

ISO Test Method

R&D Center

Water absorption (ISO 62)

1. Introduction

Water absorption is used to determine the amount of water absorbed under specified conditions. Factors affecting water absorption include: type of plastics, additives used, temperature and length of exposure. The data sheds light on the performance of the materials in water or humid environments.

2. Test Condition

- (1) 23°C / 50% R.H
- (2) 23°C / 100% R.H (water soaking)
- (3) 100°C / 100% R.H (water soaking)
- (4) Soaking time : 24 h, 48 h, 96 h, 192 h,
- (5) Specimen : (1.0 ± 0.1) mm thickness square specimen(ISO 294)

3. Calculation

- (1) Water absorption is expressed as increase in weight percent.
- (2) $c = (m_2 - m_1) / m_1 \times 100 \%$
 m_2 : the apparent mass of the specimen after soaking
 m_1 : the apparent mass of the specimen before soaking

Density (ISO 1183-1, method A, immersion method)

1. Definition

- (1) Density : ratio of the mass of a sample to its volume expressed in g/cm³
- (2) Specific gravity : the ratio of the mass of a given volume of the impermeable portion of the material at 23°C to the mass of an equal volume of gas-free distilled or de-mineralized water at the same temperature

2. Test condition

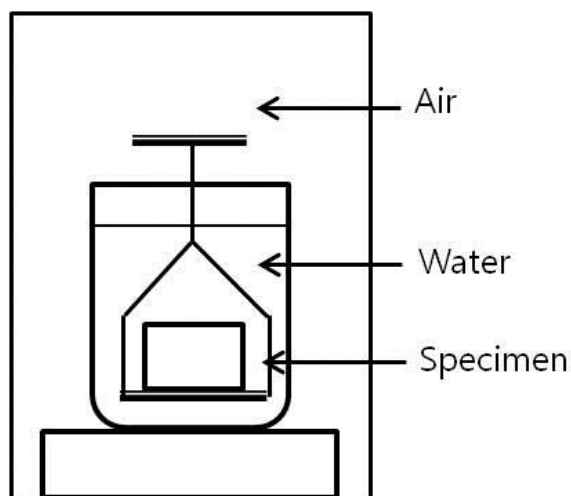
- (1) Conditioning of the test specimen : over 88 h at (23 ± 2) °C and (50 ± 5) % R.H.
- (2) Specimen : Specimens may be in any void-free form. They shall be of a convenient size to give adequate clearance between the specimen and the immersion vessel and should preferably have a mass of at least 1 g.

3. Calculation

- (1) Density, $\rho = m_{s,a} \cdot \rho_{IL} / (m_{s,a} - m_{s,IL})$
 $m_{s,a}$: the apparent mass of the specimen in air (g)
 $m_{s,IL}$: the apparent mass of the specimen in the immersion liquid (g)
 ρ_{IL} : the density of the immersion liquid (g/cm³)

[Unique density of polymers]

Material	Density (g/cm ³)	Material	Density(g/cm ³)
ABS	1.05	PPO	1.08
Acetal(POM Co.)	1.41	PPS	1.55
PA6 / PA66	1.14	PE	0.91~0.96
PC	1.20	PP	0.90~0.91
PBT	1.31	PS	1.05
PET	1.36	PTFE	2.14



Tensile properties (ISO 527-1, ISO 527-2)

1. Summary

The test specimen is extended along its major longitudinal axis at a constant speed until the specimen fractures or until the stress (load) or the strain (elongation) reaches some predetermined value. During this procedure, the load sustained by the specimen and the elongation are measured.

