INNOVATIVE PLASTICS

QUALITY+ PERFORMANCE

ELECTRICAL AND LIGHTING APPLICATIONS

CHEMISTRY THAT MATTERS™

A SABIC COMPANY

Innovative Plastics is a strategic business unit of SABIC. Founded in 1976, SABIC is today the first public, global multinational enterprise headquartered in the Middle East. Its products range from bulk commodity chemicals to highly engineered plastics for demanding applications. It is a leading producer of polyethylene, polypropylene, glycols, methanol and fertilizers and the fourth largest polyolefin producer.

SABIC's businesses are grouped into Chemicals, Performance Chemicals, Polymers, Innovative Plastics, Fertilizers and Metals. It has significant research resources with dedicated Technology & Innovation centers in Saudi Arabia, the Netherlands, Spain, the USA, India, China and Japan.

INNOVATING FOR CUSTOMER SUCCESS

We believe that SABIC customers deserve the full benefit of every advantage our enterprise can offer. After all, our success is defined by our customers' success. And with more than 80 years of experience pioneering advanced engineering thermoplastics, SABIC's Innovative Plastics business is positioned to help create new opportunities for growth and breakthrough applications.

We offer expertise and experience to our customers in a variety of ways:

- Material solutions to help drive innovation and market leadership.
- Design, logistics and processing expertise to spark new ideas and better efficiencies.
- Unwavering commitment to build long-term relationships with ingenuity, trust and continuous improvement.

It's what we strive for and work to deliver… a mutual benefit.

Excellence and nothing less.

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1. INTRODUCTION

SABIC is a well-established supplier of a wide range of high performance engineering thermoplastic resins to the electro technical and lighting industries. These materials are complemented by a range of sheet and film products from SABIC's Specialty Film and Sheet business. This product portfolio has been developed to help fulfill the demanding requirements in these industries and its comprehensive range of property profiles offers designers more engineering flexibility than ever before, helping manufacturers to achieve an optimum balance of performance, productivity and quality.

SABIC also helps to realize its materials' environmental as well as functional adaptibility in meeting tomorrow's needs. Engineering thermoplastics are inherently re-usable which enables easy after-use recovery and reprocessing into second and even third use applications.

With regard to the specific regulations concerning flame retardant (FR) materials, it should be noted that SABIC in Europe does not manufacture any materials containing Polybrominated Biphenyls (PBBs), Polybrominated Diphenylethers (PBDEs) or heavy metals to comply with RoHS (restriction on hazardous substances) Directive 2002/95/EU. In accordance with WEEE (Waste on Electrical and Electronic Equipment) Directive 2002/96/EU, all grades in NORYL™ resin, and a wide range of FR (Flame Retardent) CYCOLOY™ resin PC/ABS blends and FR LEXAN™ polycarbonate resins can be called bromine free. ULTEM™ resin and SILTEM™ resin are inherently flame retardant.

2. HIGH STANDARD

Working closely with its partners in industry, SABIC is committed to the development of materials, which meet the application needs of today and tomorrow.

In addition to satisfying customer requirements, these materials consistently meet, and often exceed, the increasingly stringent industry standards. Materials are routinely tested in SABIC's laboratories as part of the company's dedicated development and quality assurance program. Using advanced equipment and techniques, the company can reproduce test procedures according to international norms, which include IEC, ISO, EN, UL and a wide range of international agencies.

Throughout this brochure reference is made to the applicable European EN standards, which are replacing the corresponding national and IEC standards. (In general, it can be noted that most EN are identical to IEC standards).

In some cases, SABIC's customers use thermoplastics in applications that have been previously only been produced in traditional materials. In these instances no industrial standards exist. Therefore, test methods are developed and dedicated test equipment designed and built to simulate part performance in real-life environments, or as close to those conditions as is practicable to achieve.

3. PRINCIPAL STANDARD TESTS

The standard tests, which are conducted on thermoplastic materials used in electro technical applications can be grouped as flammability, electrical, thermal, mechanical and weathering tests.

3.1 FLAMMABILITY

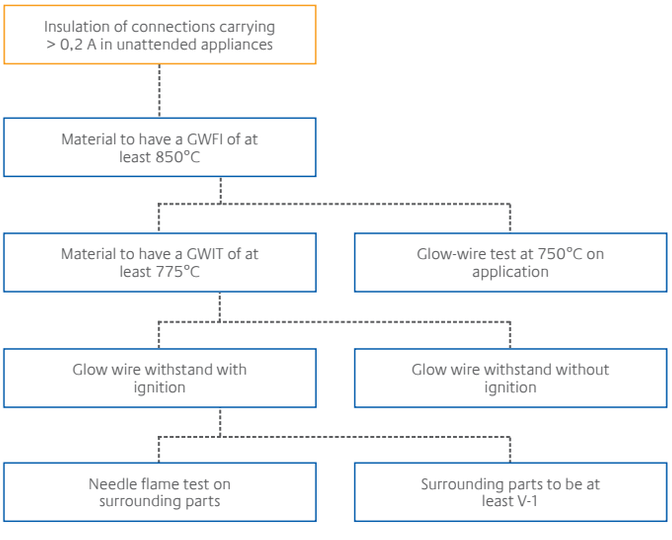
Burning behavior is not only a material characteristic but is also dependent on the shape and wall thickness of the application. As there are possibly more flammability test methods than polymer types, this brochure deals only with the most commonly recognized tests. Flammability testing can be carried out according EN 60695-11-10 & EN 60695-11-20 which are equivalent to Underwriters' Laboratories UL94.

The main tests for this classification fall into three categories
(1) HB horizontal burn test
(2) V0, V1, V2 vertical burn test
(3) 5VA, 5VB

In Europe, the flammability of polymeric materials is commonly tested using two different methods. The first is the glow wire test (GWT), according to EN 60695-2-10 through 13, and the second is the needle flame test according to EN 60695-11-5. In the glow wire test, actual test temperatures can vary from 650°C for non-current carrying parts, to 850°C and even 960°C depending on end-use requirements. As can be seen in the table (see table brochure), most engineering thermo-plastics pass this test at 650°C at 1 mm. To pass at 850°C materials are generally at least UL94V-2 rated.

TABLE 1

EN 60335 FLOW CHART FOR ELECTRICAL COMPONENTS IN UNATTENDED APPLICATIONS



Typical applications are electronic housings, washing machine timers, connectors, e-motor end-caps for washing machines, tumble dryers, ovens etc. The standard EN 60335-1 for household appliances requires materials, used in unattended appliances with a current > 0,2 A, to comply with a glow wire flammability test of 850 °C and have no ignition at 750 °C so glow wire ignition temperature of 775 °C. If materials ignite at the glow wire test at 750 °C, the surrounding materials in the appliance are tested with the needle flame unless they are rated V1 or V0.

The limited oxygen index (LOI) according to ISO 4589 is defined as the minimum concentration of oxygen, expressed as a percentage by volume, in a mixture of oxygen and nitrogen, which will just support the flaming combustion of a material the higher the value indicated, the more difficult the combustion. In general, a material with an LOI of >21% will not burn under atmospheric conditions. (several French standards require an LOI of >25%, and even >28% in some cases).

TABLE 2

SHEET - LOI CLASSIFICATION ACC. ISO 4589-2

	LOI > 25%	LOI > 32%	LOI > 45%
CYCOLAC™ RESIN	FXS630SK, SEA2X, S157, VW55, VW 300		
CYCOLOY RESIN	C2100HF, CU6800	C2100, C2800, C2950, C3600, C3650, C6200, C6600, CH6410, FXC630xy	
LEXAN RESIN	241, EXL1112, HP1, HP1R, HP2, HP2R, HP4, HP4R, HPS1, HPS1R, HPS2, HPS2R, 1xyR, 2xyR, FXD1xy, FXE1xy, FXL161R, FXM161R, HF1110, HF1130, HF1140, LI1813R, LI1191R, LS, LS2, LS3, ML3021A, ML3041, ML3042, ML3260, ML3290, ML3400, ML3729, ML3982, WR2210	3412ECR, 505R, 940A, 945, 945U, 945A, 945RSR, 9945A, BFL2000, 2010, 2014B, 2015, 2034 BPL1000, EXL1112, EXL1330, EXL1414, EXL1434, EXL9112, EXL9132, EXL9134, EXL9330, EXL9335, SLX2432T, 1278R, 2014R, 2034, 3412R, 3413H, 3414H, 500ECR, 500R, 503R, 915R, 920, 920A, 923, 923A, 925, 925A, 925AU, 925U, 940, 943, 943A, 950, 950A, 953A, 955, 955A, AK, U, FL900S, FL920, ML3019, ML3513, ML6411, ML6412	
NORYL RESIN	WCA105, WCD801, WCD891A, WCP781 FN150, GFN1, GFN1520V, GFN630V, GFN1V	CTI2550, ENV105, PX1115, PX9406N, SE0, V01505, V0150B, VO1525, VO1550, VO2570, VO3505, VO3550, VO80, V090, V180HF	
NORYL GTX™ RESIN	GTX810, GTX820, GTX830	GTX4110	
SILTEM RESIN			STM1500
ULTEM RESIN			All
VALOX™ RESIN		420SEO, 553	
XENOY™ RESIN			

3. PRINCIPAL STANDARD TESTS

3.2 ELECTRICAL

The comparative tracking index (CTI) is one of the key electrical tests, which is carried out to determine the safety of components supporting electrical current carrying parts. According to IEC 60112 and UL746A, the CTI test indicates the voltage at which a material continues to resist tracking. For direct support of current carrying parts a CTI greater than 175V is required.

