Solar America Board for Codes and Standards

Fire Classification of PV and Roofs

Larry Sherwood
Project Administrator
Solar America Board for Codes and Standards (Solar ABCs)

Fire Classification Stakeholder Meeting
August 28, 2012

Solar ABCs

Solar ABCs is a collaborative effort among experts to provide coordinated recommendations to codes and standards making bodies for existing and new solar technologies.

Acknowledgement

This material is based upon work supported by the Department of Energy under Award Number DE-FC36-07GO17034.

Jurisdictional (AHJ) Concerns

- As a result of high profile fires in California, increasing parts of the state now require a Class A fire rating of all roofing products. This raised concerns over ambiguities with regard to most common residential PV roof installation, Class c rate PV modules mounted over Class A rated roofs.
- Roof coverings and PV modules are rated separately. Little work had been done to investigate the interactions between them.

This issue applies to rack-mounted PV only

BIPV

Rack Mounted

Solar ABCs Research Project

Investigate whether and how the presence of standoff-mounted PV arrays may affect the fire class rating of common roof covering materials.

Finding

The fire classification rating of the PV module is NOT a good predictor of the fire class rating of the PV module and roof as a system.

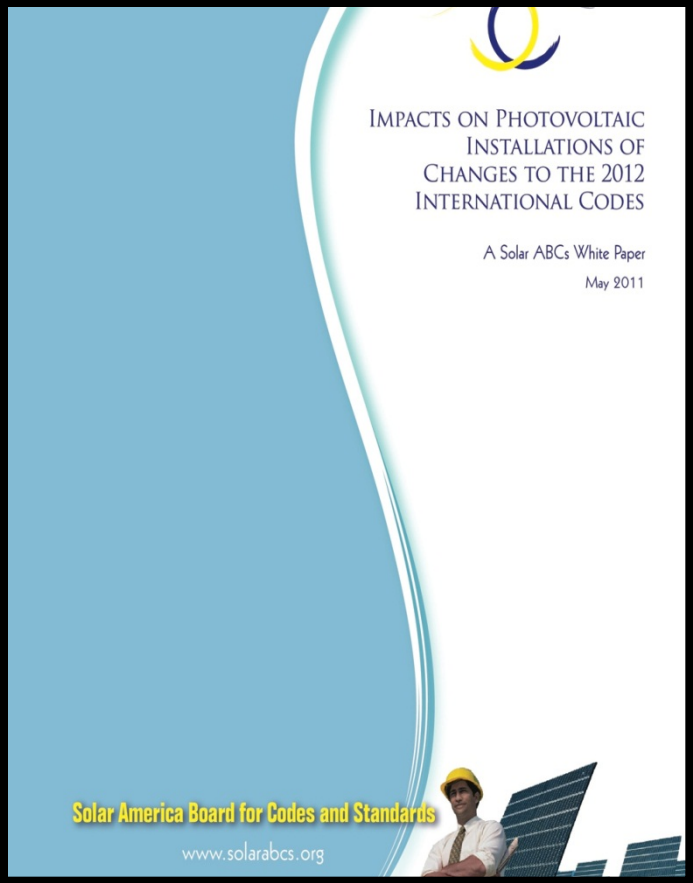
Current Work

- Develop a new PV fire classification test to be incorporated into UL 1703 (and eventually into UL 2703).

2012 International Building Code

- New language requires that fire classification of PV systems match the minimum fire classification of the roof assembly over which they are mounted.
- Straightforward implementation of this requirement is not possible at present.

2012 International Building Code



2015 International Building Code Changes

- Rooftop mounted photovoltaic panel and panels shall be tested, listed and identified with a fire classification in accordance with UL 1703.
- Rooftop mounted photovoltaic panels and modules shall have the fire classification as required by the code.
- New fire classification test required to make this language work.

Roles

- Chair of UL 1703 STP Task Force to develop new fire classification test language – Bill Brooks
- UL Fire Research – Bob Backstrom
- UL 1703 PDE – Chris Flueckiger
- UL 790 PDE – Dwayne Sloan

Objectives

- To allow stakeholders to discuss and understand the UL 1703 Fire Classification Testing Proposal
- Identify any changes required in the proposal
- Obtain consensus or near consensus on proposal so that formal comment and approval process can begin

Larry Sherwood
Solar ABCs Project Administrator
303-413-8028
Larry@sherwoodassociates.com