2. Test condition

- (1) Conditioning : 16 h at $(23 \pm 2) ^\circ\text{C}$ and $(50 \pm 5) \% \text{ R.H.}$
- (2) Test speeds : 50 mm/min, 5 mm/min (only to be quoted if strain at break is 10 %),
1 mm/min (modulus)

3. Calculation

- (1) Tensile Strength(stress at yield) : stress at the yield strain, $\sigma = F/A$

σ : the stress value in question (MPa)

F : the applied force (N)

A : the initial cross-sectional area of the specimen (mm^2)

- (2) Strain, $\varepsilon = \Delta L_0/L_0$

ε : is the strain value in question, expressed as a dimensionless ratio, or as a percentage

L_0 : is the gauge length of the test specimen (mm)

ΔL_0 : is the increase of the specimen length between the gauge marks (mm)

1) Strain at yield : the first occurrence in a tensile test of strain increase without a stress increase

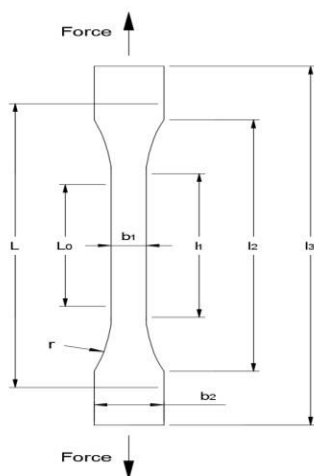
2) Strain at break : strain at which the specimen breaks

- (3) Modulus : %, $E_t = (\sigma_2 - \sigma_1) / (0.0025 - 0.0005)$

Slope of the stress/strain curve $\sigma(\varepsilon)$ in the strain interval between $\varepsilon_1 = 0.05 \%$ and $\varepsilon_2 = 0.25 \%$

σ_1 : is the stress measured at the strain value 0.05 %

σ_2 : is the stress measured at the strain value 0.25 %



l_3 : Overall length, ≥ 170 ,
 l_1 : Length of narrow parallel-sided portion, 80 ± 2
 r : Radius, 24 ± 1 ,
 l_2 : Distance between broad parallel-sided portions, 109.3 ± 3.2
 b_2 : Width at ends, 20.0 ± 0.2 ,
 b_1 : Width at narrow portion, 10.0 ± 0.2
 L_0 : Gauge length, 50.0 ± 0.5
 L : Initial distance between grips, 115 ± 1
 Specimen thickness: 4.0 ± 0.2 (Dimensions : mm)

Flexural properties (ISO 178)

1. Summary

A test specimen of rectangular cross-section, resting on two supports, is deflected by means of a loading edge acting on the specimen midway between the supports. The test specimen is deflected in this way at a constant rate at midspan until rupture occurs at the outer surface of the specimen or until a maximum strain of 5 % (see 3.8) is reached, whichever occurs first. During this procedure, the force applied to the specimen and the resulting deflection of the specimen at midspan are measured.

2. Test condition

- (1) Conditioning : over 88 h at $(23 \pm 2) ^\circ\text{C}$ and $(50 \pm 5) \% \text{ R.H.}$
- (2) Test speed : 2 mm/min

3. Calculation

- (1) Flexural stress, $\sigma_f = 3FL/2bh^2$

σ_f : the flexural-stress

F : the applied force (N)

L : the span (mm)

b : the width (mm)

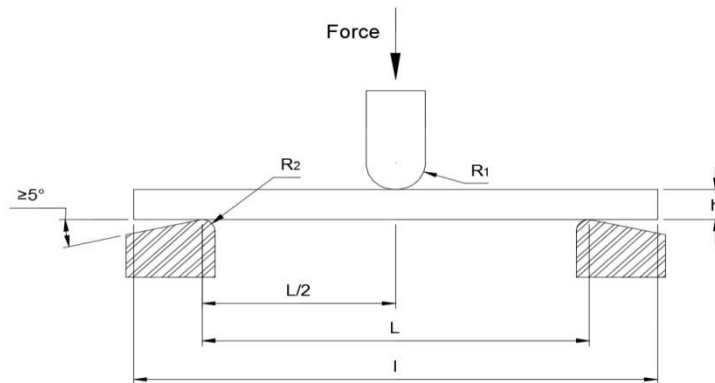
h : the thickness(mm)