Besides CTI sometimes PTI (proof tracking index) is mentioned. PTI is exactly the same test method as CTI. PTI testing is used to verify whether a material has a certain CTI.

For example, if a PTI of 250V is required, the test is conducted at 250V and the material under test should withstand the 50 drops at that voltage.

Engineering thermoplastics in general have a CTI of >175 volts. It should be noted, however, that the CTI can be affected by the addition of flame retardant additives, colorants and fillers. Carbon black, for example used in many dark colors, has a distinct negative effect on the CTI. Below table contains the CTI value tested on RAL 7035 electrical grey for those grades that pass also the ball pressure test @ 125 °C (applicable for current carrying parts).

Bosch Infomodul using LEXAN resin

TABLE 3
COMPARATIVE TRACKING INDEX (IEC 60112 – UL746A)

UL746A PERFORMANCE LEVEL CLASS	PLC 4	PLC 3	PLC 2	PLC 1	PLC 0
RESIN	> 100Volts	> 175Volts	> 250Volts	> 400Volts	> 600Volts
CYCOLAC RESIN				CRT3370, FXS610SK, FXS620SK, FXS630SK, G121, G122, G360, G361, G362, G363, G365, G366, G368, GPM5500, MGX610xy, S157, S570, S706S, S858, VW300, X11G	FXS610xy, S700, S701, S702, S703, S704, S848, S849, X37, X399
CYCOLOY RESIN		CH6410, C2100, CX7240, CX7211, CH6410, C6200, EFX830ME, FXC813SK	C1000, C1100, C1200, C3100	C2950	C2800, C3650, C1200HFM, C3600, CU6800, C8650REC
GELOY™ RESIN		HRA150, HRA170, XP4025			CR7010, CR7020, CR7520, HRA222
LEXAN RESIN	505R, BFL 2015, 500ECR, 1278R, 2814R, 3412R, 3414R, ML3513	HF500R, 9X3A, 9x5AU, 9X0, BE2130, 9945A, 9X0A, 9x5, BFL2000, BFL2010, BPL1000, EXL9330, EXL 9335, EXL9112, EXL9132, EXL6013, EXL6033, 161R, FXD161R, ML3021A, ML3260, ML3290, ML3562, ML6412	1X3R, 2X1R, 2X3R, HF1130R, ML3041, ML3803, ML6411, FXD1xy, 1X1R, HF1110R, BFL2000U, 123HSR, HP1R, HPS1R	BFL2000U, ML6411, ML6412, 123HSR, 1xy, FXD1xy, HF1110R, HP1R, HPS1R	
NORYL RESIN		725, 731, GFN1720, HF180, SE1, SE100, SE90, V01525, V090, V190, PX1115	CTI2550, GFN1630V, GFN3, N190, V01550, V02570, V0150B SE1GFN1, HS1000X, HS2000X, PX9406, LTA1350	ENV131, HB1525 SE0, V081, PPX™630, PPX640, HH180, PX1007	WCA105, WCD801, WCD910, WCP700, WCP860, PPX7110
NORYL GTX RESIN			GTX4110 GTX924,		GTX914, GTX934, GTX944, GTX964
SILTEM RESIN		STM 1500			
ULTEM RESIN	All ULTEM resin	1100, 1110, 1110R, 4000, 9070, ATX200F, CRS5001, XH6050			
VALOX RESIN		357X, 310SEO, 3607U, DR48, 451E, 457, 4512, 420SE0, 5021, 5031, 553 855,, 865, V8560, VX3608C, VX5005, VX5011, VX5022, VX8532	DR51, 4012,4 4014, 4022, 4026, 4032, 022, 4031, 412, 420, 430, 508, 815, 830, 359, 4521, 4630, 4631, 5510, VX3603C, VX4015, VX4029, VX4037, VX7024, VX8105U	735, 7523 VX4920, VX4930	260HPR, 3007, 312, 315, 325, 362, 771, FXV310SK, HR326, V3001MC, VX3101N
XENOY RESIN		ALL XENOY resin	CL500U, 6370, 6380U		X2500UV, XL1339XL1562

3. PRINCIPAL STANDARD TESTS

3.3 THERMAL

All thermoplastics will eventually soften at elevated temperature. According to ISO 75, the heat deflection temperature, HDT, or the deflection temperature under load, DTUL, is a relative measure of a material's ability to perform at elevated temperatures while supporting a load. In amorphous materials the HDT is almost the same as the glass transition temperature, (Tg). This measurement does not necessarily represent the upper use temperature of a material. Many crystalline materials can be used at temperatures well above their HDT, depending on factors such as the load, the time and whether the material is filled or unfilled.

According to IEC 60695-10-2 the ball pressure test (BPT) is the most common softening temperature test used by the electrical industry. During the BPT a steel ball is pressed against the sample in a heating cabinet for one hour. In general, the ambient temperature is 125 °C for current carrying parts and 75 °C for non-current carrying parts. The sample "passes" if the diameter of the impression caused by the ball does not exceed 2 mm.

In accordance with UL 746B, the relative thermal index (RTI) of a material is an indication of the material's ability to retain a particular property (physical, electrical, etc) when exposed to elevated temperatures for an extended period of time. There can be up to three independent RTI ratings assigned to a material electrical, mechanical with impact and mechanical without impact.

TABLE 4
BALL PRESSURE TEST RESULTS (IEC 69695-10-2).

	Pass at BPT at 75 °C	Pass at BPT at 125 °C
CYCOLAC RESIN	All	None
CYCOLOY RESIN	All	C1200HF, C2100, C2100HF, C3100
GELOY RESIN	CR7520, XTPM302, XTPM307, HRA222	XTPM309E
LEXAN RESIN	All	All
NORYL RESIN	All	All NORYL resin grades with Vicat >130 °C, see NORYL resin data overview
NORYL GTX RESIN	All	All
SILTEM RESIN	STM1500	
ULTEM RESIN	All	All
VALOX RESIN	All	All
XENOY RESIN	5730	CL500, XL1562, 6370

3.4 MECHANICAL

To withstand stresses imposed during installation and use, manufacturers should test the components to ensure that they can resist mechanical damage. The range of mechanical properties, which are typically tested, include impact strength, E-modulus, tensile elongation and hardness. Equipment may be required to withstand heat aging and humidity while retaining its mechanical properties.

3.5 WEATHERING

Weathering is the deterioration of a material under the influence of temperature, oxygen, relative humidity and UV radiation. Weathering tests assessing color shift are divided into 'real time' exterior testing and laboratory accelerated testing and, according to ISO 4892-2, include both wet and dry cycles for applications intended for external use.

Under UL746C "Polymer materials – use in electrical equipment evaluations" a UV-weathering test is described, testing retention of mechanical properties. Grades that comply with this test are marked "f1" or "f2" on the UL-Recognition card. A "f1" rating means 70% retention of mechanical and electrical properties after 1000h UV aging, no change in flammability and at least 50% retention of mechanical properties after the water immersion test. "f2" means that either not all colors were tested or that the retention was less than 70% of the initial value. It should be noted that color, an integral part of a material's formulation, could have an influence on visual appearance in UV aging performance as well as affecting the properties.

4. APPLICATIONS

4.1 WIRING DEVICES

In both the industrial and domestic sectors, SABIC offers a range of materials to comply with the leading industry standards EN 60309 “Plugs, socket-outlets and couplers for industrial purposes”. IEC 60884 “Plugs and sockets for household and similar purposes” and EN 60998 “Connecting devices for low voltage circuits for household and similar purposes”.

All of SABIC’s engineering thermoplastics are excellent candidates for non-current carrying parts. For current carrying parts, LEXAN resin, FR VALOX resin, and most grades of FR NORYL resin are typically considered. VALOX resin is usually used when a balance of chemical and heat resistance is required.

In addition to complying with stringent safety codes, domestic switches, plugs and sockets must also satisfy critical aesthetic requirements. CYCOLAC ABS resin, CYCOLOY resin PC/ABS blend, GELOY ASA resin, GELOY PC/ASA blend and LEXAN PC resin all offer a quality surface finish, high gloss or textures, in a wide range of colors. In addition, our VISUAL**FX**™ resin portfolio can offer numerous new color & effect opportunities for customers.

In an industry where UV resistance is critical, GELOY resin is often a material of choice because of its enhanced UV-stability. For non-current carrying parts that require high impact and UV performance, XENOY resin is often an appropriate choice.

Switch from Viko, made of GELOY resin

Enclosure made of LEXAN resin

4.2 ENCLOSURES

In accordance with European standard EN 60670 “Boxes and enclosures for electrical accessories for household and similar fixed electrical installations”, SABIC offers high performance engineering resins that meet the diverse requirements for enclosures, including both current carrying and non-current carrying parts. These resins are complemented by a range of thermoplastic sheet and film products from SABIC which can meet typical electrical requirements for small to medium size production series. SABIC keeps in step with industry trends through ongoing development in both materials and process technology.

