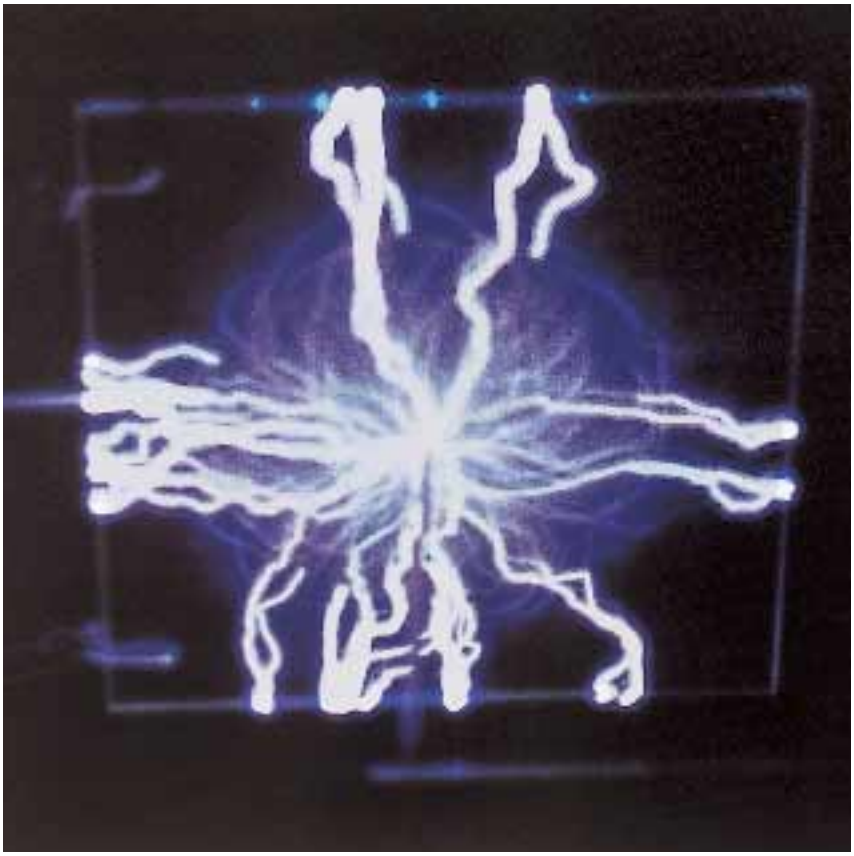
DuPont Engineering Polymers

Tests for thermoplastic materials used in the electrical and electronic industries



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Engineering Polymers

Tests for thermoplastic materials used in the electrical and electronic industries

In many applications, especially in the electrical and electronic market segment, the thermoplastic materials used and/or the final component made from them have to meet one or more electrical, flammability and heat testing standards. There are a multitude of national and international standards, sometimes with significant differences in methodology for the same test. Without a reasonable knowledge of these standards, it is difficult to ensure that the thermoplastic material selected does comply with the end-use requirements.

The purpose of this report is to give:

- A summary of the major electrical, flammability and heat standards for thermoplastic materials covering property definition, test description, and significance.
- Literature data and test results for these major electrical, flammability and heat testing standards for a range of DuPont's thermoplastic materials currently used in the electrical and electronic market.

This will then allow the reader to have a more comprehensive understanding of the basics of the test, the specimen dimension and conditioning, the significance of the ratings, enabling a better evaluation of test results and literature data. The data given in this report should only be used for *preselection of thermoplastic materials.*

In many cases the end-use specification requires testing to be done with the complete equipment, sub-assembly or component as to a great extent results will depend on wall thickness and design.

It should be noted that:

- The list of testing standards which has been compiled is not intended to be exhaustive.
- The test descriptions given herein are by no means complete and tests should not be run without consulting the most recent edition of the relevant standard for the precise details of the testing procedure.
- The data given on materials in this report, in most cases, does not release the end-user from submitting the complete equipment, sub-assembly or component for approval by the relevant testing institutes and/or authorities.

All values listed are obtained at room temperature on natural coloured resins unless indicated otherwise.

Tests are periodically modified. We believe that this information is the best currently available. It is subject to revision as additional knowledge and experience are gained.

Table of contents

Abbreviations

AFNOR **A**ssociation **F**rançaise de **NOR**malisation (national, France)

ASTM **A**merican **S**tandard of **T**esting **M**aterials (national, USA)

BS **B**ritish **S**tandard (national, U.K.)

CEE International **C**ommission on Rules for the Approval of **E**lectrical **E**quipment (international but more European Community use)

CEI **C**ommission **E**lectrotechnique **I**nternationale (international)

CEMP **C**entre d'**E**tude des **M**atières **P**lastiques (national, France)

CNET **C**entre **N**ational d'**E**tude de **T**élécommunication (national, France)

CSA **C**anadian **S**tandards **A**ssociation

CSTB **C**entre **S**cientifique et **T**echnique du **B**âtiment (national, France)

DIN **D**eutsches **I**nstitut für **N**ormung (national, Germany)

EN European Standards (**E**uropäische **N**ormen)

FAR **F**ederal **A**ir **R**egulation (national, U.S.A.)

HD **H**armonisierungs-**D**okumente

HN **H**armonisation des **N**ormes (national, France)

IEC **I**nternational **E**lectrotechnical **C**ommission (international)

ISO **I**nternational **O**rganization for **S**tandardization

LCIE **L**aboratoire **C**entral des **I**ndustries **E**lectriques (national, France)

MIL **Mil**itary Specification (national, U.S.A)

NF **N**ormes **F**rançaises (national, France)

NFC Normes Françaises Class **C** (electrical, national, France)

VDE **V**erein **D**eutscher **E**lektrotechniker e.V. (national, Germany)

UL **U**nderwriters **L**aboratories Inc. (national, U.S.A.)

Standards

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Surface resistivity ohm

Definition

Surface resistivity is the resistance to leakage of a charge across a square area of surface. The size of the square is immaterial.

