Aktuelle Entwicklungen bei den Anforderungen für Brandsicherheit und Umweltfragen bei Flammschutzmitteln

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Seminar »Moderne Flammschutzmittel«
Haus der Technik, Essen, 27. Mai 2008

Gliederung

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- Warum Flammschutzmittel?
- Flammschutzmittel in der Diskussion
- Markt-Treiber
  - Gesetze
  - Normen
  - Ecolabels
- Trends bei Brandtests und Anforderungen
- Fazit

Brandschutz in Deutschland

- Todesopfer:
  - etwa 500 Tote durch Brände pro Jahr in D
  - etwa 75 % in Privatwohnungen
  - Rauchvergiftung wichtigste Todesursache
  - 6 000 schwer Verletzte durch Brände
- Wirtschaftliche Schäden (Jahr 2000, GDV):
  - 6 Mrd. EUR insgesamt
  - 1.9 Mrd. EUR Versicherungsaufwand
  - ca. 100 000 Schadensfälle
  - ca. 200 “Millionen-Schäden” (> 500 000 EUR)
  - Kosten für Feuerwehren: ca. 4 Mrd. EUR

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Statistics USA

- Fire costs ca. 2 % of GDP = US$ 250 billion
- Total US fire casualties (including unreported) are estimated at 4 287 deaths and 260 000 injuries per year.
- The report provides a first estimate of costs of passive fire protection, in total < 10% of total fire costs:
  - meeting fire standards in equipment, particularly electronic and electrical equipment ($18 billion),
  - fire system maintenance, planning, etc ($7.2 billion),
  - costs of flame retardants and product fire testing ($2.5 billion).

- NFPA (J. Hall) “The Total Cost of Fire in the United States”, October 2005: http://www.nfpa.org/assets/files/PDF/totalcostsum.pdf
- NFPA (K. Rohr) “Products first ignited in US Home Fires”, April 2005: http://www.nfpa.org/assets/files/PDF/ProductsExecSum.pdf

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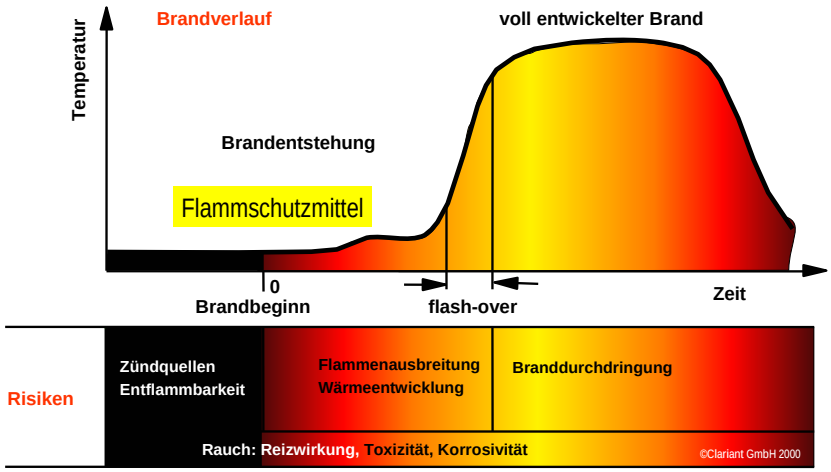
Phasen eines Brandes (2)



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Leicht entzündbare Materialien in Großbränden

2002-02-20 Rhode Island Club, USA
2001-01-01 Volendam, NL
2000-11-11 Kitzsteinhorn, A
1996-04-11 Dusseldorf Airport, D

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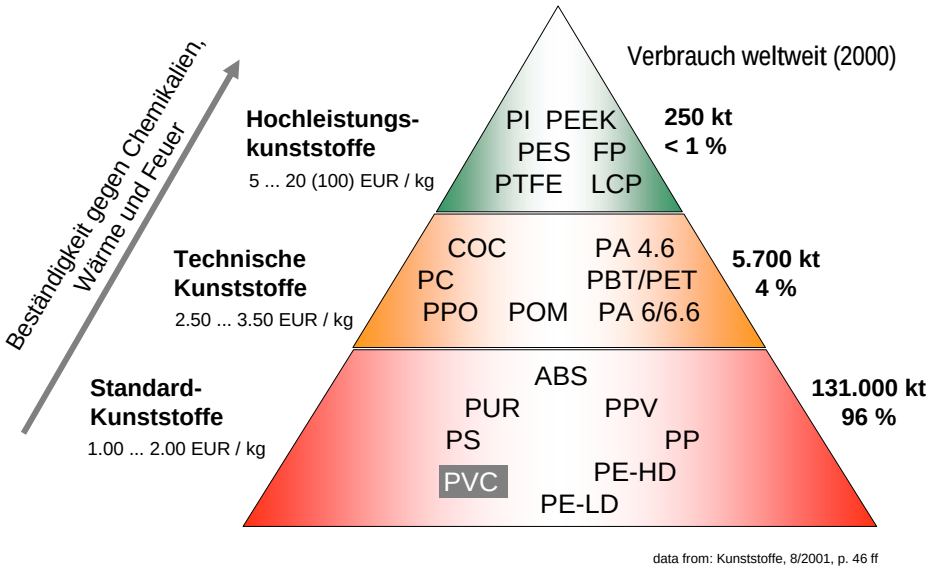
Die Kunststoff-Pyramide



data from: Kunststoffe, 8/2001, p. 46 ff

Wann werden FSM eingesetzt?

