



Understanding The Underwriters Laboratories, Inc.® (UL) Yellow Card

INTRODUCTION

The UL Yellow Card bears information relative to specific polymeric materials which a company has submitted to Underwriters Laboratories to be tested. The materials are listed on the card, hence, the phrase "UL Recognized." The listings (for plastic materials) are published in the "UL Recognized Components Directory," Volume II, Section QMFZ2, under the heading "Plastics."

The data shown in the sample are taken from an existing UL Yellow Card for Geon Polyvinyl Chloride (PVC).

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QMFZ2		October 16, 1990									
Component - Plastics											
GEON VINYL DIV										E41877 (N)	
6100 OAK TREE BLVD, CLEVELAND OH 44131										(A card)	
		RTI				H		D			
		Min	UL94	Elec	Mech	H	H	V	4	C	
		Thk	Flame		with	w/o	W	A	T	9	T
Mtl Dsg	Col	mm	Class	Imp	Imp	I	I	R	5	I	
Polyvinyl chloride (PVC) designated "Geon," furnished in the form of pellets.											
8700A(b)	All	0.71	94V-0	50	50	50	0	0	4	-	-
		3.05	94V-0	50	50	50	0	-	4	7	1
		6.10	94V-0	50	50	50	0	0	4	-	-
		0.76	94-5V	50	50	50	-	-	-	-	-
		WT, BK,									
		YL									
	All	3.18	94-5VA	50	50	50	-	-	-	-	-
		Reports: April 7, 1976; April 9, 1985									
		(Cont. on A1 card)									
774863001		H7047									
		D11/0026634									

THE IMPORTANCE OF UL TESTING

The properties of materials listed on the UL Yellow Card have been determined in accordance with established procedures. The UL evaluation of material properties is valuable to end users of the material in determining its appropriateness for a specific application. Additionally UL listings often save end users time and money by eliminating the need for further material testing.

UL testing can include the determination of a wide variety of material properties including:

- Ignition and burning characteristics from thermal and electrical sources.
- A wide range of other electrical, physical and mechanical characteristics, as well as specific analytical tests.
- The effect of exposure to elevated temperatures (air/oven aging), cold, water, ultraviolet rays, etc.

Note: Due to limited space, not all material property test results may be listed on a given UL card.

Comparative Tracking Index, Dielectric Strength, Volume Resistivity as well as other electrical and mechanical properties may be determined by means of the applicable ASTM and/or UL specifications in the Underwriters Laboratories, Inc., Standard for Polymeric Materials - "Use In Electrical Equipment Evaluations" (UL746A).

In addition to the aforementioned tests, materials which are used in applications involving support, or contact with current-carrying parts, are also required to display a minimum stability (heat-distortion, moisture-resistance, dimensional stability and mold stress) performance level as described in UL746C procedures.

To determine a material's compliance relative to a specific application, the test values generated for that material should be compared with the minimum performance level established for that application as outlined in applicable product standards.

THERMAL AGING PROGRAM

The materials covered by the UL program have, in many cases, been investigated with respect to the retention of certain critical properties (e.g., dielectric, flammability, tensile, impact, etc.) as part of an on-going thermal aging program conducted in accordance with Underwriters Laboratories, Inc., Standard for Polymeric Materials Long Term Property Evaluations (UL746B). The end-of-life of a material at each test temperature in this program has been assumed to be the time when the value of the critical property has decreased to 50 percent of its original (as received) value.

The temperature index shown in the individual recognition correlates numerically with the temperature (°C) above which the material is likely to degrade prematurely (as compared to the test results generated by a material with acceptable service results). More than one temperature index may be appropriate for a given material (depending upon property requirements for a given application).

NOTE: In certain cases, higher temperatures than indicated in the individual recognition are permitted if so specified by the applicable end-product standard.

The column heading "RTI" (Relative Thermal Index) refers to thermal aging. Test protocol involves oven-aging samples at four different temperatures (minimum 500-hours at highest temperature and 2000-hours at lowest temperature). The resultant temperature rating pertains to mechanical and/or electrical performance.

Mechanical performance can be either with or without impact. Thus the reason for two columns: "with imp" and "w/o imp". The default temperature rating, for PVC materials given when no thermal aging is done, is 50° C.