Test description

Surface resistivity, ohm			
	ASTM	DIN	IEC
No.	D 257	53482 / VDE 0303, part 3	60093
Specimen:	plate, tape, tube	120 × 120 mm, thickness not defined	plate, tape, tube
Electrodes:	flat ring or others out of metal, mercury, painted sprayed or evapourated metal, silver paint or graphite	various forms	as for ASTM
Read-off time:	1 min	1 min	1 min
Applied voltage:	500 ± 5 V	100 ± 5 V or 1000 ± 50 V	500 ± 5 V

Significance

The surface resistivity enables the calculation of surface leakage currents which can be detrimental.

ASTM D 257
DIN 53482
VDE 0303 part 3
IEC 60093

Surface resistivity, ASTM D 257, DIN 53482, IEC 60093 at 23 °C **ohm**

		DAM	50 % RH
Crastin® PBT	S600F10, S620F20	$>10^{14}$	
	ST820	$>10^{14}$	
	SK601	$>10^{14}$	
	SK602	$>10^{14}$	
	SK603	$>10^{14}$	
	SK605	$>10^{14}$	
	SK608	$>10^{14}$	
	SK609	$>10^{14}$	
	LW9020	$>10^{13}$	
	LW9030	$>10^{13}$	
	SO653	$>10^{14}$	
	SO655	$>10^{14}$	
	HTI619	$>10^{14}$	
	S650FR	$>10^{14}$	
	S680FR	$>10^{14}$	
	T850FR	$>10^{14}$	
	SK641FR	$>10^{14}$	
	SK642FR	$>10^{14}$	
	SK643FR	$>10^{14}$	
	SK645 FR	$>10^{14}$	
	CE7931	$>10^{14}$	
	SK673GW	$>10^{14}$	
	LW9020FR	$>10^{13}$	
	LW9030FR	$>10^{13}$	
	T841FR	$>10^{14}$	
	T842FR	$>10^{14}$	
	T843FR	$>10^{14}$	
Delrin® POM	100, 107	$>10^{15}$	
	100P	$>10^{14}$	
	111P		
	500	$>10^{15}$	
	507	10^{15}	
	500P	$>10^{14}$	
	511P		
	900P	$>10^{14}$	
	911P		
	100ST	10^{14}	
	100T	10^{14}	
	500T	10^{15}	
	500AL		
	500AF	10^{15}	
	500CL	10^{15}	
	570	10^{15}	
Rynite® PET	520		
	530	10^{14}	
	545	10^{14}	
	555		
	5254		
	935	10^{14}	
	FR515	10^{13}	
	415HP	10^{13}	
	408	10^{14}	
	FR530L	10^{14}	
	FR543	10^{15}	
	FR943	10^{15}	
	530CS		
	936CS		
	GW520CS		
	GW525CS		
Zytel® PA66 unreinforced	101L		$>10^{15}$
	101F	$>10^{15}$	10^{13}
	103HSL	10^{14}	10^{13}
	105F BK*		
	114L BK097		
	135F		
	E42A		$>10^{15}$
	408		10^{15}
	450		
	490		
	ST801		$>10^{15}$
Zytel® PA66 unreinforced flame retardant	FR7026V0F		
Zytel® PA66 glass reinforced, flame retardant	FR70G25GW		
	FR70G25V0	10^{15}	10^{14}
	FR72G25V0		
Zytel® PA 66 glass reinforced	79G13L	$>10^{15}$	10^{14}
	70G20HSL	10^{15}	10^{12}
	70G25HSL	10^{15}	10^{12}
	70G30HSL	10^{15}	10^{13}
	70G30PSR		
	70G33GRA BK*		
	70G35HSL	10^{14}	10^{12}
	70G50HSL		
	70G60HSL BK*		
Zytel® PA66 glass-bead reinforced	70GB40HSL		
Zytel® PA66 mineral reinforced, flame retardant	FR70M30V0	$>10^{15}$	
	FR70M40GW GY		
Minlon® PA66 mineral reinforced	10B140		10^{15}
	11C140		10^{14}
	EFE6091 BK		
Zytel® PA66/6 unreinforced, flame retardant	FR7200V0F	10^{14}	10^{14}
Zytel® PA66/6 glass reinforced, flame retardant	FR72G25V0	10^{14}	10^{13}
Zytel® PA66/6 glass reinforced	74G30L NC010		
	74G33EHSL BK354		
Zytel® PA6 unreinforced	7300		
Zytel® PA6 glass reinforced	73G15		
	73G20		
	73G30		
	73G40		
	73G50		
Zytel® HTN high performance polyamide	HTN51G35HSL NC010	10^{14}	
	HTN51G45HSL NC010	10^{14}	
	HTNFR51G35L NC010	10^{13}	
	HTN51G15HSL NC010		
	HTN51G35HSLR NC010		
	HTN52G35HSLR NC010		
	HTNFR52G30BL NC010		
	HTNFR52G35BL NC010		
Zytel® PA612	151L		
	153HSL	10^{15}	10^{14}
	158		
	77G33L	10^{15}	
	77G43L	10^{15}	
Zytel®-Kevlar® SFC	70K20HSL	10^{15}	10^{12}
Zytel® flexible nylon alloy	FN718	10^{14}	10^{14}
Hytrel® TEEE	4056	10^{14}	
	G4078	10^{12}	
	5556	10^{15}	
	7246	$>10^{15}$	
Zenite® LCP	6130 WT010	10^{16}	
	7130 WT010	10^{15}	
Teflon® fluorinated resins	PTFE	$>10^{15}$	
	FEP	$>10^{15}$	
	PFA	$>10^{15}$	
Tefzel® fluorinated resins	ETFE	$>10^{14}$	
	HT2004	10^{15}	
Surlyn® ionomer resins	8940		
	9020		
	9450		
	9720		
Vespel® polyimide resins	SP1	$>10^{15}$	
	SP21	–	

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For products or grades that do not appear on this table, please contact your DuPont representative for more information.