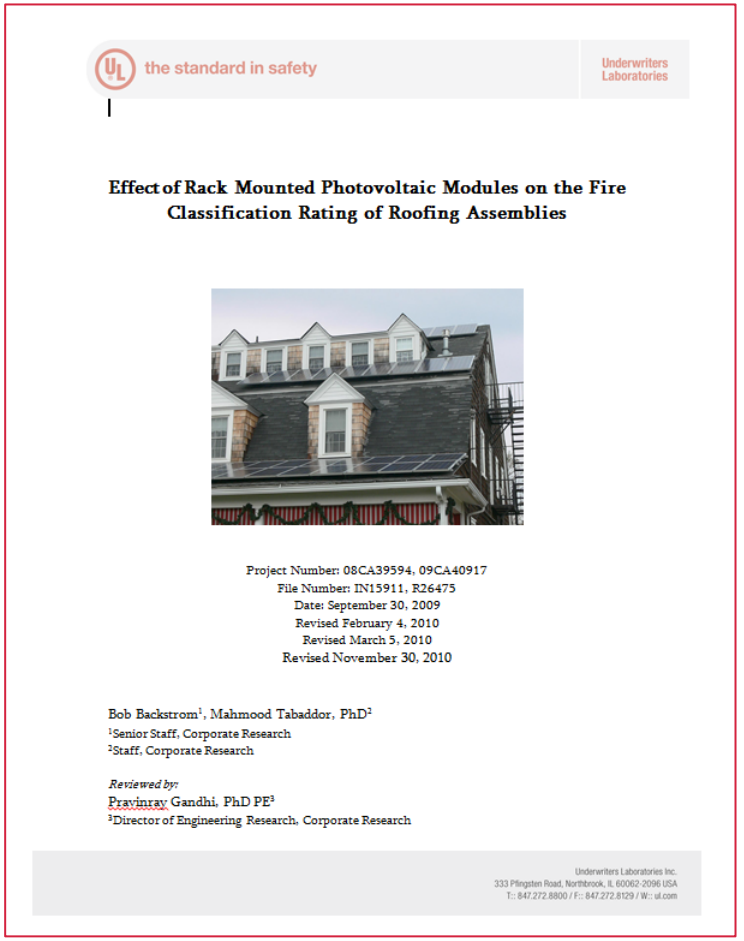
Solar ABC's Stakeholders Meeting 8/2/02012

Bob Backstrom
Research Engineer
UL Corporate Research

Phase 1 – PV Impact on Roof Fire Ratings

Addressed the AHJ ? Of ‘may or may not affect the fire rating of a roof’ & developed data on:

- surface temperature and heat flux of UL 790 fire exposure (w & w/o PV)
- Spread of flame and brand results on various combinations of roofs and PV



the standard in safety

Underwriters Laboratories

Effect of Rack Mounted Photovoltaic Modules on the Fire Classification Rating of Roofing Assemblies

Project Number: 08CA39594, 09CA40917
File Number: IN15911, R26475
Date: September 30, 2009
Revised February 4, 2010
Revised March 5, 2010
Revised November 30, 2010

Bob Backstrom[1], Mahmood Tabaddor, PhD[2]
[1]Senior Staff, Corporate Research
[2]Staff, Corporate Research

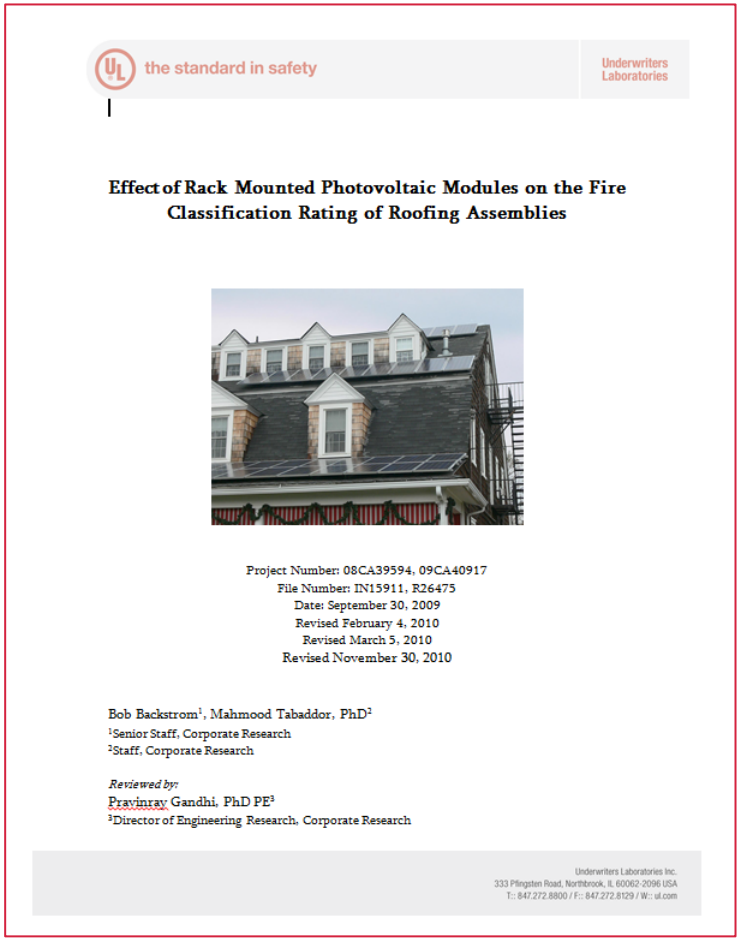
Reviewed by:
Pravinray Gandhi, PhD PE[3]
[3]Director of Engineering Research, Corporate Research