FLAMMABILITY RECOGNITION

Materials may be classified based on burning tests conducted in accordance with Underwriters Laboratories, Inc., Standard Tests for Flammability of Plastic Materials for parts in devices and appliances (UL94). By small scale tests, solid materials are classified as 94V-0, 94V-1, 94V-2, 94-5V, 94-5VA, and 94-5VB. Materials may also be evaluated using the radiant panel in accordance with ASTM E-162 (referenced in UL94); such flame spread indices are shown as "RP-10", "RP-15", etc.

UL94 small scale test data do not pertain to building materials, furnishings and related contents. UL94 small scale test data are intended solely for determining the flammability of plastic materials used in components and parts of end-product devices and appliances where the acceptability of the combination is determined by Underwriters Laboratories.

UL94: "FLAMMABILITY OF PLASTIC MATERIALS FOR PARTS IN DEVICES AND APPLIANCES."

This test measures a plastic material's ability to accept and support flame. A variety of test ratings are possible depending on performance:

VERTICAL BURNING TESTS (V-0, V-1, V-2, 5V, 5VA, 5VB)

In the vertical tests the specimen is supported in a vertical position and the flame applied directly to the bottom of the specimen in a vertical direction. The flame is applied for ten seconds and then withdrawn until the flaming ceases. The flame is reapplied immediately for ten seconds and withdrawn. This procedure balances the duration periods of flaming and glowing. A bed of surgical cotton is laid horizontally to the specimen to catch any dripping particles. If the specimen drips material, the burner may be tilted up to 45°

to permit the molten material to hit the cotton. Five sets are tested.

The following are vertical ratings:

94V-0

Materials classified as V-0 shall:

- A. Not have any bar specimen burn with flaming combustion for more than 10 seconds after either application.
- B. Not have a total flaming combustion time exceeding 50 seconds for the 10 flame applications.
- C. Not have any specimens which burn (flame or glow) up to the holding clamp.
- D. Not have any specimens which drip flaming particles that ignite the cotton.
- E. Not have any specimens with glowing combustion which persists beyond 30 seconds after the second flame.

94V-1

Materials classified as V-1 shall:

- A. Not have any bar specimen burn with flaming combustion for more than 30 seconds after either application.
- B. Not have a total flaming combustion time exceeding 250 seconds for the 10 flame applications.
- C. Not have any specimens which burn (flame or glow) up to the holding clamp.
- D. Not have any specimens which drip flaming particles that ignite the cotton.
- E. Not have any specimens with glowing combustion which persists beyond 60 seconds after the second flame.

94V-2

Materials classified as V-2 shall:

- A. Not have any bar specimens which burn with flaming combustion for more than 10 seconds after either application.
- B. Not have a total flaming combustion time exceeding 250 seconds for 10 flame applications.
- C. Not have any specimens which burn (flame or glow) up to the holding clamp.
- D. Have specimens that drip flaming particles which burn briefly, some of which ignite the cotton.
- E. Not have any specimens with glowing combustion which persists beyond 60 seconds after the second flame.

94-5V

In the 5V test, the specimen is vertical and the flame is applied to one of the lower corners at an angle of 20° from the vertical. The flame is applied for 5 seconds and removed for 5 seconds. This cycle is repeated for five applications.

Also, under 5V test procedures, some test specimens are to be heat-aged at temperatures of 90 to 120°C for between 5 to 60 days.

Materials classified as 5V shall:

- A. Not have any burning (flame or glowing) for more than 60 seconds after the five flame applications.
- B. No dripping.
- C. Not have any specimen destroyed in the area of the flame.

94-5VA

A material classified 5VA shall:

- A. Not have any bar specimens that burn with flaming or glowing combustion for more than 60 seconds after the fifth flame application.
- B. Not have any bar specimens that burn with flaming particles that ignite dry absorbent, surgical cotton located 12 inches (304.6mm) below the test specimen.
- C. Not have any plaque specimens that exhibit a burn through (hole).

