ENGINEERED PLASTICS WORKSHOP

Learn About Thermoplastics I Connect with Experts

2017 ***KING OF PRUSSIA / PENNSYLVANIA***
(PHILADELPHIA AREA)

YOUR GLOBAL COMPOUNDER OF
CUSTOM ENGINEERED THERMOPLASTICS

RTP Co.
Imagineering Plastics®

Answers to Your Burning Questions: Flame Retardants and Regulations

Jesse Dulek | Product Development Engineer
jdulek@rtpcompany.com
(507) 474-5502

3:15 p.m.

COLOR • CONDUCTIVE • FILM/SHEET • FLAME RETARDANT
STRUCTURAL • THERMOPLASTIC ELASTOMERS • WEAR

Answers to Your Burning Questions: Flame Retardants and Regulations

Jesse Dulek
Product Development Engineer

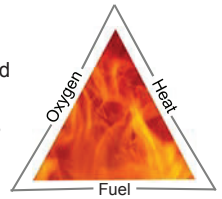
rtpcompany.com • rtp@rtpcompany.com

FLAME RETARDANT (FR) MATERIALS

Definition

Materials that do not ignite readily or propagate flames under small to moderate fire exposures

- Materials are combustible
- Fire retardants reduce the intensity and spread of fire
- Reduces smoke and toxic by-products of combustion



Fire Triangle

GOALS OF FLAME RETARDANT COMPOUNDS

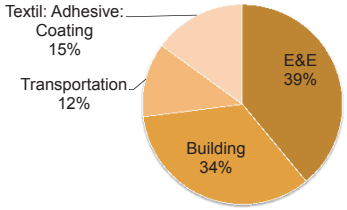
- Increase resistance to ignition
- Reduce rate of flame spread
- Reduce rate of heat release
- Reduce smoke emission

End Goal:

- Meet FR specifications
- Make the world a safer place!

MARKETS FOR FR THERMOPLASTICS

Segmentation of FR Consumption by Value



- Electrical Parts
- Electronic Enclosures
- Wire and Cable
- Appliances
- Transportation
- Building and Construction

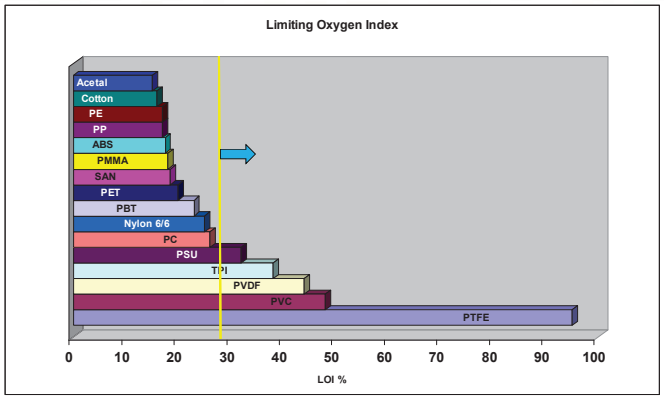
OVERVIEW

- **Thermoplastic Flammability**
  - **Flame Retardant Additive Chemistries and Mechanisms**
- Testing Standards
- Aerospace Requirements
- Case studies

THERMOPLASTIC RESIN FLAMMABILITY

Flammable	Inherently Flame Resistant
• Polyolefins • Nylons • Polycarbonate • Polyesters • Styrenics • TPEs	• Polysulfones • Polyphenylene Sulfide • Polyetheretherketone • Polyetherimide • Flouropolymers

CHALLENGES OF FLAME RETARDING PLASTICS

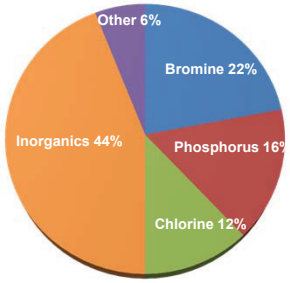


COMMON TYPES OF FR ADDITIVES

Halogenated FRs
- Brominated
- Chlorinated

Halogen Free FRs
- Metal hydroxides
- Phosphorous based
- Melamine based

Flame Retardant Additive Usage, 2011



HALOGENATED FR MECHANISM

- Halogenated technology inhibits the chemical reaction in the gas/vapor phase
- Various molecules that efficiently get large amounts of free radicals to the gas phase

