

Fire-resistant plastic materials and their properties

Many applications, such as electronics, vehicles and construction, require materials that fulfill the fire safety requirements of product safety standards regarding heat resistance and self-extinguishing. This document provides a brief description of the fire safety of plastic materials, as well as their testing and classification.



TELKO

<http://www.telko.com>

Keilaranta 17

FI-02151, Espoo

+358 9 5211

telko.finland@telko.com





What is fire resistance?

The correct terminology must be used when discussing the fire safety of plastics. No plastic material is fully fireproof or can be made so. Instead, plastic materials can be treated to be fire-resistant enough to fulfill the requirements of product safety standards.

Fire resistance means that the material is self-extinguishing: if the plastic is set alight, it will extinguish itself soon after the heat source is removed. Some plastic materials are inherently self-extinguishing and do not need additives to meet this requirement. Other plastics can use additives to meet the requirement of being self-extinguishing.



Uses of self-extinguishing plastic materials

The need for self-extinguishing plastic materials is largely the result of the development of electronics, particularly consumer products. The use of self-extinguishing materials became widespread due to the numerous fires started by appliances and home entertainment devices, such as televisions. Vehicles are also laden with electronic equipment, necessitating the use of self-extinguishing materials in their covers and cases.

The primary function of a self-extinguishing or fire-resistant case is not to be fireproof and protect the equipment within, but to prevent any internal fires from spreading outside the case.

One of the key requirements – in addition to the reasonably quick extinguishing of flames – is that no burning plastic is allowed to drip from the device, as this could ignite other surrounding materials.

The materials used in the construction industry have their own fire ratings. Applications that require self-extinguishing materials include switchgears and power sockets. Compliance with standards is particularly important in locations like airports that are subject to new strict requirements.



Fire resistance classification systems

A rating system is needed to classify different grades of fire resistance. The best known of these systems is the one created by the US-based **Underwriters Laboratories** (UL for short, www.ul.com) called the **UL 94** Standard. The standard's ratings are based on a test of burning times, the ignition of a cotton indicator, the burning of a vertical specimen up to a certain point and the total extinguishing times in repeated tests.



A picture of the UL 94 V (vertical) burning test.

The vertical test ratings are V-0, V-1 and V-2. The criteria for the ratings are presented in the table below.

UL 94 pCriteria for UL 94 ratings V-0, V-1 and V-2

Condition	Flammability Rating Criteria		
	V-0	V-1	V-2
Afterflame time t1 for each specimen	Less than or equal to 10 seconds	Less than or equal to 30 seconds	Less than or equal to 30 seconds
Afterflame time t2 for each specimen	Less than or equal to 10 seconds	Less than or equal to 30 seconds	Less than or equal to 30 seconds
Afterflame time total t1+t2 for all specimens	Less than or equal to 50 seconds	Less than or equal to 250 seconds	Less than or equal to 250 seconds
Afterflame time + afterglow time t2+t3 for each specimen	Less than or equal to 30 seconds	Less than or equal to 60 seconds	Less than or equal to 60 seconds
Travel of afterflame or afterglow up to holding clamp for any specimen	No	No	No
Cotton indicator ignited by flaming particles or drops	No	No	No

Source: UL

Another well-known fire rating is "happy burning" or HB, as defined by the horizontal burning test of the UL 94 Standard; here the specimen is placed horizontally and then ignited on one end. The material is rated HB if its rate of burning is less than 76 mm/min for specimens under 3 millimeters thick and the fire self-extinguishes before advancing 100 millimeters or more.

The test's nickname "happy burning" is quite justified when it is compared to the much stricter V test and ratings.

In addition to the above, the UL 94 Standard also includes the ratings of 5VA and 5VB as follows:

- 5VB: flame is extinguished within 60 seconds with a vertical specimen; no dripping; plate specimens may burn through.
- 5VA: flame is extinguished within 60 seconds with a vertical specimen; no dripping; plate specimens may not burn through.