In the enclosures industry, for example, predominant trends are for materials with improved low temperature performance, chemical and UV resistance and halogen-free flame retardancy. Colorability is also an important feature as is the suitability for laser printing.

Each SABIC material type offers a different balance of key properties, which include dimensional stability, impact strength, flame retardancy and electrical properties. Power tool housings, for example, typically require high chemical resistance and impact performance. SABIC’s VALOX resin or XENOY resin are often considered for these applications. Housings for fuse boxes and cable distribution frames also require high impact resistance combined with good tracking resistance and constant electrical properties in humid conditions. XENOY resin, VALOX resin, NORYL resin and LEXAN resin, with their properties combination, are more typically used for these applications. For enclosures that require UL-recognition for the U.S.A., UL746C compliance is required according below table.

TABLE 5

UL746C, POLYMERIC MATERIALS - Use in electrical equipment evaluations.

Flame class	HWI-PLC	HAI-PLC	CTI-PLC
HB	2	1	3
V-2	2	2	3
V-1	3	2	3
V-0	4	3	3

PLC = Performance level class
HWI = Hot wire ignition test
HAI = High current arc ignition test
CTI = Comparative tracking index
These properties are mentioned on the UL-recognition card of most grades.

4. APPLICATIONS

4.3 INSTALLATIONS

In this industry segment, leading standards IEC 60614 “specification for conduits for electrical installations” and EN 61386-1 “conduit systems for cable management” require a flame test on the finished part as well as a GWT pass at 750 °C on fittings.

SABIC’s offers low toxicity and corrosivity flame retardant LEXAN resin EXL933X, CYCOLOY resin C3650 and NORYL resin ENV105 & ENV131 extrusion grades that meet the requirements for halogen free parts for applications such as cable channels, conduits, pipes and industrial trunking.

LEXAN resin 9XX series, e.g. LEXAN resin 925 series, and NORYL resin LS175 are also specified for consideration in applications where low smoke is a requirement. ULTEM resin can meet the critical safety and performance demands of many aerospace applications as it offers inherent flame retardancy, combined with low smoke generation in the event of a fire.

TABLE 6

MATERIALS FOR MASS TRANSIT WITH TYPICAL I/F/M CLASSIFICATIONS. Specification NF F 16101/102. Classifications are thickness dependent.

	I1 or M1	I2 or M2	I3 or M3	I4 or M4	Not tested
F0					
F1	LEXAN 2814R resin	LEXAN resin 505R, 925, ULTEM resin LTX300A	LEXAN resin 920, 925A(U)		
F2		CYCOLOY resin C3650, LEXAN resin 2034(E), 500R, EXL9330, NORYL resin ENV150, ULTEM resin 1010, 2300	LEXAN resin 3412ECR		NORYL resin GTX4110
F3	CYCOLOY resin C6200	CYCOLOY resin C2100, C2950	CYCOLOY resin C6200		
F4		CYCOLAC resin S850			

I Classification glow wire/oxygen index
F Classification smoke/toxity behavior
M Classification flame behavior

Tyco Raychem fiber optic splice box using LEXAN, CYCOLOY and VALOX resin

4.4 SWITCHGEAR, RELAYS & CIRCUIT BREAKERS

SABIC's materials, notably LEXAN and VALOX resins, have become standard in many switch assemblies and relays. Their electrical properties and, in particular, their resistance to tracking and arcing, provide reliability in contaminated atmospheres and at elevated temperatures.

The increasing economies of multi-chassis designs have further increased the popularity of these resins because of their processing ease. The current European standards for these applications are EN60439 "Low-Voltage switchgear and controlgear assemblies" and EN60947-1 "Low-Voltage switchgear and controlgear", which will place even more stringent demands on materials in the future.

EN 60898 is the European standard for circuit breakers for overload protection for household and similar installations. When the circuit is abruptly broken the part must reliably withstand the high forces and the temperatures, which can exceed 200 °C.

A solution that meets the requirements for halogen free parts in this important circuit protection segment is the use of flexible NORYL resin for use in isolator plates between the current phases of a conductor or MCCB.

Flexible NORYL resin, like WCD931, offers lower specific density in combination with good mechanical properties like elongation at break. Glass-reinforced VALOX resin offers good dimensional stability and exceptional thermal and electrical properties. Several filled FR VALOX resin grades have a CTI >250 volts and some even have CTI > 400 or 600 volts.

Fuji Electric switch gear using low modulus NORYL resin for isolator plates

4. APPLICATIONS

4.5 ELECTRICITY METERS

This application area is governed by EN 62053 “Electricity metering equipment (A.C.) with stringent flammability requirements. Terminal blocks must pass the glow wire test at 960 °C and have a HDT of 135 °C.

SABIC materials that are typically used in this area include LEXAN resins 9xx series and 50XR grades, and VALOX 420SE0 resin. For electric meter covers and cases, SABIC recommends that customers consider flame retardant NORYL resin, CYCOLOY resin, C6200 and CU6800 grades for an excellent balance of impact performance and flow, and all LEXAN resins. The ability to laser-mark serial numbers is also an important advantage of LEXAN resin.

4.6 INSULATION SYSTEMS

SABIC offers the electrical design engineer a portfolio of dedicated materials, which have been tested in accordance with UL standard 1446 and EN 60085 for use as insulation in transformers and industrial motors of up to 600 volts. These high performance engineering thermoplastics, which include specific grades of VALOX and ULTEM resins, have been found to be compatible with the insulation components listed in UL File E75735, the most extensive material selection guide available.

SABIC’s electrical insulation materials offer important advantages over traditional materials. In addition to outstanding insulation and electrical properties, these include increased strength and stiffness, excellent dimensional stability, V-0 and 5V flammability ratings according to UL94, low water absorption and reduced processing steps.

TABLE 7

THERMAL EVALUATION AND CLASSIFICATION OF ELECTRICAL INSULATION

System component	System temperature class
VALOX resin 420, 420SEO, DR51, DR48, 412, 730, 780	130(B)
VALOX resin 310SEO, 325, 451E, NVB407, V9330, 771, 4630, 508	130(B)
VALOX resin 420, 420SEO, DR51, DR48, 412, 730, 780	155(F)
VALOX resin 451E, V9560, V9231, V9260, V9530, 4630	155(F)
ULTEM resin 2110, 2310, 5000B, XH6050B	180(H)

kWh meter made of LEXAN resin

4.7 CAPACITOR HOUSINGS

A range of NORYL and VALOX resin, including NORYL SE100 and VALOX 4631 resin grades, are excellent candidates for use in capacitor housings primarily because it provides high dimensional stability and high resistance to heat deformation. Furthermore, these resins offer manufacturers easy, consistent processability and compatibility with laser marking processes. Capacitors that consist of metalized plastics film are widely used in the electrical industry.

SABIC's engineering thermoplastic film range includes VALOX FR and LEXAN FR resin grades, which are laminated to a conductive foil, such as copper or aluminum. As defined in UL94, these films provide a flammability rating of VTM-0 and V-0 respectively, and offer excellent dielectric strength, which allows the use of an ultra-thin plastic film while maintaining insulation properties.

4.8 CONNECTORS

In the connector industry, no specific IEC material criteria exists, however different segments require an individual balance of material properties. SABIC offers connector manufacturers an extensive range of high performance materials, that provides an excellent balance of electrical properties, temperature resistance, dimensional stability and processability.

STANDARD CONNECTORS

Glass-reinforced VALOX resin is a well-established product for standard connectors, which use compliant push-fit contacts. For example, VALOX 420SE0 resin, a 30% glass-filled grade, or the VALOX 4521 resin, a 20% glass-filled grade, are excellent materials of choice for use in data connectors as both provide a V-0 flammability rating at a wall-thickness of 0.8 mm according to UL94, high impact performance and excellent flow properties. Unreinforced VALOX resin grades can offer halogen free alternatives to help set the standard in your industry.

In automotive connectors, there is a growing trend towards VALOX resin, which offers tight dimensional stability, chemical resistance and high heat performance (typically 10,000 hours at 160 °C-170 °C).

4. APPLICATIONS

In telecommunications connectors, there is an excellent fit for halogen-free flame retardant LEXAN and NORYL resin, specifically in large dimension connectors in less aggressive environments. For high flow, less heat requiring connectors CYCOLOY resin is an excellent material of choice.

LEXAN 3412R resin has a V-0 flammability rating at wall thicknesses of 1.58 mm according to UL 94 and and NORYL V02570 resin has a V-0 flammability rating at wall thicknesses of 0.8mm and both meet the most critical performance requirements of thin walled connectors. Furthermore, both LEXAN and NORYL resin families can provide engineering latitude to applications such as insulation displacement connectors. For parts which require an optimum balance of chemical resistance, stiffness and flow properties, a glass-filled flame retardant VALOX resin such as the VALOX 420SE0 resin grade may also be considered.

FLEXIBLE HINGE CONNECTORS

To satisfy the specific design criteria of flexible hinge connectors, SABIC offers tailor made grades of unreinforced VALOX resin. VALOX 3007 and 3101N resin offer good flow, chemical resistance, high elongation and dimensional stability.

LARGE CONNECTORS

For large connector fuse boxes where low warpage, excellent dimensional stability and good heat and chemical resistance are needed, SABIC offers a range of low warpage materials NORYL GTX PA/PPO resin, VALOX PBT/PC resin and PBT/ASA blends.