Underwriters Laboratories Inc.
333 Pfingsten Road, Northbrook, IL 60062-2096 USA
T:: 847.272.8800 / F:: 847.272.8129 / W:: ul.com

Phase 1 - Mitigation

Developed data on potential mitigation techniques to minimize flame spread:

- Vertical Flashings
- Angled Flashings
- Fire Barriers
- Screens
- Setbacks



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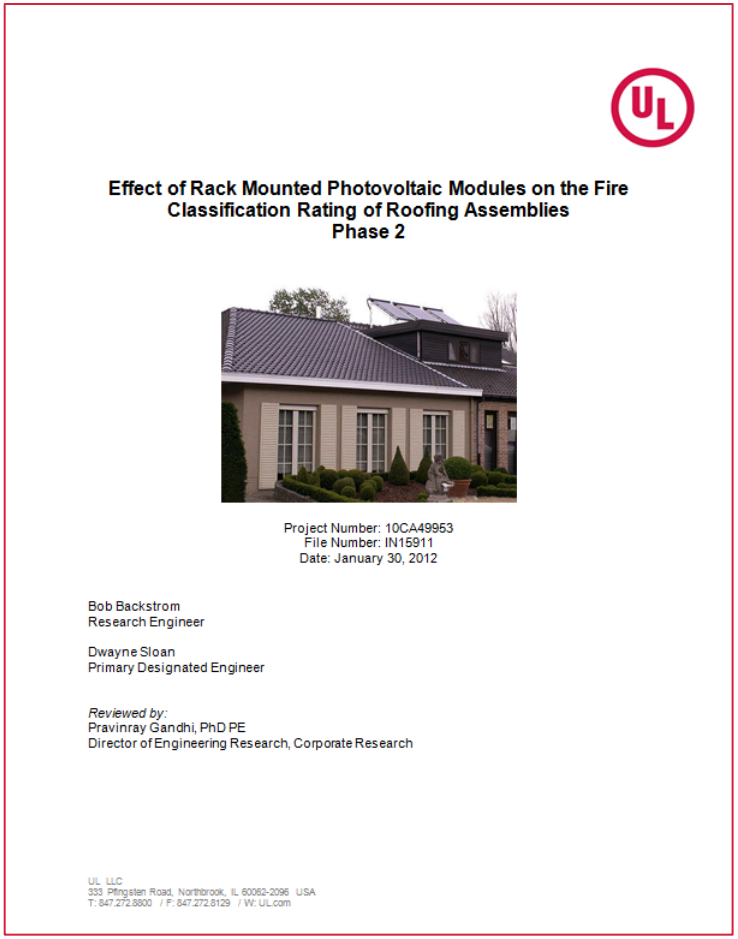
Phase 2 – Non Parallel With Gap Installations & Debris & Brand Demonstrations

- PV modules mounted at angles (positive and negative)
- PV modules mounted at zero clearance
- Burning Brand and Debris



Effect of Rack Mounted Photovoltaic Modules on the Fire Classification Rating of Roofing Assemblies
Phase 2

Project Number: 10CA49953
File Number: IN15911
Date: January 30, 2012

Bob Backstrom
Research Engineer

Dwayne Sloan
Primary Designated Engineer

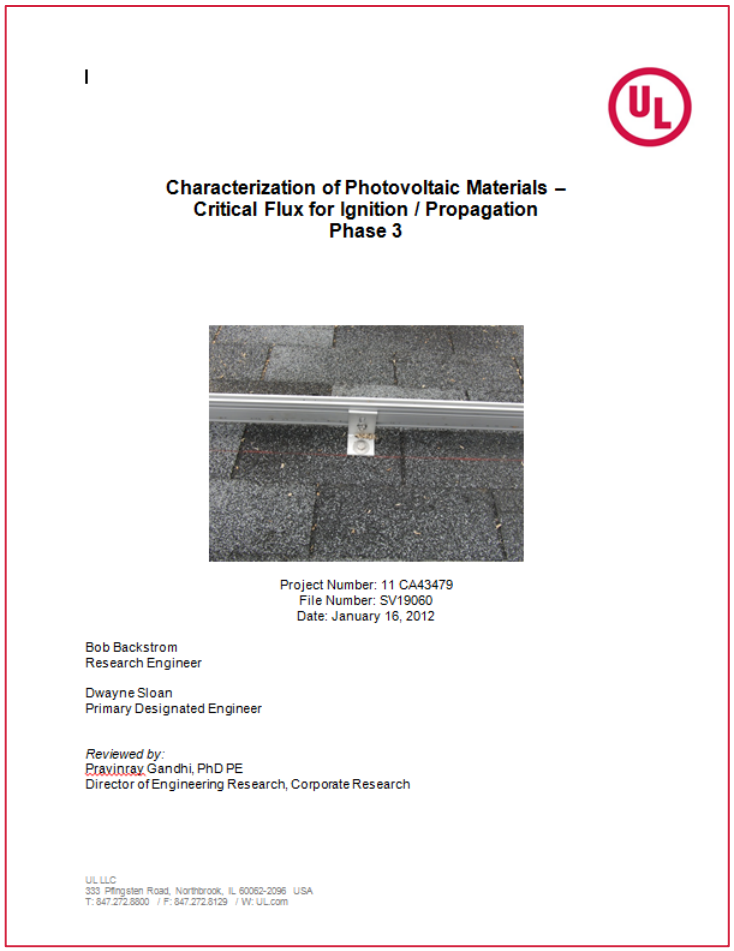
Reviewed by:
Pravinray Gandhi, PhD PE
Director of Engineering Research, Corporate Research

