear each other at the same time and participation by such means shall constitute presence in person at the meeting.

ARTICLE 5: BOARD OF DIRECTORS

Section 1. General Authority

There shall be a Board of Directors of the Corporation, which shall manage the affairs of the Corporation. The Board of Directors shall be vested with the powers to appoint and remunerate agents and employees, to disburse the funds of the Corporation, and to adopt such rules and regulations for the conduct of its business, responsibility and authority as shall be deemed advisable, insofar as such delegation of authority is not inconsistent with or repugnant to the Articles of Incorporation or Bylaws of the Corporation (in their present form or as they may be amended) or to any applicable law. The Board of Directors shall have the power to determine the policy positions of the Corporation.

Section 2. Membership

The Board of Directors of the Corporation shall be comprised of 11 individuals commencing with the individuals named in the Corporation's Articles of Incorporation. There shall be six (6) positions filled from the first class of members as described in Section 2(a) of Article 3. Five (5) positions shall be filled from the class of members as described in Section 2(b) of Article 3. Not withstanding the foregoing, not more than one individual who is an officer, director, employee, agent, representative or affiliate of a member or its subsidiaries or affiliates (if any and despite whether they have independently become members of the Corporation) may serve on the Board of Directors at any given time. The directors shall be elected by the members of the Corporation at the annual meeting of the members or by mail, faxed or electronic transmission ballot before the meeting.

Section 3. Term of Office.

Directors shall be divided into three classes so that approximately one-third of the directors shall be elected each year. Each director of the Corporation, shall serve for a term of three (3) years except, as shorter terms are required to initiate rotation. Each term shall begin at the Board of Directors meeting following the annual Board of Directors election. Directors shall be eligible for election for three (3) consecutive terms. After serving three (3) consecutive terms, a director must wait until the next election cycle to become eligible for re-election. Incomplete terms resulting from vacancies filled pursuant to Section 6 of this Article shall not be counted for purposes of the foregoing three (3) consecutive term limit.

Section 4. Resignation

Any director may resign at any time by giving written notice to the Chairman, who shall bring such resignation to the attention of directors and officers of the Corporation in a timely manner and, in any case, before the next meeting of the Board of Directors. Such resignation shall take effect at the time specified therein, or, if no time is specified, at the time of acceptance thereof as determined by the Chairman.

Section 5. Removal

Any director may be removed from such office by a two-thirds vote of the directors at any regular or special meeting of the Board of Directors at which a quorum is present, for: (1) violation of these Bylaws; or (2) engaging in any other conduct prejudicial to the best interests of the Corporation.

Such removal may occur only if the director involved is first provided:

(1) With adequate notice of the charges against him or her in the form of a statement of such charges and of the time and place of the meeting of the Board of Directors scheduled for the purpose of hearing or considering such action, sent by certified or registered mail to the last known address of such director;

(2) an opportunity to appear before the Board of Directors no sooner than thirty (30) days after sending such notice or to forward a written statement in presentation of any defense of such charges within thirty (30) days after the sending of such notice; and

(3) a written explanation as to why (if such is the case) such director is removed.

In this regard, the Board shall act on the basis of reasonable and consistent criteria, always with the objective of advancing the best interests of the Corporation. The removal from the Board of Directors of a director who is also an officer of the Corporation shall constitute his or her automatic termination from office.

Section 6. Vacancies

Vacancies, as they occur on the Board of Directors by resignation, death, incapacity or the like, of one or more members thereof shall be filled by an act of a majority of the Board of Directors.

Section 7. Additional Powers.

The Board of Directors may at any time impose or confer upon any officer such other duties or powers as in its discretion it deems necessary or appropriate.

Section 8. Regular Meeting

A regular meeting of the Board of Directors of the Corporation shall be held at least twice each year, at such time, day and place as shall be designated by the Chairman of the

Board of Directors in the notice of the meeting, for the purpose of transacting such business as may come before the meeting. Notwithstanding Section 14, below, at least one of the two required regular meetings shall be held in person. The Board of Directors may, by resolution, provide for the holding of additional regular meetings.

Section 9. Special Meetings

Special meetings of the Board of Directors may be called at the direction of the Chairman of the Board or by a majority of the voting directors then in office, to be held at such time, day and place as shall be designated in the notice of the meeting.

Section 10. Notice.

Notice of the time, day and place of any meeting of the Board of Directors shall be given at least fifteen (15) days previous thereto by notice sent by mail, e-mail, telegram or telephone to each director at his or her address as shown by the records of the Corporation. If mailed, such notice shall be deemed to be delivered when deposited in the United States mail in a sealed envelope so addressed, with postage thereon prepaid. If notice is given by telegram, such notice shall be deemed to be delivered when the telegram is delivered to the telegraph company. The purpose or purposes for which a special meeting is called shall be stated in the notice thereof. Any director may waive notice of any meeting. The attendance of a director at any meeting shall constitute a waiver of notice of such meeting, except where a director attends a meeting for the express purpose of objecting to the transaction of any business because the meeting is not lawfully called or convened.

Section 11. Quorum

Fifty-one (51) percent of the directors entitled to vote shall constitute a quorum for the transaction of business at any meeting of the Board of Directors. If less than such number of directors is present at such meeting, a majority of the directors present entitled to vote may adjourn the meeting from time to time without further notice.

Section 12. Manner of Acting

Except as otherwise provided in the Articles of Incorporation or the Bylaws, the act of a majority of directors present (even if by phone) and entitled to vote at a meeting of the Board of Directors shall be the act of the Board of Directors. In the absence of a quorum, any action taken shall be recommendatory only, but may become valid if subsequently confirmed by a majority vote of the Board of Directors in conformance with the quorum requirements. Proxy voting shall not be allowed.

Section 13. Informal Action by Directors

Any action of the directors may be taken without a meeting if a consent in writing or by electronic transmission setting forth the action taken is given by all directors entitled to vote and filed with the minutes of the Corporation.

Section 14. Telephone Conference.

Members of the Board of Directors or any committee thereof may participate in a meeting of the Board or such committee by means of conference telephone or similar communications equipment by means of which all persons participating in the meetings can hear each other at the same time and participation by such means shall constitute presence in person at the meeting.

Section 15. Compensation

Members of the Board of Directors, the Executive Committee and the task forces shall not be compensated by the Corporation for their services, but the Board of Directors may authorize the reimbursement of said members by the Corporation for expenditures related to the activities of the Corporation.

Section 16. Ex Officio Directors

The Environmental Protection Agency, Department of Energy, Lawrence Berkeley National Laboratory and Oak Ridge National Laboratory may each appoint one representative to serve as an ex officio director to offer advice to the Board of Directors. The chairmen of the committees of the Corporation shall also serve as ex officio directors to offer advice to the Board of Directors if not already serving as directors. Any past Chairmen of Board of the Corporation who are willing shall also serve as ex officio directors to offer advice to the Board of Directors. An ex officio director shall have no right to vote or to become an officer of the Corporation.

ARTICLE 6: OFFICERS OF THE CORPORATION

Section 1. Officers of the Board of Directors

The officers of the Board shall be a Chairman/President, a Vice Chairman, a Treasurer, and a Secretary. Officers of the Board shall be elected by the Board. They shall be selected from among the membership of the Board, and it is preferred that each candidate for an officer position has served on the Board of Directors for at least one year prior to being elected as an officer. Their terms of office shall be of a duration of two years, with their selection for office to occur within thirty (30) days following the annual Board of Directors election. There shall be no restriction on the number of consecutive terms of office that may be served by the officers of the Board of Directors. It is a condition to be eligible for continued service in each office that the person holding such office remain a member of the Board of Directors. More than one office may be held by the same person concurrently, except that the offices of (1) Chairman and Vice Chairman and (2) Chairman and Treasurer shall not be held by the same person concurrently.

Section 2. Chairman of the Board.

The duties of the Chairman of the Board shall include but not be restricted to the convening and management of all meetings of the Board of Directors. In addition, the Chairman shall retain a general knowledge of the on-going business of the Corporation. In the foregoing endeavors, the Chairman shall be assisted and informed by the Administrator of the Corporation.

Section 3. Vice Chairman

In general, the Vice Chairman shall perform all duties commonly incident to and vested in the office of the Vice Chairman of a corporation and such other duties as from time to time may be assigned to him or her by the Chairman or by the Board of Directors. The Vice Chairman shall serve as Chairman in the absence or inability to act of the Chairman.

Section 4. Treasurer

In general, the Treasurer shall perform all duties commonly incident to and vested in the office of the treasurer of a corporation and such other duties as from time to time may be assigned to him or her by the Chairman or by the Board of Directors. The Treasurer's responsibilities and duties shall include, but not be limited to, the following: The Treasurer shall be responsible for developing and reviewing the fiscal policies of the Corporation. The Treasurer shall ensure that an account is maintained of all monies received and expended for the use of the Corporation. The Treasurer shall ensure that all monies of the Corporation are deposited in a bank or banks or trust company or trust companies approved by the Board of Directors, and that authorized disbursements are made therefrom. The Treasurer shall render a report of the finances of the Corporation at the regular meetings of the Corporation or whenever requested by the Chairman of the Board of Directors showing all receipts and expenditures for the current year. In the foregoing endeavors, the Treasurer shall be assisted and informed by the Administrator of the Corporation.

Section 5. Secretary

In general, the Secretary shall perform all duties commonly incident to and vested in the office of the secretary of a corporation and such other duties as from time to time may be assigned by the Chairman or by the Board of Directors. The Secretary's responsibilities and duties shall include, but not be limited to, the following: The Secretary shall attend all meetings of the Board of Directors and be responsible for keeping, preserving in the books of the Corporation, and distributing true minutes of the proceedings of all such meetings. The Secretary shall ensure that all notices are given in accordance with these Bylaws. In the foregoing endeavors, the Secretary shall be assisted and informed by the Executive Director of the Corporation.

Section 7. Resignation

Any officer may resign at any time by giving written notice to the

Chairman. Such resignation shall take effect at the time specified therein, or, if no time is specified, at the time of acceptance thereof as determined by the Chairman.

Section 8. Removal

Any officer may be removed by a two-thirds vote of the Board of Directors at any regular or special meeting of the Board at which a quorum is present for engaging in conduct prejudicial to the best interests of the Corporation. The removal of an officer of the Corporation from such position of office shall not constitute his or her automatic removal from the Board of Directors.

Section 9. Vacancies

In the case of resignation of an officer of the Corporation or if, for any other reason including ineligibility or removal, an officer of the Corporation is unable to serve in such capacity, the Board of Directors shall select a successor.

ARTICLE 7: Executive Director

The Board shall retain an Executive Director who shall provide organizational and managerial assistance to the Board of Directors and/or the Executive Committee. Under direction of the Board of Directors, the Executive Director shall conduct such research and development, information transfer and communication activities as may be necessary to further the activities of the Corporation. The Executive Director shall attend meetings of the committees of the Board and provide planning, management, logistical and technical support for the Board of Directors, the Executive committee and/or other committees. The Board of Directors shall maintain a staff, or contract services with an organization management firm. The Executive Director shall have the authority to solicit and to coordinate Members solicitation of funding for projects and programs of the Corporation.

ARTICLE 8: COMMITTEES

Section l. Executive Committee of Directors.

The Executive Committee of the Corporation shall be comprised of the Chairman, Vice Chairman, Treasurer, Secretary, and the most recent Past Chairman. An additional at-large Director, appointed by the Board of Directors, may serve in a non-voting advisory capacity. All members of the Executive Committee must also be members of the Board of Directors. The Committee shall have and exercise the authority of the Board of Directors in the management of the Corporation, except that such Committee shall have no authority to amend, alter, or repeal the Bylaws, to elect, appoint or remove any Director or officer of the Corporation, or to approve any charter document required to be filed with the State Department of Assessments and Taxation of Maryland.

Section 2. Other Committees

The Board of Directors may by resolution constitute and appoint such other committees to perform such other duties and functions as the Board may deem appropriate.

Section 3. Term of Office.

Each member of every committee shall continue in office at the pleasure of the Board of Directors.

Section 4. Chairman.

One member of each committee shall be appointed chairman; either directly by the Board of Directors or in such other manner as the Board of Directors may prescribe.

Section 5. Quorum

Unless otherwise provided in the resolution of the Board of Directors designating a committee, a majority of the whole committee shall constitute a quorum and the act of a majority of the members present at a meeting at which a quorum is present shall be the act of the committee.

Section 6. Rules.

Each committee may adopt rules for its own government not inconsistent with the Articles of Incorporation, with these Bylaws, with rules adopted by the Board of Directors, or with any applicable law of the State of Maryland.

ARTICLE 9: FISCAL YEAR

The fiscal year of the Corporation shall commence on January 1 and terminate on December 31.

ARTICLE 10: SEAL

The Board of Directors of the Corporation may provide a corporate seal, which shall be in the form of a circle and shall have inscribed thereon the name of the corporation and the words "Corporate Seal, State of Maryland." In lieu of affixing the corporate seal to any document, it shall be sufficient to meet the requirements of any law, rule, or regulation relating to a corporate seal to affix the word "(SEAL)" adjacent to the signature of the authorized officer of the Corporation.

ARTICLE 11: CONTRACTS, CHECKS, DEPOSITS AND GIFTS

Section l. Contracts.

The Board of Directors may authorize any officer or officers, agent or agents of the Corporation, in addition to the officers so authorized by these Bylaws, to enter into any contract or execute and deliver any instrument in the name of and on behalf of the Corporation, and such authority may be general or confined to specific instances.

Section 2. Checks, Drafts, Etc.

All checks, drafts or orders for the payment of money, notes or other evidences of indebtedness issued in the name of the Corporation, shall be signed by such officer or officers, agent or agents of the Corporation, and in such manner as shall from time to time be determined by resolution of the Board of Directors.

Section 3. Deposits.

All funds of the Corporation shall be deposited from time to time to the credit of the Corporation in such banks or other depositories as the Board of Directors may select.

Section 4. Gifts.

The Board of Directors may accept on behalf of the Corporation any contribution, gift, bequest or devise for the general purposes or for any special purpose of the Corporation.

ARTICLE 12: INDEMNIFICATION

The Corporation shall indemnify its currently acting and its former directors, officers, agents and employees for the defense of claims and civil or criminal actions or proceedings to the extent permitted by applicable law, provided that the individual in the particular instance acted within the scope of his or her official duties and in good faith for a purpose which he or she reasonably believed to be in the best interests of the Corporation and, in the case of a criminal action or proceeding, in addition, had no reasonable cause to believe that his or her conduct was unlawful.

This indemnification shall be made only when it has been determined that the individual has met the above standard by a court, by the Corporation as herein provided, or as otherwise provided under the law of the State of Maryland. The Corporation shall make a determination when advised by its Board of Directors acting: (1) by a quorum consisting of directors who are not parties to such action or proceeding; or (2) if a quorum under (1) is not obtainable with due diligence, upon the opinion in writing of independent legal counsel that, the director or officer has met the foregoing applicable standard of conduct. If the foregoing determination is to be made by the Board of Directors, it may rely, as to all questions of law, on the advice of independent legal counsel.

ARTICLE 13: AMENDMENTS TO BYLAWS

These Bylaws may be altered, amended or repealed and new Bylaws may be adopted at any regular or special meeting of the members, at which a quorum is present, by an affirmative vote of two-thirds of the members present at such meeting, provided that at least thirty (30) days written notice is given of the intention to alter, amend or repeal or adopt new Bylaws at such meeting. An amendment so made shall be effective immediately after adoption unless an effective date is specifically adopted at the time the amendment is enacted.

The Board of Directors shall be authorized to make corrections of administrative or factual errors in these Bylaws.

ASPHALT ROOFING MANUFACTURERS ASSOCIATION

ARMA Health, Safety, & Environment Committee

ARMA HSE Committee
Washington Runoff Studies Update and Recommendations

The Washington State University and ARMA have been working together since 2012, based on the Washington Department of Ecology recommendations for studies of the Puget Sound Basin in relation to salmon viability. A literature review by the Department of Ecology implicated asphalt roofing materials as a significant source of contaminants in Puget Sound. Based on this information and the questions regarding the asphalt roofing's environmental impact, ARMA became involved in future studies.

ARMA members reviewed the most recent study report "Roofing Materials Assessment: Investigation of Toxics in Roof Runoff at the Washington Stormwater Center" published by Washington State University, dated February 2018. Members of ARMA who reviewed the report have the following concerns or questions:

- The executive summary has no statements on the meaning of the data or the risk to the environment.
- The report seems to equate the presence of selected metals with the perceived hazard of a metal, regardless of concentration. For example, copper and zinc are both essential elements. Only at "higher" concentrations is there risk of adverse effects.
- The executive summary statements do not seem to match the analytical evidence and data presented in the body of the report: the use of ranges vs. averages or totals can be misleading, particularly the significance of outliers that was not evaluated.
- In the executive summary, CCA roofing materials (TWO) release 4 times the amount of copper as algae resistant shingles, but this is not noted in the report. They also release over 15,000 times the arsenic as the control with only a note of "reduced levels" rather than indicating quantitative results (in the executive summary). For someone only reading the summary, the presentation of the information could be misleading.
- Analytical data to address levels below quantitation limits and detection limits are not handled in a way consistent with current regulatory standards, such as EPA methods.
- Many analytical quality control samples, while present, are not at levels found in the samples and therefore have questionable relevance.
- Salmon are very sensitive to metal concentrations. Standard testing methodologies and metal concentrations were not followed for test fishes acclimated in the "pre-study" test media. The results are that the fish were less healthy and more sensitive to changes in solution composition than they would be in the environment. The result is an increase in adverse effects relative to a real-world exposure.
- Fate and transport impacts are not included in the study.

ARMA members suggest the following next steps to evaluate the Washington State University study in an unbiased and scientific manner:

- Have ARMA formally request all data associated with the current (February 2018) and past (2012-present) published reports related to roofing impacts and toxicity studies.
- Identify third party consultants and or academics who would be experts in this area to provide an unbiased review of the reports and data. A few experts have been identified who could perform this type of review.

- Create a scope of work/RFP (request for proposal) for the third party. This scope of work could include a review of the Washington Runoff reports and associated data. The deliverables could be a white paper summary of the study, answer any specific questions posed by ARMA on the reports/data, (validity of the toxicity studies and analytical, what inconsistencies existing in the report summaries and conclusions, and executive summary). It could also include a recommendation on possible next steps or the next type of study (for instance, possibly a fate and transport study).

Thank you.

August 6, 2018

***Via* DEQ Web Portal**
Oregon Department of Environmental Quality
700 NE Multnomah St.
Portland, OR 97232-4100

Re: ARMA Comments on the Proposed Cleaner Air Oregon (CAO) Program

The Asphalt Roofing Manufacturers Association (ARMA) represents the North American asphalt roofing manufacturing industry. ARMA members include all major North American makers of asphalt roofing products, and account for approximately 85 percent of North American asphalt roofing production. Three of ARMA's members have manufacturing facilities in Oregon and will be significantly impacted in a negative way if the proposed rule is adopted.

ARMA submits these comments to express support for and agreement with the comments of Oregon Business and Industry (OBI) as set forth in OBI's statement in DEQ's July 12, 2018 public hearing on the CAO proposal (Attachment 1). ARMA members believe that the CAO proposal would have major adverse impacts on Oregon asphalt roofing manufacturing plants, including additional permitting requirements, operating fees, and community outreach requirements. Most importantly, under a conservative reading of the proposal, the program would likely result in standards that are economically infeasible. These impacts will inevitably force the affected companies to reassess their operations in Oregon, potentially resulting in decisions to cancel facility expansions or modernizations (which often include more effective emission controls), or even to relocate to other jurisdictions with more reasonable regulatory programs that ensure the shared goal of protecting human health and the environment.

More broadly, a January 2018 economic impact assessment sponsored by OBI (Attachment 2) finds that these and other significant adverse economic effects will be felt throughout the state. The proposal would result in increased costs of over $2 million on average for affected facilities over the first five years of the program. While this estimate was based on the 2017 CAO proposal, there is no reason to expect that the costs of the 2018 proposal would be materially lower. In addition to discouraging economic investment in Oregon, these unnecessary costs are expected to exceed the financial operating margins of many smaller businesses, forcing them to close. Overall, the proposal would erode Oregon's appeal as a locus for business and manufacturing, eliminate Oregon jobs and significantly cut state tax revenues that fund vital government services like education, public health and safety, and the environment.

Even worse, these economic effects result from extreme requirements that will do little to improve public health or the environment. The following provisions are of special concern to ARMA members:

1. The CAO proposal would substantially lower the various risk criteria that determine the scope of the air toxics permit program and the stringency of the emissions limits facilities must meet.

   - An air toxic permit would be required for all sources above the Source Permit Levels (excess lifetime cancer risk of 0.5 in 1 million; non-cancer Hazard Index of 0.5).

- Pre-construction approval would be required for new toxic emission units above the *de minimis* Risk Action Levels (excess lifetime cancer risk of 0.1 in 1 million; non-cancer Hazard Index of 0.1).
- New sources would be required to apply Toxic Lowest Achievable Emissions Rate (TLAER) control technology if the risk is greater than the TLAER Risk Action Levels (excess lifetime cancer risk of 10 in 1 million; non-cancer Hazard Index of 1).

These risk triggers are well below current criteria for permitting and new source review programs. Because of of the heavy element of public health conservativism built into current risk assessment methodologies, DEQ should articulate a reasonable science- and policy-based rationale for such a marked reduction in risk thresholds, particularly in light of the sizeable economic impacts of these stringent criteria.

2. Although DEQ claims that the program is science-based, in key respects the program's regulatory criteria are based on arbitrary factors that have little or no bearing on protection of public health.

- Risk targets will in many cases be based on external benchmarks established from a select list of "authoritative" bodies which excludes other authoritative reviews (e.g., the World Health Organization) and, more importantly, fails to provide an adequate opportunity to address the latest scientific studies which may not have been considered in setting these benchmarks.
- Risk targets would also be based on estimated concentrations in locations other than those where people actually live or congregate, such as in remote locations where a person spent a couple hours during an afternoon.

3. The proposal vastly expands the scope and administrative costs of current reporting, risk assessment and permitting requirements and imposes onerous emission limitations.

- 30 days is not sufficient time to respond to a request from DEQ for an updated emissions inventory.
- The proposal would establish Community Engagement risk levels for new and existing sources and require notification as the greater of the area of impact or 1.5 kilometers.
- Under the proposal, sources may be required to conduct ambient air monitoring in lieu of, or in addition to, exposure modelling
- Emission limitations could be based on potential to emit, rather than on actual emissions.

As DEQ states in its CAO program overview,[1] the proposal is based on an overall finding that Oregon's current air toxics rules "have gaps and limits." ARMA believes, however, that the proposal goes far beyond merely filling gaps in the current system that can be linked to recent findings of localized pollution resulting from facilities in full compliance with existing air toxics programs. The most costly elements of the program appear instead to be designed to effectuate a sharp increase in the scope and stringency of Oregon's air toxics program. To justify such a change, DEQ must do more than

[1] DEQ, "Cleaner Air Oregon: Overview of 2018 proposed rules" (June 2018), available at https://www.oregon.gov/deq/Regulations/rulemaking/Pages/Rcleanerair2017.aspx.

summarily proclaim, as it does in its Overview, that facilities like roofing manufacturing plants operating in compliance with the current program "still emit pollutants at levels that could harm people's health." The federal program for controlling hazardous air pollutants – the basis for the current Oregon program – calls for challenging technology-based standards, supplemented where necessary by even tougher health-based standards, that "provide an ample margin of safety to protect public health."

We are confident that an objective, science-based assessment would conclude that the CAO proposal would achieve small or negligible risk reduction benefits while imposing disproportionately great cost on businesses that, in the end, will force companies to limit their presence in Oregon. ARMA also believes that a program tailored specifically to the gaps in regulatory coverage that have been identified would likely draw support from all stakeholders, including industry, who share the public health objectives of the air toxics program while seeking also to preserve and foster a healthy and growing economic environment.

* * * * * * * * *

ARMA appreciates the opportunity to provide input on this important proposal. Please contact me if you have any questions or wish to discuss the matter by phone conference.

Sincerely,

Reed B. Hitchcock, Executive Vice President

cc: Joe Westersund, DEQ, via e-mail (Joe.WESTERSUND@state.or.us)

<u>Attachment 1</u>

OREGON BUSINESS & INDUSTRY | OBI

Cleaner Air Oregon Rulemaking Hearing 7.12.18

Thanks for this opportunity to give testimony on DEQ's proposed Cleaner Air Oregon rules.

My name is Abbie Laugtug. I am Oregon Business & Industry's Vice President of Legislative Affairs covering environmental policy issues. I am commenting today on behalf of OBI and a coalition of individual businesses and manufacturing associations representing over 1,700 employers in Oregon and their approximately 250,000 employees.

OBI, and our members, have participated closely in the Cleaner Air Oregon rulemaking and legislative process since its outset. We have repeatedly submitted public comments and testimony.

OBI is supportive of a new program to reduce air toxics and protect public health. We supported passage of SB 1541.

OBI is concerned that aspects of DEQ's proposed rules do not meet the agreed upon objectives passed by the legislature. We are specifically requesting the Commission's oversight to ensure that the proposed rules are fully consistent with SB 1541.

I'd like to highlight five aspects of greatest concern to OBI members and where DEQ's proposed rule diverts from the legislative intent of SB 1541:

The first is on regulatory thresholds: SB 1541 established risk thresholds for regulation of existing businesses. But the proposed rules would mandate public meetings at risk thresholds <u>less</u> than regulatory risk thresholds set by the legislature. Meetings should not be mandated unless SB 1541 risk thresholds are exceeded.

The second aspect is small business impacts: In DEQ's proposed rules, existing businesses would be required to obtain a permit if the calculated risk exceeds an arbitrary *de minimis* threshold. This threshold proposed by DEQ is far below thresholds for existing businesses set by SB 1541. OBI believes that the air permits should be reserved for facilities that <u>exceed</u> the thresholds set by the Oregon legislature. That would be consistent with SB 1541 and save small businesses presenting minimal risk the expense of obtaining a new permit. Under the proposed rules, air toxics permitting would run thousands of dollars in DEQ fees alone for the smallest sources.

The third aspect is the SB 1541 requirement to focus on serious noncancer risks: We are concerned that in preparing the proposed rules DEQ did not consider the legislature's requirement for DEQ to evaluate noncancer risk by reference to the toxicity level (for each chemical) at which "no serious adverse human health effects are expected". DEQ must revisit its proposed toxicity values against the legislatively mandated "serious effects" standard.