- (2) Flexural modulus, $E_t = (\sigma_2 - \sigma_1) / (0.0025 - 0.0005)$

slope of the stress/strain curve $\sigma(\epsilon)$ in the strain interval between $\epsilon_1 = 0.05 \%$ and $\epsilon_2 = 0.25 \%$

σ_1 : is the stress measured at the strain value 0.05 %

σ_2 : is the stress measured at the strain value 0.25 %



Length of specimen $l = 80.0 \pm 2.0$
 Width $b = 10.0 \pm 0.2$
 Thickness $h = 4.0 \pm 0.2$
 Length of span between supports $L = 64 \text{ mm}$
 (Dimensions : mm)

Charpy impact strength (ISO 179-1/1eA)

1. Summary

The test is carried out with the specimen notch / un-notched bar. The test specimen, supported as a horizontal cantilever beam, is broken by a single impact of a striker

2. Test condition

(1) Conditioning of the test specimen : over 16 h at $(23 \pm 2) ^\circ\text{C}$ and $(50 \pm 5) \% \text{ R.H.}$

(2) Impact speed : 2.9 m/s

3. Calculation

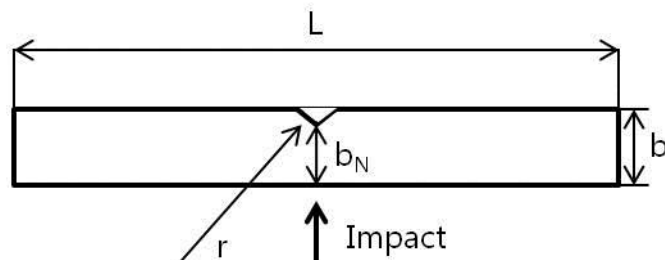
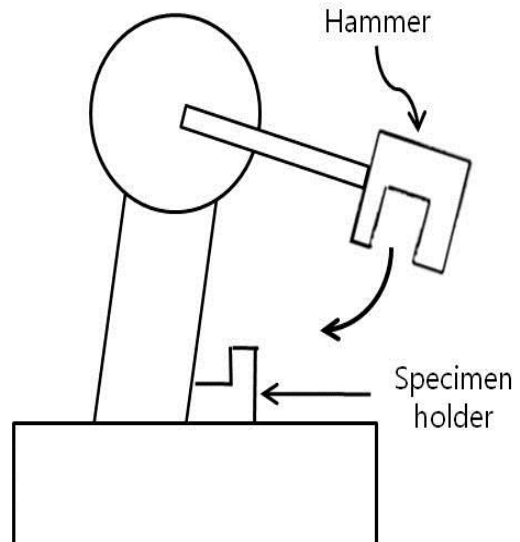
(1) Impact Strength

$$a_{cN} = E_c / h * b_N * 10^3$$

E_c : the corrected energy absorbed by breaking the test specimen(J)

h : the thickness of the test specimen(mm)

b_N : the remaining width of the test specimen(mm)



Length $l = 80.0 \pm 2.0$

Width $b = 10.0 \pm 0.2$

Thickness $h = 4.0 \pm 0.2$

Remaining width at notch base $b_N = 8.0 \pm 0.2$

Radius of notch base $r_N = (0.25 \pm 0.05)$

(Dimensions : mm)

Angle of notch base $45^\circ \pm 1^\circ$

Melt index (ISO 1133-1, ISO 1133-2)

1. Summary

Melt index is calculated by measuring rate of extrusion of a molten resin through a die of specified length and diameter under prescribed conditions of temperature, load and piston position in the cylinder of an extrusion plastometer, the rate being determined as the mass extruded over a specified time. We can find out the rheological behavior of resin with melt index.