UL LLC
333 Pfingsten Road, Northbrook, IL 60062-2096 USA
T: 847.272.8800 / F: 847.272.8129 / W: UL.com

Phase 3 – Critical Flux

Developed critical flux values for representative low & steep slope roofs:

- Most roofing products > than or close to what was measured in Phase 1 without a PV (~15 kW/m^2)
- All roofing products << what was measured with a PV installed at a gap of 5” (41 kW/m^2)
- The critical flux for ignition of low slope roof products ~ same high slope roof products.



Characterization of Photovoltaic Materials – Critical Flux for Ignition / Propagation Phase 3

Project Number: 11 CA43479
File Number: SV19060
Date: January 16, 2012

Bob Backstrom
Research Engineer

Dwayne Sloan
Primary Designated Engineer

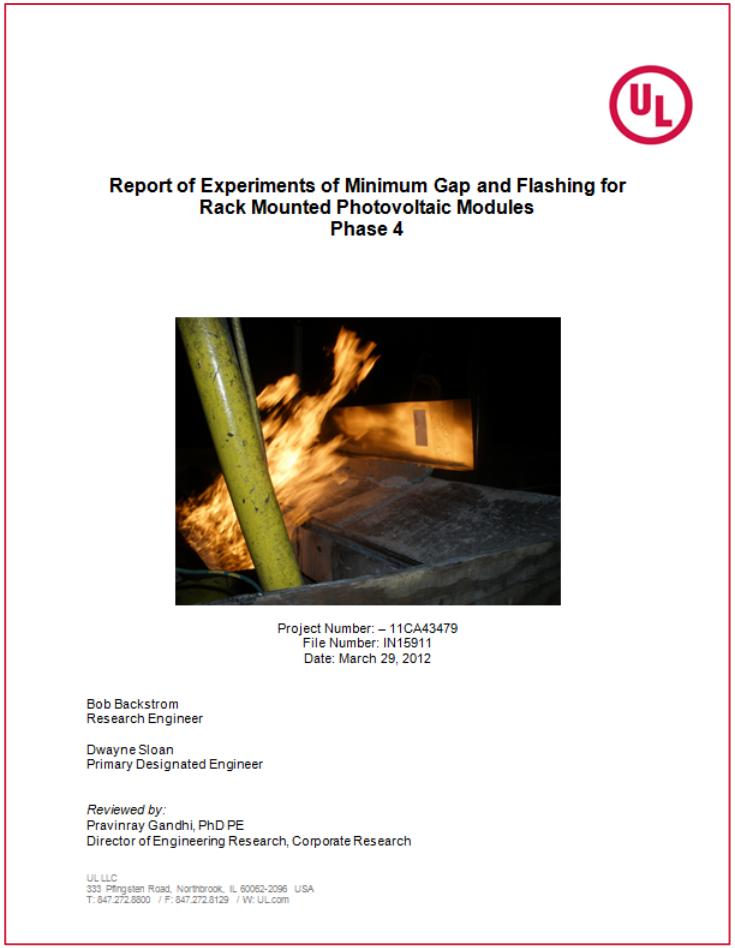
Reviewed by:
Pravinray Gandhi, PhD PE
Director of Engineering Research, Corporate Research

UL LLC
333 Pfingsten Road, Northbrook, IL 60062-2096 USA
T: 847.272.8800 / F: 847.272.8129 / W: UL.com

Phase 4 – Code Proposal Validation

Developed data on minimum gaps and flashing with ½" gap:

- A noncombustible PV surrogate and a Class C PV module @ 12"above a Class A shingled steep slope roof → Class A roof rating.
- A noncombustible PV surrogate and a Class C PV module @ 24" above a Class A shingled low slope roof ≠ Class A roof rating.
- A continuous metal flashing between the rooftop and the PV module → Class A roof rating.
- A metal flashing with a ½ gap & low slope roof ≠ Class A roof rating.
- A metal flashing with a ½ gap & steep slope roof → Class A roof rating



Report of Experiments of Minimum Gap and Flashing for Rack Mounted Photovoltaic Modules
Phase 4