The fourth aspect is best available science: DEQ's revised rule provides that the agency will refer to a fixed hierarchy of sources when establishing the toxicity of individual compounds or evaluating facility risk. For example, DEQ has stated that it would not consider World Health

Organization research because the WHO is not on DEQ's list. If Oregon's air toxics program is to be "science-based," then the toxicity values used in rule should be based on the best available science, and not limited to values from an arbitrary hierarchy of sources. Similarly, businesses that proceed to the most advanced stages of risk modeling should be allowed to introduce science supporting a deviation from DEQ's default toxicity assumptions.

The final aspect is receptors (the locations where impacts are assessed): As proposed, DEQ's rules would require businesses to assess ambient impacts in places other than where people actually live or congregate, such as in an agricultural field where a person spent a couple hours on an afternoon. This provision removes an important incentive for manufacturers to build facilities outside of urban areas and is inconsistent with SB 1541, which that specifies risk should be assessed where people actually live or normally congregate.

OBI appreciates that DEQ is at work on a separate rulemaking that would implement the process provided in SB1541 for adjusting the Hazard Index. While this process is in its early stages, it is important to recognize the importance and complexity in identifying chemistries that are associated with developmental health effects or other severe human health effects. With that in mind we strongly recommend the agency and EQC take the time necessary to evaluate the science and prioritize chemistries- and not just rush through without thoughtful evaluation.

OBI appreciates the Commission's attention on this important rulemaking. We also appreciate the Department's work. OBI will submit detailed written comments that will include our recommendations on how the proposed rules can be improved, reduce the regulatory burden on Oregon businesses and protect public health.

We ask that you please consider our comments, as they will reflect the collective concerns and ideas of Oregon's larger business community.

Attachment 2

MAUL FOSTER ALONGI

MEMORANDUM

To: Oregonians for Fair Air Regulations

Date: January 19, 2018

From: Gretchen Greene, PhD Project: 1534.01.01

RE: Comments on Notice of Proposed Rulemaking, Cleaner Air Oregon Statement of Fiscal and Economic Impact

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Oregonians for Fair Air Regulations has requested that the economists at Maul Foster & Alongi, Inc. (MFA) review the Notice of Proposed Rulemaking (NOPR) for Cleaner Air Oregon, Statement of Fiscal and Economic Impact. We appreciate this opportunity to report our technical comments to you and to the Oregon Department of Environmental Quality (DEQ) on behalf of Oregonians for Fair Air Regulations. MFA regularly participates in such economic fiscal regulatory analyses and respects the effort put forth by the DEQ in developing their document. The purpose of preparing these comments is to assist DEQ in developing a more scientifically accurate and complete understanding of the potential economic impacts of the proposed regulation for Oregon air toxics. A summary begins the discussion. The second section provides comments on cost impacts, and a third section addresses impacts to small businesses.[1] Following the impacts to small businesses, comments on potential benefit calculations are developed, and then conclusions are briefly restated.

SUMMARY

Cleaner Air Oregon (CAO) would result in unknown and unquantified benefits to human health and the environment, and guaranteed costs to facilities in Oregon. The costs of even the simplest air toxics inventory and assessment are significant for an individual facility, and it is likely that all 2,563 facilities[2] that DEQ estimates will be affected will face some increased costs due to implementation of CAO. While DEQ did not attempt a full cost-benefit analysis in the NOPR fiscal and economic impact statement (FEIS), we have attempted to use the information provided in DEQ's own analysis to more thoroughly evaluate the costs through time and provide a more complete understanding of

[1] It is important to note, however, that this analysis does not reflect any specific Oregon facility, and the information available to MFA is insufficient to allow estimation of whether any specific facility will incur increased costs or the value of those costs.

[2] Page 3 of the Statement of Fiscal and Economic Impact prepared by DEQ (ORS 183.335 (2)(b)(E)). The Notice of Proposed Rulemaking Cleaner Air Oregon (NOPR) prepared by DEQ, October 20, 2017 includes the number of small firms (1,090) and large firms (1,360), the sum of which totals 2,450 estimated number of affected firms (which is not the same as number of affected facilities).

fiscal impacts. This analysis applies the assumptions and estimates in the NOPR FEIS. Where needed, we have developed additional conservative assumptions to demonstrate the overall impact that was not captured by DEQ in the NOPR. Some of the key findings from our analysis include:

- CAO would impose an estimated cost of $2.8 billion in net present value (NPV) to regulated Oregon industries over 20 years, for the medium cost scenario.
- The true cost of CAO to regulated Oregon industries over the next 20 years is uncertain, ranging from $44 million to $8.4 billion NPV.
- CAO's medium annualized average cost to Oregon industry totals more than $140 million each year.
- The expected per-facility cost for CAO over the program's first five years (assuming 80 facilities) ranges from a low of $149,000 (which, as discussed below, is unrealistic) to a high of $15 million, with a medium estimated per-facility cost of over $2.1 million.
- CAO would impose costs on Oregon's small businesses that could meet or exceed the typical profit for small business and discourage future small businesses from locating in Oregon.
- The value of CAO's benefits is uncertain, ranging between $500,000 to $3 million per year, but is not likely to meet or exceed the overall cost to industry.
- Using simple assumptions based on the information provided by DEQ, it is possible that the cost-benefit ratio could be 76 to 1, or that every dollar of benefit costs the state, and Oregon businesses, $76.

Although MFA's analysis incorporates DEQ's own assumptions, it is also important to note that we identified a number of key assumptions in DEQ's analysis that are very conservative, causing DEQ to underestimate CAO's true overall cost. These include:

- Fee increases likely imposed over time to offset the growing cost to DEQ to implement the program as it expands.
- Compliance costs, especially the initial costs of purchasing and setting up pollution control equipment, are greatly underestimated and will likely be much higher than what DEQ assumed in its analysis.
- DEQ's estimated "low cost" for several items are not realistic, such as:
  - Installation and cost of a fabric filter cannot be completed for the estimated low cost of $14,000.
  - Electrostatic precipitators tend to be more costly than fabric filters and cannot be installed for $13,000.

   - The set up and installation of a wet scrubber requires plumbing, insulation, and electrical configurations at a minimum and cannot be completed for the estimated low of $25,000.

- Similarly, the "high cost" estimates provided by DEQ are more representative of midrange costs and do not represent the higher end of anticipated initial costs to facilities. Examples include:

   - Fabric filters and electrostatic precipitators can easily run more than one million dollars, though the high cost stated in the DEQ NOPR is $240,000.
   - The high-end estimate for a wet scrubber should be closer to $750,000 instead of $170,000. In addition to the plumbing, electrical, and insulation costs, these remedies often require that a water treatment system be established. Further, the cost of the scrubbers and chemical inputs can be significant.
   - Biofilters could cost up to ten times as much as the high value of $360,000 identified by DEQ. Biofilters require careful monitoring of the conditions that support microbial communities that consume pollutants. Further, there could be up to an acre of land needed to maintain a facility for the biofilter, plus construction and retrofitting older facilities.

As a result of these notable underestimates, the following analysis that is based on DEQ's underestimates of costs should be considered extremely conservative.

COST ANALYSIS

In an economic analysis of a proposed regulation, the costs (and benefits) are typically evaluated throughout a 10- or 20-year time horizon. This is done by adding up the costs (and benefits) over the time period and discounting the future year costs (and benefits) using a discount rate. This is helpful to capture all impacts, because impacts are often different in the first few years as compared with later years. Results are then presented using the concept of NPV which captures the stream of future costs (and benefits) in one comparable metric. Although DEQ did not complete a cost-benefit analysis for the CAO, MFA developed estimates of the NPV of costs over time using the assumptions made by DEQ for the costs of control mechanisms and other actions required by the proposed rule. Note that there is significant uncertainty in the estimates, resulting in a very large range of potential costs. However, a comprehensive analysis is still possible and MFA has developed this analysis using the DEQ cost values paired with low, high, and medium cost scenarios, as further described below.

The Fiscal and Economic Impacts Analysis developed by the DEQ provided cost ranges for each component of the CAO program and recognizes that the total cost of the program will depend on:

- The number of facilities required to complete the risk assessments
- The specific pollution controls that will be needed for each facility
- Reporting requirements and level of community engagement required for each facility

The program is structured so that each facility will begin assessing its risk by performing a "Level 1 Risk Assessment." This is the simplest and least detailed of the risk assessment types included in the proposed rule, intended to "screen out" facilities from further treatment by the rule. Facilities that do not screen out at Level 1 will need to complete increasingly complex risk assessments, up to a Level 4 Risk Assessment, at which point they will likely be required to implement pollution controls and engage in substantial and repeated public outreach.[3] As proposed, the DEQ will require that only the 80 facilities posing the highest risk (as judged by the DEQ) be included in the program in the first five years. After the first five years, all permitted facilities (identified by the DEQ as totaling 2,563) will be subject to the program.[4]

Table 1 shows the low and high costs for the CAO program as estimated by the DEQ, along with the midpoint (average) for each cost range calculated by MFA.

Table 1
Cost Estimates for CAO from Fiscal and Economic Impact Statement

Program Costs	LOW	HIGH	MIDPOINT
Permitting Fees (total)[a]	$2,500,000	$3,138,395	$2,819,198
Per-Facility Costs			
Reporting Requirements[b]	$120	$1,200	$660
Community Engagement/Public Meetings[c]	$1,400	$6,400	$3,900
Emissions Inventory[d]	$1,200	$60,000	$30,600
Level 1 Risk Assessment[d]	$100	$5,000	$2,550
Level 2 Risk Assessment[d]	$5,000	$35,000	$20,000
Level 3 Risk Assessment[d]	$5,000	$100,000	$52,500
Level 4 Risk Assessment[d]	$5,000	$500,000	$252,500
Initial Cost of Pollution-Control Equipment[e]			
Fabric filter	$14,000	$420,000	$217,000
Electrostatic precipitator	$13,000	$240,000	$126,500
Enclosure	$25,000	$170,000	$97,500

[3] Page 9 of the NOPR.
[4] Page 38 of the NOPR: "...the proposed tiered implementation plan will delay potential impacts to many facilities…"

Table 1
Cost Estimates for CAO from Fiscal and Economic Impact Statement

Program Costs	LOW	HIGH	MIDPOINT
HEPA filter	$17,000	$6,200,000	$3,108,500
Wet scrubber	$25,000	$170,000	$97,500
Thermal oxidizer	$17,000	$6,200,000	$3,108,500
Regenerative thermal	$940,000	$7,700,000	$4,320,000
Catalytic reactor	$21,000	$6,200,000	$3,110,500
Carbon adsorber	$360,000	$2,500,000	$1,430,000
Biofilters	$360,000	$360,000	$360,000
Fume suppressants	$-	$122,000	$61,000
AVERAGE	**$162,909**	**$2,752,909**	**$1,457,909**
Annual Cost of Pollution-Control Equipment[f]			
Fabric filter	$180,000	$6,200,000	$3,190,000
Electrostatic precipitator	$100,000	$7,600,000	$3,850,000
Enclosure	$400	$10,000	$5,200
HEPA filter	$-	$-	$-
Wet scrubber	$19,000	$830,000	$424,500
Thermal oxidizer	$3,500	$5,200,000	$2,601,750
Regenerative thermal	$110,000	$550,000	$330,000
Catalytic reactor	$3,900	$1,700,000	$851,950
Carbon adsorber	$-	$-	$-
Biofilter	$-	$-	$-
Fume suppressants	$-	$-	$-
AVERAGE	**$37,891**	**$2,008,182**	**$1,023,036**

[a]Low numbers from Table 3, page 17 of the Statement of Fiscal and Economic Impact prepared by DEQ (ORS 183.335 (2)(b)(E)), and high numbers from Table 4 of NOPR.
[b]Low and high numbers from Page 26 of the NOPR.
[c]Low and high numbers from Page 27 of the NOPR.
[d]Low and high numbers from Table 6, page 21 of the NOPR.
[e]Low and high numbers from Table 7, pages 23-25 of the NOPR.
[f]Table 7, pages 23-25 of the NOPR.

In order to bound these costs and estimate the economic impact of CAO, MFA prepared scenarios which are then paired with the low, medium, and high costs shown in Table 1. The low-cost estimate assumes that no facilities would be required to complete a Level 2 or higher risk assessment. That is, all facilities would perform a simple Level 1 Risk Assessment, consequently "screen out," and not have to perform any further risk assessment or action under the CAO rule. As a result, in the low-cost scenario, no facility would have to implement any pollution controls nor conduct any community engagement. This outcome is highly unlikely—if this were the case, there would be no need for the CAO program. We present this low-cost/least-likely scenario to produce the lowest possible estimate of program costs.

The high-cost estimate assumes the opposite: every component of the program will cost the maximum estimated cost provided by the DEQ. Further, we assume that all 80 facilities participating in the program in the first five years will perform a Level 4 Risk Assessment and be required to implement pollution controls and engage in public outreach. We assume that the cost of the pollution controls is the average of the maximum cost for each pollution control estimated by the DEQ. Of the remaining 2,483 facilities included in the next 15 years, we assume that 50 percent of facilities will need to conduct a Level 2 Risk Assessment, 25 percent will conduct a Level 3, and five percent will conduct a Level 4 and will need to implement pollution controls and engage in public outreach. This high-cost estimate is one possible outcome of the program and is intended to reflect a plausible, upper bound on the rule's costs, but one that is reasonably likely. It is worth reiterating here that this upper bound should still be considered conservative, given that it is constrained by use of the DEQ underestimates of cost (see Summary, above).

We also calculate a medium-cost estimate, which relaxes some of the assumptions of the high-cost estimate. We assume that each component of the program will have a cost at the midpoint of the ranges presented by the DEQ. We also assume that of the 80 facilities participating in the first five years, only 75 percent will complete a Level 2 Risk Assessment, 31 percent a Level 3, and 25 percent a Level 4. These Level 4 facilities will need to implement pollution controls and engage in public outreach. Of the remaining 2,483 facilities participating in the following 15 years, only 50 percent will conduct a Level 2 Risk Assessment, 25 percent a Level 3, and five percent a Level 4 requiring pollution controls and public outreach. We view the medium cost outcome as reasonably likely. A summary of the assumptions for all three scenarios is shown in Table 2.

Table 2
Assumptions Used to Develop Scenarios (In Percent)

Scenario Assumptions	Low	Medium	High
In the first five years:			
Facilities completing Level 1 Risk Assessment:	100%	100%	100%
Facilities completing Level 2 Risk Assessment:	0%	75%	100%
Facilities completing Level 3 Risk Assessment:	0%	31%	100%
Facilities completing Level 4 Risk Assessment:	0%	25%	100%

Table 2
Assumptions Used to Develop Scenarios (In Percent)

Scenario Assumptions	Low	Medium	High
In the remaining years:			
Facilities completing Level 1 Risk Assessment:	100%	100%	100%
Facilities completing Level 2 Risk Assessment:	0%	50%	50%
Facilities completing Level 3 Risk Assessment:	0%	25%	25%
Facilities completing Level 4 Risk Assessment:	0%	5%	5%

NOTES:
The number of facilities requiring pollution controls and public engagement is equivalent to the number of facilities completing a Tier 4 Risk Assessment. The cost per pollution control and public engagement is assumed to be the average of the maximums of cost ranges for each pollution control.

Reporting costs and total permitting costs are assumed to be the maximum of cost ranges.

The cost of completing a risk assessment is assumed to be the maximum of cost ranges for that risk assessment tier.

Use of the low scenario assumptions and lowest costs estimated by the DEQ for each program component results in a total cost of $44.5 million in NPV at a 3 percent real discount rate over a 20-year program time horizon. Use of the high scenario assumptions and maximum costs estimated by the DEQ for each program component results in a total cost of $8.4 billion NPV at a 3 percent discount rate for the 20-year program. Use of the medium assumptions and the midpoint of costs estimated by the DEQ for each program component results in a total cost of $2.8 billion NPV at a 3 percent discount rate. These results for the low, high, and medium scenario are provided in Table 3. Table 3 also provides the total industry costs for the first five years, as well as the 20-year costs per facility and the first five-year costs per facility under each of the three scenarios.

Table 3
Estimated Costs to Industry of Proposed CAO Rule

	Low (NPV)	Medium (NPV)	High (NPV)
20 Year Total Cost to Oregon	$44,510,182	$2,813,067,873	$8,375,753,580
5 Year Total Cost to Oregon	$11,942,030	$172,031,115	$1,226,410,338
20 Year Cost Per Facility (2,563 Facilities)	$17,366	$1,097,568	$3,267,949
5 Year Cost Per Facility (80 Facilities)	$149,275	$2,150,389	$15,330,129

Table 4 shows the average cost per facility for the next 20 years. The values represent the total costs paid by the entire set of permitted industrial facilities identified by DEQ as subject to the CAO program, divided by the total number of facilities. Note that these averages are not representative of what any specific facility will pay but simply reflect the estimated average across all facilities. Based on risk and the need for pollution controls, some facilities may pay less, but others may pay much more than the value presented in this table.

Table 4
Facility Program Costs for CAO under Low, Medium, and High Scenarios

Average Cost per Facility	Low Scenario	Medium Scenario	High Scenario
Year 1	$32,670	$165,531	$753,230
Year 2	$30,456	$779,863	$5,781,994
Year 3	$29,569	$413,594	$3,018,705
Year 4	$28,708	$401,548	$2,930,782
Year 5	$27,872	$389,852	$2,845,419
Year 6	$2,032	$70,317	$198,585
Year 7	$917	$136,625	$324,840
Year 8	$891	$75,178	$206,867
Year 9	$865	$72,989	$200,841
Year 10	$840	$70,863	$194,992
Year 11	$815	$68,799	$189,312
Year 12	$791	$66,795	$183,798
Year 13	$768	$64,850	$178,445
Year 14	$746	$62,961	$173,248
Year 15	$724	$61,127	$168,202
Year 16	$703	$59,347	$163,302
Year 17	$683	$57,618	$158,546

Table 4
Facility Program Costs for CAO under Low, Medium, and High Scenarios

Average Cost per Facility	Low Scenario	Medium Scenario	High Scenario
Year 18	$663	$55,940	$153,928
Year 19	$643	$54,311	$149,445
Year 20	$625	$52,729	$145,092
Average Annual	**$8,099**	**$159,042**	**$905,979**

IMPACTS TO SMALL BUSINESSES

The state of Oregon requires an analysis be conducted to evaluate impacts to small businesses, stating in Oregon Revised Statues 183.540,

> If the statement of cost of compliance effect on small businesses required by ORS 183.335 (2)(b)(E) shows that a rule has a significant adverse effect upon small business, to the extent consistent with the public health and safety purpose of the rule, the agency shall reduce the economic impact of the rule on small business.

However, although DEQ provided a range of costs (adverse impact) for small businesses, the analysis does not include mitigation of those economic impacts as required. Instead, the small business impacts section provides some potential costs to small businesses for complying with the proposed rule, such as for administration and equipment. The costs provided have large ranges and some appear very high for a small business. To give two examples, the DEQ analysis states:

> (1) that the cost could increase from $100 to $500,000, based on whether the firm would be required to perform computer modeling or a health risk assessment if cancer risk, chronic noncancer risk, or acute noncancer risk is above risk action levels; and
>
> (2) that the proposed rule could result in initial equipment costs of approximately $13,000 to $18.5 million and then approximately $400 to $7,600,000 in annual operating costs.

The high end of these ranges is not sustainable for most small businesses. However, the analysis does not discuss the potential for the proposed regulation to drive some small businesses out of operation or to relocate out of the state. For example, consider a small business in the metal fabrication industry with about 45 employees. The annual revenue for this company is $6,092,211.[5] Based on the average net profit margin of 2.68 percent to 5.41 percent for this industry,[6] the

[5] Dun & Bradstreet. 2017. Business Information, accessed September 28, 2017.
[6] CSI Market. 2017. Iron and Steel Industry Profitability. Available at (https://csimarket.com/Industry/industry_Profitability_Ratios.php?ind=107), accessed September 28, 2017.

company's net profit might reasonably have ranged from $163,271 to $329,589. Given this, even the low/least-likely scenario would reduce the profits between 9 and 18 percent, and the medium scenario would consume the entire profit margin, accounting for between 130 and 263 percent of profits. Using these numbers, the high-cost scenario would surely drive the company out of business, with the average annual cost estimate exceeding the profits by 930 to 1,878 percent. These estimates are shown in Table 5 below.

Table 5
Potential Impact to Small Business Example

Example Small Business Profits	Estimated Profits	Low Annual Costs/Profit	Medium Annual Cost/Profit	High Annual Cost/Profit
Low	$163,271	18%	263%	1,878%
Midpoint	$246,430	12%	175%	1,244%
High	$329,589	9%	130%	930%
Average	**$246,430**	**13%**	**189%**	**1,351%**

The impacts of the CAO, as proposed, will impose significant costs on small businesses, and will likely result in either: (1) forcing shutdowns of the businesses, or (2) causing the small firms to relocate to states with less formidable regulatory operating costs. The latter result, known as "leakage," implies that Oregon jobs will be lost.

In addition to the loss of jobs that Oregon will face if small firms close or leave the state, such a result implies a concentration of industry, reduced competition, and a less favorable environment for future small businesses to locate or start up in Oregon.

BENEFIT ANALYSIS

The DEQ Fiscal and Economic Statement rightly points out that in order to measure the benefits of the proposed CAO regulation, one would need to know specifically how much improved health might come about with the regulation in place, compared with the health status in Oregon absent the regulation. The analyst would need to know (among other factors) the specific chemicals being emitted, the dose-response relationships, the proximity of populations to facilities and emissions, the specific portion of health illnesses that are related to air toxics, and the prevalence of these illnesses in Oregon now. The best that DEQ can offer is to suggest that "reducing emissions *could* prevent substantial health costs"[7] (emphasis added).

Absent the specific information required to conduct a benefit analysis, the DEQ does estimate total health care costs in Oregon related to asthma, cancer, cardiovascular disease, and birth outcomes. This information is helpful but fails to address the question of whether the proposed CAO rule is likely to impact (reduce) the health outcomes or health care costs.

7 Page 31 of the NOPR:

Some information regarding whether or not the regulation will bring about the desired health improvement may be found in the Portland Air Toxics Solutions Air Toxics Pollutant Summaries.[8] The report shows that many of the sources of the air toxics in Portland were related not to the proposed regulated facilities (Industry, point sources), but to mobile sources, small businesses like gas stations and home sources (all titled "Area" sources), off road construction equipment (off road mobile sources), "Background" sources from naturally occurring sources, and "Secondary" sources from chemical reactions that take place in the atmosphere. Figures 1 and 2 below show the percentage of each source found for 20 different air toxics of concern, as analyzed in the summary. Figure 1 shows all of the sources, and Figure 2 adjusts the color of the point sources for several of the compounds. For trichloroethylene and perchloroethylene, the concentrations of those pollutants were found to be below the benchmark for concern. For lead, manganese, and nickel compounds, these were not found to be above the benchmark with certainty, but instead the conclusions are that "some local areas of Portland may be above the benchmark."[9] Consequently, the color for those three compounds is displayed using a hatched pattern, while the color for trichloroethylene and perchloroethylene are shown in light blue.

[8] DEQ, 2011. Air Toxics Pollutant Summaries, Portland Air Toxics Solutions, available at: http://www.oregon.gov/deq/FilterDocs/05-AQ-003_AirToxics.pdf

[9] DEQ, 2011. Air Toxics Pollutant Summaries, Portland Air Toxics Solutions, available at: http://www.oregon.gov/deq/FilterDocs/05-AQ-003_AirToxics.pdf, page 17

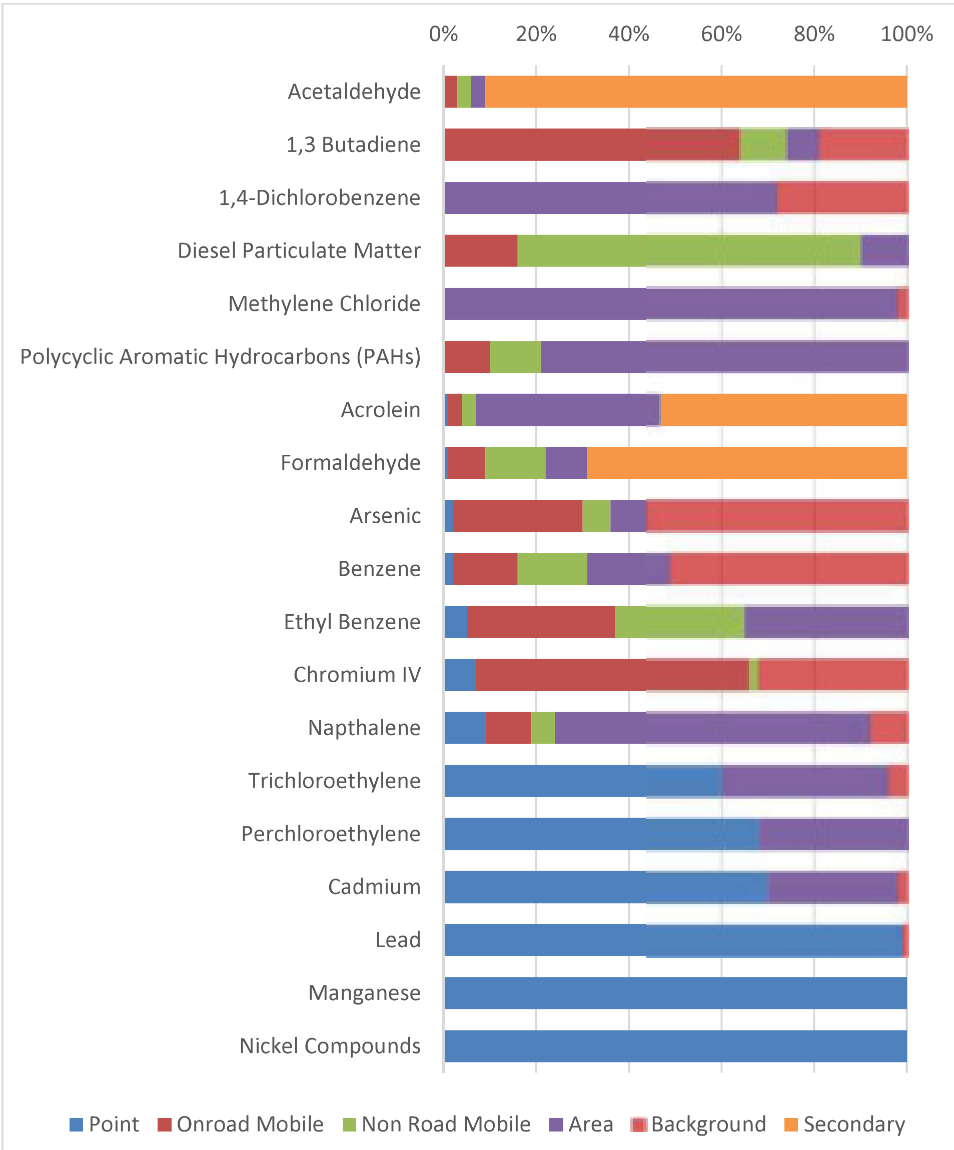

Figure 1: Sources for 20 Air Toxics in Portland Analyzed by DEQ (2011).