FIBRE OPTIC CONNECTORS

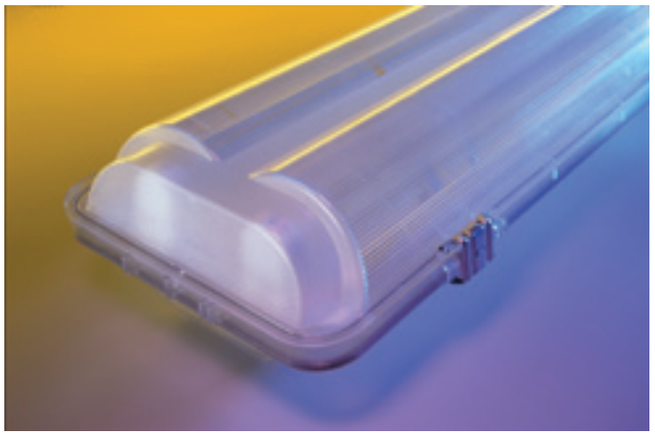
ULTEM and glass-filled NORYL resins have an excellent fit in the optical fibre connector industry where key design specifications include dimensional stability, tight tolerances and a low, uniform coefficient of thermal expansion.

ULTEM resin unreinforced grades offer a HDT of 200 °C at 1.82 Mpa, and excellent flame retardancy. These are complimented by ULTEM glass-reinforced resins, which provide even greater rigidity and improved dimensional stability while retaining excellent processability. Furthermore, these resins offer the possibility of metalization using different methods.

4.9 LIGHTING

The leading European standard for lighting applications is EN 60598. Part I covers general requirements on flammability, GWT and CTI and part 2 covers more specific requirements by application.

With an extensive portfolio of materials satisfying low, medium and high heat requirements, SABIC offers lighting manufacturers the design freedom to replace metal and thermoset plastics in a broad range of applications.



4. APPLICATIONS

4.10 DIFFUSERS

LEXAN resin is an excellent material to consider for diffusers produced by injection molding, extrusion or blow molding. This high impact, transparent material provides an exceptional balance of mechanical, optical and thermal properties, complemented by low uniform shrinkage and dimensional stability and consistent processability. Furthermore, where long-term weatherability is a requirement, SABIC offers UV stabilized grades of LEXAN resin.

On top of this our new LEXAN SLX resin can supply extended weatherability behavior with impact retention in combination with improved chemical resistance and color stability. LEXAN SLX resin has the toughness of typical polycarbonate resins, which can be maintained for over five years, with significantly improved color and clarity retention compared to other polycarbonate materials. The available portfolio of products covers two different flows with both HB and V2 UL94 ratings. These resins are available in a variety of colors to meet specific application needs.

FIGURE 2

Xenon arc weathering ISO-4892-2A protocol

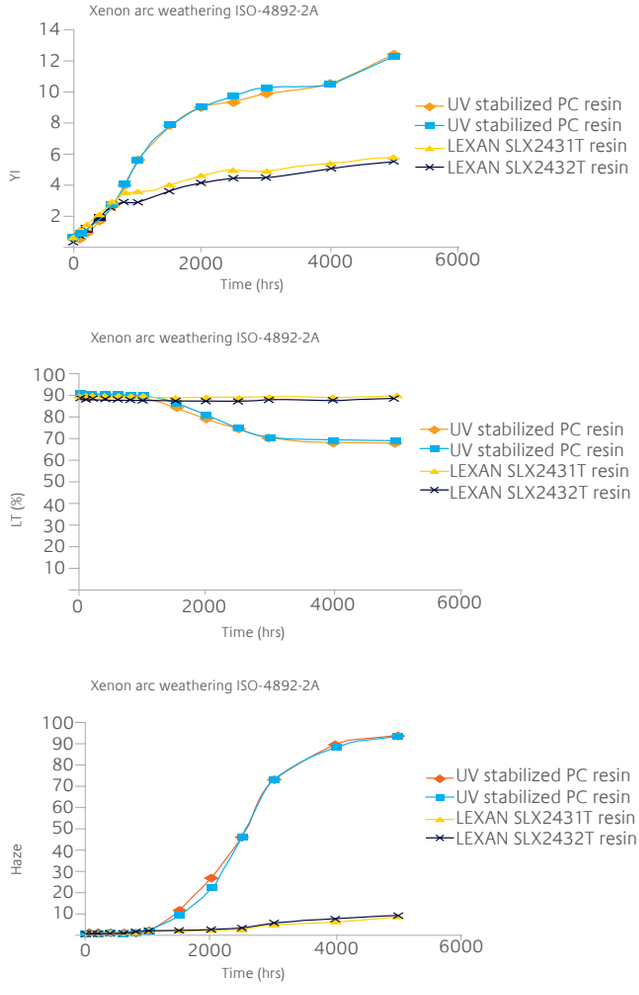


TABLE 8

MATERIALS TYPICALLY USED IN DIFFUSER APPLICATIONS

Extrusion moulding	Blow injection	Standard flow injection	High flow
LEXAN resin ML3290	LEXAN resin ML3012A	LEXAN resin 143R	LEXAN resin HF1130R LEXAN resin ML3729

4.11 HOUSINGS

SABIC offers a variety of materials that provide the necessary high impact strength, high heat distortion temperatures and weathering resistance, combined with the design flexibility to produce complicated moldings with maximum integration.

STREET LAMPS

LEXAN, NORYL, GELOY, and VALOX resin offer designers a balance of lightweight and mechanical strength, combined with snap-fit design and functional integration often required in for high quality, durable street lamps. The absence of corrosion helps easy, inexpensive maintenance with low replacement costs.

TRAFFIC LIGHTS, WARNING AND HAZARD LIGHTS

LEXAN resin is being used in traffic light production, due to its excellent balance of mechanical and electrical properties, combined with good dimensional stability and weatherability. Furthermore, the resin features fast molding times and allows the elimination of expensive finishing operations through snapfit assembly. For the internal parts of traffic, warning and hazard lights, SABIC recommends that customers consider VALOX and NORYL resin as they provide good dimensional stability and low water absorption.

SPOTLIGHTS

SABIC's range of engineering thermoplastics provides design latitude to meet varying levels of service temperature. Glass fibre reinforced LEXAN resin has a relative thermal index (RTI) of 130 °C, VALOX resin 145 °C and ULTEM resin up to 180 °C.

Excellent dimensional stability, high temperature resistance and the ability to achieve tight tolerances make ULTEM resin a material of choice for many critical components.

EMERGENCY LIGHTS

The European luminary product standard EN 60 598 2:22 requires that the housings on emergency illumination on escape routes must pass the glow wire test at 850 °C.

LEXAN 92x and 94x resin and CYCOLOY C6200 and C2100HF polycarbonate/ ABS blends have been repeatedly used in luminary base applications. CYCOLOY resin is characterized by superior impact performance and UV stability. Furthermore, FR CYCOLOY resin can meet the flammability requirements, and offers excellent flow properties for thin wall designs.

LEXAN 143R resin is often used for emergency light diffusers as, in addition to its glass-like transparency for a high light output, it provides the design freedom for clean, attractive styling and an exceptional property profile which includes impact resistance, heat resistance, dimensional stability and structural strength. Furthermore, its lightweight compliments ease of installation. For improved weatherability we recommended you to consider our LEXAN SLX series.

4. APPLICATIONS

EXPLOSION-PROOF LIGHTS

Explosion-proof lighting is the most demanding of lighting applications, and, as such, is subject to stringent regulatory requirements for quality and safety. LEXAN 143R resin has often been used in diffusers on the sealed light fixtures, which are typically found in hazardous environments such as mines and oilrigs. Compared to many traditional diffuser materials, this unfilled material exhibits good flow and excellent physical properties, notably outstanding impact strength over a wide range of temperatures, from sub 0 °C to over 100 °C. As it is virtually shatterproof, it offers a high degree of safety and durability in service, even in the event of an explosion. It passes the glow wire test at 850 °C at 1 mm and has a CTI of >250 volts. When improved cold impact or flow or a combination of both is needed our LEXAN EXL resin is a great option.

The recent development of LEXAN 2X3R resin offers a comparable property profile to the non FR LEXAN 1X3R grade but features a higher flammability rating of UL 94V2. Both materials offer excellent, long lasting optical qualities, which are maintained through good weatherability and superior scratch and chemical resistance. As with automotive headlamps, this resistance can be further increased through the application of a silicone hardcoat.

4.12 REFLECTORS

SABIC offers reflector manufacturers a brighter future in terms of greater design freedom and cost efficiency. For example LEXAN ML3042 resin, which is a white opaque grade, exhibits a light reflectance of 90%, is a well-suited candidate for the production of reflectors for the fluorescent and low wattage incandescent lamps.

The excellent combination of heat resistance and good surface finish make VALOX, ULTEM and NORYL resin ideal candidates for the production of highly efficient vacuum metalized reflectors. For applications requiring exceptional heat resistance, SABIC recommends that its customer considers the grades mentioned in the table below.

LEXAN and ULTEM resin are both suitable considerations for use with dichroic coatings without the need for a primer. These coatings allow the transmission of infra-red rays and reduce the quantity of heat reflected by the metalized surface. This has enabled SABIC's materials to be used in the cool beam reflector industry with end use applications ranging from the home and office to the hospital. Highly reflective, white LEXAN ML3042 resin has been used for the production of bulkhead reflectors for energy-saving and fluorescent lamps.

