NIST Special Publication 1129

Summary of the 2011 Workshop on Research Needs for Full Scale Testing to Determine Vulnerabilities of Decking Assemblies to Ignition by Firebrand Showers

Samuel L. Manzello
Sayaka Suzuki

National Institute of Standards and Technology • U.S. Department of Commerce

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Engineering Laboratory

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U.S. Department of Commerce
Rebecca M. Blank, Acting Secretary

National Institute of Standards and Technology
Patrick D. Gallagher, Under Secretary of Commerce for Standards and Technology and Director

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1. Introduction

1.1 Objective for this workshop

The Engineering Laboratory (EL) at the National Institute of Standards and Technology (NIST) in Maryland has a research effort seeking a better understanding of disastrous Wildland-Urban Interface (WUI) Fires (http://www.nist.gov/index.html).

Firebrands are known to be a major cause of structure ignition of WUI fires in the United States (USA). To this end, NIST has developed an experimental apparatus, known as the NIST Firebrand Generator (NIST Dragon), to investigate ignition vulnerabilities of structures to firebrand showers [1-2]. The experimental results generated from the marriage of the NIST Dragon to the Building Research Institute's (BRI) Fire Research Wind Tunnel Facility (FRWTF) in Japan have identified the vulnerabilities that structures possess to firebrand showers for the first time [3-4]. The detailed experimental findings are being considered as a basis for performance-based building standards with the intent of making structures more resistant to firebrand attack.

In support of building construction methods to reduce disastrous wildfire losses, NIST planning is underway for a new series of experiments scheduled to investigate the vulnerabilities of decking assemblies to firebrand bombardment using the NIST Dragon installed in the FRWTF at BRI in Japan. Input is desired for this experimental series from interested parties in California (e.g. building officials, Office of the State Fire Marshall (OFSM), code consultants, construction industry, and product manufacturers) since large WUI fires have occurred in this state recently. Specifically, guidance is desired in order to conduct experiments that will have the potential to provide the scientific basis for improvements for existing codes and development of new codes.

To this end, the Los Angeles (LA) Basin Chapter of the International Code Council (ICC; http://www.iccsafe.org) hosted a workshop on June 15, 2011 in Norwalk, CA. The workshop was moderated by Mr. Ruben Grijalva, former CALFIRE director and Mr. Stuart Tom, Certified Building Official (C.B.O.) from the city of Glendale, CA, served as the official note taker. Mr. Neville Pereira, LA Basin ICC Chapter President, arranged the venue and location.

This is a follow-up of the successful workshop held in 2010 to generate input for an experimental series focused on exposing siding treatments, glazing assemblies, and eaves to wind driven firebrand showers using the NIST Dragon [5]. Input was considered from that workshop to complete a series of full scale experiments in the fall of 2010. Results of those experiments were presented at recent conferences [6-7] and the June 2011 ASTM E05 research review [8].

1.2 Session Agenda

- Overview of the WUI problem in California, delivered by Mr. Ruben Grijalva, Former State Fire Marshal and Former CALFIRE Director (Presentation is provided in Appendix 2).

- Overview of NIST WUI Research and in particular structure ignition research, delivered by Dr. Samuel L. Manzello, EL-NIST (Presentation is provided in Appendix 2).

- Summary of proposed experimental campaign to determine vulnerabilities to decking assemblies to firebrand bombardment using the NIST Dragon installed in the Fire Research Wind Tunnel Facility (FRWTF) at the Building Research Institute (BRI) in Japan, delivered by Dr. Samuel L. Manzello, EL-NIST (Presentation is provided in Appendix 2).

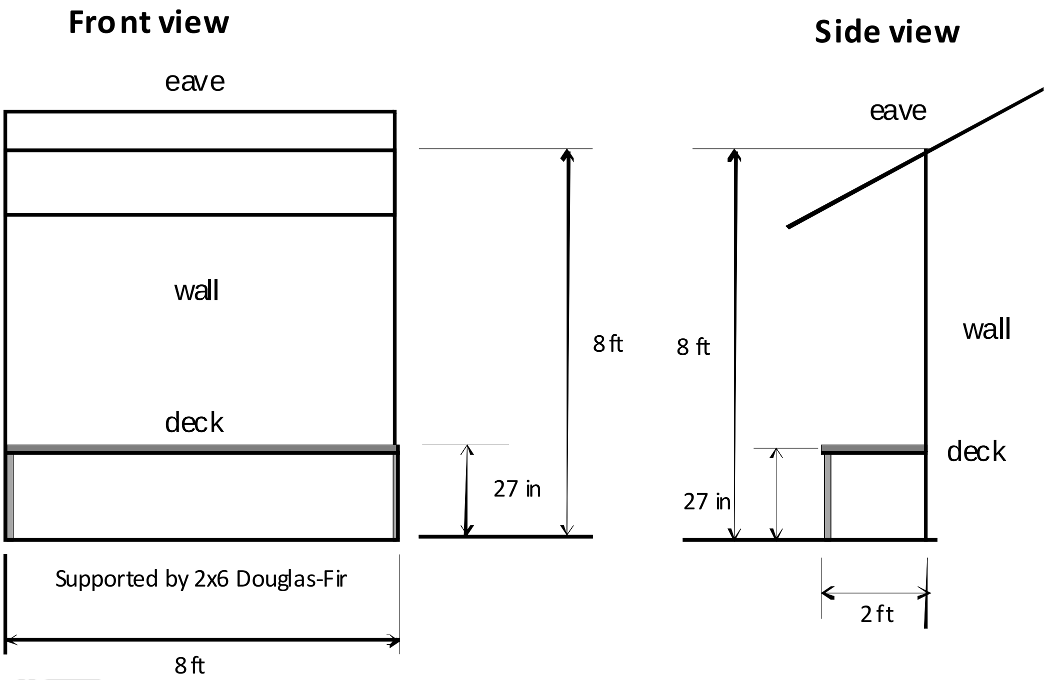
- Group input, discussion, and exchange of information.

2. Results

2.1 Input related to importance of exposing decking assemblies to firebrand showers

NIST presentation about decking assemblies is summarized below (see page 3). Since NIST considered many facets of decking assemblies, a series of questions was asked of the audience. Specific questions asked from the group included:

- Thoughts on type of wall assembly used to attach decking (vertical wall or reentrant corner)?
- How about the depth of the deck assembly?
- What about the height of decking assembly?
- Should the wall assembly be non-combustible in order to consider influence of deck only?
- What materials are most commonly used for decks in California?
    - What is not commonly used?
- Are the profiles of the decking board important? Plank vs. Channel?
- What about the framing used to support the deck?
    - What about ledger board to attach deck to wall assembly?
- What about deck board orientation, or patterns?
- Is a railing needed for the experiments?



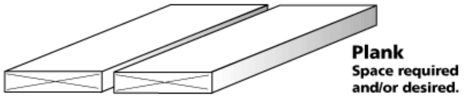
Wall with siding, decking and eave

Board Materials

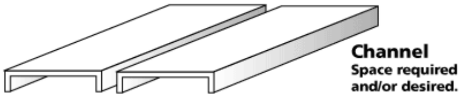
- Wood (treated wood or wood which is naturally resistant to decaying)
  - Treated pine
  - Cedar
  - Redwood
  - Ipé
- Composite
  - Wood/plastic
  - Fiber/PVC
- Plastic
- Metal

Profiles

Profiles---Depends on materials



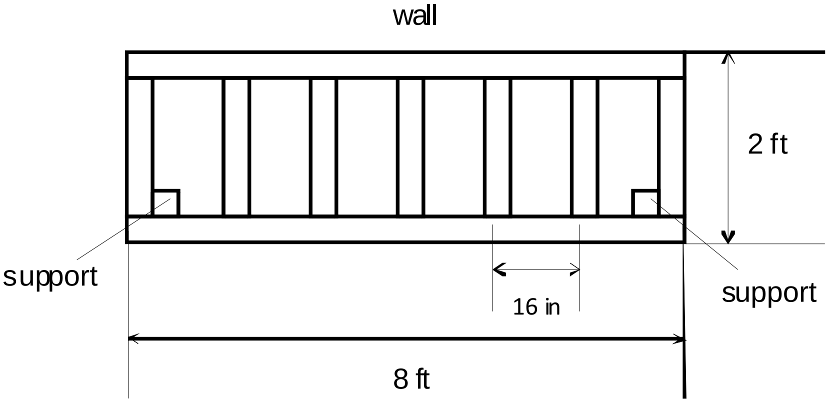
Plank---wood or composite



Channel–-composite

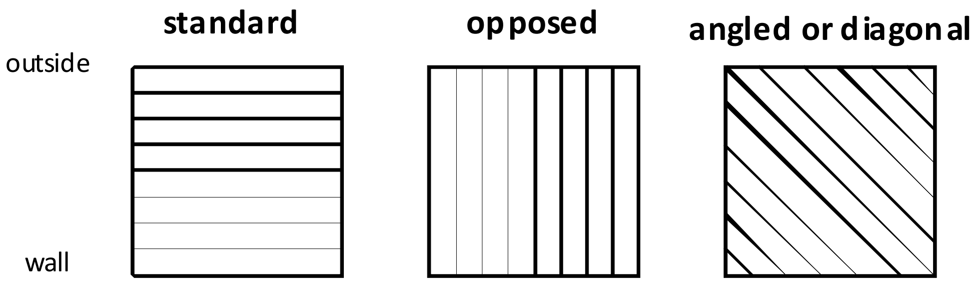
Spacing	**between boards**	5mm
	between board ends	1/8”
	between board and wall	1/4”

Framing



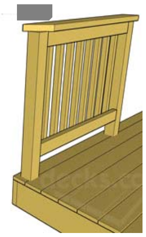
Made from 2 x 8

Patterns

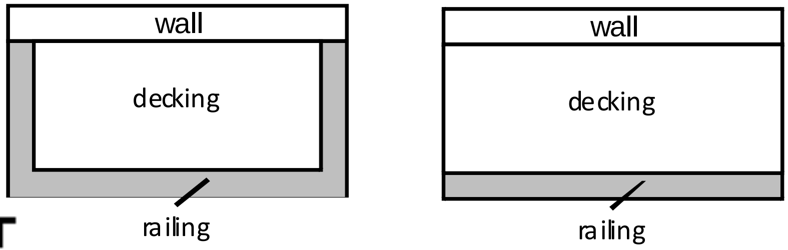


Which pattern is the easiest for firebrands to be stuck with? Or no difference?

Railing



- Railing is needed??
- If yes,
  - surface of deck is 30 inches above the ground
  - railing is 36 inches above the surface of deck
  - a sphere with a diameter of 4 inches cannot pass through the space between each rail or any gaps



Discussion and Input from Attendees (General Comments)

The Office of the State Fire Marshall (OFSM) in California adopted the test method known as State Fire Marshall (SFM) STANDARD 12-7A-4 [9]. The current version, accessed from the California Building Standards Commission Website (http://www.bsc.ca.gov/default.htm), is reproduced in appendix 3.

- The focus of the group discussion was on the burning brand test; specifically SFM STANDARD 12-7A-4 Part B.
- The under deck test was not the focus of this workshop at this time.
- Before proceeding to the detailed discussion regarding testing input, some general comments were made as to what is the issue with the current SFM test method. Is new testing required?
- Regarding the SFM burning brand test, NIST made the following points:
    - The SFM test method is intended to determine the response of decks to firebrand exposure.
    - The simulation of firebrand exposure is very similar to the ASTM E108 [10] roofing test.
    - ASTM E108 has been used for more than 100 years and brand exposure has never been revisited.
    - Namely, a firebrand is simulated by placing a burning wood crib (either Class A, Class B, or Class C firebrand) on top of a section of a deck assembly under an air flow.
    - Test standard does not simulate the processes observed in real Wildland-Urban Interface (WUI) fires.
    - The dynamic process of multiple firebrands attacking decking materials as a function of time is not taken into account in this standard.
    - Firebrand showers have been observed in actual WUI fires over and over again.
    - Based on firebrand attack from real WUI fires, it is expected that multiple firebrands would accumulate within gaps/crevices of decking materials.
    - In addition to not simulating a dynamic firebrand attack, no attempt is made to relate the size and mass of the firebrand used in this standard to actual firebrands produced from burning vegetation and structures.
    - What evidence is provided to suggest that this test is a ‘worst-case’ firebrand exposure?
    - Based on the development of the NIST Dragon technology coupled to a full scale wind tunnel facility at BRI in Japan, it is now possible to expose decking assemblies to wind driven firebrand showers.
    - Recently, using the NIST Dragon, the danger of a dynamic firebrand attack has been demonstrated for ceramic tile roofing assemblies [3].
    - Based on these experiments, it was observed that ceramic tile roof assemblies were vulnerable to ignition from a dynamic firebrand attack.
    - These experiments provided the first confirm of this vulnerability documented in the field [11].

