MEETING LOG

SUBJECT: Organohalogen Flame Retardants (OFRs) in Electronic Device Casings Tech-to-Tech Meeting

LOCATION: CPSC National Product Testing and Evaluation Center (NPTEC), 5 Research Place, Rockville, MD 20850

DATE: September 27, 2018

ENTRY DATE: September 28, 2018

LOG ENTRY SOURCE: Jacqueline Campbell

COMMISSION ATTENDEES: Kristina Hatlelid, David Miller, Andrew Trotta, Joel Recht, Barbara Little, Matthew Dreyfus, Alice Thaler, Huy Le, Simon Lee, Jay Kadiwala, Yeon Seok Kim, Mike Babich, Xinrong Chen, Steven Hanway, George Borlase, Patricia Pollitzer, Gib Mullan, Dorothy Yahr, Stephanie Synnott

NON-COMMISSION ATTENDEES: See attached attendee list.

MEETING SUMMARY:
The U.S. Consumer Product Safety Commission (CPSC) staff hosted a technical meeting on the use of organohalogen flame retardants (OFRs) in consumer electronics. The purpose of the event was to bring stakeholders together for a technically-focused meeting to exchange information on the use of additive, non-polymeric OFRs and alternative flame retardant technologies in plastic enclosures (casings) for electronics; existing requirements and standards for flammability performance of electronic enclosures; manufacturing practices for electronic enclosures; and other topics of interest. There were 11 speakers over the course of the day (see agenda and presentations attached).

Organohalogen Flame Retardants (OFRs) in Electronic Device Casings (Enclosures) Tech-to-Tech Meeting

National Product Testing and Evaluation Center
5 Research Place, Rockville, MD
September 27, 2018

9:00 am Introductory Remarks

9:10 am Session 1

- Katie Reilly, Consumer Technology Association (CTA)
- George Fechtmann and Scott MacLeod, UL
- Ralph Buoniconti, SABIC
- Donald Hoffmann, Safety Engineering Labs, Inc

10:30 am Break

10:50 am Session 2

- Sergei Levchik, Israel Chemicals Ltd (ICL)
- Rehan Ehsan, Consumer Technology Association (CTA)
- Tony Kingsbury, TKingsbury Consulting

12:00 pm Lunch Break

1:30 pm Session 3

- Chris Cleet, Information Technology Industry Council (ITI)
- Michael Kirschner, Design Chain Associates
- Sriram Gopal, Association of Home Appliance Manufacturers (AHAM)
- Muhammad Ali, National Electrical Manufacturers Association (NEMA)

2:50 pm Closing Remarks

3:00 pm Adjourn

CPSC OFRs in EDCs Tech to Tech Meeting
September 27, 2018

	LAST NAME	FIRST NAME	AFFILIATION/COMPANY	SIGNATURE
1	Ali	Muhammad	NEMA	[signature]
2	Arnold	Benjamin	Consumer Technology Association	
3	Buoniconti	Ralph	SABIC	[signature]
4	Cassidy	Timothy (Tim)	Best Buy	
5	Clarke	Marie	ISPA	
6	Cleary	Jennifer	Association of Home Appliance Manufacturers (AHAM)	
7	Cleet	Chris	Information Technology Industry Conucil (ITI)	[signature]
8	Ehsan	Rehan	Consumer Technology Association	[signature]
9	Falvey	Cheryl	Crowell & Moring	
10	Fechtmann	George	UL LLC	[signature]
11	Gopal	Sriram	Association of Home Appliance Manufacturers	[signature]

12	Greenauer	Derek	UL LLC	
13	Greene	Eva	Whirlpool Corporation	
14	Hochschwender	Lane	American Chemistry Council	
15	Hoffmann	Donald	Safety Engineering Laboratories, Inc.	
16	Hughes	Meg	Bureau Veritas	
17	Reilly	Katie	Consumer Technology Association	
18	Kingsbury	Tony	TKingsbury LLC Consulting	
19	Kirschner	Michael	Design Chain Associates, LLC	
20	Lazas	Amy	IKEA North America Services, LLC	
21	Levchik	Sergei	ICL-IP America	
22	Little	Barbara	Albemarle Corporation	
23	MacLeod	Scott	UL LLC	
24	Miller	Bob	Albemarle Corporation	
25	Mlsna	Alex	Kimball Intl	
26	Mond	Rebecca	TIA	
27	Moore	Autumn	Retail Industry Leaders Association	
28	Radford	Ryan	Samsung	

CPSC OFRs in EDCs Tech to Tech Meeting
September 27, 2018

	LAST NAME	FIRST NAME	AFFILIATION/COMPANY	SIGNATURE
29	Ravikumar	Laxmi	Intertek	
30	Rowe	Teresa	IPC	
31	Simon	Robert	American Chemistry Council	
32	Spack	Emily	Consumer Technology Association	
33	St. Maxens	Tom	for Mattel, Inc.	
34	Tenney	Joel	Icl	
35	Wakelyn	Phil	Wakelyn Associates	
36	Warnick	Patsy	MC DPS	
37	Yahr	Dottie	CPSC	
38	Young	Pat	Byrne Electrical Specialists	
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Consumer Technology Association™

CES®

CTA.tech

Consumer Technology Trend, Commitments and Alternatives

Katie Reilly
Senior Manager, Environmental Policy and Sustainability
September 27, 2018

Outline

- Market Trends
  - Industry Snapshot
  - Material Impacts
  - Energy Efficiency
- Industry Commitments
  - Chemicals Management Programs
  - Safety Concerns
- Trade-Offs of Alternatives

Electronics are Different

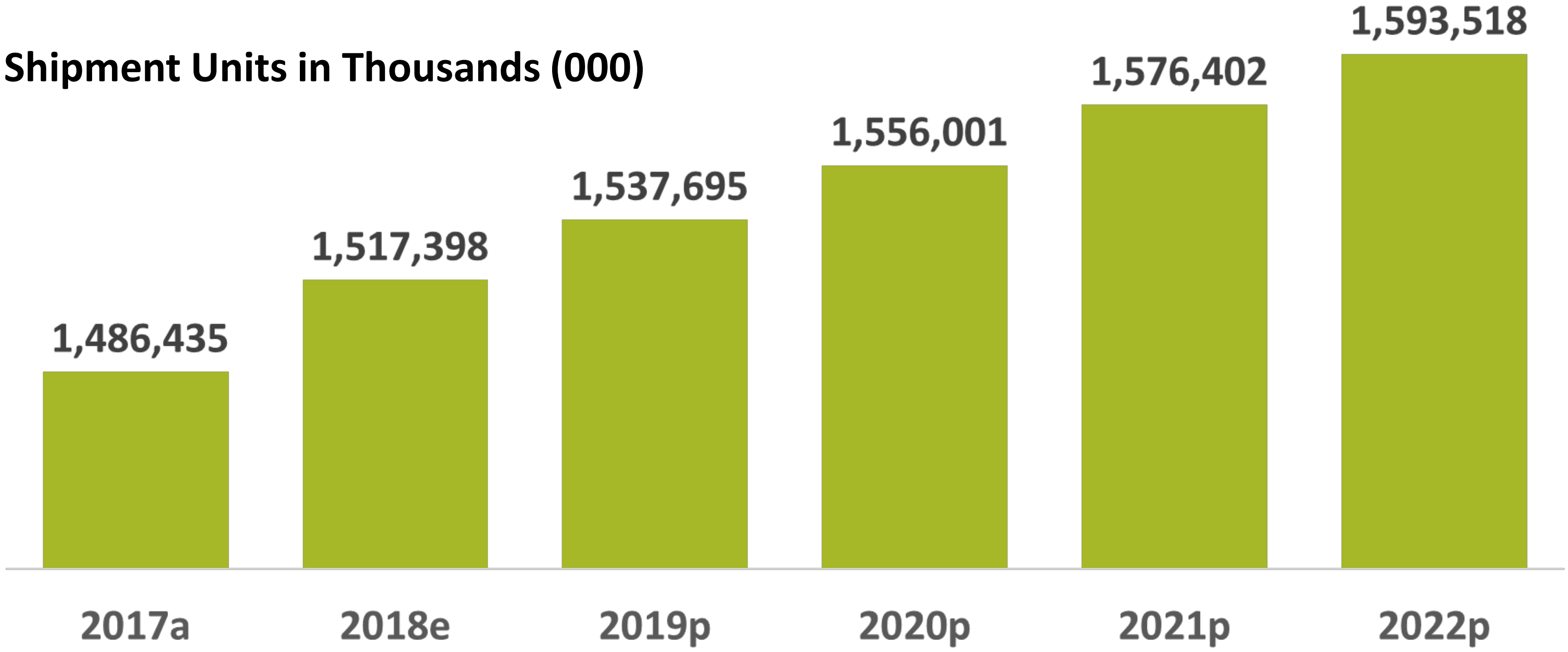
Market Trends

- Industry Snapshot
- Decreasing material usage
  - Net material footprint is decreasing
  - Convergence of products
- Increasing energy efficiency

Industry Snapshot

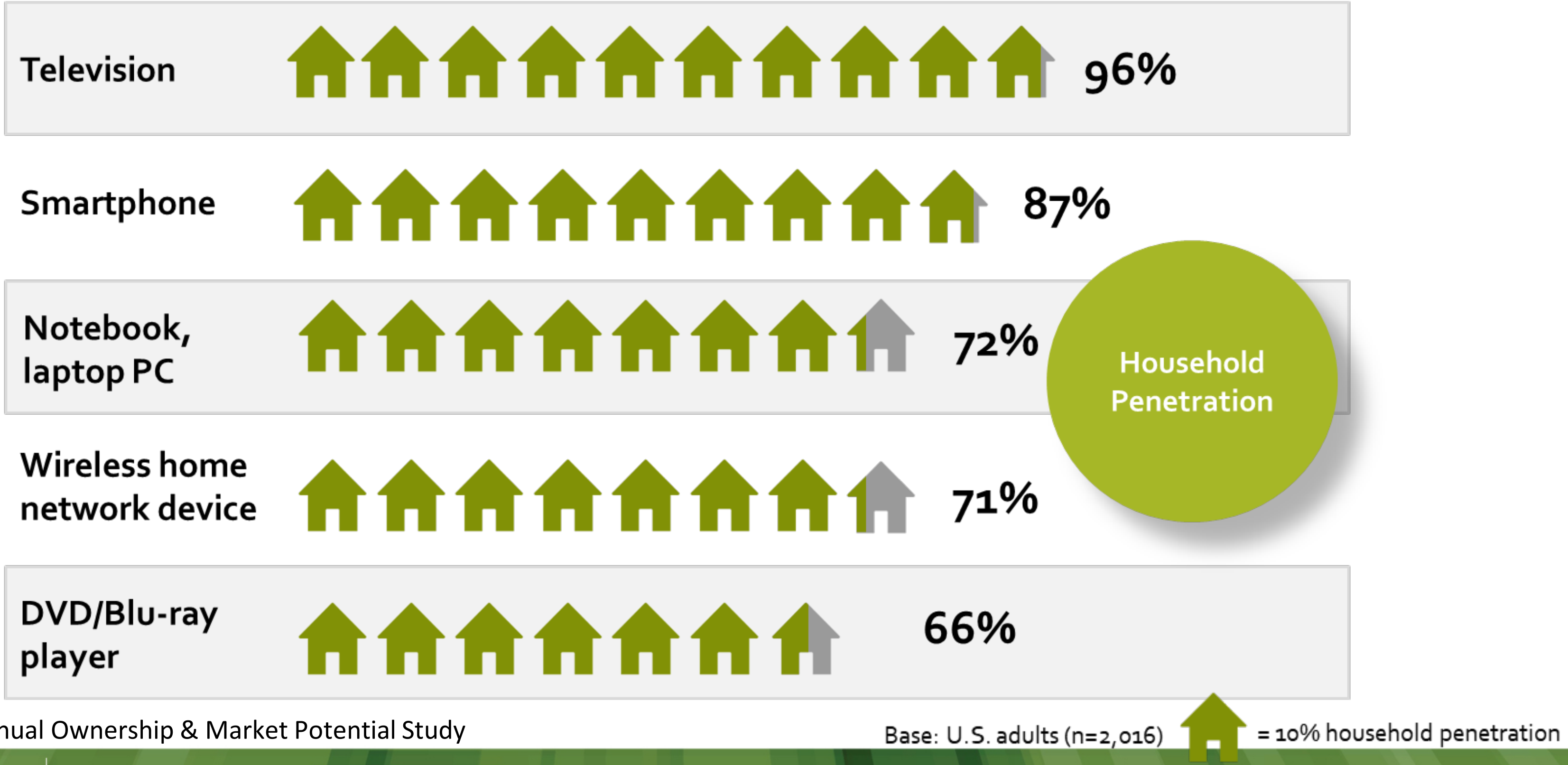
- US consumer technology sales are expected to grow +6% in 2018 on the strength of new, emerging product categories and stability in existing categories
- Screen devices including TVs, PCs, and mobile products continue to proliferate in the home
- The notion of lifestyle in technology is taking root in the industry
- Automation and intelligence are the major factors expected to shape future industry growth

U.S. Consumer Technology Industry Growth



Source: CTA Sales & Forecast July 2018

Most Commonly Owned Tech Products Feature Screens

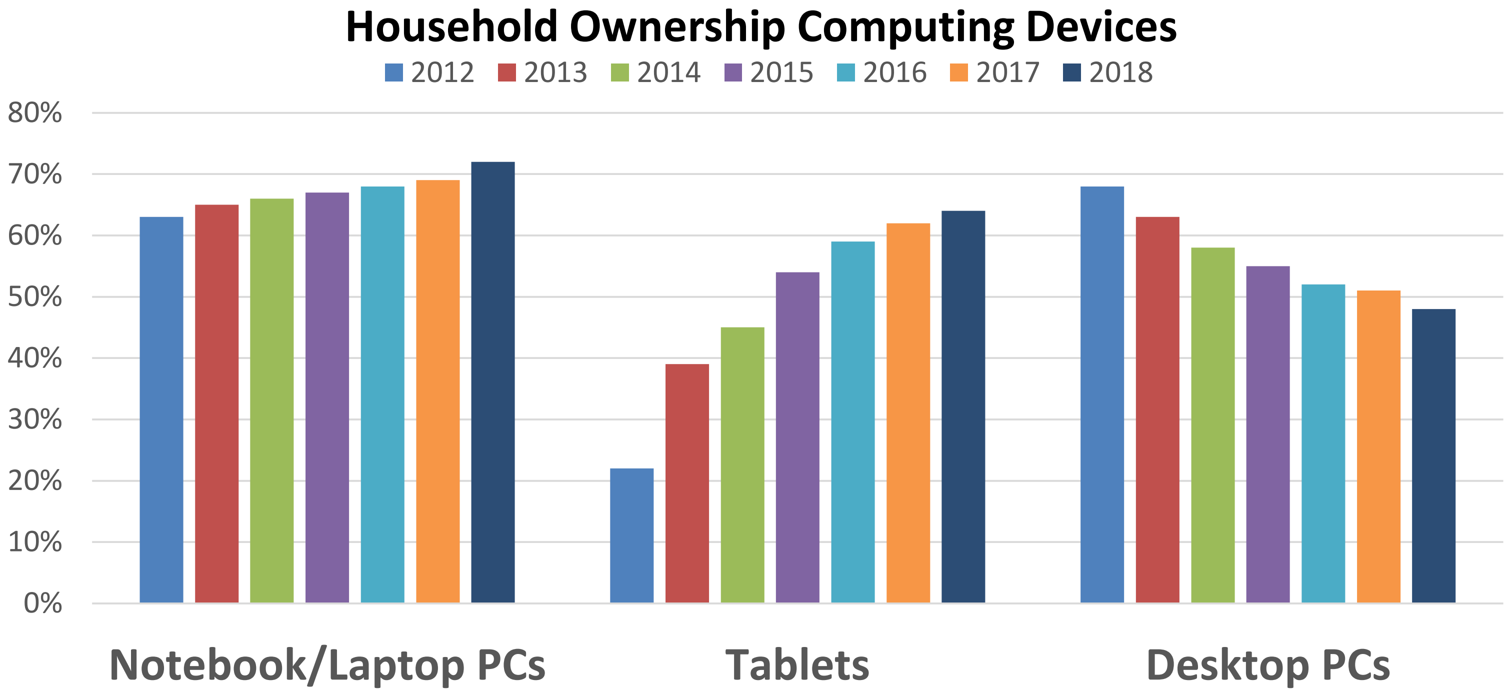


Source: CTA 20th Annual Ownership & Market Potential Study

Base: U.S. adults (n=2,016)

Innovations in Screen Technology Will Drive Future Market Demand

Computing Continues to Shift Between Formfactors



Source: CTA 20th Annual Ownership & Market Potential Study

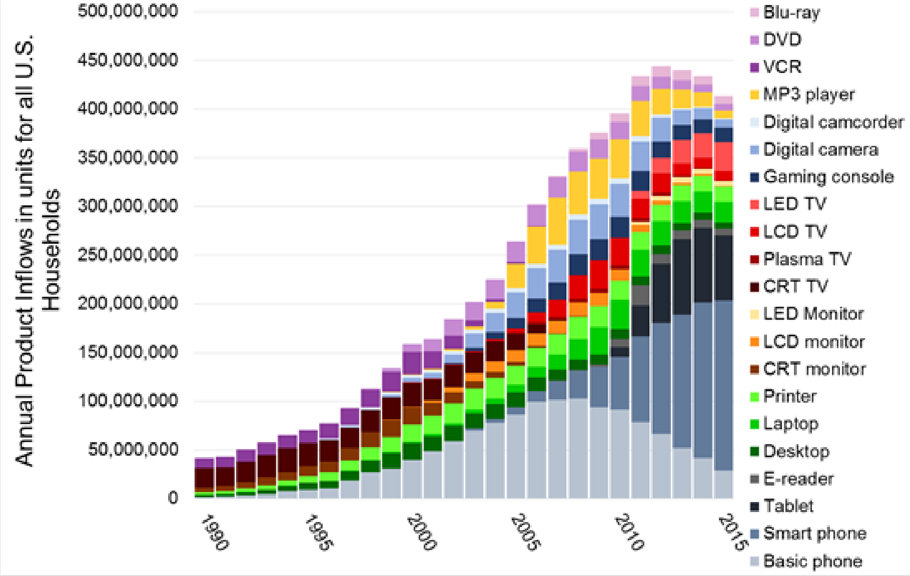
Emerging Product Categories are Beginning to Contribute to Industry Growth

Emerging Technology
2019 Growth Forecast (USD$)