94-5VB

A material classified as 5VB shall:

- A. Not have any bar specimens that burn with flaming or glowing combustion for more than 60 seconds after the fifth flame application.
- B. Not have any bar specimens that drip flaming particles that ignite dry absorbent, surgical cotton located 12 inches (304.6mm) below the test specimen.
- C. Permit a burn through (hole) on plaque specimens.

HORIZONTAL BURNING TESTS (HB, HBF, HF-1, HF-2)

94HB

Specimens 5.0 x 0.5 x 0.125 inches (with a designated minimum thickness) are tested. Each specimen is marked with a line 1 inch, and a second line 4 inches from one

end of the test specimen. It is clamped at the end farthest from the 1 inch mark - horizontally with its transverse axis inclined at an angle of 45°.

A flame is applied at the free end at the lower edge of the sample for 30 seconds. If the specimen burns to the 1 inch mark before 30 seconds, the flame is to be cut off at the 1 inch mark. The burning rate is to be measured from 1 inch to 4 inches.

Materials classified as HB shall:

- A. Not have a burning rate exceeding 1.5 inches / minute over a 3-inch span on widths (thickness) between 0.120 to 0.500 inches.
- B. Not have a burning rate exceeding 3 inches / minute over a 3-inch span for widths less than 0.120 inches.
- C. Cease to burn before the flame reaches the 4-inch mark.

HORIZONTAL BURNING FOAMED MATERIAL

Test specimens are cut from a representative sample of the material, with standard test specimens 6 inches long by 2 inches wide (maximum thickness not to exceed 0.51 inches).

If the material is to be considered in a range of densities or colors, specimens representing the extremes of the range are to be tested and considered representative of the range (if test results are essentially the same). Color pigments, known by experience to have adverse effects, must be provided for testing.

Test procedure involves supporting the test specimen in such a manner that the major section is horizontal and 0.5 inches above a burner wing tip, and 7 inches above a 2 inch by 2 inch horizontal layer of dry, absorbent cotton, thinned to a free-standing height of 0.24 inches.

Each specimen is marked across its width with three gauge marks 0.98 inches, 2.4 inches, and 4.9 inches in from one end. It is then placed flat on a wire cloth with the gauge marks facing up. The end closer to the 2.4 inch mark is placed in contact with the upturned end of the wire cloth.

The burner, with a blue flame 1.5 inches high, is placed beneath the wire gauze under the upturned end of the specimen support with the center of the wingtip in line with the longitudinal axis of the specimen. The flame is applied for 60 seconds. A time is started as the test flame is removed. Another timing device is started when the flame front reaches the 0.98 gauge mark.

94HBF

Materials classified as HBF shall:

- A. Not have any specimens with a burning rate exceeding 1.5 inches/mm. over a 4.0 inch span.
- B. Have each specimen cease to burn before flaming or glowing reaches the 5.0 inch gauge mark.

NOTE: If only one specimen (from a set of five) does not comply with requirements (A, B, listed above) another set of five specimens, subjected to the same conditioning, shall be tested. All specimens from the second set shall comply with the requirements (A,B) for the material in that thickness and density to be classed 94HBF.

94HF-1

Materials classified as HF-1 shall conform to the following:

- A. Afterflame time should not exceed 2 seconds (4 out of 5 test specimens), and 10 seconds (1 out of 5 test specimens).
- B. Afterglow time should not exceed 30 seconds.
- C. Surgical cotton below the test specimen should not be ignited by flaming particles.
- D. Test specimen damage should not exceed 2.4 inches.

94HF-2

Materials classified as HF-2 shall conform to the following:

- A. Afterflame time should not exceed 2 seconds (4 out of 5 test specimens), and 10 seconds (1 out of 5 test specimens).
- B. Afterglow time should not exceed 30 seconds.
- C. Test specimen damage should not exceed 2.4 inches.

ELECTRICAL PROPERTIES

To avoid an excessive level of implied precision and bias, material performances for several tests are recorded as Performance Level Categories (PLC), based on mean test results (rather than recording exact numerical results), as indicated in the table following the test description.

HOT-WIRE IGNITION (HWI)

Test specimens are wrapped with resistance wire that dissipates a specified level of electrical energy. Test objectives are to ignite standard specimens or to burn through the specimen without ignition.

