



# UL FLAMMABILITY – WHAT IT MEANS IN THE UL PRODUCT RECOGNITION PROCESS

Ralph Buoniconti, SABIC, Pittsfield, MA

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A decorative graphic at the bottom of the slide features two overlapping, wavy lines. The top line is yellow and the bottom line is blue, both curving across the width of the slide.

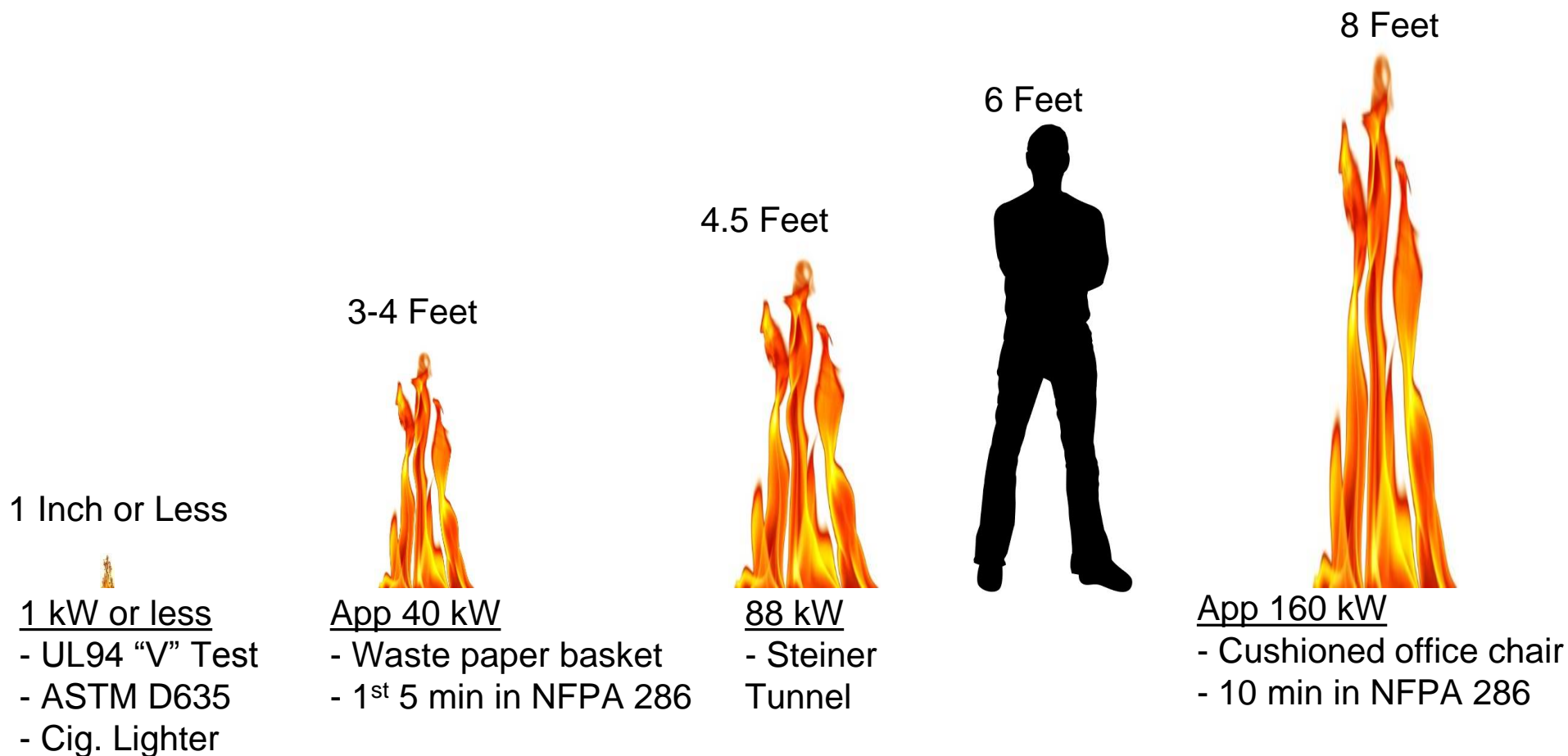
CHEMISTRY THAT MATTERS™

# TOPICS

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- Scale of fire tests
- UL standards & material properties
- Determining risk of fire and steps taken to mitigate effects
- Pre-selection testing
- Focus on UL 94 V Test