    - Another key issue is that the firebrand size and mass produced using the NIST Dragon has been tied to those measured from full-scale tree burns and an actual WUI fire [11].
    - NIST conducts post-WUI fire damage surveys as well (work of Mr. Alexander Maranghides of NIST [12]); decks have been observed to be an ignition vulnerability based on post-fire damage surveys.
    - NIST is interested in using the NIST Dragon technology to determine vulnerabilities of building components to wind driven firebrand showers.
    - Before NIST developed the Dragon in 2006, no capability to expose building components to wind driven firebrand showers on realistic scale.
    - NIST is interested in providing <u>scientific basis</u> for new building codes/standards.
    - NIST Dragon Research has been focused on parametrically investigating building component vulnerability to wind drive firebrand showers.
        - So far, experiments conducted for vents, eaves, siding, glazing in conjunction with observed vulnerabilities seen in post-WUI fire surveys

- Participants pointed out that:
    - SFM standard testing did not necessarily do a good job simulating actual fire storm conditions.
    - ASTM E-108 – Class "A" firebrand is <u>not</u> an ember.
    - Individual embers behave differently than standard brands (Class A/B/C brands are wood cribs; see ASTM E108 [10]).
    - Showers of embers behave differently than standard brands.
    - Accumulation, intrusion, etc, are different ignition mechanisms.
    - Chapter 7A of the California Building Code [9], where the decking test is listed, was the best that was possible based on the information that was available at the time.
    - At the time that Chapter 7A [9] was developed, discussion occurred and consensus was reached with regard to the test method.
    - Also at that time, there was an agreement that new research and science needs to be utilized to either substantiate that test method or modify the test method.
    - NIST now has the capability to compare the SFM brand test to NIST Dragon and understand differences.

Discussion Input from Attendees (Specific Deck Testing Comments)

- NIST subsequently presented plans for decking experiments; detailed comment follows:
- NIST parametric approach to date is a key to understanding vulnerabilities.
- Use the NIST Dragon to compare to the SFM Standard; use the same configuration but compare results between the Class A Brand to the flying firebrands from the Dragon.
- Install the deck in a realistic configuration; attached to wall assembly since the NIST experiments can consider full scale assemblies.
- The exterior wall used in the experiments should be non-combustible; this way the test is specific to the decking material.
- Construct reentrant corner and install deck samples for testing in such a configuration; place a window on one of the walls and see if fire produced from burning deck (assuming that the deck ignites) can produce window breakage.

- Regarding materials, the following suggestions were obtained:
    - Consider Douglas Fir.
    - Fire retardant treated wood not commonly used for decks; not recommend for NIST experimental campaign.
- Comments on the orientation of the deck boards:
    - The diagonal installation probably does not need to be tested.
    - The standard installation is the same orientation as the SFM Standard.
    - The opposed installation may create a different result particularly when evaluating the up-slope wind direction.
    - Manufacturer's installation instructions do NOT specify orientation.
- Use manufacturer's instructions when spacing and installing the boards on the deck; deck installed is generally manufacturer specific.
- Typical deck installation will include a ledger board attached directly to the house:
    - Ledger against exterior building wall without a gap (common construction practice)
    - Ledger against exterior building wall with a gap (also common practice); may facilitate ember accumulation.
- When comparing the SFM Standard to the NIST Dragon experiments, use materials which passed the SFM Standard and use materials which failed the SFM Standard; this will help provide a relative comparison between the two test methods.
- Use CALFIRE's WUI Products Handbook to see which decking materials passed brand test.
- No consensus as to whether a railing should be used.
- Does the fact that a typical deck is located over a slope rather than a level surface make a difference in the results? Can the wind flow coming up-slope beneath the deck have a more significant impact on the ignition of the deck?

2.2 Summary

In WUI fires, decks have been observed to be an ignition vulnerability based on post-fire damage surveys. Current standard test methods do not simulate the dynamic process of multiple, wind driven firebrands bombarding decking assemblies. Before the development of the NIST Firebrand Generator (NIST Dragon) and the subsequent coupling of this device to the Fire Research Wind Tunnel Facility (FRWTF) at the Building Research Institute (BRI) in Japan, there were no experimental methods to actually generate wind firebrand showers in a controlled, laboratory setting to quantify these vulnerabilities [1-4].

Therefore, full scale tests are planned to quantify the vulnerabilities of decking assemblies to firebrand showers using the NIST Dragon coupled to BRI's FRWTF. Decks have been observed to be an ignition vulnerability based on post-fire damage surveys. This publication summarizes the results obtained from a workshop that was held in June, 2011 by NIST to provide input on the type of decking assemblies commonly found as well as the type of configuration that may be useful to expose to wind driven firebrand showers. The focus has been placed on the state of California since many large WUI fires have occurred there over the past 10 years [13]. These findings will be considered as NIST develops their experimental plans. The results of the full scale tests will be reported and may serve as the basis for developing reduced scale test methods for decking assemblies as well as providing the scientific basis for building code change.

3. References

[1] S.L. Manzello, J.R. Shields, J.C. Yang, Y. Hayashi, D. Nii, On the Use of a Firebrand Generator to Investigate the Ignition of Structures in WUI Fires, In Proceedings of the 11th International Conference on Fire Science and Engineering (INTERFLAM), Interscience Communications, London, (2007) pp. 861-872.

[2] S.L. Manzello, *et al*., On the Development and Characterization of a Firebrand Generator, *Fire Safety Journal*, 43: 258-268, 2008.

[3] S.L. Manzello, Y. Hayashi, T. Yoneki, Y. Yamamoto, Quantifying the Vulnerabilities of Ceramic Tile Roofing Assemblies to Ignition during a Firebrand Attack, *Fire Safety Journal*, 45:35-43, 2010.

[4] S.L. Manzello, S.H. Park, J.R. Shields, Y. Hayashi, S. Suzuki, Comparison Testing Protocol for Firebrand Penetration Through Building Vents: Summary of BRI/NIST Full Scale and NIST Reduced Scale Results, NIST TN 1659, January 2010.

[5] S.L. Manzello and S. Suzuki, Summary of Workshop on Research Needs for Full Scale Testing to Determine Vulnerabilities of Siding Treatments and Glazing Assemblies to Ignition by Firebrand Showers, *NIST Special Publication 1111*, 2010.

[6] S.L. Manzello, S. Suzuki, Y. Hayashi, Exposing Siding Treatments and Walls Fitted with Eaves to Wind-Driven Firebrand Showers, *Fire and Materials Conference*, San Francisco, CA, February, 2011.

[7] S.L. Manzello, S. Suzuki, and Y. Hayashi, Exposing Glazing Assemblies to Firebrand Showers, *Japan Association for Fire Science and Engineering*, Tokyo, Japan, May, 2011.

[8] S.L. Manzello, Quantify Structure Vulnerabilities to Ignition from Firebrand Showers, ASTM E05 Research Review, Anaheim, CA, June 13, 2011.

[9] California Building Standards Commission Website (http://www.bsc.ca.gov/default.htm).

[10] ASTM E108 Standard Test Methods for Fire Tests of Roof Coverings, ASTM International, West Conshohocken, PA, 2003.

[11] E.I.D. Foote, J. Liu, and S.L. Manzello, Characterizing Firebrand Exposure During Wildland-Urban Interface (WUI) Fires, *Fire and Materials Conference*, San Francisco, CA, 2011.

[12] A. Maranghides, W.E. Mell, A Case Study of A Community Affected by the Witch and Guejito Fires, NIST TN 1635, April, 2009.

[13] W.E. Mell, S.L. Manzello, A. Maranghides, B. Butry, and R. Rehm, Wildland-Urban Interface Fires: Overview and Research Needs, *Int'l J. Wildland Fire*, 19: 238-251, 2010.

4. Acknowledgements

Mr. Ruben Grijalva, former State Fire Marshal and former CALIFRE director gave a presentation on overview of WUI problem in California and moderated this workshop. His excellent help is really appreciated. Mr. Stuart Tom, C.B.O, served as the official note taker and Mr. Neville Pereira, LA Basin Chapter President, arranged the venue and location. Their great help is really appreciated. The valuable input of all participants is warmly appreciated. The Science and Technology Directorate of the U.S. Department of Homeland Security sponsored the production of this material under Interagency Agreement IAA HSHQDZ-10-X-00288 with the National Institute of Standards and Technology (NIST).

Appendix 1

Attendance List

No.	Name (Alphabetical by last name)	Organization
1	Brent Berkompas	Fire Vent Safety Association
2	Laura Blaul	Orange County Fire Authority
3	Tom Christopher	Laguna Beach Fire Department
4	Tom Czlapinski	California Redwood Association
5	Chris Dicus	California Polytechnic University at San Luis Obispo
6	Ken Dunham	Lumber Association of California and Nevada
7	Tom Fabian	Underwriters Laboratories (UL)
8	Ethan Foote	CALFIRE (unable to attend, reviewed presentations and provided post-workshop input)
9	Scott Franklin	Scott Franklin Consultants
10	Chris Freeman	Ganahl Lumber Company
11	Rich Geary	Hoover Treated Wood Products
12	Ruben Grijalva	Former California State Fire Marshall; Former CALFIRE Director
13	Chip Herr	Timber Tech
14	Bill Hendricks	Safer Building Solutions
15	Tim Hummel	California Timberline, Inc.
16	Joe Lozano	Boise Cascade
17	Ian MacDonald	Southern California Fire Prevention Officers/CALCHIEFS
18	Samuel Manzello	NIST
19	Rodney McPhee	Canadian Wood Council
20	Pete Melchtry	Ganahl Lumber Company
21	Don Oaks	Southern California Fire Prevention Officers/CALCHIEFS
22	Mark Pawlicki	Sierra Pacific Industries
23	Neville Pereira	LA Basin ICC Chapter President
24	Steve Quarles	IBHS/University of California Cooperative Extension
25	Alan Schall	Azek
26	Kevin Scott	International Code Council (ICC)
27	Kuma Sumathipala	American Wood Council
28	Stuart Tom	City of Glendale, California
29	Jon Traw	ASTM E05.14.08 - WUI Exposures Chairman
30	Steven Winkel	The Preview Group

Appendix 2

Presentations delivered in workshop

Introduction
Past, Present & Future

Ruben Grijalva

Former State Fire Marshal

Former CAL FIRE Director

State Fire Marshal
Issues

State Building Standards and ICC

State Fire Marshal

Issues

Wildland Urban Interface Building Standards

Fire Siege

Direct Protection Area

Of California’s 100 million acres:

- 1/3 is CAL FIRE protection
- 1/3 is federal protection
- 1/3 is local protection

Fire Siege

Initial Attack Philosophy

Fire Protection Objective: Suppress 95% of all wildfires to 10 acres or less

Fire Siege

Pre-Season Preparation

Governor’s Executive Order

Fire Siege

Pre-Season Preparation

700 More Firefighters

Fire Siege

Pre-Season Preparation

4.0 Staffing on State Engines

Fire Siege

Pre-Season Preparation

200 Defensible Space Inspectors

Fire Siege

Pre-Season Preparation

3 Year Contract with DC-10

Fire Siege

Pre-Season Preparation

Hit fires fast, hit them with lots of resources, large air tanker assets to backup boots on the ground

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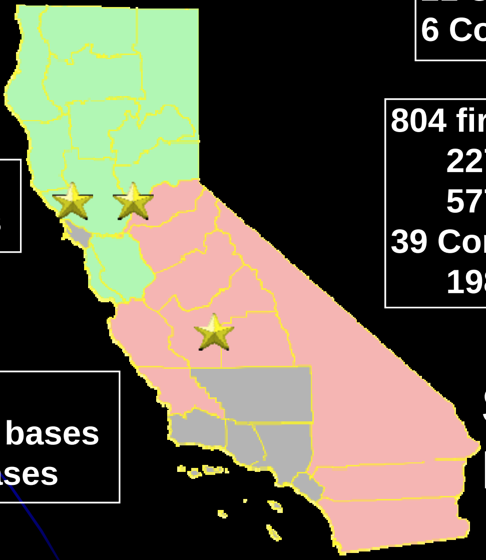
CAL FIRE Resources



Northern Region

21 Units
6 Contract Counties

Sacramento Headquarters

804 fire stations
- 227 state
- 577 local government

39 Conservation Camps
- 198 fire crews

Air Attack
- 13 air attack bases
- 9 helitack bases

Southern Region

Fire Siege

Conditions

- CA has various micro climates
- Santa Ana Wind Event
- Sustained wind speeds – 40-60 MPH
- Wind gusts – up to 100 MPH
- Fuel moistures drop to single digits – 9%-12%
- Dead and dying trees and brush from freeze, disease, and infestation