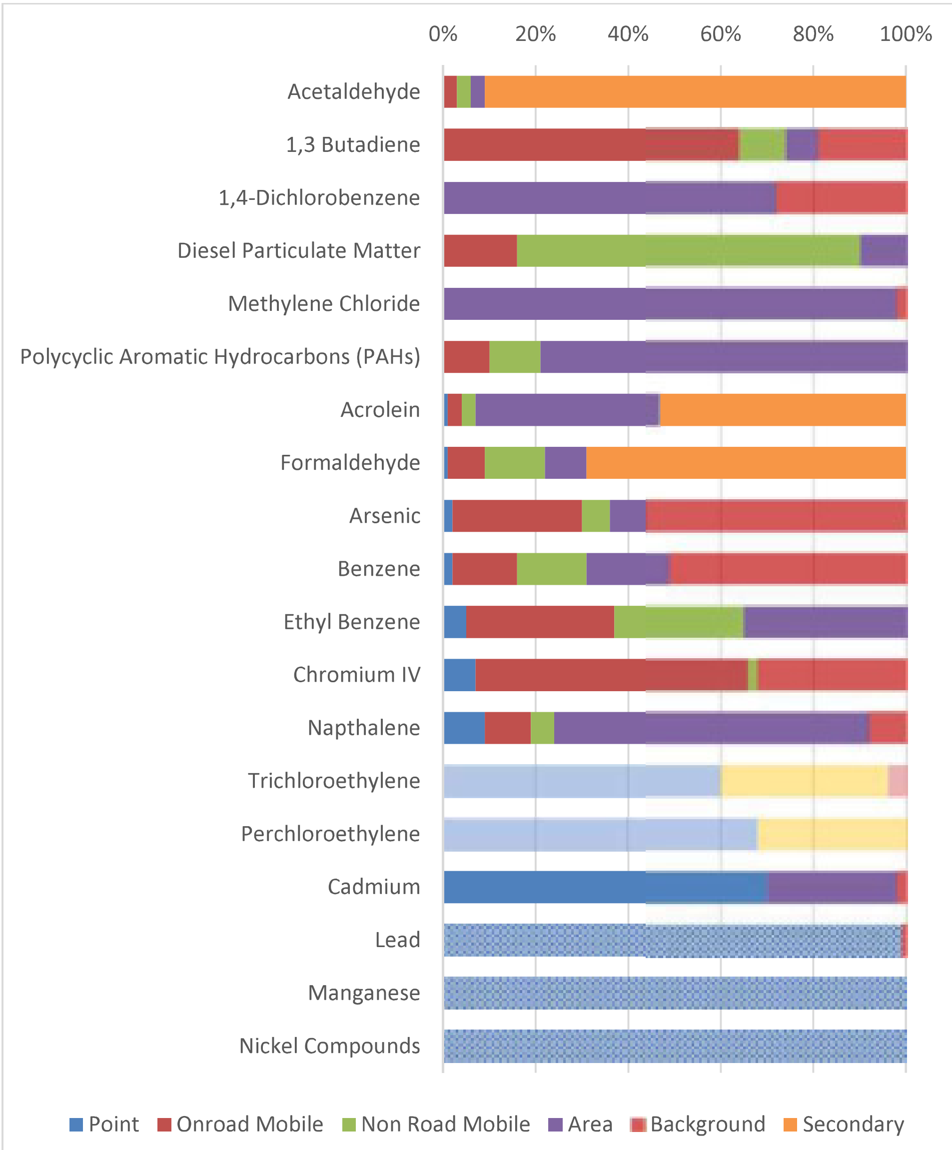

Figure 2: Sources for 20 Air Toxics in Portland Analyzed by DEQ (2011), with point source colors adjusted because concentrations were found to be below the benchmark or results were uncertain.

The implications of this analysis suggest that a total of 6.25 percent of the sources for all pollutants analyzed in this study are related to the point sources that the proposed CAO rule will address.[10] To bring about an improvement in the health impacts of toxics, the question must be raised about how to address the other 93.5 percent of source types.

Further extrapolating from the benefit discussion in the DEQ statement about annual costs that are potentially attributable to ALL environmental factors can produce some additional insights. First, starting with all costs for each type of health concern and then multiplying by the stated fraction attributable to all environmental factors, the following totals can be calculated for Oregon as annual totals for all environmentally sourced illnesses:

- Asthma—$411,000 to $1.2 million
- Cancer—$38 million to $190 million
- Cardiovascular disease, (assuming 1 to 10 percent are attributable to environmental conditions)—$36 million to $360 million

Totaling these results in $74 to $551 million per year in total costs for all asthma, cancer, and cardiovascular disease estimated to be environmentally attributable. However, which portion of all environmental causes might be attributable to air toxics? DEQ's analysis does not even attempt to say. But, for purposes of illustration, by applying a conservative assumption that 10 percent of all environmentally attributable illnesses were related to air toxic emissions, and that 6.25 percent of those emissions were from point sources, then the total potential benefit in terms of health care cost savings would be between $446,000 and $3.3 million per year. And over 20 years, this totals between $9 and $66 million in NPV–compared to the estimated $2.8 billion in 20-year costs to Oregon businesses under the medium scenario, which is $140 million on an annualized basis.

To take this further, we consider an extreme case and assume that:

- All four million Oregonians live within an exposure radius to a regulated facility (which they do not).
- All facilities were found to require some compliance modification (which, if true, would mean that the costs of this regulation would far exceed the estimated $2.8 billion in the medium scenario).
- The average exposure reductions from the compliance were to be 10 in one million.

This extreme case would imply approximately 40 reduced cases of cancer-, or cardiovascular-, or asthma-related diseases. Given the DEQ estimates of $11,410 in health care costs for a cancer

[10] The 6.25 percent estimate does not account for the different quantities of each of the 20 pollutants, and was developed by excluding the two pollutants that are under the benchmark, and weighing the three that "may be" above the benchmark at 50 percent.

case, and $2,000 to $16,760 for a cardiovascular disease case, then the 40 cases would translate into a savings of at most $640,000 in health care costs at the expense of $2.8 billion.

Finally, the DEQ agrees that health outcomes decline with unemployment, so given the potential for leakage as explained in the small business comments, it is not clear whether this regulation would provide a net benefit gain in public health–that is, more gain than loss. For example, researcher Kate Strully analyzed data from the U.S. Panel Study of Income Dynamics that included over 8,000 individuals.[11] She concluded that:

> Losing a job because of an establishment closure increased the odds of fair or poor health by 54%, and among respondents with no preexisting health conditions, it increased the odds of a new likely health condition by 83%.

CONCLUSIONS

The DEQ's Fiscal and Economic Impacts analysis failed to calculate the overall costs and benefits of the program and, overall, was an incomplete analysis. Nevertheless, after completing a fuller analysis using DEQ's assumptions, the overall result of our review points to the fact that the industry share of the cost burden associated with the proposed CAO is not justified with evidence of commensurate or even any specific benefits from the regulation. The industry could face $8.4 billion or more in NPV costs over the next 20 years extrapolating from estimates provided by the DEQ regarding industry costs. We suspect this number could be much larger if more realistic costs were used in the analysis. Further, the estimate of total cost would be much more accurate if some assessment were made to better understand the magnitude of facilities that might need to adopt additional control technologies as a result of this rule.

In comparison to the certain costs facing the industry, the benefits of the proposed regulation are highly uncertain, and it is not clear if there will be any such benefit. The regulation only addresses facilities, which (as point sources) are a small component of the total sources of toxic emissions. As such, if there is a statewide problem with toxic emissions (which does not seem to have yet been answered by DEQ) then it is still not clear that the CAO rule, as designed, will significantly address the problem. In very crude terms, we have estimated a potential health care cost savings associated with this regulation totaling between $446,000 and $3.3 million per year, with a middle value of $1.8 million if job loss is not taken into consideration. This may be compared with approximately $140 million on average in annualized costs to Oregon businesses under the medium scenario described above. Hence, the potential benefit might be just 1.3 percent of the costs of the regulation, which translates to a benefit to cost ratio of 0.013. In other words, there might be approximately $76 dollars in cost invested to produce $1 dollar of benefit.

Finally, the potential for indirect impacts have not been evaluated. These include the potential for firms, especially small businesses, subject to the CAO rule to either shut down or move to other

[11] Strully, Kate W. 2009. Job Loss and Health in the U.S. Labor Market, Demography, May; 46(2): 221-246.

states. This would reduce the competitiveness of Oregon firms and increase unemployment in Oregon. The increased unemployment in turn would have its own set of health impacts and associated costs.

OREGONIANS FOR FAIR AIR REGULATION

Frequently Asked Questions

Our coalition believes:

- Oregon can have both clean air and a healthy economy with fair and reasonable air regulations.
- New regulations should be driven by science, not politics.
- Air permit holders should be responsible for their own emissions, not for pollution from sources they don't control.
- The state should not force businesses to shut down or move facilities to another state, costing thousands of Oregonians their family-wage jobs.

DEQ's proposed Cleaner Air Oregon rule framework, as currently proposed, would have devastating effects on Oregon businesses and communities. To help better understand the coalition's position, here are answers to some frequently asked questions:

What is the Fair Air Regulation coalition?

Fair Air Regulation coalition members includes dozens of Oregon businesses across many industries employing tens of thousands of Oregonians and operating facilities with state air quality permits.

Does the coalition oppose the Governor's goal of creating new, human health based air toxics regulations?

No. Regulated employers in the state have long worked – and continue to work – with the Oregon Department of Environmental Quality (DEQ), Oregon Health Authority (OHA) and other stakeholders to develop air quality regulations that protect public health and can be implemented by businesses without overburdening the agency. Protecting the health and safety of our employees and communities is our priority as well as our responsibility.

Do Oregon businesses oppose the entire Cleaner Air Oregon framework[1] as currently proposed?

No. However, we believe the recently proposed framework needs refinement. The 25-element framework would apply a new approach to regulating air toxics from manufacturing and commercial sources, including hospitals, gas stations and dry cleaners. Some aspects of the framework are reasonable. Others would significantly increase compliance costs for the regulated community and impose new burdens on DEQ without commensurate benefits in air quality or community health. Still other elements, such as the proposed requirement for a first of its kind "community-wide assessments," have not been sufficiently developed by the agencies to

[1] The draft Cleaner Air Oregon framework was released March 21, 2017. It may be downloaded here – http://cleanerair.oregon.gov/wp-content/uploads/2017/03/Draft-CAO-Framework-3-21-2017.pdf

be part of the program at its inception. Understanding details within each element of the complex framework are critically important to implementing new rules, both for the agencies and for regulated community. Before the coalition can endorse the framework, the state must disclose more details about how the program would work. Unfortunately, some details already revealed would pose significant problems.

What are "allowable risk levels?"

Because the new Cleaner Air Oregon regulations will be "health based," the framework proposes to create "allowable" or "acceptable" health risk levels that will drive the regulatory program. The risk levels are described in terms of either excess lifetime cancer risk (usually expressed as some number in a million), or a non-cancer "Hazard Index." The excess lifetime cancer risk imparted by a facility is approximated by modeling or measuring air concentrations at a particular location, and then preforming calculations to estimate the increased risk of contracting cancer due to that facility's air emissions (i.e., only the facility's "excess" above background).[2] Similarly, the hazard index is the ratio of observed air concentrations at a location attributable to a facility divided by the air concentration that would have "no adverse health effect."[3] Both risk assessment methodologies rely upon very conservative assumptions (e.g., a person suffering a constant exposure in a single location for several decades or a lifetime), causing the methodologies to overstate the actual risk that may be presented by a given facility, which is probably much lower than calculated, even zero.

Using these methods of attributing risk to a particular facility, regulators can then set "allowable" risk levels. By way of example, under the Cleaner Air Oregon rule framework, an existing facility would be regulated if it is responsible for risk exceeding 10 in a million or a Hazard Index greater than one. To put these risk levels in context, the lifetime risk of developing cancer is 42.05% for males, 37.58% for females[4] – approximately 400,000 in a million. OHA has indicated that it is difficult to detect increased cancer rates at anything less than 10,000 in a million[5].

What are the problems with the allowable risk level thresholds included in the current proposed framework?

"Allowable risk levels" in framework elements 14 and 15 are set very low, posing an existential threat to Oregon manufacturers, including many of Oregon's largest regional employers. The details of these elements must be reworked or Oregon will risk losing our critical manufacturing base (both large and small), and there will be significant consequences for many other businesses and public services that rely on power sources or processes that produce air emissions (e.g.,

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[2] See also, *National Air Toxics Assessment Glossary of Terms – https://www.epa.gov/national-air-toxics-assessment/nata-glossary-terms*

[3] See also, *National Air Toxics Assessment Glossary of Terms – https://www.epa.gov/national-air-toxics-assessment/nata-glossary-terms*

[4] American Cancer Society estimates of Lifetime Risk of Developing or Dying from Cancer. *[https://www.cancer.org/cancer/cancer-basics/lifetime-probability-of-developing-or-dying-from-cancer.html]*

[5] Cleaner Air Oregon Advisory Committee Presentation, Oregon Health Authority, April 4, 2017

hospitals and emergency dispatch centers that rely on backup generators). If facilities are regulated as a consequence of these allowable risk levels – like similar programs in other states – the direct impact of unreasonably low risk levels, ripple effects will have significant economic consequences, threatening tens-of-thousands of Oregon jobs.

In 2015, the San Joaquin Valley Unified Air Pollution Control District (San Joaquin) assessed[6] whether it was appropriate to revise the allowable risk levels in their air management district. San Joaquin had, up to that point, set the excess allowable lifetime cancer risk level for existing sources at 100 in a million and for new/modified sources at 10 in a million. By comparison, the proposed Cleaner Air Oregon framework would set allowable risk for existing sources at 10 in a million and for new/modified sources at 1 in a million. Those levels that are 10 times more stringent than the San Joaquin allowable risk levels. As part of its 2015 assessment, San Joaquin considered and rejected levels akin to what the Cleaner Air Oregon framework now proposes. San Joaquin explained why in a Final Staff Report, which concludes:

> *"Maintaining the 10 in a million cancer risk threshold for permitting decisions would be very likely to lead to unreasonable restrictions to growth and installations of critical equipment, such as emergency generators (including those at hospitals and 911 call centers), gasoline installations, etc.* [see FAQ 9]. *Therefore, this approval threshold must be increased to comply with the Governing Board's direction to avoid unreasonable restrictions on permitting and CEQA decisions."*

In the end, the San Joaquin regulators determined that the 100-in-a-million excess cancer risk threshold does not pose an unreasonable risk to public health and supports the District's economic vitality, recognizing the value of economic development and its health and safety benefits. For similar reasons, San Joaquin actually *increased* the allowable risk level for new and modified sources from 10 in a million to 20 in a million.

Are there allowable risk levels that would meet the goals of a health-based air quality program and would not burden businesses and state agencies unnecessarily?

Yes. We believe that reasonable allowable risk levels for existing sources are 100 in a million excess cancer risk and a Hazard Index of 10. These are the acceptable risk levels used in the San Francisco Bay area for nearly 30 years, and that air district credits its program with substantial reductions in air toxics. It is worth noting that most businesses still need to work through the screening process to determine the risk levels attributable to their facilities. Based on an initial analysis of several manufacturing sources, however, we believe there are major businesses that would be impacted at these risk thresholds. Importantly, the state must still determine what precisely will happen to businesses that are over the allowable risk levels, especially those that have installed toxics best available control technologies (T-BACT) as defined by EPA, but still do not meet the allowable risk level. If there are no controls available to businesses that would allow

[6] San Joaquin Valley Unified Air Pollution Control District Update to District's Risk Management Policy to Address the State Office of Environmental Health Hazard Assessment's Revised Risk Assessment Guidance Document – May 28, 2015. [https://www.valleyair.org/busind/pto/staff-report-5-28-15.pdf]

them to meet the standard, then the agency needs to decide whether those businesses will be shut down or participate in a separate compliance path. Curtailing operations for those over extremely low allowable risk levels could cost Oregon thousands of jobs.

The agencies said that their program is like other states' programs. Does the coalition agree?

The Cleaner Air Oregon framework is much more restrictive than other states' programs. It most closely resembles the approach several California air management control districts have pursued in regulating air toxics from industrial sources. However, the proposed standards for Oregon would be significantly more stringent than most California air districts, including nearly three times more stringent than the South Coast air toxics program (Los Angeles) and 10 times more than the Bay Area air toxics program (Oakland). Given the information we have, it appears that no state has a statewide program as restrictive as the proposed Cleaner Air Oregon framework.

DEQ claims "these rules will not require wholesale changes in any of Oregon's vital urban and rural industries that would disrupt our communities or our economy." Does the coalition agree?

No. Depending on implementation, many businesses that would be required to meet the allowable risk levels in the current draft framework could face significant curtailment or closure. These businesses are large, regional employers across the state. Rules implementing the proposed framework would have profoundly negative impacts on employees, families, vendors and the communities in which they operate.

What facilities could be impacted by this proposed framework?

According to early analysis and California state agencies, a variety of facilities either could not be permitted or would have a difficult time obtaining a permit to operate in Oregon, including: hospitals, prisons, gas stations, automobile repair shops, wood products manufacturers, metals manufacturers, and more.

Protocol
NRCA/ARMA Silica Study, Phase 1
(January 27, 2017)

Background:

After NRCA proposed a jointly-sponsored study to develop what OSHA calls "objective data" showing that worker silica exposures are reliably below the 25 ug/m3 action level (AL) established in the new OSHA Silica Standard during tear-off and installation of asphalt roofing products, an ARMA task force of IHs discussed possible study protocols. Although a study focused on high exposure scenarios was preferred, this approach was rejected because: (1) the complete absence of exposure data made it impossible to quantitatively assess the impacts of job characteristics that constitute high exposure scenarios; (2) this approach would entail a high degree of selectivity in identifying jobs to be included in the study, which was problematic because of the difficulties the industry has encountered in enlisting jobs for previous industrial hygiene studies; and (3) OSHA had provided little guidance on the meaning of "objective data" and, with a new Administration having just taken office, considerable uncertainty existed about the degree of rigor OSHA will find to be adequate to support claims that specific operations do not involve exposures at or above the AL.

Accordingly, the task force recommended that a preliminary "pilot" study of jobs identified by NRCA meeting broad qualifying criteria be conducted to develop baseline data that (i) will enable contractors to assert an exemption from the exposure assessment requirement of the standard for a significant portion of asphalt roofing installation and removal jobs; and (ii) will provide an evidence-based foundation for designing a Phase Two study of high exposure jobs if appropriate. The decision whether to conduct such a second phase study will depend on the results of the pilot study and the greater information hoped to be available at that time on the criteria OSHA will use to determine whether the "objective data" standard has been met

Protocol:

1. Conduct and Management of Study

   Sponsors: NRCA & ARMA
   Contractor: NRCA & ARMA
   Project Administrators: NRCA & ARMA staff (initially Harry Dietz & Chelsea Ritchie)
   Project Management: A group of ARMA and NRCA representatives with knowledge and expertise in industrial hygiene, biostatistics and the roofing operations (initially Mark Klein, James Dodson, Ed Puhala, Harry Dietz)

2. Scope and Number of Job Sites

   Types of Operations Included: The proposed Phase One Study will include jobs involving the following types of operations:
   - → Four job sites involving installation of asphalt shingles
   - → Four job sites involving removal of asphalt shingles

- → Six job sites involving installation of BUR or ModBit roofing systems
- → Six job sites involving removal of BUR or ModBit roofing systems

Excluded Jobs: Any job involving the removal or cutting of concrete or other silica-containing roof structures or components, or operations that will otherwise damage such structures or components, will be excluded from the joint study unless such operations are an essential part of the installation or removal of an asphalt-based roof, such as cutting flashing reglets into stone, brick and mortar during shingle installation, or the application of aggregate surfacing to a BURA system. For example, jobs involving (i) removal of asphalt membrane roofs installed over a concrete deck, and (ii) removal of asphalt membrane roofs installed over lightweight insulating concrete will be excluded

Selection of Specific Jobs: Any job which has been identified as falling within the scope of the study as defined in Paragraphs 2.a. and 2.b. above, and for which agreement to participate in the study has been obtained from the parties needed for such participation, will be accepted into the study until the job targets have been reached. BUR preferred for low-slope jobs.

3. Air and Bulk Material Samples:
   - → Bulk samples of cores of removed roofing
   - → Upwind area samples
   - → Sampling & analysis of occupational exposure for up to 10 workers

4. IH Reports for Each Jobsite, including documentation of basic job site information as well as relevant activity, work methods, and conditions that may impact exposures, viz., worksite layout, surrounding structure elevations, activity description of each worker, and weather and environmental conditions including wind speed and direction.

NRCA Silica Study
Summary as of July 2, 2018

Date	Jobsite Name	IH Rpt	Core Rpt	Roof System	No. of Workers	Exposure Range (mg/m3)	Sampling Period	Specific Remarks [2]
SHINGLE RE-ROOFING - PHASE ONE GOAL = 4								
5,6-Jul-17	Southside Church, Munster IN	Y	Y	Shingle	5	All BDL	Full-shift	Lack of detail on tools, work practices, type of new shingles.
25-Aug-17	Residence, Corvallis OR	Y	Y	Shingle	3	All BDL	6-7 hrs	
8-Sep-17	Residence, Portland OR	Y	?	Shingle	2	BDL-0.021	Full-shift	One result was near (but below) the AL. Poor detail on tools/practices, especially for removal & disposal (the likely source of the higher exposure).
6-Sep-17	Residence, Fairfield OH	Y	Y	Shingle	5	BDL - 0.019	Full-shift	
LOW SLOPE REMOVAL - PHASE ONE GOAL = 6								
8-Aug-17	Clackamas OR; Re-Roof	Y	?	BUR	3	BDL-0.023	Half-shift	The report does not specifically identify the type of roof being removed or say anything about its thickness, condition or the presence of silica (e.g., whether it was a gravel-surfaced membrane). The description of the removal tools and equipment is consistent with a BUR roof. One worker had a half-shift exposure of 23 ug/m3. Once the separate sample of the installation work is included, the full-shift TWA was 17 ug/m3.
15-Dec-17	Berwyn IL Low-Slope Re-Roof	Y [1]	Y	Gravel-Surfaced BUR	5	All BDL	7.5 hrs	Descriptions of the materials removed and installed inadequate. However, description of the tools and equipment indicate strongly that BUR was removed.

								Information external to the report indicates that the BUR was gravel-surfaced. A single sample was taken over the entire shift, combining both removal and installation activities. This may make it difficult statistically to compare these results to other site surveys that report task-specific sampling results.
1-Aug-17	Munster IN; Korellis Roofing; Southside Church, Re-Roof	Y	Y	Granulated MB cap replaced by a MB membrane.	5	All BDL	4-6 hrs	Inadequate detail on removal practices and the replacement material. Three workers did removal for the entire shift.

LOW SLOPE INSTALLATION - PHASE ONE GOAL = 6

8-Aug-17	Madison WI; Huegel Elementary; Install	Y	n/a	Torch applied MB	6	All BDL	Full-shift	New roof inadequately characterized. Report describes application of a single layer, but the product (Siplast Paradiene 20 PR TG) is described by the manufacturer as "a high performance modified bitumen finish ply designed for use in gravel-surfaced, homogeneous multi-layer modified bitumen roof membrane systems."
8-Aug-17	Clackamas OR Re-Roof	Y	n/a	Hot-applied MB	3	All BDL	Half shift	
5-Sep-17	Wheeling IL; Shure Electronics; Install	Y	n/a	MB	7	All BDL	≈ 8 hrs	
20-Oct-17	Milwaukee Water Works; Install	Y	n/a	Gravel onto BUR flood coat	6	All BDL	≈ 6.5 hrs	

EXCLUDED JOBS

23-Aug-17	Wheeling IL; Shure Electronics; Removal	Y	Y	"built-up roofing (BUR) modified bitumen"	7	BDL-0.081	≈ 7 hrs	Information external to the report indicates that the existing roofing included a perlite coverboard between the layers of BUR and modified; perlite boards contain crystalline silica. The membrane was removed using a power roof cutter. These observations disqualify this job from the study.
29-Sep-17	Milwaukee Water Works; Re-Roof	Y	Y	MB & BUR w gravel surfacing	3	All BDL	≈ 2.5 hrs	The report mentions operations involving "screwing down DensDeck®" but provides no information on the nature or composition of this product. Based on a quick web search, it may be a gypsum board product that contains crystalline silica. In addition, the report mentions an operation involving the saw-cutting of concrete. The statements indicate this job did not meet the study inclusion criteria.
2-Oct-17	Mendota Hgts MN Re-Roof	Y	?	BUR	3	0.0091-0.012	≈ 6.5 hrs	The report states that the job involved drilling into the concrete deck, which disqualifies it under the study protocol. It provides inadequate detail on the replacement BUR, but in any case a single sample was taken over the entire shift for all workers, combining both removal and installation activities.

NOTES

[1] **Sampling done by another consultant (Hygieneering) because Terracon personnel unavailable**

[2] **In addition to specific remarks, all reports submitted to date have the following shortcomings:**

- **Existing roofing material inadequately characterized (viz., age, condition, number of layers/plies)**
- **Inconsistent approach to determining 8-hour TWAs. Some reports assume zero exposure for unsampled periods; others assume continuation of the sampled conditions.**
- **In general, the reports read like IH regulatory compliance evaluations rather than straightforward exposure assessments.**
- **OELs other than the OSHA AL are mentioned and compared; these benchmarks are non-germane.**
- **Unnecessary summary of the requirements of the OSHA Silica Standard; unnecessary analysis of the applicability of the OSHA Silica Standard for Construction.**

ASPHALT ROOFING
MANUFACTURERS ASSOCIATION

ARMA Technical Affairs Committee

Attendance

Melissa Spittler	CertainTeed Corporation
Marty Grohman	GAF
Eileen Dutton	Malarkey Roofing
Tim McQuillen	ARMA Director of Technical Services
Reed Hitchcock	ARMA Executive Vice President

Call to Order

Tim McQuillen called the meeting to order at 12:02pm ET. McQuillen read the roll call and reminded all that the meeting would be subject to ARMA's Antitrust Compliance Policy.

Review of Task Force Objective

McQuillen provided the task force objective on the screen for everyone to view and provide comment. No comments or questions were brought forward by the participants.