## RELATIVE SCALE OF SOME FIRE TESTS



**Smaller Tests Can Be Appropriate Based On Threat**

UNDERWRITERS  
LABORATORIES  
METHODOLOGY

# USE OF STANDARDS - RECOGNITION/COMPLIANCE

## Underwriters Laboratories, Inc<sup>†</sup>

### End products

- End Product Standards (PCs, copiers, phones, dishwashers, etc.)
- UL746C (Electrical Enclosures, Barriers, etc.)
- Material Pre-selection Guidance

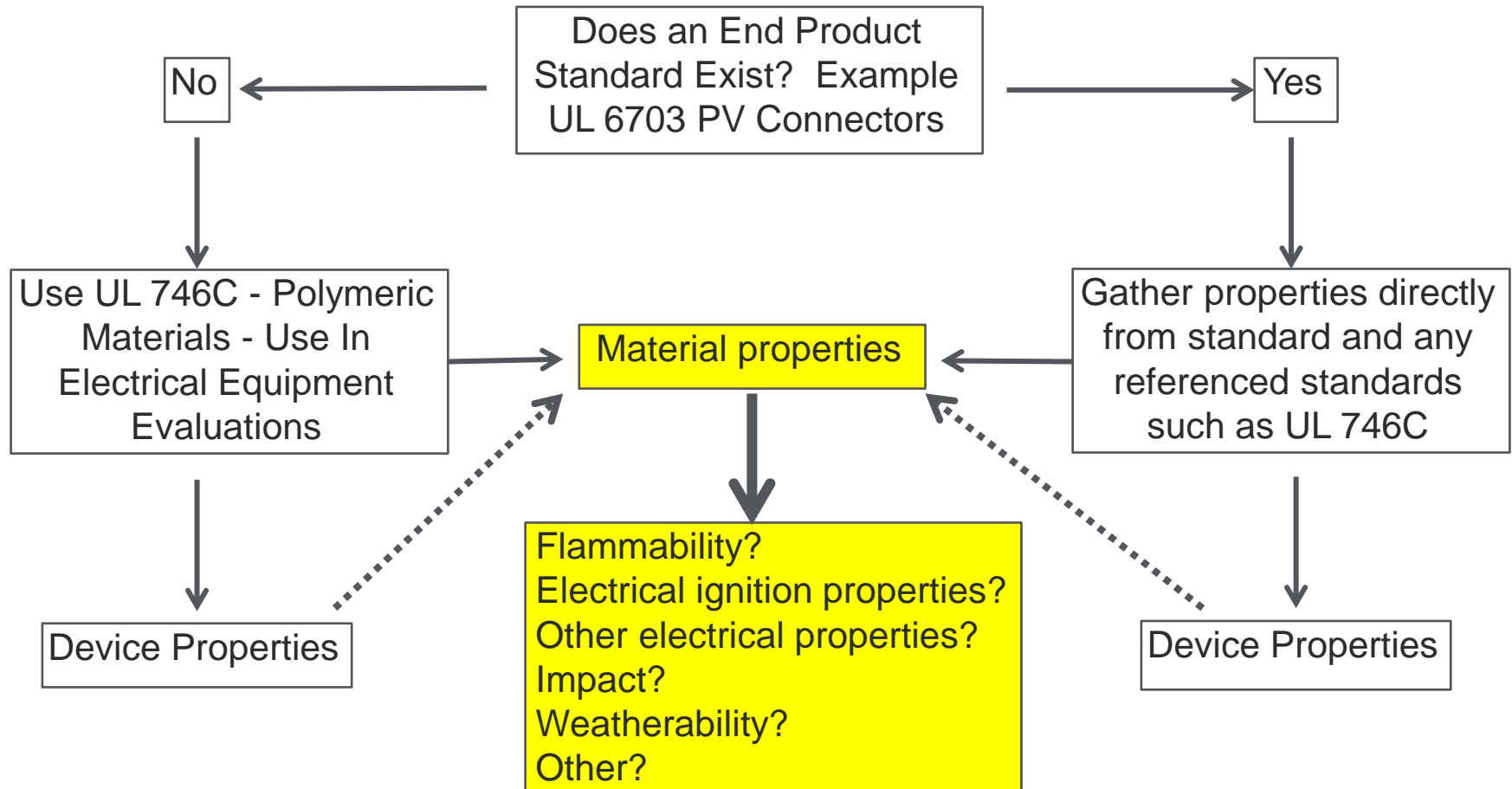
### Polymeric Materials

- UL 94 (Flammability)
- UL 746A (short-term properties)
- UL746B (long-term properties)
- UL746C (Use of polymer mat'ls in electrical equipment)
- UL746D (Finished Parts)

### Recognition, Listing, & Compliance

- Recognition Files (Organization, Control & Maintenance)
- Factory ID
- Follow-up Service - compliance to current recognition
- Publicly available information

# HOW UL DETERMINES PROPERTIES OF A PLASTIC PART IN ELECTRICAL EQUIPMENT



**Flammability of materials is a concern when there is a “Risk of Fire”**

## IS THERE A RISK OF FIRE? ... PER UL 746C, PAR. 3.34

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- 3.34 Risk Of Fire** – A risk of fire is considered to exist at any two points in a circuit where:
- The open circuit voltage is more than 42.4 V peak and the energy available to the circuit under any condition of load, including short circuit, results in a current of 8 A or more after one minute of operation, or
  - A power of more than 15 watts can be delivered into an external resistor connected between the two points.

**Then, UL 746C takes steps to mitigate the effect of a fire:**

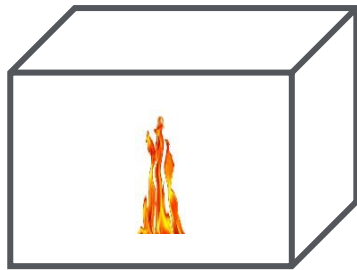