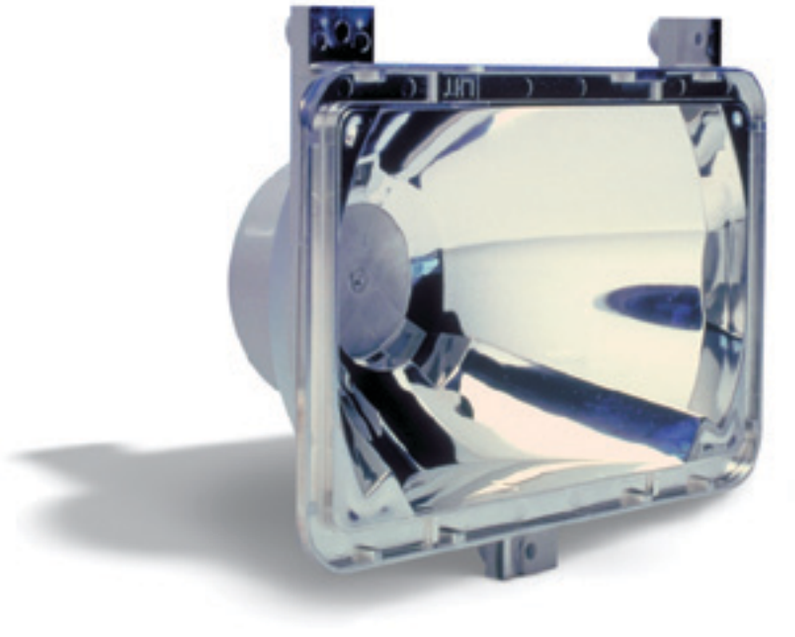
TABLE 9
MATERIALS FOR REFLECTORS

	Low heat	Medium heat	High heat
PRIMER			VALOX 815, DLV3000, DLV3100
NO PRIMER	CYCOLAC S705, GPM 5500, G360	LEXAN ML3042, 161R ATX100	VALOX V3001MC ULTEM 1010, 2100, XH6050 ATX200

4.13 LAMP HOLDERS

For manufacturers of lamp-holder housings and fittings, SABIC's high performance engineering thermoplastics have brought unique design capabilities in compliance with European standards EN 60400 (fluorescent lamp holders) and EN 60238 (Edison screw lamp holders). In addition to an optimum balance of mechanical, thermal, electrical and optical properties, these materials can offer cost-effective production and unprecedented strength to weight ratios. Furthermore, they are available in a wide variety of colors with a long-lasting finish, which can be matte, high gloss or metalized. Materials like LEXAN and ULTEM resins also have very low tendency to outgas which is the emission of low molecular weight species that can deposit on colder areas of the reflector and dew and cause reduction in light output.

In general, materials are selected according to the size and the temperature class of the lamp holder. According EN 60238 for temperature class T1 180 °C and T2 190 °C we recommend considering VALOX DR48 and for 420SE0. For T3 210 °C we recommend considering our VALOX 9000 series and ULTEM 2300 resin.



5. WASTE LEGISLATION & ECO LABELS

WEEE DRAFT STATUS

(A) WEEE (WASTE ON ELECTRICAL AND ELECTRONIC EQUIPMENT) DIRECTIVE 2002/96/EC

Producer responsibility for collection and recovery end of life EEE. Plastic containing brominated flame retardants to be removed from waste, separate treatment.

(B) RESTRICTIONS OF USE OF HAZARDOUS SUBSTANCES (ROHS) DIRECTIVE 2002/95/EC

Phase-out lead, mercury, cadmium, hexavalent chromium, polybrominated biphenyls (PBB) and polybrominated diphenylethers (PBDE) in EEE (Prob. '07).

BLUE ANGEL

Blue Angel is a German environmental label introduced in 1977/1978, it is the property of the Federal Minister of the environment, nature conservation and nuclear safety, requirements are set by an independent Environmental Label Jury.

TCO

TCO stands for "The Swedish Confederation of Professional employees". TCO started with environmental labeling of complete computers. Now there are ecology requirements for displays, system units and key boards. A CRT, flat panel displays, printers, faxes, copiers, mobile phones.

NORDIC SWAN

The Nordic Swan label is the official ecolabel in Norway, Sweden, Finland, Denmark and Iceland. It has been adopted in November 1989 by the Nordic Council of Ministers. The scheme is administered by national boards, organized under the Nordic Ecolabeling Board. Labels do exist for personal computers, faxes and printers, copying machines and toner cartridges, but also for washing machines, dishwashers and refrigerators, freezers and audiovisual equipment.

MILIEUKEUR

Milieukeur is the Dutch environmental label. A number of labels have been developed, some however have expired or have been inactivated at a later stage.

EU ECOLABEL

The EU Ecolabel scheme is laid down in Council Regulation (EEC) No. 880/92 and is in operation since 1993. Ecolabels have been established for personal computers, portable computers, TV-sets, washing machines, dishwashers and refrigerators. The EU Ecolabel award scheme is implemented at national level, the Member States are required to designate competent bodies to award the label.

TABLE 10

USE OF BROMINATED, NON-BROMINATED FLAME RETARDANT SYSTEMS

	Grades	No brome	Brominated FR
LEXAN RESIN	2x3R, 915R, 925, 945, 955, 9x5A, ML6411, 9945A, EXL9112, EXL9330, EXL9335, FL3000, FL900S, 500ECR, 505R, 341xECR	√	
	920, 923, 940, 943, 950, 953, 500R, 503R, 341xR		√
CYCOLOY RESIN	C2100, C2100HF		√
	C2800, C2950, C2951, C3600, C3650, C6200, C6600, C6840, CH6310, CH6410, CU6800, FXC630, MC5400, CX7240, CX7211, CX7010	√	
GELOY RESIN	HRA222	√	
NORYL RESIN	All grades	√	
ULTEM RESIN	All grades	√	
VALOX RESIN	All FR grades		√
CYCOLAC RESIN	All FR grades		√

6. DESIGNED FOR SERVICE

SABIC's Global Application Technology team helps customers with their application development. Their design experience combined with an in depth material knowledge will help customers find cost effective material solutions delivered against tight time lines.

SABIC has a global presence with application development centers in Pittsfield - MA, Southfield - MI, Moka - Japan, Shanghai - China, Bangalore - India, Bergen op Zoom - The Netherlands, and Sungnam City - Korea.

The team is designed to help you through the complete application development process

Industrial designers and design engineers can provide trend analysis, do teardowns, assist with CNM mapping, style the part or product and finally deliver design options for your consideration with wall thickness that can meet processing as well as mechanical requirements.

The predictive engineering team is equipped to do simulations to assist customers in optimizing their part before tool cutting is started. To do this they have access to and extensive experience with state of the art processing, structural, impact and thermal simulation programs.

The processing team can help customers optimize their injection molding, extrusion, blow molding or other process to convert the pellets into parts. Each application development center has access to the equipment in other locations through our flexible virtual lab video collaboration system, enabling customers from one pole to get application development assistance in another pole.

The secondary operations team is developing and applying knowledge on painting, powder coating, vacuum metalization, welding and other bonding techniques. Their labs enable us to quickly check the performance of paint system / material combinations and how two materials welded together will perform. Experienced people will be able to give advice on various secondary operations related processes.

Once the application is ready the part performance teams are available to help customers verify if the product satisfies all criteria. Accurate dimensional measurements, impact testing, climate cycles and structural rigidity are the examples of the tests that can be performed. The strength of this team is the capability to build custom-made test set-ups in very short times.

As you can see, Global Application Technology has all capabilities to assist you through your complete application development process.

7. OVERVIEW

Applicable standards for plastic materials in electrical and lighting applications

7.1 WIRING DEVICES

EN60309 Plugs, socket outlets and couplers for industrial purposes
IEC 60884 Plugs and socket outlets for household and similar purposes
EN 60998 Connecting devices for low voltage circuits for household and similar purposes

SUMMARY OF APPLICABLE REQUIREMENTS FOR WIRING DEVICES

	BPT	GWT	CTI	Typical resins
CURRENT CARRYING PARTS	125	850	175	LEXAN resin, sev.FR-NORYL, CYCOLOY C2100, CH6410, FRVALOX
OTHER	70/80	650	-	CYCOLAC resin, CYCOLOY resin, NORYL resin, GELOY resin and XENOY resin.

7.2 ENCLOSURES

EN60670 General requirements for enclosures, for accessories, for household and similar fixed electrical installations

SUMMARY OF APPLICABLE REQUIREMENTS FOR MATERIALS FOR ENCLOSURES

	BPT	GWT	CTI	Typical resins
CURRENT CARRYING PARTS	125	850	175	LEXAN resin, sev FR-NORYL resin, CYCOLOY resin C2100, FRVALOX resin, selected ULTEM resin Grades (because of CTI)
OTHER	70/90	650	-	CYCOLAC resin, CYCOLOY resin, LEXAN resin, NORYL resin, VALOX resin, XENOY resin

7.3 SWITCHGEAR, RELAYS AND CIRCUIT BREAKERS

EN 60439 Low voltage switchgear and control gear assemblies
EN 60947 Low voltage switchgear and control gear
EN 60898 Circuit breakers for over current protection for household and similar installations
EN 61008-1 Residual current operated circuit breakers without integral over current protection for household and similar uses (RCCB's)
EN 61009-1 Residual current operated circuit breakers with integral over current protection for household and similar uses (RCBO's)

SUMMARY OF APPLICABLE REQUIREMENTS FOR MATERIALS FOR CONTACTERS, RELAYS, MCCB'S ETC.