Additive Type	Polymeric Type
• Higher halogen content • Lower loadings • High thermal stability	• Melt blendable • Less effect on physical properties • Enhanced flow

Halogenated flame retardants are compatible in most resin systems with the exception of Acetal

NON-HALOGEN MECHANISMS

Phosphorous	Hydrated Minerals	Melamine Cyanurate
• Various forms • Contributes to the condensed phase char formation	• Produce water during combustion process, dilute flammable vapors • Insulative char formation	• Endothermic decomposition • Physical removal of flame from surface

Resin Systems

Polyolefins, Polyamides, Polyesters, Polycarbonate and alloys	Polyolefins, Polyamides	Polyamides, used as a synergist for other Phosphorous technologies

HALOGEN VS. HALOGEN-FREE

Halogenated	Halogen Free
• Lower cost • Better processing • Better efficiency • Better physical properties	• Evolving economics • Improved processing • Wide variety of products • Low smoke • Lower toxicity • Less corrosive • Lower specific gravity

CHOOSING A FR SYSTEM

How do we decide which FR mechanism to use?

- Resins system
- FR specification
- Part function
- Fillers/additives
- Regulatory concerns
  - Halogen, RoHS, etc.

OVERVIEW

- Thermoplastic Flammability
  - Flame Retardant Additive Chemistries and Mechanisms
- **Testing Standards**
- Aerospace Requirements
- Case studies

INDUSTRY AND MARKET DRIVEN

Electrical and Electronics (E&E)

- UL 94
  - V, 5V, HB
- UL 746
  - HAI, HWI, CTI

UL94 RATINGS

UL94 Ratings

- HB
- V-2
- V-1
- V-0
- 5VB
- 5VA

Ratings in order of difficulty to meet!

UL94 RATINGS

HB

- Handheld electronics
- Cell phone

V-2

- Low-voltage, attended
- Electric shaver

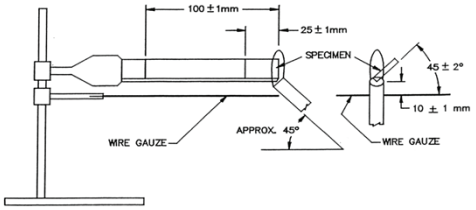
V-1/V-0

- High-voltage, un-attended
- Electronic connectors

- **5VB/5VA**
  - Electronic enclosures

UL94 - HB

Horizontal burning test for HB classification



Classification Criterion

3.0 mm to 13.0 mm thickness

- *slower than 40 mm/minute or…*
- *combustion ceases prematurely*

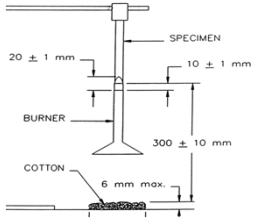
< 3.0 mm thickness

- *slower than 75 mm/minute or…*
- *combustion ceases prematurely*

***** In general most thermoplastics meet this criteria*****

UL94 - VB

Classification Criteria	V-0	V-1	V-2
Number of bar specimens	5	5	5
Maximum flame time per specimen per flame application, sec	10	30	30
Maximum total flame time 5 specimens, 2 ignitions, sec	50	250	250
Specimen drips, ignites cotton	No	No	Yes
Maximum afterglow time per specimen, sec	30	60	60
Burn to holding clamp	NO	NO	NO

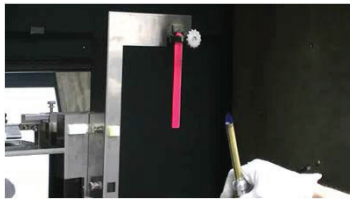


*****Thickness dependent ratings*****

UL94 VERTICAL BURN DEMO

Flame Retardant – V-0

Non- Flame Retardant – No Rating



RTP COMPANY UL CERTIFICATION

RTP Company has 600+ UL Yellowcards

- Continuous expansion of UL listed products

UL Certified Laboratory under Client Test Data Program (CTDP)

- Short term properties to UL94
- Long term thermal aging (RTI)

RTP Company offers custom UL certifications to achieve full commercialization

- Quick turnaround
- Compress your Time to Market!