- Limits ignitability of materials
- Limits spread of flame, if ignition occurs
- Reduces chance of flame breaching certain enclosures

**Underlying assumption: A small fire of electrical origin will happen.  
Tries to keep fire from growing out of control.**

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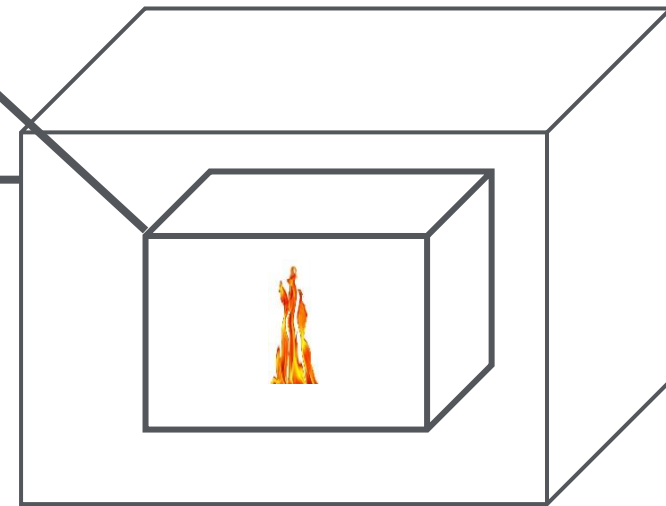
# FIRE/SHOCK RISKS NEED AN ENCLOSURE\*

Can be single “box”



- 1) “Primary” safety enclosure – fire and/or shock
- 2) “Secondary” enclosure: keep out the elements (water, UV), prevent accidental contact, provide insulation/grounding, as needed.

Or, “box-within-box”



\* Defined term in UL 746C



# UL746C POLYMERIC ENCLOSURE FLAMMABILITY REQUIREMENTS

Application	Minimum Flame Rating	Alternative Testing**
Portable* Attended* Household* Equipment	UL 94 HB	- GWIT per par. 3.20 of at least 575°C or a GWFI per par. 3.21 of at least 550°C, or - enclosure complies with 12 mm or 20 mm end-product flame tests per Sections 15 and 16 respectively
All other Portable Equipment	UL 94 V (V-0, V-1, or V-2)	- Enclosure complies with 12 mm or 20 mm end-product flame tests per Sections 15 and 16 respectively. - Exception: An HB enclosure material may be used in portable unattended household equipment that complies with the criteria specified in Section 5.
All other Equipment	UL 94 5VA	-Enclosure complies with 127 mm end-product flame tests per Section 17

\* - Defined terms in UL 746C

\*\* - If area > 10 ft<sup>2</sup>, then spread of flame per UL 723 (similar to ASTM E84) or ASTM E162 (Radiant Panel) See section 19.