	BPT	GWT	CTI	Typical resins
CURRENT CARRYING PARTS	125	960	175	LEXAN resin, 500R; VALOX resin 420SE0, 4631, 7523, 855, 865
OTHER	70	650	-	LEXAN resin, VALOX resin, NORYL resin

7. OVERVIEW

7.4 ELECTRICITY METERS

EN 62053-21 Electricity metering equipment (A.C.) Particular requirements - part 21 static meters for active energy (classes 1 and 2)

SUMMARY OF APPLICABLE REQUIREMENTS FOR MATERIALS FOR WATTHOUR METERS

	HDT	GWT	CTI	Typical resins
TERMINAL BLOCK	125	960	-	LEXAN resin 920, 500XR; VALOX resin 420 SE0, VALOX resin 4631
OTHER	-	650	-	LEXAN resin, CYCOLOY resin, NORYL resin

7.5 LIGHTING

EN 60598 Luminaires
EN 60400 Lamp holders for tubular fluorescent lamps and starter holders
EN 60238 Edison screw lamp holders
EN 61199 Single capped fluorescent lamps-safety specifications

SUMMARY OF APPLICABLE REQUIREMENTS FOR MATERIALS IN LIGHTING APPLICATIONS

	BPT	GWT	Needle flame test	CTI
CURRENT CARRYING PARTS	125	-	10 sec	175
OTHER	75	650	-	-

TEMPERATURE RESISTANCE DEPENDENT ON SIZE AND TEMPERATURE CLASS OF THE LAMPHOLDER.

TYPICAL RESINS FOR HOUSINGS

Low heat	Medium heat	High heat
CYCOLOY C1200, C2950, C2100	LEXAN 143R, 920, 500R resin	NORYL GTX 810, 820, 830
CYCOLAC X37, S157 resin	NORYL SE1GFN1	VALOX 420, 815, 830, 420SE0, 855, 865 resin
		ULTEM 1000, 2300 resin

7.6 GLOW WIRE TEST

EN 60695-2-10 Glow wire apparatus and common test procedure
EN 60695-2-11 Glow wire flammability test method for end-products
EN 60695-2-12 Glow wire flammability test method for materials
EN 60695-2-13 Glow wire ignitability test method for materials

The glow wire test simulates the effect of thermal stresses, which may be produced by heat sources such as glowing elements or overloaded resistors, for short periods, in order to assess the fire hazard by a simulation technique. A sample of the insulating material is held vertically for 30 seconds with a one Newton force against the tip of an electric heated glowing wire. The travel of the glow wire tip through the sample is limited. After withdrawing the sample, the time for extinguishing flames, plus the presence of any burning drops are noted.

Actual live parts or enclosures are tested in a similar way.

The temperature level of the glow wire tip is dependent on how the finished part is used

- Attended or unattended
- Continuously loaded or not
- Used near or away from a central supply point
- In contact with a current-carrying (live)rt or used as an enclosure or cover
- Under less or more stringent conditions

Depending upon the required level of severity for the final part environment, the following test temperatures are preferred 550, 650, 750, 850 or 960 °C. The appropriate test temperature should be chosen by estimating the risk of failure due to abnormal heat, ignition and spread of fire.

GWT GLOW WIRE TEST ON END-PRODUCTS EN 60695-2-11

The application part is held for 30 seconds against a heated wire (550, 650, 750, 850, 960 °C). After that application period the part and wire are separated. The time the part is burning is measured. To pass this method the extinguishing time should be 30 seconds or less. No ignition of the wrapping tissue underneath. Only 1 part needs to be tested.

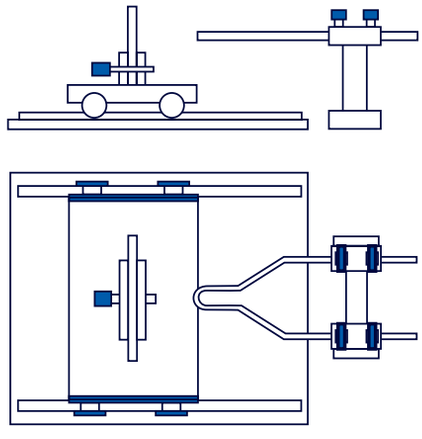


FIGURE 3
Schematic drawing glow wire test

GWFI GLOW WIRE FLAMMABILITY INDEX EN 60695-2-12

Moulded samples should be >_60mm by >_60mm in the preferred thickness 0.75, 1.5 and 3.0mm. Test is to be performed in the center of the test specimen (contact location wire-material). The material plaques/disc is hold for 30 seconds against a heated wire (550, 650, 750, 850, 960 °C).

After that application period the plaque/disc and wire are separated. The time the part is burning is measured. To pass this method the extinguishing time should be 30 seconds or less and no ignition of the wrapping tissue underneath. This test should be performed 3 times.

GWIT GLOW WIRE IGNITION TEMPERATURE EN 60695-2-13

Molded samples should be >_60mm by >_60mm in the preferred thickness 0.75, 1.5 and 3.0mm. Test is to be performed in the center of the test specimen (contact location wire-material). The material plaques/disc is hold for 30 seconds against a heated wire. During this 30 seconds period the material should NOT ignite (burn). The definition of burning in the standard is that the flame is visible for at least 5 seconds. The temperature of the wire is increased/decreased (minimum step of 25K) in such way that the highest temperature found does NOT show ignition/burning. The test is then to be performed three times on this temperature.

A reported GWIT 775 °C/3,0 means no ignition at 750 °C in 3 mm thickness.

REMARKS

Certain PBT grades continuously ignite and extinguish in less than a second (often called flashes). Test institutes say that this is an ignition because these flashes last for more than 5 seconds.

7. OVERVIEW

7.7 NEEDLE FLAME TEST EN 60695-11-5

The needle flame test simulates the effect of small flames that may result from faulty conditions within electrical equipment.

To evaluate the likely spread of fire (burning or glowing particles), either a layer of the subject material or components normally surrounding the specimen, or a single layer of tissue paper is positioned underneath the specimen. The test flame is applied to the sample for a certain time period usually 5, 10, 20, 30, 60 or 120 seconds.

Unless otherwise specified in the relevant specification, the specimen is considered to have withstood the needle flame test if one of the following situations apply

1. If the specimen does not ignite.
2. If flames or burning or glowing particles falling from the specimen do not spread fire to the surrounding parts to the layer placed below the specimen, and if there is no flame or glowing of the specimen at the end of application of the test flame.
3. If the duration of the burning is less than 30 seconds.
4. If the extent of burning is specified in the relevant specification has not been exceeded.

7.8 ELECTRICAL TESTING

DIELECTRIC STRENGTH EN 60243
Dielectric strength reflects the electric strength of the insulating materials at power frequencies (48 Hz to 62 Hz), or the measure of dielectric breakdown resistance of a material under an applied voltage.

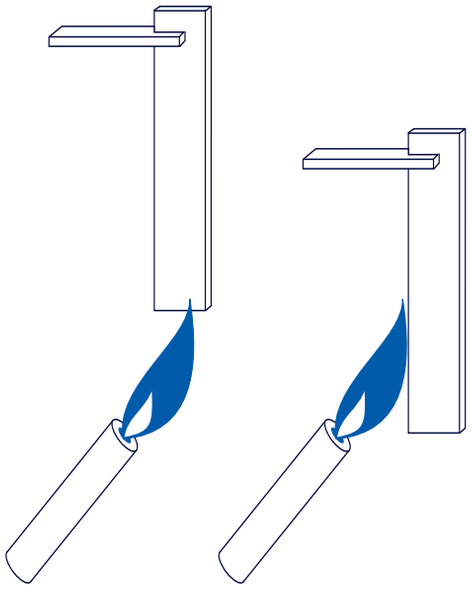
The applied voltage just before breakdown is divided by the specimen thickness to give the value in kV/mm. The surrounding medium can be air or oil. The thickness dependence can be significant all values are reported at specimen thickness.