2. Test condition

(1) Conditioning of the test specimen : over 16 h at $(23 \pm 2) ^\circ\text{C}$ and $(50 \pm 5) \% \text{ R.H.}$

(2) Test temperature and load

Material	Temperature	Load
POM	190 $^\circ\text{C}$	2.16 kg
PA 6	235 $^\circ\text{C}$	2.16 kg
PA 66	275 $^\circ\text{C}$	2.16 kg
PET	290 $^\circ\text{C}$	2.16 kg
PBT	250 $^\circ\text{C}$	2.16 kg
PPA	340 $^\circ\text{C}$	2.16 kg
PA.MXD6	270 $^\circ\text{C}$	2.16 kg

(3) The preheat time of 5 min begins immediately after charging of the cylinder has been completed.

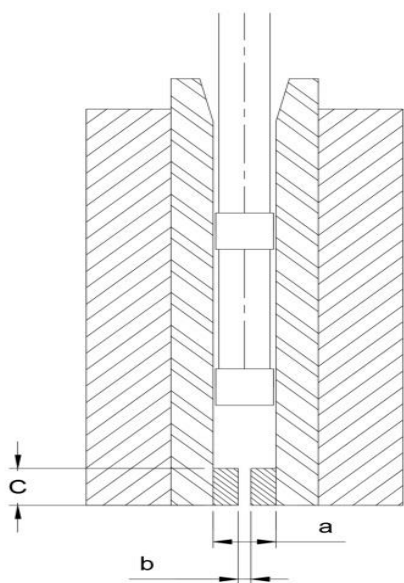
3. Calculation, $\text{MFR}(T, m_{\text{nom}}) = 600 \times m / t$

m_{nom} : is the mass, exerting the nominal load (kg)

600 : is the factor used to convert grams per second into grams per 10 min (600 s)

m : is the average mass of the cut-offs (g)

t : is the cut-off time-interval (s)



$a = 9.550 \pm 0.007$, Cylinder radius

$b = 2.095 \pm 0.005$, Orifice radius

$c = 8.000 \pm 0.025$, Orifice length

(dimensions : mm)

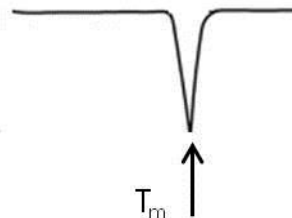
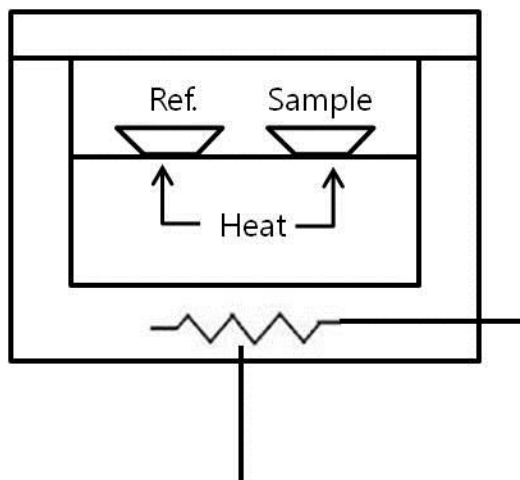
Melting point (ISO 11357-1, ISO 11357-3)

1. Summary

- (1) DSC(Differential Scanning Calorimetry) measures the temperature of solid-liquid phase change and the temperature is defined as melting temperature.
- (2) DSC can give information of not only melting temperature but also glass transition temperature, crystallization temperature, enthalpy of fusion etc., by measuring difference in heat flow between reference and sample.