Project Number: – 11CA43479
File Number: IN15911
Date: March 29, 2012

Bob Backstrom
Research Engineer

Dwayne Sloan
Primary Designated Engineer

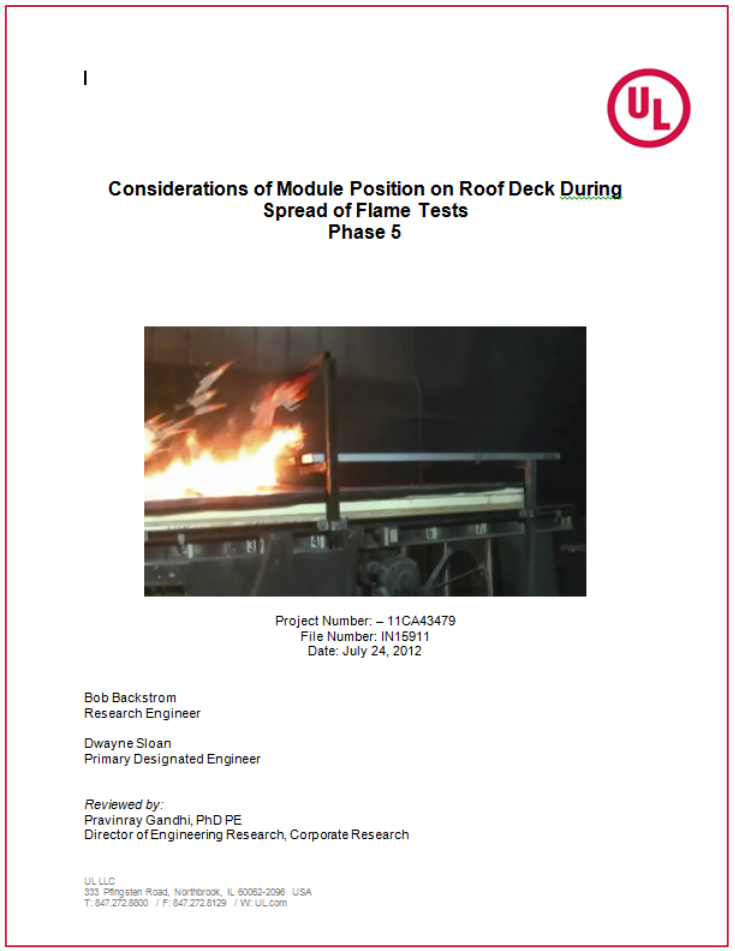
Reviewed by:
Pravinray Gandhi, PhD PE
Director of Engineering Research, Corporate Research

UL LLC
333 Pfingsten Road, Northbrook, IL 60062-2096 USA
T: 847.272.8800 / F: 847.272.8129 / W: UL.com

Phase 5 - Module Position

Developed data on offset modules to document concept of first item ignited (roof) and second item ignited (PV).

- Dwayne will delve deeper.



Considerations of Module Position on Roof Deck During Spread of Flame Tests
Phase 5

Project Number: – 11CA43479
File Number: IN15911
Date: July 24, 2012

Bob Backstrom
Research Engineer

Dwayne Sloan
Primary Designated Engineer

Reviewed by:
Pravinray Gandhi, PhD PE
Director of Engineering Research, Corporate Research

UL LLC
333 Pfingsten Road, Northbrook, IL 60062-2096 USA
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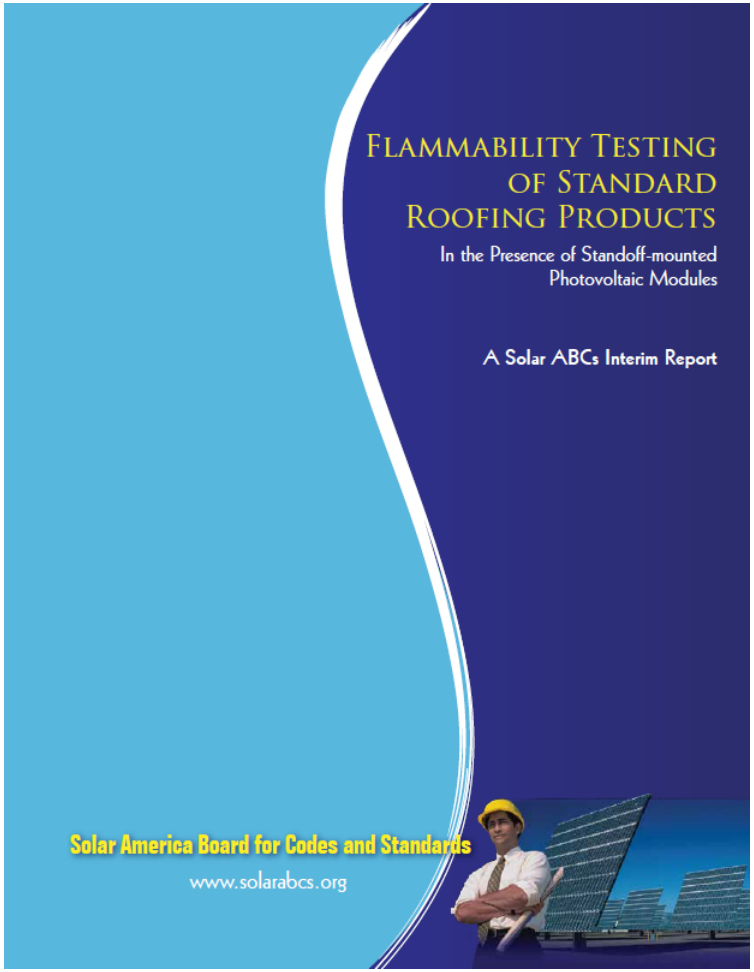
Reports