As the thickness of the material will affect its performance in the burning test, this has been accounted for by only granting the rating for the material thickness used in the test.

Product safety standards and their fire rating requirements

Electrical equipment

The International Electrotechnical Commission (IEC, www.iec.ch) is an international cooperation body for defining the safety standards for electrotechnology. The IEC standards are used by all of its member countries and applied as-is, but with some national additions. When validation is sought for an electrical device, this can be done in direct comparison to the IEC standards or their national versions.

Different product and device groups have specific standards. Several standards may apply to a device; for example, in the case of devices with wall plugs, they are subject to their device-specific standard and the wall plug standard. These standards combined define the minimum requirements.

The standards also define the relevant concepts, such as fire enclosures, which are protective device enclosures that prevent the spread of internal device fires into the environment, as well as electrical enclosures, which protect against electric shock.

A rating of UL 94 V-1 or better is commonly required for fire enclosures. The device may receive product approval without a separate burning test, if the material of its fire enclosure has a minimum thickness equivalent to or greater than the one registered by UL in their test.

Fire safety standards for vehicles and construction

The aforementioned fire ratings are used outside the standards for electrical devices. For example, the US Federal Motor Vehicle Safety Standards (FMVSS) define the allowed burning rates for vehicles according to the UL 94 HB test, but the industry also has some standards of its own.

The standards for material-specific UL 94 ratings and the standards for entire structures or devices differ greatly. The standards for entire devices and structural assemblies do not specify the properties of the materials as such, as they aim to determine the amount, toxicity and thickness of the smoke caused by the burning of the whole structure, as well as the amount of heat generated, or the burning times required to burn through a structure.

For example, the compliance of a plastic sheet used as a vapor barrier cannot be determined without considering factors like the wall insulation material. Respectively, when determining the rating of an object like an armchair, the result is affected by factors, such as whether the armrest's mounting is flammable or not. These cases will nearly always require compliance testing of the product or structure using different burning tests.

UL Listing and the UL Yellow Card

As mentioned with the IEC standards, a separate burning test may not be needed for approval, if the material has been registered by UL. This is a great advantage, especially when seeking international approval for a product. The use of UL Listed materials expedites the product approval process and also lowers the cost of product approval.

Many manufacturers provide standards-compliant materials with sufficient fire ratings, but no UL Listing. This means that the products using these materials will require separate burning tests for approval. The same applies if UL Listed raw materials have been modified with additives like pigments – this will void the UL Listing. In this case, neither party – not the original manufacturer of the material or UL – can guarantee the properties of the material, as its composition has changed from the original.

This may result in a costly liability issue, if a faulty device causes a fire, or if a non-compliant structure is discovered after an accident. Compensation and damages will be sought, and the party found to be non-compliant is an easy target. Device manufacturers can rest easy when their products are officially approved and certified safe.

The UL Yellow Card and its contents

The UL Yellow Card is a registration certificate that lists the material's registered ratings, such as fire ratings.



The Yellow Card lists the values for the fire ratings sought by the material's manufacturer. At minimum, the fire rating can be classified with a single thickness, traditionally 1.5 to 1.6 millimeters or the closest inch fraction.

The fire rating of different thicknesses is often listed, e.g. 1 mm/V-1, 1.5 mm/V-0 and 3 mm/V-0 or 5VB, meaning the same material can have different ratings. The card will also note the color of the material. For example, this may be "ALL", meaning every color variant of the material offered by the manufacturer, or "Black" for just the black variant.

Furthermore, the card may list the material's relative thermal index (RTI), its IEC ball pressure temperature (BPT; maximum continuous operating temperature), softening temperature, different ignition ratings, the comparative tracking index (CTI) and so on.

Raw material manufacturers may test and add these ratings to the card according to the needs of their customers. As the testing and listing of the values on the card are relatively expensive, it is common to exclude some information from the card.