Volume resistivity

ohm · cm

Definition

Volume resistivity is the internal resistance of an insulating material to current flow.

Test description

Volume resistivity, ohm			
	ASTM	DIN	IEC
No.	D 257	53482 / VDE 0303, part 3	60093 (ISO 1325)
Specimen:	plate, tape, tube	120 × 120 mm, thickness not defined	plate, tape, tube
Electrodes:	guarded or unguarded rings with metal electrodes	guarded or unguarded ring with metal electrodes	guarded ring with electrodes of mercury, metal foil or graphite
Read-off time:	1 min	1 min	1 min
Applied voltage:	500 ± 5 V	100 ± 5 V or 1000 ± 50 V	1 or 10 or 100 V depending on thickness

Significance

High volume resistivity guarantees that the material acts as an insulator. The volume resistivity test is often used in checking the uniformity of an insulating material, either to determine the uniformity of processing or to detect traces of impurities which affect the qualtity of the material and which may not be readily detected by other means. It is also used to determine the effect of moisture on a material.

ASTM D 257
DIN 53482
VDE 0303 part 3
ISO 1325
IEC 60093

Volume resistivity, IEC 60093, ASTM D257, at 23°C **ohm·cm**

		DAM	50% RH
Crastin® PBT	S600F10	$>10^{15}$	
	S620F20	$>10^{15}$	
	ST820	$>10^{15}$	
	SK601	$>10^{15}$	
	SK602	$>10^{15}$	
	SK603	$>10^{15}$	
	SK605	$>10^{15}$	
	SK608	$>10^{15}$	
	SK609	$>10^{15}$	
	LW9020	$>10^{15}$	
	LW9030	$>10^{15}$	
	T805	$>10^{15}$	
	SO653	$>10^{15}$	
	SO655	$>10^{15}$	
	HTI619	$>10^{15}$	
	S650FR	$>10^{15}$	
	S680FR	$>10^{15}$	
	T850FR	$>10^{15}$	
	SK641FR	$>10^{15}$	
	SK642FR	$>10^{15}$	
	SK643FR	$>10^{15}$	
	SK645FR	$>10^{15}$	
	CE7931	$>10^{15}$	
	SK6733GW	$>10^{15}$	
	LW9020FR	$>10^{15}$	
	LW9030FR	$>10^{15}$	
	T841FR	$>10^{15}$	
	T843FR	$>10^{15}$	
	T845FR	$>10^{15}$	
Delrin® POM	100	10^{15}	
	107	10^{15}	
	100P	10^{13}	
	111P	10^{13}	
	500	10^{15}	
	507	10^{15}	
	500P	10^{13}	
	511P	10^{13}	
	900P	10^{13}	
	911P	10^{13}	
	100ST	10^{14}	
	100T	10^{14}	
	500T	10^{14}	
	500AL		
	500AF	10^{15}	
	500CL	10^{15}	
	570	10^{15}	
Rynite® PET	520	10^{15}	
	530	10^{15}	
	545	10^{15}	
	415HP	10^{13}	
	5254	10^{13}	
	935	10^{15}	
	408	10^{15}	
	FR515	10^{15}	
	FR530L	10^{15}	
	FR543	10^{15}	
	FR943	10^{15}	
	530CS, 936CS		
	GW515CS, GW520CS, GW525CS		
Zytel® PA66 unreinforced	101L	10^{15}	10^{13}
	101F	10^{15}	10^{13}
	103HSL	10^{15}	10^{11}
	105F BK010		
	114L BK097	10^{14}	10^{13}
	135F		
	E42A	10^{15}	10^{13}
	408	10^{15}	10^{13}
	450	10^{15}	10^{12}
	490	10^{14}	10^{13}
	ST801	10^{14}	10^{13}
Zytel® PA66 unreinforced, flame retardant	FR7026V0F		

		DAM	50% RH
Zytel® PA66 glass reinforced, flame retardant	FR70G25GW		
	FR70G25V0	10^{15}	10^{11}
	FR72G25V0		
Zytel® PA 66 glass reinforced	79G13L	10^{15}	10^{12}
	70G20HSL	10^{15}	10^{11}
	70G25HSL	10^{15}	10^{11}
	70G30HSL	10^{15}	10^{11}
	70G30PSR	10^{15}	10^{11}
	70G33GRA BK*		
	70G35HSL	10^{15}	10^{11}
	70G50HSL	10^{15}	
	70G60HSL BK*		
Zytel® PA66 glass-bead reinforced	70GB40HSL	10^{15}	10^{11}
Zytel® PA66 mineral reinforced, flame retardant	FR70M30V0	$>10^{15}$	10^{11}
	FR70M40GW		
Minlon® PA66 mineral reinforced	10B140		10^{12}
	11C140		10^{11}
	EFE6091 BK		
Zytel® PA66/6 unreinforced, flame retardant	FR7200V0F	10^{15}	10^{11}
Zytel® PA66/6 glass reinforced, flame retardant	FR72G25V0	10^{15}	10^{10}
Zytel® PA66/6 glass reinforced	74G30L NC010		
	74G33EHSL BK354		
Zytel® PA6 unreinforced	7300		
Zytel® PA6 glass reinforced	73G15HSL		
	73G20HSL		
	73G30HSL		
	73G40HSL		
	73G50HSL		
Zytel® HTN high performance polyamide	HTN51G35HSL NC010	10^{14}	
	HTN51G45HSL NC010	10^{14}	
	HTNFR51G35L NC010	10^{13}	
	HTN51G15HSL NC010		
	HTN51G35HSLR NC010		
	HTN52G35HSLR NC010		
	HTNFR52G30BL NC010		
	HTNFR52G35BL NC010		
Zytel® PA612	151L	10^{15}	10^{13}
	153HSL	10^{14}	10^{13}
	158	10^{15}	10^{15}
	77G33L	10^{15}	
	77G43L	10^{15}	
Zytel®-Kevlar® SFC	70K20HSL		
Zytel® flexible nylon alloy	FN718		
Hytrel® TEEE	4056	10^{11}	10^{10}
	G4078	10^{11}	
	5556	10^{13}	10^{10}
	7246	10^{13}	10^{10}
Zenite® LCP	3130 WT010		
	6130 WT010	10^{17}	
	6330 WT010		
	7130 WT010	10^{15}	
Teflon® fluorinated resins	PTFE	$>10^{18}$	
	FEP	$>10^{18}$	
	PFA	$>10^{18}$	
Tefzel® fluorinated resins	ETFE	$>10^{16}$	
	HT2004	10^{16}	
Surlyn® ionomer resins	8940	$>10^{16}$	
	9020	$>10^{16}$	
	9450	$>10^{16}$	
	9720	$>10^{16}$	
Vespel® polyimide resins	SP1	10^{16}-10^{17}	
	SP21	10^{14}-10^{15}	