**UL 94 tests are “pre-selection tests” for alternative end product tests.... a hallmark of UL flammability methodology**

## END PRODUCT TESTS FOR UL 94 V & 5V TESTING

Test Name/Section	Criteria	Details
12 mm flame per Section 15 and 20 mm flame per Section 16	<ul style="list-style-type: none"> <li>- Not flame for more than 1 minute after either of two 30-second applications of test flame, with an interval of 1 minute between</li> <li>- Not be completely consumed</li> </ul>	<ul style="list-style-type: none"> <li>- Tested on inside, if possible, near sources of ignitions</li> <li>- 3 samples tested</li> <li>- If 1 fails, another set of 3 must pass.</li> <li>- Internal components are left in place, if possible</li> </ul>
127 mm (5 inch) flame per section 17	<ul style="list-style-type: none"> <li>- Not flame for more than 1 minute after fifth 5-second flame application, with interval of 5 seconds between</li> <li>- No drops igniting cotton</li> <li>- No flame on protected side or &gt; 3mm hole formation</li> </ul>	<u>Same as above</u>

### Can be cumbersome:

- Actual equipment tested
- Change in internal design, shape, thickness, etc. could prompt re-testing
- Equipment manufacturer responsible for flame testing

**Complications associated with end-product flame testing tend to cause OEMs to look for materials with pre-selection (UL 94V / 5V) test ratings**

## HOW UL 746C USES FLAMMABILITY WITH “IGNITABILITY”

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**Insulation / Support of Live Parts:** Live parts in close proximity\*\* to combustible materials prompt additional “ignitability” tests

Flame	HWI	HAI
HB	2	1
V-2	2	2
V-1	3	2
V-0	4	3

HWI = Hot Wire Ignition. Measure of ignition resistance when exposed to heated wire.

HAI = High-current Arc Ignition. Measure of ignition resistance when exposed to electrical arcs

\*\* 9 generalized diagrams in UL 746C to define when these test may be needed

**HWI and HAI are pre-selection tests with their own end-product test alternatives.**

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# UL 94 TESTING – FOCUSSING ON “V” TEST

# UL94 SMALL SCALE FLAMMABILITY – RELATIVE COMPARISON

**HB**

Generally used in “lowest concern” areas: decorative trim, enclosures for attended household items (ex., hair dryer), etc.

Materials can burn to completion

**VTM series -**  
VTM-2  
VTM-1  
VTM-0

Thin films only – usually 0.010” or less – electrical insulation or “barrier films”. Never used for Enclosures.

Materials must either  
a) Not ignite, or  
b) Main specimen (excluding drips) must extinguish during test  
Note: Some ratings = no flaming drips

**V series -**  
V-2  
V-1  
V-0

Usually found in “higher concern” areas: enclosures for un-attended household items, commercial items, material directly supporting live parts, electrical insulation, etc. The specific V-0, V-1, or V-2 requirement is either based upon end-product Standard or product design evaluation taking into account additional material “ignitability” properties.