White Paper/Technical Bulletin-Truths about RAS and RAP

McQuillen provided an overview of the purpose of the white paper, i.e., to address the negative position that several states have taken pertaining to the use of recycled asphalt shingles in paving materials. Mr. Grohman cited a project in Colorado which blamed RAS for the paving failure; however, the mix for the paving project in question included only 2% RAS. Other cities were mentioned that were writing RAS out of specifications for paving projects. McQuillen placed on the screen an outline draft provided by Dan Horton with ASR that could be used as a starting point of the paper. It was suggested to see if Lacy Tiarks (PRI Construction Materials Technologies) could attend the ARMA Summer meeting in August to provide further insight on this topic. In addition, the participants on the call mentioned tMA should collect and review other papers addressing this topic. ARMA staff were asked to obtain an update on what the Asphalt Institute is doing on this topic.

ASTM D8013 "Standard Guide Establishing a Recycle Program for Roof Coverings"

McQuillen placed the standard on the screen for the participants to review and provide feedback. McQuillen mentioned that a meeting time has been established for this working group when ASTM meets in December in Washington DC. McQuillen asked if the participants thought the standard needed to be updated or revised to include more details to address shingle recycling. McQuillen stated he would review again at the upcoming Summer Committee Meeting in Tampa.

New /Other Business

No new business was brought forward.

Action Item Review

McQuillen provided an overview of the action items. Eileen Dutton was to follow up with PRI on inviting Lacy Tiarks to the ARMA summer committee meeting in Tampa. Reed Hitchcock to follow up with Pete Grass of the Asphalt Institute to obtain an update on their recycling efforts. McQuillen to follow up with Dan Horton on further development of the white paper. The group as a whole is to circulate current articles and or papers that are in the public domain on the RAS/RAP topic.

Adjournment

The meeting was adjourned at 12:42 PM.

Comparison of Cumulative Heat Exposure Experienced by Asphalt Shingles and Underlayment Installed over Vented and Unvented Attics and Simulation of Associated Product Aging

Introduction

ARMA advocates for the ventilation of attics as the preferential method for structures that use asphalt shingles as a roof cover.[1] Attic ventilation is recommended by asphalt shingle manufacturers to "help ensure the performance of the roof."[2] According to ARMA, failure to properly address attic ventilation during building design may result in a variety of problems, including "Premature failure of the roofing system."[3] While ARMA members may have studied the performance of their specific products, the Association has accumulated limited technical data to bolster the position supporting attic ventilation and the associated product performance assertions.

Energy conservation concerns are stimulating significant changes in building construction practices. Options for unvented attic construction have expanded in the International Building Code (IBC)[4] and International Residential Code (IRC)[5] during several previous code development cycles. California strongly supports unvented attic construction as an element of their state-driven energy conservation initiative. Many builders, designers, and contractors advocate energy conservation construction practices, including unvented attics, for a variety of reasons in all areas of the U.S. and Canada. The overall trend toward unvented attic construction is contrary to ARMA's position that ventilated attics are the superior design option for buildings with asphalt shingle roofing.

In areas where there is a hazard to buildings from wildfires, an unvented attic (and the commensurate solid soffit materials) is considered a defense against ember intrusion into attics that can ignite the building. This concern about fire risk to the structure, combined with energy efficiency concerns, is expected to lead to increase in the numbers of low-rise buildings constructed with unvented attics.

Installation of air impermeable insulation directly beneath the roof deck sheathing has been permissible by the International building codes since 2009. Introduction in the 2018 IRC of an unvented attic design that permits use of air permeable insulation, such as fiberglass blanket insulation, beneath roof decks is the most recent option supporting the increased market penetration of unvented attic construction.

Proposal

ARMA should sponsor research to investigate whether installation of asphalt shingles and roofing underlayment (self-adhesive and saturated felt) over unvented attic spaces can be expected to

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[1] (Asphalt Roofing Manufacturers Association 2017)

[2] (Asphalt Roofing Manufacturers Association 2015). This Technical Bulletin is not publicly available as of the date of this document; it is under review by the responsible ARMA committee; the quotation above may change prior to publication.

[3] (Asphalt Roofing Manufacturers Association 2015)

[4] (International Code Council Inc. 2017). International Building Code.

[5] (International Code Council Inc. 2017). International Residential Code.

adversely affect long-term performance of the roofing products when compared to vented attics. The research should include the most commonly used approach (i.e. air impermeable insulation installed on the underside of the roof deck), as well as the newest option (i.e. air permeable insulation positioned immediately beneath the roof deck). A ventilated attic can serve as a control. One potential means to create a meaningful comparison is to measure the cumulative heat exposure of roofing underlayment and roof covers installed on constructions made with each design and use those results as a proxy for thermal degradation of the underlayments and roof covers. The Arrhenius equation, (i.e. temperature dependence of reaction rates) can serve as a starting point for a mathematical simulation that projects the effect of attic-design-related temperature differences on roofing underlayment and roof cover performance. The initial temperature comparative study may be used to develop subsequent research investigations.

Bibliography

Asphalt Roofing Manufacturers Association. 2017. "Technical Bulletin: Attic Ventilation Best Practices for Steep Slope Asphalt Shingle Roof Systems." *asphaltroofing.org.* May. Accessed June 5, 2018. https://asphaltroofing.org/wp-content/uploads/2017/11/Ventilation-Best-Practices.pdf.

—. 2015. "Technical Bulletin: Ventilation and Moisture Control for Residential Roofing." Asphalt Roofing Manufacturers Association, January.

International Code Council Inc. 2017. "Section 1202.3 Unvented attic and unvented enclosed rafter assemblies." In *2018 International Building Code*, by International Code Council Inc., 321-322. International Code Council Inc.

International Code Council Inc. 2017. "Section R806.5 Unvented attic and unvented enclosed rafter assemblies." In *2018 International Residential Code for One- and Two-Family Dwellings*, by International Code Council Inc., 428-429. International Code Council Inc.

METHOD EVALUATION WORKING GROUP UPDATE*

** Indicates a voting item*

Technical Committee Meeting

Chicago, IL

August 23, 2018

AGENDA

- Working Group background
- Review of modeling results
- Recommendation to Technical Committee
- Discussion/vote

BACKGROUND (CONT.)

- Board established Re-Testing Working Group, with the following objective:
  - *Establish a Re-Testing Protocol to handle changes/updates to CRRC test methods that maintains the technical accuracy and credibility of the CRRC rating program and allows sufficient transition to the roofing industry participants with CRRC ratings.*
- Objective of TC Working Group:
  - Develop a technical basis for determining whether retesting of CRRC products is necessary

BACKGROUND (CONT.)

- Method Evaluation WG tasked with exploring practical significance through energy modeling:
  - Whole building simulation: too complex
  - Use of ASTM E1980 Equation 1 to calculate quasi-steady roof surface temperature T_s

$$\alpha I = \varepsilon\sigma(T_s^{\ 4} - T_{sky}^{\ 4}) + h_c(T_s - T_a)$$

OBJECTIVE

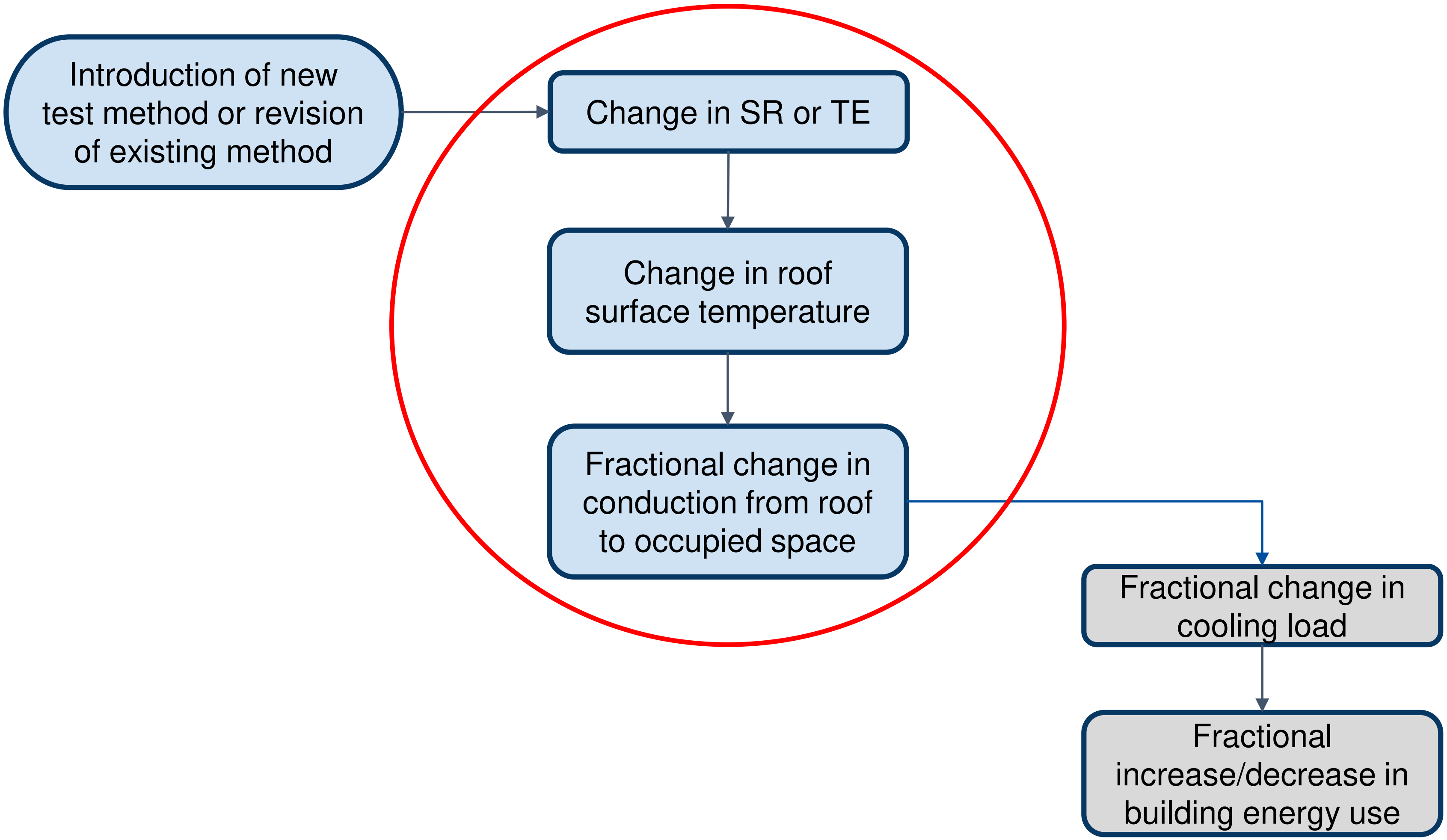
Answer the question:

"What change in Solar Reflectance or Thermal Emittance will significantly affect roof surface temperature and conduction of heat into the conditioned space?"

or:

"How large of a change in Solar Reflectance or Thermal Emittance will **not** significantly affect roof surface temperature and conduction of heat into the conditioned space?"

OBJECTIVE (CONT.)



REVIEW OF MODELING RESULTS

METHODOLOGY

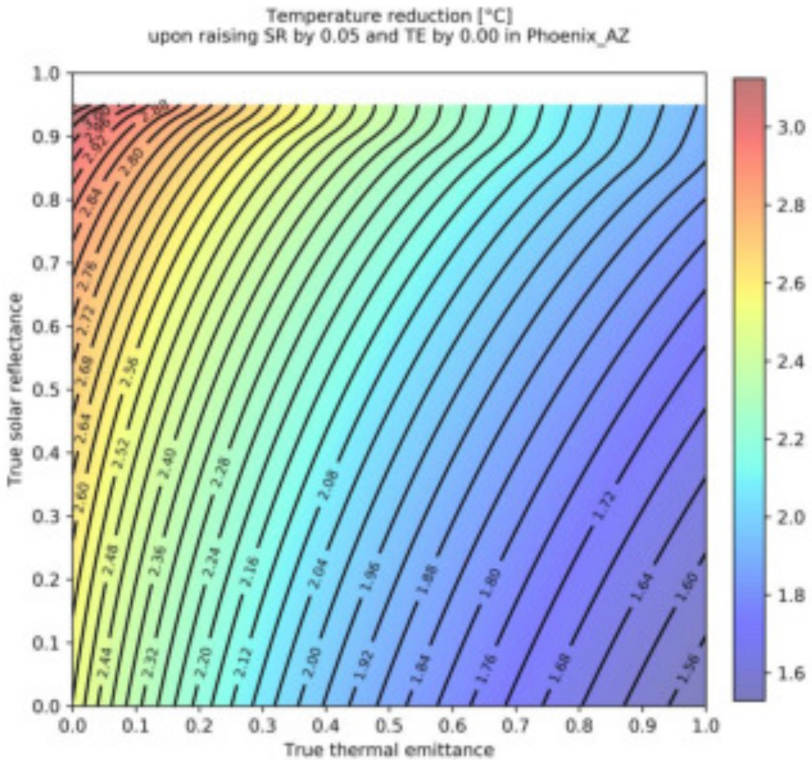
- Obtain climate data
- Compute hourly roof surface temperatures following E1980, varying TE and SR from 0.00 to 1.00 with step 0.01
- Calculate mean roof temperature on summer afternoons (June – August, 12:00 – 18:00 LST) for each combination of TE and SR
- Compute how increasing TE or SR by 0.05, 0.10 changes temperature and heat flows

RESULTS

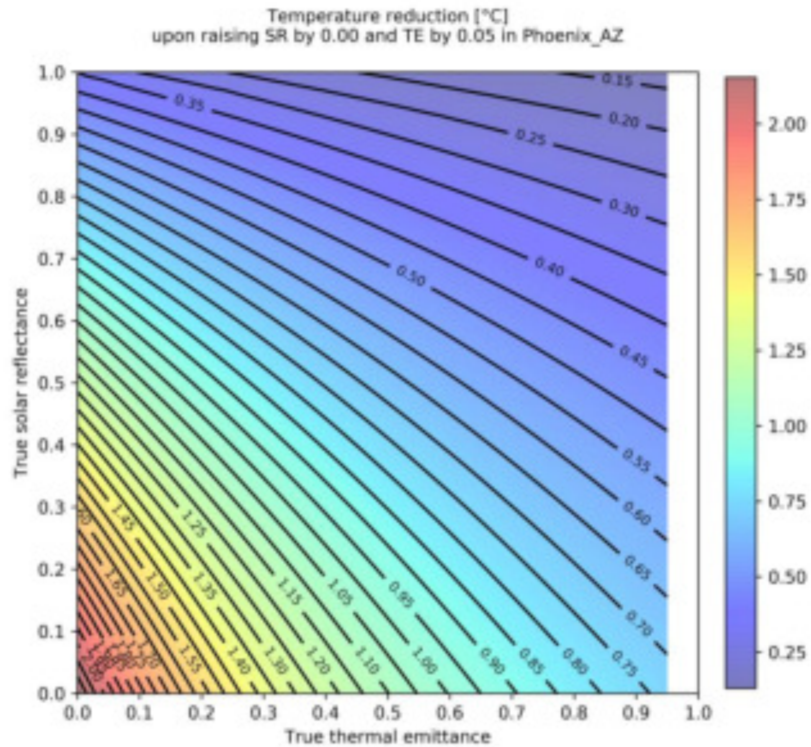
- Series of contour plots that detail the effect of changing SR or TE by 0.05 and 0.10
- Completed at three locations:
  - Phoenix, AZ
  - Cleveland, OH
  - Miami, FL

PHOENIX, AZ – TEMPERATURE REDUCTION

ΔSR = +0.05



ΔTE = +0.05



EXAMPLES

- Two theoretical products:
  - Product A: Initial SR = 0.75, TE = 0.88
    - (example: white membrane)
  - Product B: Initial SR = 0.34, TE = 0.80
    - (example: cool-colored metal)
- Four scenarios:
  - Scenario 1: Raise SR by 0.05, hold TE constant
  - Scenario 2: Raise SR by 0.10, hold TE constant
  - Scenario 3: Raise TE by 0.05, hold SR constant
  - Scenario 4: Raise TE by 0.10, hold SR constant

SCENARIO 1

- Raise SR by 0.05, hold TE constant

	Product A		Product B	
	Temperature reduction(°C)	Change in heat conduction (%)	Temperature reduction(°C)	Change in heat conduction (%)
Arizona	1.8	9	1.7	5
Ohio	1	20	0.9	7
Florida	0.7	10	0.7	5

SCENARIO 2

- Raise SR by 0.10, hold TE constant

	Product A		Product B	
	Temperature reduction(°C)	Change in heat conduction (%)	Temperature reduction(°C)	Change in heat conduction (%)
Arizona	4	20	3.6	13
Ohio	2	70	1.9	15
Florida	1.5	25	1.5	13

SCENARIO 3

- Raise TE by 0.05, hold SR constant

	Product A		Product B	
	Temperature reduction(°C)	Change in heat conduction (%)	Temperature reduction(°C)	Change in heat conduction (%)
Arizona	0.4	2	0.6	2
Ohio	0.2	3	0.3	2
Florida	0.1	1	0.2	1

SCENARIO 4

– Raise TE by 0.10, hold SR constant

	Product A		Product B	
	Temperature reduction(°C)	Change in heat conduction (%)	Temperature reduction(°C)	Change in heat conduction (%)
Arizona	0.6	3	1.2	4
Ohio	0.3	6	0.5	4
Florida	0.2	2	0.3	2

SUMMARY

- Changes in TE do not produce significant changes in surface temperature or heat conduction (Scenarios 3 and 4)
- Only notable variation between Products 1 & 2 (“cool” vs. “standard”) occurred in conduction values for Scenario 1 and Scenario 2

RECOMMENDATION

RECOMMENDATION

- Approve addition of E1980 as practical significance methodology in Retesting Guide
- “Pass” practical significance test if:
  - change in Solar Reflectance is less than 0.05
  - change in Thermal Emittance is less than 0.10

QUESTIONS?

Product Category Rule (PCR) Guidance for Building-Related Products and Services

Publisher:
UL Environment

Tracking of versions

Version	Comments	History
1.0	Creation of PCR Part B for Asphalt Roofing Products to conform with ISO 21930: 2017, UL Part A, and align with ASTM PCR for Asphalt Shingles, Built-up Asphalt Membrane Roofing and Modified Bituminous Membrane Roofing. This PCR has been updated to align with international standards with the intent of allowing manufacturers to create EPDs which are global in scope.	xxxxxx, 2018

This PCR is valid for a period of five (5) years, set to expire in xxxxxxxx, 2023.

I. Background Information and Acknowledgements

These sub-category Product Category Rules (PCR) were developed to address the product specific rules for the creation of Environmental Product Declarations (EPD) for asphalt shingles, built-up asphalt membrane roofing, modified bituminous membrane roofing products, and hot-applied rubberized asphalt membrane, collectively referenced throughout this PCR as "asphalt roofing products". When used to self-reference this document, "PCR" refers to "sub-category PCR."

Other PCRs considered in the development of this PCR include:

- Product Category Rule for Asphalt Shingles, Built-up Asphalt Membrane Roofing and Modified Bituminous Membrane Roofing. ASTM. July 2014.
- Part A: Life Cycle Assessment Calculation Rules and Report Requirements UL Environment (February 2018, version 3.1)
- EN 15804: 2012-04 - Sustainability of construction works - Environmental Product Declarations - Core rules for the product category of construction product.
- ISO 21930: 2017 - Sustainability in building construction -- Environmental declaration of building products

The scope of this PCR differs from the previously published ASTM PCR in that it conforms with ISO 21930:2017 and a Part A/Part B structure. This PCR assumes a 75 year building service life to be consistent with ASHRAE 189.1 (2014, Section 9.5.1).

Interested Parties

This Part B has been prepared with input from the following stakeholders:

Trade associations

- Asphalt Roofing Manufacturers Association (ARMA)

Manufacturers/Consultants

- Atlas Roofing
- Building Products of Canada
- Johns-Manville
- Malarkey Roofing

Commented [Jean-Fran1]: A potential addition to the list of asphalt roofing products is "hot-applied rubberized asphalt membrane", pending participation of manufacturers of this type of product.

Commented [Jean-Fran2]: Is this number comparable to those used in other building materials PCR?

Commented [Jean-Fran3]: This list is to be reviewed in light of current participants and their affiliation.

- Saint-Gobain (CertainTeed)
- GAF
- Firestone Building Products
- Soprema
- PABCO Roofing Products
- Owens Corning
- TAMKO

Governance

There are a number representatives of asphalt roofing manufacturers participating in the update of this Product Category Rule ("PCR") for asphalt roofing products, including the Asphalt Roofing Manufacturers Association (ARMA). These parties represent a majority of the companies in their particular sector of the asphalt roofing industry. Moreover, the manufacturing parties participating in the PCR update represent the vast majority of the asphalt roofing sold in North America in the product categories included in this PCR. The very purpose and function of a trade association is to inform its members of important industry developments and to represent their interests in projects such as the update of a PCR affecting their products. This is important because it effectively demonstrates that a large percentage of the asphalt roofing industry is represented in the effort to renew the PCR for asphalt roofing products.

The role of participants is to establish requirements and procedures to be applied in the development of EPDs for asphalt roofing products. This is an update to an existing PCR, and therefore, this effort begins with the vetting of required changes in scope and structure. A fundamental aspect of the utility of an LCA is understanding a product's environmental impact, so maintaining applicability of EPDs certified under the existing PCR is a critical consideration for participants. In the development of this document, Part B, participants are responsible for ensuring alignment with Part A and conformance with the scoped standards: EN 15804, ISO 21930, and ISO 14025.

Involvement of Interested Parties

UL Environment shall be responsible for producing the PCR document by establishing an open consultation process that includes the involvement of interested parties (ISO 21930 Section 5.2 and 6.2.1). Reasonable efforts were made to achieve a consensus throughout the process (ISO 14020:2000, 4.9.1, Principle 8 and cited in both ISO 14025 and ISO 21930), demonstrated by a vote of participating interested parties.

ARMA informed their memberships of the PCR creation through their regularly scheduled association committee meetings, newsletters, e-mail messages, and similar types of outreach. Trade associations operate at the behest of its members, and the fact that trade associations are participating in the update of a PCR for asphalt roofing products is an indication that their memberships are aware of this project and have authorized their association to represent them in this important endeavour.

UL Environment posted an open call for participation in this PCR update in May 2018 via its standards website, social media outlets, and outreach to original committee stakeholders.

XX% of the industry as represented by regional market production volume was included in the update to this PCR with a minimum of three companies.

Commented [Anna Lass4]: Tim to confirm representation number.

Update Process

The PCR is valid for a duration of five (5) years from the publication date, at which time it may be revised at the request of industry stakeholders. The PCR may be revised before the five year date if the following occurs in the industry:

- The industry desires an update
- Core governing standards ISO 14040, 14044, 14025, 21930, or EN 15804 are updated with

substantial material changes

Note: When the PCR is updated, the Program Operator shall communicate with the original committee, any new EPD participants, and initiate a new public call for interested parties.

Public Consultation

Public consultation was utilized during the PCR review process. The public consultation of the completed draft PCR included a minimum 30-calendar-day period for comments to be submitted to UL Environment. After public comments were submitted, the PCR committee reviewed and developed responses for all comments. All comments from the review panel and public consultation were addressed and satisfactorily resolved by the PCR committee prior to the publication of this PCR.

Review

The review process of this Part B PCR included a review through public consultation in xxxxxxx – xxxxxxx 2018 and a panel review, comprised of the following individuals:

TBD	TBD	TBD

II. Scope

This document contains the Product Category Rule (PCR) requirements for Asphalt Shingles, Built-up Asphalt Membrane Roofing and Modified Bituminous Membrane Roofing Environmental Product Declarations (EPDs) published in coordination with the EN 15804 and ISO 21930 standards. The requirements for the background Life Cycle Assessment (LCA) project report used to inform the EPD are contained in UL Environment's Part A: Life Cycle Assessment Calculation Rules and Report Requirements. This Part B document, coupled with the Part A, conforms to the EN 15804, ISO 21930, and ISO 14025 sustainability standards for EPD reporting in addition to the US Green Building Council PCR Guidance.

This PCR has been updated to align with international standards with the intent of allowing manufacturers to create EPDs which are global in scope.

General Guidance

The scope of this PCR applies to the product group "asphalt roofing products" and includes all residential and commercially available installed asphalt roofing products according to the standards or technical approvals shown under Section 8, including asphalt shingles applied over underlayment, and low-slope roofing assemblies consisting of various combinations of factory-produced asphalt-saturated/coated base sheets, ply sheets and cap sheets together with specified viscous asphalt coatings, adhesives and surfacings.

Commented [Nicholson5]: To add

This PCR applies to the entirety of a packaged product intended for individual sale, including but not limited to adhesives and sealants.

Applicable Products

The following Construction Specification Institute (CSI) Masterformat codes cover the scope of this Part B:

- 07 12 13 Built-Up Asphalt Waterproofing
- 07 12 16 Built-Up Coal Tar Waterproofing
- 07 13 13 Bituminous Sheet Waterproofing

Commented [Jean-Fran6]: Is waterproofing a function that is / should be covered by this PCR?

- 07 13 52 Modified Bituminous Sheet Waterproofing
- 07 13 26 Self-Adhering Sheet Waterproofing
- 07 13 52 Modified Bituminous Sheet Waterproofing
- 07 14 13 Hot Fluid-Applied Rubberized Asphalt Waterproofing
- 07 31 13 Asphalt Shingles
- 07 31 13.13 Fiberglass-Reinforced Asphalt Shingles
- 07 51 13 Built-Up Asphalt Roofing
- 07 51 13.13 Cold-Applied Built-Up Asphalt Roofing
- 07 51 16 Built-Up Coal Tar Roofing
- 07 51 23 Glass-Fiber-Reinforced Asphalt Emulsion Roofing
- 07 55 51 Built-Up Bituminous Protected Membrane Roofing
- 07 55 52 Modified Bituminous Protected Membrane Roofing
- 07 55 56.13 Hot-Applied Rubberized Asphalt Protected Membrane Roofing

Non-Applicable Products

Products that provide the same function but are not asphalt-based are not within the scope of this PCR. These excluded CSI codes are:

- Xxx
- xxxxx

System Boundary

The system boundary for EPDs created using this PCR is either cradle to gate with options (end of life) or cradle to grave.

The EPD requirements include:

- EN 15804 standard
- ISO 21930:2017 standard
- ULE General Program Instructions v 2.3, February 2018 (available upon request)
- The calculation rules for the Life Cycle Assessment and Requirements on the Project Report are specified in a separate document as Part A of the Product Category Rules, available at http://industries.ul.com/environment/transparency/product-category-rules-pcrs

Commented [Nicholson7]: Are fluid applied products within scope?