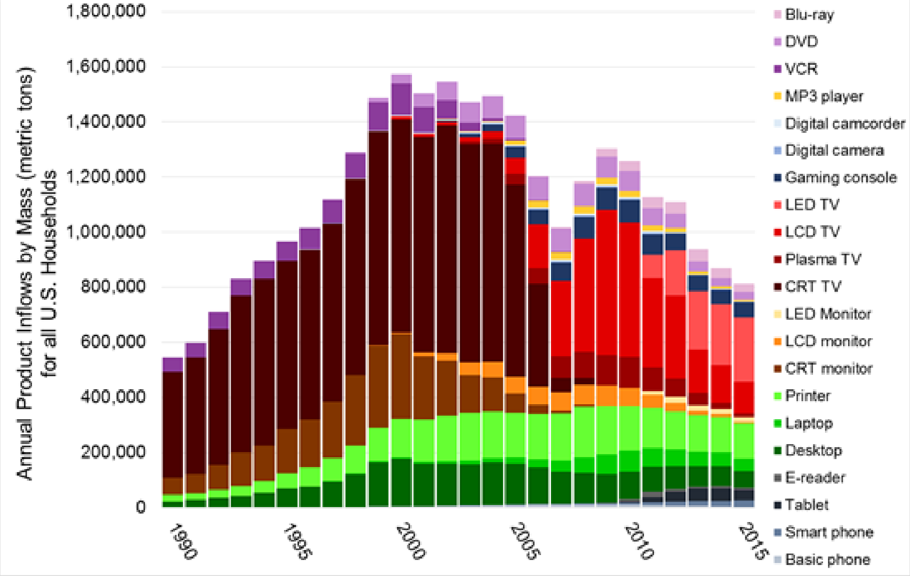
18%	15%	19%	47%

Material Impacts

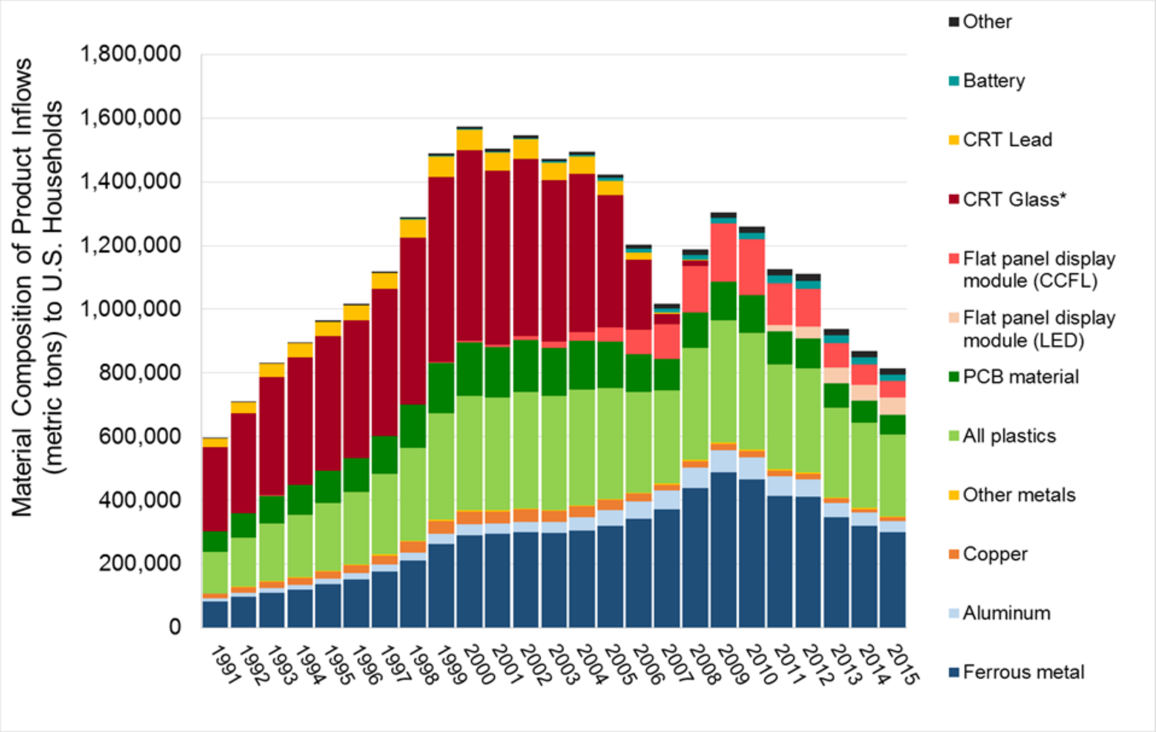
Sales (Units)



Weight (metric tons)



Material Impacts Continued



Market Trends

- Industry Snapshot
- Decreasing material usage
  - Net material footprint is decreasing
  - Convergence of products
- **Increasing energy efficiency**

Chemical Management Programs

- Proactive engagement by industry
- Supply chain management programs
- Chemical technology needs to be applied carefully

Balance of Fire Safety

Trade Offs in Product Design

- Design Intent
- Functionality
- Consumer Utility

Thank you!

Katie Reilly
Senior Manager, Environmental Policy and Sustainability
kreilly@cta.tech

George J. Fechtmann, PE
Scott C. MacLeod
Corporate Fellows
UL LLC

September 27, 2018

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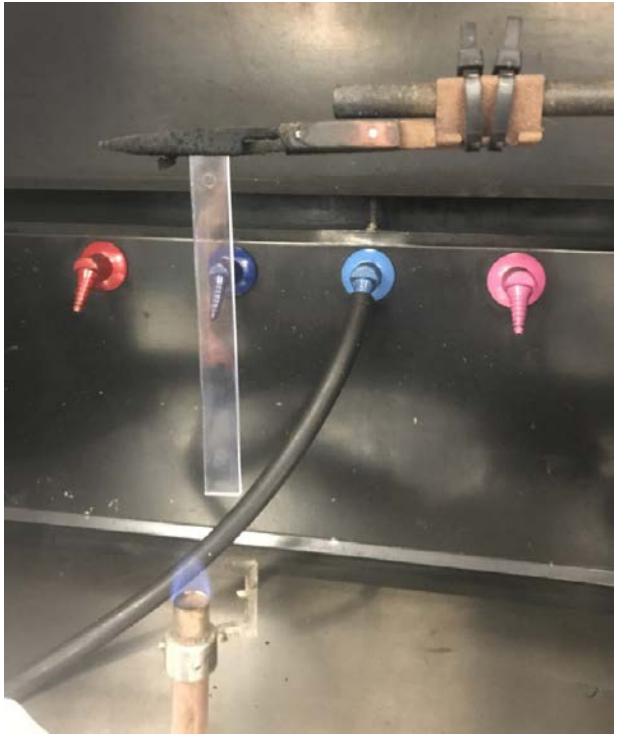
UL Product Fire Hazard Assessment

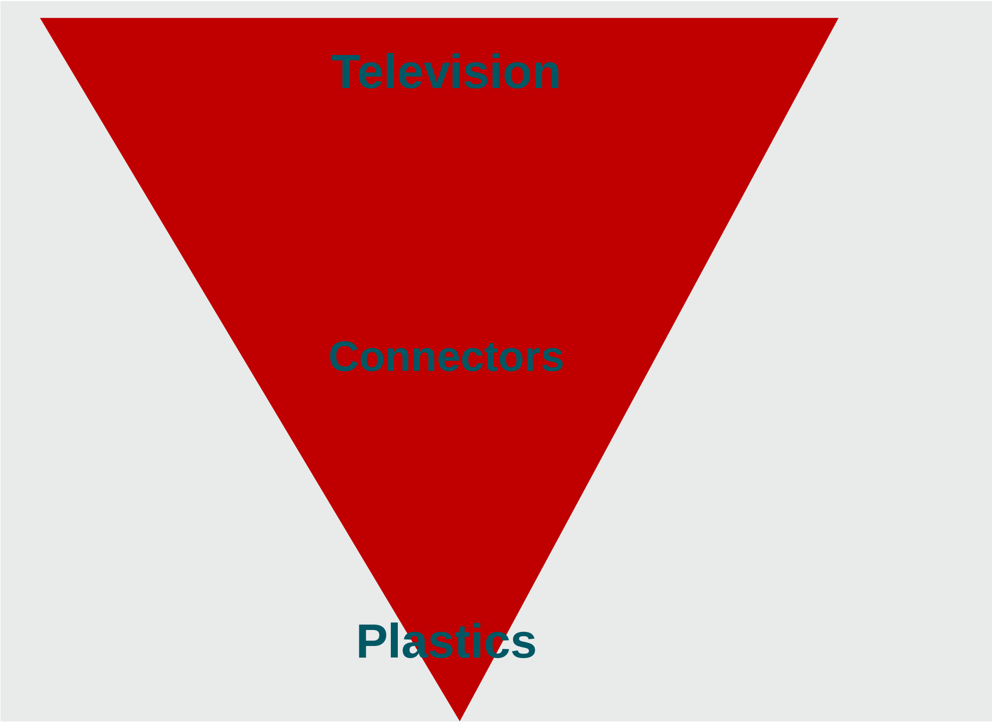
- Fire Risk Needs To Be Assessed For Each Product Design

- Assessment Can Include Testing At The Product (e.g. TV) Level Or At The Materials / Component Level (“Preselection”)



UL Component Recognition (Certification)

- Upstream Evaluation of Materials (e.g. Plastics) & Components (e.g. Power Supplies, Connectors)
- Mandate Their Performance Requirements in Downstream Product (e.g. Television) Standards
- Eliminate Duplicative Evaluation Downstream
- Identify & Communicate Recognized Properties (UL iQ & Certification Directory)
- “Pre-Select” Materials With Appropriate Performance Properties



Component Recognition & Preselection of Plastics

1938 World's Fair – Television is exhibited for the public with plastics as the major insulating material.

WWII – New synthetic resins developed for military applications.

1941 – Combustibility research testing of plastics.

1964 – Plastics fact-finding sponsored by Manufacturers Chemists Association.

1967 – "Guide to Requirements for Polymeric Materials used as Electrical Insulation" issued.

Recognized Plastics

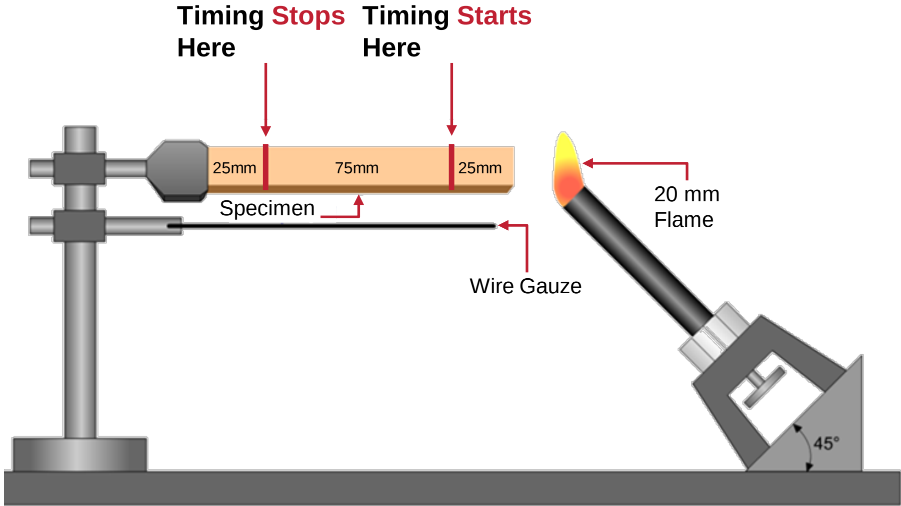
- Safety Performance Property Requirements (e.g. Flammability, Electrical, Thermal Index, etc.) in UL 746 Series & UL 94
- **Chemical Formulation And /Or The Use of Flame Retardants Is Not Specified Nor Mandated or Specified In The Safety Requirements**
- Optional Halogen Content Ratings (“Non-Halogenated / Non Chorine & Bromine”)

History of the UL Flame Ratings

1960's	Early 1970's	Late 1970's (UL 94)
Slow Burning	Slow Burning	HB
-	SE-0	V-0
Self-Extinguishing Group 1	SE-1	V-1
Self-Extinguishing Group 2	SE-2	V-2

Horizontal Burning Test (HB)

- Horizontal Burning
- Most flammable
- Previously known as “Slow-Burning” materials
- Generally no flame-retardant added
- Test measures burning rate

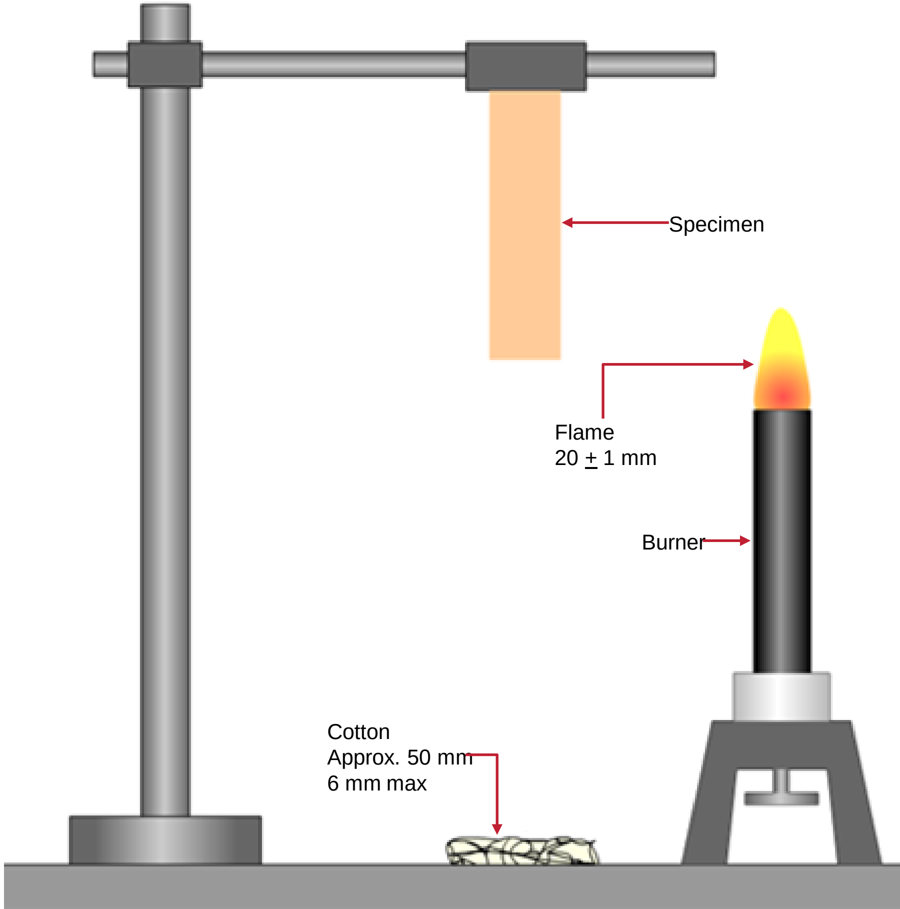


Vertical Flame Classification

	V-0	V-1	V-2
Burning to the Holding Clamp	No	No	No
Indv. Flame Time (t_1 or t_2)	$\leq$ 10 sec.	$\leq$ 30 sec.	$\leq$ 30 sec.
Total Flame Time (t_1 and t_2) Set of 5 Specimens	$\leq$ 50 sec.	$\leq$ 250 sec.	$\leq$ 250 sec.
Glowing Time	$\leq$ 30 sec.	$\leq$ 60 sec.	$\leq$ 60 sec.
Cotton Ignition	No	No	Yes

20mm Vertical Burning Test; V-0,V-1,V-2

- Same flame as HB
- Vertically oriented sample
- Cotton indicator @ 300 mm
- 2 - ten second flame applications
- Observe
  - flame/glow time
  - cotton indicator
  - extent of burn



Flame Ratings: Global Harmonization

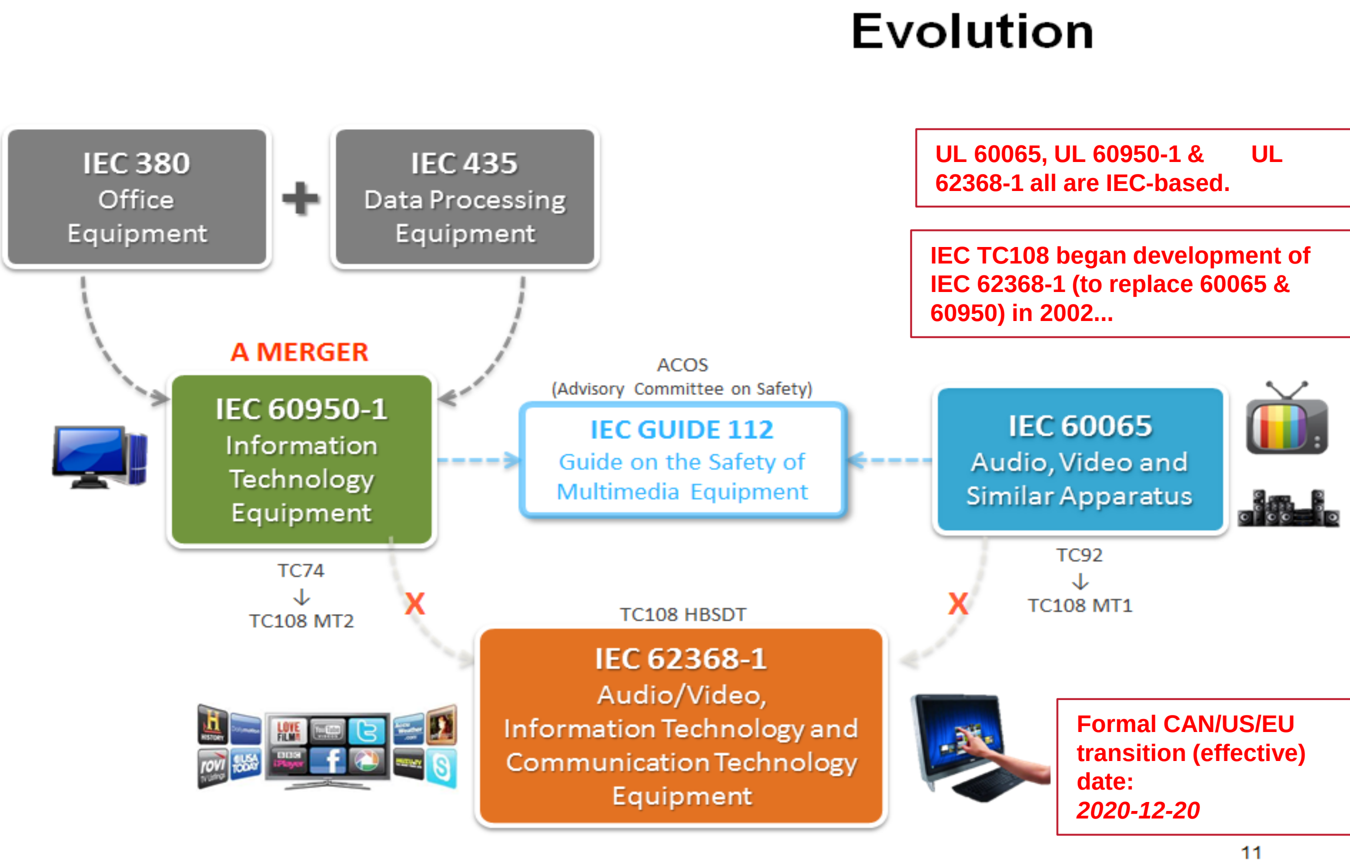
ANSI/UL	ASTM	CSA	IEC/ISO
94 HB	D635 HB	C22.2 No. 0.17 **HB***	IEC 60695-11-10 HB, HB40, HB75
94 V-0, V-1, V-2	D3801 V-0, V-1, V-2	C22.2 No. 0.17 V-0, V-1, V-2	IEC 60695-11-20 V-0, V-1, V-2
94 5VA, 5VB	D5048 5VA, 5VB	C22.2 No. 0.17 5VA, 5VB	60695-11-20 5VA, 5VB
94 VTM-0, -1, -2	D4804 VTM-0, -1, -2	C22.2 No. 0.17 VTM-0, -1, -2	ISO 9773 VTM-0, -1, -2
94 HF-1, -2, HBF	D4985 HF-1, -2, HBF	C22.2 No. 0.17 HF-1, -2, HBF	ISO 9772 HF-1, -2, HBF