Copies of these reports and the Solar ABC's initial interim report can be downloaded from their website:

http://solarabcs.org/current-issues/fire_class_rating.html

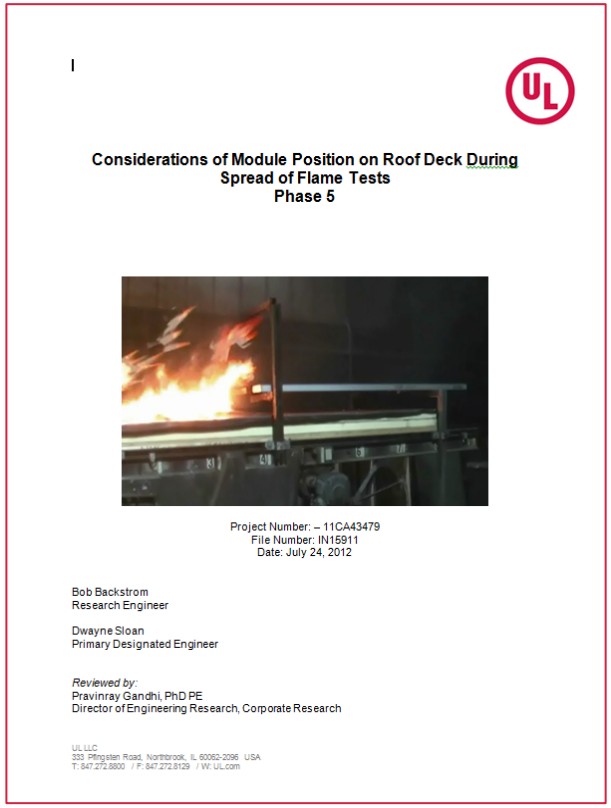
If I may be of service…

Robert.g.backstrom@ul.com



PHASE 5 - *Considerations of Module Position on Roof Deck During Spread of Flame Tests*

A NEW OBJECTIVE



Considerations of Module Position on Roof Deck During
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PHASE 5 - *Considerations of Module Position on Roof Deck During Spread of Flame Tests*

Working Task Group for UL1703 proposed the concept of igniting roof first, and then tracking fire progression into module mounting region

Objective of this Phase was to test concept of first-to-ignite, second-to-ignite (FTI / STI)

PHASE 5 - *Considerations of Module Position on Roof Deck During Spread of Flame Tests*

FOCUS

- Develop baseline fire performance of standard roof types for UL1703
- Determine distance from flame source that provides a “representative” stresses roof/module interface point sufficient to differentiate the performance of PV designs and mounting designs
- Use non-combustible surrogate module to help discover the critical set back distances

PHASE 5 - *Considerations of Module Position on Roof Deck During Spread of Flame Tests*

Initial Results of FTI/STI

	April 16, 2012 Initial Tests								
System	Slope	Material	Underlayment	Gap Height (in)	Angle	Panel Position (in)	Pass/Fail	Flame Spread (ft)	Time
1	Steep	Shingle	30# Felt	5	0	52	Pass	4	9:38
2	Steep	Shingle	30# Felt	N/A*	N/A*	N/A*	Pass	4	9:17
3	Low	FR EPDM	2" Isocyanurate	5	0	52	Pass	4.5	7:35
4	Low	LSFR EPDM	2" Isocyanurate	N/A*	N/A*	N/A*	Fail	6.5	8:42
5	Low	EPDM	2" Isocyanurate	N/A*	N/A*	N/A*	Pass	4.5	9:17
6	Low	LSFR-EPDM	2" Isocyanurate	5	0	34	Fail	8	8:06
7	Low	EPDM	2" Isocyanurate	5	0	34	Fail	8	6:31
8	Low	EPDM	2" Isocyanurate	12	0	34	Fail	8	3:50
9	Low	Rolled Asphalt	2" Isocyanurate	N/A*	N/A*	N/A*	Pass	5	9:38
10	Low	TPO	2" Isocyanurate	N/A*	N/A*	N/A*	Pass	5	9:03
	April 20, 2012 Initial Tests								
System	Slope	Material		Gap Height (in)	Angle	Panel Position (in)	Pass/Fail	Flame Spread (ft)	Time
1	Low	Rolled Asphalt	2" Isocyanurate	5	1/2"	40	Fail	7.5	8:58
2	Low	TPO	2" Isocyanurate	5	1/2"	40	Fail	6.5	10:00
3	Steep	3-Tab Shingle	30# Felt	N/A*	N/A*	N/A*	Pass	4.5	5:40
4	Steep	3-Tab Shingle	30# Felt	5	0	48	Pass	4.5	6:53
* = No PV Module									

PHASE 5 - *Considerations of Module Position on Roof Deck During Spread of Flame Tests*

Initial Results of FTI/STI

- 52 in. is extent of flame from test apparatus. Started with this distance.
- 52 in. is too far back to properly stress interface point for both steep and low slopes.
- 34 in. and 40 in. too close for low slope.
- 48 in. too far back for steep slope.