Commented [Jean-Fran8]: See my comment on page 2 on this topic.

Commented [Anna Lass9]: For committee review - insure appropriate codes are referenced; add or delete as necessary.

Commented [Anna Lass10]: Homework item for committee - are there definitive categories which should be excluded from this PCR, such as waterproofing materials?

Commented [Jean-Fran11]: Is it a good thing to have options for boundaries in the PCR? Some EPDs might choose cradle to gate, other might choose cradle to grave. There goes the potential for comparison!

Commented [Anna Lass12]: For additional discussion. UL's recommendation is to allow maximum flexibility under PCR for creating both B2B and B2C EPDs.

III. Industry-Average EPD Requirements

Industry-Average EPD Scope
The products represented within an single industry-average EPD created using this PCR are limited to the primary materials defined in the product specification standards in Section 9 that characterize the specific product in commerce.

Involvement of Interested Parties

A call for involvement of interested parties in the creation of an industry-average EPD shall be published in at least one industry trade publication. At a minimum, at least three (3) different manufacturing locations from no less than three (3) companies should be involved and represented in an industry-average EPD. The method for determining representativeness shall be justified and described per the requirements listed in Section 2.2.4.1.

Industry-Average EPD Participation

A manufacturer qualifies for participation in an industry-average EPD created using this PCR if the manufacturer provides LCA data used to calculate the EPD average.

Retroactive participation:

A manufacturer desiring retroactive inclusion in the industry average EPD shall provide the manufacturing and product data information submitted in the original industry average EPD to the LCA practitioner. The LCA practitioner will then recommend to the Program Operator a determination for inclusion in the industry average on the basis of results falling within a reasonable range for any impact category. The maximum and minimum should be reported in the LCA background report for each impact category based on the highest and lowest impact product or facility within the original industry-wide LCA.

When determining a manufacturer's participation eligibility, the EPD Program Operator shall follow the recommendations of the primary sponsor(s) of the industry average EPD and participating manufacturers unless the Program Operator has information to the contrary, in which case the Program Operator, LCA practitioner, primary sponsor of the industry average EPD, and manufacturer shall confer in an effort to reach consensus.

Commented [Anna Lass13]: For committee review.

Governance

An industry organization, such as a trade association, shall inform possible industry participants through association meetings, newsletters, e-mail messages, and similar types of outreach, including public notices in the trade press publications. Confidential business information shall be collected by a third party. Data from the third party shall be provided to the facilitator as aggregated data with no trace to the original source of data.

The development of an industry-average EPD and or update of an EPD should involve a series of meetings and exchanges in which all participants are invited and kept apprised of the developments. Notices of these meetings should be given to all possible participants regardless of their commitment to active involvement. Minutes of meetings, along with meeting notices, should be preserved as documentation of the process and due diligence observed in the creation or renewal of the EPD.

Data Responsibility/Ownership

Trade associations that lead the development of industry-average EPDs may need to collect confidential business information from individual members. This data can include proprietary chemical formulations and processes or other confidential information. In this case, a designated third-party entity such as an LCA practitioner shall be identified as the "industry agent". The industry agent shall be responsible for activities including collection, secure storage and analysis of such data needed for the EPD development, and will preserve the privacy of individual company information while executing these duties.

Per ISO 21930 Section 5.4, the manufacturer, or group of manufacturers, of the construction product is the sole owner of the EPD and is responsible for developing the EPD of the construction product according to the PCR. Only the manufacturer or group of manufacturers is authorized to declare the environmental performance of the construction product using an EPD.

The group of manufacturers responsible for developing an industry-average EPD shall be responsible for, including but not limited to, ensuring industry-average EPD updates are made based on the most recent LCA modeling software version and impact assessment version available.

Industry-Average EPD Updates

Industry-average EPDs created using this PCR shall expire five (5) years after publication. An update to the existing EPD, or new EPD, may need to be developed prior to the five years if: 1) significant changes have occurred in the manufacturing process; 2) new industry participants; 3) significant changes or alterations in raw materials; 4) major regulatory changes that mandate or trigger changes to operational procedures; or 5) major technological changes would also justify creation of an updated EPD.

Additional companies may be added to an existing industry-average EPD at the scheduled review by submitting data required for retroactive participation. However, this shall not automatically trigger a recalculation of the industry average impacts.

1. General Information

EPD Program and Program Operator Name, Address, Logo, and Website	Program Operator Provided
General Program Instructions and Version Number	Program Operator Provided
Manufacturer Name and Address	
Declaration Number	Program Operator Provided
Declared Product & Functional Unit or Declared Unit	
Reference PCR and Version Number	
Description of product's intended application and use (as Identified when Determining Product RSL)	
Product RSL Description (if Appl.)	
Markets of Applicability	
Date of Issue	Program Operator Provided
Period of Validity	Program Operator Provided
EPD Type	[Industry-average or product-specific]
Range of Dataset Variability	[Industry-average only; mean, median, standard deviation]
EPD Scope	[Cradle to gate with options (specify options), or cradle to grave]
Year(s) of reported manufacturer primary data	
LCA Software & Version Number	
LCI Database(s) & Version Number	
LCIA Methodology & Version Number	
The sub-category PCR review was conducted by:	Program Operator Provided Program Operator Provided Program Operator Provided
This declaration was independently verified in accordance with ISO 14025: 2006. The UL Environment "Part A: Calculation Rules for the Life Cycle Assessment and Requirements on the Project Report," v3.1 (February 2018), based on CEN Norm EN 15804 (2012) and ISO 21930:2017, serves as the core PCR, with additional considerations from the USGBC/UL Environment Part A Enhancement (2017) ☐ INTERNAL ☐ EXTERNAL	Program Operator Provided
This life cycle assessment was conducted in accordance with ISO 14044 and the reference PCR by:	Program Operator Provided
This life cycle assessment was independently verified in accordance with ISO 14044 and the reference PCR by:	Program Operator Provided

Limitations

Environmental declarations from different programs (ISO 14025) may not be comparable.

Comparison of the environmental performance of Asphalt roofing Products using EPD information shall be based on the product's use and impacts at the building level, and therefore EPDs may not be used for comparability purposes when not considering the building energy use phase as instructed under this PCR.

Full conformance with the PCR for Products allows EPD comparability only when all stages of a life cycle have been considered. However, variations and deviations are possible". Example of variations: Different LCA software and background LCI datasets may lead to differences results for upstream or downstream of the life cycle stages declared.

2. EPD Content

2.1. Description of Company/Organization

The name of the manufacturing entity(ies) as well as the place(s) of production shall be provided. General information about the manufacturing entity(ies) may be provided, such as the existence of quality systems or environmental management systems, according to ISO 14001 or any other environmental management system in place.

2.2. Product Description

A narrative description of the product shall be provided that enables clear identification of the product. This description will include:

2.2.1 Product Identification

The declared product(s) in an industry-average EPD shall be identified by material type(s) and by simple visual representation, which may be by photograph or graphic illustration
The declared product(s) in a manufacturer-specific EPD shall be identified by brand name(s), by material type(s), by production code(s) (if applicable), and by simple visual representation, which may be by photograph or graphic illustration.

Commented [Jean-Fran14]: This requirement is fine for a manufacturer-specific EPD but identification of products in an industry-average EPD in accordance with this requirement will be cumbersome, without providing much value. Consider a specific identification requirement for each EPD type.

2.2.2 Product Specification

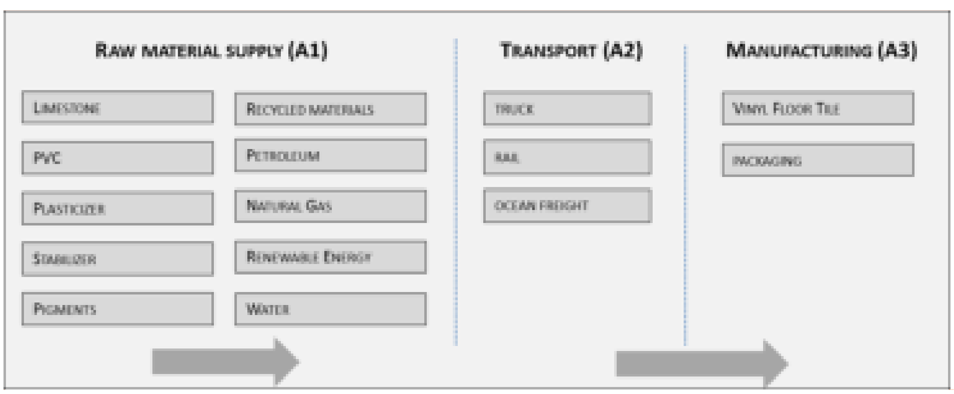
Similar products grouped and reported as an average product in the same EPD satisfying the variation criteria of Part A, Section 5 shall constitute an individual declared product. For each declared product, list the physical characteristics defined by the standards in Section 2.5 – in the form that the product would be installed – along with the reference to the test standard for each. When pertinent, provide a description of the asphalt roofing product. Mass shall be based on the total amount of material needed to produce 1 m² of the given product, i.e. prior to yield losses, including any and ancillary materials. Other relevant product specification values may be provided here.

The appropriate ASTM or CSAproduct specification shall be provided, including additional pertinent physical properties and technical information.

2.2.3 Flow Diagram

A graphical depiction of a flow diagram illustrating main production processes according to the scope of the declaration shall be included such as the examples in Figure 1.

Figure 1. Example Product Flow Diagram – xxxxxx[1]



Commented [Nicholson15]: To be updated

[1]This example flow diagram is specific to xxxxxxx product and other product types covered in this PCR will differ.

2.2.4 Product Average

2.2.4.1 Industry-Average EPD (if relevant)

The method for creating an industry-average EPD shall be described per Part A: Life Cycle Assessment Calculation Rules and Report Requirements, Section 2.5.1.

2.2.4.2 Product Specific EPD

The method for creating a company specific individual product/product group EPD shall be described, including the method for determining a weighted average across products based on production volume as described in Part A: Life Cycle Assessment Calculation Rules and Report Requirements, Section 2.5.2.

2.3. Application

The intended application(s) for the referenced product(s) shall be specified, along with the functional unit and RSL.

2.4. Declaration of Methodological Framework

The following items shall be specified: the type of EPD with respect to life cycle stages, and the life cycle stages covered and not covered (i.e. B2B, cradle-to-gate with modules A1-A3 and C1-C4 included or B2C with all modules included).

The reference conditions for achieving the declared technical and functional performance and the Reference Service Life (RSL) shall be included, per Part A: Life Cycle Assessment Calculation Rules and Report Requirements, Section 2.8.2.

The cut-off and allocation procedures shall be described according to the requirements of Sections 2.9 and 3.3 of Part A: Life Cycle Assessment Calculation Rules and Report Requirements. Include the statement “no known flows are deliberately excluded from this EPD.”

2.5. Technical Data

The following technical data for the product as delivered shall be provided with reference to the test standard.

Table 2. Technical data

Product	Description/Specification
Asphalt Shingles	ASTM D3018, ASTM D3462, ASTM D226, ASTM D4869, ASTM D6757, ASTM D1970 (together or in combination); CSA A123.5, CSA A123.3, CSA A123.22 (together or in combination); ICC-ES AC438, ASTM D226, ASTM D4869, ASTM D6757, ASTM D1970 (together or in combination)
Built-up Asphalt Membrane Roofing	ASTM D4601, ASTM D4897, ASTM D2626, ASTM D2178, ASTM D3909, ASTM D41, ASTM D312, ASTM D6152, ASTM D4586, ASTM D3747, ASTM D1863 (together or in combination); CSA A123.2, CSA A123.3, CSA A123.4, CSA A123.16, CSA A123.17 (together or in combination), UL55A, ASTM D226
Atactic-Polypropylene (APP) Membrane Roofing	ASTM D6222, ASTM D6223, ASTM D6509, CSA A123.23
Styrene-Butadiene-Styrene (SBS) Modified Bituminous Membrane Roofing	ASTM D6162, ASTM D6163, ASTM D6164, ASTM 6298, ASTM D7505, ASTM D7530, CSA A123.23
Hot fluid applied rubberized asphalt	TBD

Commented [Anna Lass18]: Homework item for committee - review technical standards listed for product su-categories.

Commented [Sid Dinwi16]: Is there some significance to the phrase "together or in combination"? It would seem more appropriate for this to read "separately or in combination".

Commented [Jean-Fran17]: Why is there repetition of some standards?

Commented [Anna Lass19]: Homework item for committee - review technical standards listed for product su-categories.

Commented [Anna Lass20]: Homework item for committee - review technical standards listed for product su-categories.

Commented [Anna Lass21]: Homework item for committee - review technical standards listed for product su-categories.

Waterproofing products? (if in scope)	TBD

2.6. Market Placement / Application rules

The respective standard and/or general technical approval or comparable national regulation shall be indicated. Standards shall be quoted as shown in Section 8.

The product(s) declared in this document complies with the following codes or regulations.

- Example: AATCC Test Method 134-2011 Electrostatic Propensity of Carpets (Normative value ≥ 3.5 kV)

Note: Compliance with model building codes does not always ensure compliance with state and local building codes, which may be amended versions of these model codes. Always check with local building code officials to confirm compliance.

The final evaluation report/certification/ registration is available at: [Insert link]

2.7. Properties of Declared Product as Delivered

The dimensions/quantities of the declared product(s) as delivered to the site of installation/application shall be indicated.

2.8. Material Composition

The main product components or materials that make up the asphalt roofing product shall be described and given in percentage by mass.

Statements of material non-inclusion, such as "… is free of …" may not be used. Ancillary materials and additives remaining in the product shall also be declared. If additives such as flame retardants, softeners or biocides are used, their functional chemical group shall be indicated.

Regulated Hazardous substances and dangerous substances shall be reported per Part A: Life Cycle Assessment Calculation Rules and Report Requirements, Section 4.11.

Note: This disclosure is intended to enable the user of the EPD to understand the composition of the product in delivery condition and support a safe and effective installation, use and disposal of the product. With appropriate justification, this requirement does not apply to confidential or proprietary information relating to materials and substances that apply due to a competitive business environment or covered by intellectual property rights or similar legal restrictions. It also might not be appropriate for information concerning intangible products.

2.9. Manufacturing

The manufacturing process and locations shall be described. If the EPD applies to several locations, the production processes for all locations shall be described and reference to quality management systems may be included.

2.10. Packaging

Information on product-specific packaging: type, composition and possible reuse of packaging materials (paper, strapping, pallets, foils, drums, etc.) shall be included in this Section. The EPD shall describe specific packaging scenario assumptions, including disposition pathways for each packaging material by reuse, recycling, or landfill disposal based on packaging type.

In the absence of specific primary data, the data assumptions from Part A, Section 2.8.5, Table 2 shall be used.

In the case of reusable packaging designed to last for multiple reuse cycles, one reuse shall be assumed in the absence of primary manufacturer data. At the end of its reuse cycle, reusable packaging shall be assumed to go to landfill.

2.11. Product Installation

A description of the type of processing, machinery, tools, dust extraction equipment, auxiliary materials, etc. to be used during installation shall be included. Information on industrial and environmental protection may be included in this section.

Any waste treatment included within the system boundary of installation waste should be specified.

2.12. Use Conditions

Any relevant information may be provided in this section regarding specific product use conditions and/or limitations relevant to each product application and/or use, including a description of any maintenance, repair, replacement or refurbishment processes and/or a reference to where such descriptions may be found.

All quantitative information related to this section shall be reported in Section 4 “Scenarios and additional technical information”.

2.13. Product Reference Service Life and Building Estimated Service Life

The indication of the Reference Service Life (RSL) is imperative for EPDs covering the complete use stage (modules B1-B7), or if a use stage scenario is described, which refers to the lifetime of the product.

The reference service life and building estimated service life shall be indicated according to Section 2.8.2 of Part A: Life Cycle Assessment Calculation Rules and Report Requirements.

The assumptions upon which the designated RSL is based and for which the RSL exclusively applies shall be provided in the Section 4, Table 6. Influences on ageing, when applied, shall be in accordance with the state of the art.

2.14. Re-use phase

The possibilities of re-use, recycling and energy recovery shall be described. If an Extended Producer Responsibility initiative such as a product take-back program exists, this may be included.

2.15. Disposal

The possible disposal channels shall be indicated in accordance with disposal routes and waste classification referenced in Section 2.8.5 and 2.8.6 of Part A: Life Cycle Assessment Calculation Rules and Report Requirements.

2.16. Further Information

A reference source for additional information may be provided here, e.g. homepage, reference source for safety data sheet.

3. LCA Calculation Rules

3.1. Functional Unit

For EPDs covering the complete life cycle, a functional unit shall be defined based on the functional use or performance characteristics of the product integrated into a building or other type of construction in the use phase. The functional unit shall be 100 m² [1076.4 ft²] of constructed area using the product, including all layers required to achieve the expected performance. Explanation of the selected functional unit shall be stated clearly, including the reference service life, installation methods and all ancillary materials such as ballasting, fasteners and adhesives.

3.2. Declared Unit

For EPDs not covering the complete life cycle, e.g. leaving out the use stage, a declared unit is defined. A declared unit shall be applied if the precise function of the product is not stated or not known. Conversion factors (e.g. density, thickness, moisture content, etc.) shall be provided in order to allow the users to conduct further calculations (e.g. transport impacts, energy simulations). A declared unit shall be 1 m² [10.8 ft²]. A weighted average thickness or other applicable aspects of the product shall be stated when the EPD deals with a generic or representative product group with different thicknesses. The weights shall reflect the relative production volumes for the relevant materials.

The functional or declared unit, mass, and thickness to achieve the functional or declared unit shall be indicated in Table 1 as declared.

TABLE 1. FUNCTIONAL OR DECLARED UNIT PROPERTIES

Name	Value	Unit
Functional or Declared unit		
Mass		kg
Thickness to achieve Functional or Declared Unit		m

3.1. SYSTEM BOUNDARY

The type of EPD shall be specified as either cradle to gate with end of life or cradle to grave. The modules considered in the LCA shall be described in brief as per “System boundaries” outlined in Section 2.8 of Part A. It should be apparent as to what processes are considered in what modules per the module descriptions in Section 2.8 of Part A. Any relevant aspects or impacts not included in an information module shall be supported with relevant additional environmental information and the omissions shall be justified.

Capital goods and infrastructure flows for asphalt roofing do not significantly affect the results and conclusions of the LCA or additional environmental information and shall be excluded from unit processes used to model the LCIA.

3.2. PRODUCT SPECIFIC CALCULATIONS FOR USE PHASE (MODULES B1-B7)

Use-stage environmental impacts of asphalt roofing products during building operations depend product maintenance. Guidance for determining use phase impacts is included in this section.

3.2.1. PRODUCT MAINTENANCE

Information on maintenance shall be provided based on the manufacturer’s recommendations. In the absence of primary data, cleaning assumptions shall be documented.

3.3. UNITS

SI units are required for all LCA results. Other units commonly used in a regional market may be optionally included in addition to the required SI units.

3.4. ESTIMATES AND ASSUMPTIONS

Key assumptions and estimates in this section should be included in the Life Cycle Assessment, provided that they are not dealt with in Section 3 “LCA: Calculation rules”, or Section 4 “LCA: Scenarios and additional technical data”.

TABLE 6. MANDATORY CONVERSION FACTORS TO BE USED IF OPTIONALLY REPORTING IN IMPERIAL UNITS

Convert from	To	Multiply by
square meter (m^2)	Square foot (ft^2)	10.76391
kilogram (kg)	Pound (lb)	2.204622
Mega joule (MJ)	British Thermal Unit (BTU)	947.8170
degree Celsius (°C)	degree Fahrenheit (°F)	t/°C = (t/°F - 32)/1.8
cubic meter (m^3)	cubic foot (ft^3)	35.31466

Transport, installation, and deconstruction procedures are common to all products within the category. In the absence of primary data, the following assumptions should be used for products sold in North America. Any deviations from these assumptions (e.g. different geographies) shall be justified and explained.

TABLE 7. TRANSPORT, INSTALLATION, AND DECONSTRUCTION PROCEDURES

Product transport from point of purchase to building site	Product transport from building site to waste processing	Installation & deconstruction procedures
Mode: Diesel-powered truck/trailer Distance: 800 km	Mode: Diesel-powered truck/trailer Distance: 161 km	Manual (no operational energy use)

3.5. CUT-OFF RULES

Cut-off rules as specified per the PCR, Part A: Life Cycle Assessment Calculation Rules and Report Requirements Section 2.9 shall be used and documented. All known mass and energy flows shall be reported. No known flows should be deliberately excluded.

3.6. DATA SOURCES

Data sources shall be documented per Part A: Life Cycle Assessment Calculation Rules and Report Requirements, Section 3.1.

3.7. DATA QUALITY

An evaluation shall be provided regarding data quality, including temporal, geographical, technological representativeness, and completeness and shall follow the requirements outlined in PCR, Part A: Life Cycle Assessment Calculation Rules and Report Requirements, Section 3.1.1.

3.8. PERIOD UNDER REVIEW

The period under review and ensuing averages shall be documented.

3.9. ALLOCATION

Part A, Section 3.3 shall be used as the basis for allocation decisions, and mass should be used as the primary basis for co-product allocation in this Part B. Allocation methods deemed more appropriate than on the basis of mass may be used but only when justified. The allocations of relevance for calculation (appropriation of impacts across various products) shall be indicated, at least:

- Allocation in the use of recycled and/or secondary raw materials
- Allocation of energy, ancillary and operating materials used for individual products in a factory

whereby reference shall be made to the modules in which the allocations are performed.

3.10. COMPARABILITY AND BENCHMARKING

Comparison of EPD results between non-competitive products may be included this section per the requirements in Part A: Life Cycle Assessment Calculation Rules and Report Requirements, Section 9.

4. LCA: Scenarios and additional technical information

The following information shall be reported for declared modules. Irrelevant or non-applicable module rows may be excluded in the EPD; additional information may also be listed if necessary

The following technical information is a basis for the declared modules or may be used for developing specific scenarios in the context of a building assessment if modules are not declared (MND).

TABLE 11. TRANSPORT TO THE BUILDING SITE (A4)

Name	Value	Unit
Fuel type		
Liters of fuel		l/100km
Vehicle type		
Transport distance		km
Capacity utilization (including empty runs, mass based)		%
Gross density of products transported		kg/m^3
Weight of products transported (if gross density not reported)		kg
Volume of products transported (if gross density not reported)		m^3
Capacity utilization volume factor (factor: =1 or <1 or ≥ 1 for compressed or nested packaging products)		-

TABLE 12. INSTALLATION INTO THE BUILDING (A5)

Name	Value	Unit
Ancillary materials		kg
Net freshwater consumption specified by water source and fate (e.g., X m3 river water evaporated, X m3 city water disposed to sewer)		m^3
Other resources		kg
Electricity consumption		kWh
Other energy carriers		MJ
Product loss per functional unit		kg
Waste materials at the construction site before waste processing, generated by product installation		kg
Output materials resulting from on-site waste processing (specified by route; e.g. for recycling, energy recovery and/or disposal)		kg
Biogenic carbon contained in packaging		kg CO_2
Direct emissions to ambient air, soil and water		kg
VOC emissions		µg/m3

The VOC emissions shall be determined in accordance to “Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources using Environmental Chambers- version 1.2” CA Specification 01350.

TABLE 13. REFERENCE SERVICE LIFE

Name	Value	Unit
RSL		Years
Declared product properties (at the gate) and finishes, etc.		Units as appropriate
Design application parameters (if instructed by the manufacturer), including references to the appropriate practices and application codes)		Units as appropriate
An assumed quality of work, when installed in accordance with		Units as

the manufacturer's instructions		appropriate
Outdoor environment, (if relevant for outdoor applications), e.g. weathering, pollutants, UV and wind exposure, building orientation, shading, temperature		Units as appropriate
Indoor environment, (if relevant for indoor applications), e.g. temperature, moisture, chemical exposure)		Units as appropriate
Use conditions, e.g. frequency of use, mechanical exposure.		Units as appropriate
Maintenance, e.g. required frequency, type and quality of replacement components		Units as appropriate

TABLE 14. MAINTENANCE (B2)

Name	Value	Unit
Maintenance process information (cite source in report)		-
Maintenance cycle		Cycles/ RSL
Maintenance cycle		Cycles/ ESL
Net freshwater consumption specified by water source and fate (e.g., X m3 river water evaporated, X m3 city water disposed to sewer)		m^3
Ancillary materials specified by type (e.g. cleaning agent)		kg
Other resources		kg
Energy input, specified by activity, type and amount		kWh
Other energy carriers specified by type		kWh
Power output of equipment		kW
Waste materials from maintenance (specify materials)		kg
Direct emissions to ambient air, soil and water		kg
Further assumptions for scenario development (e.g. frequency and time period of use, number of occupants)		

4.1. TABLE 15. REPAIR (B3)

Name	Value	Unit
Repair process information (cite source in report)		-
Inspection process information (cite source in report)		-
Repair cycle		Cycles/ RSL
Repair cycle		Cycles/ ESL
Net freshwater consumption specified by water source and fate (e.g., X m3 river water evaporated, X m3 city watert disposed to sewer)		m^3
Ancillary materials specified by type (e.g. cleaning agent)		kg
Energy input, specified by activity, type and amount		kWh
Waste materials from repair (specify materials)		kg
Direct emissions to ambient air, soil and water		kg
Further assumptions for scenario development (e.g. frequency and time		

period of use, number of occupants);		

4.2. REPLACEMENT (B4) / REFURBISHMENT (B5)

The number of replacements of product expected during the building ESL of 75 years shall be declared. Required or expected maintenance are to be modelled according to manufacturer's guidelines. Assumptions and key parameters shall be clearly stated and the manufacturer is to submit supporting documentation to justify the assumptions made.

If the RSL is less than the building's ESL of 75 years, the number of replacements that will be necessary to fulfil the required performance and functionality over the building ESL shall be identified.

Replacements should be rounded-up to the nearest tenths of the ESL of the building; e.g., 1.47 rounded to 1.5.