2. Test condition

- (1) Specimen : Specimens should preferably have a mass of at least 5 mg to 10 mg.
- (2) Testing Procedure
 - 1) Heat the cell to 30 °C above T_m at a rate of 10 °C/min or 20 °C/min
 - 2) Hold the temperature for 5 minutes.
 - 3) Cool the cell to 50 °C below T_c at a same rate of number 1
 - 4) Hold the temperature for 5 minutes.
 - 5) Heat the cell to 30 °C above T_m at a same rate of number 1



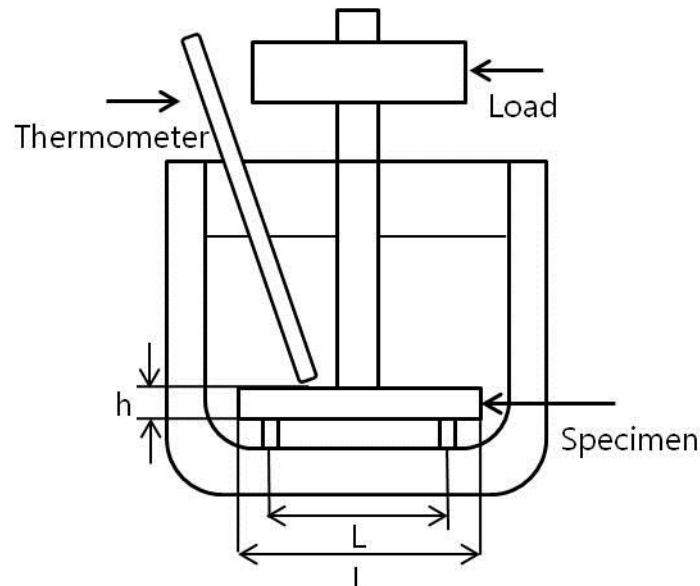
Heat deflection temperature (ISO 75-1, ISO 75-2)

1. Summary

HDT is the temperature at which the deformation amount of the test specimen reaches regular standard value at elevated temperature under load at a specified rate of temperature increase. We can determine the heat stability of resin with HDT.

2. Test condition

- (1) Conditioning of the test specimen : over 16 h at $(23 \pm 2) ^\circ\text{C}$ and $(50 \pm 5) \% \text{ R.H.}$
- (2) Flatwise Test
- (3) Scan condition : The rate of temperature increase is $(120 \pm 10) ^\circ\text{C/h}$ from under $27 ^\circ\text{C}$
- (4) Load : 1.80 MPa
- (5) Measure the temperature at which the deformation amount of the test sample reaches 0.34 mm.



Span length $L = 64 \pm 1$
Length $l = 80.0 \pm 2.0$
Width $b = 10.0 \pm 0.2$
Thickness $h = 4.0 \pm 0.2$ (Dimensions : mm)

The coefficient of linear expansion (ISO 11359-1, ISO 11359-2)

1. Summary

Thermal expansion is the tendency of matter to change in volume in response to a change in temperature through heat transfer. Temperature is a monotonic function of the average molecular kinetic energy of a substance. When a substance is heated, the kinetic energy of its molecules increases. Thus, the molecules begin moving more and usually maintain a greater average separation. Materials which contract with increasing temperature are unusual; this effect is limited in size, and only occurs within limited temperature ranges (see examples below). The degree of expansion divided by the change in temperature is called the material's coefficient of thermal expansion and generally varies with temperature.

2. Test condition

- (1) Load : 4.0 ± 0.1 kPa, scan speed : under 5 °C/min
- (2) Specimen : Square specimen of length 5 mm ~ 10 mm, width 5 mm.

3. Calculation, $\alpha = \Delta L / (\Delta T \cdot L_0)$

L_0 : Specimen length at room temperature(μm)

ΔL : Difference in length(μm)

$\Delta T (= T_2 - T_1)$: Difference in temperature(absolute temperature)

Volume Resistivity & Surface Resistivity (IEC 60093)

1. Summary

- (1) surface resistivity(Dimensions: Ω) : The surface resistance of a plastic is, as the name suggests, the resistance to the flow of electrical current across its surface. This is in contrast to the volume resistivity (or simply electrical resistivity), which is the resistance to flow through the three-dimensional volume of a sample.
- (2) volume resistivity(Dimensions : $\Omega \cdot \text{cm}$) : This is an intrinsic property that quantifies how strongly a given material opposes the flow of electric current. A low resistivity indicates a material that readily allows the movement of electric charge.