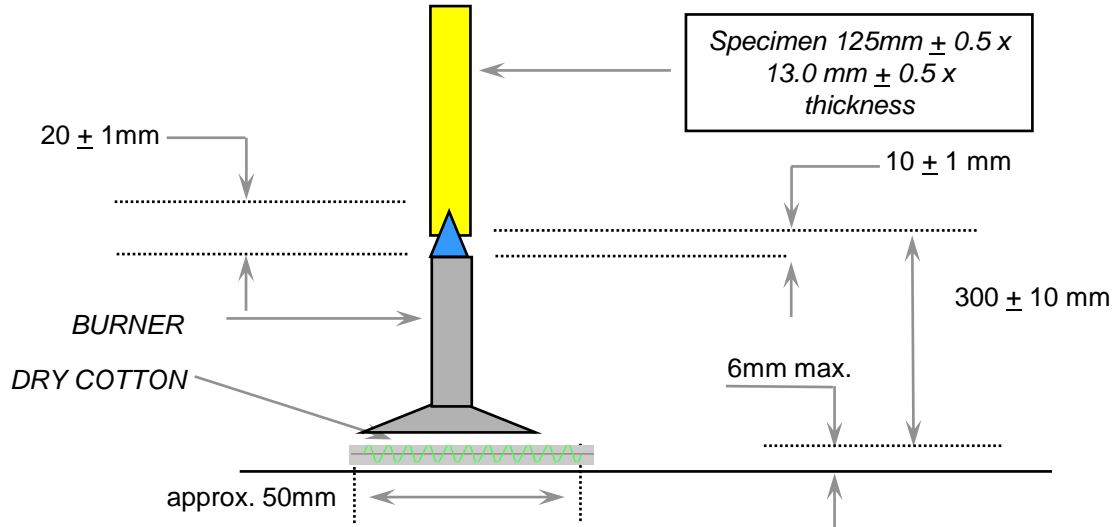
**5V --**  
5VB  
5VA

Usually found in “highest concern” areas: enclosures in stationary or “fixed” equipment. A or B requirement is function of product design. Products now need to be V-0 or V-1, before a 5VA or 5VB rating is granted.

Increasing In Severity (Generally)

See appendix for details on HB, VTM, and 5V tests.

# THE UL 94V TEST



## CONDITIONING

- Two sets of five specimens at  $23 \pm 2^\circ\text{C}/50 \pm 5\% \text{RH}/48 \text{ hrs.}$
- Two sets of five specimens at  $70 \pm 1^\circ\text{C}$  for seven days and cooled in desiccator for 4 hours.
- Lab atmosphere of  $15\text{-}35^\circ\text{F}/45\text{-}75\% \text{RH.}$

## PROCEDURE

- Calibrate flame.
- Two 10-second applications of flame.
- If flaming of the first application ceases, immediately reapply flame.
- If only 1 out of 5 fails, re-test another set of 5. All must pass

Criteria	94V-0	94V-1	94V-2
After flame time for each individual specimen $t_1$ or $t_2$ .	$\leq 10\text{s}$	$\leq 30\text{s}$	$\leq 30\text{s}$
Total afterflame time for any condition set ( $t_1$ plus $t_2$ for the 5 specimens)	$\leq 50\text{s}$	$\leq 250\text{s}$	$\leq 250\text{s}$
Afterflame plus afterglow time for each individual specimen after the second flame application ( $t_2 + t_3$ )	$\leq 30\text{s}$	$\leq 60\text{s}$	$\leq 60\text{s}$
Afterflame or afterglow of any specimen up to the holding clamp	No	No	No
Cotton indicator ignited by flaming particles or drops	No	No	Yes

## TO BE LISTED AS V-0, TEST SPECIMENS MUST...

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- Not ignite during V test, or
- Ignite but extinguish during the test

AND

- Not drip during test, or
- Drip but not ignite cotton

### Key Wording is “During the Test”

- Pitfalls exist if too much is assumed from test results
- A “V-0” rating does not mean the material is “self extinguishing”
- Example: Bar of basic magnesium can be V-0 based on not igniting during test. When ignited, it is not self extinguishing

**A V-0 listing means a V-0 test has been met, not that the material has flame retardant additives**

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## SPECIMEN REACTION-TO-FIRE BEHAVIOR: V-0 AND V-2

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V-2 & V-0 fire behaviors can be very similar:

- 0 sec. Burn time, dripping with no cotton ignition = V-0
- 0 sec. Burn time, one drip igniting cotton = V-2

Also can be very far apart:

- 0 sec. Burn time, dripping with no cotton ignition = V-0
- 0 sec avg. Burn times, continuous flaming dripping = V-2
- 20 sec avg. Burn times, continuous flaming dripping = V-2

**V-2 criteria allows for a wide range of reaction-to-fire behavior, including a “pool” fire provided the bar drips to extinguishment**

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## NO SUCH THING AS A “V-0 MATERIAL”