* Only available in black. ** Only available in natural colour.

For products or grades that do not appear on this table, please contact your DuPont representative for more information.

Dielectric strength

MV/m or kV/mm

Definition

Dielectric strength is the voltage which, applied to a material, results in the destruction of its insulation properties. Failure is constituted by the passage of an arc through the test piece. The voltage gradient is obtained by dividing the voltage at breakdown by the thickness of the insulation at the point of failure. It is expressed in MV/m or kV/mm of insulation thickness. The MV/m at breakdown changes with the mateial wall thickness. The thinner the sample, the higher the value.

Test description

Dielectric strength, MV/m or kV/mm			
	ASTM	DIN	IEC
No.:	D 149	53481/VDE 0303, part 2	60243 (ISO 1325)
Specimen:	sheets/films	sheets	sheet or film
Electrodes:	51 mm ∅	25, 50, 75 or 100 mm ∅ cylinders or other shapes	75 and 25 mm ∅
Rise of voltage:	• Short time 100/200/500/1000/2000/5000 V/s	• Step by step 8 % of foreseen breakdown voltage	• Short time steady speed
		• Step by step	• Step by step
	• Step by step equal increments working with expected breakdown voltage		20 s steps/50 V to 10 kV
Medium:	air; gas; oil	air	air; oil; gas; see IEC 212
Temperature:	25 ± 5°C	23 ± 2°C	23°C

REMARK

Dielectric strength values are highly affected by the conditions of the test (e.g. sample thickness, temperatures, type of voltage, AC or DC, frequency, electrodes and test medium). The values therefore vary from one method to the other. Particular attention must be paid to the conditions under which the application must function.

Significance

Dielectric strength is the essential property of plastic insulators that makes them an outstanding protection for people and devices against parts under high voltage.

ASTM D 149
DIN 53481
VDE 0303 part 2
ISO 1325
IEC 60243

Dielectric strength, ASTM D 149

kV/mm or MV/m

		Short time								Step by step
		DAM					50 % RH			DAM
		23°C				95°C	23°C			23°C
		0,8 mm	1,6 mm	2,3 mm	3,2 mm	1 mm	1 mm	2 mm	3,2 mm	3,2 mm
DELRIN® POM	100, 107			19,7	–					
	100P			18,9	–					
	111P									
	100ST			19	–					
	500, 507		19		–					
	500P			19,7	–					
	511P									
	500T			16						
	500AL									
	500AF			–	15,8					
	500CL			–	15,8					
	900P									
	911P									
	570				19					

Dielectric strength, ASTM D 149 (continued) **kV/mm or MV/m**

		Short time								Step by step
		DAM					50 % RH			DAM
		23°C				95°C	23°C			23°C
		0,8 mm	1,6 mm	2,3 mm	3,2 mm	1 mm	1 mm	2 mm	3,2 mm	3,2 mm
RYNITE® PET	520									17,3
	530	45	29,6		21,7	31				
	545				21,3					
	555				19,7					16,6
	5254									
	935				22,5					17
	940									
	FR515	43	26		19	32				13,8
		25 [1]	16,5 [2]		13 [2]					
	FR530L	41	25,6		16,9	28				15,1
	FR543		23,2		17,2					
	FR943		26,0		18,9					
	936CS									17,3
ZENITE® LCP	3130L WT010									
	6130 WT010									
	6330 NC010									
	7130 WT010									
	7145 WT010									
ZYTEL® PA66 unreinforced	101L								13	
	101F									
	103HSL									
	105F BK010									
	135F									
	E42A				30,5					
	408				33,5					
	450, 490, ST801									
ZYTEL® PA66 glass unreinforced, flame retardant	FR7026V0F									
ZYTEL® PA66 glass reinforced, flame retardant	FR70G25GW									
	FR70G25V0									
	FR72G25V0									
ZYTEL® PA66 glass reinforced	79G13L				21,5			28	18,5	
	70G20HSL				21		28	22	16	
	70G25HSL				21		28	21	15,5	
	70G30HSL				20,5			20	16,5	
	70G33GRA BK*									
	70G35HSL				20,5		28,5	20	16	
	70G50HSL									
	70G60HSL BK*									
ZYTEL® PA66 glass-bead reinforced	70GB40HSL									
ZYTEL® PA66 mineral reinforced, flame retardant	FR70M30V0				16				18	
	FR70M40GW									
MINLON® PA66 mineral reinforced	10B140									
	11C140									
ZYTEL® PA66/6 glass reinforced, flame retarded	FR72G25V0									
ZYTEL® PA66/6 glass reinforced	74G30L NC010									
	74G33EHSL BK354									
ZYTEL® PA6 unreinforced	7300									
ZYTEL® PA6 glass reinforced	73G15HSL									
	73G20L, 73G30HSL									
	73G40L, 73G50HSL									
ZYTEL® PA612	151L, 153HSL, 158									
	77G33L, 77G43L									
ZYTEL®-KEVLAR® SFC	70K20HSL									
HYTREL® TEEE	4056	31 (1,0 mm)	22		15 (3,0 mm)		29	19	15	
	5556, 7246	28 (1,0 mm)	22		15 (3,0 mm)		28	20	15	
TEFLON® fluorinated resins	PTFE	56 (0,25 mm)								
	FEP, PFA	>80 (0,25 mm)			20					
TEFZEL® fluorinated resins	ETFE	>80 (0,25 mm)			16–20					
	HT2004	59 (0,25 mm)			14		56 (0,25 mm)		16,3	
SURLYN® ionomer resins	8940	33,6			16,0 (3,3 mm)					
	9020	35,6			16,1 (3,3 mm)					
	9450	38,1			18,1 (3,3 mm)					
	9720	43,3			16,1 (3,3 mm)					
VESPEL® polyimide resins	SP1			22 (2 mm)						
	SP21			9,8 (2 mm)						