TABLE 16. REPLACEMENT (B4)

Name	Value	Unit
Reference Service Life		Years
Replacement cycle		(ESL/RSL) - 1
Energy input, specified by activity, type and amount		kWh
Net freshwater consumption specified by water source and fate (e.g., X m3 river water evaporated, X m3 city watert disposed to sewer)		m^3
Ancillary materials specified by type and amount (e.g. cleaning agent)		kg
Replacement of worn parts, specify parts/materials		kg
Direct emissions to ambient air, soil and water		kg
Further assumptions for scenario development, e.g. frequency and time period of use		As appropriate

TABLE 17. REFURBISHMENT (B5)

Name	Value	Unit
Refurbishment process description (cite source in report)		
Replacement cycle		Cycles/ RSL
Replacement cycle		Cycles/ ESL
Energy input, specified by activity, type and amount		kWh
Net freshwater consumption specified by water source and fate (e.g., X m3 river water evaporated, X m3 city watert disposed to sewer)		m^3
Material input for refurbishment, including ancillary materials specified by type (e.g. cleaning agent)		kg
Waste material(s), specified by material		kg
Direct emissions to ambient air, soil and water		kg
Further assumptions for scenario development (e.g. frequency and time period of use, number of occupants);		

4.3. Table 18. Operational energy use (B6) and Operational water use (B7)

Name	Value	Unit
Net freshwater consumption specified by water source and fate (e.g., X m3 river water evaporated, X m3 city water disposed to sewer)		m^3
Ancillary materials		kg
Energy input, specified by activity, type and amount		kWh
Equipment power output		kW
Characteristic performance (e.g. energy efficiency, variation of performance with capacity utilization)		Units as appropriate
Direct emissions to ambient air, soil and water		kg
Further assumptions for scenario development (e.g. frequency and time period of use, number of occupants);		As appropriate

4.4. Table 19. End of life (C1-C4)

Name		Value	Unit
Assumptions for scenario development (description of deconstruction, collection, recovery, disposal method and transportation)			
Collection process (specified by type)	Collected separately		kg
	Collected with mixed construction waste		kg
Recovery (specified by type)	Reuse		kg
	Recycling		kg
	Landfill		kg
	Incineration		kg
	Incineration with energy recovery		kg
	Energy conversion (specify efficiency rate)		
Disposal (specified by type)	Product or material for final deposition		kg
Removals of biogenic carbon (excluding packaging)			kg CO_2

Table 20. Reuse, recovery and/or recycling potentials (D), relevant scenario information

Name	Value	Unit
Net energy benefit from energy recovery from waste treatment declared as exported energy in C3 (R>0.6)		MJ
Net energy benefit from thermal energy due to treatment of waste declared as exported energy in C4 (R<0.6)		MJ
Net energy benefit from material flow declared in C3 for energy recovery		MJ
Process and conversion efficiencies		
Further assumptions for scenario development (e.g. further processing technologies, assumptions on correction factors);		

5. LCA: Results

In Table 21, "Descriptions of the system boundary modules," all declared modules shall be indicated with an "X".

Modules A1, A2, and A3 may be declared as one aggregated module A1-A3.

Per Part A, life cycle impact assessment (LCIA) results shall be reported for each declared module as follows. Results shall be declared with three digits using scientific notation (e.g. 1.23E-5 = 0.0000123) for each module. A uniform format shall be used for all indicator values.

- North America (Part A, Section 4.7, Table 7, TRACI indicators)
- EU (Part A, Section 4.8, Table 8, CML indicators)
- Rest of World (Part A, Section 4.9, Table 8, indicators as provided)

Results derived from the product life cycle inventory (LCI) shall be reported as follows:

- Resource use indicators (Part A, Section 4.1, Table 4)
- Output flows and waste category indicators (Part A, Section 4.1.2, Table 5)
- Carbon emissions and removals (Part A, Section 4.6, Table 6)

Table 21. Descriptions of the system boundary modules

PRODUCT STAGE			CONSTRUCTION PROCESS STAGE		USE STAGE							END OF LIFE STAGE				BENEFITS AND LOADS BEYOND SYSTEM BOUNDARY
A1	**A2**	**A3**	**A4**	**A5**	**B1**	**B2**	**B3**	**B4**	**B5**	**B6**	**B7**	**C1**	**C2**	**C3**	**C4**	**D**
Raw material supply	Transport	Manufacturing	Transport from gate to site	Assembly/Install	Use	Maintenance	Repair	Replacement	Refurbishment	Bldg. Operational Energy Use During Product Use	Bldg. Operational Water Use During Product Use	Deconstruction	Transport	Waste processing	Disposal	Reuse, Recovery, Recycling Potential

Cradle to grave	Required	Required (based on scenarios)	Required	Optional

.

6. LCA: Interpretation

Interpretation requirements for the Project Report are provided in Part A: Life Cycle Assessment Calculation Rules and Report Requirements, Section 5.

An interpretation shall be provided in the EPD which discusses the assumptions and limitations associated with the interpretation of results as declared in the EPD, both methodology and data related.

This interpretation shall also include a description of the time frame and/or variance of the LCIA results if the EPD is valid for several products. An illustration of the results with figures is recommended in the EPD, e.g. for the dominance analysis, the distribution of impacts across the modules, the CO_2-balance, etc. as appropriate for a reader's understanding of the environmental profile of the declared product.

7. Additional Environmental Information

7.1. Environment and Health During Manufacturing

Measures relating to environmental and health protection during the product manufacturing process extending beyond national guidelines (of the production country) may be described, e.g. reference to a product safety data sheet (SDS), description of Environmental Management Systems or similar, programs addressing air emissions, wastewater, noise, etc.

7.2. Environment and health during installation

Information should be provided in this section on the relationship between the product, the environment and health, including any possible harmful substances or emissions e.g. reference to a product safety data sheet (SDS). Any recommendations concerning cleaning, maintenance, etc. of the declared product should be listed in Section 4 "Technical information on scenarios".

7.3. Extraordinary effects

Fire

Information should be included on the product's fire performance and possible impacts on the environment e.g. reaction-to-fire, other relevant fire tests as applicable, and emissions to air, including smoke toxicity.

Water

Information should be included on the product's performance and possible impacts on the environment following unforeseeable influence of water, e.g. flooding.

Mechanical destruction

Information should be included on the product's performance and possible impacts on the environment following unforeseeable mechanical destruction.

7.4. Delayed Emissions

If a manufacturer wishes to declare quantitative or qualitative information on delayed emissions used to calculate Global Warming Potential within the EPD, information may be provided here. See Part A, Section 4.4 for more information.

7.5. Environmental Activities and Certifications

Other environmental activities, such as participation in recycling or recovery programs along with the details of these programs and contact information, may be provided.

For certifications applied to the product and listed in the EPD, a statement shall be included on where an interested party can find details of the certification program.

7.7. Further Information

A reference source for additional information may be provided here, e.g. homepage, reference source for safety data sheet.

8. Supporting Documentation

The Project Report Content, Structure, and Accessibility requirements to support an EPD created using this document are provided in Part A: Section 2. Project Report elements include general information (Part A: Section 2.1), study goal (Part A: Section 2.2), study scope (Part A: Section 2.8), and the life cycle inventory analysis, impact assessment, and interpretation (Part A: Section 3, 4, and 5). Additionally, the Project Report shall include additional required supporting documentation specified in this sub-category Part B and according to Part A: Section 6.

If relevant to the scope of the declared product, or due to the product material composition, it is recommended to provide sufficient supporting documentation in the EPD and Project Report. When providing documentation, testing protocols and other relevant information shall be indicated. If supporting documentation is not provided, the reasons shall be indicated in the EPD and Project Report.

As a general rule, all statements shall be documented with measured data (presented by the corresponding test certificates). In the case of non-verifiable substances, the limit of detection shall be included in the declaration. Interpreting statements such as "… free of …" or "… are entirely harmless …" are not permissible.

9. References

The literature referred to in the Environmental Product Declaration shall be quoted in full from the following sources. Standards and standards relating to evidence and/or technical features already fully quoted in the EPD do not need to be listed here. This Part B PCR document shall be referenced.

UL Environment

UL Environment General Program Instructions April 2017, version 2.1

Part A: Life Cycle Assessment Calculation Rules and Report Requirements UL Environment (March 2018, version 3.1)

Characterization methods

IPCC. 2014. Climate Change 2013. The Physical Science Basis. Cambridge University Press.
http://www.ipcc.ch/report/ar5/wg1/

Hauschild M.Z., & Wenzel H. Environmental Assessment of Products. Springer, US, Vol. 2, 1998

Heijungs R., Guinée J.B., Huppes G., Lankreijer R.M., Udo de Haes H.A., Wegener Sleeswijk A. Environmental Life Cycle Assessment of Products: Guide and Backgrounds. CML. Leiden University, Leiden, 1992

Jenkin M.E., & Hayman G.D. Photochemical ozone creation potentials for oxygenated volatile organic compounds: sensitivity to variations in kinetic and mechanistic parameters. Atmospheric Environment. 1999, 33 (8) pp. 1275–1293

WMO. 1999. Scientific Assessment of Ozone Depletion: 1998, World Meteorological Organization Global Ozone Research and Monitoring Project – Report No. 44, WMO, Geneva

Use Phase Assumptions

United States Environmental Protection Agency, WaterSense, Office of Wastewater Management (4204M), 2014
https://www.epa.gov/aboutepa/about-office-water#wastewater

Sustainability Reporting Standards

EN 15804: 2012-04 - Sustainability of construction works — Environmental Product Declarations — Core rules for the product category of construction product.

ISO 14025: 2006 - Environmental labels and declarations — Type III environmental declarations — Principles and procedures

ISO 14040: 2006 - Environmental management – Life cycle assessment – Principles and framework

ISO 14044:2006 - Environmental management – Life cycle assessment – Requirements and guidelines

ISO 14046:2013 - Environmental management- Water footprint- Principles, requirements and guidelines

ISO 15392:2008 - Sustainability in building construction- General principles

ISO 15686-1:2011 - Buildings and constructed assets- Service life planning- Part 1: General principles

ISO 15686-2:2008 - Buildings and constructed assets- Service life planning Part 2: Service life prediction procedures

ISO 15686-7:2008 - Buildings and constructed assets- Service life planning Part 7: Performance evaluation for feedback of service life data from practice

ISO 15686-8:2008 - Buildings and constructed assets- Service life planning Part 8: Reference service life and service life estimation

ISO 21930: 2007 - Sustainability in building construction -- Environmental declaration of building products

Product Category Rule Guidance Development Initiative. Guidance for Product Category Rule Development. (August 28, 2014, version 1.0).

TESTING AND CLASSIFICATION REFERENCES

American Conference of Governmental Industrial Hygienists (ACGIH®) Threshold Limit Values and Biological Exposure Indices

Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources using Environmental Chambers- version 1.2, January 2017.

RELEVANT FEDERAL STANDARDS AND SOPS

Environment Canada, National Pollutant Release Inventory (NPRI) (http://www.ec.gc.ca/inrp-npri/)

EPCRA 313 Toxic Release Inventory Reporting (U.S.) (https://www.epa.gov/toxics-release-inventory-tri-program) Accessed 08 December 2017.

US EPA, ORD/NRMRL/Sustainable Technology Division, Systems Analysis Branch, SOP No. S-10637-OP-1-0- Tool for the Reduction and Assessment of Chemical and other Environmental Impacts (TRACI), Software Name and Version Number: TRACI version 2.1, USER'S MANUAL, 24 July, 2012

US: Resource Conservation and Recovery Act (RCRA), Clause C (https://www.epa.gov/rcra) Accessed 08 December 2017.

40 CFR 50 Protection of Environment - Part 50: National Primary and Secondary Ambient Air Quality Standards (U.S.) (https://www.epa.gov/criteria-air-pollutants/naaqs-table) Accessed 08 December 2017.

Clean Air Act (CAA) Section 112(r): Accidential Release Prevention/Public Management Rule (https://www.epa.gov/sites/production/files/2013-10/documents/caa112_rmp_factsheet.pdf) Accessed 08 December 2017

CERCLA Hazardous Substances (U.S.) (https://www.epa.gov/epcra/epcracerclacaa-ss112r-consolidated-list-lists-march-2015-version) Accessed 08 December 2017.
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Relevant PCRs

ISO 21930: 2017 - Sustainability in building construction -- Environmental declaration of building products

Part A: Life Cycle Assessment Calculation Rules and Report Requirements UL Environment (March 2018, version 3.1)

Part B: Requirements on the EPD for Bathtubs and showers made of steel enamel or acrylic. Institute of Construction and Environment e.V., Königswinter (July 2014, version 1.6)

PCR Guidance-Texts for Building-Related Products and Services, From the range of Environmental Product Declarations of Institute of Construction and Environment e.V. (IBU), Part B: Requirements for the EPD for Floor coverings,v1.6, November 2017

Product Category Rule for Environmental Product Declarations, Asphalt roofing: Carpet, Resilient, Laminate, Ceramic, Wood. Version 2. NSF.

New Method for Measuring the Wind Resistance of Asphalt Roofing Shingles

By Raymond L. Corbin

On behalf of the Asphalt Roofing Manufacturer's Association

Full-scale test house.

In the early 1990s, in response to a growing concern in the building industry, the Asphalt Roofing Manufacturer's Association (ARMA) undertook the challenge to establish a Wind Uplift Performance Test and Evaluation Procedure that would more closely approximate conditions experienced on the roof.

Through the efforts of a special task force formed of member companies, a multi-year program was conducted at Colorado State University's (CSU) Wind Engineering Laboratory to determine and characterize the effects of wind passing over sloped roofs and the resulting effects on the attached asphalt roofing shingles. The ARMA-funded research included studies of wind effects over full roofs as well as scale models of various roof shapes and how airflow affects the individual shingle. ARMA extends its appreciation to fellow ARMA members for their efforts and assistance with the ARMA High Wind Research Program. These include Charles Harper (retired), Tamko Roofing Products; Robert Metz, Celotex Corporation; and Joe Jones (retired), ARMA.

Initial investigation disclosed that the various building codes and design standards should recognize that, as individual units, asphalt roofing shingles could not effectively be evaluated by test procedures designed for membrane assemblies.

Asphalt roofing shingles have long been recognized for their inexpensive cost and good performance, making them the choice for most homes in the United States. Initially, wind resistance was provided by interlocking shingle designs or through the use of heavier products. This changed in the late 1950s with the introduction of the self-sealing asphalt roofing shingle.

The wind resistant feature of the self-sealing asphalt roofing shingle was first tested and certified by U.L. 997 and ASTM D-3161. These tests did not duplicate actual rooftop conditions, but rather provided a reasonable test method to distinguish between wind-resistant and non wind-resistant asphalt roofing shingles.

Additional data gathered after severe wind events, such as hurricanes, have further established the favorable performance of properly applied and sealed asphalt roofing shingles. The data disclosed, however, that varying the wind velocity alone could not explain the different performance of similarly-applied and conditioned asphalt roofing shingle roofs.

The primary disagreement with U.L. 997 and ASTM D-3161 was that the test procedures were run under controlled conditions, blowing air at one velocity and direction across the shingle surface, dislodging any shingle with a bond weaker than the test conditions. In the real world, each roof has a different history of design, application, temperature, and wind exposure.

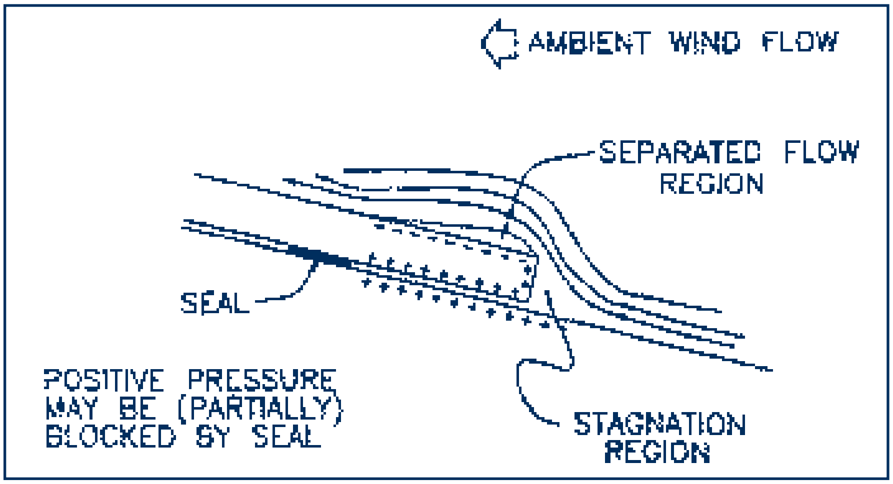

Figure 1: Local wind flow over shingle showing uplift mechanism.

Proper application, (such as fastener type, number, and placement), along with adequate sealing are the keys to asphalt roofing shingle performance. For areas of severe weather, asphalt roofing shingles are tested to higher wind speeds. This alone is not enough to simulate the varying forces which occur on the roof. Testing at higher wind speed alone could even lead to false expectations that might not be realized on the roof under actual wind conditions.

Observations of actual conditions after a severe wind event show that damage varies from roof to roof, even on adjacent structures exposed to similar wind conditions. Damage can occur in areas such as around the eaves, ridge, rake, and valley, while nearby mansards or other slopes are undamaged. Older roofs can go undamaged while newer roofs are blown off. Entire decks have been blown off the building while the attached asphalt roofing shingles stayed intact.

The various results cannot be explained by wind velocity alone, as variables such as application, sealing, and asphalt roofing shingle style and type can account for a number of the inconsistencies. Observation and research suggest that consideration must be given to the swirling characteristics of the wind as it impinges on roofs of different shapes, sizes, and slopes.

Other variables that the study identified that must be factored into the equation are:

- Wind (instantaneous) velocity
- Roof shape
- Slope
- Height of eaves
- Ridge height
- Duration of the gusts
- Peak speed of the gusts
- Wind (average) velocity
- Shape of the shingle
- Shape of the self-sealant adhesive on the shingle
- Air density
- Shingle position relative to roof penetrations
- Pattern of wind acceleration
- Other factors

Because of the scope and size of this research project, the initial study was divided into three phases. This allowed for previously gathered Colorado State University research information to become an integral part of the next phase. Phase IV is currently underway and when completed will produce a final report.

Phase I

Research conducted at Colorado State University used the Meteorological Wind Tunnel to study surface effects of wind on scale models of whole buildings and sections of full-scale roof decks. The models were subjected to wind at different angles and velocities, measuring the lifting forces that lead to blow-off . Data were gathered to track wind patterns and relative wind speeds. Peak wind speeds caused by turbulence generated by various wind angles and roof shapes were identified. These "hot spots," where vortices and gusts are generated, had a much higher wind speed than the average approach wind speed. This research supported the belief that the industry practice (ASTM D-3161) of predicting wind resistance by directing a steady wind across a small section of roof deck was not representative of actual rooftop conditions.

Phase II

Phase II used the data gathered during Phase I to measure the

Wind Load Model

$$\hat{P} = \frac{1}{2}\rho \bar{U}^2_{ref}\left(\frac{\hat{U}_{max}}{\bar{U}_{ref}}\right)^2 C_p$$

where

$\hat{P}$ – peak uplift pressure that a shingle must resist, Pa.

$\hat{U}_{max}$ – peak gust wind speed on the roof, m/s.

ρ – air density, kg/m³.

$\bar{U}_{ref}$ – mean wind velocity approaching the building at eave height, m/s.

$\bar{C}_p$ – shingle uplift pressure coefficient

Figure 2: Wind load model.

effects of roof penetrations (such as chimneys, dormers, etc.) as well as how the velocities and pressures affected sealed as well as unsealed shingles. This data allowed a "Load Model" to be designed that related peak wind approach speeds to the uplift force generated on the tabs.

Phase III

Phase III incorporated prior data to design a full-scale building , constructed on a turntable, in an area that frequently experiences high winds. A scale model of this building was also studied in the Wind Tunnel to verify the correlation between the tunnel and the actual full-scale test. This study validated the "Load Model" as a realistic method to calculate the relationship between the wind speed and uplift force.

Summary

This research on a "New Method for Measuring the Wind Resistance of Asphalt Roofing Shingles," has provided an important scientific understanding and basis for describing the interaction of high wind with asphalt roofing shingles. Further, this research conducted both in the wind tunnel and correlated under actual rooftop conditions, has designed a "Load Model" that can now be used by manufacturers when designing and producing asphalt roofing shingles. Phase IV, the final step of the wind research, is scheduled to be completed in the year 2000. Phase IV is being conducted jointly by ARMA and Underwriters Laboratories (U.L.). When finished, the complete research findings will be published and submitted to major model building code groups for inclusion in their building codes. (Basic data of this initial paper is contained in a report issued by Dr. J.A. Peterka of Colorado State University and can be obtained by request from ARMA.) When completed, this research will provide the roofing industry with the ability to define and establish a realistic method for measuring the wind resistance of asphalt roofing shingles. ■

References

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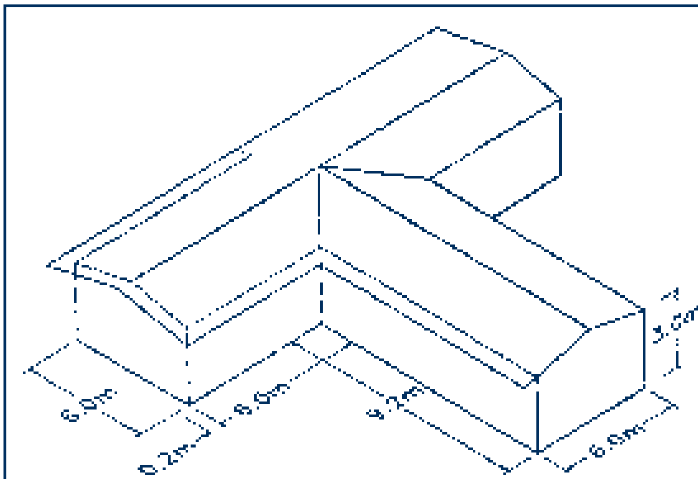
Residential Roofing Committee, Asphalt Roofing Manufacturers Association

About the Author

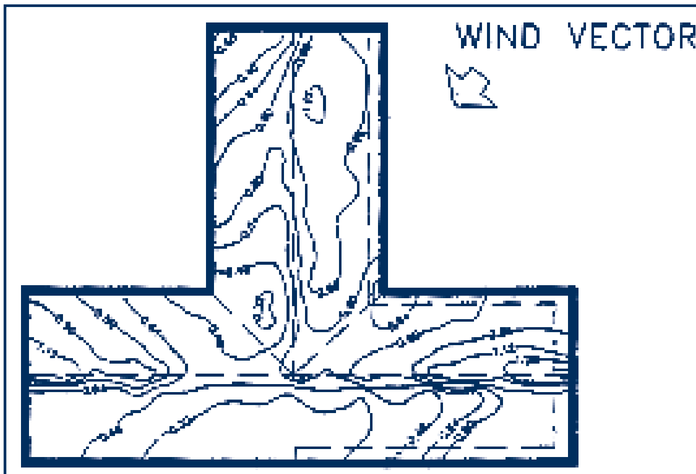
Ray Corbin is Director of the Better Understanding of Roofing Systems Institute (BURSI), spon sored by Johns Manville. He holds several U.S. roofing shingle design and application patents, is a faculty member of RIEI, and has served as Chairman of the Code Committee for ARMA. Corbin is a former recip ient of the Horowitz Award for his contributions to *Interface* journal.

Ray Corbin



T-Shaped House Used for Wind Acceleration Measurements

Figure 3



Mean Velocity Contours $\bar{U}_{roof}/\bar{U}_{ref}$ for 5:12 Roof Slope House Roof for Wind Direction Shown

Figure 4

An Historical Perspective on the Wind Resistance of Asphalt Shingles

By Craig R. Dixon, EI; Forrest J. Masters, PhD, PE; David O. Prevatt, PhD, PE; and Kurtis R. Gurley, PhD

INTRODUCTION

Asphalt shingle materials and attachment methods have changed significantly since the development of the first asphalt shingle product in 1893. This paper presents an historical overview of asphalt shingle roof systems and the advancements in design, composition, and research that have improved shingles' resistance to wind loading. This document is organized chronologically into four time periods. Performance issues are addressed throughout, with emphasis on the behavior of in-service systems during windstorms. This document provides the relevant background for ongoing research led by the University of Florida regarding the wind resistance of aged shingle systems.

THE EARLY YEARS (1893-1950)

The first steep-slope asphalt roofing system was introduced in 1893. Known as asphalt-prepared roofing, it consisted of a thin, reinforcing cotton rag felt impregnated with asphalt (Abraham, 1920). Installation was similar to today's asphalt roll roofing. In 1897, top-surface mineral granules were added to improve the durability of the product (Cullen, 1992). It was later discovered that the mineral granules served an important function in absorbing the ultraviolet (UV) light from the sun. UV oxidizes the top surface of asphalt coating and leads to accelerated degradation of the asphalt coating (Berdahl *et al.*, 2008).

Asphalt shingles were introduced in the beginning of the 20th century. Shingles were manufactured by cutting asphalt-prepared roofing into smaller sections in order to create a discontinuous roof covering resembling wood shakes or slate. Similar to today's three-tab style, single-tab shingles (typically 9 in. by 16 in.) and multitab shingles (typically 10 in. by 32⅛ in.) were produced. The individual tab shingles had exposed leading edges that were often designed with interlocking mechanisms to hold the shingles down during windstorms. The multitab styles had unrestrained leading edges, allowing the shingle tab to lift in the wind (Abraham, 1920; Cash, 1995).

By the late 1920s, the cotton-reinforcing felts were replaced with substitute materials due to a price increase in cotton rags. In 1926, the Asphalt Shingle and Research Institute and the National Bureau of Standards (NBS; now the National Institute of Standards and Technology) jointly investigated the effects of weathering on the newer substitute felts. Results of the three-year weathering study showed no adverse aging effects on the shingles containing the substitute materials (cf. Cullen, 1993). The use of asphalt shingles increased as a result of World War II construction demands, prompting another change of reinforcing felt to a less expensive wood-based organic material. Greenfeld (1969) would later show that the new "organic"-reinforced asphalt shingles performed as well as their predecessors.

Blake (1925) developed one of the earliest known shingle-attachment schedules for a four-tab strip shingle that called for five ¾-in.-long galvanized clout nails to be placed ½ in. above each cutout. As shown in *Figures 1* and *2*, the specified fasteners are similar to earlier prepared asphalt roll-roofing products. Single-tab and multitab shingles were installed on the roof in a stair-step pattern that mimics today's standards (Abraham, 1920). By 1941, three-tab strip shingles came onto the market with fastening requirements of four 11- or 12-gauge galvanized nails per shingle. Snoke (1941) notes that three-tab shingles with six nails would be more resistant in high wind-prone areas, a statement that is echoed in today's shingle specifications. The 1947 standard for shingle attachment called for six galvanized roofing nails with a minimum 3/8-in.-diameter head 1 in. from the shingle edge and 1.5 in. on either side of each tab cutout's centerline (Strahan, 1947). The most likely premature shingle failure during this era was due to wind, signaling that attachment requirements were inadequate. During moderate wind, continued flexing of the unrestrained exposed shingle tabs weakened the nailed connection, increasing the vulnerability of the shingle to blow-off in strong wind gusts (Cullen, 1992).