Many factors may influence the values

- Thickness, homogeneity and moisture content of the test specimen
- Dimensions and thermal conductivity of the test electrodes
- Frequency and wave form of the applied voltage
- Ambient temperature, pressure and humidity
- Electrical and thermal characteristics of the ambient medium

FIGURE 4

Schematic drawing needle flame test



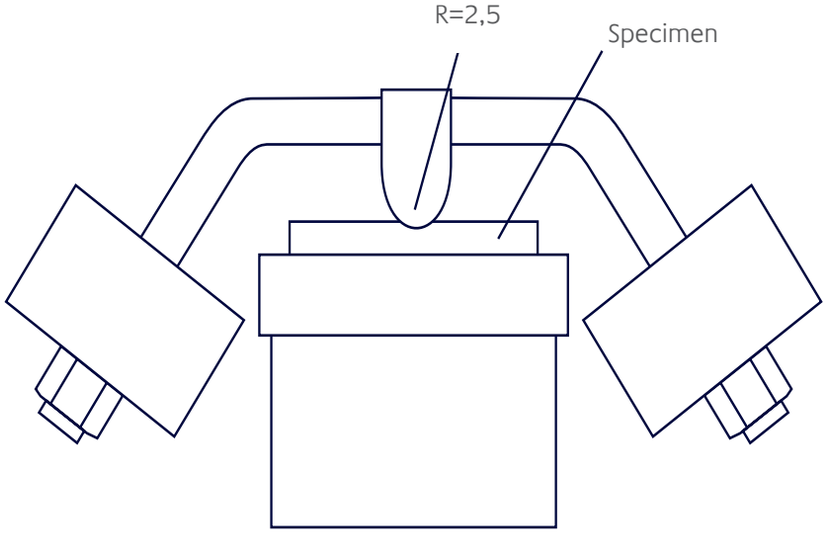
BALL PRESSURE TEST EN 60695-10-2

This is a softening temperature test, similar to the Vicat method. The sample is horizontally positioned on a support in a heating cabinet and a steel ball of 5 diameter is pressed onto it with a force of 20 N. After one hour, the ball is removed, the sample is cooled in water for 10 seconds, and the remaining impression caused by the ball is measured. When the impression diameter is <2 mm, the material is reported to meet the ball pressure test at the applied temperature. Depending on the application, the test temperature can be varied

-75 °C for non current-carrying parts
-125 °C for support of current carrying parts

FIGURE 5

Schematic drawing ball pressure test



7. OVERVIEW

7.9 FLAMMABILITY TESTING

UL 94 & EN 60695-11-10 UL94 FLAMMABILITY IN GENERAL

The most widely accepted flammability performance standards for plastic materials are UL94 ratings. These are intended to identify a material's ability to extinguish a flame, once ignited. Several ratings can be applied based on the rate of burning, time to extinguish, ability to resist dripping and whether or not drips are burning. Each material tested may receive several ratings based on color and/or thickness. When specifying a material for an application, the UL rating should be applicable for the thinnest wall section in the plastic part. The UL rating should always be reported with the thickness; just reporting the UL rating without mentioning thickness is insufficient. EN 60695-11-10 is the International equivalent of UL94

SUMMARY OF THE UL 94 RATING CATEGORIES

HB
- Slow burning on a horizontal specimen
- Burning rate < 75 mm/min for thickness < 3 mm
- Burning rate < 40 mm/min for thickness > 3 mm

V0
- Burning stops within 10 seconds on a vertical specimen;
- No drip of flaming particles, that ignite cotton indicator, allowed

V1
- Burning stops within 30 seconds on a vertical specimen;
- No drip of flaming particles, that ignite cotton indicator, allowed

V2
- Burning stops within 30 seconds on a vertical specimen;
- Drips of flaming particles are allowed

FLAMMABILITY UL 94 EN 60695-11-10 UL94HB

Where flammability is a safety requirement, HB materials are normally not permitted. In general HB classified materials are not recommended for electrical applications except for mechanical and/or decorative purposes. Sometimes misunderstood non-FR materials (or materials that are not meant to be FR materials) do not meet automatically HB requirements. UL94HB is although the least severe – a flammability classification, and has to be checked by testing.

UL94V0, V1 AND V2

The vertical tests take the same specimens as are used for the HB test. Burning times, glowing times, when dripping occurs and whether or not the cotton beneath ignites, are all noted. Flaming drips - widely recognized as a main source for the spread of fire and flames distinguish from V2.

FLAMMABILITY UL 94 EN 60695-11-20 UL94-5V

UL94-5V is the most stringent of all UL classifications. It involves two steps

STEP 1

A standard flammability bar is mounted vertically and subjected to each of five applications of a 127 mm flame, five seconds duration. To pass, no bar specimen may burn with flaming or glowing combustion for more than 60 seconds after the fifth flame application. Also, no burning drips are allowed that ignite cotton placed beneath the samples. The total procedure is repeated with five bars.

STEP 2

A plaque - with the same thickness as the bars – is tested in a horizontal position with the same flame. The total procedure is repeated with three plaques. Two classifications result from this horizontal test 5VB and 5VA
- 5VB allows holes (burn-through)
- 5VA does not allow holes

UL94-5VA is the most stringent of all UL tests, specified for fire enclosures on larger office machines. For those applications with expected wall thickness of less than 1.5 mm, glass filled material grades should be used.

5V - Burning stops within 60 seconds after five applications of a flame - larger than used in V-testing

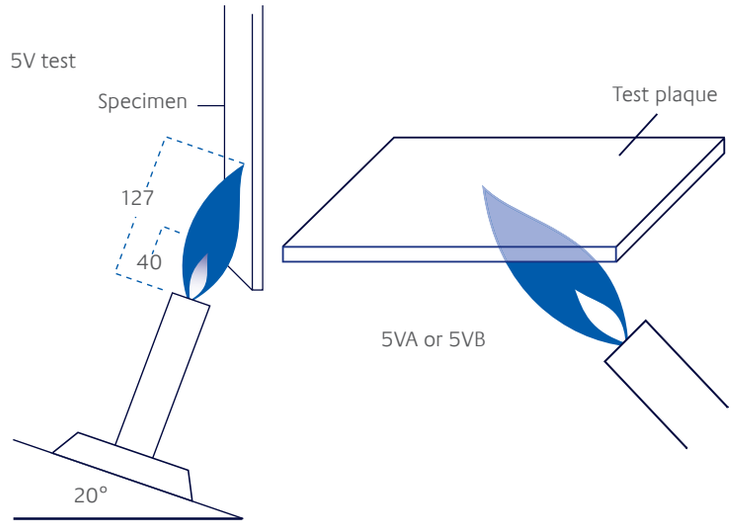
5VB - Plaque specimens may have a burn-through (have hole)
- Plaque specimens may not have a burn-through (no hole – highest UL rating)

CSA C22.2 NO 0.6 M

TODAY, CSA (CANADIAN STANDARDS ASSOCIATION) HAS HARMONISED THEIR FLAMMABILITY STANDARDS WITH UL.

UL and CSA have entered into a MoU (memorandum of understanding) granting each other acceptance of test-data. SABIC no longer maintains a separate recognition file for CSA.

FIGURE 6
Schematic drawing UL94 5V flammability test



7. OVERVIEW

COMPARATIVE TRACKING INDEX EN 60112

The tracking index is the relative resistance of electrical insulating materials to tracking when the surface is exposed - under electrical stress - to contaminants containing water. Comparative tracking index, or CTI, and CTI-M tests are undertaken to evaluate the safety of components carrying live parts insulating material between live parts must be resistant to tracking. CTI is defined as the maximum voltage at which no failure occurs at 50 drops of ammonium chloride in water. High values of CTI are desirable. Materials meeting the CTI requirements at 600 volts are called ”high tracking” resins.

The CTI test procedure is complex. Influencing factors are the condition of the electrodes, electrolyte and sample surface and of the applied voltage. Values can be lowered by additives such as
- pigments - in particular carbon black
- flame retardants
- glass fibers

Thus black, FR and GF materials in general, are not recommended when tracking resistance is a key requirement. Minerals (TiO_2) tend to raise CTI values.

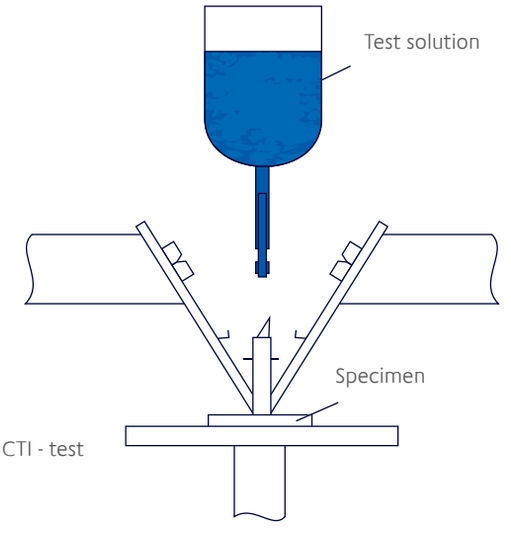
CTI

The CTI test is carried out with two platinum electrodes of given dimensions placed with the slightly rounded “chisel” edge flat on the test sample. A potential difference is applied between the electrodes - usually a minimum of 175 volts. Where parts will be exposed to high electrical stress, 250 volts is specified. The voltage is applied in steps of 25 volts; the maximum voltage is 600 V. The surface of the test specimen is wetted by 50 drops of a solution of 0.1% ammonium chloride in distilled water - the so called solution A - falling centrally between the two electrodes. Both size and frequency of the electrolyte drops are specified. When no current is flowing at the chosen voltage, the test is repeated with a 25V higher voltage, until there is a flow of current. This voltage-decreased with one step of 25V - is called the CTI. The test is then repeated with a voltage of 25V below the CTI value and with 100 drops instead of 50.

The voltage is determined at which 100 drops do not create a flow of current. This 100 drops value can be reported in addition to the 50 drops CTI values between brackets ().