2. Calculation

- (1) Volume resistivity ($\Omega \cdot \text{cm}$)

$$\rho = A \cdot R_V / t$$

A : effective area of guarded electrode, cm^2

R_V : measured volume resistance, Ω

t : thickness, cm

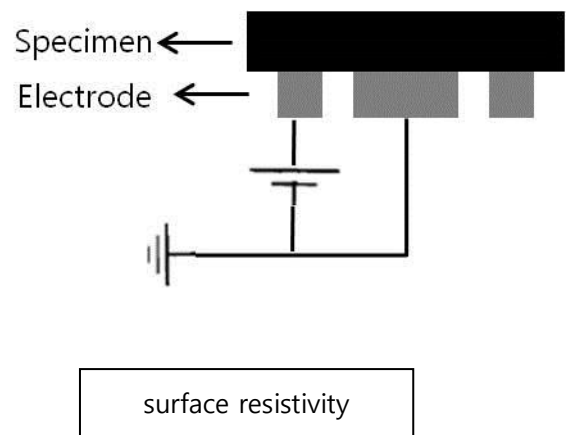
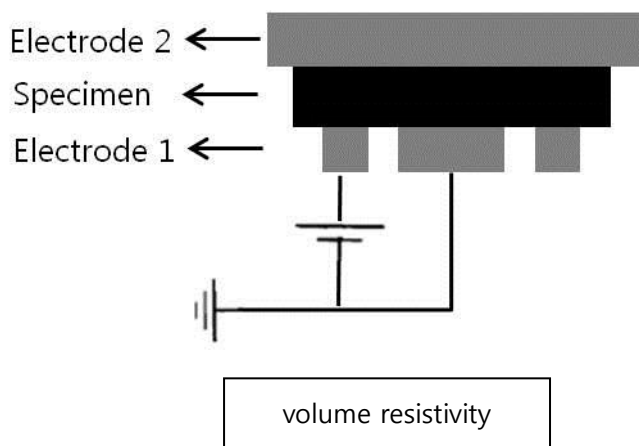
- (2) Surface resistivity (Ω)

$$\sigma = R_x \times p / g$$

R_x : measured surface resistance(Ω)

p : real distance of guarded electrode(cm)

g : distance between two electrodes(cm)



Dielectric breakdown voltage (Dielectric breakdown strength, IEC 60243-1)

1. Summary

The field strength at which breakdown occurs depends on the respective geometries of the dielectric (insulator) and the electrodes with which the electric field is applied, as well as the rate of increase at which the electric field is applied. Because dielectric materials usually contain minute defects, the practical dielectric strength will be a fraction of the intrinsic dielectric strength of an ideal, defect-free, material. Dielectric films tend to exhibit greater dielectric strength than thicker samples of the same material.

2. Test condition

(1) Voltage increase rate : 100 V/s, 200 V/s, 500 V/s, 1,000 V/s, 2,000 V/s, 5,000 V/s etc.

3. Calculation

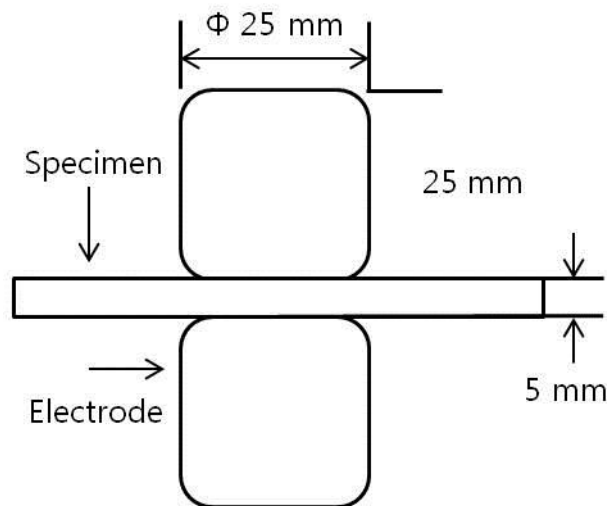
(1) Dielectric breakdown strength

$$E(\text{kV/mm}) = V(\text{kV})/d(\text{mm})$$

E : Dielectric breakdown strength

V : Dielectric breakdown voltage

d : Thickness of the specimen



Molding shrinkage (KEP method)