UL 746C Minimum Flame Ratings

Path	I	II	III
Application Area	**Portable Attended Household Equipment**	**All other Portable Equipmentk**	**All other Equipment**
Applicable requirements shown below			
Minimum Flammability Rating	HB [a,d]	V [b,d]	5VA [c,d]
Material Properties per Table 6.1	Yes	Yes	Yes
Impact Test per Section 22	Yes	Yes	Yes
Crush Resistance per 21.1	No	No	Yes
Abnormal Operations Test per 27.1	Yes	Yes	Yes
Severe Conditions Test per 28.1	Yes [l]	No [l]	Yes
Mold-Stress Relief Distortion per Section 29.1	Yes [e]	Yes [e]	Yes [e]
Input after Mold-Stress Relief per 30.1	Yes	No [l]	Yes
Strain Relief Test per 31.1	Yes [f]	Yes [f]	Yes [f]
UV Resistance per 25.1.	Yes [g]	Yes [g]	Yes [g]
Water Exposure and Immersion per Sec. 26	Yes [h]	Yes [h]	Yes [h]
Dimensional Stability per 26.2	Yes	Yes	Yes
Conduit Connections	No	No	Yes [l]

[a] HB or has a GWIT and GWFT of 750°C, or the enclosure complies with the 12 mm or 20 mm end-product flame tests as described in Section 15 and 16 respectively

Consumer Electronics



UL 60065, UL 60950-1 & UL 62368-1 all are IEC-based.

IEC TC108 began development of IEC 62368-1 (to replace 60065 & 60950) in 2002...

Formal CAN/US/EU transition (effective) date:
2020-12-20

	UL/IEC 60065 (AV)	UL/IEC 60950-1 (ITE)	UL/IEC 62368-1 (AV/ICT)
External* Thermoplastic Fire Enclosures** ***-Preselection Option	**V-2**, unless • *Stationary/Permanently Connected,* **5V,** or • Assoc. with high voltage (e.g., CRT TVs), **V-1 or V-0** (depending on size of plastic material). Alternatively, equivalent flammability test is conducted on end product enclosure per IEC 60695-11-xx standards.	**V-1** (if equipment mass ≤18kg), or else, **5V.** Alternatively, equivalent flammability test is conducted on end product enclosure per IEC 60695-11-xx standards .	**V-1** (if equipment, or circuit power ≤ 4,000W), or else, **5V.** Alternatively, equivalent flammability test is conducted on end product enclosure per IEC 60695-11-xx standards .
-Single Fault Performance Option **(no Fire Enclosure required)**	-	Permitted on products, or parts of products with limited number of circuits: single fault testing, with no evidence of risk of fire (e.g., molten metal, etc.). (Limited historical use in practice.)	Permitted if ≤ 4, 000W: single fault testing, with no evidence of risk of fire, plus min. separation requirement for combustible parts from *Potential Ignition Sources (PIS)* (> 15W, or > 50V). (Anticipate limited use in practice.)
***External* Thermoplastic Decorative Enclosure/Casing**	**HB** (or Glow Wire, 550C)	**HB** (or Glow Wire, 550C)	**HB** (or Glow Wire, 550C)

	UL/IEC 60065 (AV)	UL/IEC 60950-1 (ITE)	UL/IEC 62368-1 (AV/ICT)
***Internal* Thermoplastic Parts**	**V-2** (preselection), or flammability test per Annex G (or UL 746C), or no flame rating required if part mounted on **V-1** printed circuit board. Internal fire barriers (for PIS separation) require min. **V-1.** Other considerations & exceptions for specific parts, such as decorative, size, mass, etc., e.g., **HB, HBF, Glow Wire, VW-1,** etc.	**V-2** (preselection), or equivalent flammability test (incl. needle flame) per Annex A, or no flame rating required if part mounted on **V-1** printed circuit board. Other considerations & exceptions for specific parts, such as decorative, size, mass, etc., e.g., **HB, HBF, Glow Wire, VW-1,** etc.	**V-2** (preselection), or equivalent flammability test (incl. needle flame) per Annex S, or no flame rating required if part mounted on **V-1** printed circuit board. Internal fire barriers (for PIS separation) require min. **V-1.** Other considerations & exceptions for specific parts, such as decorative, size, mass, etc., e.g., **HB, HBF, Glow Wire, VW-1,** etc.

Recognized Plastics & The "Yellow Card"

~50,000 Recognized "Yellow Card" Plastics in UL iQ

>150,000 UL iQ Database Yellow Card Searches Every Month

Searchable / Parametric

- Publically Available
- Free of Charge
- Supply Chain

UL iQ for Plastics

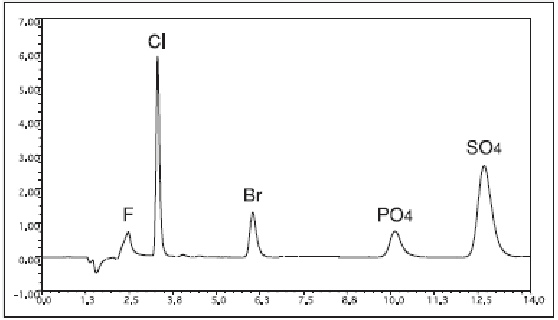
Optional Non-Halogenated “Yellow Card” Certification Ratings Requirements

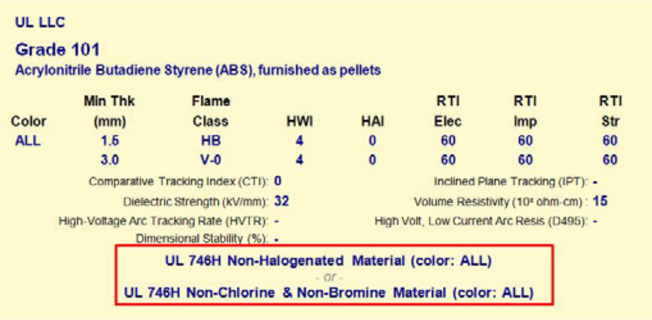
Based on

- UL Outline of Investigation UL746H, “Non-Halogenated Materials”

Testing

- Combustion – Ion Chromatography





UL LLC

Grade 101

Acrylonitrile Butadiene Styrene (ABS), furnished as pellets

Color	Min Thk (mm)	Flame Class	HWI	HAI	RTI Elec	RTI Imp	RTI Str
ALL	1.5	HB	4	0	60	60	60
	3.0	V-0	4	0	60	60	60

Comparative Tracking Index (CTI): 0
Inclined Plane Tracking (IPT): -
Dielectric Strength (kV/mm): 32
Volume Resistivity (10^x ohm-cm): 15
High-Voltage Arc Tracking Rate (HVTR): -
High Volt, Low Current Arc Resis (D495): -
Dimensional Stability (%): -

UL 746H Non-Halogenated Material (color: ALL)
- or -
UL 746H Non-Chlorine & Non-Bromine Material (color: ALL)

Non-Halogenated

- < 0.09% Chlorine (Cl)
- < 0.09% Bromine (Br)
- < 0.09% Fluorine (F)
- < 0.15% Total Cl + Br + F

Non-Chlorine & Non-Bromine

- < 0.09% Chlorine (Cl)
- < 0.09% Bromine (Br)
- < 0.15% Total Cl + Br

Thank You

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CHEMISTRY THAT MATTERS™

FLAME TESTS AND ELECTRICAL DEVICE SAFETY

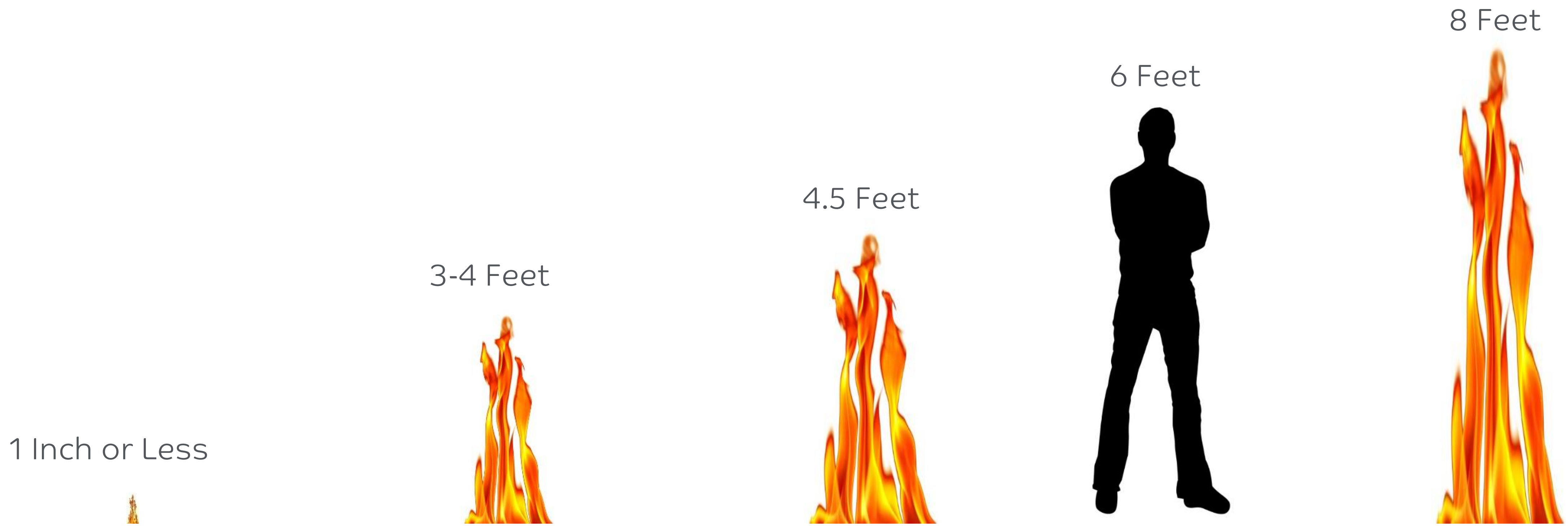
Ralph R. Buoniconti
CPSC Meeting, Rockville, MD, September 27, 2018

TOPICS

- Scale of fire tests
- Underwriters Laboratories (UL) standards & material properties
- Determining risk of fire and steps taken to mitigate effects
- Pre-selection testing in lieu of end-product testing
- Overview of flame and key ignitability ratings
- Other complexities of choosing materials for enclosures/housings

FLAME TESTS: SCALE, STANDARDS, AND WHAT DRIVES THEIR USE

RELATIVE SCALE OF SOME FIRE TESTS



1 kW or less
- UL94 "V" Test
- ASTM D635
- Cigarette Lighter

Approx. 40 kW
- Waste paper basket
- 1st 5 min in NFPA 286

88 kW
- Steiner Tunnel

Approx. 160 kW
- Cushioned office chair
- 10 min in NFPA 286

Smaller tests can be appropriate based on threat

USE OF UL STANDARDS - RECOGNITION/COMPLIANCE

Underwriters Laboratories, Inc.

End Products

- End product standards (PCs, copiers, phones, dishwashers, etc.)
- UL746C (electrical enclosures, barriers, etc.)
- **Material Pre-selection Guidance**

Polymeric Materials

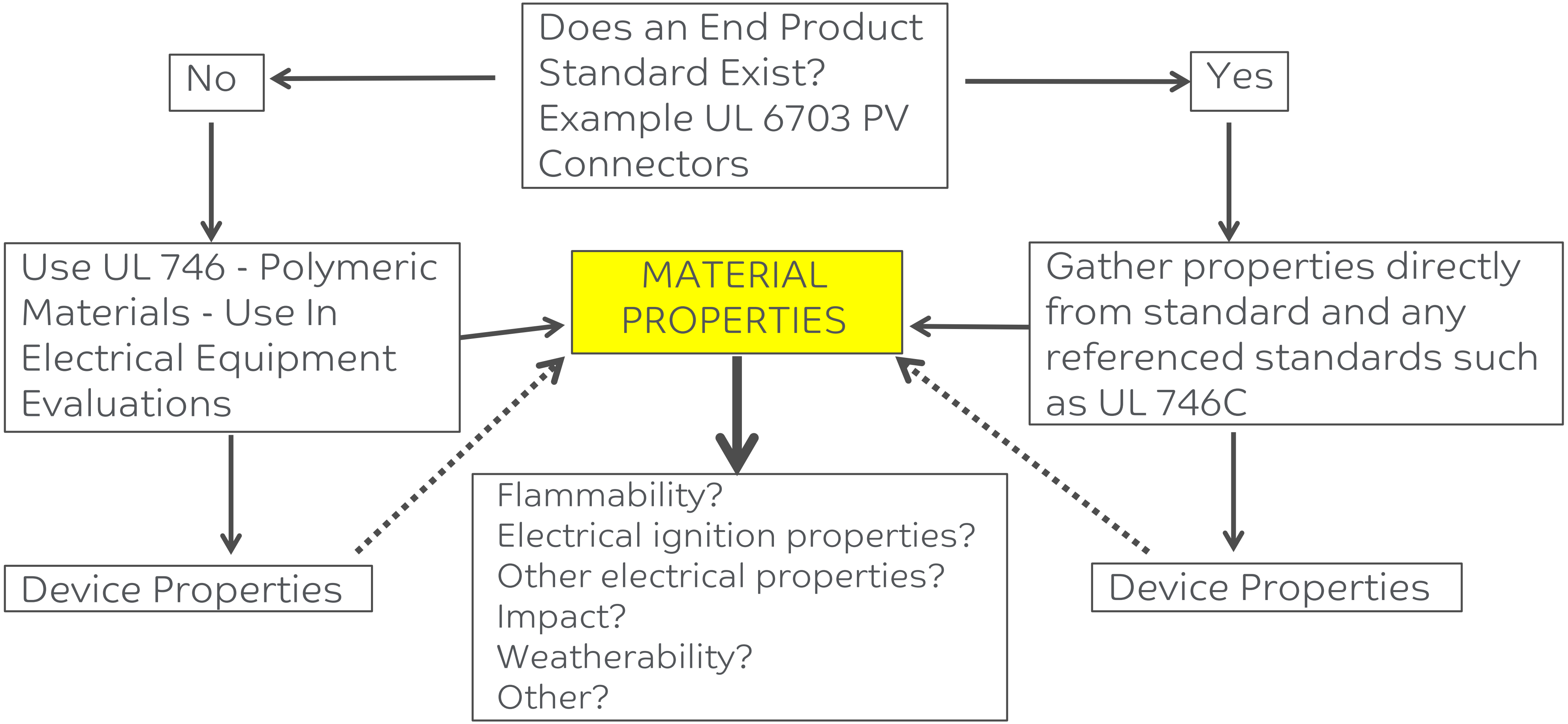
- UL 94 (flammability)
- UL 746A (short-term properties)
- UL746B (long-term properties)
- UL746C (Use of polymer matls in electrical equipment)
- UL746D (finished parts)

Recognition, Listing, & Compliance

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

Material pre-selection flame tests are related to device flammability

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

* Current edition – Feb. 5, 2018

3.34 Risk Of Fire – A risk of fire is considered to exist at any two points in a circuit where:

a) 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
b) 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

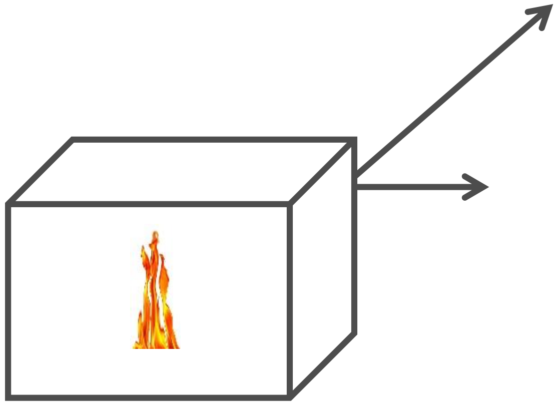
The underlying assumption is that a small fire of electrical origin will happen. Steps are then taken to keep the fire from growing out of control.