[1] In oil at 170°C, 1 mm. * Only available in black.
[2] In oil at 170°C. ** Only available in natural colour.

For products or grades that do not appear on this table, please contact your DuPont representative for more information.

Dielectric strength, according to IEC 60243-1 **kV/mm or MV/m**

		P25/P75, sample 1 mm thick VDE 0303, part 2	20 s steps, sample 2 mm thick, at 23°C IEC 243
Crastin® PBT	S600F10	26	15
	S620F20	26	15
	ST820	–	–
	SK601	30	17
	SK602	27	17
	SK603	29	17
	SK605	31	17
	SK608	32	15
	SK609	33	14
	LW9020	35	20
	LW9030	36	21
	T805	29	17
	SO653	25	17
	SO655	25	17
	HTI619	35	17
	S650FR	25	15
	S680FR	25	15
	T850FR	27	17
	SK641FR	26	17
	SK642FR	28	17
	SK643FR	28	17
	SK645FR	28	17
	LW9020FR	29	20
	LW9030FR	29	20
	T841FR	27	16
	T843FR	27	16
	T845 FR	27	16

Dielectric strength, IEC 60243-1 **kV/mm or MV/m**

Zenite® LCP	Sample 1 mm thick			
	at 23°C	at 120°C	at 150°C	at 200°C
6130 WT010	46	45	44	39
7130 WT010	57	47	45	45
6330 NC010	66	53	49	42
	Sample 2 mm thick			
	at 23°C	at 120°C	at 150°C	at 200°C
6130 WT010	39	36	35	31
7130 WT010	44	38	38	35
6330 NC010	40	31	35	30
	Sample 3 mm thick			
	at 23°C	at 120°C	at 150°C	at 200°C
6130 WT010	31	30	30	26
7130 WT010	36	28	31	28
6330 NC010	32	27	27	26

For products or grades that do not appear on this table, please contact your DuPont representative for more information.

Dielectric strength, IEC 60243-1 **kV/mm or MV/m**

		Short time	
		DAM 23°C 1 mm	50 % RH 23°C 1 mm
Delrin® POM	100, 107, 100P, 500, 507	32	
	111P		
	500P	33	
	511P		
	900P	32	
	911P		
	100ST, 500T	39	
Rynite® PET	520	34	
	530	35	
	545	32	
	555	35	
	935	39	
	FR515	34, 25[1)]	
	FR530L	33	
	FR543	32	
	FR943	35	

Dielectric strength, IEC 60243-1 (continued) **kV/mm or MV/m**

		Short time	
		DAM 23°C 1 mm	50 % RH 23°C 1 mm
Zenite®	3130L WT		
	6140L WT		
	7145L WT		
Zytel® PA66 unreinforced	101L	32	
	101F	31	26
	103HSL	31	28
	105F BK010		
	135F	25	
	E42A	31	
	408	34	
	450, 490		
	ST801	31	39
Zytel® PA66 unreinforced, flame retardant	FR7026V0F		
Zytel® PA66 glass reinforced, flame retardant	FR70G25V0F		
	FR70G25V0	37	26
Zytel® PA66 glass reinforced	79G13L	37	35
	70G20HSL, 70G25HSL		
	70G30HSL	38	32
	70G30PSR, 70G33GRA BK*		
	70G35HSL		
	70G50HSL, 70G60HSL BK*		
Zytel® PA66 glass-bead reinforced	70GB40HSL		
Zytel® PA66 mineral reinforced, flame retardant	FR70M30V0	40	33
	FR70M40GW		
Minlon® PA66 mineral reinforced	10B140	40	
	11C140	36	27
	EFE6091 BK		
Zytel® PA66/6 unreinforced, flame retardant	FR7200V0F	26	23
Zytel® PA66/6 glass reinforced, flame retardant	FR72G25V0	35	26
Zytel® PA66/6 glass reinforced	72G30L NC010		
	74G33EHSL BK354		
Zytel® PA6 unreinforced	7300		
Zytel® PA6 glass reinforced	73G15HSL		
	73G20L, 73G30HSL		
	73G40L, 73G50HSL		
Minlon® PA6 mineral reinforced	73M30		
Zytel® HTN high performance polyamide	HTN51G35HSL NC010	36	36
	HTN51G45HSL NC010	35	34
	HTNFR51G35L NC010	34	34
	HTN51G15HSL NC010		
	HTN51G35HSLR NC010		
	HTN52G35HSL NC010		
	HTNFR52G30BL NC010		
	HTNFR52G35BL NC010		
Zytel® PA612	151L, 153HSL, 158		
	77G33L, 77G43L		
Zytel®-Kevlar® SFC	70K20HSL		
Zytel® flexible nylon alloy	FN718		
Hytrel® TEEE	4056	24	
	G4078		
	5556	24	
	7246		
Teflon® fluorinated resins	PTFE	56 (0,25 mm)	
	FEP, PFA	>80 (0,25 mm)	
Tefzel® fluorinated resins	ETFE	>80 (0,25 mm)	
	HT2004	59 (0,25 mm)	
Surlyn® ionomer resins	8940	33,6	
	9020	35,6	
	9450	38,1	
	9720	40,9	
Vespel® polyimide resins	SP1, SP21		

[1)] In oil at 170°C. * Only available in black. ** Only available in natural colour.