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- Gesetze
- Produktnormen
- Brandtests
- Flammschutzmittel

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Rauchmelder + Flammschutz

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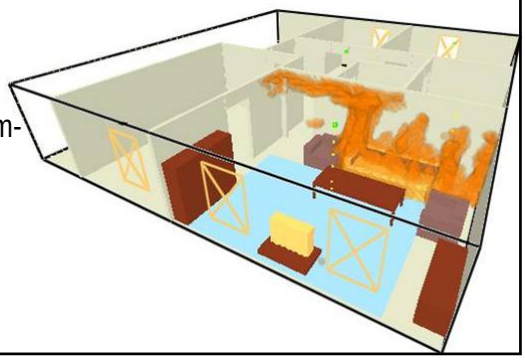
- Studie an der BAM, Berlin
- Rauchmelder sind sinnvoll
- Wohnungsbrände können sich rasant entwickeln – wenige Minuten bis zum Flashover
- Gegenstände mit hohem Brandrisiko sollten zusätzlich flamm-geschützt sein



Rauchmelder + Flammschutz

Clariant
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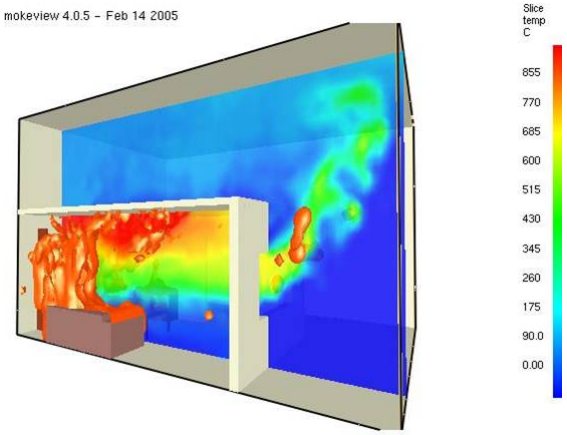
- Computer-Simulation von Bränden in Wohnungen



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Elektrogeräte: Externe Zündquellen

- Bisher: Hersteller sehen sich nur für „Eigensicherheit“ des Geräts in der Verantwortung
- Inzwischen: Einsicht, dass mit wenig Aufwand die Brandsicherheit erheblich verbessert werden kann
- Selbstverpflichtung von Sony, Panasonic, Philips, Finlux zum Flammschutz von Fernsehgehäusen (www.acfse.org)
- IEC TC 108 erarbeitete eine Technische Spezifikation zur External Ignition (TS 62441) – UL 94 V1 Materialien

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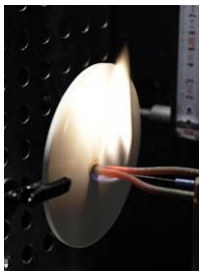
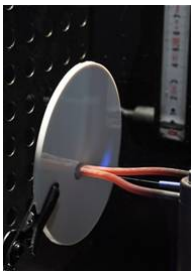
Glow Wire Test – Flame Definition

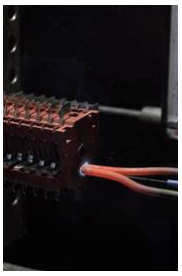
- During the glow wire test (according to the temperature settings required by the standard) the following phenomena can occur:



Flame



No Flame



No Flame

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Fire safety in transportation

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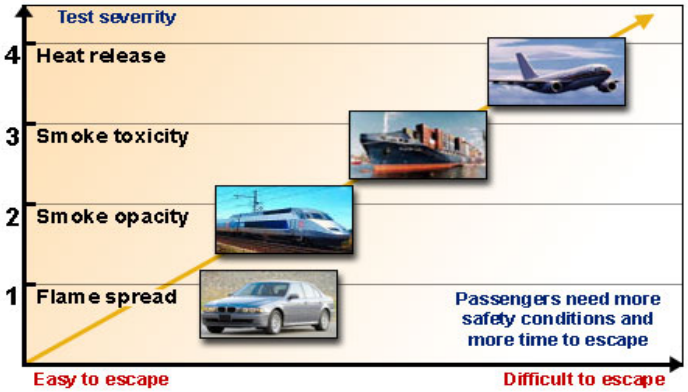
- Different transportation modi = different fire safety issues

  = different tests & requirements



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Fire Safe Cigarettes (USA)

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- Specially made cigarettes that, unless puffed regularly by a smoker, stop smoldering
  - wrapped in special ultra-thin paper with "speed bump" bands that inhibit burning unless a smoker draws in air
- Legally required in New York, California and Vermont
  - Cigarettes are the most common ignition source for fatal home fires and causing 30% of the fire deaths in the United States.
  - A common scenario is the delayed ignition of a sofa or mattress by a lit cigarette dropped by a smoker.

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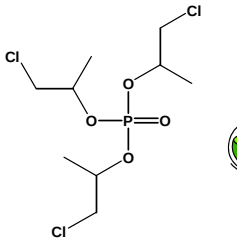
Feuerwehren fordern besseren Brandschutz im Wohnbereich

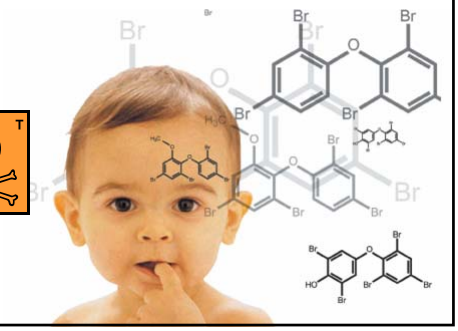
- „Die Arbeitsgemeinschaft der Berufsfeuerwehren (AGBF) fordert, in Deutschland – wie bereits in mehreren europäischen Staaten umgesetzt – Maßnahmen zur Prävention im Wohnbereich einzuführen. Hierzu gehören insbesondere die Verpflichtung zum Einbau von Rauchwarnmeldern sowie das Verbot leicht entflammbarer Polstermöbel und entflammbarer Gehäuse von Elektrogeräten."
  - Aus: Thesen der Arbeitsgemeinschaft der Berufsfeuerwehren (AGBF) 2004; Albrecht Broemme, AGBF-Vorsitzender; in BrandSchutz – Deutsche Feuerwehr-Zeitung 7/2004, S. 507

Die Umweltdiskussion

- Bedenken wegen des Umweltverhaltens und Toxizität von bestimmten Flammschutzmitteln
- Wissenschaftliche Studien z.B. in Deutschland, Schweden, Dänemark, Großbritannien und der Schweiz
- Thema: Persistenz, Bioakkumulation, Toxizität (PBT)
- Flammschutzmittel in der Umweltmedien, Lebewesen, Raumluft