BUILDING / INDUSTRIAL

Requirements focus on:

- Low smoke, heat release, burn rate, flame spread

Various standard that apply:

- UL2043, UL723/ASTM E84, ASTM E1354, NFPA 701, FM 4996, CAL TB133

Applications

- Wall coverings, furniture, plenum, pallets, storage systems, roofing, floor coverings, ventilation

OVERVIEW

- Thermoplastic Flammability
  - Flame Retardant Additive Chemistries and Mechanisms
- Testing Standards
- **Aerospace Requirements**
- Case studies

AIRCRAFT INTERIORS FR REQUIREMENTS

All Commercial Aircraft (FAR 25.853 (a))

- Appendix F, Part 1, (a)(1) = Interior compartments occupied by crew & passengers
  - **(i) = 60 second Vertical Burn Test**
    - Ceiling & Wall Panels, Partitions, Galley Structure, Large Cabinet Walls, Structural Flooring, Stowage Compartments
  - **(ii) = 12 second Vertical Burn Test**
    - Floor Covering, Textiles, Seat Cushions, Paddings, Fabric, Leather, Trays, Galley Furnishings, Electrical Conduit, Air Ducts, Joint & Edge Covering, Trim Strips, & Others

AIRCRAFT INTERIORS FR REQUIREMENTS (CONT.)

All Commercial Aircraft (FAR 25.853 (a))

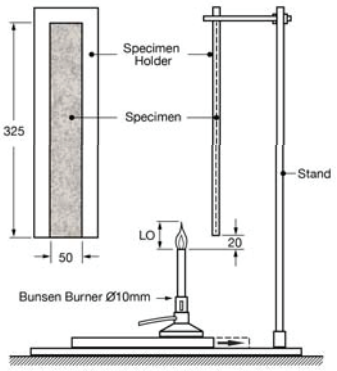
- Appendix F, Part 1, (a)(1) = Interior compartments occupied by crew & passengers
  - **(iv) = 15 second Horizontal Burn Test <2.5 in/min**
    - Clear Plastic Windows & Signs, Parts Made From Elastomers, Edge Lighted Instruments, Seat Belts, Containers/Bins/Pallets, and Others
  - **(v) = 15 second Horizontal Burn Test <4.0 in/min**
    - Small parts that would not contribute significantly to propagation of a fire (Knobs, Handles, Rollers, Clips, Grommets, Rub Strips, Pulleys and Others)

FAR 25.853(A) BURN TESTS

Vertical Burn

- 60 Second Ignition (i)
  - <15 sec flame time
  - <3 sec drip flame time
  - <6 in. avg. burn length
- 12 Second Ignition (ii)
  - <15 sec flame time
  - <5 sec drip flame time
  - <8 in. avg. burn length

FAR Part 25 testing in a vertical position

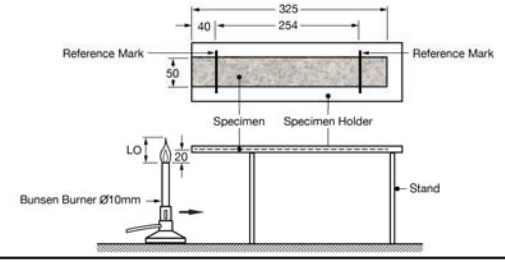


FAR 25.853(A) BURN TESTS

Horizontal Burn

- 15 Second Ignition
  - <2.5 in/min average burn length (iv)
  - <4.0 in/min average burn length (v)

FAR Part 25 testing in a horizontal position



AIRCRAFT INTERIORS FR REQUIREMENTS (CONT.)