Dielectric constant (relative permittivity) Dissipation factor (tg δ)

Definitions

The Dielectric constant is the ratio of the permittivity of an insulator to the permittivity of vacuum. (The electric field multiplied by the permittivity gives the electric displacement.)

The Dissipation factor or tg δ is the tangent of the loss angle. The loss angle for an insulator is the angular change in the current (I), voltage (V) relation induced by the insulator in a capacitor versus an ideal capacitor.

Significance

Dielectric constant is the most fundamental property of an insulating material. Generally, high values for the dielectric constant signify that the material is particularly good for use in a capacitor, and low values mean the material is well suited for other electrical applications.

Like other electrical properties, dielectric constant values are affected by AC frequency, temperature and humidity.

Dissipation factor is a dimensionless number used to calculate power losses in an insulator. Usually the lower the value the better.

Test description

The test methods cover the determination of relative permittivity, dissipation factor, loss index, power factor, phase angle, and loss angle of the specimens of solid electrical insulating materials. The frequency range that can be covered extends from less than 1 Hz to several hundred mega-Hertz.

Test description

Dielectric constant			
	ASTM	DIN	IEC
No.	D 150	53483 / VDE 0303, part 4	60250 (ISO 1325)
Specimen:	sheet or disc of not defined dimension >1,5 mm	120 × 120 mm, thickness not defined	sheet or film, thickness not defined
Electrodes:	guarded or unguarded plate or cylinder, metal foils, silver, mercury, sprayed or evapourated metal	plate or cylinder of metal, or silver, graphite, zinc, or evapourated or painted metal	evapourated or painted silver, pressed metal, foil discs
Temperature:	20°C	20 ± 2°C	23°C
Applied voltage and frequency:	V not defined 1 Hz to 10^8 Hz	V not defined 15 Hz to 10^{10} Hz	1 V per mm of sample thickness, 50 Hz to 1 MHz

ASTM D 150
DIN 53483
VDE 0303 part 4
ISO 1325
IEC 60250

Dielectric constant, acc. to ASTM D 150, IEC 60250 **Dimensionless**

		Dry as moulded				50% R.H.		
		50 Hz	100 Hz	10^3 Hz	10^6 Hz	100 Hz	10^3 Hz	10^6 Hz
CRASTIN® PBT	S600F10, S620F20	3,8			3,2			
	ST820							
	SK601	3,9			3,5			
	SK602	4,1			3,5			
	SK603	4,2			3,6			
	SK605	4,4			3,8			
	SK608, SK609	4,1			3,9			
	LW9020	3,6			3,4			
	LW9030	3,8			3,6			
	T805	4,4			4,0			
	SO653	4,0			3,7			
	SO655	4,6			3,9			
	HTI619	4,4			3,8			
	S650FR, S680FR	3,5			3,5			
	T850FR	3,4			3,2			
	SK641FR	3,6			3,4			
	SK642FR	3,7			3,5			
	SK643FR	3,8			3,7			
	SK645FR	4,5			3,8			
	CE7931	4,2			4,1			
	SK673GW	4,0			3,6			
	LW9020FR	3,7			3,5			
	LW9030FR	3,8			3,6			
	T841FR	4,0			3,8			
	T843FR	4,1			3,9			
	T845FR	4,2			4,0			
DELRIN® POM	100		3,4		3,3			
	100P		3,4		3,4			
	111P							
	500		3,4		3,3			
	500P		3,4		3,4			
	511P							
	900P		3,4		3,4			
	911P							
	100ST, 100T, 500T		3,9	3,9	3,9			
	500AL							
	500AF		3,9	3,7	3,7			
	500CL		3,5	3,5	3,5			
RYNITE® PET	520		–	4,0				
	530		–	4,1	3,9			
	545		–	4,4	3,9			
	555				3,8			
	935			4,4	3,7			
	940							
	FR515			3,7	3,0			
	FR530L			4,0	3,6			
	FR543, FR943			4,1	4,1			