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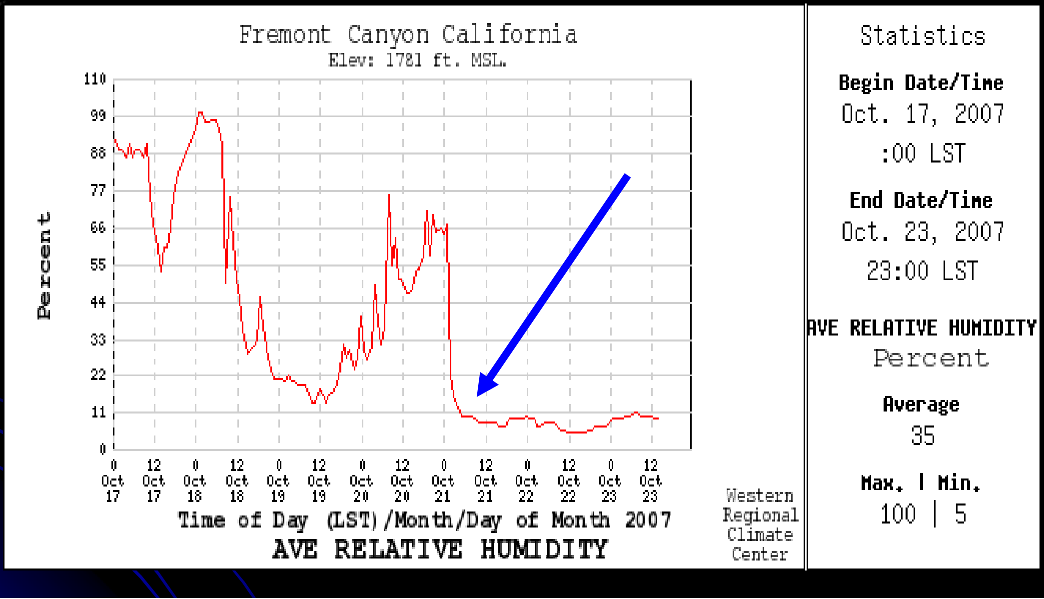


Statistics

Begin Date/Time
Oct. 17, 2007
:00 LST

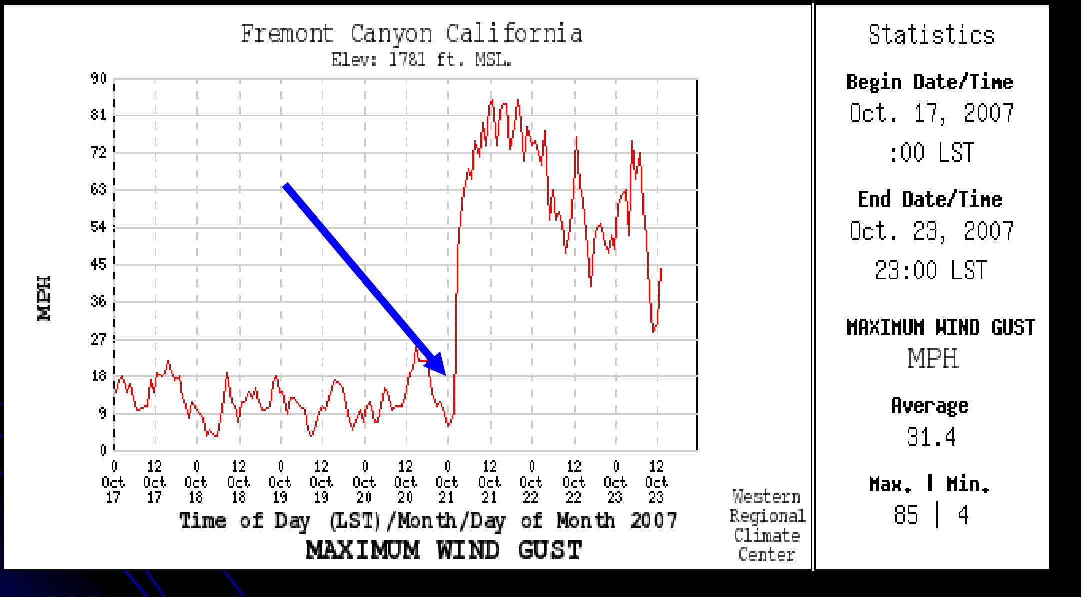
End Date/Time
Oct. 23, 2007
23:00 LST

AVE RELATIVE HUMIDITY
Percent

Average
35

Max. | Min.
100 | 5

A 7-Day graph of average Relative Humidity at Fremont Canyon RAWS RH fell sharply early on the 21st, and has now been <12% for 2 ½ days.



Statistics

Begin Date/Time
Oct. 17, 2007
:00 LST

End Date/Time
Oct. 23, 2007
23:00 LST

MAXIMUM WIND GUST
MPH

Average
31.4

Max. | Min.
85 | 4

A 7-Day graph of maximum wind gusts at Fremont Canyon RAWS
The sharp spike seen early on Sunday Oct. 21 is the Santa Ana onset

---

Fire Siege

Fire Conditions

Perfect Storm

- Wind driven
- Fuel driven
- Topography driven
- Structure to structure driven
- Direct flame, radiant heat, ember driven

Fire Siege

What Works Well

California Mutual Aid System

Fire Siege

What Works Well

Mobilize a massive amount of personnel in a condensed period of time.

October Fire Siege 2007

What Worked Well

Multi-State Response. The number of different fire departments involved approx. 1,148.

October Fire Siege 2007

What Worked Well

Total firefighters: 15,616
Engines: 2,585
Strike Teams/Task Forces: 263
Dozers: 225
Handcrews: 298
Watertenders: 284
Overhead personnel: 1,707

Fire Siege

Lessons Learned

Need for Better Land Use / Planning / Prevention

Fire Siege

Lessons Learned

Need for more local resources / staffing / surge capacity

Fire Siege

Lessons Learned

Need for streamlined resource re-deployment system

Fire Siege

Preventing the Next Firestorm

Better Land Use / Planning

Fire Siege

Preventing the Next Firestorm

More Fuels Treatment

Fire Siege

Preventing the Next Firestorm

Building Construction with Ignition Resistant Materials

Fire Siege

Preventing the Next Firestorm

Adequate Local Emergency Response Resources

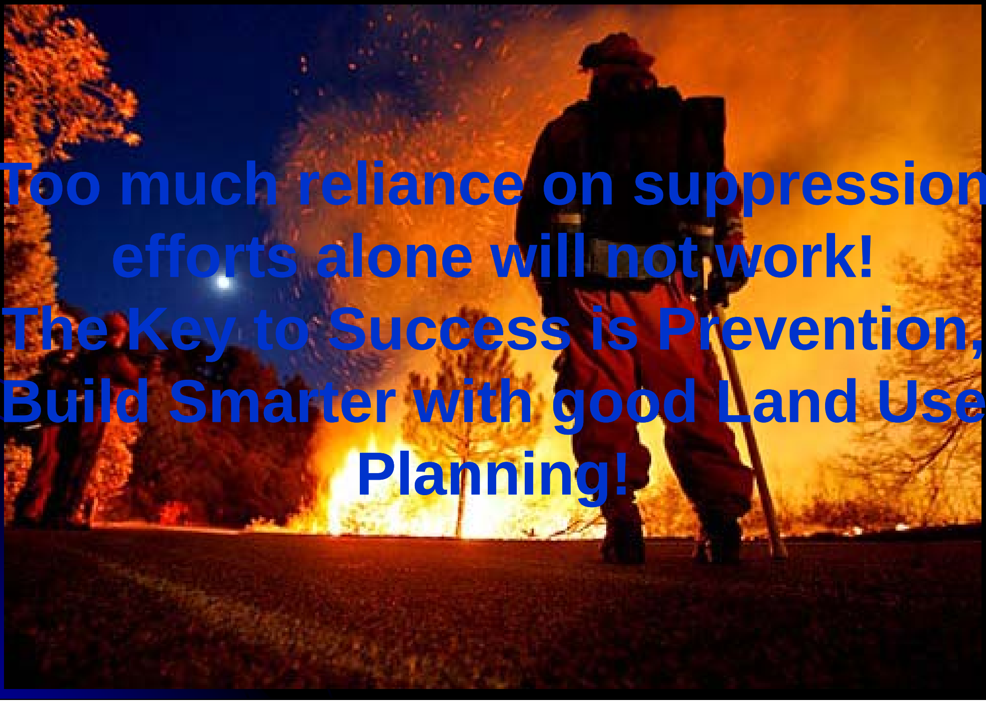
Fire Siege

Preventing the Next Firestorm

Increase Surge Capacity

Fire Siege

Preventing the Next Firestorm



Too much reliance on suppression efforts alone will not work!

The Key to Success is Prevention, Build Smarter with good Land Use Planning!

Quantifying Structure Vulnerabilities to Ignition from Firebrand Showers

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Decking Workshop
June 15th, 2011

Special Thanks

- **Dr. Sayaka Suzuki (NIST)**
- **Dr. Yoshihiko Hayashi (BRI)**

- **Mr. Ruben Grijalva**
- **Mr. Stuart Tom**
- **Mr. Neville Pereira**

Wildland-Urban Interface (WUI) Fires

WUI – structures and wildland vegetation coexist

Of the 10 largest fire loss incidents (> $1B) in U.S. history, 5 were WUI fires - all within the last 17 years

Photo by JOHN GIBBINS / Union-Tribune

Cedar Fire about to engulf the Scripps Ranch residential community

Proven risk assessment and mitigation tools are needed

Structure Ignition in Urban and WUI Fires

- **Firebrands major cause of ignition**
- **Understanding firebrand ignition of structures – important to mitigate fire spread Australia/Japan/USA**

Objective: Investigate ignition of structures to firebrand showers

Partnerships

- BRI - Japan
- US Department of Homeland Security

Customers

- CALFIRE
- ASTM (Manzello voting member)
- ASTM E05.14 External Fires

- Results useful for:
  - ASTM, CALFIRE, ICC, NFPA, ISO, Insurance Industry, Homeowners

---

International Collaboration BRI (Japan) and BFRL-NIST (USA)

- Firebrands: generation, transport, ignition
- Research focused on how far firebrands travel for 40 yrs!!
- Nice Academic Problem – Not helpful to design structures

- Vulnerable points where firebrands may enter structure
  - Unknown/guessed!
- Difficult to replicate firebrand attack!
- Entirely new experimental methods needed!

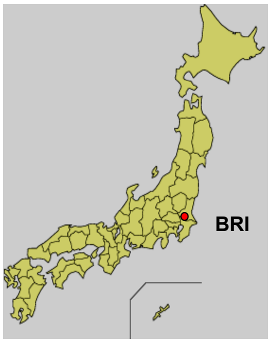
Goals

Science - Building Codes/Standards; Retrofit construction

Design structures to be more resistant to firebrand ignition

Building Research Institute (BRI)

- Fire Research Wind Tunnel Facility (FRWTF)
- Unique facility – investigate influence of wind on fire
  - Constructed more than 10 years before IBHS wind tunnel



Fire Research Wind Tunnel Facility (FRWTF)

NIST Dragon 龍

First Generation Device

Firebrand size/mass commensurate to full scale tree burns and actual WUI fire (2007 Angora Fire)

Roofing Studies

Current Roofing Standards

Roofing test: ASTM E108; UL 790
Does not simulate dynamic firebrand attack!

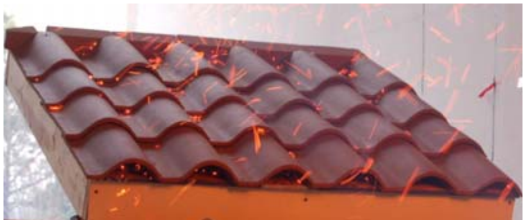
Japan/USA
Use This Test!