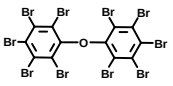


TCPP

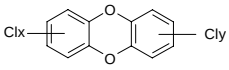


Bedenken: Dioxine

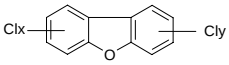
- Bedenken:
  - »Bestimmte halogenierte FSM können Dioxine und Furane bilden während der Produktion, im Gebrauch, bei Brand, bei der Entsorgung oder dem Recycling.«
- Bemerkung:
  - nur sehr wenige bromierte FSM sind direkte Precursoren für Dioxine und Furane
  - bei hohe Temperaturen können diese FSM Dioxine und Furane bilden (Verarbeitung, Brand)
- Lösung:
  - solche Dioxin-Precursor FSM durch andere FSM ersetzen



Decabromdiphenylether (Deca)



chloriertes Dibenzodioxin



chloriertes Dibenzofuran

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Bedenken: Persistenz + Bioakkumulation

- Bedenken:
  - »Einige halogenierte Produkte und ihre Abbauprodukte sind persistent in der Umwelt und akkumulieren in Organismen.«
- Bemerkung:
  - nur wenige halogenierte FSM sind relativ persistent
  - eine gewisse chemische Stabilität ist notwendig für ihre Funktion
  - Persistenz bedeutet nicht automatisch Bioakkumulation
  - analytische Methoden können winzigste Mengen feststellen - haben diese einen Effekt auf Organismen?
- Lösung:
  - ein FSM, das bioakkumulativ ist, wird in Europa verboten werden (Penta-BDE), eine andere Gruppe (PBB) wird nicht mehr produziert
  - sorgfältige Risikobewertungen
  - Wechsel zu nicht-persistenten und nicht-bioakkumulativen FSM

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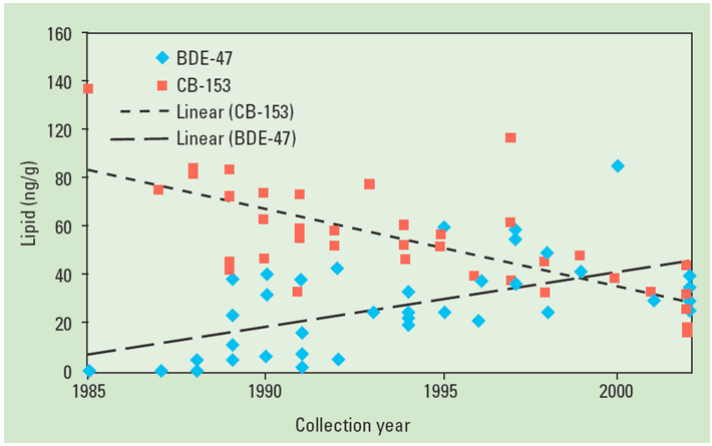
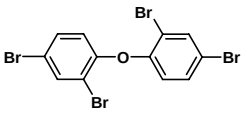
Bioakkumulation PBDE ./. PCB



Created for ES&T by Andreas Sjödin of the U.S. Centers for Disease Control, shows the levels of the most bioaccumulative PBDE congener, BDE-47, and the most bioaccumulative PCB congener, CB-153, in U.S. human blood samples. ES&T, 37, p. 384, 2003

Bromierte FSM in der Umweltdiskussion

- Metaboliten von PBDEs (Hydroxy-BDEs)
- Deca-BDE in vielen Tieren nachgewiesen, auch in Humanmilch (deutlich geringere Konz. als BDE-47)
- Hexabromcyclododecan (HBCD) und Tetrabrombisphenol-A (TBBPA) werden zunehmend untersucht + gefunden
- Expositionspfade: Nahrung ./. luftgetragen (Staub)?



BDE-47

Presseinformation Nr. 20/2008

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Umwelt Bundes Amt
Für Mensch und Umwelt

Bromierte Flammschutzmittel: Schutzengel mit schlechten Eigenschaften?

Über Nutzen, Risiken und Ersatzstoffe informiert ein neues Hintergrundpapier des Umweltbundesamtes

- Kritische Beurteilung von Deca-BDE, HBCD und TBBPA trotz EU Risko-Bewertungen – Empfehlung zu (langfristigem) Verzicht auf diese FSM
- Bis auf HBCD sind technische Alternativen vorhanden

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FSM in Innenraumluft

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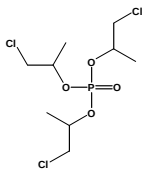
- Schweizer Studie zu Phosphor-FSM in Innenraumluft (BAG, 2002)
  - Analysen auf 10 übliche P-FSM, gemessen in 11 Gebäuden
  - Schlussfolgerungen:
    - Konzentrationen waren eine Größenordnung (Faktor 10) geringer als die Schwelle eines möglichen Risikos
    - Monitoring sollte im Abstand von einigen Jahren regelmäßig wiederholt werden, um auf mögliche Langzeiteffekte zu kontrollieren
- Studie des Umweltbundesamts (UBA) mit Prüfkammern, 2003:
  - extrem geringe Freisetzung von FSM aus Produkten, Ausnahme TCPP
- Fraunhofer WKI Studie zu PKW Innenräumen:
  - hohe TCPP Konzentrationen nur bei Luftstagnation und hohen Temperaturen