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- Materials listed at specific thicknesses
- Materials listed in specific colors, or an “All-Color” listing
- UL uses “Bracketing” methods for product variables (including thickness & pigment levels)
- Formulations are “fingerprinted”, variations must follow specific guidelines which can lead to re-testing
- Follow-up testing is done for specific properties

**Plastics recognitions are maintained through testing  
and most are freely available on UL’s website**

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## SUMMARY

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Small scale reaction-to-fire tests can be informative, based on threat

UL methodology focuses on reducing certain risks in end products

UL standards often allow “pre-selection” material tests to avoid end-product testing

Understanding the nuances of the “V” test ratings and how UL standards use the ratings will aid in making better judgments of their suitability beyond UL standards

Any material’s “V, 5V, HB, or VTM” rating is based on thickness, color, and other variables. If one seeks a correlation test, understand the boundaries of the correlation

**Knowing the details helps to make better decisions**

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**Thank you for  
attending.**

# DISCLAIMER

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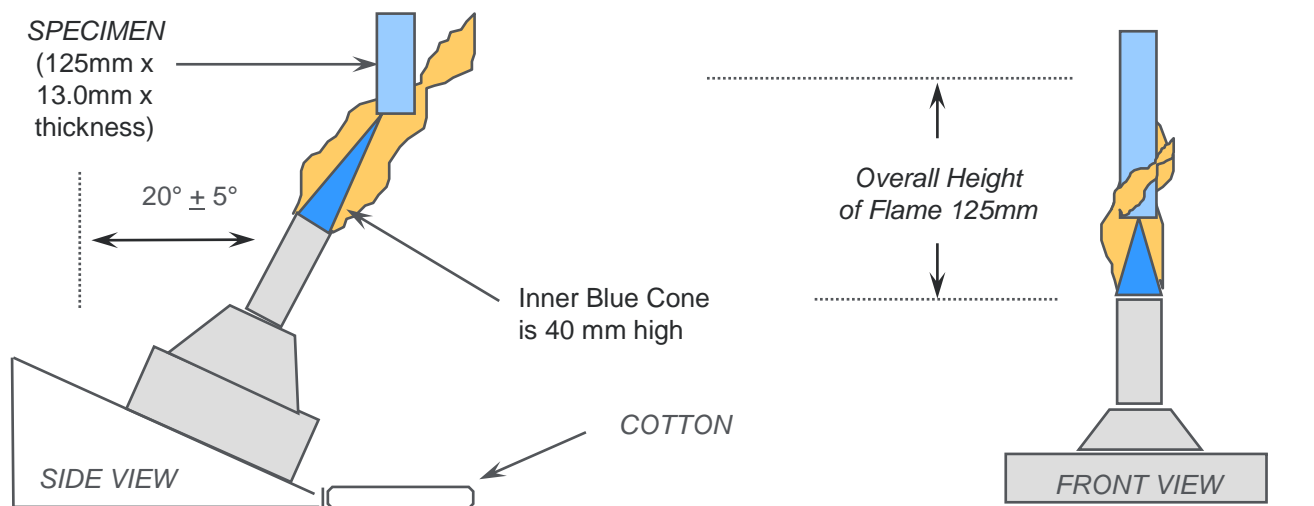
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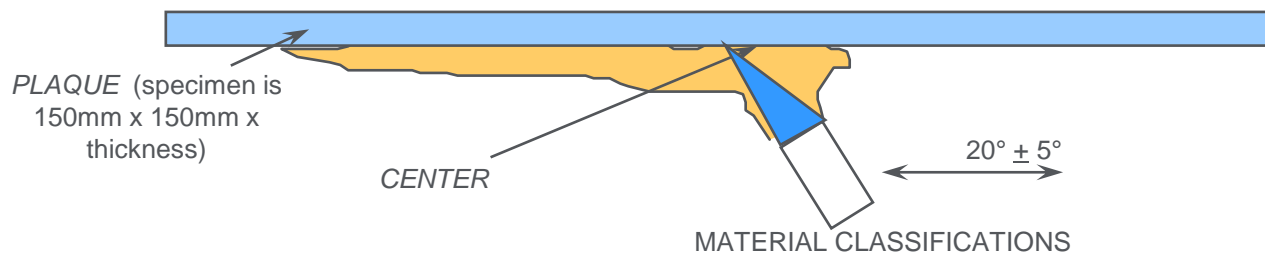
# APPENDIX