12 mi/hr
(5.3 m/s)

Mitchell &Patashnik [2007] – possible correlation homes ignited in 2003 Cedar Fire with those homes fitted with ceramic tile roofing

Ceramic Roofing

Aged Roofing Simulated: OSB, then tiles (no tar paper)



U_∞ (m/s)	OSB/TP/CT No Bird Stops	OSB/TP/CT With Bird Stops	OSB/CT No Bird Stops	OSB/CT With Bird Stops
7	SI	NI	SI to FI	SI
9	SI	NI	SI to FI	SI

New Roofing Construction: OSB, Tar Paper, then Ceramic Tiles

NIST
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Ceramic Roofing

Aged Roofing Simulated: OSB, then tiles (no tar paper)

U_∞ (m/s)	OSB/TP/CT No Bird Stops	OSB/TP/CT With Bird Stops	OSB/CT No Bird Stops	OSB/CT With Bird Stops
7	SI	SI	SI to FI	SI
9	SI	SI	SI to FI	SI

New Roofing Construction: OSB, Tar Paper, then Ceramic Tiles

Pine Needles/Leaves Under Tiles

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Detailed Investigation of Firebrand Penetration through Building Vents

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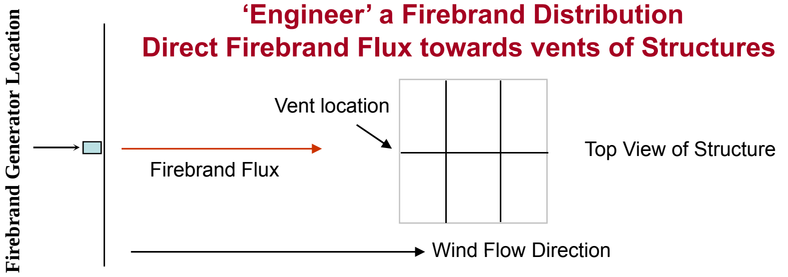
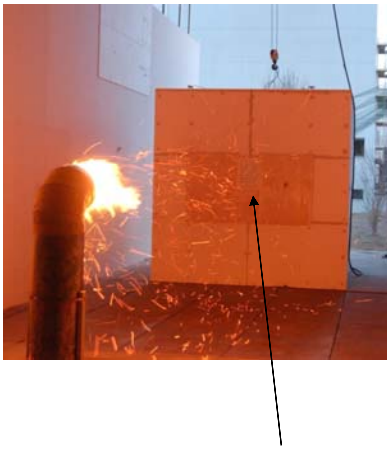
Firebrand Penetration Through Vents

Experiments conducted in 2007

‘Engineer’ a Firebrand Distribution
Direct Firebrand Flux towards vents of Structures




Gable Vent

Firebrand Goes Through

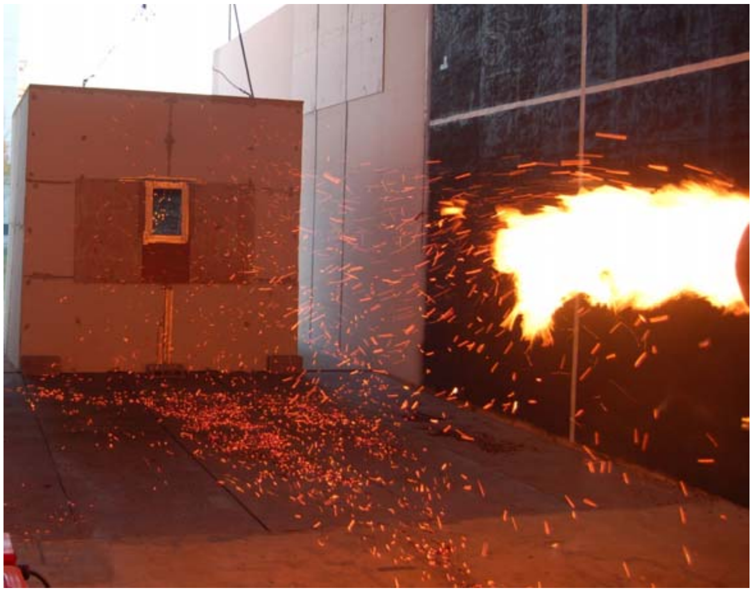
Screen Behind Vent
Three sizes tested 6 mm , 3 mm , and 1.5 mm

Research Plan

- Quantify firebrand penetration through building vents
  - Full scale experiments at BRI
    - Only full scale wind driven testing in the world
  - Compare to new NIST reduced scale tests (Dragon's LAIR)
    - Wind driven firebrand attack at reduced scale
  - 6 mesh sizes (5.72 mm to 1.04 mm)
  - Four types of ignitable materials behind mesh
    - Cotton,
    - Shredded Paper,
    - OSB – Wood Crevice (filled with shredded paper)
    - OSB – Wood Crevice (bare – no shredded paper)

BRI/NIST Full Scale Experiments

20 x 20 mesh (1.04 mm) is shown



Summary of BRI/NIST Results

- SI – Smoldering Ignition; FI – Flaming Ignition
- NI – No Ignition
- Each case – three repeat experiments

Mesh	Paper	Cotton	Crevice	Crevice with paper
4 x 4 (5.72 mm)	SI to FI	SI	SI	SI to FI (paper) SI (OSB)
8 x 8 (2.74 mm)	SI to FI	SI	SI	SI to FI (paper) SI (OSB)
10 x 10 (2.0 mm)	SI to FI	SI	NI	SI to FI (paper) (SI OSB)
14 x 14 (1.55 mm)	SI	SI	NI	SI (paper) SI (OSB)
16 x 16 (1.35 mm)	SI	SI	NI	NI
20 x 20 (1.04 mm)	Two tests: NI; One test SI	Two tests: SI One Test NI	NI	NI

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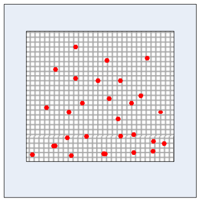
Mesh Effectiveness

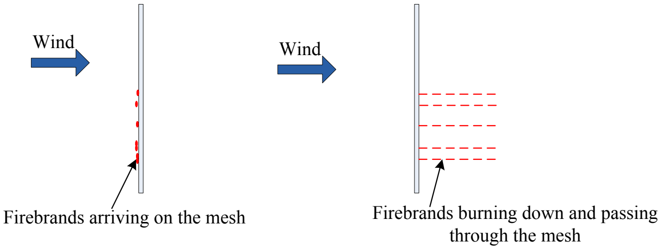
BRI/NIST full scale and NIST reduced scale tests - mesh is not effective

(a) Front view



Mesh not effective!

(b) Side view



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Exposing Siding Treatments, Walls Fitted with Eaves, and Glazing Assemblies to Firebrand Showers

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Research Plan

- Determine siding treatment vulnerability to firebrand showers
  - Do firebrands become trapped within corner post/under siding itself?
- Determine glazing assembly vulnerability to firebrand showers
  - Do firebrands accumulate inside corner of framing of glazing assemblies, and lead to window breakage?
- Determine eave vulnerability to firebrand showers
  - Do firebrands become lodged within joints between walls/eave overhang?
- Determine if fine fuels adjacent to structure can produce ignition

First experiments ever conducted

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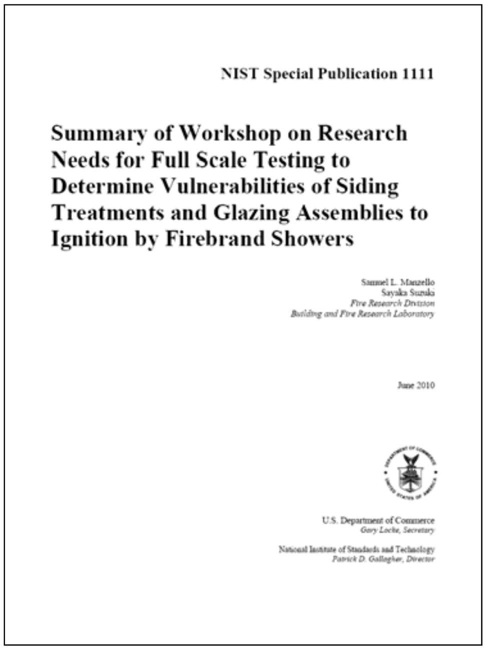
Workshop Held For Testing Input in CA



NIST Special Publication 1111

Summary of Workshop on Research Needs for Full Scale Testing to Determine Vulnerabilities of Siding Treatments and Glazing Assemblies to Ignition by Firebrand Showers

Samuel L. Manzello
Sayaka Suzuki
Fire Research Division
Building and Fire Research Laboratory

June 2010

U.S. Department of Commerce
Gary Locke, Secretary

National Institute of Standards and Technology
Patrick D. Gallagher, Director

Industry
Fire Service
CALFIRE/OSFM
Building Officials
Code Consultants

Siding Treatments

- **Corner - believed that firebrands may become trapped within the corner post and under the siding itself**
- **OSB, moisture barrier applied (OSB dried; 11 %)**

Image of vinyl siding (from bottom) after firebrand exposure at 7 m/s

Siding Treatment Results

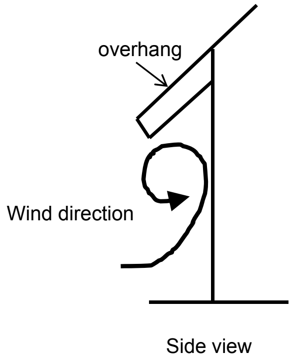
Polypropylene siding is newer to the market; used as has the look/feel of cedar siding

U_∞ (m/s)	**Vinyl Siding OSB Sheathing Dried**	**Vinyl Siding OSB Sheathing Not Dried**	**Polyproplylene Siding OSB Sheathing Dried**	**Polyproplylene Siding OSB Sheathing Not Dried**
7	Siding melted/holes Burns on Tyvek OSB NI	Siding melted/holes Burns on Tyvek OSB NI	Siding melted Burns on Tyvek OSB NI	Siding melted Burns on Tyvek OSB NI
9	**Siding melted/holes** **Burns on Tyvek** **OSB SI**	Siding melted/holes Burns on Tyvek OSB NI	Siding melted Burns on Tyvek OSB NI	Siding melted Burns on Tyvek OSB NI

Eave Vulnerability

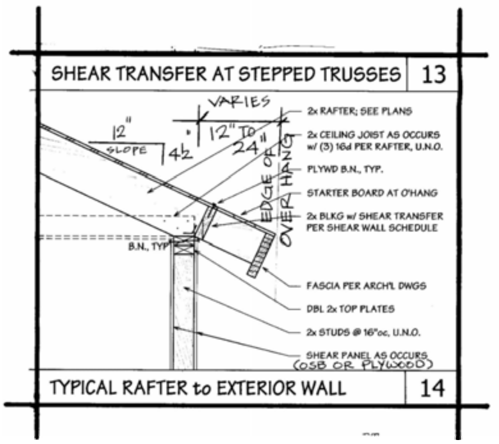
- **A very important, long standing question is whether firebrands may become lodged within joints between walls and the eave overhang**
- **There are essentially two types of eave construction commonly used in California and the USA**
  - **Open eave**
  - **Boxed in eave**
- **In open eave construction, the roof rafter tails extend beyond the exterior wall and are readily visible**
- **In the second type of eave construction, known as boxed in eave construction, the eaves are essentially enclosed and the rafter tails are no longer exposed**

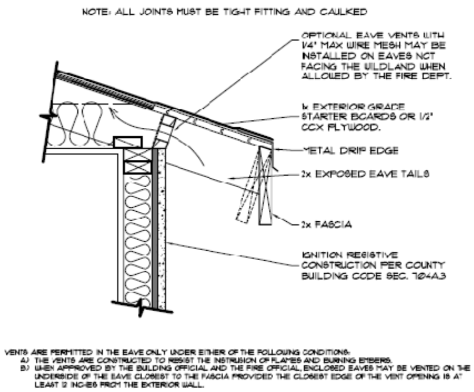
Firebrand accumulation in eaves
Does this really happen??



Typical Open Eave Construction

- **Since the open eave construction is thought to the worst possible situation, this configuration was used**
- **Common construction type used in CA shown**





VENTS ARE PERMITTED IN THE EAVE ONLY UNDER EITHER OF THE FOLLOWING CONDITIONS:

A) THE VENTS ARE CONSTRUCTED TO RESIST THE INSTRUSION OF FLAMES AND BURNING EMBERS.

B) WHEN APPROVED BY THE BUILDING OFFICIAL AND THE FIRE OFFICIAL, ENCLOSED EAVES MAY BE VENTED ON THE UNDERSIDE OF THE EAVE CLOSEST TO THE FASCIA PROVIDED THE CLOSEST EDGE OF THE VENT OPENING IS AT LEAST 12 INCHES FROM THE EXTERIOR WALL.