TCPP

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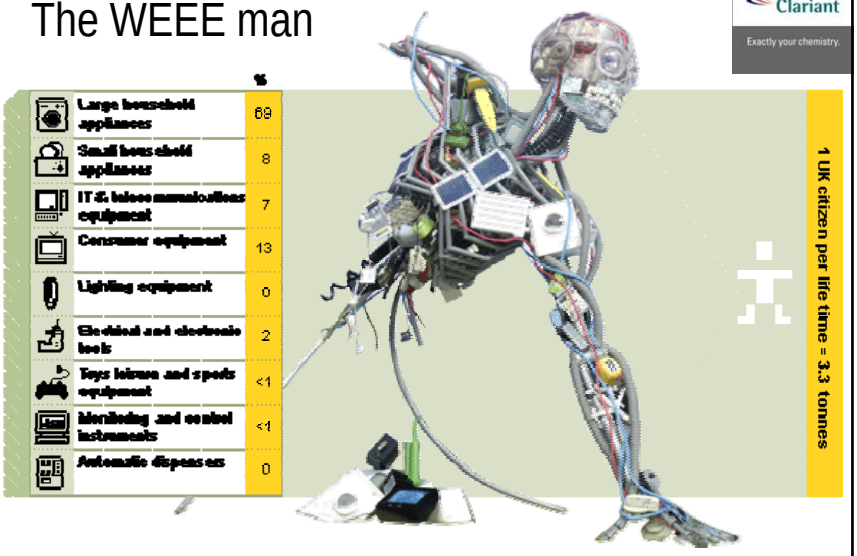
The WEEE man



- He represents the amount of waste electrical and electronic equipment (WEEE) the average British person throws away in their lifetime – over 3 tonnes per person. www.weeeman.org

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Europäische WEEE Direktive

- Directive on the Waste of Electrical and Electronic Equipment
  - 2002/96/EC veröffentlicht am 13-Feb-2003
- Ziel: die Hersteller von Elektrogeräten sollen verantwortlich sein für Sammlung, Recycling und Wiederverwertung von Altgeräten
- Auswirkung auf bromierte FSM:
  - Annex II: Kunststoffe mit bromierten FSM müssen vor Recycling, energet. Verwertung oder Entsorgung abgetrennt werden
  - das bedeutet teure Sonderbehandlung
  - Umsetzung in die Praxis noch unklar

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RoHS – Auswirkungen für FSM

- European Directive on Restriction of certain Hazardous Substances in E&E (2002/95/EC):
  - Seit 01-Juli-2006 Verbot von Blei (Pb), Quecksilber (Hg), sechswertigem Chrom (CrVI), Cadmium (Cd), polybromierten Biphenylen (PBB) und polybromierten Diphenylethern (PBDE)
  - Max. Konzentration 0,1 % (Cadmium: 0,01 %)
- Verbot von polybromierten Biphenylen (PBB) und penta- und octa-BDE seit August 2004 (2003/11/EC)
- Deca-BDE wurde von aus der RoHS ausgenommen
  - 2005/717/EC veröffentlicht 15-Oct-2005
- 2008-04: Europ. Gerichtshof hebt Ausnahme für Deca-BDE wieder auf, Verbot gilt ab 2008-07
  - Dänemark und das Europ. Parlament hatten Klage eingereicht gegen die Deca Ausnahme
- RoHS hat die Nachfrage nach halogenfreien FSM verstärkt

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RoHS 2.0 – weitere Stoffe ?

- Ökoinstitut von Europ. Kommission beauftragt
- http://hse-rohs.oeko.info/
- Kandidatenliste mit 46 Substanzen, u.a. Tetrabrombisphenol-A und andere bromierte FSM
- auch die 28 Ausnahmen werden revidiert
- Zeitplan:
  - im Juni 2008 Bericht an Europ. Kommission
  - Inkrafttreten geplant für 2012

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Deca-BDE

- Ergebnis des Europäischen Risk Assessments:
  - Keine Risiken identifiziert, keine Beschränkungen für Deca-BDE
  - Hersteller haben sich verpflichtet:
    - Weitere Neurotox-Studien durchzuführen
    - Biomonitoring von Deca fortzuführen, um weitere Entwicklung der Konzentrationen in Umwelt und Menschen zu verfolgen
- Norwegen: seit 2008-04-01 Verbot von Deca-BDE in Textilien, Möbeln und Insoliermaterialien (0,1 % max.)
  - mögliche Einschränkungen auch für TBBPA und HBCD
- USA: die Bundesstaaten Washington und Maine haben ein Verbot von Deca für bestimmte Anwendungen erlassen
- Hoch-politisches Thema

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China RoHS

- In Kraft getreten 2007-03
- Die gleichen Substanzen wie in Europa sind reguliert
- Liste der Geräte, die betroffen sind (im Gegensatz zu Kategorien in EU)
- Tests / Analysen durch chinesische zertifizierte Labors sind vorgeschrieben
- Elektronische Geräte, die die verbotenen Substanzen enthalten, müssen mit Label 2 gekennzeichnet werden, das die „sichere Gebrauchsdauer“ in Jahren angibt
- www.aeanet.org/chinarohs

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WEEE – Germany: ElektroG (2005-03)

- Ab dem 24.11.2005 müssen sich Hersteller von Elektro- und Elektronikgeräten registrieren lassen, bevor sie Elektro- und Elektronikgeräte in Verkehr bringen.
- Die Rücknahme und Verwertung der Altgeräte ist Sache der Hersteller. In der Praxis gehen sie jedoch Kooperationen mit Entsorgungs- und Logistikspezialisten ein.
- Verbraucher können ab 24.3.2006 in Deutschland Elektro- und Elektronikgeräte kostenlos bei kommunalen Sammelstellen abgeben. Die Hersteller müssen die gesammelten Geräte dort abholen und wiederverwenden oder entsorgen lassen.
- Ab Juli 2006 dürfen die Schwermetalle Pb, Cd, Hg und Cr(VI) sowie die bromierten Flammschutzmittel PBDE und PBB in neuen Geräten nicht mehr verwendet werden
  - Es gibt Ausnahmeregelungen für bestimmte Anwendungen
  - Deca-BDE wurde ausgenommen, Ausnahme gilt nicht mehr ab 2008-07

WEEE – Germany: ElektroG (2)

- Elektro- und Elektronikgerätegesetz
  www.bmu.de/files/pdfs/allgemein/application/pdf/elektrog.pdf
- Elektro-Altgeräte-Register
  www.stiftung-ear.de
- Informationsseite des ZVEI zum Elektro- und Elektronikgerätegesetz:
  www.altgeraete.org
- EU-Elektronikschrott-Richtlinie
  http://europa.eu.int/eur-lex/pri/de/oj/dat/2003/l_037/l_03720030213de00190023.pdf