UL METHODOLOGY AND THE CONCEPT OF PRE-SELECTION TESTS FOR MATERIALS

FIRE AND/OR SHOCK RISKS* NEED AN ENCLOSURE*

* Defined terms in UL 746C

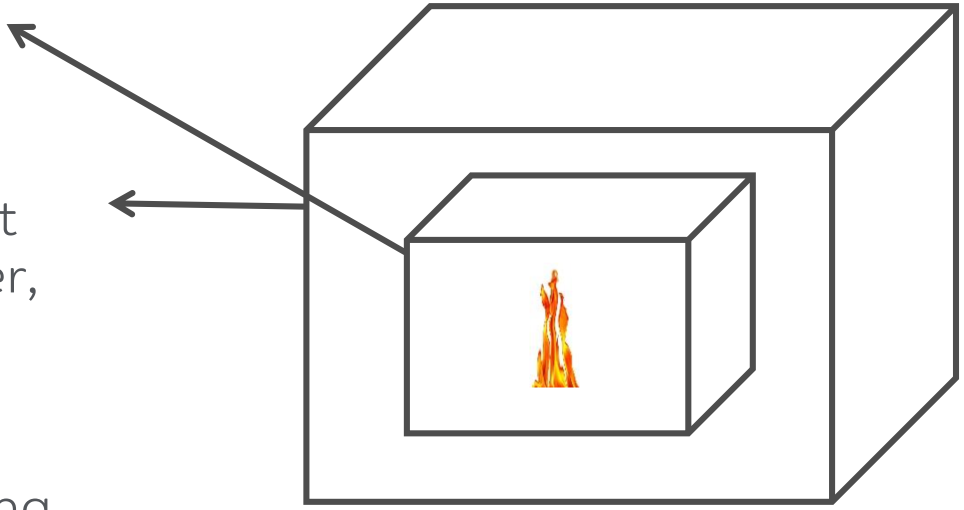
Can be single "box"



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"



Thinner, less weight, increased device functionality, and cost = drivers for enclosures to be "primary" enclosures

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

* Current edition – Feb. 5, 2018
** If area > 10 ft^2, then spread of flame per UL 723 (similar to ASTM E84) or ASTM E162 (Radiant Panel) See section 19.
*** Defined terms in UL 746C

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	• Not flame for more than 1 minute after either of two 30-second applications of test flame, with an interval of 1 minute between • Not be completely consumed	• Tested on inside, if possible, near sources of ignitions • 3 samples tested • If only 1 fails, another set of 3 must all pass. • Internal components are left in place, if possible
127 mm (5 inch) flame per section 17	• Not flame for more than 1 minute after fifth 5-second flame application, with interval of 5 seconds between • No drops igniting cotton • No flame on protected side and no > 3mm hole formation	Same as above

Can be cumbersome, expensive, and time consuming:

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

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

HOW UL OFTEN USES FLAMMABILITY WITH “IGNITABILITY”

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

Lower numbers are better than higher numbers (think “golf scores”)

* 9 generalized diagrams in UL 746C to define when these tests (or more) may be needed
** Since this presentation is focused on enclosures/housings, no mention of the “very thin material” (VTM) flame test ratings appears in the chart

- 1) HWI and HAI are pre-selection tests with their own end-product test alternatives.
- 2) As ignition resistance declines, the flame ratings must increase (lower numbers are better than higher numbers)

SMALL SCALE FLAME TESTS OVERVIEW AND COMPLEXITIES WHEN CHOOSING MATERIALS FOR PARTS

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 the test Note: Except for V-2 & VTM-2, these ratings also require 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 all of the above tests.

ENCLOSURE MATERIALS – NO "ONE SIZE FITS ALL"

Other safety and/or practical concerns:

Manufacturability
- Part geometry & quantity vs. cost equation
- Thickness

Durability
- Impact
- Load?
- Chemical resistance
- Wear resistance?

Appearance
- Specific integrated color
- Texture
- Gloss
- Translucent…tints?

Temperature
- Low (with mechanical stress?)
- High (with mech. stress?)
- Broad range?

Specialty
- Combination: Electrical insulation & thermally conductive?
- EMI/RFI

Testing needs : Important variables from materials and the environment :

- Material type: Basic chemistry and the inherent reaction to fire properties
- Material thickness: Assuming formulation does not change, as a material is tested to thinner gauges, flame ratings often decrease (ex., V-0 may shift to V-2, 5V-A may shift to 5V-B, etc.)
- Material color: Pigment loadings must be tested or bracketed according to UL methodology
- Will ultraviolet light testing and/or water exposure testing be needed for the device? Tests must show a retention of key properties (including flame). See UL 746C for details.
- Other tests, such as elevated longer-term temperature exposure are routinely done on materials to demonstrate retention of flame and other key properties.

Flame retardants, if used, are typically part of comprehensive engineered material solutions

SUMMARY

- Small scale reaction-to-fire tests are often part of an overall risk mitigations strategy. Underwriters Laboratories' methodology was briefly described.
- UL methodology often focuses on reducing fire & shock risks (among others) in end products.
- UL standards often allow "pre-selection" material tests to avoid end-product testing
- The way a device is designed can determine what material requirements are needed. Not all relevant design elements may be apparent by studying the device (OEM expertise is needed).
- Design trends such as making devices thinner, lighter, more cost-effective, and with more built-in functionality tend to require enclosures to have both fire and shock mitigation elements.
- UL uses ignitability tests in conjunction with flame tests if live parts cause additional risks due to their proximity to, and configuration with, combustible materials.
- Material selection and flame retardant choices (if needed) are often part of a complex balance of written (test) requirements, and practical manufacturing & end-use environment requirements.

Understanding the complexities will lead to a better understanding of how and why small scale flame tests are part of an overall risk mitigation strategy

COMMON UL FLAME TESTS – ONE PAGE DESCRIPTIONS

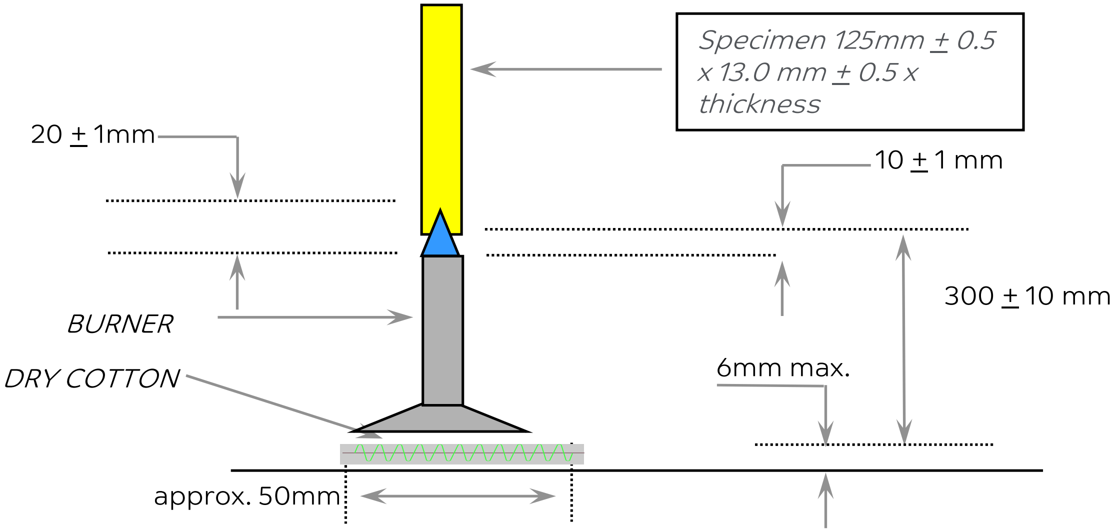
UL 94 V test – producing UL 94 V-0, V-1, and V-2 ratings

UL 94 5V test – producing UL 94 5VA and 5VB ratings

UL 94 HB test – for the UL 94 HB rating

UL 94 VTM test – producing UL 94 VTM-0, VTM-1, and VTM-2 ratings

THE UL 94V TEST – FOR V-0, V-1, OR V-2 CLASSIFICATIONS



CONDITIONING

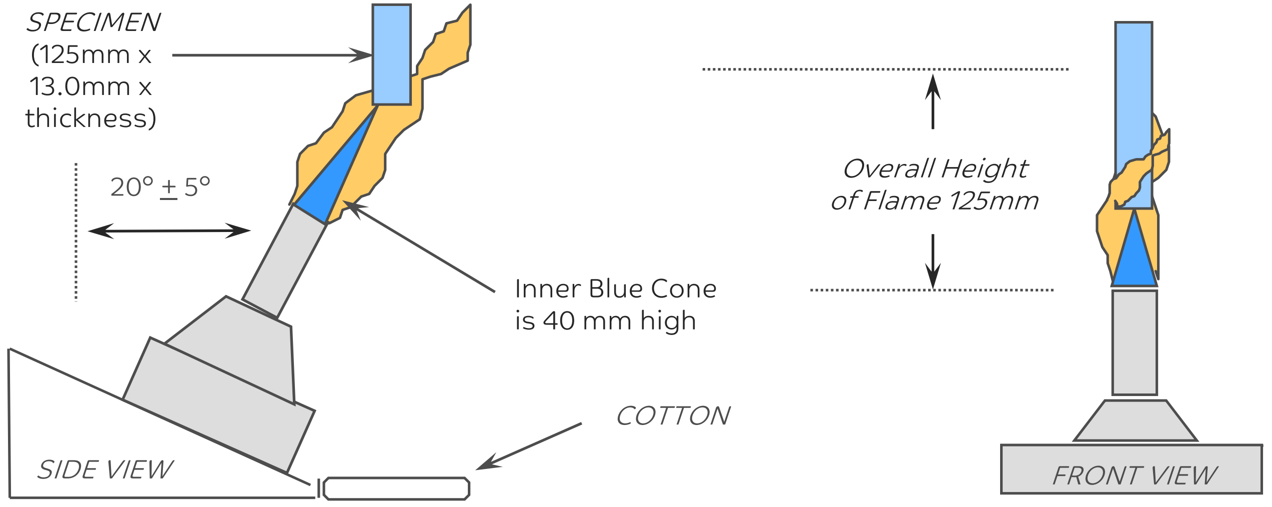
- Two sets of five specimens at 23 ± 2°C/50 ± 5% RH/48 hrs
- Two sets of five specimens at 70 ± 1°C for seven days and cooled in desiccator for 4 hours
- Lab atmosphere of 15-35°F/45-75% RH

PROCEDURE

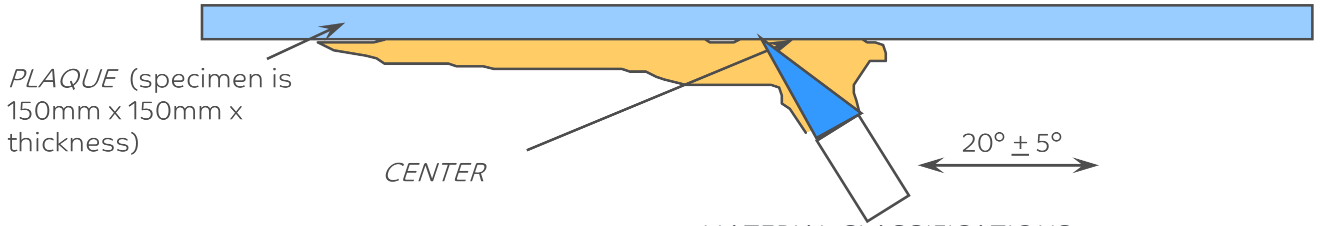
- Calibrate flame
- Two 10-second applications of flame
- If flaming of the first application ceases, immediately reapply flame
- If only 1 out of 5 fails, re-test another set of 5. All must pass

Criteria	94V-0	94V-1	94V-2
After flame time for each individual specimen t_1 or t_2.	≤ 10s	≤ 30s	≤ 30s
Total afterflame time for any condition set (t_1 plus t_2 for the 5 specimens)	≤ 50s	≤ 250s	≤250s
Afterflame plus afterglow time for each individual specimen after the second flame application ($t_2 + t_3$)	≤ 30s	≤ 60s	≤ 60s
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

THE UL 94 5V TEST FOR 5VA, OR 5VB CLASSIFICATIONS



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



CONDITIONING

- Two-day and seven-day

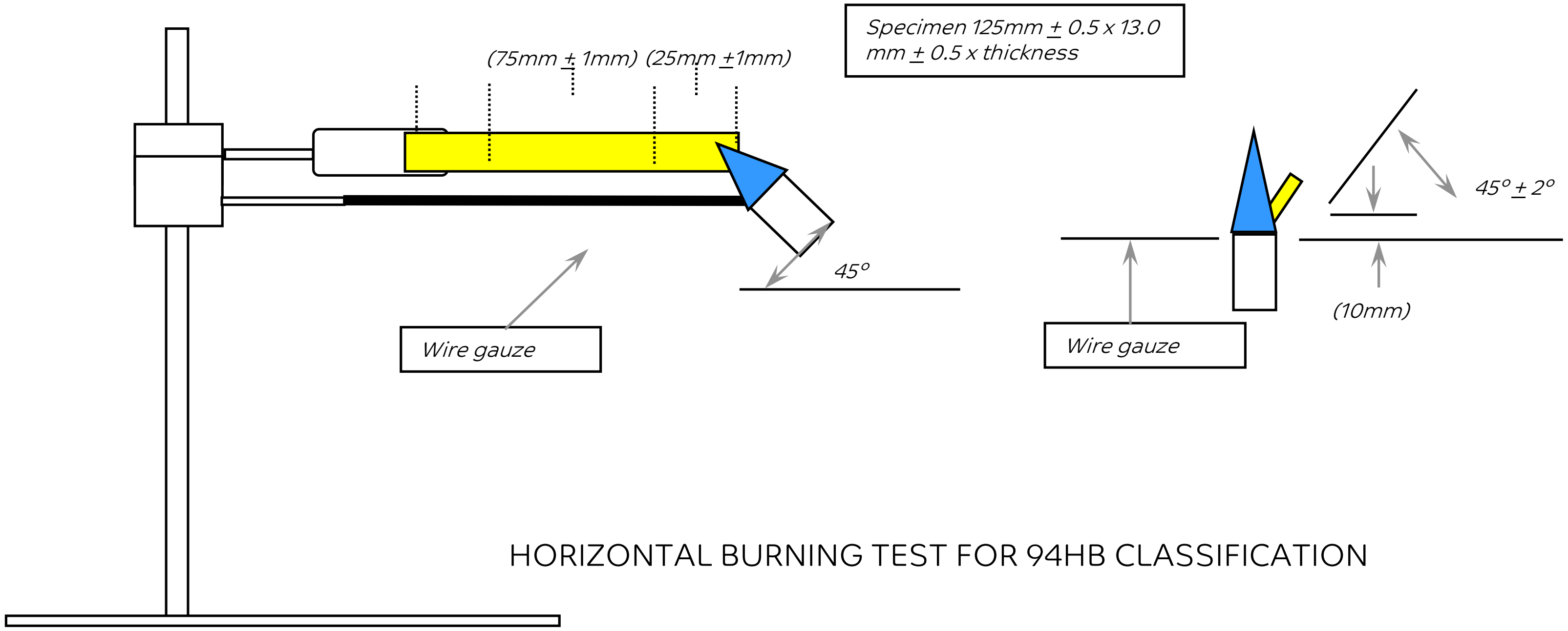
PROCEDURE

- Calibrate flame temp; test flame bars
- Five/5-second applications of flame
- Test plaques to establish A or B rating

MATERIAL CLASSIFICATIONS

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

HORIZONTAL BURNING TEST FOR UL 94HB CLASSIFICATION



HORIZONTAL BURNING TEST FOR 94HB CLASSIFICATION

<u>CONDITIONING</u> - Specimens conditioned at 23± 2°C and 50± 5 percent RH for a minimum of 48 hours

<u>PROCEDURE</u>

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

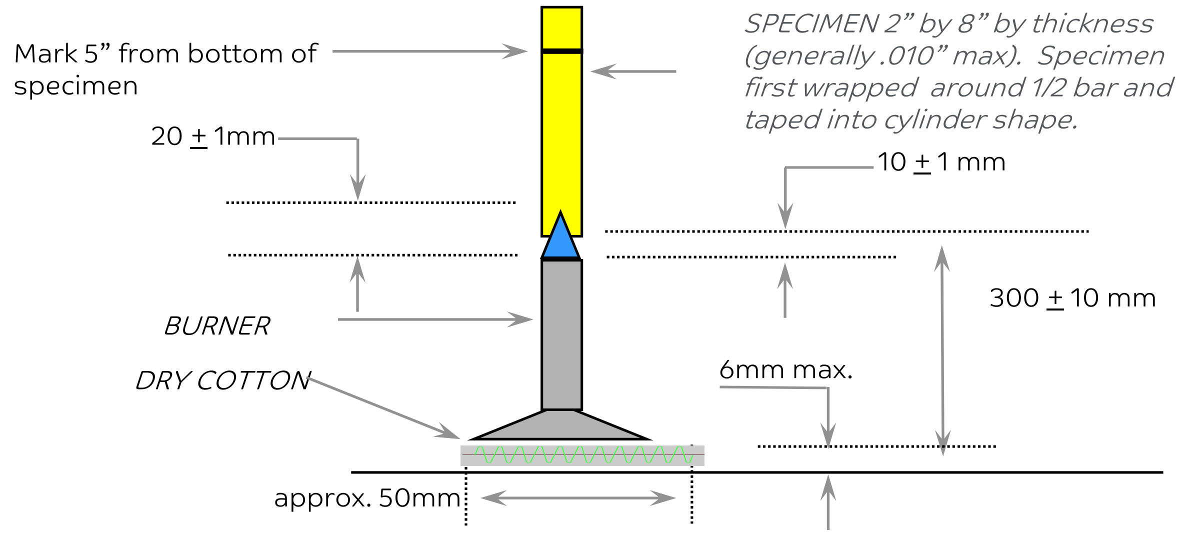
<u>A material classed 94HB shall:</u>

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

THE UL94 VTM TEST FOR VTM-0, VTM-1, OR VTM-2 CLASSIFICATIONS



CONDITIONING

- Two sets of five specimens at 23 ± 2°C/50 ± 5% RH/48 hrs
- Two sets of five specimens at 70 ± 1°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.	≤ 10s	≤ 30s	≤ 30s
Total afterflame time for any condition set (t_1 plus t_2 for the 5 specimens)	≤ 50s	≤250s	≤250s
Afterflame plus afterglow time for each individual specimen after the second flame application (t_2 + t_3)	≤ 30s	≤ 60s	≤ 60s
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


THANK YOU

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US Consumer Products Safety Commission
Organohalogen Flame Retardants (OFRs) in Electronic Device Casings:
Tech-to-Tech Meeting
September 27, 2018

SAFETY STANDARDS FOR ELECTRONICS – FIRE PERFORMANCE REQUIREMENTS

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CURRENT FLAMMABILITY REQUIREMENTS FOR ELECTRONIC DEVICE ENCLOSURES

- Many individual standards for different devices/categories of devices
  - UL 1017 - Vacuum Cleaners, Blower Cleaners, and Household Floor Finishing Machines
  - UL 60950-1 - Information Technology Equipment - Safety
  - UL 66065 - Standard for Audio, Video and Similar Electronic Apparatus
  - UL 62368-1 - Audio/Video, Information and Communication Technology Equipment
- Standards are developed by Standard Technical Panels – interested individuals with expertise in the design and use of those devices

CURRENT FLAMMABILITY REQUIREMENTS FOR ELECTRONIC DEVICE ENCLOSURES

- STPs do not necessarily have any expertise in fire and flammability
- Individual device standards require compliance with fire performance standards
  - UL 94
  - UL 746A
  - UL 746B
  - UL 746C

TEST PROCEDURES IN STANDARDS

- Exposure to ignition sources from 50 to 500 Watts
  - Small ignition sources

- Exposure to high current arc, hot wire and glowing wire

WHY THESE IGNITION SOURCES?