Walls Fitted With Eaves

Images of eave assemblies constructed for testing

Open eave construction is thought to the worst possible situation, this configuration was used

Wall Size: 2.44 m by 2.44 m
Eave Overhang: 61 cm (2 ft)

Vent holes: 50 mm (2”)
fitted with mesh 2.75 mm opening

Wall Fitted With Eave Exposed to Firebrand Showers

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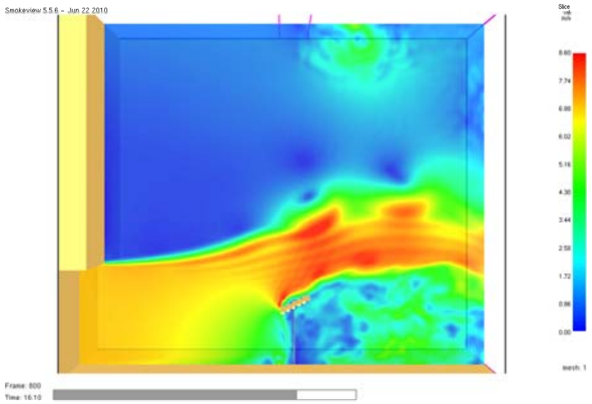
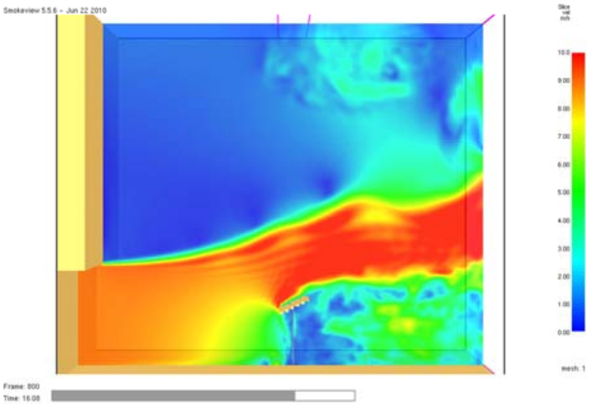
CFD Simulations

Only air profiles shown

Under eave, little or no flow velocity required to drive firebrands into joints between eave and wall assembly

EXPERIMENTS NEEDED UNDER HIGHER WIND SPEEDS





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Wall Fitted With Eave Results

- The number of firebrands arriving at the vent locations increased as the wind speed increased
- Yet was very small as compared to the number of firebrands that bombarded the wall/eave assembly

U_∞ (m/s)	Open Eave With No Vents	Open Eave with Vents
7	**No Accumulation**	11 Firebrands Arrived at Vents
9	**No Accumulation**	28 Firebrands Arrived at Vents

Wall Fitted With Eave Results

- The base of the wall actually ignited due to the accumulation of firebrands (9 m/s)
- It was very easy to produce ignition outside the structure since many firebrands were observed to accumulate in front of the structure during the tests
- Although some firebrands were observed to enter the vents, the ignition of the wall assembly itself demonstrates the dangers of wind driven firebrand showers
- The base of wall assembly ignited without the presence of other combustibles that may be found near real structures (*e.g*. mulch, vegetation)

Glazing Assemblies

Do firebrands become trapped, accumulate inside the corner of the framing of glazing assemblies, and lead to window breakage?

Vertically and Horizontally Sliding Window Assemblies
Window Size: 91 cm by 91 cm

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Firebrand Accumulation in Front of Obstacles

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Firebrand Accumulation

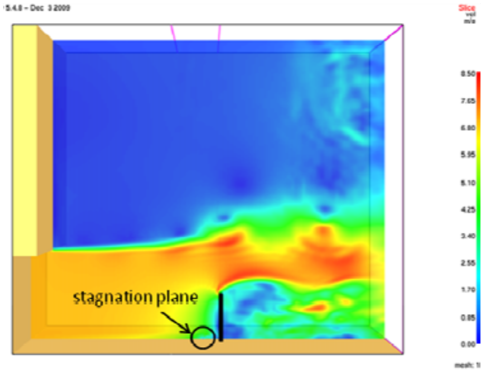
Wood Boards Placed
In Front

Easily Ignited!!!

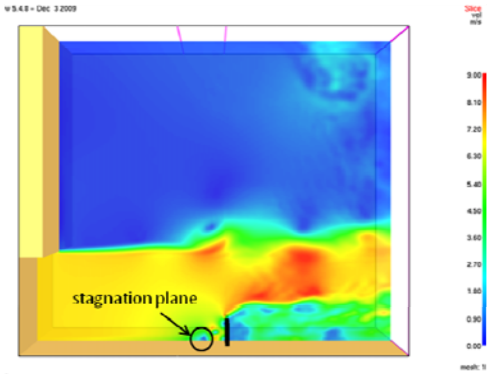
Fine Fuels Near Structure

Wall Ignited

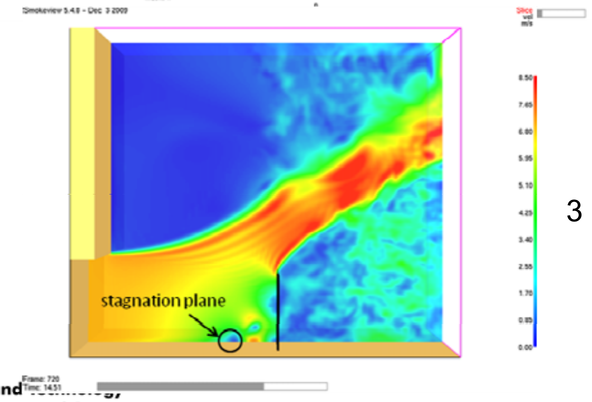
Obstacles in Flow



1 m by 2 m



2 m by 1 m



3 m by 3 m

Firebrand Production from Building Components

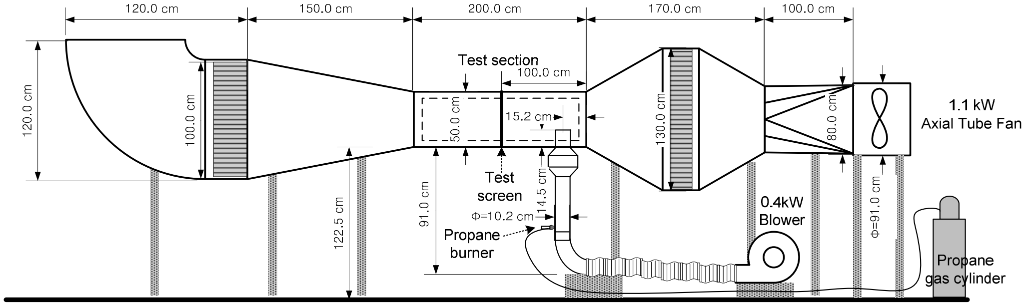
Work in Progress

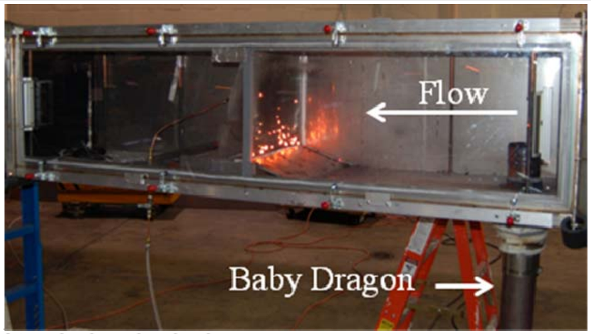
- Firebrand generation from:
  - Structure Components

NIST Reduced Scale Building
NIST Dragon's LAIR

NIST Dragon’s LAIR (Lofting and Ignition Research)

Couple ‘Baby Dragon’ with wind tunnel
Reproduced results from full scale tests





Typical experiment using Dragon’s LAIR
A 14 x 14 (1.55 mm) mesh

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Summary of NIST Results

- SI – Smoldering Ignition; FI – Flaming Ignition; NI – No Ignition
- Velocities behind mesh matched to full scale experiments
- Mesh assembly – same area as full scale experiments – 1600 cm^2

Mesh	Paper	Cotton	Crevice	Crevice with paper
4 x 4 (5.72 mm)	SI to FI	SI to FI	SI	SI to FI (paper) SI (OSB)
8 x 8 (2.74 mm)	SI to FI	SI	SI	SI to FI (paper) SI (OSB)
10 x 10 (2.0 mm)	SI to FI	SI	NI	SI to FI (paper) (SI OSB)
14 x 14 (1.55 mm)	SI	SI	NI	SI (paper) SI (OSB)
16 x 16 (1.35 mm)	SI	SI	NI	NI
20 x 20 (1.04 mm)	NI	SI	NI	NI

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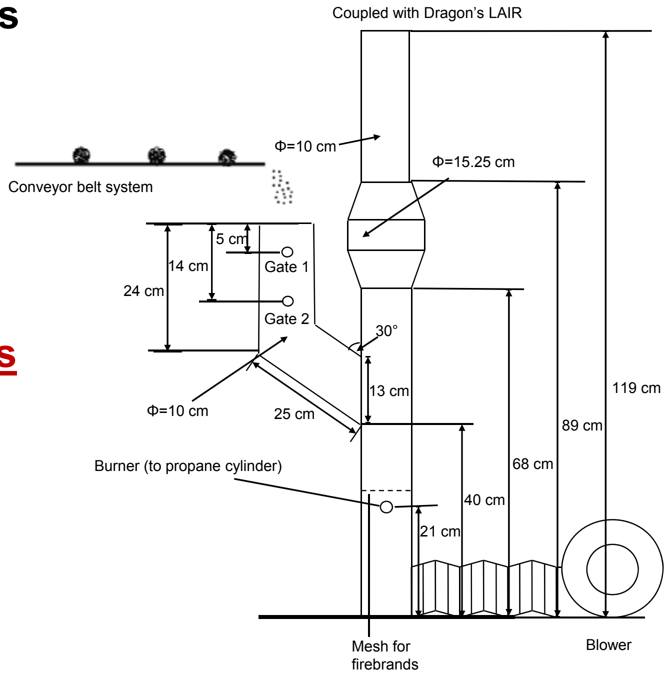
Continuous Feed Baby Dragon

- Generate continuous firebrand showers
- Coupled to Dragon's LAIR

Ability to rate materials To firebrand exposure



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Improved NIST Dragon's LAIR (Lofting and Ignition Research)

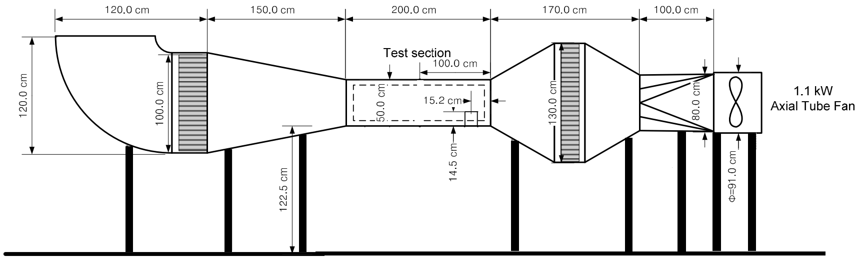
Expose materials to continuous, wind driven firebrand showers

Conveyor

Firebrand Injection into Wind Tunnel

Gates

Burner



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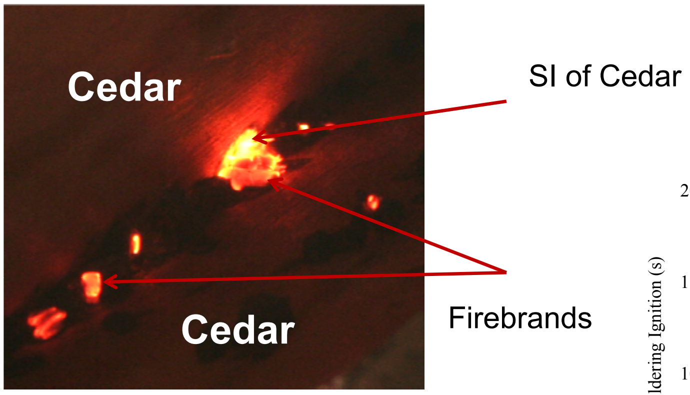
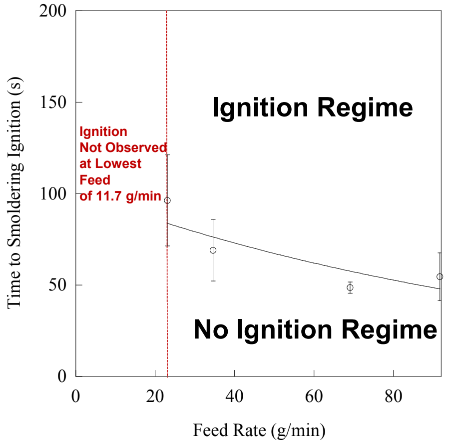
Improved NIST Dragon’s LAIR



IGNITION REGIME MAPS

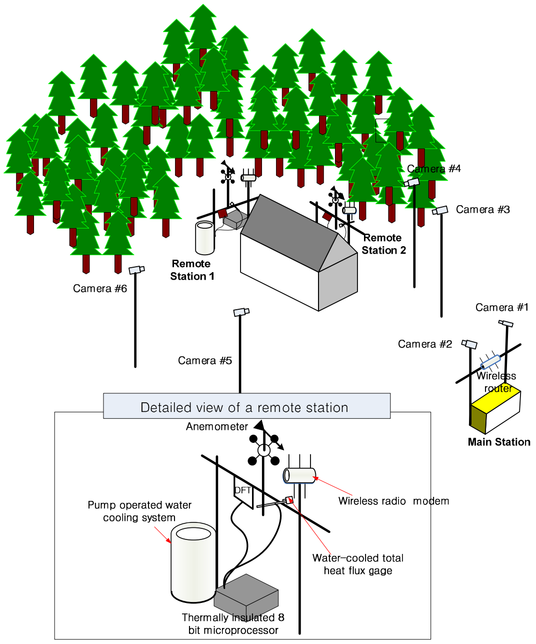


Developing Rapid Response Instrumentation Packages to Quantify Structure Ignition In Wildland-Urban Interface (WUI) Fires

WHAT IS THE NEW TECHNICAL IDEA?

