



TECH NOTES

LAIRD TECHNOLOGIES



#148

UL-94 - Test for Flammability of Plastic Materials for Parts in Devices and Appliances By Caroline Gold

Overview

Plastics have become one of the most useful types of material known to mankind. Plastic is a high molecular weight material composed of repeating organic molecules (monomers). Due to their chemical composition, plastics can often easily ignite when exposed to sufficient heat in the presence of oxygen. Due to the tendency for plastics to burn, considerable efforts have been directed to study and minimize the flammability issues of these materials. Examples of such efforts are the use of design of experiments to classify and measure burning characteristics of plastics and the addition of flame retardant chemicals to prevent or minimize the combustion of these materials.

There are a variety of industrial flammability tests that are widely used in industry. Each one is designed to measure different fire response characteristics. Unfortunately, most of them fail to predict the behavior of plastics under the massive effect of heat present in a large-scale fire. Different sectors of the industry adopt different flame test specifications. The specification that best meets the I/S needs (and is mostly used by the electronic industry) is the flammability specification known as UL-94.

Flammability Testing: UL-94

The test for flammability of plastic material used in parts for electronic devices and appliances is commonly known as UL-94. It is a flammability specification issued by the Underwriters Laboratories Inc. Underwriters Laboratories is a non-profit organization that operates laboratories around the world for examination and testing of devices, systems and materials. Underwriters Laboratories identifies material properties and their hazards. They also define and publish specifications that provide procedures for testing each material.

The flammability specification UL-94, contains several small-scale flame tests procedures that define parameters

for flame testing of plastic polymers. In this specification, the behavior of plastic when exposed to fire is expressed quantitatively. These numbers are obtained from measurements of the "afterflame" time or from the amount of material burned in a specific length of time. Afterflame time refers to the length of time, in seconds, a material continues to burn after removal of the heat source. The amount of material burned refers to the length of sample that burns in a specified period of time.

The UL-94 contains 6 different flame tests but just four of them are of interest in the EMI gasketing industry. They are divided into two categories: vertical and horizontal testing. In the vertical flame test, a flame is applied to the base of the specimen held in the vertical position and the extinguishing times are determined upon removal of the test flame. In the horizontal flame tests, the flame is applied to the free end of specimens held in horizontal position and the rate of burning is determined as the flame front progresses between two bench marks. All methods described in the UL-94 specification involve the use of a standard specimen size, a controlled heat source and a conditioning period for the specimen prior to the test. These parameters vary according to the test chosen.

Conditioning:

Before testing, the specimens must be conditioned. There are two methods to condition the specimen. One method requires that the specimens be maintained at 70°C for 7 days in an air-circulating oven. After the 7 days period, the specimen is removed from the oven and cooled down in a desiccator for at least 4 hours prior to testing. The other method requires maintaining the specimens at 23°C and 50% relative humidity for at least 48 hours prior to the testing. Some tests in UL-94 require testing on specimens conditioned in both manners.



Ignition Source

The ignition source is a laboratory Bunsen burner that uses methane as fuel source. The gas flow is controlled with a suitable regulator and meter for uniform gas flow. The typical flame testing set up is shown in Figure 1:

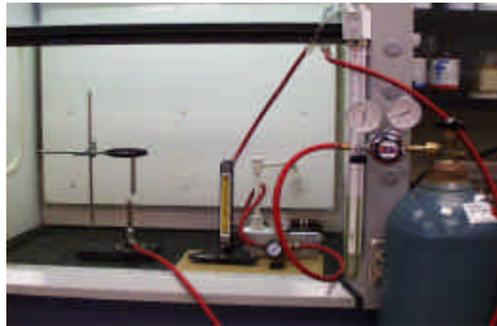


Figure 1: Flame Testing Set Up

than 2s and flaming particles do not ignite cotton placed under the specimen. The rating HF-2 allows the cotton indicator to be ignited.



Figure 2: Horizontal Flame Testing Set Up

Horizontal Burning Test

The horizontal burn test is used with polymer materials, with the test specimen oriented in the horizontal direction. The specimen rests on a wire screen with the specimen thickness oriented in the vertical direction (Figure 2). This test determines the rate of burning of a material as the flame front progresses between two benchmarks. The flame is applied to the free end of the specimen for 30 seconds. The length of the test specimen is 125mm with benchmarks at 25mm and 100mm position. The time for the flame front to move between the benchmarks is measured.

HB Rating: A material having a thickness between 3 and 13mm will be classified as a HB material if it does not have a burning rate exceeding 40mm per minute. For material with thickness less than 3mm the burning rate should not exceed 75mm per minute. The material will also be rated as HB if it ceases to burn before the 100mm mark independent of thickness.

Horizontal Burning Foamed Material Test

This test is similar to the horizontal burning test but it is specifically designed for foamed polymers. The flame application time is increased to 60 seconds. The 150mm-long test specimen is marked on the 25mm, 60mm and 125mm positions and the burning rate is measured between a 100mm span.

HBF Rating: This test grants three different types of ratings depending on burning rates and or afterflame times. A material will be classified as a HBF material if it does not have a burning rate exceeding 40mm per minute over a 100 mm span or if ceases to burn before flaming or glowing reach the 125mm mark.