- Every energized circuit carries an inherent fire hazard; ignition within an enclosure should be contained by the enclosure
- The selected ignition sources correlate with the amount of energy we would expect to see if an unwanted failure occurred within an electronic devices/appliances
- The test methods measure performance of the material when exposed to an energy source of that size, not under a specific ignition scenario

WHAT FIRE PERFORMANCE CHARACTERISTICS ARE MEASURED?

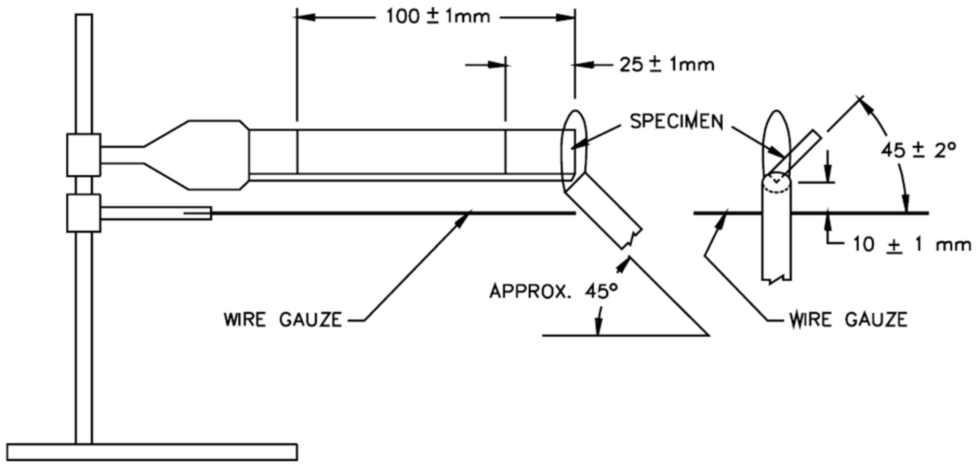
- Ease of ignition
- Sustained burning
- Dripping of flaming materials

TEST PROCEDURES

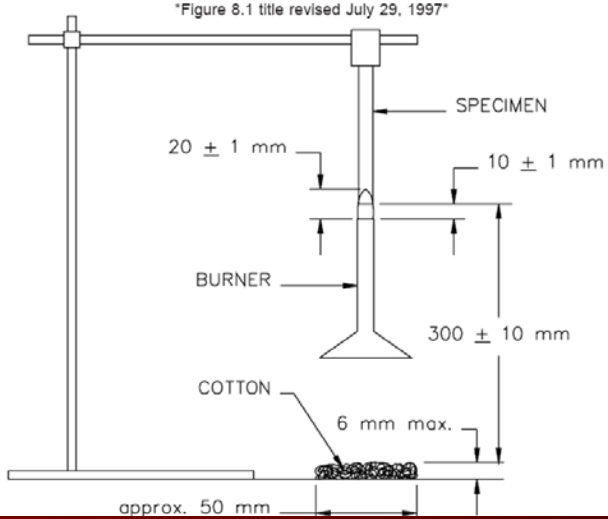
Horizontal Burn Test	
Criteria conditions	HB
Flame front passing 25mm yes/no	Cease to burn before 100mm reference mark
Flame front between 25 and 100mm	
if above, elapsed time	
if above, damage length	
Flame front passing 100mm yes/no	
if above, time between 25 to 100mm	
Calculated linear burn rate	≤40 mm/min

Vertical Burn Test			
Criteria conditions	V-0	V-1	V-2
Afterflame time for each specimen	≤10s	≤30s	≤30s
Total afterflame time for any condition set	≤50s	≤250s	≤250s
Afterflame plus afterglow time for each individual specimen after the second flame application	≤30s	≤60s	≤60s
Afterflame or afterglow of any specimen up to the holding clamp	NO	NO	NO
Cottom indicator ignited by flaming particles or drops	NO	NO	YES

Horizontal burning test for HB classification
"Figure 7.1 revised July 10, 1998"



Vertical burning test for V-0, V-1, V-2 classification
"Figure 8.1 title revised July 29, 1997"



UL 94 VERTICAL BURN TEST

HB

V-0

UL 94 HORIZONTAL BURN TEST

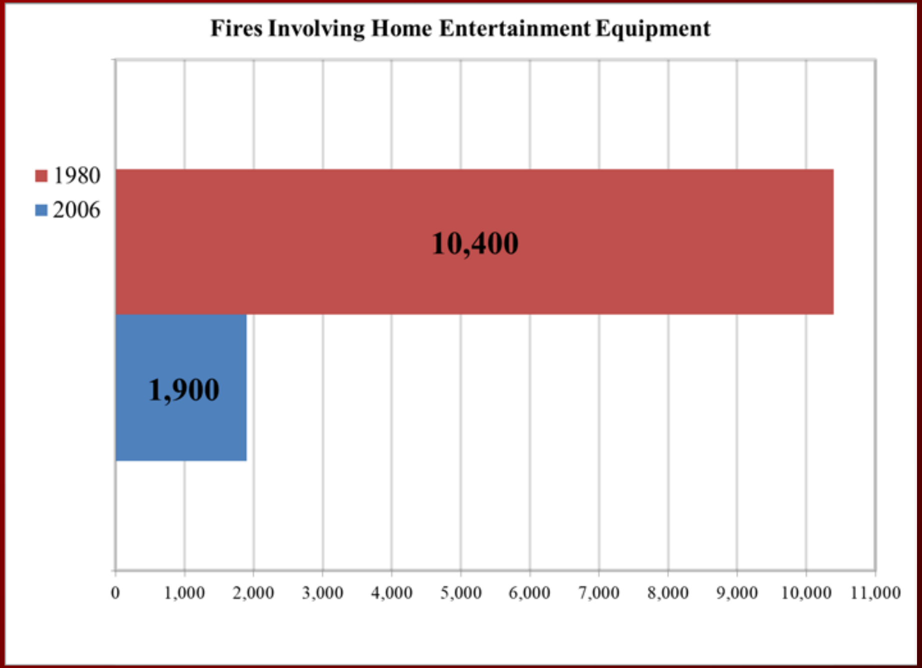
HB

V-0

ROLE OF MATERIAL PERFORMANCE IN FIRE SAFETY

- NFPA estimates 1,170 electronic device/equipment fires annually where electrical failure or malfunction was a contributing ignition factor and an additional 730 residential fires involving computers and office equipment

- In 1980, 10,400 fires involving home entertainment equipment (televisions, radios, stereo equipment) were reported; in 2006, 1,900



ROLE OF MATERIAL PERFORMANCE IN FIRE SAFETY

- Late 1970s – the voluntary standard for US televisions required the use V-0 enclosures instead of HB
- *The use of V-0 rated materials instead of HB in television enclosures coincided with a precipitous decline in fires involving televisions in the US*

ROLE OF MATERIAL PERFORMANCE IN FIRE SAFETY

- *Most plastics used in electronic device enclosures need fire retardants in them to meet the UL standards and provide an acceptable level of fire safety*

Cone Calorimeter Data Summary—30 kW/m^2 Irradiance Tests

Sample	NFR /FR	Mass (g)	% Mass burned	Ign. Time (s)	Peak $\dot{q}''$ (kW/m^2)	Peak $\dot{q}''$ time (s)	Tot. q'' (MJ/m^2)	Eff. Δh_c (MJ/kg)
TV Cabinet H	NFR	34	99	107	970	190	87	30
TV Cabinet G	FR	38	98	84	340	184	46	12
Bus. Machine F	NFR	37	88	108	650	168	96	30
Bus. Machine A	FR	39	81	134	380	370	65	21

CONCLUSIONS

1. Most if not all standards for electrical devices and appliances requires V-1 or greater plastic performance.

2. Most plastic enclosures need fire retardants to meet the V-1 or greater requirement.

3. Removing the fire retardants will substantially reduce the fire resistance capability of the enclosures due to electrical failures.

4. Past history shows that fire retarded enclosures reduce the number of electrical appliance/device caused fires from a failure of an electrical component.

References

NFPA – Home and Non-Home Fires Involving Office Equipment
NFPA – Electrical Fires
NFPA – Home Fires Involving Entertainment Equipment
Hoffmann - Full Scale Burn Tests of Television Sets and Electronic Appliances
Babrauskas – Heat Release in Fires
Troitzsch – Plastics Flammability Handbook

Where needs take us

Flame Retardant Enclosures

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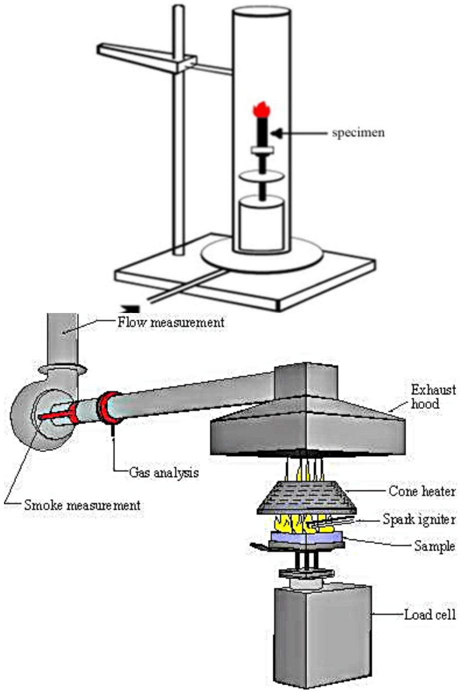
Rockville, MD

Flammability of Plastic Enclosures

Polymer	LOI	pHRR kW/m²
Polypropylene	18	1150
High Impact Polystyrene (HIPS)	18	720
Acrylonitrile-butadiene-styrene (ABS)	19	610
Poly(butylene terephthalate)	22	850
Polyamide 6.6	24	520
Poly(ethylene terephhatalate)	25	880
Polycarbonate (PC)	27	140
PC/ABS	19-27	
Poly(phenylene oxide) (PPO)	32	150
PPO/HIPS	18-32	220



Pure PPO is not processable. Most common PPO/HIPS = 60/40 has LOI = 26

Limiting Oxygen Index (LOI) – minimal oxygen concentration to sustain candle-like combustion of plastic material.

Plastics with LOI > 30 can be considered as inherently flame retardant.

Peak heat release rate (pHRR) measured at 20 kW/m².

Most plastics are flammable if left untreated

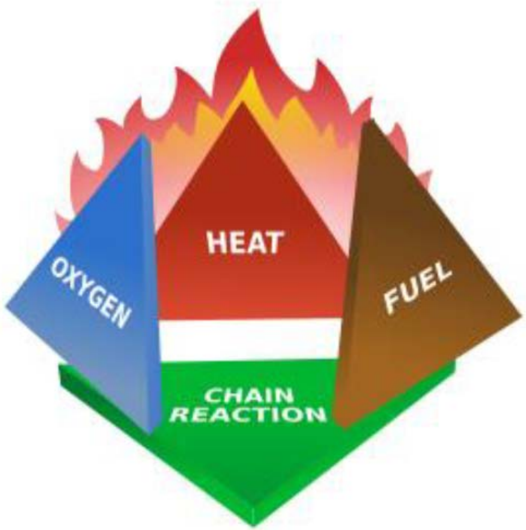
Combustion of Plastics

- Intensity of the flame depends on the orientation.
  - Upward combustion is the most energetic and flame spreads faster.
  - Plastics for electronics are tested in voluntarily UL-94 vertical test.
  - UL-94 addresses both internal and external ignition sources.
- Rate of combustion depends on the thickness.
  - Plastics are tested at the thickness at which they are used.
  - Miniaturization leads to smaller and thinner parts. Thinner plastics burn faster.
  - 15 years ago 1.6 mm was standard thickness for testing.
  - Nowadays some parts are tested at 0.4 mm.

Today's thinner parts burn faster. Vertical burn rate is key.

Flame Retardants

Chemistry of Fire



- Fires are difficult to extinguish because of highly energetic branching chain reactions in the flame.
- Flame retardants is the first line of defense in the case of fire.
- Flame retardants are always close to the ignition source.
- Then role of flame retardants in the electronic
  - preventing accidental ignition
  - stop flame growth which prevents electronic device becoming larger ignition source for other items
- Decreasing heat of combustion is important, but electronics typically are minor contributors to the room fires.

Energized electronics can initiate fires but are not a major fuel load

Flame Retardants Mode of Action

- There are four major classes of flame retardants
  - Inorganic
  - Halogen
  - Phosphorus
  - Nitrogen
- There is no single flame retardant which provides just one mode of action.

- Modes of action
  - Breaking of chain reactions in the flame
  - Cooling flame
  - Heat transfer barrier between fuel (plastic) and the flame
  - Mass transfer barrier
  - Heat reflective layer
  - Run away from the ignition source

Wide variety of plastics and applications require wide variety of FRs

Applicability of Different FRs

- Inorganic – heat removal from the flame, heat reflective layer.
  - Require > 50% addition level. Only elastomers can tolerate such high loading.
  - Used in cables, sometimes connectors, not in enclosures.
- Halogens – break flame chain reactions, heat and mass transfer barrier
  - Most efficient and universal.
  - Work in all types of polymers.
  - Often used in enclosures.
- Phosphorus – heat and mass transfer barrier, sometimes break of chain reactions.
  - Work only in specific polymers because need to react with the polymers.
  - In enclosures are used in PC/ABS and PPO/HIPS.
- Nitrogen – run away from ignition source, cooling flame
  - Used in connectors or as synergists with other FRs.
  - Can be found in enclosures as a minor component.

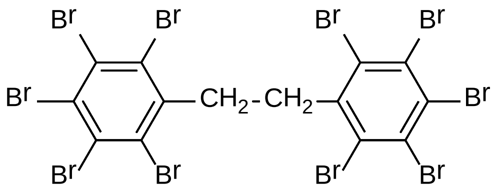
Halogens are the highly effective and useful FRs

Organohalogen FRs

- Chlorine-based FRs are not used in enclosures.
- Bromine-based FRs are very common in electronics and specifically in enclosures.
  - There are 7 non-polymeric brominated FRs which can be found in enclosures.
  - There are 5 classes of polymeric brominated FRs used in electronics. Polymeric FRs are common in connectors and frames, but not very common in enclosures.
  - Mostly reactive FRs are used in printed wiring boards.

Additive FRs used for enclosures; Polymerics inside of the device

Non-polymeric BFRs



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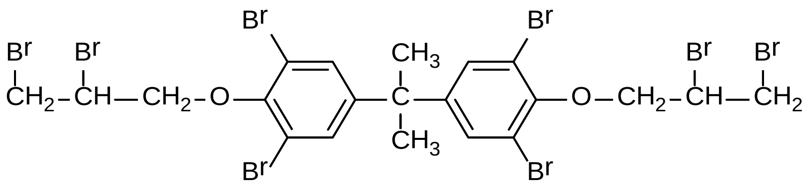

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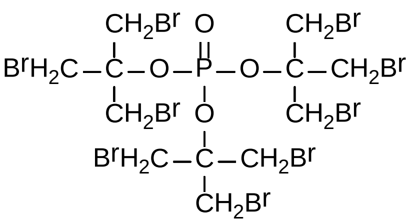

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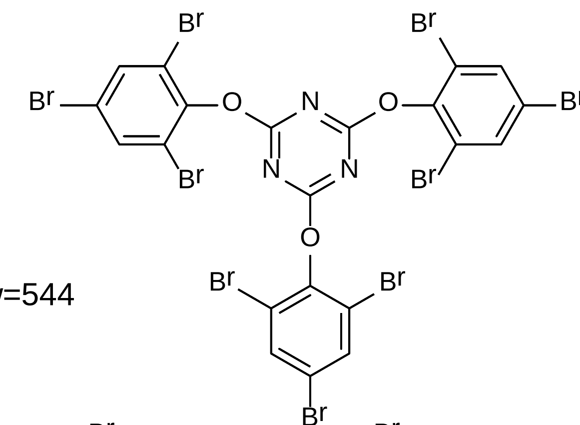

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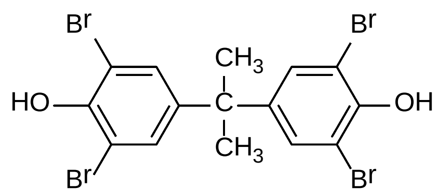

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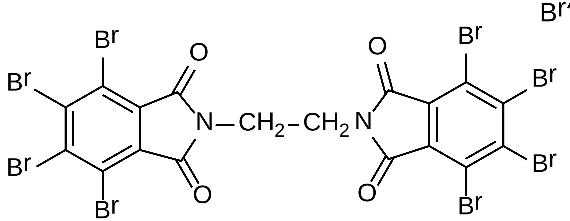

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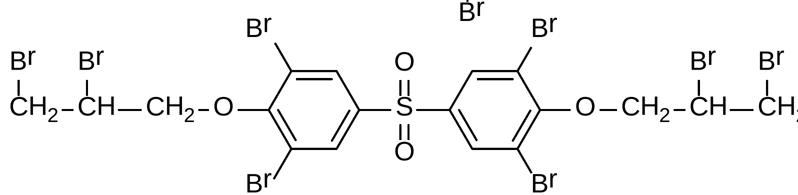

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Non-polymeric BFR are all different and should not be treated as a single group.

FR migration

- In technical terms migration of additives from the plastics called “blooming” for solids and “exudation” for liquids.
- Migration depends on
  - Compatibility of the polymer and the additive. “Similar dissolves in similar”.
  - Molecular weight.
  - Partial vapor pressure.
- Manufacturers give clear recommendations what BFRs are compatible with what polymers.
  - Mismatch typically also lead to the deterioration of physical properties
- Molecular weight of many non-polymeric BFRs is close to 1000 is close to the lower limit of polymers (1500).
  - For comparison molecular weight of BADP = 692, RDP = 574.
- Partial vapor pressure of non-polymeric BFRs is negligible.