Field deployable instruments – heat flux, wind speed, firebrand generation

Quantify WUI Fire Exposures



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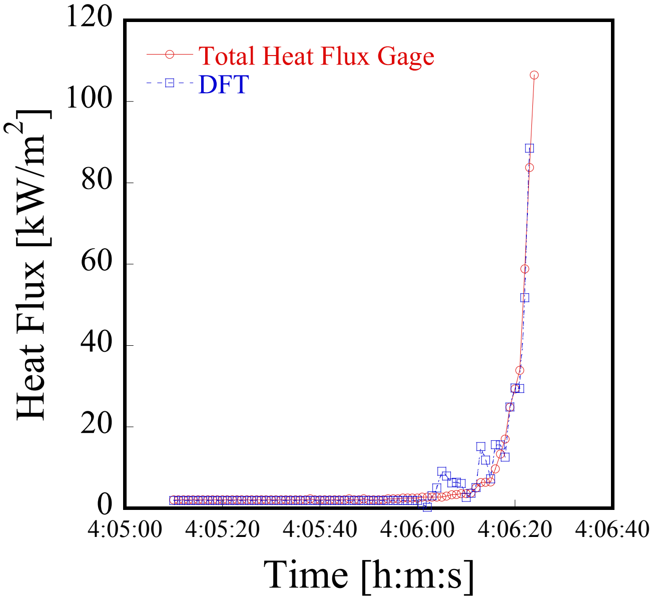
Heat Flux as Fire Approached



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Recent Impacts

- State of New Jersey using NIST video in training courses
- Worked with CALFIRE as part of a task force (invitation only) to reduce mesh size used to cover building vent openings to lessen the potential hazard of firebrand entry into structures.
  - Changes were formally adopted into the 2010 California Code of Regulations, Title 24, Part 2, Chapter 7A, and are effective January, 2011
- "Your research will certainly further our understanding of the risks of flying embers during a wildfire event, and will help guide us as we make recommendations to our policyholders on how to better protect their home from the threat of wildfires"

  Stan Rivera – Chartis Insurance (http://www.chartisinsurance.com)
- Work has garnered the attention of Australian Government.
  - ABCB is joint initiative of all levels of Australian Government
  - ABCB has requested a formal partnership with NIST to assess Australian Standards to see whether they can account for ignition vulnerabilities observed by firebrands
- IBHS has used NIST's Dragon concept for use in their wind tunnel facility to generate firebrand showers

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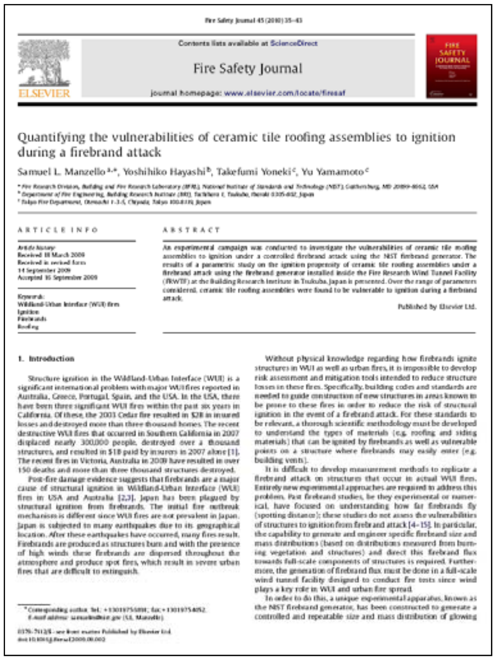
Recent Publications



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Fire Safety Journal

journal homepage: www.elsevier.com/locate/firesaf

Quantifying the vulnerabilities of ceramic tile roofing assemblies to ignition during a firebrand attack

Samuel L. Manzello[a,*], Yoshihiko Hayashi[b], Takefumi Yoneki[c], Yu Yamamoto[c]

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Firebrands
Roofing

ABSTRACT

An experimental campaign was conducted to investigate the vulnerabilities of ceramic tile roofing assemblies to ignition under a controlled firebrand attack using the NIST firebrand generator. The results of a parametric study on the ignition propensity of ceramic tile roofing assemblies under a firebrand attack using the firebrand generator installed inside the Fire Research Wind Tunnel Facility (FRWTF) at the Building Research Institute in Tsukuba, Japan is presented. Over the range of parameters considered, ceramic tile roofing assemblies were found to be vulnerable to ignition during a firebrand attack.

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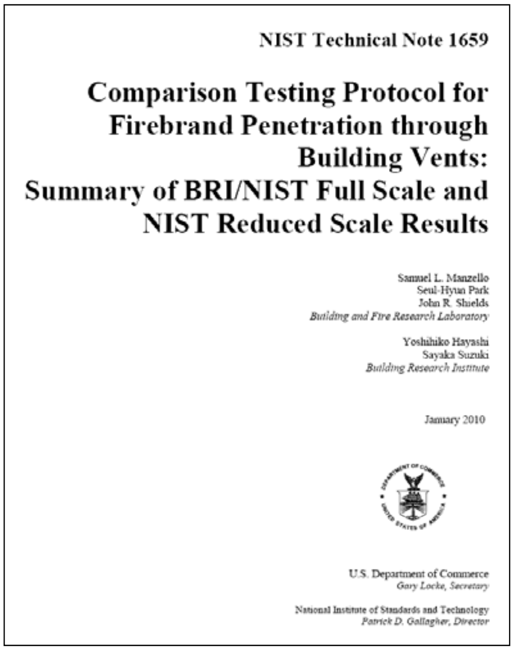
1. Introduction



NIST Technical Note 1659

Comparison Testing Protocol for
Firebrand Penetration through
Building Vents:
Summary of BRI/NIST Full Scale and
NIST Reduced Scale Results

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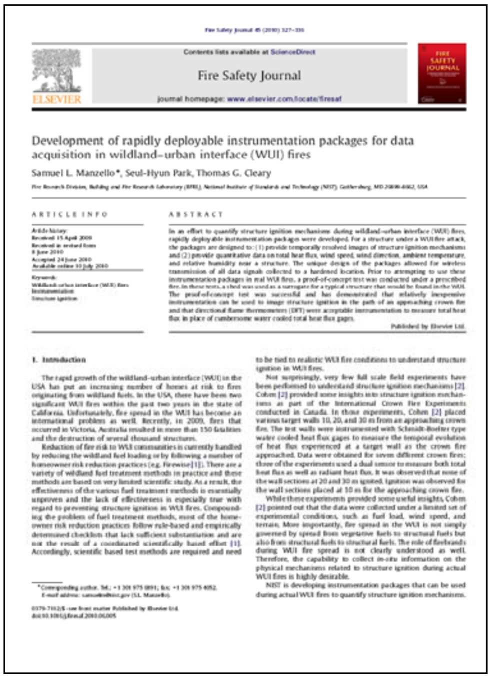
January 2010

U.S. Department of Commerce
Gary Locke, Secretary

National Institute of Standards and Technology
Patrick D. Gallagher, Director

Recent Publications



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ELSEVIER

Development of rapidly deployable instrumentation packages for data acquisition in wildland–urban interface (WUI) fires

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Keywords:
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Instrumentation
Structure ignition

ABSTRACT

In an effort to quantify structure ignition mechanisms during wildland–urban interface (WUI) fires, rapidly deployable instrumentation packages were developed. For a structure under a WUI fire attack, the packages are designed to: (1) provide temporally resolved images of structure ignition mechanisms and (2) provide quantitative data on total heat flux, wind speed, wind direction, ambient temperature, and relative humidity near a structure. The unique design of the packages allowed for wireless transmission of all data signals collected to a hardened location. Prior to attempting to use these instrumentation packages in real WUI fires, a proof-of-concept test was conducted under a prescribed fire. In these tests, a shed was used as a surrogate for a typical structure that would be found in the WUI. The proof-of-concept test was successful and has demonstrated that relatively inexpensive instrumentation can be used to image structure ignition in the path of an approaching crown fire and that directional flame thermometers (DFT) were acceptable instrumentation to measure total heat flux in place of cumbersome water cooled total heat flux gages.

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1. Introduction

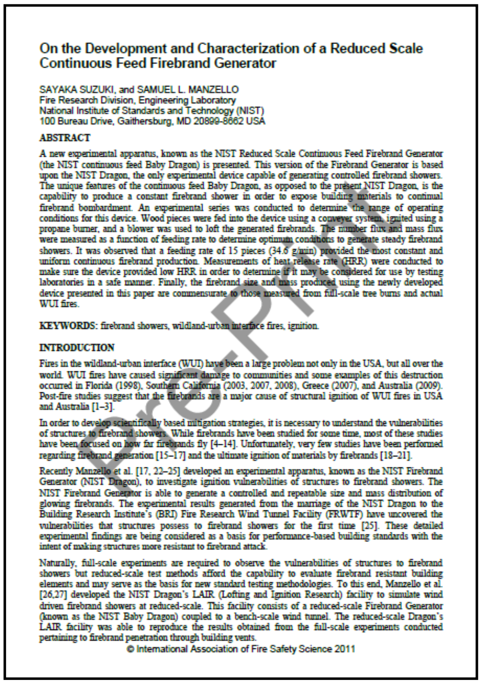
The rapid growth of the wildland–urban interface (WUI) in the USA has put an increasing number of homes at risk to fires originating from wildland fuels. In the USA, there have been two significant WUI fires within the past two years in the state of California. Unfortunately, fire spread in the WUI has become an international problem as well. Recently, in 2009, fires that occurred in Victoria, Australia resulted in more than 150 fatalities and the destruction of several thousand structures.

Reduction of fire risk to WUI communities is currently handled by reducing the wildland fuel loading or by following a number of homeowner risk reduction practices (e.g. Firewise [1]). There are a variety of wildland fuel treatment methods in practice and these methods are based on very limited scientific study. As a result, the effectiveness of the various fuel treatment methods is essentially unproven and the lack of effectiveness is especially true with regard to preventing structure ignition in WUI fires. Compounding the problem of fuel treatment methods, most of the homeowner risk reduction practices follow rule-based and empirically determined checklists that lack sufficient substantiation and are not the result of a coordinated scientifically based effort [1]. Accordingly, scientific based test methods are required and need to be tied to realistic WUI fire conditions to understand structure ignition in WUI fires.

Not surprisingly, very few full scale field experiments have been performed to understand structure ignition mechanisms [2]. Cohen [2] provided some insights into structure ignition mechanisms as part of the International Crown Fire Experiments conducted in Canada. In those experiments, Cohen [2] placed various target walls 10, 20, and 30 m from an approaching crown fire. The test walls were instrumented with Schmidt-Boelter type water cooled heat flux gages to measure the temporal evolution of heat flux experienced at a target wall as the crown fire approached. Data were obtained for seven different crown fires; three of the experiments used a dual sensor to measure both total heat flux as well as radiant heat flux. It was observed that none of the wall sections at 20 and 30 m ignited. Ignition was observed for the wall sections placed at 10 m for the approaching crown fire.

While these experiments provided some useful insights, Cohen [2] pointed out that the data were collected under a limited set of experimental conditions, such as fuel load, wind speed, and terrain. More importantly, fire spread in the WUI is not simply governed by spread from vegetative fuels to structural fuels but also from structural fuels to structural fuels. The role of firebrands during WUI fire spread is not clearly understood as well. Therefore, the capability to collect in-situ information on the physical mechanisms related to structure ignition during actual WUI fires is highly desirable.

NIST is developing instrumentation packages that can be used during actual WUI fires to quantify structure ignition mechanisms.