FIGURE 7

Schematic drawing comparative tracking index (CTI)



CTI-M

The CTI-M test is similar to the CTI test, except it uses a more aggressive wetting agent (M stands for “mouillé”, French for wetted). Holes created by erosion can be measured as well and reported in mm depth.
An example of reporting
CTI 375 (300) M - 0.8 means

- 50 drops of solution B create no flow of current below 375 volts
- 100 drops create no flow of current below 300 Volts
- Depth of erosion holes in the surface can be 0.8 mm

RELATIVE TEMPERATURE INDEX, RTI UL 746B

Formerly named the continuous use temperature rating or CUTR, the RTI is the maximum service temperature at which the critical properties of a material will remain within the acceptable limits over a long period of time. As established by UL 746B, there can be up to three independent RTI ratings assigned to the material

- Electrical by measuring dielectric strength
- Mechanical with impact - by measuring tensile impact strength
- Mechanical without impact – by measuring tensile strength

These three properties were selected as critical indicators due to their sensitivity to the high temperatures as used in the test. The long-term thermal performance of a material is tested relative to a second control material which already has an established RTI and which exhibits good performance. Hence the term relative temperature index. The control material is used because thermal degradation characteristics are inherently sensitive to variables in the testing programmed itself. The control material will be affected by the same unique combination of these factors during the tests, thus providing a good basis for comparison with the subject material.

Ideally, long-term thermal performance would be evaluated by aging the subject material at normal operating temperatures for a long time. However, this is impractical for most applications. Therefore, accelerated aging tests are conducted at much higher temperatures. For accelerated aging tests, samples of the subject and control materials are placed in ovens maintained at set constant temperatures. Samples of both materials are removed at predetermined times and then tested for retention of key properties.

By measuring the three mentioned properties as functions of time and temperature, the “end of useful service” may be mathematically determined for each temperature. This ”end of service” life is defined as the time at which a material property has degraded to 50% of its original value. Through an arrhenius representation of the test data, the maximum temperature at which the subject material will have a satisfactory service life can be predicted. This predicted temperature is the RTI for each property. An understanding of how the RTI is determined helps the designer to use the temperature index to predict how parts molded from a given material will work in elevated temperature end-use environments.

7. OVERVIEW

SURFACE RESISTIVITY IEC 60093 - (ASTM D257)

When an insulating plastic is subjected to a voltage, some portion of the resultant current will flow along the surface of the plastic molding if there is another conductor or ground attached to the same surface. Surface resistivity is a measure of the ability to resist that surface of current. It is measured as the resistance when a direct voltage is applied between surface mounted electrodes of unit width and unit spacing. It is reported in Ohm; sometimes called “ohms per square”.

VOLUME RESISTIVITY IEC 60093 (ASTM D257)

When an electric potential is applied across an insulator, the current flow will be limited by the resistance capabilities of the material. Volume resistivity is the electrical resistance when an electrical potential is applied between opposite faces of a unit cube. Measured in Ohm. cm. volume resistivity will be affected by environmental conditions imposed upon the material. It varies inversely with temperature, and decreases slightly in moist environments. Materials with volume resistivity values above 108 Ohm.cm are considered insulators. Partial conductors have values of 103 to 108 Ohm.cm.

RELATIVE PERMITTIVITY – IEC 60250

“The relative permittivity of an insulating material is the ratio of capacity of a capacitor, in which the space between and around the electrodes is entirely and exclusively filled with the insulating material in question, to the capacitance of the same configuration of electrodes in vacuum”- as stated in IEC 60250. In AC dielectric applications, good resistivity as well as low energy dissipation are desirable characteristics. The dissipation of electrical energy results in inefficiencies in an electronic component and causes heat build-up in the plastic part which acts as a dielectric. In an ideal dielectric material - such as a vacuum - there is no energy loss to dipole motion of the molecules. In solid materials - such as plastics - the dipole motion becomes a factor. A measure of this inefficiency is the relative permittivity (formerly called dielectric constant). It is a dimensionless factor derived by dividing the parallel capacity of the system with a plastic material, by that of an equivalent system with a vacuum dielectric. The lower the number, the better the performance of the material as an insulator.

DISSIPATION FACTOR – IEC 60250

"The dielectric loss angle of an insulating material is the angle between applied voltage and resulting current deviates from pi/2 rad, when the dielectric of the capacitor consists exclusively of the dielectric material. The dielectric dissipation factor tan d of an insulating material is the tangent of the loss angle d." – as stated in IEC 60250.

In a perfect dielectric the voltage wave and the current are exactly 90 °C out of the phase. As the dielectric becomes less than 100% efficient the current wave begins to lag the voltage in direct proportion. The amount the current wave deviates from being 90 °C out of phase with the voltage is defined as the "dielectric loss angle". The tangent of this angle is known as the "loss tangent" or "dissipation factor". A low dissipation factor is important for plastic insulators in high frequency applications such as radar equipment and microwave parts smaller values mean better dielectric materials. A high dissipation factor is important for welding capabilities. Both relative permittivity and dissipation factor are measured using the same test equipment. Test values obtained are highly dependent on temperature, moisture levels, frequency and voltage.

ARC RESISTANCE – ASTM D495

When an electric current is allowed to travel across an insulator's surface, this surface will damage over time and become conductive. Arc resistance is a measure of the time in seconds required to make an insulating surface conductive under a high voltage, low current arc. Or, the arc resistance is the elapsed time in which the surface of a plastic material will resist the formation of a continuous conducting path when subjected to a high voltage, low current arc under specific conditions.

8. PRODUCT PROPERTIES

TABLE 11

TYPICAL MATERIAL PROPERTIES AND MARKET OVERVIEW

Product	Properties	Electrical engineering	Lighting
CYCOLAC ABS resin	Ease of molding Surface quality Thermal stability Impact resistance Wide range of colors	Enclosures, housings and covers, alarm systems switches, plugs, connectores.	Lamphousings, reflectors.
CYCOLOY PC/ABS thermoplastic alloys	Ease of molding Excellent flow Low temperature impact UV stability Flame retardancy	Enclosures, battery housings, junction boxes, kWh meter housings, switches, plugs, sockets, cable cannel, corrugated pipes	Indoor and outdoor lighting parts; kitchen lamps; reflectors.
GELOY PC/ASA	UV stability Property retention after weathering Ease of processing Flame retardant 125C BPT	Wall switches, plugs & sockets, enclosures Alarm systems	End caps
LEXAN Polycarbonate resin	Transparency High impact Dimensional stability Temperature resistance Flame retardancy	Motor housings, relay separators, connectors, fuse boxes, switches, plugs, sockets, circuit breakers, transformers, KWh meter housings, corrugated pipes	Housings, covers, reflectors and lenses for indoor and outdoor lighting; high intensity discharge lighting, spotlights; traffic lights, downlights
NORYL Modified PPO resin	Electrical properties Dimensional stability Hydrolysis resistance Temperature resistance Low water absorption Flame retardancy	KWh meter housings, conduits, connectors, ignition coils, bobbins, yokes, switches, plugs, sockets, components for junction boxes, temperature controllers, enclosures, wire coating, busbars, rigid pipes	Reflectors, warning lamps; profiles.
NORYL GTX Modified POP alloys	On-line paintability, Low temperature impact Temperature resistance Chemical resistance Low mould shrinkage	Motor housings; plugs, switches, thermostatic controls; profiles, connector box,	Indoor lighting parts. conductive housings (online painting)
ULTEM Polyetherimide resin	Chemical resistance, temperature resistance, dimensional stability, inherent flame retardancy, platable, vacuum metalizable, high strength/ stiffness up to high temp., excellent dielectric properties	internal MCB, MCCB and conductor parts, films; printed circuit boards; switches, plugs,transformers; wire and cable coating (SILTEM). connectors, controls	Reflectors and housings for indoor and outdoor lighting, dichroic reflectors; spotlights.
VALOX Thermoplastic polyester resin	Excellent electrical properties Chemical resistance Temperature resistance Flame retardancy Fast molding	Rotors, connectors, sensors, sockets, plugs, coils; distributor caps, ignition bobbins, terminal blocks, switches, transformers, fuse boxes; housings and enclosures; electric motors-endcaps	Reflectors and housings for indoor and outdoor lighting; halogen lamps and spotlights; switches.
XENOY Thermoplastic alloys	High impact resistance, Chemical resistance, Dimensional stability UV stability	Enclosures and housings; connector boxes.	Housings for street lighting

TABLE 11 (CONTINUED)
TYPICAL MATERIAL PROPERTIES AND MARKET OVERVIEW

Product	Properties	Electrical engineering	Lighting
GELOY PC/ASA Thermoplastic alloys	Ease of moulding, excellent flow weatherability performance, UV stability, impact	switches, plugs, cable cannel, enclosures covers, trasnformer housings	housings, downlights
STAT-KON™ Electrically active compounds	Electrostatic dissipation Static protection Protection from sparking Electrical conductivity	housings, enclosures, connector box, rotors, rotor-housings	housings
FARADEX™ Electrically active compounds	EMI-RFI shielding capable Colorable Highest electrical conductivity	housings, enclosures	
LUBRICOMP™ Internally lubricated compounds	Wear resistance Noise reduction Reduced friction Enhanced product life cycle Reduced maintenance costs	gears, lever, slider, bobbins, push bottons,	
THERMOCOMP™ Fiber and mineral reinforced compounds	Tight tolerances High strength & stiffness	housings, enclosures, rotors, connector cable ties, bobbins, coils, slider, lever, covers, transformers	housings

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