PHASE 5 - *Considerations of Module Position on Roof Deck During Spread of Flame Tests (June 2012)*

Final Results of FTI/STI – Low Slope

Table 1 - Summary of Repositioning Experiments – Low Slope

					Roof					PV						
		Gap		Module	Time of Flame Spread			Max			Time Flame Spread					
	System	Height	Angle	Offset	3.0'	3.5'	4.0'	Distance	Time	Ign	1'	2'	3'	4'	Full Panel	
System #	Notes	(in)	(deg)	(in)	(m:s)	(m:s)	(m:s)	(ft)	(m:s)	(m:s)	(m:s)	(m:s)	(m:s)	(m:s)	(m:s)	Pass/Fail
Tests conducted June 6, 2012																
12	Baseline	N/A	N/A	N/A	3:07	NR	4:33	5	10:00	N/A	N/A					Pass
14	With PV	5	0	48	2:45	3:08	4:01	8	7:08	4:33	4:52	5:27	5:38	5:54	6:19	Fail
15	NC	5	0	48	2:30	NR	3:02	8	5:58							Fail
15	NC	5	0	52	2:10	2:40	3:05	8.5	5:58							Fail
17	With PV	5	10	48	2:51	NR	3:39	4	10:00							Pass
Tests conducted June 7, 2012																
14	2 PV, 12" apart	5	10	24	2:48	2:50	2:51	6.5	4:04							Fail

NR = Not Recorded

NC = Noncombustible

LSFR EPDM over 4" Poly iso

PHASE 5 - *Considerations of Module Position on Roof Deck During Spread of Flame Tests (June 2012)*

Final Results of FTI/STI – Steep Slope

Table 2 - Summary of Repositioning Experiments – Steep Slope

							Roof					PV						
				Gap		Module	e of Roof Flame Spr			Max. Flame Spread		Time of PV Underside Flame Spread						
System		Shingle	System	Height	Angle	Offset	3.0'	3.5'	4.0'	Distance	Time	Ignition	1'	2'	3'	4'	Full Panel	
#	Slope	Material	Notes	(in)	(deg)	(in)	(m:s)	(m:s)	(m:s)	(ft)	(min:sec)	(m:s)	(m:s)	(m:s)	(m:s)	(m:s)	(m:s)	Pass/Fail
Tests conducted June 6, 2012																		
11	Steep	Mfg 3	Baseline	N/A	N/A	N/A	6:31	7:12	8:04	4	10:00	N/A	N/A					Pass
1	Steep	Mfg 1	Baseline	N/A	N/A	N/A	4:16	5:04	8:42	4	10:00	N/A	N/A					Pass
4	Steep	Mfg 2	Baseline	N/A	N/A	N/A	4:41	6:07	7:04	4	10:00	N/A	N/A					Pass
6	Steep	Mfg 1	PV	5	0	42	5:18	7:03	NR	3.5	10:00							Pass
Tests conducted June 7, 2012																		
6	Steep	Mfg 3	PV	5	0	42	6:10	NR	7:20	4	10:00	7:55	8:30					Pass
2	Steep	Mfg 1	PV	5	0	36	7:01	8:11	8:49	4	10:00							Pass
3	Steep	Mfg 1	NC	5	0	36	5:00	5:48	7:15	4	10:00	N/A						Pass
7	Steep	Mfg 2	NC	5	0	24	4:16	4:36	5:13	8	7:01	N/A						
8	Steep	Mfg 3	PV	5	0	36	4:08	4:53	5:41	4.5	10							
9	Steep	Mfg 1	Baseline	NA	NA	NA	5:33	6:11	7:11	4	10	N/A	N/A					Pass

NA = Not Applicable
NC = Noncombustible module surrogate

PHASE 5 - *Considerations of Module Position on Roof Deck During Spread of Flame Tests (June 2012)*

FTI/STI – Steep Slope

PHASE 5 - *Considerations of Module Position on Roof Deck During Spread of Flame Tests*

SUMMARY – LOW SLOPE

Low slope roof baseline experiment (no PV) exhibited a flame spread of 60 in.