EU Risiko-Bewertungen

Substance		Rapporteur	Priority List no. (year)	Status
Antimony trioxide	ATO	Sweden	4 (2000)	Under way
Short-chain Chlorinated Paraffins	SCCP	UK	1 (1994)	Published
Medium-chain Chlorinated Paraffins	MCCP	UK	3 (1997)	Draft circulated
Pentabromodiphenyl ether	PBDE	UK	2 (1995)	Published
Octabromodiphenyl ether	OBDE	UK/France	1 (1994)	Published
Decabromodiphenyl ether	DBDE	UK/France	1 (1994)	Published
Hexabromocyclododecane	HBCD	Sweden	2 (1995)	Draft circulated
Tris(2-chloroethyl) phosphate	TCEP	Germany	2 (1995)	Draft circulated
Tetrabromobisphenol A	TBBPA	UK	4 (2000)	Under way
Tris(2-chloroisopropyl) phosphate	TCPP	Eire/UK	4 (2000)	Under way
Tris(1,3-dichloroisopropyl)phosphate	TDCPP	Eire/UK	4 (2000)	Under way
2,2-bis(chloromethyl)trimethylene bis(bis(2-chloroethyl)phosphate)	V6	Eire/UK	4 (2000)	Under way

- PEC = Predicted Environmental Concentration
- PNEC = Predicted No Effect Concentration
- MOS = Margin of Safety
- http://ecb.jrc.it/existing-chemicals/

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Schweizer Konsensplattform

- Konsensplattform «Bromierte Flammschutzmittel»
  - im Rahmen des Nationalen Forschungsprogramms «Hormonaktive Stoffe»

FONDS NATIONAL SUISSE
SCHWEIZERISCHER NATIONALFONDS
FONDO NAZIONALE SVIZZERO
SWISS NATIONAL SCIENCE FOUNDATION

- TBBPA gebunden als Copolymer ist in der Anwendungsphase unbedenklich
- Basierend auf verfügbaren Daten ist Penta-BDE eine hormonaktive Substanz, Deca-BDE nicht, TBBPA und HBCD sind “potentielle” hormonaktive Substanzen
- Die Industrie sollte ihre Anstrengungen verstärken, Flammschutzmittel mit günstigerem Risikoprofil zu entwickeln und einzusetzen

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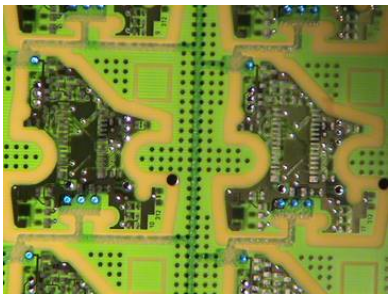
Halogen free projects: US-EPA

- Evaluation of environmental and health properties of alternatives to TBBPA
- Many stakeholders involved
- www.epa.gov/dfe

Halogen free projects: HDPUG

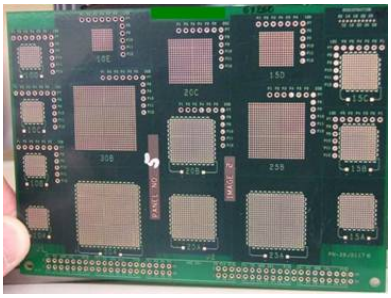
- High Density Packaging User Group: Major OEMs and component suppliers
- Halogen free project:
  - guideline on halogen free materials
  - database on HF products / components



Halogen free projects: iNEMI

- Technical and electronic properties of commercially available halogen free materials
- Will build dedicated „test vehicles“ with commercially available halogen free laminates

iNEMI
International Electronics Manufacturing Initiative



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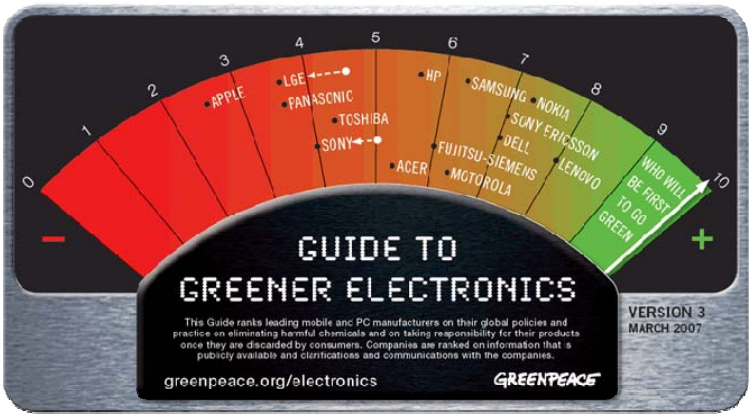
Greenpeace „greenometer“



- ..\..\FR_Engineering\Bilder\Graphics\Charts_diagrams\Greenpeace_rankingguide7thedition_2008-03.swf

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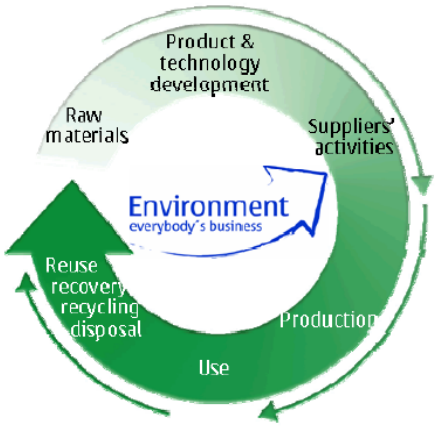
IPP Mobile Phones

- aims to reduce and eliminate the use of certain flame retardants, and phthalates in plastics from mobile phones.