# VERTICAL BURNING TEST FOR 94-5VA, B CLASSIFICATION



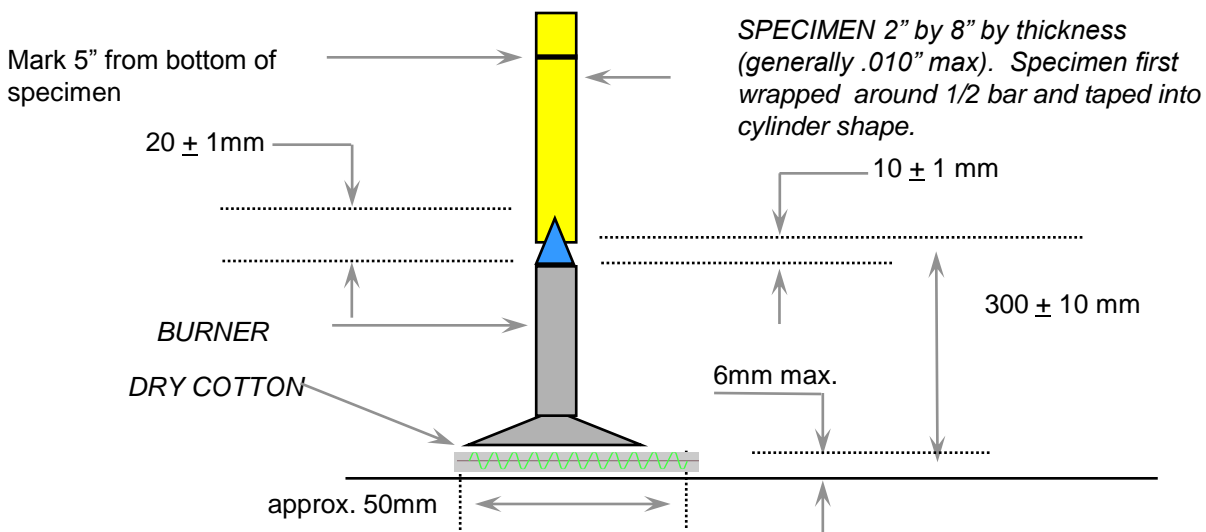
- CONDITIONING**
- Two-day and seven-day
- PROCEDURE**
- Calibrate flame temp; test flame bars.
  - Five/5-second applications of flame
  - Test plaques to establish A or B rating.

## VERTICAL BURNING TEST FOR 94-5VA, B CLASSIFICATION - PLAQUE SPECIMENS



Criteria Conditions	94-5VA	94-5VB
Afterflame plus afterglow time after the fifth flame application for each individual bar specimen	≤ 60s	≤ 60
Cotton indicator ignited by flaming particles or drops from any bar specimen	No	No
Burn-through (hole) of any plaque specimen	No	Yes