Molecular weight of BFRs is nearly that of polymers

SAFR® - Systematic Assessment for Flame Retaradants

- Encompasses analytical methods to assess blooming, exudation, leaching and volatilization – basis for exposure
- Hazard is based on GHS toxicity profile

HAZARD / EXPOSURE	LOW	MEDIUM	HIGH	UNACCEPTABLE
LOW POTENTIAL	RECOMMENDED	RECOMMENDED	ACCEPTABLE	TO BE PHASED OUT
MEDIUM POTENTIAL	RECOMMENDED	ACCEPTABLE	NOT RECOMMENDED	
HIGH POTENTIAL	ACCEPTABLE	NOT RECOMMENDED	NOT RECOMMENDED	

SAFR is a useful tool for consideration of risk in use

Key Points

- Plastics for enclosures are very flammable and require use of flame retardants to mitigate risk of incidental fires.
- Phosphorus based FRs can be used only with limited plastics.
- Brominated FRs are most suitable for all types of plastics.
- Each non-polymeric BFR is different and they cannot be grouped in one class.
- Non-polymeric BFRs have high molecular weight approaching cut point of polymers.

Thank you!

Consumer Technology Association™

CES®

CTA.tech

Overview

CTA is the trade association representing the $377 billion U.S. consumer technology industry, which supports more than 15 million U.S. jobs. Our membership includes more than 2,200 companies, including manufacturers, retailers, distributors and installers of the consumer technology products that appear to be within the broad scope of this proceeding. Eighty percent of CTA's members are small businesses and startups, and others are among the world's best known manufacturer and retail brands. Our members have long been recognized for their commitment and leadership in innovation and sustainability, often taking measures to exceed regulatory requirements on environmental design and energy efficiency.

Overview

- CTA's Product Safety Working Group
  - 50+ members
  - Product safety specialists
  - Support domestic and international safety standards activities
- Existing Flammability Standards
- Layers of safety standards
  - Plastics
  - Enclosures
  - End product

Existing Product Standards

- UL 150 Edition 4-Standard for Antenna Rotators
- UL 452 Edition 7-tandard for Antenna - Discharge Units
- UL 469 Edition 4-Standard for Musical Instruments and Accessories
- UL 813 Edition 7-Standard for Commercial Audio Equipment
- UL 1412 Edition 5-Standard for Fusing Resistors and Temperature-Limited Resistors for Radio- and Television- Type Appliances

- UL 1413 Edition 6-Standard for High-Voltage Components for Television-Type Appliances
- UL 1416 Edition 6-Standard for Overcurrent and Overtemperature Protectors for Radio- and Television- Type Appliances
- UL 1417 Edition 6-Standard for Special Fuses for Radio- and Television- Type Appliances
- UL 1492 Edition 2-Audio-Video Products and Accessories
- UL 1676 Edition 3-Standard for Conductive-Path and Discharge-Path Resistors for Use in Radio-, Video-, or Television-Type Appliances
- UL 6500 Edition 2-Standard for Audio/Video and Musical Instrument Apparatus for Household, Commercial, and Similar General Use
- UL 60065 Edition 8-Standard for Audio, Video and Similar Electronic Apparatus - Safety Requirements
- UL 60950 Edition 2-Information Technology Equipment - Safety - Part 1: General Requirements
- UL 62368-1 Edition 1-Audio/video, information and communication technology equipment - Part 1: Safety requirements

Existing Component Standards

Plastics/Flammability

- UL 94 - Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances
- UL 1694 – Standard for Tests for Flammability of Small Polymeric Component Materials
- UL 746A – Standard for Polymeric Materials - Short Term Property Evaluations
- UL 746B – Standard for Polymeric Materials - Long Term Property Evaluations
- UL 746C – Standard for Polymeric Materials - Use in Electrical Equipment Evaluations
- UL 746D – Standard for Polymeric Materials – Fabricated Parts
- UL 746E - Standard for Polymeric Materials - Industrial Laminates, Filament Wound Tubing, Vulcanized Fiber, and Materials Used In Printed-Wiring Boards

UL 94 – Flammability Rating

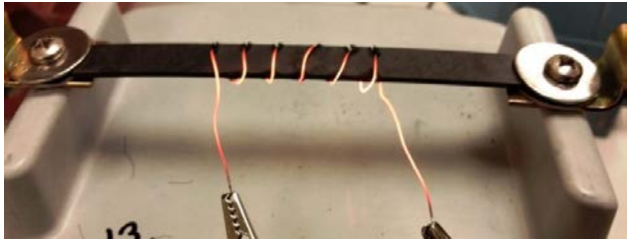
- UL 94 evaluates the flammability of polymeric materials in response to a small, open flame or radiant heat source
- Specifies six different flame tests cover 12 potential classification ratings
  - HB: slow burning on a horizontal specimen; burning rate < 76 mm/min for thickness < 3 mm or burning stops before 100 mm
  - V-2: burning stops within 30 seconds on a vertical specimen; drips of flaming particles are allowed.
  - V-1: burning stops within 30 seconds on a vertical specimen; drips of particles allowed as long as they are not inflamed.
  - V-0: burning stops within 10 seconds on a vertical specimen; drips of particles allowed as long as they are not inflamed.
  - 5VB: burning stops within 60 seconds on a vertical specimen; no drips allowed; plaque specimens may develop a hole.
  - 5VA: burning stops within 60 seconds on a vertical specimen; no drips allowed; plaque specimens may not develop a hole

UL 746A – Flammability Evaluation

- Assess the material's ability to resist ignition from electrical sources
- Possible electrical ignition sources:
  - Overheated electrical conductors and components
  - Arcing parts, such as the open contacts of switches and relays
  - Arcing at broken or loose connections
- Three tests are used to evaluate a material's ability to resist ignition
  - Hot-wire ignition
  - High-current arc ignition
  - Glow-wire ignition test

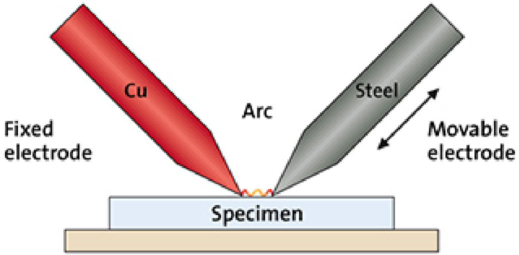
UL 746A-HWI

- Test determines a material's resistance to ignition when exposed to abnormally high temperatures
- This method is used to determine the ignition times of electrical insulation materials
- A performance level category is assigned based on the amount of time it takes to either ignite or burn through a specimen



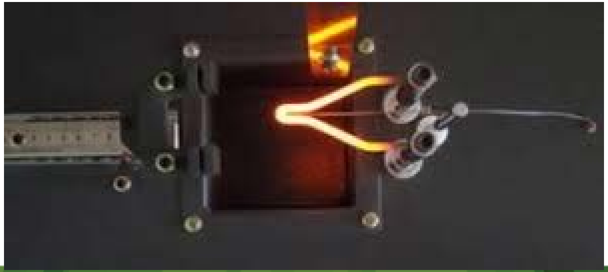
UL 746A – HAI

- Test determines a material's ability to withstand electrical arcing either directly on or just above the surface of the plastic material
- 40 arcs per minute are ignited between a fixed and a movable electrode
- Performance is expressed as the number of arc rupture required to ignite a specimen



UL 746A - GWIT

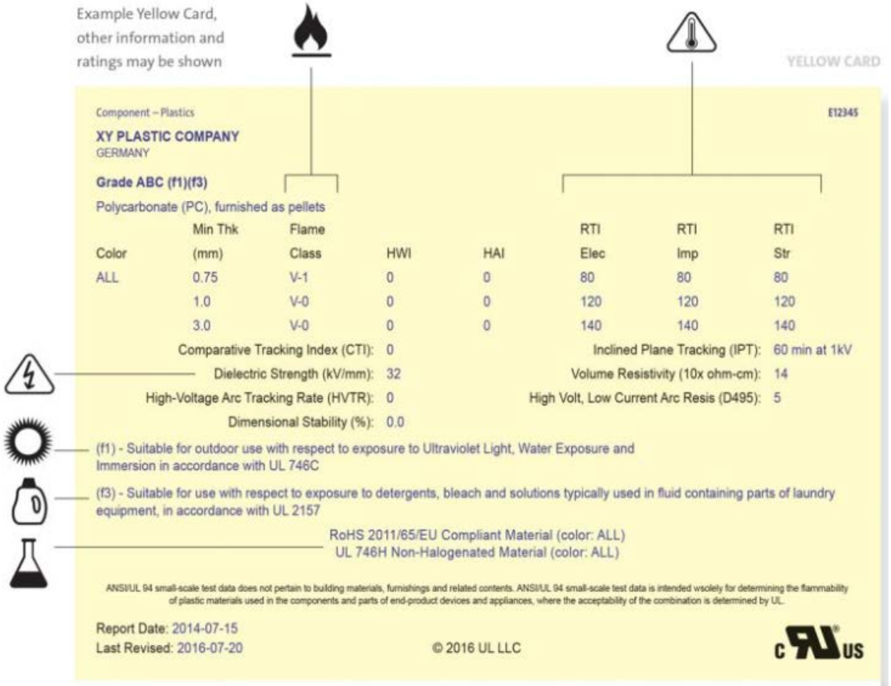
- This test simulates the risk of fire from overheated or electrically energized parts which may cause the plastic material to ignite
- Testing is performed by heating an element to a pre-determined temperature
- After reaching the pre-determined temperature, the element is then pressed into a sample material under a set force of 1N for 30 seconds.



UL 746C – Enclosure Flammability

- These requirements cover parts made of polymeric materials that are used in electrical equipment
- Following tests applied
  - Flammability -12 mm Flame
  - Flammability - 20 mm (3/4-Inch) Flame
  - Flammability - 127 mm (5 Inch) Flame
  - Enclosure Flammability
  - Large Surface Area Considerations
  - Flame Retardant

UL Yellow Card



Example Yellow Card, other information and ratings may be shown

YELLOW CARD

Component – Plastics

E12345

XY PLASTIC COMPANY
GERMANY

Grade ABC (f1)(f3)

Polycarbonate (PC), furnished as pellets

Color	Min Thk (mm)	Flame Class	HWI	HAI	RTI Elec	RTI Imp	RTI Str
ALL	0.75	V-1	0	0	80	80	80
	1.0	V-0	0	0	120	120	120
	3.0	V-0	0	0	140	140	140

Comparative Tracking Index (CTI): 0
Dielectric Strength (kV/mm): 32
High-Voltage Arc Tracking Rate (HVTR): 0
Dimensional Stability (%): 0.0
Inclined Plane Tracking (IPT): 60 min at 1kV
Volume Resistivity (10x ohm-cm): 14
High Volt, Low Current Arc Resis (D495): 5

(f1) - Suitable for outdoor use with respect to exposure to Ultraviolet Light, Water Exposure and Immersion in accordance with UL 746C

(f3) - Suitable for use with respect to exposure to detergents, bleach and solutions typically used in fluid containing parts of laundry equipment, in accordance with UL 2157

RoHS 2011/65/EU Compliant Material (color: ALL)
UL 746H Non-Halogenated Material (color: ALL)

ANSI/UL 94 small-scale test data does not pertain to building materials, furnishings and related contents. ANSI/UL 94 small-scale test data is intended solely for determining the flammability of plastic materials used in the components and parts of end-product devices and appliances, where the acceptability of the combination is determined by UL.

Report Date: 2014-07-15
Last Revised: 2016-07-20

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c UL us

- Snapshot of material properties
- Many different characteristics affect flammability rating
  - Pigmentation
  - Thickness
  - Mechanical/electrical properties

Example End Product Standard

- UL 60065-Audio, Video and Similar Electronic Apparatus
  - Scope of products
    - Sound Amplifiers
    - Video Projectors
    - Video Cameras
    - Video Monitors, others

UL 60065 – Flammability Requirement

- Resistance to Fire Requirements
  - Products shall be so designed that the start and spread of fire is prevented as far as possible, and shall not give rise to danger of fire to the surroundings of the apparatus. Can be achieved by:
    - using good engineering practice in design and production of the apparatus to prevent the formation of potential ignition sources
    - using materials of low flammability for internal parts within the specified distances of potential ignition sources; and
    - using fire enclosures and/or barriers to limit the spread of fire.

UL 60065 – Flammability Requirement

- Reference UL 94 and UL 746 standards for material evaluation
- Examples of Construction Parameters
  - Exemption from testing for components contained in an enclosure of material V-0 with openings not exceeding 1 mm in width
  - Material of printed circuit boards on which the available power exceeds 15 W at a voltage between 50 V and 400 V (peak) a.c. or d.c. meets V-1 or better

UL 60065 – Flammability Requirement

- Specific requirement for enclosures
  - Potential ignition sources with open circuit voltage > 4 kV (peak) a.c. or d.c. contained in a fire enclosure to V-1
  - Internal fire enclosures with openings not exceeding 1 mm in width and with openings for wires completely filled

Summary

- Flammability Standards
  - Written using a consensus based process with participation from industry, consumers, and regulators
  - Materials
  - Components
  - End Product

Organohalogen Flame Retardants (OHFRs) in Electronic Device Casings: **Choosing the Right FR is Tough**

TONY KINGSBURY
PRESIDENT & FOUNDER
TKINGSBURY CONSULTING

TKingsbury Consulting
Specializing In Chemical & Plastic Sustainablilty

My Background

President & Founder: TKingsbury Consulting

VP, Sustainability, Cardno ChemRisk

Executive-in-Residence @ University of California, Berkeley, Taught and Directed a Multi-disciplinary Sustainability Program

Dow Chemical: Experience

- Plastics Production Engineer… including plastics made for TV enclosures
- Product Development Plastics – Packaging, Electronics, Medical, etc.
- Marketing, Public Affairs
- Public Policy – State, Federal, International
- Global Environmental Affairs
- Global Sustainability for Dow Plastics
  - Including all FR's used by Dow
- Breakthroughs to World Challenges Corporate Goal Owner

Choosing the Right FR is Tough

There are literally 100’s of flame retardant, choosing the right one is not as easy as it might appear to a layman.

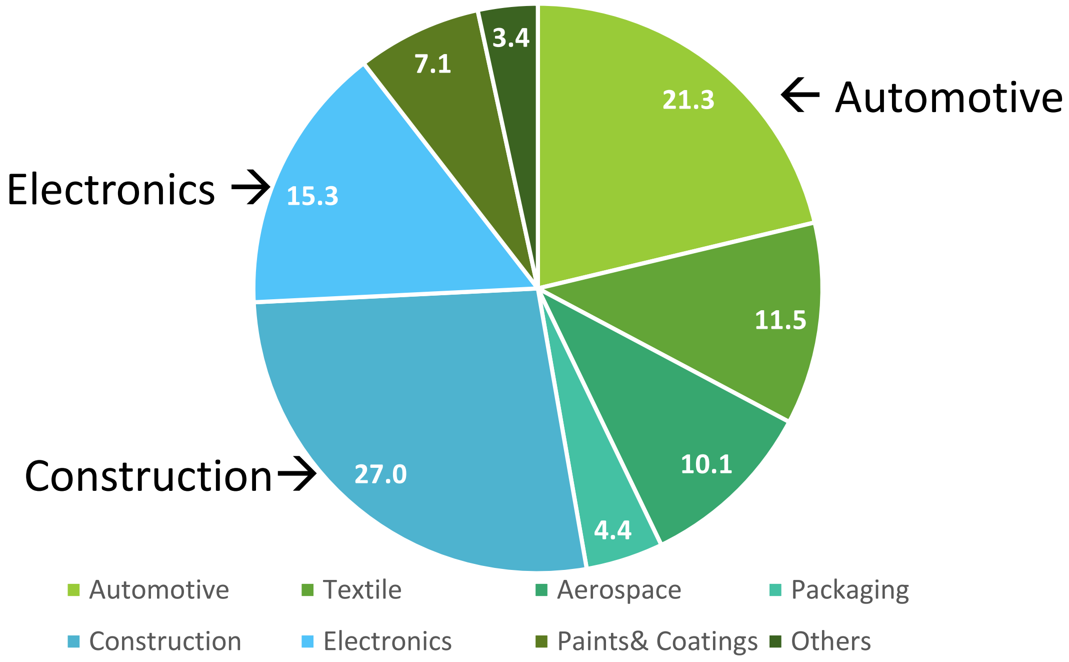
Why don’t companies just pick the cheapest non-toxic FR and call it a day?

FRs Are Used in Many Sectors

Electronics (#3) represent less than a 1/6th of the FR uses. Enclosures are only a portion of this. Construction (#1) and Automotive (#2)

Global Fire Retardant US$ Market Value (%)

Source: Credence Research, Dec 2017, Report Code: 58884-12-17



Design

Before you select a Flame Retardant, you need to determine what plastic resin you will be using to make your enclosure.

Flow – Can it fill the Mold

Strength – Rigidity, Impact Resistance, etc.

Color – Can it be colored black, white, clear, etc.

Availability – Is it available where the enclosure is being produced

Mold – Existing or New

Requirements – Power, Regulatory / UL etc.

Cost Constraints

Choosing the Right FR

What FRs work with that resin?

- Common plastic resins for enclosures include ABS, PC/ABS, HIPS

What FRs meet the UL requirements (V-O, V-2, etc.)?

- Not all FRs work with every plastic resin

What FR's meet the physical requirements?

- The addition of FRs increases flame retardancy but decreases strength, impact resistance, etc.

What FRs meet companies non-regulatory policies?

- Some companies have internal restrictions on the use of various FRs

Supply Chain

Where is the enclosure being made?

Is the FR available there at a competitive cost?

Is the enclosure being made for global sales?

Is the mold already in existence? If so, how does a change in FRs and or plastic resin affect the shrinkage rate… thus affect the dimensions of the final part.

Chemistry of FRs

The Chemistry of FRs falls into a handful of broad categories.

- Halogenated (Contains Bromine or Chlorine) – Todays discussion point
- Phosphonated – Organic molecules that contain a phosphorus molecule
- Combined Phosphonated-Halogenated – self explanatory
- Nitrogen – Most common is melamine
- Mineral – aluminum and magnesium hydroxides. Not widely used in enclosures because of the high processing temperatures.
- Synergists – added so less of the main FR is needed

FRs a Tool for Fire Safety

FRs a tool to prevent or slow down full scale fires allowing people to escape

FRs a tool with decades of proven effectiveness

OHFRs includes a wide variety of chemistries and not all are bad

OHFRs are not all created equal. Thus it is inappropriate to lump them all together. This is like saying all halogens need to be removed from children's pharmaceutical's because a few were not allowed on the market.