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REACH – Neues EU Chemikalien-Recht

- Registration, Evaluation and Authorisation of Chemicals
- Inkrafttreten 2007-06
- Alle Chemikalien müssen registriert werden, dazu müssen je nach Produktsmenge bestimmte Daten zu Toxikologie und Umweltverhalten geliefert werden
- Chemikalien in Produkten, die importiert werden, sind schwach geregelt
  - http://europa.eu.int/comm/environment/chemicals/reach.htm
  - http://europa.eu.int/comm/enterprise/reach/
  - http://www.cefic.org/ [REACH im linken Menü]

REACH

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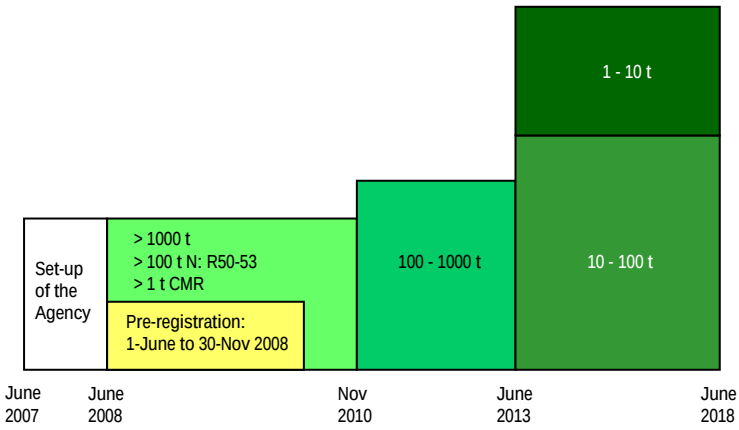
REACH Zeitplan



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Ecolabels (Umweltzeichen)

- viele verschiedene nationale Systeme
  - seit Ende der 1970er, wie z.B. der Blaue Engel in D
- Blauer Engel:
  - Beschränkungen halogenierter FSM in einigen Produkten - Ausnahmen für Recycling und Teile < 25 g bzw. < 10 g
- EU Blume, überarbeitete Kriterien:
  - Verweis auf Risiko-Sätze (offizielle Chemikalien-Klassifizierung), nur wenige Substanzen (z.B. PBDEs) explizit verboten;
  - Überlegungen, die Anforderungen für FSM zu vereinheitlichen und zu lockern (z.B. kein R 52 mehr in Kriterien für Computer)

EG-Umweltzeichen

TCO Development

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www.halogenfree-flameretardants.com

Clariant
Exactly your chemistry.

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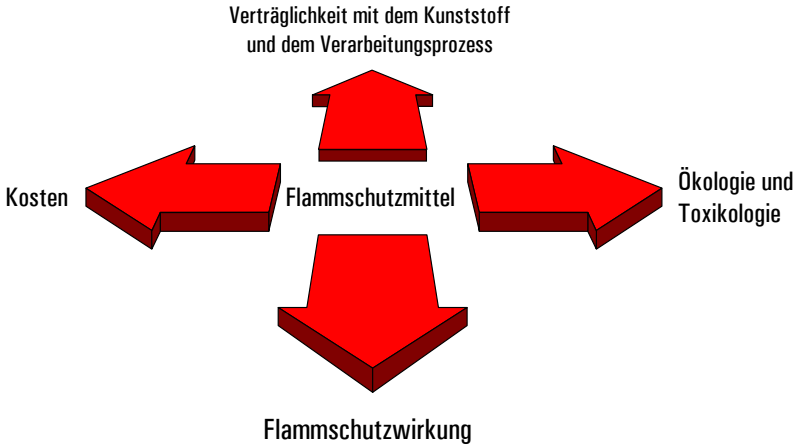
Anforderungen an Flammschutzmittel

Clariant
Exactly your chemistry.



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Clariant
Exactly your chemistry.

Wie können wir Flammschutzmittel umweltfreundlicher machen?

Clariant
Exactly your chemistry.

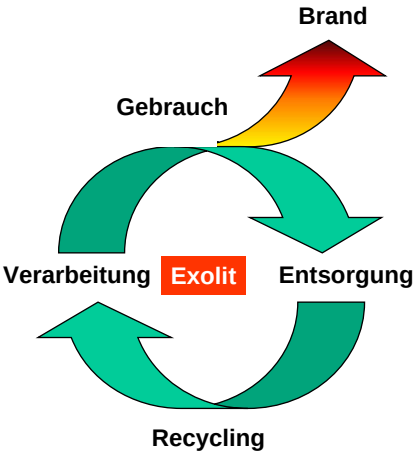
Strategie für moderne Flammschutzmittel

Moderne Flammschutzmittel sollten:

- nicht toxisch für Menschen, Tiere und Pflanzen sein
- nicht migrieren, das heisst nicht aus dem fertigen Produkt durch Ausgasung freigesetzt werden
- beim Brand keine zusätzlichen toxischen oder korrosiven Rauchgase freisetzen
- die Recyclingeigenschaften der Produkte nicht negativ beeinflussen
- umweltverträglich, also neutral oder abbaubar in der Natur sein

Flammschutzmittel im Lebenszyklus von Produkten

- Studie des Fraunhofer-Instituts UMSICHT
- Emissonen
- Toxische Abbau- / Verbrennungsprodukte?
- Vergleich mit Hintergrund-werten (reines Polymer) und Stand der Technik



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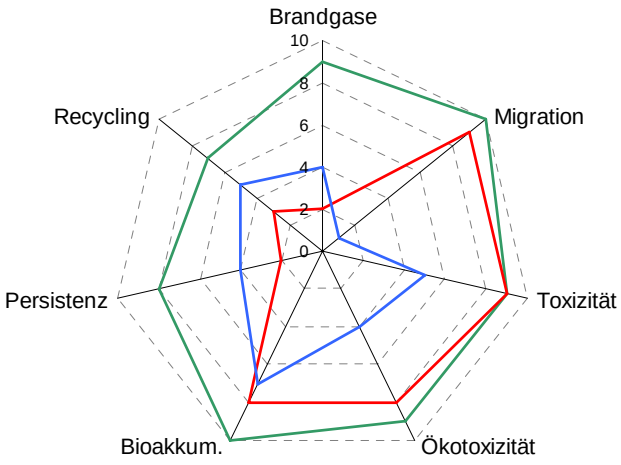
Bewertung von FSM-Profilen



- Definition der Achsen?
- Gesamtbewertung?