# VERTICAL BURNING TEST FOR 94VTM-0, -1, -2



## CONDITIONING

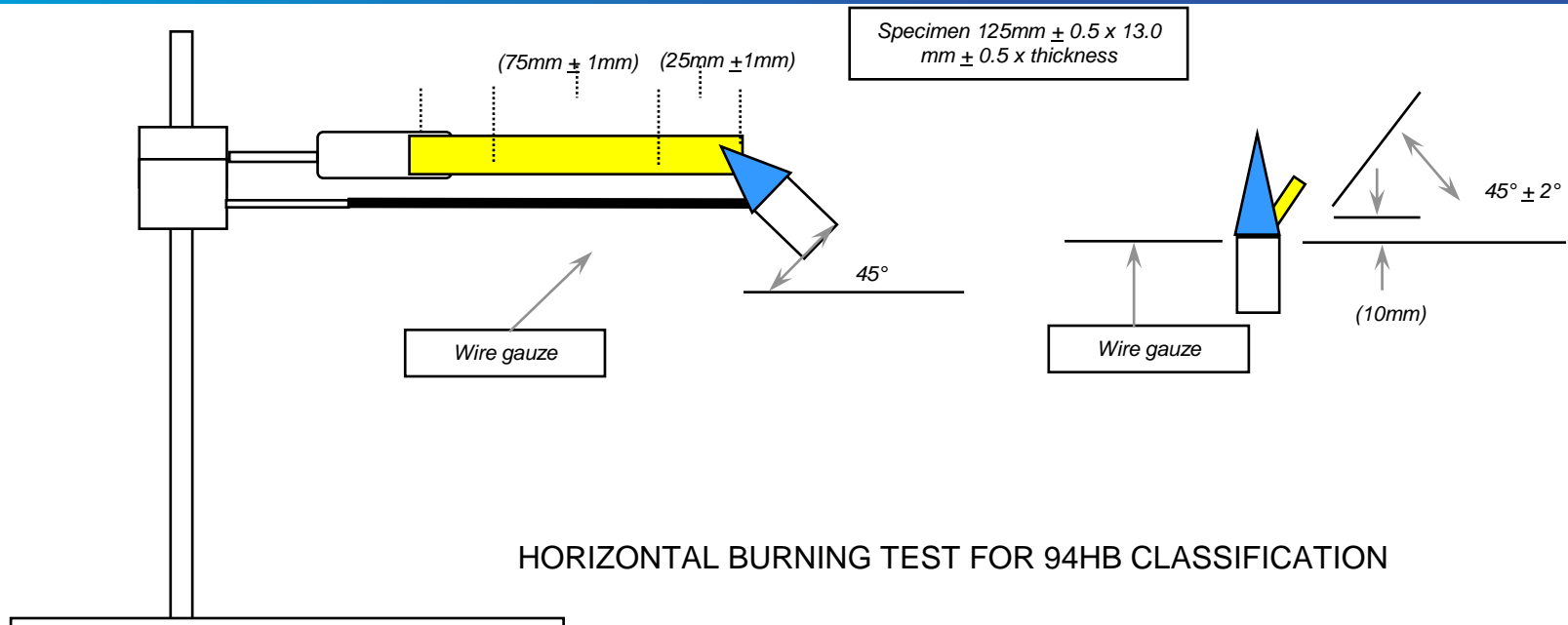
- Two sets of five specimens at  $23 \pm 2^\circ\text{C}/50 \pm 5\%$  RH/48 hrs.
- Two sets of five specimens at  $70 \pm 1^\circ\text{C}$  for seven days and cooled in desiccator for 4 hours.
- Lab atmosphere of 15-35°F/45-75% RH.

## PROCEDURE

- Calibrate flame.
- Two 3-second applications of flame.
- If flaming of the first application ceases, immediately reapply flame.
- If only 1 out of 5 fails, re-test another set of 5. All must pass

Criteria Conditions	94VTM-0	94VTM-1	94VTM-2
After flame time for each individual specimen $t_1$ or $t_2$ .	$\leq 10\text{s}$	$\leq 30\text{s}$	$\leq 30\text{s}$
Total afterflame time for any condition set ( $t_1$ plus $t_2$ for the 5 specimens)	$\leq 50\text{s}$	$\leq 250\text{s}$	$\leq 250\text{s}$
Afterflame plus afterglow time for each individual specimen after the second flame application ( $t_2 + t_3$ )	$\leq 30\text{s}$	$\leq 60\text{s}$	$\leq 60\text{s}$
Afterflame or afterglow of any specimen up to the 5" mark	No	No	No
Cotton indicator ignited by flaming particles or drops	No	No	Yes

# HORIZONTAL BURNING TEST FOR 94HB CLASSIFICATION



**CONDITIONING** - Specimens conditioned at  $23 \pm 2^\circ\text{C}$  and  $50 \pm 5$  percent RH for a minimum of 48 hours.

## **PROCEDURE**

- Three specimens tested.
- Flame applied for  $30 \pm 1$  seconds or until combustion front reaches 25mm reference mark.
- Flame spread is timed.

## **A material classed 94HB shall:**

- a) Not have a burning rate exceeding 40 mm per minute over a 75 mm span for specimens having a thickness of 3.0-13.0 mm, OR
- b) Not have a burning rate exceeding 75 mm per minute over a 75 mm span for specimens having a thickness less than 3.0 mm, OR
- c) Cease to burn before the 100 mm reference mark.