DEVELOPMENT OF THE FIRST TEST STANDARDS FOR WIND RESISTANCE (1950-1980)

The 1950s saw the introduction of two-tab sealing methods in order to improve performance under wind loading (Cullen, 1960). The first method consisted of a thermally activated "self-seal" adhesive strip that was applied on the asphalt shingle dur-

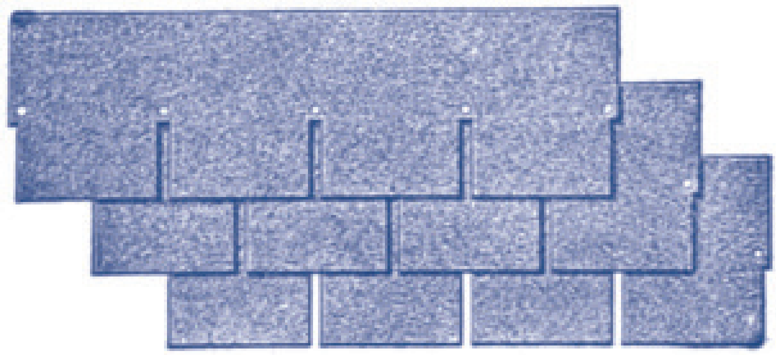


Figure 1

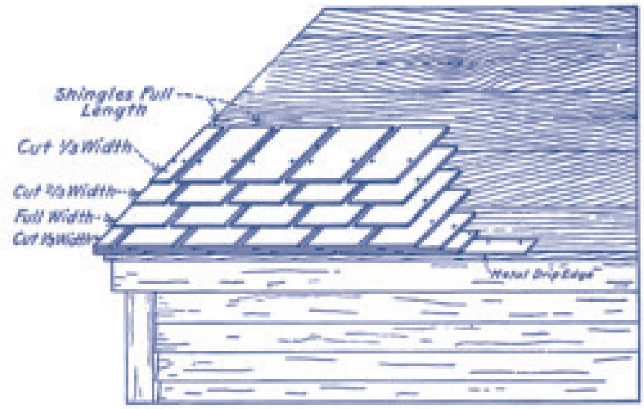


Figure 2

ing the manufacturing process. Early tab seals were typically resin-based materials, which are asphalt byproducts that have a sudden softening point that adheres the leading edge of the shingle tab to the shingle below. Early formulations of resin-based tab seals were susceptible to brittle fracture failures as a result of thermal fluctuations. Today, tab sealants consist of either limestone or fly-ash-modified resins, or polymer-modified bitumen (Nichols, 2010). The second method consisted of a field application of asphalt roof cement dollops along the underside of each shingle tab (Cullen, 1960). This method is still recommended for roofs with slopes greater than 60 degrees and for repairs to shingle tabs that have lost adherence of their self-seal systems.

In the early 1950s, a letter survey was sent to military installations along the east coast of the U.S. to ascertain the performance of asphalt shingles installed on their buildings. The results were poor: 67% of those surveyed noted that wind damage had occurred with their shingles. The survey results, coupled with increasing insurance claims on wind-damaged shingles, prompted the first investigation of asphalt shingle wind performance in 1955, led by NBS. The goal of the investigation was to assess the wind resistance of organic-reinforced asphalt shingles through laboratory, simulated-service, and field-performance evaluations (Cullen, 1960).

There is some evidence that manufacturers were already testing asphalt shingle wind performance prior to the NBS study (Cullen, 1960). However, this was the first published study of this kind. The major component of the investigation was the laboratory-simulated wind testing of asphalt shingle test decks. There were two goals to this test:

1. Evaluation of the performance of free-tab shingles (i.e., unrestrained shingle tabs) and its correlation to the weight of the strip shingle.
2. Evaluation of the performance of restrained shingle tabs by either self-seal or asphalt roof-cement methods.

At the time, free-tab systems were losing popularity to restrained-tab systems. Given the amount of building stock still using the free-tab products, however, it was important to understand how the weight of the shingle affected performance. This would also be useful for later studies on restrained tabs that have lost their adhesive bonds. The laboratory tests consisted of bond strength tests on the tab sealants and windstorm simulation tests. In his report of the wind tests, Cullen (1960) notes that laboratory wind tests fell short of completely simulating in-service wind behavior, but that these tests may serve as a useful tool when combined with other methods. The simulation was conducted by using an open-jet configuration. No mention of the flow characteristics of the jet (i.e., magnitude of turbulence) is provided in Cullen's report. A 4- by 3-ft. test deck with a slope of 2 in. on 12 in. was placed in front of the jet.

The free-tab test decks—nine in total—were subjected to a mean wind speed of 30 mph for an unknown amount of time, with the rise of the leading edge measured to describe performance. Good-performing free-tab shingles were defined as having smaller lifts during wind testing. Not surprisingly, heavier shingles performed the best, and a near-linear relationship between performance and weight was identified for a given uniform shingle thickness.

The goal of the wind investigation was to assess the sealing characteristics of several manufacturers' self-sealing three-tab organic-reinforced shingles. Therefore, the test decks containing self-sealing shingles—twelve in total—were subjected to three different curing temperatures (120°F, 140°F, and 160°F) for 16 hours each. The test consisted of four step-and-hold mean wind velocities of 30, 40, 50, and 60 mph. The time held at the first three wind velocities was not reported. The time for the 60-mph test was two hours. Failure during these tests was defined as failure of the adhesion on one shingle tab. The tests revealed that nine of the 12 shingle deck specimens could withstand 60 mph for two hours when they were conditioned at 140°F for two hours. The remaining three required a 160°F cure.

Bond strength tests correlated well with the wind tests' findings. Twelve asphalt shingle products were subjected to the same variation in cure temperature for five and 16 hours and then tested for uplift resistance of their tab seals (Cullen, 1993). From these two tests, it was reported that a cure temperature of 140°F and time of 16 hours were adequate to evaluate the wind performance of self-sealing shingle systems. To validate the findings of the laboratory tests, Cullen investigated the performance of self-sealing shingle systems in the natural environment. Twenty-two test decks were exposed for a period of one year in Washington, DC, starting in the spring. The tab seals were periodically inspected for adherence, and results showed that all decks had full adhesion within 50 days. When the tab seal bonds were broken the following December, all shingles had resealed by the following spring.

At the time of the Cullen (1960) report, no standard wind performance tests existed for asphalt shingles, but as a result of this investigation, the Underwriters Laboratory's (UL) 997, *Wind Resistance of Prepared Roof Covering Materials* (1995), was developed. The test is similar to Cullen's 1960 work in both test setup and conditioning. When first drafted in 1960, 60 mph was near the limit of fan controllability; therefore, the test decks were subjected to a maximum of 60 mph despite the likelihood of higher in-service wind speeds. The American Society for Testing and Materials' (ASTM) D3161, *Standard Test Method for Wind-Resistance of Asphalt Shingles* (2005), was first published in 1972 with an identical test procedure. These standards are based on data from shingles that were developed and manufactured using 1950s technology.

Following up on Cullen's experiments, UL conducted a study of self-seal organic-reinforced asphalt shingle response to higher wind speeds and wind speed fluctuations (Benjamin and Bono, 1967). This research was conducted using a larger fan system capable of wind speeds up to 100 mph. Additional tests were conducted on shingles that passed the UL 997 60-mph wind test. All of the 225 shingle test decks passed a 15-minute, 75-mph mean wind-speed test, and 95% of the test decks passed a 5-minute, 100-mph mean wind-speed test. To replicate the fluctuating component of the wind speed, the speed was varied between 30 mph and 100 mph. Each wind speed was held for 60 seconds for some decks and 30 seconds for others before a series of "practically instantaneous" (from Benjamin and Bono, 1967) wind-speed changes cycling from 30 mph to 100 mph for a total of 20 oscillations were applied. All test decks passed the wind fluctuation tests. While results of higher wind-speed research showed good asphalt shingle wind performance in simulated hurricane-strength wind speeds, concerns surrounding the validity of the ASTM D3161/UL 997 test methods soon followed.

With the advent of the asphalt shingle self-seal tab system and its improved wind resistance, the weight of the asphalt shingle

Figure 3

was no longer the main source of wind resistance. This allowed the use of lighter-weight and cheaper-shingle mats (Cash, 1995). In 1960, glass fiber strand-based mats were introduced as a replacement for the organic material-based mat (Cullen, 1992). The drawback to the fiberglass mat is an increase in flexibility of the shingle; that is, if a self-seal were to fail, the shingle would be more likely to lift in the wind compared to a heavier and stiffer organic-reinforced shingle. Beyond their lighter weight and lower manufacturing costs, the new "fiberglass" shingles contain a chemical saturant that gave the fiberglass-reinforced shingles a Class A fire rating. Organic-reinforced asphalt shingles typically have a lower-class (Class C) rating due to the combustibility of the organic material. The growth of the fiberglass-reinforced asphalt shingle market can be partly attributed to the increase in condominium and commercial construction that required Class A fire ratings. By 1982, production of fiberglass-reinforced asphalt shingles overtook organic-reinforced asphalt shingle production—a trend that has continued (Cash, 1995).

DEVELOPMENT OF THE ASPHALT SHINGLE WIND UPLIFT MODEL (1980-1997)

The goal of the UL 997 test was to provide a predictive method for in-service asphalt shingle wind performance. However, during in-house product testing in the early 1980s using the UL 997 wind test standard, Owens-Corning Fiberglas™ observed no appreciable shingle performance differences between products that should have produced significantly different results. Following this, Drs. Jon Peterka and Jack Cermak of Colorado State University (CSU) were contracted by Owens-Corning to reevaluate UL 997 and develop a more refined test method that would more accurately simulate in-service wind loading conditions. This work (Peterka and Cermak, 1983) led to today's asphalt shingle wind uplift model.

Dr. Peterka's experiments concentrated on modifying the UL 997 procedure to include more realistic wind effects. The standard 3- by 4-ft. test deck was placed inside CSU's Meteorological Boundary-Layer Wind Tunnel to conduct tests using turbulent boundary-layer wind that simulated natural wind behavior (*Figure 3*). Unsealed organic-reinforced and fiberglass-reinforced shingles from several manufacturers were subjected to wind speeds up to

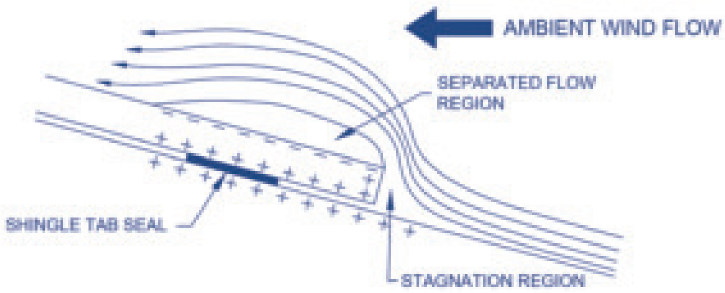


Figure 4

80 mph. To evaluate the effects of temperature on shingle performance, the shingles were tested at two temperatures: 75°F and 35°F. At the time, it was thought that lower temperatures would increase the brittleness of the shingles, thereby exacerbating shingles pulling out over the fasteners during wind events. The goal of the test was to observe how the shingles behave during this new test method and to discern if performance differences could be extrapolated. It was observed that organic-reinforced shingles sustained less damage than fiberglass-reinforced shingles, likely due to a higher shingle mass, resulting in a greater resistance to uplift. Greater shingle damage was observed in tests on the colder (35°F) shingles. The overall outcome from the testing was that performance of the shingles in the new test correlated to the predicted quality of the shingle.

From wind-flow visualization tests, a wind uplift mechanism was proposed. It states that as wind flow encounters the leading edge of a shingle's tab, the flow separates above the shingle surface, causing a negative pressure relative to the ambient pressure in this separated region. A positive pressure relative to ambient is produced at the leading edge and is forced under the shingle. The effect of the positive pressure below the shingle and the negative pressure above the shingle produce a net uplift force on the shingle (*Figure 4*). Future experiments by Dr. Peterka's group would attempt to validate this model (Peterka *et al.*, 1983).

Following the initial shingle uplift experiments, Peterka *et al.* (1983) experimentally investigated the proposed wind uplift model as well as shingle permeability and the distribution of wind-induced uplift pressures on asphalt shingles. Relatively air-impermeable roofing materials such as membranes are susceptible to uplift pressures developed by the separation of wind flow over the building. The pressure in this separated region is lower than the internal pressure of the building, producing wind uplift pressure distributions and magnitudes found in building standards such as ASCE-7 for impermeable systems. A permeable roofing system will allow for partial equalization of pressure between the upper and lower surfaces of the system. If the permeability is high enough, the loads developed within the separation region will be of a small magnitude due to rapid venting of pressure through the system surface.

To examine the permeability of shingles, a box was sealed to an asphalt shingle deck with a vacuum attached to rapidly reduce the pressure within the sealed volume. Two different tests were conducted: one with shingles installed in accordance with installation and the other with all shingle tab and deck joints sealed with silicone.

Pressure measurements above and below the asphalt shingle revealed that asphalt shingles rapidly vent air between their upper and lower surface. The results suggested that, given a high permeability in asphalt shingles, a significant uplift load will not be generated by the larger-scale flow separation region. Rather, the proposed mechanism of localized flow separation at the shingle tab leading edge may be the genesis of asphalt shingle uplift.

Pressure measurements taken simultaneously above and below shingles during wind testing showed that wind flow near the roof surface was correlated to uplift pressure, further validating the new uplift model. Expected uplift pressures for asphalt shingles subjected to 80-mph wind testing varied from 1 to 3 psf, significantly lower than pressures found on impermeable roofing systems.

The results of these two studies (Peterka and Cermak, 1983; Peterka *et al.*, 1983) provided three major conclusions about asphalt shingle wind loading:

1. For wind flowing up the roof slope, localized flow separation at the leading edge of the shingle tab may be the largest contributor to asphalt shingle wind uplift. Asphalt shingles are a relatively air-permeable assembly and may not be significantly affected by the larger-scale flow separation bubble.
2. Near-roof-surface wind speed may be used as a prediction for asphalt shingle uplift pressures.
3. Near-freezing temperatures may increase the brittleness of fiberglass-reinforced asphalt shingles, which in turn may increase the vulnerability of the wind-related damage.

Seeking to develop a more refined predictive method for asphalt shingle wind resistance than the current UL 997/ASTM D3161 test standards, the Asphalt Roofing Manufacturers Association (ARMA) formed the High Wind Task Force in 1990. The goal of the task force was to determine the relationship between wind speeds and asphalt shingle tab uplift resistance (Shaw, 1991). A two-phase program was developed: 1) create a standardized test method that would determine the uplift resistance of a shingle tab's self-seal adhesive strip (described in the next section), and 2) define the physics of shingle wind uplift and resulting loads on the tab's adhesive strip (described below).

Dr. Peterka and his colleagues were contracted to perform the wind-tunnel and outdoor studies that validated the asphalt-shingle-load model previously developed (Peterka and Cermak *et al.*, 1983; Peterka *et al.*, 1983). He proposed the asphalt shingle uplift equation. See *Equation 1*.

With this equation, the peak uplift pressure exerted on a shingle can be predicted

$$D\hat{P} = \frac{1}{2}\,\rho\,\overline{U}_{ref}^{2}\left(\frac{\hat{U}_{roof}}{\overline{U}_{ref}}\right)^{2} D\overline{C}_{p}$$

Where:

$D\hat{P}$ = peak uplift pressure that the shingle must resist
ρ = density of air
$\overline{U}_{ref}$ = mean approach wind velocity at the eave height of the building
$\hat{U}_{roof}$ = peak gust wind speed on the roof
$D\overline{C}_{p}$ = uplift differential pressure coefficient, unique for each shingle design

Equation 1 (Peterka et al., (1997)

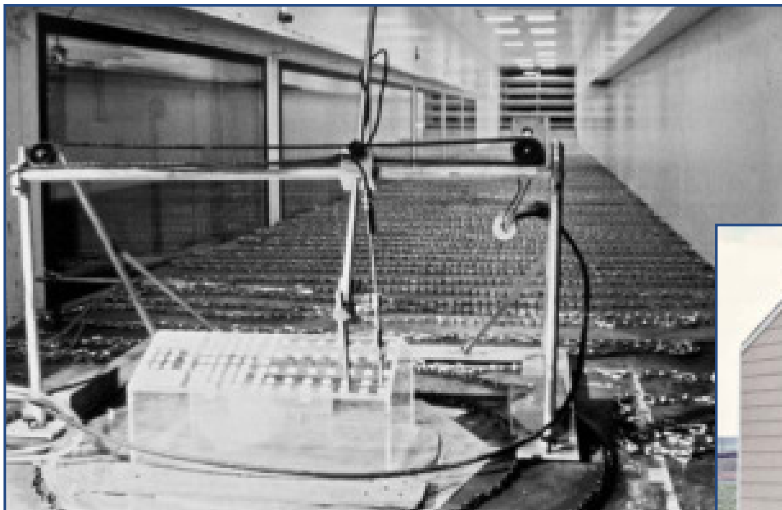


Figure 5A

Figure 5B

by knowing the approach flow characteristics, the near-roof-surface wind flow characteristics, and the uplift pressure coefficient that will be unique to each shingle design. Building standards such as ASCE 7 represent uplift loads as pressure coefficients, a dimensionless number that defines the relative pressure for a given flow field independent of the flow velocity. For asphalt shingles, a differential pressure coefficient is used to describe the net uplift pressure on asphalt shingles. The wind experiments conducted in the early 1990s by Peterka *et al.* (1997) investigated parameters of the components in this uplift equation by three methods:

1. Magnitude and distribution of near-roof-surface wind flow on model-scale residential buildings in a boundary-layer wind tunnel.
2. Correlation between near-surface roof flow and uplift pressures generated on a full-scale asphalt shingle test deck in a boundary-layer wind tunnel.
3. Evaluation of uplift pressures and near-roof-surface wind flow generated on a full-scale residential building located outdoors and subjected to natural wind.

For component one, three 1:25-scale T-shape model buildings were constructed (*Figure 5A*) with roof slopes of 2:12, 5:12, and 9:12. Also tested was a 1:25-scale model gable-roofed building that matched a full-scale building constructed for validation of the model-scale data (*Figure 5B*). Each building was placed inside the boundary-layer wind tunnel at CSU and subjected to a wind flow corresponding to open country exposure (i.e., ASCE 7, Exposure C). Because the flow near the roof surface was of greatest interest for asphalt shingle wind loading, flow measurements were taken over each building's roof surfaces at a height of 0.04 in. (1 in. at full scale) above the roof surface. The ratio between the peak observed near-roof-surface wind speed and the mean wind speed of the upwind air flow is needed for *Equation 1*. An upper-bound ratio of 2.5 was observed in the scaled model wind-tunnel tests. The highest observed near-roof-surface wind speeds for all four buildings were located near the intersection of the roof ridge and gable end (Cochran *et al.*, 1999).

The design of the leading edge of the asphalt shingle plays an important role in the aerodynamics of asphalt shingle uplift. These design factors may include the location of the self-seal adhesive, the installed pattern (or distribution) of the self-seal adhesive (i.e., a discontinuous pattern may allow airflow behind the seal, increasing the pressure on the underside and thereby increasing the net uplift on the shingle), and the profile of the leading edge of the shingle tab (i.e., thick butt, sharp edge, etc.). The second component of the Peterka *et al.* (1997) investigation utilized the same elevated 4- by 3-ft. asphalt shingle test deck developed during the 1983 experiments (Peterka and Cermak, 1983). The deck was subjected to a boundary layer flow in the CSU wind tunnel with two different turbulence intensity levels of 4% and 17%. The CSU wind tunnel was unable to replicate full-scale turbulence intensities found in natural wind; therefore, it was necessary to determine the effect of the magnitude of turbulence intensity on the developed shingle uplift pressure coefficients.

The shingle tab located in the middle of each deck was instrumented with pressure taps above and below the shingle surface, and wind flow measurements were obtained 1 in. above the instrumented shingle using either a hot-film anemometer or a pitot-static probe. Mean pressure coefficients captured during this test showed that the uplift force is higher in front of the tab sealant compared to behind (up-slope of) the tab sealant (*Table 1*). This likely occurs for three reasons: 1) a separated flow region is generated above the leading edge of the shingle with reattachment occurring a few inches upwind, 2) the tab seal reduces/prevents the positive pressure behind the tab sealant (depending on the sealant design), and 3) tab cutouts assist in

SHINGLE PART	SHINGLE THICKNESS	
	SINGLE, ~0.11 IN.	DOUBLE, ~0.22 IN.
Seal strip to front edge	-0.4	-0.8
Top of cutout to seal strip	-0.1	-0.1
Top of cutout to front edge for unsealed shingle	-0.4	-0.8

Table 1 – Wind-tunnel-measured $D\overline{C}_p$ three-tab shingle with cutouts (Peterka et al.*, 1997).*

pressure equalization behind the seal strip. Therefore, the location of the tab sealant will play a large role in the loading mechanism generated on the tab adhesive.

Differences also exist in pressure coefficients between the three-tab and double-thickness shingles (*Table 1*). To investigate the role of near-surface wind flow on uplift pressures, the middle shingle tab from a test deck was replaced with a thin, rectangular piece of brass that would mimic a shingle tab—both in dimension and location on the deck—with a seal located where one would be on an asphalt shingle. Fifty-four pressure taps were installed on the brass shingle (half on the top surface, half on the bottom surface), as this would allow for larger area averages to be determined. The deck was placed on the floor, oriented such that the generated wind flow would travel up the 4:12 sloped test deck with a smooth, curved transition between the wind-tunnel floor and the test deck. As with the previous pressure measurements, near-surface roof flow at 1 in. above the brass shingle was captured. From these data, it was observed that asphalt shingle uplift pressures correlate with near-roof-surface flow in flow fluctuations up to 12 Hz for a wind flow of 22.5 mph.

The final component of the Peterka *et al.* (1997) investigation was the validation of wind tunnel test data using a full-scale, gable-roofed building constructed outside in a windy location near Fort Collins, CO. The house consisted of a 23- by 34.5-ft. one-story building with a 5:12 gable roof. Three-tab fiberglass-reinforced asphalt shingles were installed on the roof with pressure taps installed above and below the shingles at several locations on the roof. To capture simultaneous velocity and pressure data, unidirectional velocity sensors were installed above the tapped shingles and oriented down the roof slope. The house could be rotated 360 degrees to provide uplift/velocity data for all wind azimuths. To capture the approach flow conditions, a 197-ft. instrumented meteorological tower was located near the house, and a 33-ft. meteorological tower was installed upwind of the house. Data from the observation towers, shingle-pressure transducers, and roof surface velocity sensors were captured during strong windstorms with peak wind gusts ranging from 30 to 60-plus mph. Several observations were made from the comparison of the full-scale outdoor tests and the wind tunnel experiments:

1. The full-scale data appeared to validate the wind tunnel data, and the highest pressures observed were within the prediction of the uplift model.
2. For wind flow up the roof slope, asphalt shingle uplift pressures correlated well with near-surface roof flow.
3. The highest observed shingle uplift pressures corresponded to a 50-degree wind azimuth relative to the ridgeline of the building (*Figure 6*). Due to the unidirectional nature of the velocity sensors, only the upslope component of the wind velocity vector could be obtained for this azimuth.
4. Significant shingle uplift pressures were observed for wind flow approaching the leeward side of the roof (with respect to the instrumented shingles). While the wind uplift model only describes wind flow up the roof slope, it may correctly model the local flow at other wind azimuths.

Following Peterka *et al.*'s (1997) tests, ARMA and UL drafted a standard test method to determine the loads generated on a shingle's tab seal. UL 2390, *Test Methods for Wind-Resistant Asphalt Shingles With Sealed Tabs (2003)*, was published in May 2003. The identical ASTM D7381, *Wind Resistance of Asphalt Shingles (Uplift Force/Uplift Resistance Method) (2008d)* was published in 2005. These standards are based on a standards development report (Peterka and Esterday, 2000) that is not publicly available, since the provisions are published in the standard. These methods can be separated into three parts:

1. **Determine uplift rigidity of the shingle through mechanical uplift testing.** Shingles will lift in the wind, and the magnitude of this lift will depend on the stiffness of the shingles. The aerodynamics of asphalt shingles change as the shingle lifts; therefore, the resulting pressures exerted on the shingle can change. The stiffer the shingle, the lower the resulting loads. A conservatively low stiffness (EI) of 2.5 lbs-in^2 may be used as a default. This shingle stiffness value is used for Part 2 to determine pressure coefficients.
2. **Determine the wind uplift pressure coefficients on the asphalt shingle.** Shingles are installed on a 4- by 3-ft. test deck with one shingle tab in the middle of the deck containing four pressure taps above and four taps below the shingle. Similar to ASTM D3161, these decks are conditioned and placed in front of a fan system. However, fan speeds are limited to 35 mph, and a small amount of turbulence is introduced into air flow. Mean uplift pressures are captured for shingles lying flat on the deck surface and for shingles that have their edges raised with shims at the leading edge to simulate shingle uplift during strong wind events. The pressure coefficients are used in combination with the Peterka wind uplift equation to determine the uplift loading of asphalt shingles at various peak 3-second gust wind speeds.
3. **Determine the uplift resistance of the asphalt shingle tab sealant through mechanical uplift testing** (outlined in the next section). Results of this test are compared to the predicted uplift loads determined in Part 2.

From ASTM D7158, asphalt shingles are classified and labeled on their packaging according to their predicted resistance to peak 3-second gust (basic) wind speeds

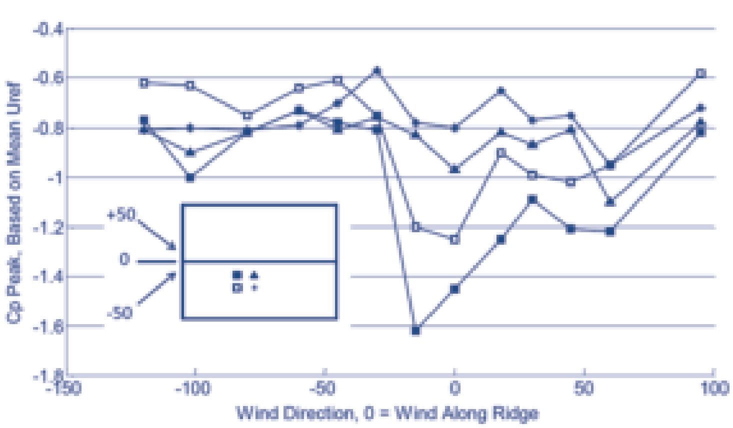


Figure 6

at 33 ft. in Exposure C (open country), following ASCE 7-05. Adjustment factors are required for various environmental/building factors such as buildings higher than 60 ft. and if the user is using the ASCE 7-10 design standard. The shingle classification is thus:

- *Class D* – Passed at basic wind speeds up to and including 90 mph
- *Class G* – Passed at basic wind speeds up to and including 120 mph
- *Class H* – Passed at basic wind speeds up to and including 150 mph

Most United States residential building codes refer to ASCE 7-05 as their wind load standard; therefore, this classification system provides a direct comparison between shingle requirements and shingle performance. A 2011 survey of asphalt shingle products offered by seven major manufacturers shows that 91% of their shingle products have been wind-tested by ASTM D7158, and all of those tested were classified with Class H ratings (Inspections, 2011). The same survey noted that all products listed have a Class F (110 mph) ASTM D3161 classification as well.