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Ausblick und Trends

- Internationalisierung von Vorschriften zum Brandschutz
- Erhöhung der Sicherheitsstandards
- verstärkter Trend zu halogenfreien Flammschutzmitteln
  - getrieben vom Markt, Ecolabels und Regularien
- Flammschutzmittel-Neuentwicklungen:
  - emissionsarm, halogenfrei
  - intensive Entwicklungskooperation aller Beteiligten
- Sachgerechtere Risiko-Kommunikation?
  - „zu Risiken und Nebenwirkungen fragen Sie Ihren Flammschutzmittelhersteller oder Compounder“

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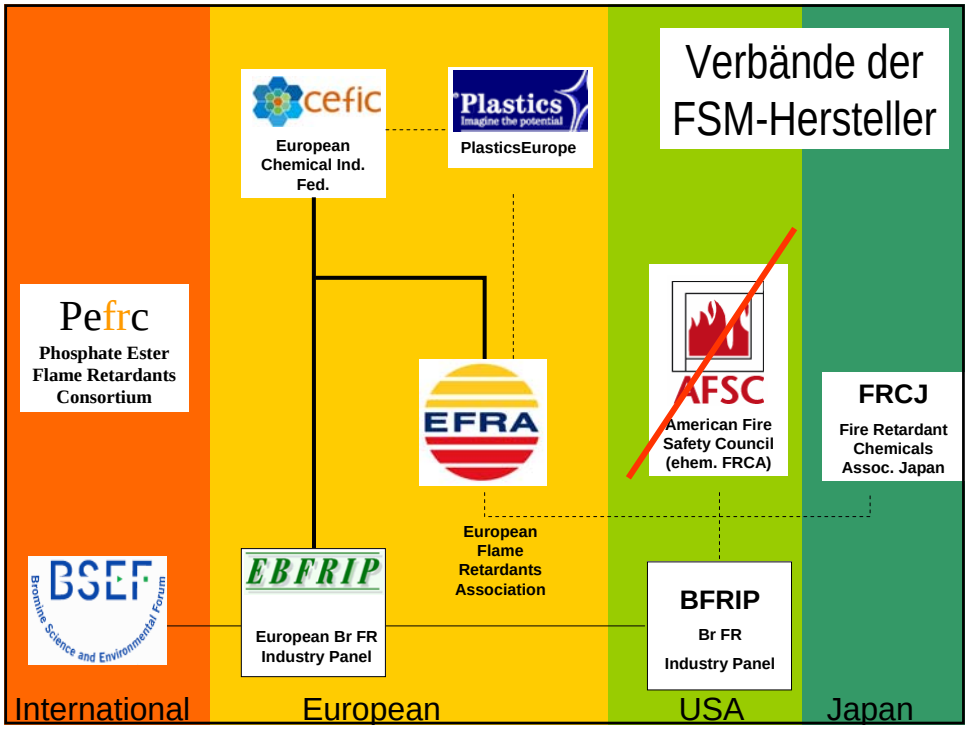

Kontakt + weitere Informationen

Clariant
Exactly your chemistry.

Internet:
www.exolit.com
www.flammschutz-online.de
www.flameretardants.eu

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Commercially Available Halogen free Alternatives to Halogen-Containing Flame Retardant Systems in Polymers

1 Overview of flame retardants by polymer

This table gives an overview of commercially available non halogenated flame retardants. Often, combinations of the given substances are used. The individual formulation is up to the polymer compounder and often regarded as company know how. The abbreviations are listed at the end of the document. Please send any comments or information on new FRs and applications to jtroitzsch@troitzsch.com.

Polymer	Application / Product	Fire Safety Requirement	Halogen-Containing FR System	Halogen free FR System
Thermoplastics				
PE	E&E	UL94V0	Deca / ATO DBDE / ATO EBTPI / ATO TBNPP / ATO CP / ATO	Intum P-based P-red / halfreeFR
		UL94V2		P-red
	Building Films DE	DIN4102B2	TBNPP / ATO DBDE / ATO	NorHals
	Wire & Cable	IEC 60332-3		ATH
PE / EVA	Wire & Cable	IEC 60332-3		ATH / Nano
PP	E&E	UL94V0	Deca / ATO DBDE / ATO EBTPI / ATO TDPE / ATO	Intum P-based MOH

Polymer	Application / Product	Fire Safety Requirement	Halogen-Containing FR System	Halogen free FR System
			BEO / ATO	
			CP / ATO	
		UL94V2	HBCD / ATO	
			TBNPP	
	Building Pipes DE	DIN4102B1	TDPE	
	Building Films DE	DIN4102B2	BEO / ATO	
	Building FR	NFP92507 M2	TBNPP / ATO	Intum Pbased
	Wire & Cable	IEC 60332-3		ATH or MOH
HIPS	E&E	UL94V0	Deca / ATO	
			DBDE / ATO	
			EBTPI / ATO	
			BEO / ATO	
			TBBPA / ATO	
			CP / ATO	
		UL94V2	HBCD	RDP
				TPP
				BDP
				PolyDP
EPS	Building foam DE	DIN4102B1	HBCD	
ABS	E&E	UL94V0	Deca / ATO	
			DBDE / ATO	
			EBTPI / ATO	
			BEO / ATO	
			TBBPA / ATO	
PA	E&E	UL94V0	Dech / ATO	P-red
			PBBPA / ATO	MC
			BrPS / ATO	MPP
			BEO / ATO	MePh
				MOH
PET	E&E	UL94V0	Deca / ATO	P-red
			DBDE / ATO	MePh
			BEO / ATO	
			EBTPI / ATO	
			TBBPA-CO / ATO	
	Fibres	BS5852Crib5		Dopo
				Oxa
PBT	E&E	UL94V0	Deca / ATO	MePh