On the Development and Characterization of a Reduced Scale Continuous Feed Firebrand Generator

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ABSTRACT

A new experimental apparatus, known as the NIST Reduced Scale Continuous Feed Firebrand Generator (the NIST continuous feed Baby Dragon) is presented. This version of the Firebrand Generator is based upon the NIST Dragon, the only experimental device capable of generating controlled firebrand showers. The unique features of the continuous feed Baby Dragon, as opposed to the present NIST Dragon, is the capability to produce a constant firebrand shower in order to expose building materials to continual firebrand bombardment. An experimental series was conducted to determine the range of operating conditions for this device. Wood pieces were fed into the device using a conveyer system, ignited using a propane burner, and a blower was used to loft the generated firebrands. The number flux and mass flux were measured as a function of feeding rate to determine optimum conditions to generate steady firebrand showers. It was observed that a feeding rate of 15 pieces (34.6 g/min) provided the most constant and uniform continuous firebrand production. Measurements of heat release rate (HRR) were conducted to make sure the device provided low HRR in order to determine if it may be considered for use by testing laboratories in a safe manner. Finally, the firebrand size and mass produced using the newly developed device presented in this paper are commensurate to those measured from full-scale tree burns and actual WUI fires.

KEYWORDS: firebrand showers, wildland-urban interface fires, ignition.

INTRODUCTION

Fires in the wildland-urban interface (WUI) have been a large problem not only in the USA, but all over the world. WUI fires have caused significant damage to communities and some examples of this destruction occurred in Florida (1998), Southern California (2003, 2007, 2008), Greece (2007), and Australia (2009). Post-fire studies suggest that the firebrands are a major cause of structural ignition of WUI fires in USA and Australia [1–3].

In order to develop scientifically based mitigation strategies, it is necessary to understand the vulnerabilities of structures to firebrand showers. While firebrands have been studied for some time, most of these studies have been focused on how far firebrands fly [4–14]. Unfortunately, very few studies have been performed regarding firebrand generation [15–17] and the ultimate ignition of materials by firebrands [18–21].

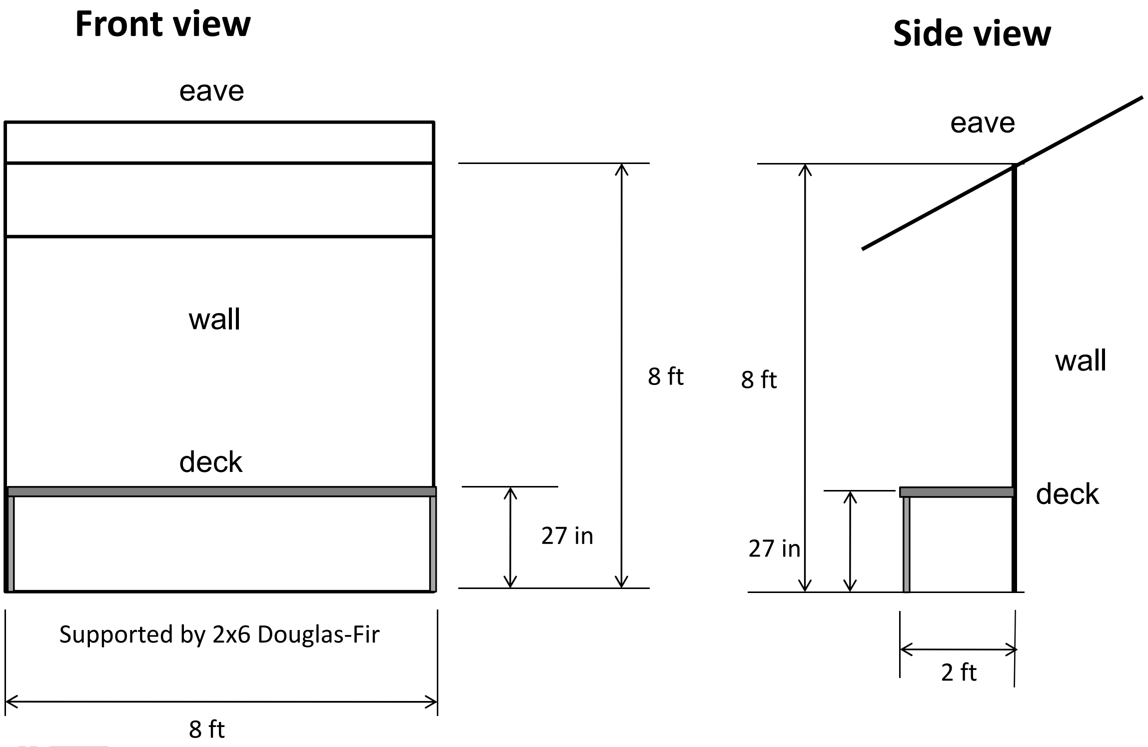
Recently Manzello et al. [17, 22–25] developed an experimental apparatus, known as the NIST Firebrand Generator (NIST Dragon), to investigate ignition vulnerabilities of structures to firebrand showers. The NIST Firebrand Generator is able to generate a controlled and repeatable size and mass distribution of glowing firebrands. The experimental results generated from the marriage of the NIST Dragon to the Building Research Institute's (BRI) Fire Research Wind Tunnel Facility (FRWTF) have uncovered the vulnerabilities that structures possess to firebrand showers for the first time [25]. These detailed experimental findings are being considered as a basis for performance-based building standards with the intent of making structures more resistant to firebrand attack.

Naturally, full-scale experiments are required to observe the vulnerabilities of structures to firebrand showers but reduced-scale test methods afford the capability to evaluate firebrand resistant building elements and may serve as the basis for new standard testing methodologies. To this end, Manzello et al. [26,27] developed the NIST Dragon's LAIR (Lofting and Ignition Research) facility to simulate wind driven firebrand showers at reduced-scale. This facility consists of a reduced-scale Firebrand Generator (known as the NIST Baby Dragon) coupled to a bench-scale wind tunnel. The reduced-scale Dragon's LAIR facility was able to reproduce the results obtained from the full-scale experiments conducted pertaining to firebrand penetration through building vents.

Summary

- NIST Dragon coupled to BRI's FRWTF
  - Capability to experimentally expose structures to wind driven firebrand showers for first time!
- Structure vulnerability experiments conducted for:
  - Roofing (cermaic/asphalt)
  - Vents/mesh (gable/different mesh sizes)
  - Siding (vinyl, polypropylene, cedar)
  - Eaves (open)
- NIST Dragon's LAIR Facility
  - Capability to expose materials/firebrand resistant technologies to wind driven firebrand showers
  - With newly developed Continuous Feed Baby Dragon, potential to evaluate and compare relative performance

Decking Vulnerabilities



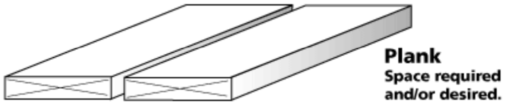
Wall with siding, decking and eave

Board Materials

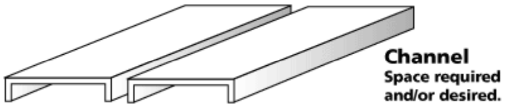
- Wood (treated wood or wood which is naturally resistant to decaying)
  - Treated pine
  - Cedar
  - Redwood
  - Ipé
- Composite
  - Wood/plastic
  - Fiber/PVC
- Plastic
- Metal

Profiles

Profiles---Depends on materials



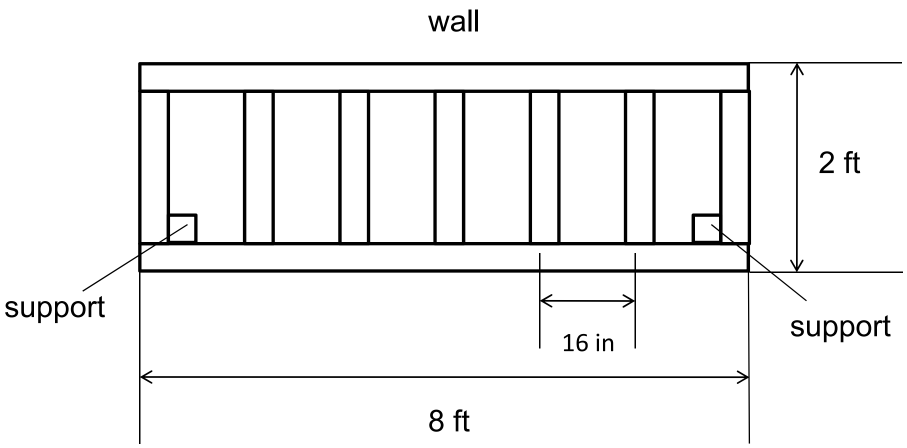
Plank ---wood or composite



Channel---composite

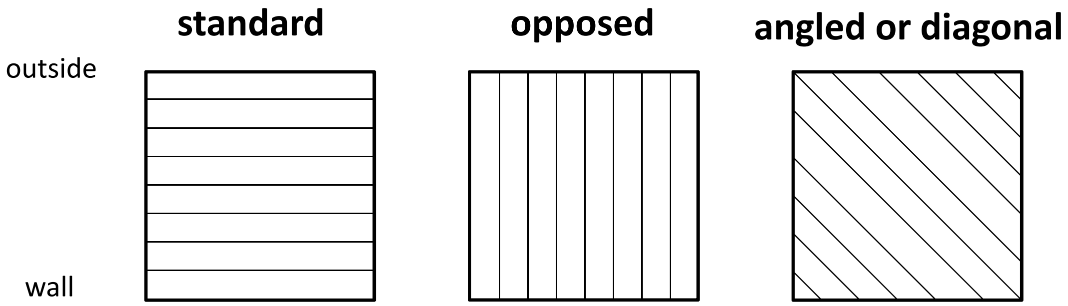
Spacing	**between boards**	5mm
	between board ends	1/8”
	between board and wall	1/4”

Framing



Made from 2 x 8

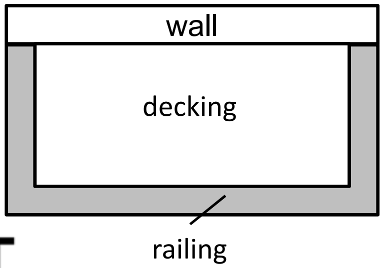
Patterns

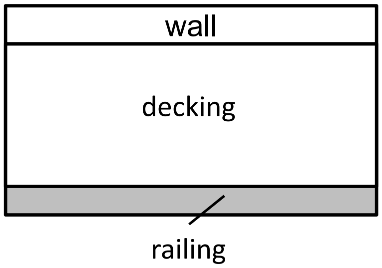


Which pattern is the easiest for firebrands to be stuck with? Or no difference?

Railing

- Railing is needed??
- If yes,
  - surface of deck is 30 inches above the ground
  - railing is 36 inches above the surface of deck
  - a sphere with a diameter of 4 inches cannot pass through the space between each rail or any gaps





Appendix 3

SFM STANDARD 12-7A-4

12-7A-4.1 Application. The minimum design, construction and performance standards set forth herein for unloaded decks are those deemed necessary to establish conformance to the provisions of these regulations. Materials and assemblies that meet the performance criteria of this standard are acceptable for use as defined in *California Building Standards Code*.

12-7A-4.2 Scope. This standard evaluates the performance of decks (or other horizontal ancillary structures in close proximity to primary structures) when exposed to direct flames and brands. The under-deck flame exposure test is intended to determine the heat release rate (HRR) and degradation modes of deck or other horizontal boards when exposed to a burner flame simulating combustibles beneath a deck. The burning brand exposure test is intended to determine the degradation modes of deck or other horizontal boards when exposed to a burning brand on the upper surface.

12-7A-4.3 Referenced document.

1. ASTM D 4444, Test Methods for Use and Calibration of Hand-Held Moisture Meters.

2. ASTM E 108, Test Methods for Fire Tests of Roof Coverings.

3. *California Building Code*, Chapter 7A.

4. UL 790, Standard Test Methods for Fire Tests of Roof Coverings.

12-7A-4.4 Definitions.

1. **Deck boards.** Horizontal members that constitute the exposed surface of the ancillary structure.

2. **Deck surface area.** The test specimen area defined by the overall specimen length and width after assembly.

3. **Heat release rate.** The net rate of energy release as measured by oxygen depletion calorimetry.

12-7A-4.5 Test assembly.

1. **Size.** The overall size of the test deck shall be nominally 24 x 24 inches (610 x 610 mm) unless width variation of deck boards requires an increase in overall deck width (i.e., the direction of joists) in order to meet the overall dimensions. The length of individual deck boards shall be 24 inches (610 mm).