1. Summary

This covers the measurement of specimen shrinkage for injection and compression molding. Data for mold shrinkage should be used for material comparison. Actual mold shrinkage values are highly dependent on part geometry, mold configuration, and processing conditions.

Mold shrinkage for many materials differs for flow and transverse (or across flow) directions. Flow direction is taken as the direction the molten material is traveling when it exits the gate and enters the mold.

2. Test specimen

Circle specimen : Φ diameter 100 mm \times 3.2 mm

3. Calculation

$$S_{mp} = 100 \times (l_c - l_1) / l_c$$

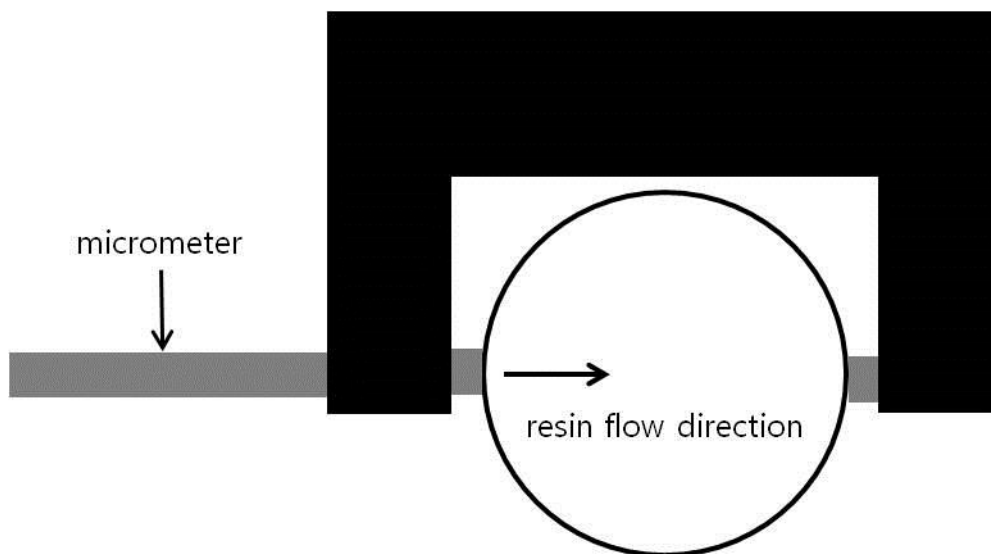
$$S_{mn} = 100 \times (b_c - b_1) / b_c$$

l_c : Length of mold (100 mm)

l_1 : Length of specimen

b_c : Width of mold (100 mm)

b_1 : Width of specimen



Non-flammability (UL94)

1. Summary

- (1) Test method to indicate non-flammability of plastics for electrical parts.
- (2) It is divided into HB, V-0, V-1, V-2 by order of non-flammability.

2. Test condition

(1) Horizontal method (UL 94HB)

- ① Thickness : 3 ~ 13 mm Burning speed : ≤ 40 mm/min
- ② Thickness : < 3.0 mm Burning speed : ≤ 75 mm/min

HB Rank is obtained with above condition.