Polymer	Application / Product	Fire Safety Requirement	Halogen-Containing FR System	Halogen free FR System
			DBDE / ATO	
			EBTPI / ATO	
			BEO / ATO	
			TBBPA-CO / ATO	
PC	E&E	UL94V0	Deca / ATO	SulSalts
			DBDE / ATO	TPP
			EBTPI	RDP
			TBBPA-CO / ATO	BDP
			TBBPA reactive	
PC / ABS	E&E	UL94V0	Deca / ATO	RDP
			DBDE / ATO	BDP
			EBTPI / ATO	TPP
			TBBPA-CO / ATO	
			BEO / ATO	
PPE / HIPS	E&E	UL94V0	Deca / ATO	RDP
			DBDE / ATO	BDP
			EBTPI / ATO	TPP
			TBBPA-CO / ATO	
Thermosets				
EP	E&E	UL94V0	Deca / ATO	ATH
			DBDE / ATO	ATH / APP
			EBTPI / ATO	P-red
				PhPol
		FR4	TBBPA reactive	PhPol
				Dopo
				MePh
				PhPho
	Transport Air			Dopo
PIRrig	Building DE	DIN4102B1	BrPol / TCPP	
	Building FR	NF P 92501 M1	P-red / TCPP	
	Building DE	DIN4102B2		P-red
				APP
PURrig	Building DE	DIN4102B2 and SBI Class C	BrPol / TCPP	APP
				PhPol
				TEP
				DMPP

Polymer	Application / Product	Fire Safety Requirement	Halogen-Containing FR System	Halogen free FR System
				P-red
	Building USA	ASTM E84	BrPol / TCPP	
PURflex	Transport Auto	MVSS 302	TCPP	PhPol
			BrPol	CDP
				TCP
				APP
				APP / Intum
	Transport Air	KerosBurner	TCPP / Mel / EG	
	Building UphFur UK	BS5852Crib5	TCPP / Mel	APP / Mel / EG
			TCPP / Mel	
	USA	CalTB117		PhPol
				CDP
				TCP
UP	E&E	UL94V0	Deca / ATO	ATH
			DBPE / ATO	ATH / P-red
			EBTPI / ATO	ATH / APP
			TBBPA reactive	DMPP
			CP / ATO	DMPP+WMP
			HET-acid	
			TCEP	
			TCPP	
	Transport Sea	Flame Spread		ATH
	Transport Rail DE	DIN 5510		APP

2 Abbreviations

Applications

UphFur	Upholstered furniture
E&E	Electrical & electronic equipment
Transport	Transportation
- Air	Aircraft
- Auto	Automotive
- Rail	Railways
- Sea	Ships

Polymers

2.1 Thermoplastics

ABS	Acrylonitrile/butadiene/styrene terpolymer
EPS	Expandable polystyrene
HIPS	High impact polystyrene
PA	Polyamide
PBT	Polybutylene terephthalate
PC	Polycarbonate
PC/ABS	Polycarbonate/ABS blend
PE	Polyethylene
PET	Polyethylene terephthalate
PP	Polypropylene
PPE/HIPS	Polyphenylene ether/high impact polystyrene blend

2.2 Thermosets

EP	Epoxy resins
PIRrig	Rigid polyisocyanurate foam
PURflex	Flexible polyurethane foam
PURrig	Rigid polyurethane foam
UP	Unsaturated polyester resins

Flame retardants

Brominated flame retardants

BEO	Brominated epoxies
BrPS	Brominated polystyrene
BrPol	Brominated polyols
DBDE	Decabromodiphenyl ethane
Deca	Decabromodiphenyl ether
EBTPI	Ethylene bis(tetrabromophthalimide)
HBCD	Hexabromocyclododecane
PBB-PA	Poly(pentabromobenzyl acrylate)
TBBPA	Tetrabromobisphenol-A
TBBPA-CO	TBBPA carbonate oligomer
TBNPP	Tris(bromoneopentyl) phosphate
TDPE	TBBPA (2,3-dibromopropyl ether)

Chlorinated flame retardants

CP	Chloroparaffin
Dech	Alicyclic chlorinated compound (Dechlorane plus)
HET-acid	Hexachloroendomethylenetetrahydrophthalic acid
TCEP	tris(chloroethyl) phosphate
TCPP	tris(chloropropyl) phosphate

Organo phosphorous flame retardants

BDP	Bisphenol A bis(diphenyl phosphate)
CDP	Cresyldiphenyl phosphate
DMPP	Dimethylpropane phosphonate
Dopo	Dihydrooxaphosphaphenanthrene oxide
MePh	Metal phosphinate
Oxa	Oxaphospholane
PhPol	Phosphorous polyol
PolyDP	Polymeric diphenyl phosphate
RDP	Resorcinol bis(diphenyl phosphate)
TCP	Tricresyl phosphate
TEP	Triethyl phosphate
TPP	Triphenyl phosphate
WMP	Intumescent system based on ethylenediamino phosphate

Nitrogen-containing flame retardants

MC	Melamine cyanurate
Mel	Melamine
MPP	Melamine polyphosphate
NorHals	N-alkoxy hindered amine

Inorganic flame retardants

APP	Ammonium polyphosphate
APP/intum	Intumescent system based on APP
ATH	Aluminium hydroxide
ATO	Antimony trioxide
EG	Expandable graphite
Intum P-based	Intumescent flame retardant system based on APP, MC, etc…
MOH	Magnesium hydroxide
Nano	Nanocomposite based on montmorillonite clays
P-red	Red phosphorous

Other

SulSalts	Sulfonate salts

3 Overviews and environmental assessments of alternatives to specific halogen-containing flame retardants

There are some third party overviews / assessments of flame retardants from various consultants and environmental agencies. These reports sometimes come to different conclusions on the same products and are often seen as controversial by the FR producers. One controversial point is that the flame retardants deca-BDE, TBBPA and HBCD have undergone comprehensive risk assessments, while the substitution products often have not. However, this will change in the near future with the implementation of REACH, as extensive data will have to be provided for all flame retardants.

Examples are:

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