Materials also can be classified as a HF-1 material if four specimens out of five have an afterflame time equal or less

20mm Vertical Burning Test

This test measures the self-extinguishing time of the vertically oriented polymer specimen. The top of the test specimen is clamped to a stand and the burner is placed directly below the specimen (Figure 3). The flame is brought into contact with the test specimen for 10 seconds, after which the burner is removed. The flame should be a blue flame and 20mm in height.

V Rating: This test can provide the so-called V-0 rating as well the less demanding V-1 and V-2. The material will be rated V-0 if the flame extinguish within 10 seconds after removal of the burner. The V-1 and V-2 rating requires that the flame extinguish after 30 seconds after removal the burner. The V-2 rating allows the cotton indicator be ignited by flaming particles.

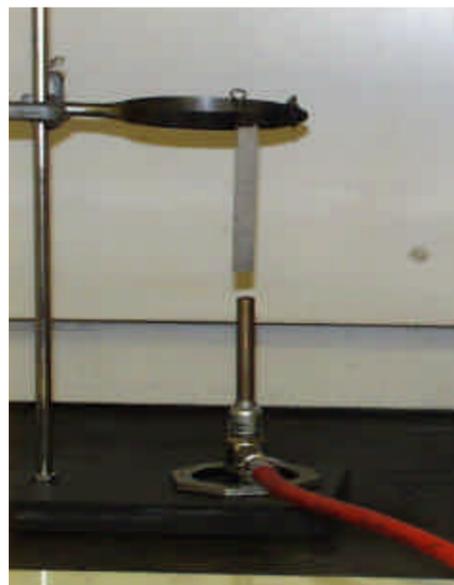


Figure 3: Vertical Flame Testing Set

Thin Material Vertical Burning Testing

This is a vertical test that is intended to be performed on materials that, due their thickness, distort or shrink or are consumed up to the holding clamp when tested using the 20mm Vertical Burning Testing. This test is similar to the vertical burning test except that the material is wrapped around a mandrel before clamping to the stand and the flame application is reduced. In this test, the flame is applied only for 3 seconds. As in the Vertical Burning Testing, three ratings can be granted in this test: VTM-0 and the less demanding VTM-1 and VTM-2. They have requirements similar to the previous described ratings. The specific details of each of the tests are described in Table I.

Test	# Specimens	Specimens Dimensions (L x W)	Type of Conditioning	Type of Rating
Horizontal	2 sets of three specimens	125mm x 13mm max. thick: 13mm	23°C and 50% RH for at least 48 hours	HB
20mm Vertical	4 sets of five specimens	125mm x 13mm max. thick: 13mm	Two sets at 23°C and 50% RH for at least 48 hours Two sets at 70°C for 7 days	V-0; V-1 and V-2
125mm Vertical (bar and plaque specimens)	4 sets of five bars	125mm x 13mm max. thick: 13mm	Two sets at 23°C and 50% RH for at least 48 hours Two sets at 70°C for 7 days	5 VA; 5VB Also need to comply with 20mm Vertical Burning Test
	4 sets of three plaque	150mm x 150mm max. thick: 13mm	Two sets at 23°C and 50% RH for at least 48 hours Two sets at 70°C for 7 days	
Thin Material Vertical	4 sets of five specimens	200mm x 50mm	Two sets at 23°C and 50% RH for at least 48 hours Two sets at 70°C for 7 days	VTM-0; VTM-1 and VTM-2
Radiant Panel Flame Spread Test	1 set of 4 specimens	460mm x 150mm	none	RP15 through RP200
Foamed Horizontal	4 sets of five specimens	150mm x 150mm max. thick: 13mm	Two sets at 23°C and 50% RH for at least 48 hours Two sets at 70°C for 7 days	HBF; HF-1 and HF-2

The Material Laboratory at Instrument Specialties has the ability to conduct the flame testing described in UL-94 and does so on regular basis. Instrument Specialties has many products with UL recognition in the market (Table II). The flame resistance of these materials has been tested and certified by Underwriters Laboratories. When a product evaluation has been successfully completed, the product is added to the UL Listing and it can bear the UL mark, although it is not mandatory to use the mark on the product. In addition, UL laboratory provides the Yellow Card, a proof of the recognition, and the Follow-Up Service procedure. The Yellow Card is a written document that contains general information about the product and type of recognition obtained by that product. Many customers like to have a copy of the Yellow Card when purchasing a recognized material. The Follow-Up Service procedure is a document for use by the manufacturer and UL's field representative. UL's field representative makes regular, unannounced visits to the production facilities. The representative checks production controls, witness testing, conduct inspections and periodically select

Table II – EMI Gasket (Ratings as of 4/1/00)	
Gasket	Flame Rating
Ni/Cu Plated ElectroFab	V-0
Ag Plated Electrofab	V-0
Nickel/ Graphite Silicone (EcE 12)	V-1
Silver/Glass Fluorosilicone (EcE 11)	HB
Ag Plated Nylon ("Boot" Fabric)	HB

samples for further testing at UL laboratory.

References

- 1) UL-94 - Test for Flammability of Plastic Materials for Parts in Devices and Appliances, Fifth Edition (October 96), Underwriters Laboratories Inc.
- 2) Hilado, C.J., Flammability Handbook of Plastics, Fifth Edition, Technomic Publishing Co., Lancaster, PA