An example of the UL Yellow Card

 Component - Plastics File Number: E53898		
EMS-CHEMIE AG EMS CHEMIE HOLDING, VIA INNOVATIVA 1, DOMAT/EMS 7013 CH		
Grivory: Grivory XE 3876 (f1), Grivory HT2V-3X V0 (f1) Polyamide 6T/66 (PA6T/66), pellets (f1) - Suitable for outdoor use with respect to exposure to Ultraviolet Light, Water Exposure and Immersion in accordance with UL 748C.		
Flammability	Value	Test Method
Flame Rating		UL 94 IEC 60695-11-10, -20
0.350 mm, ALL	V-0	
0.750 mm, ALL	V-0	
1.00 mm, ALL	V-0	
1.40 mm, ALL	V-0	
1.50 mm, ALL	V-0	
2.00 mm, ALL	V-0	
3.00 mm, ALL	V-0	
1.40 to 13.0 mm, NC	V-0, 5VA	
Glow Wire Flammability Index		IEC 60695-2-12
1.00 mm	960 °C	
1.50 mm	960 °C	
2.00 mm	960 °C	
3.00 mm	960 °C	
Glow Wire Ignition Temperature		IEC 60695-2-13
1.00 mm	775 °C	
1.50 mm	775 °C	
2.00 mm	825 °C	
3.00 mm	850 °C	
Electrical	Value	Test Method
Hot-wire Ignition (HWI)		UL 746
0.350 mm	PLC 2	
0.750 mm	PLC 1	
1.00 mm	PLC 1	
1.40 mm	PLC 1	
1.50 mm	PLC 0	
2.00 mm	PLC 0	
3.00 mm	PLC 0	
1.40 to 13.0 mm	PLC 1	
High Amp Arc Ignition (HAI)		UL 746
0.350 mm	PLC 0	
0.750 mm	PLC 0	
1.00 mm	PLC 0	
1.40 mm	PLC 0	
1.50 mm	PLC 0	
2.00 mm	PLC 0	
3.00 mm	PLC 0	
1.40 to 13.0 mm	PLC 0	
Comparative Tracking Index (CTI)	PLC 0	UL 746

The card in the picture above is the Yellow Card for EMS Grivory HT2V-3X V-0. The material's "E Number", i.e. its UL File Number, is printed at the top of card on a red background.

This number is followed by the manufacturer information, the product's trade name and product name. "F1" indicates that the material is approved for outdoors use. The flame rating section lists the fire rating and associated thickness, and mentions ALL, meaning it applies to all the color variants offered by the manufacturer.

The majority of the plastic materials in Telko's selection have a UL Yellow Card, but we also offer materials without Yellow Cards. The cardless materials are fully serviceable, but, as in the case of pigment-modified natural raw materials, separate product burning tests will be required for product approval.

Telko has UL Listed materials readily available, including the following:

- PA6/66 EMS Grilon TS V-0
- Glass fiber reinforced Grilon TSG-30/4 V-0
- LG Chem ABS AF 345 V-0
- LG Chem PC Lupoy GN-1006 Fm
- LG Chem PC + 20% GF Lupoy GN-2201Fm
- LG Chem PC/ABS Lupoy GN-5001SF V-0
- LG Chem PBT+ 30% GF, V-0 Lupox GP -2306F

In addition to the above, we also have UL cards for several V-2 and HB rated plastic materials.

We will help you choose the best plastic for you

If you are uncertain what plastic would be the best fit, our expertise is at your disposal – get in touch!

**Get assistance in choosing
materials for your products from here!**

<https://www.telko.com/support-and-assistance-in-choosing-materials-for-your-products>

**If you want to contact an expert in technical plastics directly,
Juri Kopponen is your man:**

Tel. +358 9 521 7467
firstname.lastname@telko.com

Telko Oy
Keilaranta 17
PL 43, 02151 Espoo, Finland

Tel: (09) 521 1
Fax: (09) 521 7478