ASTM D6381, *STANDARD TEST METHOD FOR MEASUREMENT OF ASPHALT SHINGLE TAB MECHANICAL UPLIFT RESISTANCE*

Prior to the initiation of the Peterka wind load studies, the ARMA task force began development of a test method that would determine the uplift resistance of a shingle's tab sealant (Shaw, 1991). From the initial Peterka *et al.* report (1983), it was evident that the greatest uplift loads would occur nearest the leading edge of the shingle. At the time, shingles were typically produced with ¾- to 1-in. distances between the leading edge of the tab sealant and the leading edge of the shingle tab (Hahn *et al.*, 2004). The resultant wind loading on this cantilever span would produce a peel-type uplift force on the tab sealant. The mechanical uplift test was developed to simulate this loading condition. The test specimen consisted of a 3.5-in.-wide by 7-in.-long asphalt shingle lower piece with a 3.5-in.-wide by 4-in.-long upper tab piece. The tab was installed over the lower piece's sealant such that the in-service tab bond is replicated.

Prior to uplift testing, the bond between the lower and upper shingles was conditioned at 140°F for 16 hours, the same as the ASTM D3161/UL 997 conditioning procedure. Mechanical uplift testing consisted of the specimen attachment to a clamp assembly along the 3.5-in. edges. The uplift load was generated from a clamp affixed along the leading edge of the shingle specimen. This clamp was connected to a universal testing machine, which provided a constant velocity uplift of 5 in./min. and simultaneous measurement of uplift load on the shingle tab. Seven testing labs were utilized for round-robin testing of this draft standard to confirm repeatability of test methods and results (Shaw, 1991). After confirmation, the standard was published in 1999 and designated as ASTM D6381, *Standard Test Method for Measurement of Asphalt Shingle Mechanical Uplift Resistance.*

As described below, recent modifications to the mechanical uplift test have been made in response to changes in the tab sealant design and market trends. Many shingles now have tabs seals located closer to the shingle tab's leading edge. A decrease in distance between the tab sealant and the leading edge will reduce the total uplift loading generated ahead of the sealant. Therefore, this loading mechanism can change from a peel-type to a direct tension-type loading (Hahn *et al.*, 2004). The way an adhesive is loaded (i.e., peeling, direct tension, etc.) is known to have a significant effect on its strength (Shiao *et al.*, 2004). Results of asphalt shingle tab sealant mechanical uplift resistance tests comparing peel, direct tension, and combined showed that direct tension produced over double the resistance of the D6381 peel-type resistance (Shiao *et al.*, 2004). The combined test consisted of an attachment that mimicked the Peterka wind load model, with forces being generated on shingle specimens ahead and behind the tab sealant. The sealant strength for this loading fell between the low peel strength and high direct-tension strength, suggesting that the actual loading of a tab seal is a combination of peel and direct tension. As a result, the 2008 edition of the ASTM D6381 test requires direct-tension testing be conducted along with the original peel test. Depending upon the magnitude of the pressure coefficients obtained from ASTM D7158/UL 2390 testing, the results of each test may be used separately or in combination to determine total uplift resistance of a shingle's tab seal (Hahn *et al.*, 2004).

Questions remain on the applicability of this test method in predicting in-service shingle wind resistance. Foremost among them is the loading protocol, which specifies a constant displacement velocity of 5 in./min. Near-roof-surface wind flow is turbulent in nature; therefore, the uplift loading from wind will also contain fluctuations (Peterka *et al.*, 1997). Shiao *et al.* (2004) have shown that an increase in loading rate correlates to a higher shingle-tab-seal resistance (i.e., the current ASTM D6381 loading rate produces conservative resistance results). However, shingles are potentially subjected to thousands of wind gusts throughout their lifetimes, and the long-term performance of shingle tab seal to these fluctuations (i.e., fatigue resistance) has not been quantified. Thus, with the current ASTM D6381, it is difficult to predict how the tab's seal will respond to gusts later in the shingle's service life. See *Table 2*.

IN-SERVICE WIND PERFORMANCE OF ASPHALT SHINGLES

Laboratory wind testing of asphalt shingles provides a relatively simple method for predicting in-service wind performance. However, these methods cannot completely replicate the conditions that shingles are subjected to once they are installed. A key component in understanding shingle wind resistance is observations that are made following shingle damage caused by wind events. Since 1989, damage assessments made by organizations and federal agencies such as FEMA and RICOWI have provided "ground truth" on asphalt shingle performance. The observations made in these reports provide an opportunity to evaluate deficiencies in products, design, and installation. An overview of selected damage report observations is provided below.

Hurricane Hugo made landfall on the east coast of South Carolina in 1989 as a Category 4 hurricane on the Saffir-Simpson scale. Damage observations of asphalt shingle roofing by Smith and McDonald (1990) noted highly variable wind uplift performance of shingles, with some houses sustaining no damage, while others nearby sustained complete shingle loss. The damage was primarily attributed to weak tab seals. Improperly located fasteners were also often observed at damaged roofs. Failure of the roof covering did not just impact the covering itself. Rather, in financial terms, the resulting interior losses caused by roofing failure were often greater than loss from the roof covering. Smith concluded that standardized wind testing of roof coverings, including ASTM D3161 for

Test Method Designation	Year First Published	Test Method Overview
UL 997	1960	Asphalt shingles are installed on a 3- by 4-ft. test deck, cured for 16 hours at 140°F, and then subjected to two hours of 60-mph winds. Failure is defined as a shingle tab that either loses its tab adhesion or whose mechanical interlock fails.
ASTM D3161	1972	Essentially identical to UL 997 with the exception of the maximum allowable wind speed. D3161 has three classification designations: 1) Class A – passed 60 mph, 2) Class D – passed 90 mph, 3) Class F – passed 110 mph. Note: These wind speeds do not directly correlate to ASCE 7 wind speeds.
ASTM D6381	1999	Method to determine a shingle tab sealant's uplift resistance. Shingle specimens are subjected to a constant-rate peel and direct tension testing of the sealant.
UL 2390	2003	Based on the Peterka wind-load model, this test method determines a shingle's wind uplift pressure coefficients. The pressure coefficients can be used to predict the loads that will be exerted on a shingle at various ASCE 7 wind speeds.
ASTM D7158	2005	Identical to UL 2390 in test procedure. References ASTM D6381 to determine the uplift resistance of the shingle's tab sealant. Comparison between D7158 predicted uplift force and D6381 measure resistance gives three wind speed classifications: 1) Class D – up to 90 mph resistance, 2) Class G – up to 120 mph resistance, 3) Class H – up to 150 mph resistance. Note: These wind speeds correlate to winds defined by ASCE 7-05 for noncritical facilities less than 60 ft. tall in Exposure C.

Table 2 – Summary of standardized test methods to evaluate asphalt shingle wind performance.

asphalt shingles, appeared deficient in predicting wind performance. This observation would be repeated after Hurricane Andrew made landfall in South Florida in 1992, also causing damage to asphalt roofing systems on houses (Smith, 1995).

Improperly located shingle fasteners have often been observed at damaged shingles (FEMA, 2005a; Smith, 1995; Smith and McDonald, 1990). However, the extent to which the installation affects the wind resistance of the shingle has not yet been quantified. Pull-through of the shingle over the fasteners is often attributed to improper fastener placement. Smith and Millen (1999) note that it is "unrealistic to expect fasteners to be located exactly in the specified locations." Furthermore, wind tunnel tests on unsealed asphalt shingles with misplaced fasteners showed a decrease in wind performance, but no definitive conclusions could be made regarding variations in placement (Smith and Millen, 1999).

A common observation throughout post-storm reports is the failure of roof details such as hip, ridge, eave, and rake shingle conditions (FEMA, 2005a; FEMA, 2005b; FEMA, 2006; FEMA, 2009; IBHS, 2009). These failures appear to be independent of the age of the roof and more closely tied to the design and installation of these edge conditions. Bonding of the hip and ridge caps appears to be an ongoing issue, and starter courses along the eave are often improperly installed. The implications of failures to these areas of the roof range from a minor exposure of the hip and ridge deck joints to a more widespread failure propagating from eave and rake-edge failures. While damage reports continue to be a valuable source of information, more work is necessary to understand the role of installation variability in asphalt shingle wind performance.

Throughout the 2000s, hurricanes impacted the Southeast and U.S. Gulf Coast, causing extensive shingle damage. Shingle performance was variable (RICOWI, 2006). An Insurance Institute of Business & Home Safety (IIBHS, 2009) study of shingle damage in Hurricane Ike showed variable performance amongst products with the same ASTM D7158 Class H (150-mph) rating. Wind speeds at the investigated site were 110 mph (peak 3-second gust at 33 ft., Exposure C), below design level. Based on their findings, IIBHS "suggests that there remain significant differences between roof cover products with the same nominal design."

Liu *et al.* (2010) conducted an asphalt shingle damage survey in Texas after hurricanes Ike and Gustav in 2008 and found that homes with newer (less than five years old) shingle installations performed significantly better than older shingle roofs (greater than five years old), although it was not certain if age or changes to the building code around 2002 were the cause. This performance gap was also noted by RICOWI (2006) after Hurricane Charley struck Florida in 2004 and by Gurley and Masters (2011) in a post-2004 hurricane season building performance survey. All three studies postulated that while product improvement could be attributed to the better performance of newer roofs, the effects of aging could not be discounted. Experiments by Terrenzio *et al.* (1997) and Shiao *et al.* (2003) have noted that the greatest cause of asphalt shingle aging is thermal loading. Over time, the asphalt within the shingle becomes oxidized, causing embrittlement of the shingle. Currently, no studies have quantified the effects of aging on asphalt shingle wind performance. Considering that a shingle's tab adhesive is based upon an asphaltic formulation, what effects would this potential oxidation reaction have on the tab seal's adhesive strength? The current ASTM D7158/D6381 and UL 2390 standard test methods only provide information on the performance of new, laboratory-prepared asphalt shingles, making estimation of the long-term performance of the tab adhesive difficult.

LOOKING FORWARD

During the last century, asphalt shingles have evolved partially in response to developments in the understanding of asphalt shingle wind resistance. Despite the advancements made through research and damage observations, questions still remain with regard to asphalt shingle performance. Topics include the following:

1. Effects of aging on asphalt shingle wind resistance.
2. Effects of long-term wind gusts on the fatigue resistance of asphalt shingle tab self-seals.
3. Quantification of installation errors

and their impact on asphalt shingle wind resistance.
4. In-service performance of asphalt shingle tab self-seals.
5. Comparative shingle performance evaluation between ASTM D7158/UL 2390 tests and full-scale simulation of hurricane wind loads.
6. The mechanics of near-roof-surface wind flow.

Beginning in July 2010, the University of Florida commenced a research program to address the research topics outlined above. This three-year program will build upon the previous asphalt shingle wind research with the goal of improving the wind performance of shingles throughout their life cycle. Outcomes of this research will be presented in a future article.

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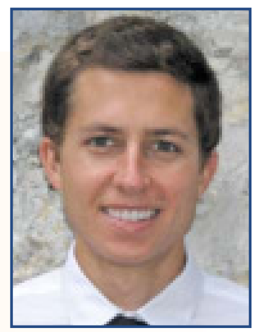

Craig R. Dixon, EI, received his undergraduate degree in civil engineering in the fall of 2008 from the University of Florida, and in the fall of 2009 he joined Dr. David O. Prevatt's wind engineering research group at the University of Florida as a research assistant. During his undergraduate work, Dixon spent six summers interning for Gale Associates in Orlando, FL, performing roof observation and roof assessment studies. Dixon's work as a research assistant includes investigations on the wind resistance of wood roof sheathing, standing-seam metal roofing, and asphalt shingles.

Dr. Forrest J. Masters, PhD, PE

Dr. Forrest J. Masters, PhD, PE, is an assistant professor of civil and coastal engineering at the University of Florida. His research program focuses on improving the resistance of residential and commercial buildings to extreme winds and rain. Experiments are conducted in the laboratory with full-scale simulators and in hurricanes to characterize the behavior of surface wind and wind-driven rain. He has received support from more than 20 grants from state, federal, and private sources, including the NSF Faculty Early Career Development (CAREER) Program. Dr. Masters is a reviewer for five journals and a member of ASCE, RICOWI, and ASTM.

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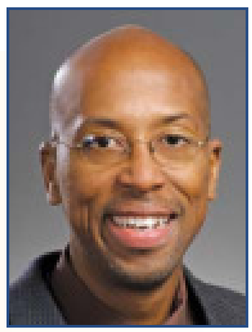
Dr. David O. Prevatt, PE



After earning his PhD from Clemson University in 1998, Dr. David O. Prevatt, PE, worked with the Boston-based ENR500 consulting engineering firm Simpson Gumpertz & Heger, Inc. in building envelope system design and remediation. He joined the faculty of Clemson University in 2004 as an assistant professor and directed the Wind Load Test Facility, conducting wind tunnel tests on low-rise building models and investigating of post-hurricane damage to residential buildings. In May 2007, Dr. Prevatt joined the University of Florida's Department of Civil and Coastal Engineering, where his research focuses on the mitigation of extreme wind damage to low-rise construction. Dr. Prevatt recently led the damage assessment teams that documented damages caused by the 2011 Tuscaloosa, AL, and Joplin, MO, tornadoes. He was recently awarded an NSF Career research grant to develop more tornado-resilient homes and communities. Dr. Prevatt is a professional engineer (registered in Massachusetts and in Trinidad and Tobago). He is a member of ASCE, the American Association for Wind Engineering, and the UK Wind Engineering Society.

Dr. Kurtis R. Gurley

Dr. Kurtis R. Gurley is an associate professor at the University of Florida. His primary areas of research are wind effects on residential structures and stochastic modeling of extreme winds and structural resistance. Dr. Gurley has largely focused on in-field measurement and modeling of ground-level hurricane winds and wind loads on occupied coastal residential structures. This field data is coupled with post-storm residential damage assessments, laboratory evaluations of component capacities, and wind tunnel studies to model the vulnerability of residential structures to hurricane wind damage. The research output from Dr. Gurley and his colleagues contributes to a variety of hazard preparation and response initiatives. Dr. Gurley is an associate editor for *ASCE Journal of Structural Engineering*, a member of the Board of Directors for the Applied Technology Council, and a member of the Technical Advisory Committee for the Federal Alliance for Safe Homes.

Selecting shingles

Shingles classified by a new wind-resistance

Wind resistance is an important performance property of asphalt shingle products and, depending on region, may be a significant consideration for building owners.

Until relatively recently, asphalt shingle products' wind resistances had been determined using a fan-induced wind test. Because of the long-standing nature of this wind test, virtually all asphalt shingle products have been tested and classified on this basis. But recently, a new wind-resistance methodology was developed and is beginning to be implemented. Currently, only a limited number of asphalt shingle products have been tested and are classified according to this new methodology.

There are important considerations you should be aware of if you use asphalt shingle products that are classified based on the new methodology.

Test methods

For more than 30 years, asphalt shingle products' wind resistances have been determined and classified based on one of two similar test methods: UL 997, "Standard for Wind Resistance of Prepared Roof Covering Materials," and ASTM D3161, "Standard Test Method for Wind-Resistance of Asphalt Shingles (Fan-Induced Method)."

When UL 997 and ASTM D3161 were initially developed, the designated fan velocity used in these tests was only 60 mph, which is representative of winds in the Beaufort Scale No. 10 range (55 mph to 63 mph). Until the mid- to late-1980s, this level of wind resistance generally was considered adequate for asphalt shingle products and most product warranties were based on this level of wind performance.

During the early 1990s, UL 997 and ASTM D3161 were revised to allow for testing and classifications at higher fan speeds, which are intended to be representative of higher wind speeds. As a result, asphalt shingles that pass the fan-induced wind test at 60 mph are designated as Class A; those that pass the test at 90 mph are designated as Class D; and those that pass the test at 110 mph are designated as Class F.

During the 1990s, building code officials and the insurance industry called for wind resistances at even higher levels for all roof systems, including asphalt shingle roof systems. But asphalt shingle manufacturers believed the fan-induced test would not be appropriate for the higher wind speeds being sought because of variances and turbulence in the fan-induced test at such high wind speeds. As a result, individual asphalt shingle manufacturers and the Asphalt Roofing Manufacturers Association (ARMA) began a long-term research project to develop a new methodology for testing, representing and classifying asphalt shingles' wind resistances.

In 1999, ASTM D6381, "Standard Test Method for Measurement of Asphalt Shingle Tab Mechanical Uplift Resistance," was published. And in 2003, Underwriters Laboratories (UL) Inc. published a new test standard, UL 2390, "Test Method for Wind-Resistant Asphalt Shingles with Sealed Tabs," that is based on ARMA's research.

UL 2390 and ASTM D6381 serve as the technical and testing basis for the new wind-resistance methodology.

UL 2390 is used to measure asphalt shingles' flexural moduli (stiffness), regions (areas) in front of and behind a shingle's self-seal strip(s), and pressure coefficients. An asphalt shingle's pressure coefficients are then multiplied by the areas, and an uplift force (load) on the asphalt shingle tab is determined.

ASTM D6381 is used to determine

for wind resistance

methodology require careful consideration

by Mark S. Graham

shingle resistance to uplift forces. The uplift-resistance value is compared with the shingle's uplift-force value (derived from UL 2390); a safety factor is added; and the appropriateness of a specific asphalt shingle for a specific wind speed is determined.

In 2006, ASTM D7158, "Standard Test Method for Wind Resistance of Sealed Asphalt Shingles (Uplift Force/Uplift Resistance Method)," was published. This standard combines the testing of UL 2390 and ASTM D6381 into a single standard and incorporates a classification system for representing tested asphalt shingles' wind resistances.

According to ASTM D7158, asphalt shingle products that are wind-resistant up to and including a 90-mph basic wind speed are classified as Class D; up to and including a 120-mph basic wind speed are classified as Class G; and up to and including a 150-mph basic wind speed are classified as Class H.

The classification system of ASTM D7158 correlates with that of UL 997 and ASTM D3161 as shown in Figure 1.

Product compliance

Review of NRCA's 2007-08 *Steep-slope Roofing Materials Guide* reveals there are at least 128 asphalt shingle products from nine manufacturers currently in the U.S. market. Seventy-two of these products are represented to have been tested according to UL 997 and/or ASTM D3161 for Class A (60 mph), Class D (90 mph) or Class F (110 mph) ratings.

Review of UL's *Roofing Materials and Systems Directory* and online certifications directory confirms the widespread classification of asphalt shingles based on UL 997 and/or ASTM D3161. Specifically, UL Category Code TFWZ, "Prepared Roof Covering Products," identifies asphalt shingle manufacturers and specific products that have been tested, classified and included in UL's labeling and follow-up service programs, ensuring ongoing compliance with the test methodology.

Regarding the new wind-resistance methodology, review of NRCA's materials guide reveals 44 asphalt shingle products from three manufacturers complied with UL 2390 and ASTM D6381 and/or ASTM D7158 when the materials guide was published.

UL's current online certifications directory, specifically UL Category Code TGAH, "Prepared Roof Coverings, Asphalt Shingle Wind Resistance," reveals 82 asphalt shingle products from seven manufacturers comply with UL 2390 and ASTM D6381 and/or ASTM D7158. The specific manufacturers and products that have been tested, classified and included in UL's labeling and follow-up service programs are identified in Figure 2.

The greater number of manufacturers and products listed in UL's certifications directory (compared with NRCA's materials guide) indicates manufacturers' recent testing, certification and implementation of the new wind-resistance methodology.

Comparison of classifications

Wind speed	UL 997 and ASTM D3161	ASTM D7158
60 mph	A	-
90 mph	D	D
110 mph	F	-
120 mph	-	G
150 mph	-	H

Figure 1: Comparison of wind-speed classifications

Important considerations

Regardless of the new methodology's increasing popularity, it is important to realize it has several notable limitations.

For instance, the methodology applies

only to asphalt strip shingles with sealant whether the sealant is factory-applied or field-applied (hand-tabbed). The methodology specifically does not apply to unsealed asphalt strip shingles, including interlocking-type shingles, which do not have self-seal strips.

In addition, the calculation procedure on which the methodology is based contains some assumptions that somewhat limit the applicability of the methodology's classifications. Specifically, the calculation procedure assumes variables from ASCE 7, "Minimum Design Loads for Buildings and Other Structures," of $K_a=1$; $K_b=0.000285$; a building height of 60 feet or less; Exposure Categories A, B or C; and Building Use Categories I or II.

As a result, the new methodology does not apply when a building is taller than 60 feet; has an Exposure Category D (flat, unobstructed areas); or Building Use Categories III (schools, health care facilities, jails) or IV (essential facilities). These conditions usually result in the highest wind-uplift loads and need for the largest wind-uplift resistances.

Also, when considering UL-classified products, it is important to realize UL's classifications only apply to specific products manufactured in specific manufacturing facilities. In some instances, an asphalt shingle product produced in one manufacturing facility will be classified but a product from the same manufacturer and of the same product name produced in a different manufacturing facility may not be similarly classified.

You should consult asphalt shingle manufacturers regarding the availability of products classified by UL 2390 and ASTM D6381 and/or ASTM D7158 in your area.

WEB EXCLUSIVE

For a link to articles about the new methodology, log on to www.professionalroofing.net.

Asphalt shingle product compliance

Manufacturer	Product	Classification
CertainTeed Corp.	Classic Horizon™	Class H
	Landmark™	
	Landmark Plus	
	Landmark Premium	
	New Horizon	
	CT™ 20	
	XT™ 25	
	XT 30	
	Landmark TL Ultimate	
	Landmark TL Ultimate (IR)	
	Presidential™	
	Presidential TL Ultimate™	
	Landmark Special	
	Woodscape®	
	Woodscape Premium	
	XT 25/SK 25	
	Jet® 25	
	Patriot™ AR	
	Carriage House™ Shangle	
	Centennial Slate™	
	Grand Manor® Shangle	
	Hatteras®	
	Landmark Premium/A 80	
	Firescreen™	
Elk Corp.	Raised Profile®	Class H
	Prestique®	
	Prestique I	
	Prestique Plus	
	Prestique Gallery	
	Prestique Grandé	
	Prestique XTRA™	
	Domain® Winslow®	
	Domain Ashford®	
	Slate Accents	
	Capstone®	
GAF Materials Corp.	Timberline® 30	Class H
	Timberline Select 40™	
	Timberline Ultra	
	Royal Sovereign®	
	Marquis® WeatherMax®	
	Sentinel®	
	Grand Sequoia®	
	Grand Canyon™	
	Timberline Canadian 40	
	Grand Timberline	

Figure 2: Manufacturers' and products' compliance with UL 2390/ASTM D6381 and/or ASTM D7158

Manufacturer	Product	Classification
GAF Materials Corp. (continued)	Jumbo Royal Sovereign®	Class H
	Country Estates™	
	Camelot™	
	Slateline®	
	Grand Slate™	
	Country Mansion®	
Malarkey Roofing Products	#202 Dura-Seal™ 20 Metric Fiberglass Shingle	Class H
	#204 Dura-Seal 25 Metric Fiberglass Shingle	
	#269 Northwest XL™ Laminated Shingle with Scotchgard™ Algae Resistance	
	#270 Northwest-XL Laminated Shingle	
	#271 Highlander-CS™ Laminated Shingle	
	#277 Highlander-CS Laminated Shingle with Scotchgard Algae Resistance	
Owens Corning	Classic®	Class H
	Supreme®	
	Supreme AR	
	Oakridge® PRO 30	
	Oakridge PRO 30 AR	
	Oakridge PRO 40	
	Oakridge PRO 40 AR	
	Oakridge PRO 50	
	Oakridge PRO 50 AR	
	Weatherguard® HP	
	Berkshire®	
	Duration	
	Duration Premium	
PABCO Roofing Products	GG-20®	Class H
	SG-30®	
TAMKO Building Products Inc.	Elite Glass Seal	Class H
	Elite Glass Seal AR	
	Glass Seal	
	Glass Seal AR	
	Heritage® 50	
	Heritage 50 AR	
	Heritage 30	
	Heritage 30 AR	
	Heritage XL AR	
	Heritage Vintage	

Notes:

1. Manufacturer, product and classification information was taken from Underwriters Laboratories Inc.'s online certifications directory, UL Category Code TGAH, "Prepared Roof Coverings, Asphalt Shingle Wind Resistance," and was current as of June 28.

2. Classification Class H reflects products passing at a basic wind speed up to 150 mph.

Also, the only thing UL provides to verify the applicability of a UL classification to a specific product is the appearance of the UL listing mark on the product's packaging. In the case of products classified by UL for compliance with UL 2390 and ASTM D6381 and/or ASTM 7158, the product's UL listing mark will indicate "also classified in accordance with UL 2390/ASTM D6381 as to uplift resistance Class [indicating D, G or H]" or "also classified in accordance with ASTM D7158 as to uplift resistance Class [indicating D, G or H]."

Finally, application of asphalt shingles in accordance with the manufacturer's printed installation instructions is important for ensuring actual wind performance is consistent with the wind-resistance methodology's classifications. With the new wind-resistance methodology, proper asphalt shingle alignment, coursing and exposure are critical. Small variations in exposure beyond manufacturer tolerances significantly can affect a shingle's actual wind performance.

Interestingly, with the new methodology, attachment of asphalt shingles to a substrate has little effect on the shingles' wind resistances provided the fasteners do not adversely interfere with the shingles' sealant.

Choose carefully

The new wind-resistance methodology's implementation in the U.S. should prove useful, particularly in high-wind regions of the U.S. where many building owners are seeking increased levels of wind performance for asphalt shingle roof systems.

If you use asphalt shingle products classified according to the new methodology, carefully select appropriate products and beware of the considerations that apply to the methodology and product classifications.

Also, I encourage you to work closely with asphalt shingle manufacturers to identify and procure appropriately classified products.

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