Dielectric constant, acc. to ASTM D 150, IEC 60250 (continued) **Dimensionless**

		Dry as moulded				50% R.H.		
		50 Hz	100 Hz	10^3 Hz	10^6 Hz	100 Hz	10^3 Hz	10^6 Hz
Zytel® PA66 unreinforced	101L		4,0	3,9	3,6	8,0	7,0	4,0
	101F		4,0	3,9	3,6	8,0	7,0	4,6
	103HSL		–	3,9	3,6	–	7,0	4,0
	105F BK		4,0	3,9	3,6	8,0	7,0	4,6
	114L BK097		3,7	3,6	3,2	6,6	5,5	3,6
	135F			3,8				3,9
	E42A		4,0	4,0	3,6	8,0	7,0	4,1
	408		3,1	3,1	4,9	5,9	4,8	3,3
	FN718				2,9			
	ST801		3,2	3,5	3,3	5,5	4,5	3,6
Zytel® PA66 unreinforced, flame retardant	FR70G26V0F							
Zytel® PA66 glass reinforced, flame retardant	FR70G25GW							
	FR70G25V0		3,5		3,3			
Zytel® PA66 glass reinforced	79G13L			3,8	3,7		7,1	4,5
	70G20HSL			4,0	3,9		7,5	4,4
	70G25HSL			4,2	4,1		8,3	4,5
	70G30HSL			4,2	4,1		7,7	4,6
	70G35HSL			4,3	4,1		7,7	4,7
Zytel® PA66 mineral reinforced, flame retardant	FR70M30V0			4,1	3,7	9,1		4,2
	FR70M40GW							
Zytel® PA66/6 unreinforced, flame retardant	FR7200V0F		4,1		3,8			
Zytel® PA66/6 glass reinforced, flame retardant	FR72G25V0		3,5		3,3			
Zytel® PA66/6 glass reinforced	74G30L NC010							
	74G33EHSL BK354							
Minlon® PA66 mineral reinforced	10B140			4,4	3,9		11	4,5
	11C140			4,2	3,6			4,5
	EFE6091 BK							
Zytel® HTN high performance polyamide	HTN51G35HSL NC010			4,3	4,0			
	HTN51G45HSL NC010			4,5	4,5			
	HTNFR51G35L NC010			4,3	4,0			
	HTN51G15HSL NC010							
	HTN51G35HSLR NC010							
	HTN52G35HSL NC010							
	HTN52G35L NC010							
	HTNFR52G30BL NC010							
Zytel® PA612	151L		4,0	4,0	3,5	6,0	5,3	4,0
	153HSL		3,9	3,3	3,0			
	158		4,0	4,0	3,5	6,0	5,3	4,0
	77G33L			3,7	3,4			
	77G43L			4,0	3,6			
Zytel®-Kevlar® SFC	70K20HSL		3,7			9,2		
Hytrel® TEEE	4056			5,1	4,6			
	5526			4,5	4,2			
	5556			4,5	4,1			
	6356			4,2	3,7			
	7246			3,9	3,5			
Zenite® LCP	3130 WT010							
	6130 WT010			4,4	3,9			
	6330 NC010							
	7130 WT010			4,3	3,8			
	7145L WT010							
Teflon® fluorinated resins	PTFE, FEP		2,05	2,05	2,05			
	PFA		2,06	2,06	2,06			
Tefzel® fluorinated resins	ETFE		2,6	2,6	2,6			
	HT2004		3,4	3,4	3,4			
Surlyn® ionomer resins	8940, 9020, 9450, 9720			2,3	2,3			
Vespel® polyimide resins	SP1		3,6	3,6	3,5			
	SP21		13,5	13,3	13,4			

* Only available in natural colour.

For products or grades that do not appear on this table, please contact your DuPont representative for more information.

Dissipation factor[1], (tg δ), acc. to ASTM D 150, IEC 60250 **Dimensionless**

		Dry as moulded				50% R.H.		
		50 Hz	100 Hz	10^3 Hz	10^6 Hz	100 Hz	10^3 Hz	10^6 Hz
CRASTIN® PBT	S600F10, S620F20	0,002			0,020			
	SK601, SK602	0,002			0,020			
	SK603	0,0021			0,019			
	SK605	0,0025			0,018			
	SK608, SK609	0,004			0,013			
	LW9020	0,003			0,018			
	LW9030	0,003			0,017			
	T805	0,010			0,022			
	SO653	0,009			0,016			
	SO655	0,014			0,019			
	HTI619	0,014			0,023			
	S650FR	0,0017			0,018			
	S680FR, T850FR	0,001			0,018			
	SK641FR, SK642FR	0,003			0,017			
	SK643FR, SK645FR	0,003			0,016			
	CE7931	0,003			0,015			
	SK673GW	0,005			0,017			
	LW9020FR, LW9030FR	0,003			0,015			
	T841FR	0,010			0,018			
	T843FR	0,011			0,017			
	T845FR	0,013			0,017			
DELRIN® POM	100			0,01	0,007			
	100P			0,02	0,007			
	111P							
	500			0,01	0,007			
	500P			0,02	0,007			
	511P							
	900P			0,02	0,007			
	911P							
	500T				0,009			
	500AL							
	500AF			0,005	0,005			
	500CL				0,006			
RYNITE® PET	520			0,002				
	530			0,008	0,017			
	545			0,007	0,011			
	555				0,025			
	935			0,014	0,025			
	940							
	FR515			0,006	0,015			
	FR530L			0,007	0,010			
	FR543			0,009	0,017			
	FR943			0,010	0,015			

Dissipation factor[1], (tg δ), acc. to ASTM D 150, IEC 60250 (continued) **Dimensionless**

		Dry as moulded				50% R.H.		
		50 Hz	100 Hz	10^3 Hz	10^6 Hz	100 Hz	10^3 Hz	10^6 Hz
Zytel® PA66 unreinforced	101L		0,010	0,016	0,026	0,200	0,200	0,075
	101F		0,010	0,020	0,020	0,200	0,200	0,100
	103HSL		–	0,013	0,025	–	–	0,070
	105F BK*		0,020	0,030	0,030	0,180	0,120	0,060
	114L BK097		0,020	0,020	0,020	0,120	0,120	0,060
	135F			0,012				0,060
	E42A	0,015	0,010	0,024	0,024	0,200	0,200	0,075
	408	0,020	0,020	0,026	0,020	0,100 [2]	0,110	0,100
	FN718				0,032			
	ST801		0,010	0,012	0,024	0,150	0,150	0,055
Zytel® PA66 unreinforced, flame retardant	FR7026V0F							
Zytel® PA66 glass reinforced, flame retardant	FR70G25GW							
	FR70G25V0		0,016		0,012			
Zytel® PA66 glass reinforced	79G13L			0,012	0,013		0,140	0,066
	70G20HSL			0,011	0,016		0,170	0,070
	70G25HSL			0,011	0,015		0,180	0,073
	70G30HSL			0,011	0,015		0,160	0,065
	70G35HSL			0,011	0,014		0,160	0,062
Zytel® PA66 mineral reinforced, flame retardant	FR70M30V0			0,013	0,014			0,05
	FR70M40GW							
Zytel® PA66/6 unreinforced, flame retardant	FR7026V0F		0,058		0,016			
Zytel® PA66/6 glass reinforced, flame retardant	FR72G25V0	0,006	0,018	0,007	0,013			
Zytel® PA66/6 glass reinforced	74G30L NC010							
	74G33EHSL BK354							
Minlon® PA66 mineral reinforced	10B140			0,014	0,023		0,200	0,06
	11C140			0,015	0,024			0,07
	EFE6091 BK							
Zytel® HTN high performance polyamide	HTN51G35HSL NC010			0,012	0,018			
	HTN51G45HSL NC010			0,012	0,012			
	HTNFR51G35L NC010			0,010	0,014			
	HTN51G15HSL NC010							
	HTN51G35HSLR NC010							
	HTN52G35HSL NC010							
	HTN52G35L NC010							
	HTNFR52G30BL NC010							
Zytel® PA612	151L, 158		0,020	0,020	0,020	0,150	0,150	0,100
	153HSL		0,020	0,020	0,020			
	77G33L, 77G43L			0,020	0,020			
Zytel®-Kevlar® SFC	70K20HSL		0,01			0,285		
Hytrel® TEEE	4056			0,008	0,06			
	5526			0,009	0,04			
	5556			0,009	0,04			
	6356			0,02	0,04			
	7246			0,019	0,03			
Zenite® LCP	3130 WT010							
	6130 WT010			0,013	0,027			
	6330 WT010							
	7130 WT010			0,013	0,029			
	7145L WT010							
Teflon® fluorinated resins	PTFE		0,00012	0,00005	0,0001			
	FEP		0,00005	0,000065	0,00055			
	PFA		0,00003	0,00002	0,0001			
Tefzel® fluorinated resins	ETFE		0,0006	0,0008	0,005			
	HT2004		0,004	0,002	0,005			
Surlyn® ionomer resins	8940				0,004			
	9020				0,010			
	9450				0,001			
	9720				0,002			
Vespel® polyimide resins	SP1		0,0018	0,0036	0,0034			
	SP21		0,0053	0,0067	0,0106			