Commercial Aircraft With Passenger Capacities > 20 (FAR 25.853 (d))

- FR Reqs same as Appendix F, Part 1, (a)(1) PLUS below for interior ceiling & wall panels, partitions, galley structure, and large cabinets & stowage compartments
- Appendix F, Part 4
  - Ohio State University (OSU) Heat Release Test
    - <65 kWminutes/m^2 total average heat release in first 2 minutes
    - <75 kW/m^2 peak heat release (Many specs require <65 kW/m^2)
- Appendix F, Part 5
  - NBS Smoke Density Test
    - <200 average Ds (3 specimens measured at 4 minutes)

STRATEGY

Product Priorities:

- *Weight Reduction*
  - *Stow Bins, Seating, Lavatory, Galley, Cockpit Controls, etc.*
  - *Part Consolidation & Metal-to-Plastic Conversion*
- *Economical Low-Smoke/Low-Toxicity Materials*
  - *Polyamide, Polypropylene, etc.*
  - *Custom Formulations & Alloys/Blends*
- *High Strength/Modulus Materials*
  - *Fasteners, Clamps, Brackets, etc.*
- *Custom Colored, OSU Materials*
  - *PEI, PES, PEEK, PPS, PPSU*
- *Lightning Strike Compounds*
- *ECO/Green Initiatives (Carbon Fiber Recycling)*

STRATEGY

Application Priorities:

- *Aircraft Interiors*
  - *Seating – Armrests, Tray Table Arms, Actuation Components*
  - *Door Frame Seals/Bumpers*
  - *Stow Bin Brackets*
  - *Trim/Rub Strips*
  - *Lavatory Components*
  - *Galley Components*
- *Flight Controls*
- *Engine Nacelles & Fuel Systems*
  - *Brackets, Fittings, etc.*
- *Fasteners, Cable Ties, and Other Fluid Systems*
- *Electronics Housings*

TRADITIONAL AIRCRAFT INTERIOR MATERIALS

- PEEK (Victrex PEEK®, Solvay KetaSpire®)
- PEI (Sabic Ultem®)
- Challenges
  - Cost
  - Availability
  - Color
  - Surface Aesthetics
  - Processability

AIRCRAFT INTERIOR MATERIALS

RTP Company Expanded Portfolio

- PEEK
- PEI
- PPS
- PPSU
- PES
- PPS
- Polyamides/Nylons (6/6, 6/12, 12, etc.)
- PC
- PC/ABS
- PP

RTP COMPANY MATERIAL OPTIONS

ENGINEERED COMPOUNDS	15 Second Horizontal Burn	12 Second Vertical Burn	60 Second Vertical Burn	Smoke Density	Toxic Gas Emission	OSU Heat Release (Reinforced)	OSU Heat Release (Unreinforced)
RTP100-Series Compounds (Polypropylene)	Pass	Pass	-	Pass	Pass	-	-
RTP 200-Series Compounds (Polyamide 6/6)	Pass	Pass	Pass	Pass	Pass	-	-
RTP 200 D-Series Compounds (Polyamide 6/12)	Pass	Pass	Pass	Pass	Pass	-	-
RTP 200 F-Series Compounds (Polyamide 12)	Pass	Pass	Pass	Pass	Pass	-	-
RTP 300-Series Compounds (Polycarbonate)	Pass	Pass	Pass	Pass	Pass	-	-
RTP 1300-Series Compounds (Polphenylene Sulfide)	Pass	Pass	Pass	Pass	Pass	Pass	-
RTP 1400-Series Compounds (Polyethersulfone / Polyphenylsulfone)	Pass	Pass	Pass	Pass	Pass	Pass	-
RTP 2100-Series Compounds (Polyetherimide)	Pass	Pass	Pass	Pass	Pass	Pass	-
RTP 2200-Series Compounds (Polyetheretherketone)	Pass	Pass	Pass	Pass	Pass	Pass	-
RTP 2200 A-Series Compounds (Polyetherketoneketone)	Pass	Pass	Pass	Pass	Pass	Pass	-
RTP 4000-Series Compounds (Polyphthalamide)	Pass	Pass	Pass	Pass	Pass	-	-
RTP Radel® R-7000 Series Compounds (Polyphenylsulfone)	Pass	Pass	Pass	Pass	Pass	N/A	Pass

WHAT IS RADEL R-7000?