HWI Range - Mean Ignition Time (IT) (in seconds)		Assigned PLC
120 and longer		0
60 and up to 120		1
30 and up to 60		2
15 and up to 30		3
7 and up to 15		4
Less than 7		5

HIGH-AMPERE ARC IGNITION (HAI)

Performance is expressed as the number of arc rupture exposures (standardized as to electrode type and shape and electric circuit) which are necessary to ignite a material when they are applied at a standard rate, either on the surface of the material or at a specified distance from it.

HAI Range - Mean Number of Arcs To Cause Ignition (NA)		Assigned PLC
120 and greater		0
60 and up to 120		1
30 and up to 60		2
15 and up to 30		3
Less than 15		4

Example: To measure resistance to a heavy current (32.5 amperes), an arc is passed intermittently between two electrodes positioned over the top surface of the test specimen (just touching the specimen). The test is continued until either the specimen ignites or a total of 200 arcs is reached.

"This test determines the durability of a material to withstand arcing on its surface at low voltage and high current levels, such as would be encountered in the mounting of contacts or the breaking of internal connections."

ARC RESISTANCE (ASTM D495)

In accordance with ASTM D495, arc resistance is expressed as the number of seconds a material resists the formation of a surface conducting path when subjected to an intermittent arc of high voltage, low current characteristics. The results of testing the nominal 1/8 inch (3.1mm) thickness are considered representative of the material's performance in any thickness.

D495 Range - Mean Time of Arc Resistance (TAR in seconds)		Assigned PLC
420 and longer		0
360 and up to 420		1
300 and up to 360		2
240 and up to 300		3
180 and up to 240		4
120 and up to 180		5
60 and up to 120		6
Less than 60		7

Test materials may fail in several different ways: become a temporary conductor, burst into flames, start a track on the surface or form a carbon layer sufficient to carry the current. Elapsed time until failure is recorded in seconds.

HIGH VOLTAGE ARC RESISTANCE TO IGNITION (HVAR)

HVAR is expressed as the number of seconds that a material resists ignition when subjected to a high voltage, low current arcing source.

HVAR Range - Mean Time to Ignition (TI in seconds)		Assigned PLC
300 and longer		0
120 and up to 300		1
30 and up to 120		2
Less than 30		3

HIGH VOLTAGE ARC TRACKING RATE (HVTR)

HVTR is denoted as the rate (mm/min) that a tracking path can be produced on the surface of the material under standardized test conditions. Note is made if ignition of the material takes place. The results of testing the nominal 1/8 inch (3.1mm) thickness are considered representative of the material's performance in any thickness.

HVTR Range - TR (mm/min)		Assigned PLC
0 through 10		0
Over 10 through 25.4		1
Over 25.4 through 80		2
Over 80 through 150		3
Over 150		4

HIGH VOLTAGE TRACK RATE

The purpose of this test is to determine the susceptibility of the test materials to track or form a visible, carbonized conducting path over the surface when subjected to high voltage, low current arcing.

The test to measure this property is similar to the high ampere arc ignition test except continuous arcing is applied. The electrodes are positioned to establish a continuous arc and are then moved farther apart at a fixed rate until a distance of two inches is achieved, or a two minute interval has passed. The tracking rate of the plastic is computed in mm/min. or inches/min.

COMPARATIVE TRACKING INDEX (CTI)

Comparative Tracking Index is expressed as that voltage which causes tracking on a material after 50 drops of 0.1 percent ammonium chloride solution has fallen. The results of testing the nominal 1/8 inch (3.1mm) thickness are considered representative of the material's performance in any thickness.

CTI Range - Tracking Index (TI in volts)		Assigned PLC
600 and greater		0
400 and up to 600		1
250 and up to 400		2
175 and up to 250		3
100 and up to 175		4
Less than 100		5

This test is intended to show susceptibility to surface tracking of solid electrical insulating materials when exposed, under electrical stress, to water and other contaminants.

CTI Range - Tracking Index (TI in volts)	Assigned PLC
600 and greater	0
400 and up to 600	1
250 and up to 400	2
175 and up to 250	3
100 and up to 175	4
Less than 100	5

This test is intended to show susceptibility to surface tracking of solid electrical insulating materials when exposed, under electrical stress, to water and other contaminants.

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