(2) Vertical method (UL 94V)

- 1) Specimen : 125 ± 5 (Length) \times 13 ± 0.5 (Width) \times 0.8 or 1.6 or 3.2 (Thickness)
(Dimensions : mm)

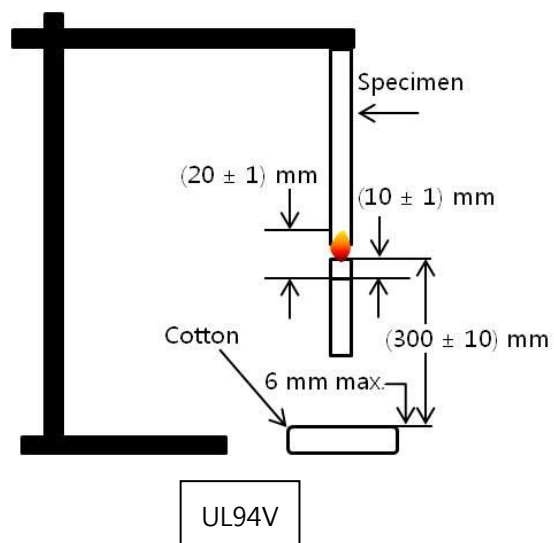
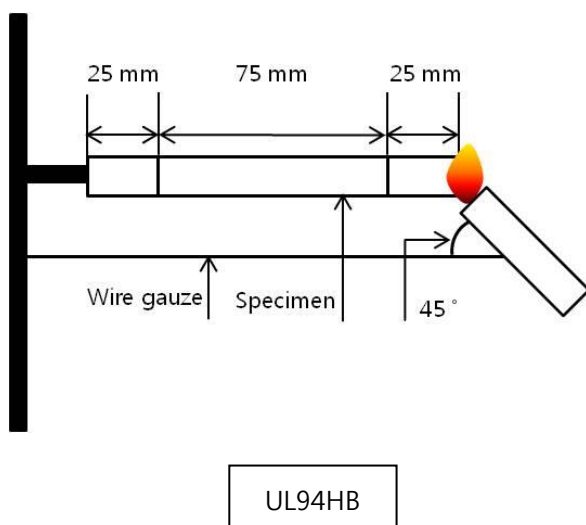
Rank	V-0	V-1	V-2
Each t_1 or t_2	≤ 10	≤ 30	≤ 30
Total ($t_1 + t_2$) of 5 specimens	≤ 50	≤ 250	≤ 250
Each ($t_2 + t_3$)	≤ 30	≤ 60	≤ 60
Check that test piece has not burnt out	No	No	No
Drip burn	No	No	Yes

t_1 : First burning time, t_2 : Second burning time, t_3 : Second burning time + growing time

Fails if even one sample does not satisfy criteria.

If total ($t_1 + t_2$) of 5 specimens is in 51 to 55 seconds or 251 to 255 seconds, retest.

- (3) Conditioning of the test specimen over 48 h at $(23 \pm 2)^\circ\text{C}$ and $(50 \pm 5)\%$ R.H.



RTI (UL 746B)

1. Summary

Relative Temperature Index (RTI) - Maximum service temperature for a material, where a class of critical property will not be unacceptably compromised through chemical thermal degradation, over the reasonable life of an electrical product, relative to a reference material having a confirmed, acceptable corresponding performance defined as RTI.

2. Definition

- (1) RTI Elec - Electrical RTI, associated with critical electrical insulating properties.
- (2) RTI Mech Imp - Mechanical Impact RTI, associated with critical impact resistance, resilience, and flexibility properties.
- (3) RTI Mech Str - Mechanical Strength (Mechanical without Impact) RTI, associated with critical mechanical strength where impact resistance, resilience, and flexibility are not essential.

3. Example

- Elec. 150 : This gives an indication of the aging temperature(150°C) that a material can endure for 100,000 hours and still retain at least half of the initial electrical RTI being measured.
- Mech. With Imp 150 : This gives an indication of the aging temperature(150°C) that a material can endure for 100,000 hours and still retain at least half of the initial mechanical impact RTI being measured.
- Mech. W/O Imp 150 : This gives an indication of the aging temperature(150°C) that a material can endure for 100,000 hours and still retain at least half of the initial mechanical impact RTI(except for impact strength) being measured.

HQ

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