Proprietary PPSU blends designed for aerospace interior applications (unfilled for cosmetic parts)

- Meet all FAR requirements for flame, smoke, toxicity, heat release
  - FAR 25.853 (a) & (d), BSS7238, BSS 7239, OSU Heat Release
- Good Impact
- Excellent Surface finish
- Chemically Resistant
- Versatile processing

Radel R-7300/R-7400/R-7625

- Fully Colorable
- Extreme Chemical Resistance
- Boeing Approved

Radel R-7700

- Fully Colorable
- Extrusion Grade

Radel R-7159

- Fully Colorable
- Boeing Approved
- More Cost Competitive Option

TYPICAL APPLICATIONS

Unfilled grades specifically targeting aesthetic aircraft interior parts

- Seating
- Passenger service units
- Stow bins
- Air grilles

ACTIVE INTERIOR PROGRAMS

Commercial Aircraft

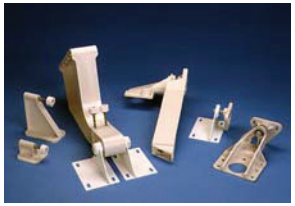
- *Stow Bin Brackets*
- *Seat Track Covers*
- *Trash Can*
- *Rub & Trim Strips*
  - *Seat Armrest*
  - *Galley*
- *Lavatory Components*
  - *Toilet Seats*
  - *Lighting*
  - *Floor Pan*
- *Flight Controls*
- *Oxygen Box Components*
- *PSU Rails*
- *HVAC/Air Handling Components*
- *Tray Table Arms*
- *Seat Actuation Components*

OVERVIEW

- Thermoplastic Flammability
  - Flame Retardant Additive Chemistries and Mechanisms
- Testing Standards
- Aerospace Requirements
- **Case studies**

APPLICATION EXAMPLE

Commercial Aircraft Stow-Bin Brackets



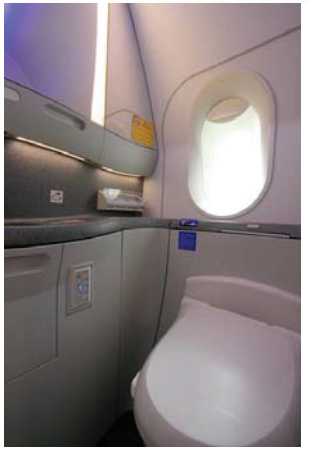
Features:
- High Stiffness
- Chemical Resistance
- FST & OSU 65/65 Compliance

Benefits:
- Metal-to-Plastic Conversion
- Lightweight
- Reduced Manufacturing Cost

- PEEK
- Glass Fiber
- Colored

APPLICATION EXAMPLE

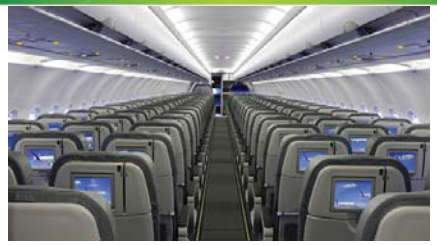
Lavatory Components



RTP 299 D X 130507 A White & Gray
- Nylon 6/12
- Non-Halogen FR
- Color Matched

Specifications
- 12 second vertical burn
- Smoke Density
- Smoke Toxicity

APPLICATION EXAMPLE



Light & Lens Covers

RTP 399 X 138339
- Polycarbonate
- Non-Halogen FR
- Light Diffusing

Specifications
- 12 Second Vertical Burn

FR MEETS TRANSPARENCY

Market
Consumer

Application
LED Lens Cover

Problem
UL 94 V-0, High Light Transmission, UV, Light Diffusion, RoHS Compliance

Solution
PC – Transparent, Flame retardant, Specialty pigment package

Benefit
Provided ample diffusion of high powered LED lights with a proprietary pigment technology while achieving the required flame performance

FR MEETS OUTDOORS / UV

Market

Consumer

Application

Marine Connector

Problem

Strength/Impact, UV Resistance, Specialty color, UL94 V-0, F1

Solution

PC/PBT – Glass reinforced, UV stabilized, Flame retardant

Benefit

Product was able to pass the required drop impact testing and stringent UL outdoor and flammability ratings

FR BREAKS THROUGH THE CEILING

Market

Industrial

Application

Speaker Unit

Problem

Plenum location, UL 2043, UL94 5VA, Rigidity

Solution

Polypropylene -- Glass fiber reinforced, Halogen free flame retardant

Benefit

Provided structural requirements needed for function and stringent UL flame resistance