2. **Joists.** The deck is supported by two nominal 2 x 6 Douglas-fir joists running perpendicular to the deck boards, and constructed with a 16-inch (406 mm) center-to-center spacing. A comparable species that may be more commonly used for structural framing of decks in a given region can be substituted for Douglas-fir.

3. **Deck board spacing and fastening.** Edge-to-edge spacing and method of attachment shall conform to the manufacturer's installation recommendations. The front deck board shall be flush with the ends of the joists, and the rear deck board shall overhang the end of the joists by 1 inch (25 mm).

> 3.1. In the absence of recommended installation guidance, the edge-to-edge spacing shall be $^{3}/_{16}$ inch (5 mm) with boards mechanically attached to the joists using deck screws.
>
> 3.2. If nominal 6-inch-wide deck boards are used, a total of 5 boards shall be used for each deck. Changing the board width could change the number of deck boards.

12-7A-4.6 Materials.

1. **Cross-sectional dimension.** All deck board materials are to have cross-sectional dimensions equivalent to use in service.

2. **Description.** The material under test should be described as completely as possible (unit weight, thickness, width, and general information regarding composition).

3. **Condition of test material.** Prior to testing, all materials (deck boards and joist material) shall be conditioned to a constant weight or for a minimum of 30 days at 73 ± 4 °F (23 ± 2 °C) and 50 ± 5 % relative humidity, whichever occurs first. Constant weight shall be defined as occurring when the change in test material weight is less than or equal to 2 percent in a 24-hour period.

12-7A-4.7 PART A. Under-deck flame test.

12-7A-4.7.1 Equipment.

1. **Burner.** A 12 x 12 inch (300 x 300 mm) sand diffusion burner shall be used. Natural gas, methane or propane shall be supplied to the burner through a metered control system. The gas supply to the burner shall produce a net heat output of 80 ± 4 kW throughout the flame exposure. Burner output can be determined from HRR or calculated from the gas flow rate, temperature, and pressure.

2. **Oxygen depletion calorimeter.** The equipment shall include a hood, associated ducting, and instrumentation to provide HRR data by oxygen depletion calorimetry.

12-7A-4.7.2 Test system preparation. See Figure No. 1.

1. **Deck support assembly.** The assembly that holds the test deck over the burner.

2. **Baffle panels and joist support.** Horizontal metal plates to support the deck joists along their

full length, and also to confine burner flames to the underside of the deck boards located between the support joists.

3. **Back wall.** Ceramic fiber board or another noncombustible panel product for the back wall material. Total height of the back wall shall be 8 feet (2.4 m).

4. **Ledger board.** A 4-foot-long (1.2 m) simulated 2 x 6 ledger board shall be constructed of layers of ceramic fiber board (or other noncombustible panel product) and attached to the wall at a height slightly below the overhang of the rear deck board of the test deck.

12-7A-4.7.3 Conduct of tests.

1. **Airflow.** The test shall be conducted under conditions of ambient airflow.

2. **Number of tests.** Conduct the test on three replicate assemblies.

3. **Burner output verification.** Without a deck in the apparatus, set the output of the burner to 80 ± 4 kW. Conduct a verification run of 3 minutes to ensure the heat release rate, and then turn off the burner.

4. **Measurement of heat release rate.** HRR is measured during the tests with a properly calibrated oxygen depletion calorimeter. Since HRR is typically a post-test analysis, this criterion for Acceptance may be determined at the end of the test.

5. **Burner positioning.** Center the burner directly under the middle deck board, midway between the joists. The distance from the top of the burner to the bottom of the deck boards shall be 27 inches (690 mm).

6. **Moisture content.** Measure the moisture content of the wooden members of the assembly using a moisture meter (ASTM D 4444).

7. **Procedure.**

    7.1 **Ignition.** Ignite the burner, controlling for a constant 80 ± 4 kW output.

    7.2. **Flame exposure.** Continue the exposure for a 3-minute period. Extinguish the burner.

    7.3. **Continued combustion.** Continue observation for an additional 40 minutes or until all combustion has ceased.

8. **Observations.** Note physical changes of the deck boards during the test, including structural failure of any deck board, location of flaming and glowing ignition, and loss of material (i.e., flaming drops of particles falling from the deck). It is desirable to capture the entire test with a video recorder to allow review of the details of performance.

12-7A-4.7.4 Report. The report shall include a description of the deck board material and the time of any degradation (effective net peak heat release rate, structural failure, flaming drops or particles falling from the deck) during the test.

1. **Calculated rate of heat release.** The effective net peak heat release rate (HRR) shall be calculated as follows:

> 1.1. During the first 5 minutes of the test (the 3 minutes during which the ignition source burner is operating and the immediately following 2 minutes) the effective net peak HRR of the test assembly shall be reported as: effective net peak HRR = (peak heat release rate - 80 kW) / (deck surface area).
>
> 1.2. During the remaining test duration the effective net peak heat release rate of the test assembly shall be reported as: effective net peak HRR = (peak heat release rate) / (deck surface area)

12-7A-4.7.5 Conditions of Acceptance. Should one of the three replicates fail to meet the Conditions of Acceptance, three additional tests may be run. All of the additional tests must meet the Conditions of Acceptance.

1. Effective net peak heat release rate of less than or equal to 25 kW/ft^2 (269 kW/m^2).

2. Absence of sustained flaming or glowing combustion of any kind at the conclusion of the 40-minute observation period.

3. Absence of falling particles that are still burining when reaching the burner or floor.

12-7A-4.8 PART B. Burning brand exposure.

12-7A-4.8.1 Equipment.

1. **Wind tunnel.** The wind tunnel shall have the capability of providing 12 mph (5.4 m/s) airflow over the deck assembly.

2. **Anemometer.** Device for measuring airflow across the deck.

3. **Burner.** Gas-fueled burner for brand ignition.

12-7A-4.8.2 Test system preparation. See Figure 2. The ASTM E 108 "A" brand roof test apparatus is to be used, with the following modifications:

1. **Deck support.** The deck shall be supported horizontally with the center 60 inches (150 mm) from the front opening of the wind tunnel and the joists parallel to the airflow and resting on two transverse metal supports. The top surfaces of these supports, no more than 3 inches (75 mm) wide, are at the same height as the floor of the wind tunnel.

2. **Fragments.** Burning fragments shall be free to fall to the floor of the room.

12-7A-4.8.3 Conduct of tests.

1. **Number of tests.** Conduct the test on three replicate assemblies.

2. **Moisture content.** Measure the moisture content of the wooden members of the assembly using a moisture meter (ASTM D 4444).

3. **Procedure.** Adhere to ASTM E 108 "Standard Test Methods for Fire Tests of Roof Coverings" (burning brand test, "A" brand), with apparatus modified as described above in "Test system preparation" and the following procedure:

> 3.1 The air velocity shall be calibrated using the 60-inch (1.5 m) framework spacing, with a smooth noncombustible calibration deck at a 5-inch per 12-inch horizontal incline positioned 60 inches (1.5 m) from the front opening of the wind tunnel. All other measurement details shall be followed as specified in Sections 4.4.2, 4.4.3, and 4.4.4 of ASTM E 108. Although ASTM E 108 specifies calibration to be conducted with the 33-inch (840-mm) framework spacing used for the intermittent flame test set up, tests have shown that at the nominal 12 mph setting, there was not difference in measured velocity between the 33- and 60-inch framework spacing.
>
> 3.2 Mount the test specimen at a zero horizontal incline positioned 60 inches (1.5 m) from the front opening of the wind tunnel.
>
> 3.3 Ignite the "A" brands as specified in Section 9.4 of ASTM E 108 as reprinted here:
> 1. Each 12- x 12-inch (300 x 300 mm) face for 30 seconds.
> 2. Each 2.25- x 12-inch (57 x 300 mm) edge for 45 seconds.
> 3. Each 12- x 12-inch (300 x 300 mm) face again for 30 seconds.
>
> 3.4 Center the burning brand laterally on the deck with the front edge 2.5 inches (64 mm) from the entering air edge of the deck.
> 3.5 Continue the exposure for a 40-minute period or until all combustion of the deck boards ceases. The test shall be terminated immediately if flaming combustion accelerates uncontrollably (runaway combustion) or structural failure of any deck board occurs.
>
> Heat Release Rate is not monitored because of the impracticability with the specified airflow.

4. **Observations.** Note physical changes of the deck boards during the test, including deformation from the horizontal plane, location of flaming and glowing combustion, and loss of material (i.e., flaming drops of particles falling from the deck). It is desirable to capture the entire test with a video recorder to allow review of the details of performance.

12-7A-4.8.4 Report. The report shall include description of the deck board material, and the time of any degradation (accelerated combustion, board collapse, flaming drops or particles falling from the deck).

12-7A-4.8.5 Conditions of Acceptance. Should one of the three replicates fail to meet the

Conditions of Acceptance, three additional tests may be run. All of the additional tests must meet the Conditions of Acceptance:

1. Absence of sustained flaming or glowing combustion of any kind at the conclusion of the 40-minute observation period.

2. Absence of falling particles that are still burning when reaching the burner or floor.

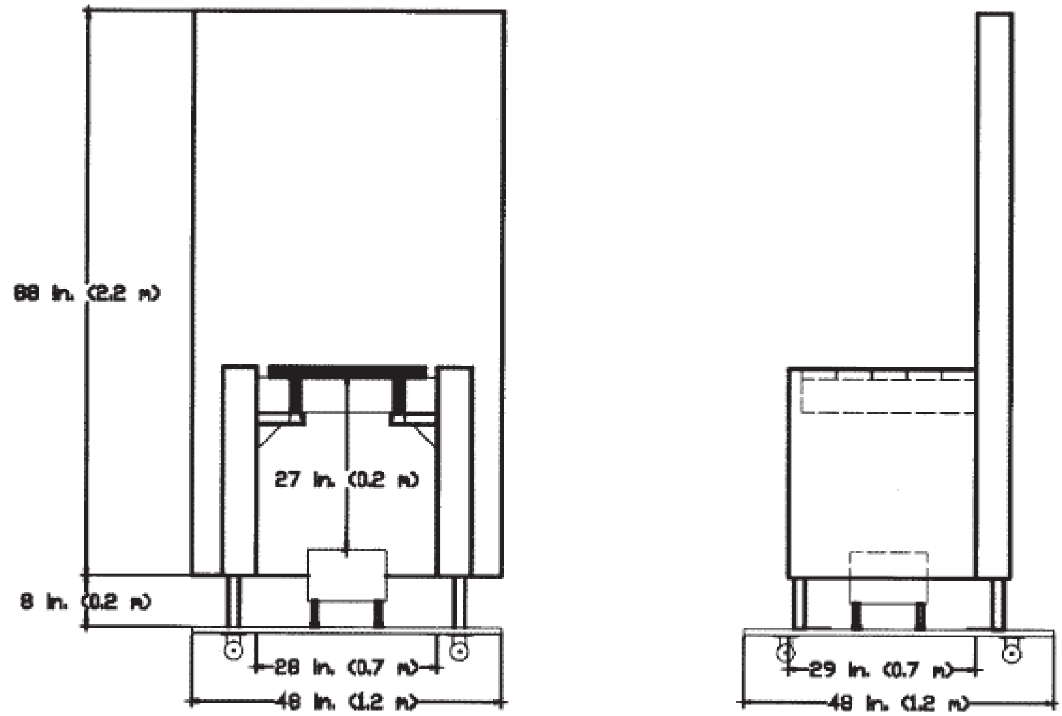


FIGURE 1. DECK TEST ASSEMBLY (UNDER DECK-FLAME)

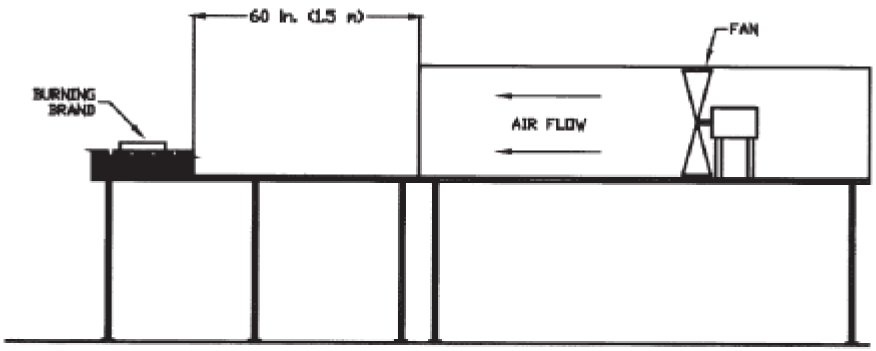


FIGURE 2. DECK TEST ASSEMBLY (BURNING-BRAND)