Noncombustible representation of a PV module or a Class C PV module mounted parallel, elevation of 5 inches, offsets of 48 and 52 in. - flame spreads were in excess of Class A performance requirements

A PV module mounted at a slight inclination (10°) to and at an elevation of 5 in. above the roof and at a 48 in. offset did comply with Class A requirements

PHASE 5 - *Considerations of Module Position on Roof Deck During Spread of Flame Tests*

SUMMARY – LOW SLOPE

A single experiment conducted with two modules angled to the roof (10° inclination), the first offset 24 in. and the second space 12 in. from the first did not comply with Class A requirements

The overall results of low slope tests with the PVs present were fairly consistent with tests using a surrogate noncombustible PV

PHASE 5 - *Considerations of Module Position on Roof Deck During Spread of Flame Tests*

SUMMARY – STEEP SLOPE

Steep slope roof baseline experiments (no PV) exhibited a flame spread of 48 in.

Noncombustible representation of a PV module mounted parallel, elevation of 5 in., offset of 42 in. complied with Class A requirements

Two experiments conducted with PV modules mounted parallel to and at an elevation of 5 in. above the roof with an offset of 42 in. complied with Class A requirements

PHASE 5 - *Considerations of Module Position on Roof Deck During Spread of Flame Tests*

SUMMARY – STEEP SLOPE

PV modules mounted parallel to and at an elevation of 5 in. above the roof with an offset of 36 in. complied with Class A requirements

Noncombustible sheet mounted parallel to and at an elevation of 5 in. above the roof with an offset of 24 in. did not comply with Class A requirements

The overall results of steep slope tests with the PVs present were fairly consistent with tests using a surrogate noncombustible PV

DRAFT REVISIONS TO UL1703

Spread of Flame Tests (Steep Slope) ≥ 3 in. slope

- Module mounted directly on a noncombustible deck and oriented such that the ignition flame is directed on the top surface of the module or panel; 5 in. slope

- Module installed on steep slope as an assembly and oriented such that the ignition flame is directed into the interstitial space below the module and above the roof at 5 in. slope, 5 in. gap height, 36 in. between the edge of the flame test apparatus and the edge of the PV mounting system

  - Roofing substrate: 15/32 in. thick plywood
  - Underlayment: ASTM D226 30 lb roofing felt

  - Roof Covering: Listed Class A 3 tab asphalt shingle, ASTM D3462, having demonstrated a maximum spread of flame distance result of 48 in. or greater in two out of three baseline tests, and a minimum weight per unit area 160 lbs / 100 ft^2

DRAFT REVISIONS TO UL1703

Spread of Flame Tests (Steep Slope) < 3 in. slope

- Module installed on low slope as an assembly and oriented such that the ignition flame is directed into the interstitial space below the module and above the roof at ½ inch slope, 5” gap height, 42” between the edge of the flame test apparatus and the edge of the PV mounting system

  - Roofing substrate: 15/32 inch thick plywood
  - Insulation: 4 inch polyisocyanurate insulation

  - Roof Covering: Single-ply, mechanically attached, Low-Sloped Fire Retardant EPDM (LSFR EPDM) rubber membrane with the system having demonstrated a Class A rating, and a spread of flame distance result of 54” or greater in two out of three baseline tests. Minimum thickness 0.060 inch as identified by the manufacturer or determined as described in ASTM E4637

DRAFT REVISIONS TO UL1703

BURNING BRAND TESTS

Two different tests—ONLY for steep slope

- Test 1 - Surface of PV module above 15/32” plywood deck, 3-Tab shingle roof

- Test 2 - Class B brand between the PV module and the Class A roof

Note: Test 2 is only performed if the array does not have a perimeter guard. Perimeter guard cannot allow the pass through of a 1/8” probe

Recap - UL1703 Proposed Revisions

- Spread of Flame on surface of PV now involves testing on a plywood deck
- Spread of Flame will additionally apply flame in between the standardized low and steep slope roof and PV rather than just on the surface of the module
- Class A Burning Brand test on surface of PV now conducted with a standardized steep slope roof covering
- Class B Burning Brand test is applied between with a standardized steep slope roof covering beneath the PV module
- Modules not tested individually. PV systems are tested based on type of module (Glass/polymer; Glass/Glass)

Solar ABCs PV Flammability Activities

FINAL THOUGHTS

- Fire performance is a function of the PV module, the mounting system, and the roof covering as a system
- Typing of modules and use of standardized roof covering dramatically reduces the number of tests necessary
- Qualification of critical radiant flux for PV modules and roofing materials ensured that the testing would be representative
- Must have a solution that the UL1703 STP will likely approve and is defensible with AHJs, PV industry, and roofing industry

Solar ABCs PV Flammability Activities

Updates on Results from New Fire Rating Research

http://www.solarabcs.org/currentissues/fire_class_rating.html

www.solarabcs.org

Current Issues

Fire and Flammability

Fire Class Rating of PV Systems

Solar ABCs PV Flammability Activities

To Provide Comments for
UL1703 if not on STP

Bill Brooks
UL1703 Fire Resistance Task Group Leader
bill@brooksolar.com