We need some way to evaluate them. Perhaps CPSC could work with the EPA to establish a protocol

Banning OHFRs will; (1) cause uncertainty around flame resistance and (2) drive the use of newer chemistries with less known about them

Thanks

Questions?

Tony Kingsbury

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Ph: 925-482-7766

ITI

The Global Voice of the Tech Sector

Electronics Industry Design Trends and Drivers

Chris Cleet – Information Technology Industry Council (ITI)
September 27, 2018

ITI

The Global Voice of the Tech Sector

3M
accenture High performance. Delivered.
acer
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AMD
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amazon
ANALOG DEVICES
ARROW
AUTODESK
BlackBerry
brother at your side
Canon
ca technologies
cisco
Cognizant
CORNING
CSRA
DELL
Dropbox
ebay
EPSON
EQUINIX
ERICSSON
facebook
FLEXTRONICS
FUJITSU
FUNAI
GARMIN
GE
GLOBALFOUNDRIES
Google
Hewlett Packard Enterprise
Honeywell THE POWER OF CONNECTED
hp
IBM
intel
intuit
JUNIPER NETWORKS
KEYSIGHT TECHNOLOGIES
KONICA MINOLTA
Lenovo
Lexmark
LG
logitech
mastercard
McAfee
Micron
Microsoft
MITSUBISHI
MOTOROLA SOLUTIONS
NATIONAL INSTRUMENTS
NCR
NetApp
nielsen
NOKIA
NVIDIA
Oath: A Verizon company
ORACLE
paloalto NETWORKS
Panasonic
Pitney Bowes
QUALCOMM
RAPID7
RICOH
Rockwell Automation
salesforce
SAMSUNG
SAP
Schneider Electric
SONY
SWIFT
SYNOPSYS
TATA CONSULTANCY SERVICES
Tektronix
tenable
TERADATA
TEXAS INSTRUMENTS
TOSHIBA Leading Innovation
TOYOTA
VERISIGN
VISA
vmware
wish
workday
xerox
ZEBRA

Electronics Industry Involvement and Position on Petition

- The electronics industry, through ITI and CTA, has been involved in this petition since the first public hearings
- ITI and CTA supported the staff recommendations that the petition be denied
- Electronic products are unique in the scope of the petition in that they carry a current

ITI Commenting on OFR Petition, December 9, 2015

Outline

- General design trends for electronics
- Drivers
- The design cycle for electronics
- Material selection trends

General Design Trends for Electronic Products

- Move to more mobile devices
- Power and versatility
  - No longer single function devices
- Aesthetically pleasing
- Environmentally friendly and sustainable
  - Materials and energy efficiency are being maximized

Photo source: https://funalive.com/articles/the-evolution-of-cell-phones_W3M.html

Drivers for Design Trends

- Customer demand
- Standards
- Innovation
- Laws and regulations

The Design Cycle

- Design cycle is 18 – 36 months for most IT devices; longer for large devices

- Considerations
  - Drivers (as before -- what does the customer want)
  - Lifecycle of the product
  - Risk/hazard/liability
  - Costs to the customer
  - Value recovery – Circular economy

- Compliance and documentation

Material Selection

- Drivers
  - Mechanical requirements
    - Weight
    - Durability
    - Sustainability
  - Performance
    - Flame retardance
  - Customer wants
    - Aesthetics
    - Price point

Material Selection

- Continual evaluation of potentially hazardous materials
    - Industry continuously reviews materials added to a device
        - Hazard screening
        - Risk assessments
    - Many regulatory restrictions are preceded by industry materials trends
        - Example: RoHS lead restrictions
- The electronics industry works with governments, NGOs and industry to evaluate materials in products
    - IT Industry (among others) worked with Clean Production Action to develop the GreenScreen tool
    - Worked with State of California to develop Green Chemistry Alternatives Assessment process

Summary

- Many drivers on electronics design
  - Customer experience is always first driver
    - Wants/needs
    - Safety
  - Regulatory drivers
  - Innovation
    - Electronics industry is always looking for next technological advance

Thank You

Chris Cleet, QEP

Information Technology Industry Council (ITI)

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United States
CONSUMER PRODUCT SAFETY COMMISSION

Says:
Stop Using Organohalogens

Are Flame Retardants in Electronics Enclosures and Product Safety Goals Mutually Exclusive?

DESIGN CHAIN ASSOCIATES

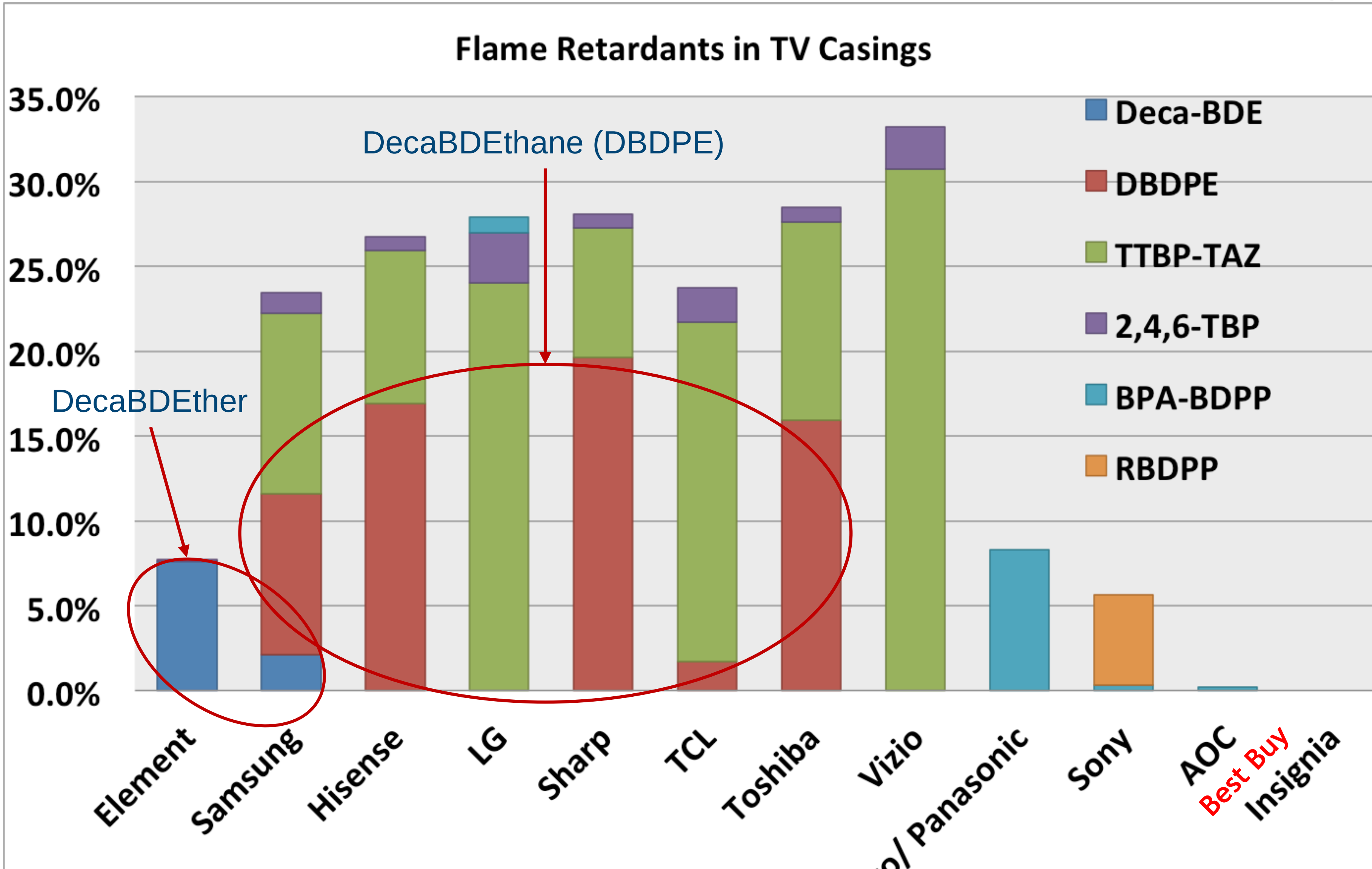
Sept. 27, 2018
CPSC OFRs in Electronics Casings Meeting
Rockville, MD

Michael Kirschner, President

Agenda

- Why are Flame Retardants Used in Electronic Enclosures / Casings?
- How Can Industry Be Expected to React to an OFR Restriction Regulation?
- How can Manufacturers Improve Environmental / Human Health Safety Outcomes for Their Products?

Flame Retardants in TV Enclosures Case Study



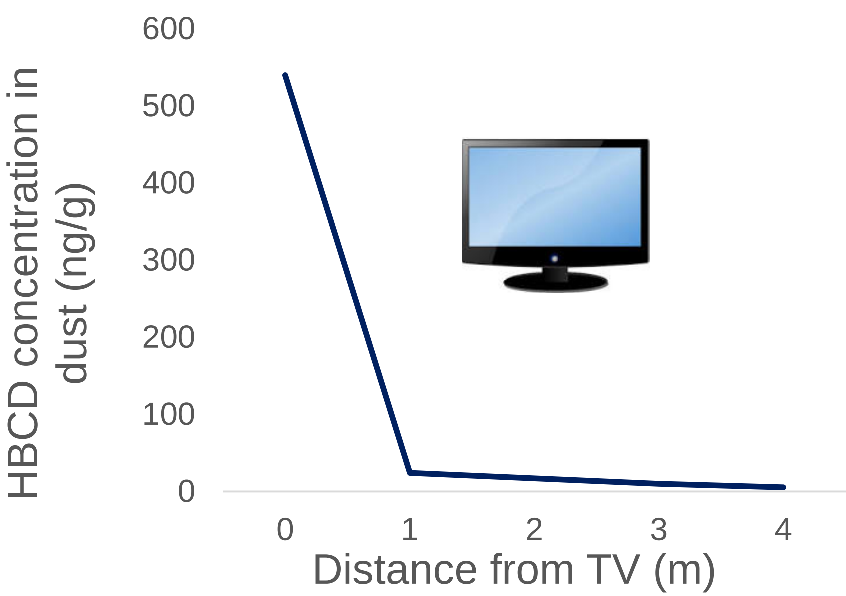
Schreder, et al. 2017 *TV Reality : Toxic Flame Retardants in TVs*.
https://toxicfreefuture.org/science/research/flame-retardants-tvs/

Flame Retardants are used in Plastics

To Meet Fire Safety goals defined in product safety standards including UL 62368-1

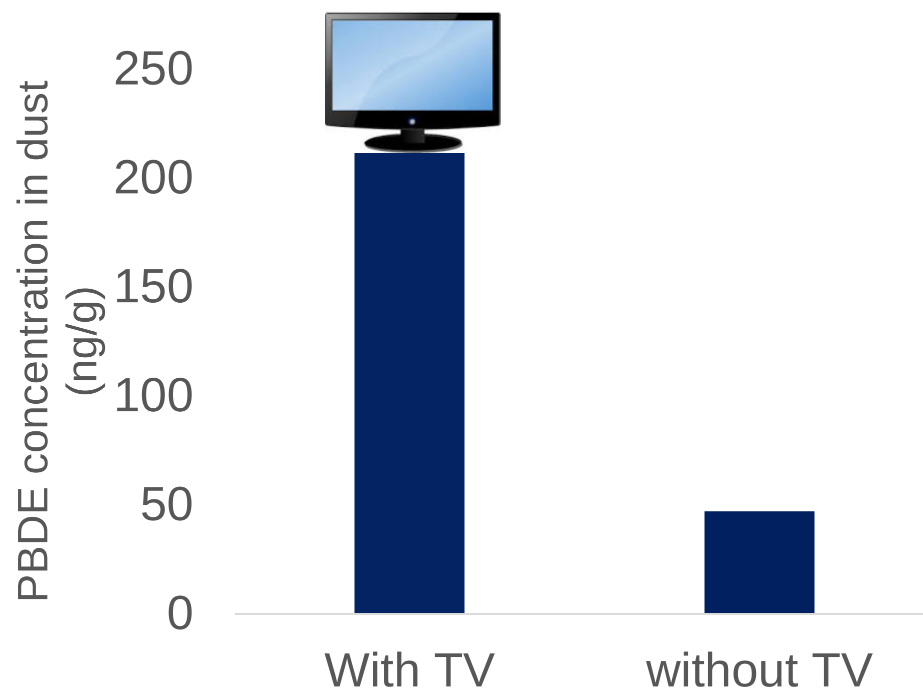
(UL 62368-1 covers IT/Video/Audio; other standards cover other categories of household electronics)

Flame Retardants Migrate from Electronics into Dust



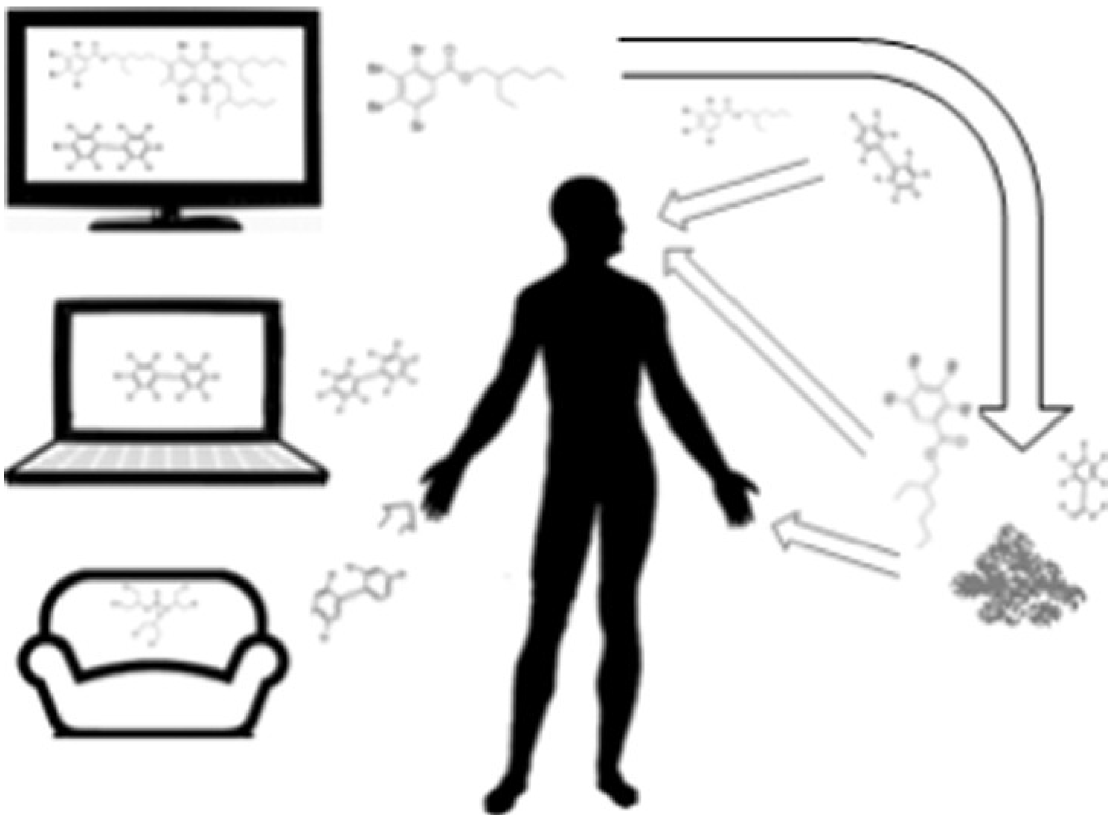
Flame retardants levels in dust are highest within one meter of the television.

Flame retardants levels in dust are higher when televisions are present.



Harrad 2008; Harrah 2009; Muehnor 2012

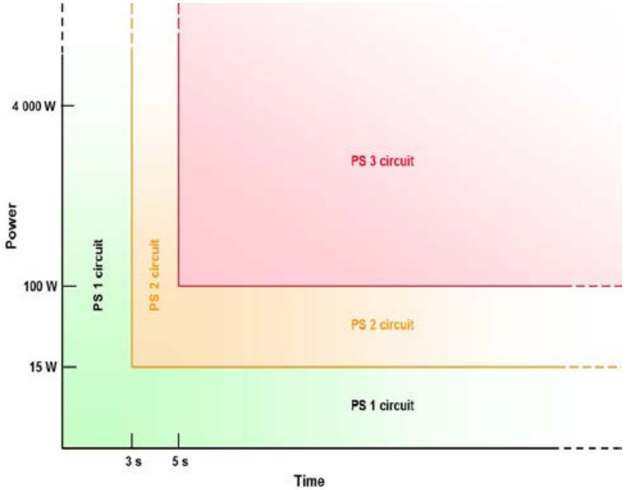
FRs from Electronics are Absorbed by People

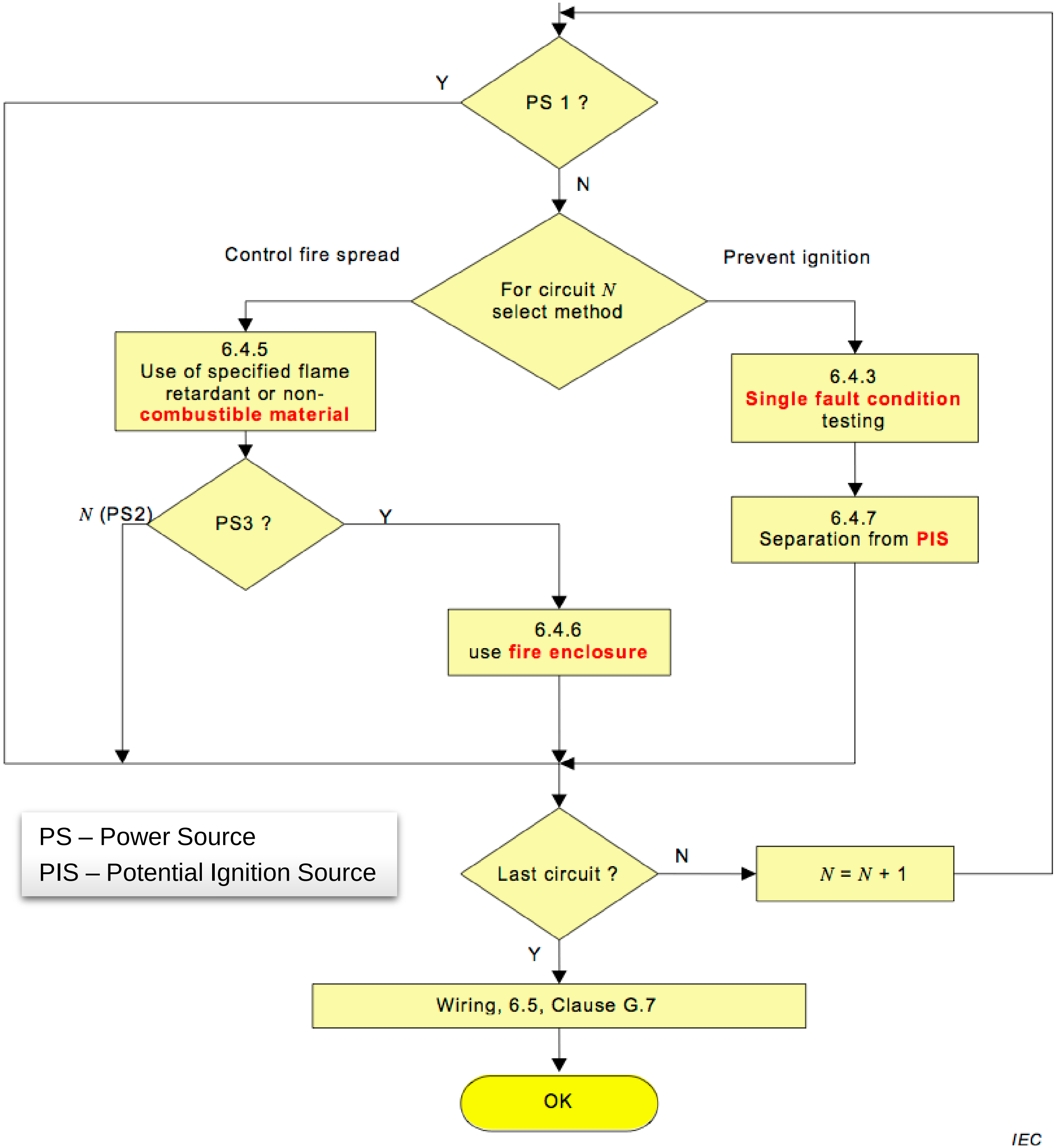


Source: Diamond, "Product screening for sources of halogenated flame retardants in Canadian house and office dust," 2016.

UL 62368-1
Clause 6

When is a fire enclosure necessary?





PS – Power Source
PIS – Potential Ignition Source

Flowchart from IEC TR62368-2

Implementing Clause 6: A “Blind Spot” for Product Safety Engineering?

- Clause 6 of UL 62368 helps safety engineers define design requirements to meet fire safety goals for IT/Video/Audio equipment
  - As do other standards for other types of Electrical/Electronic Products
- It does not define the “right” approach
  - Or what “right” means!
- It does not specify materials to use ***or*** the use of FRs
  - Or whether/how to assess those materials for environmental/human health/biological safety
- If implemented correctly, the product will pass the *<u>defined</u>* test
  - But it may not be “safe” in terms of the environment or human health

Industry Reaction to Substance/Class Restrictions

- Manufacturers go to the cheapest or most expedient alternative in the face of substance restriction, e.g.
  - Additive BFR/CFRs are likely to be replaced with unregulated reactive BFRs or Phosphorus-based FRs
  - Other options can be more expensive and possibly more time-consuming to implement
    - Re-layout/re-design or use of non-flammable enclosures
- Regulators do not tend to control replacements for restricted substances
  - This opens the door for "Regrettable Substitutions"
  - However, note that the California Safer Consumer Products Regulations attempt to do that

Product Safety vs. Health Safety

- These are not mutually exclusive
  - FR example: meeting flammability safety requirements can have negative environmental/ human health safety impacts
  - Reactive BFRs and Phosphorus-based FRs have problematic health safety and recycling profiles too
- Bad choices can and do displace fire safety issues to health safety
  - Product Safety review and assessment must incorporate environmental/human health impact assessments; they do not at most manufacturers

Controlling Replacements by Regulation

- "Regrettable Substitute" Examples
  - Electronics casings: DecaBDEther-> DecaBDEthane (DBDPE)
  - Electronics Solder: SnPb -> SnAgCu: insignificant overall environmental/human health impact improvement
  - Brake Pads: Asbestos->Cu->?: carcinogen replaced by aquatic toxin replaced by (something better?)
- Consider requiring improved lifecycle performance
  - Alternatives Assessments is one possibility
  - Provide guidance to manufacturers

Solder paper reference:

Xiaoying Zhou and Julie M. Schoenung, "An integrated impact assessment and weighting methodology: evaluation of the environmental consequences of lead-free solder alternatives," Proceedings of the 2008 IEEE International Symposium on Electronics & the Environment, San Francisco, CA, USA, May 2008. doi: 10.1109/ISEE.2008.4562924.

Summary/Recommendations

- US Product Safety Standards define the flammability safety expectations. They do not specify materials nor do they mandate the use of FRs
  - Nor do they specify environmental/human health safety expectations
- Manufacturers will typically choose the least expensive alternative. Health Safety <u>must</u> be viewed as an additional design constraint.
  - Product Safety Engineering must work closely with Environmental Compliance / Safety personnel
  - And Environmental Compliance personnel must be educated on general environmental/human health safety
- Recommendations to manufacturers:
  - Identify fire-resistant materials for enclosures that don't require FRs
  - Redesign products to minimize the need to add flame retardants to enclosures and enhance recyclability and health safety

DESIGN CHAIN ASSOCIATES

Thank You For Your Attention

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DESIGN CHAIN ASSOCIATES

About DCA

- Manufacturing Consulting firm
  - Focus on Discrete/Fabricated “Article” Manufacturers
  - Based in San Francisco, CA
- Focus 1: Strategies/Tactics for Compliance with Product-Targeted Environmental Regulation & Customer Requirements
  - Substance compliance, Recycling, Green Claims, Energy Use, Conflict Minerals, Carbon/GHG, NGOs
  - Worldwide scope
  - A&D, Industrial and Commercial, Consumer Electronics, Medical, Apparel, Agriculture, Construction, etc.
- Focus 2: Supplier/Component/Technology Selection, Management, & Integrity
  - Product development business processes that improve engineering efficiency and mitigate many supply chain problems
- See www.DesignChainAssociates.com

DESIGN CHAIN ASSOCIATES

Mike's Background

- 20 years in manufacturing companies, in product development and quality/reliability roles:

- 18 years in consultancies

- Co-Moderator: ANSI Chemicals Network
- Initial Member of California EPA DTSC Green Ribbon Science Panel: 2009-2013
- Member of American Chemical Society Green Chemistry Institute Advisory Board: 2014-current

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STATEMENT

SRIRAM GOPAL
DIRECTOR, TECHNOLOGY & ENVIRONMENTAL POLICY

ON BEHALF OF
THE ASSOCIATION OF HOME APPLIANCE MANUFACTURERS

BEFORE THE
CONSUMER PRODUCT SAFETY COMMISSION

Organohalogen Flame Retardants (OFRs) in Electronic Device Casings Tech-to-Tech Meeting

September 27, 2018
Rockville, Maryland

CPSC Staff and Interested Parties:

On behalf of the Association of Home Appliance Manufacturers (AHAM), I would like to raise the following points concerning the Consumer Product Safety Commission's interest in the use of organohalogen flame retardants in electronic casings.

AHAM represents manufacturers of major, portable and floor care home appliances, and suppliers to the industry. AHAM's membership includes over 150 companies throughout the world. In the U.S., AHAM members employ tens of thousands of people and produce more than 95% of the household appliances shipped for sale. The factory shipment value of these products is more than $30 billion annually. The home appliance industry, through its products and innovation, is essential to U.S. consumer lifestyle, health, safety and convenience. Through its technology, employees and productivity, the industry contributes significantly to U.S. jobs and economic security. Home appliances also are a success story in terms of energy efficiency and environmental protection. New appliances often represent the most effective choice a consumer can make to reduce home energy use and costs.

AHAM is also a standards development organization, accredited by the American National Standards Institute (ANSI). The Association authors numerous appliance performance testing standards used by manufacturers, consumer organizations and governmental bodies to rate and compare appliances. With respect to safety standards, we work closely with Underwriters Laboratory (UL), CSA, and other safety standards developers around the world. AHAM's consumer safety education program has educated millions of consumers on ways to properly and safely use appliances such as cooking products, portable heaters, and clothes dryers.

First, I would like to re-iterate some of the concerns that AHAM raised when CPSC first considered a petition requesting a rule making on products containing OFRs.[1] The petitioners asked the Commission to initiate a rulemaking to declare several ambiguously defined categories of consumer products to be "banned hazardous substances." Although the Petition raised important issues relating to chemical safety, the petitioners' approach was overbroad and more burdensome than necessary to accomplish its stated goals. In light of these concerns, AHAM respectfully opposed the petition in our January 19, 2016 comments, and restated those concerns in comments submitted on September 19, 2017.

AHAM's members produce hundreds of millions of products each year. They design and build products at the highest levels of quality and safety. As such, they have demonstrated their commitment to strong internal safety design, monitoring, and evaluation/failure analysis systems. AHAM supports the petitioners' intent to protect consumers against all unreasonable risks,

[1] Petition HP 15-1 Requesting a Rulemaking on Products Containing Additive Organohalogen Flame Retardants, Docket No. CPSC–2015–0022

including those associated with the exposure to potentially harmful chemicals. AHAM also firmly supports the appropriate use of flame retardant chemicals in electronic and electrical devices. Together with industry design practices, test requirements, and redundant safety mechanisms, flame retardant chemicals play an important role in the safety of household appliances. In fact, the use of OFRs in electronic devices is necessary in some cases to meet the voluntary consensus standards in whose development CPSC participated and upon which the appliance industry relies. Examples include safety standards for clothes dryers (UL 2158) and household electric ranges (UL 858). It may not be possible to replace these necessary flame retardants. For example, in at least one instance, an AHAM member conducted an alternatives assessment to replace an OFR in its products, and, after an extensive effort, determined to replace the compound in question with another OFR.

The broad grouping of OFRs in the petition is also inappropriate as it ignores other government agencies' chemical-specific work on OFRs. Here in the United States, the Environmental Protection Agency is doing a more targeted assessment of flame retardants while bodies like the European Chemicals Agency, or ECHA, is undertaking similar action internationally. Interagency and international cooperation is one of CPSC's goals and a significant way CPSC can work to mitigate burden on regulated parties without compromising consumer product safety. Thus, AHAM urges CPSC to coordinate any actions regarding OFRs with other agencies working on these issues. In particular, to the extent CPSC continues to investigate OFRs, it should coordinate with EPA.

AHAM also has concerns specific to the inclusion of electronics in the petition. First, it is unclear from the original petition and even the scope of today's meeting whether home appliances would be included in the broad categories of "electronic devices" or "electronic device casings." AHAM would oppose the inclusion of home appliances, which are not traditionally viewed as "electronic devices." If CPSC continues to investigate the use of OFRs in the outer casings of electronic devices, CPSC should first clarify the scope of the work so that the proper parties can participate and CPSC can appropriately allocate its limited resources. For example, a casing could be a component that surrounds a piece of circuitry within a device. On the other hand, as no clear definition exists, the term could also mean an entire refrigerator because that is an appliance that houses electronic components. It is because of the potential breadth and the ambiguity of the phrases "electronic devices" and "electronic device casings" that AHAM believes its products may be improperly implicated. Thus, CPSC should clarify its intent and scoping process before moving forward with any rulemaking.

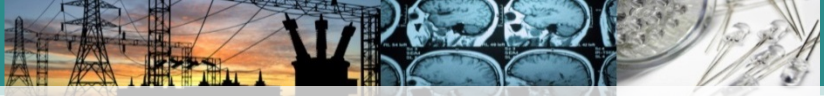
In addition to a vague and potentially overly broad definition of electronic devices, it is important to acknowledge the difference between electronic devices and the other proposed categories of products. The use of flame retardant chemicals in children's products, stuffed furniture, and mattresses and mattresses covers are to prevent those items from becoming fuel for a fire cause by some external source. The purpose of flame retardant chemicals in electronics is to prevent those electronics from becoming the source of a fire. All electrical devices inherently have some risk of starting a fire. AHAM's members work tirelessly to reduce these risks for home appliances. Nevertheless, the risk of fire inherent in all electrical components is a primary reason that electronics are contained in fire resistant enclosures. The protection from fire risks provided by electronic device enclosures is meaningfully different than preventing household goods from becoming additional fuel for a fire started by some other means. The importance of this type of fire protection to human safety must be considered in the Commission's work on this issue.

The CPSC staff conducted a thorough analysis of the initial petition and AHAM agrees with the analysis and conclusions in the Staff Briefing Package. As we previously commented, we continue to believe the petition was overly broad and insufficiently justified in its claims—CPSC staff reached the same conclusion. The staff also concluded that the Petition failed to show a connection between the exposure to a substance and personal injury or harm from that exposure, which is a necessary showing to initiate a rulemaking under the Federal Hazardous Substances Act. Moreover, CPSC staff found that the data presented in the Petition were insufficient to draw specific conclusion and that there was no evidence to suggest that a rulemaking would provide any consumer benefit.

While AHAM seeks to maintain its working relationship with CPSC on matters of safety and is willing to provide support in the Commission's efforts to minimize unnecessary exposure to OFRs, the Commission must narrow the scope and clearly define the intent of its efforts.

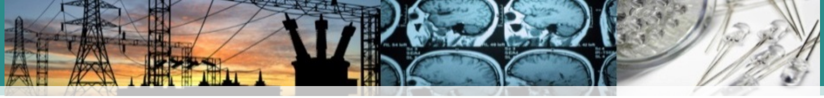
Respectfully submitted,

Sriram Gopal



Organohalogen Flame Retardants (OFRs) in Electronic Device Casings (Enclosures)

Muhammad Ali, Program Manager
National Electrical Manufacturers Association



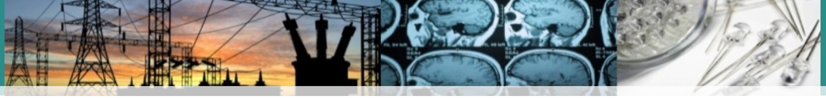
NEMA Products

- *"Electronic devices with additive organohalogen flame retardants in their plastic casing."*
    - Enclosures
    - Outlets and Switch Boxes
    - Audible and visual signals including bells, horns, speakers and strobes for use in fire alarm systems.
    - Automatic detectors for fire protection and other life safety hazards including heat, smoke, flame, gas, biohazard detectors, etc.
    - Smoke Alarms, CO Alarms and combination Alarms
    - Life safety protective signaling systems

RoHS

- Restriction on the use of certain Hazardous Substances

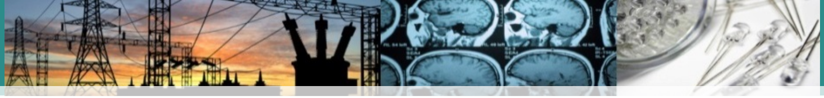
- RoHS 3:
  - Lead (Pb): < 1000 ppm
  - Mercury (Hg): < 100 ppm
  - Cadmium (Cd): < 100 ppm
  - Hexavalent Chromium: (Cr VI) < 1000 ppm
  - Polybrominated Biphenyls (PBB): < 1000 ppm
  - Polybrominated Diphenyl Ethers (PBDE): < 1000 ppm
  - Bis(2-Ethylhexyl) phthalate (DEHP): < 1000 ppm
  - Benzyl butyl phthalate (BBP): < 1000 ppm
  - Dibutyl phthalate (DBP): < 1000 ppm
  - Diisobutyl phthalate (DIBP): < 1000 ppm



Electrical Enclosures

- Halogenated flame retardants are commonly used in a wide range of products to inhibit the ignition and spread of flames

- Due to RoHS and Prop 65 directives, some manufacturers have:
  - Discontinued the use of halogens;
  - Been using the flame retardant materials in open and closed molding processes containing aluminum trihydrate. It is halogen free, and contains NO antimony oxide or bromine;
  - Been using halogen free materials in injection molding;
  - Chosen to use the wires and equipment inside the enclosure to be flame retardant with non-halogenated materials.



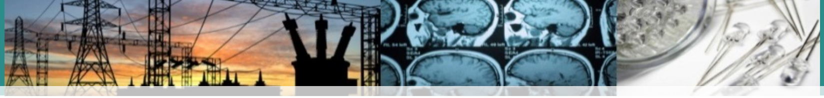
Product Standards

- NEMA is an ANSI accredited Standards Development Organization (SDO)
- We develop performance based standards tailored to specific industry needs
- Some of these performance standards contain flammability requirements for polymeric (plastic) materials to ensure that the plastic encasings do not ignite in the proximate presence of an electrical current. In order to meet these particular requirements, the products are manufactured with flame retardants.

Installation Codes

- Beyond product standards is the category of installation codes. The National Fire Protection Association (NFPA) owns and maintains many of these, including the National Electrical Code (NEC), which dictates how and where electrical products should be installed.

- The NEC also incorporates by reference many of the product standards (developed by NEMA, Underwriters Laboratories and other ANSI accredited standards developers) and requires that those products be "listed" to a performance standard. This means that in order for a product to be installed in accordance with the installation requirements of the NEC, a product must also meet the requirements of the referenced performance standard (e.g. flammability requirements).



Electrical Hazard

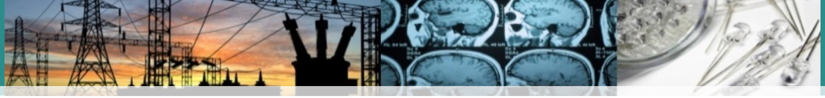
- Electronic and electrical devices are in constant contact with an electrical current. Indeed, products such as hard-wired carbon monoxide alarms and arc fault circuit interrupters do not and cannot have an "on/off" switch to disrupt the flow of electricity through the product because they must be continually "on" to protect against electrical hazards.
- Not only does the electrical circuitry result in an immediate heated environment, but electrical arcing is also a risk. Accordingly, in electrical products it is absolutely imperative that the intrinsic risk of electrical hazards be mitigated.
- Removing the flame retardants currently in use could lessen the products' ability to perform this function.

What are the Alternatives?

- There are materials which are inherently flame and/or heat resistant (to the extent necessary) which might theoretically be used to encase the electrical wiring inside of the product instead of plastic, thereby avoiding the need for additive flame retardants.

- Alternative OFRs may be inorganic, nitrogen, and phosphorus-based FRs.

- However, none of these materials has proven to be a viable alternative to the plastic casings due to other inherent characteristics such as weight, instability or drastically increased cost.



What are the Alternatives?

- Substitution will require manufacturers to consider various factors such as:
  - Flammability Performance
  - Material Properties
  - Overall Product Performance
  - Product Redesign
  - Cost