[1] Literature data. * Only available in black.
[2] Same result also at 50 Hz. ** Only available in natural colour.

For products or grades that do not appear on this table, please contact your DuPont representative for more information.

Arc resistance

seconds

Scope

1.1 This method is intended to differentiate, in a preliminary fashion, among similar materials with respect to their resistance to the action of a **high-voltage, low-current** arc close to the surface of insulation, in tending to form a conducting path therein or in causing the material to become conducting due to the localized thermal and chemical decomposition and erosion.

Test description

ARC resistance, s	ASTM D 495/UL 746 A
Specimen:	plate, 3,2 mm thick
Electrodes:	tungsten rod or stainless steel strip
Voltage:	15000 V with various sequences of 1 min. current steps

Significance

ASTM/UL Time in seconds in which sample fails (tracks or ignites).

This test gives a relative measure of the tendency of an insulator to become surface tracking due to repeated low current arc contacts under high voltage.

The use of the ASTM D 495 test results to select an insulating material for a low voltage, high current application may be insufficient or inappropriate.

For further information see page 60.

ASTM D 495
UL 746 A

Arc resistance[1], UL 746 A / ASTM D 495

seconds

		Mean time of arc resistance in seconds	UL's assigned PLC[2]
Crastin® PBT[3]	S600F10, S620F20[3]	120 and up to 180	5
	ST820[3]		
	SK601[3]	60 and up to 120	6
	SK602[3]	60 and up to 120	6
	SK603[3]	60 and up to 120	6
	SK605[3]	120 and up to 180	5
	SK608[3]	120 and up to 180	5
	SK609[3]	120 and up to 180	5
	LW9130[3]	120 and up to 180	5
	LW9020[3]	60 and up to 120	6
	LW9030[3]	120 and up to 180	5
	T805[3]	60 and up to 120	6
	SO653[3]	60 and up to 120	6
	SO655[3]	60 and up to 120	6
	HTI619[3]	120 and up to 180	5
	S650FR[3]	Up to 60	7
	S680FR[3]		
	T850FR[3]	60 and up to 120	6
	SK641FR[3]	60 and up to 120	6
	SK642FR[3]	60 and up to 120	6
	SK643FR[3]	60 and up to 120	6
	SK645FR[3]	120 and up to 180	5
	CE7931[3]	Up to 60	7
	SK673GW[3]	–	
	LW9020FR[3]	60 and up to 120	6
	LW9030FR[3]	60 and up to 120	6
	T841FR[3]	60 and up to 120	6
	T843FR[3]	60 and up to 120	6
	T845FR[3]	60 and up to 120	6
	HTI681FR[3]	60 and up to 120	6
	HTI668FR[3]	180 and up to 240	4
	HTI688FR[3]	120 and up to 180	5
Delrin® POM	100	180 and up to 240	4
	107	180 and up to 240	4
	100P	120 and up to 180	5
	111P		
	500	180 and up to 240	4
	507	180 and up to 240	4
	500P	180 and up to 240	4
	511P		
	900P	120 and up to 180	5
	911P		
	100ST	120 and up to 180	5
	100T	120 and up to 180	5
	500T	120 and up to 180	5
	500AL		
	500AF	120 and up to 180	5
	500CL	120 and up to 180	5
	570	120 and up to 180	5
Rynite® PET	520	60 and up to 120	6
	530	120 and up to 180	5
	545	120 and up to 180	5
	555	120 and up to 180	5
	935	120 and up to 180	5
	940		
	FR515	Less than 60	7
	FR530L	60 and up to 120	6
	FR543	120 and up to 180	5
	FR943	60 and up to 120	6
	530CS		
	936CS		
	GW520CS		
	GW525CS		
Zytel® PA66 unreinforced	101L	60 and up to 120	6
	101F	60 and up to 120	6
	103HSL	60 and up to 120	6
	105F BK*	60 and up to 120	6
	114L BK097	60 and up to 120	6
Zytel® PA66 unreinforced *(continued)*	135F	60 and up to 120	6
	E42A	120 and up to 180	5
	408	120 and up to 180	5
	450, 490		
	ST801	60 and up to 120	6
Zytel® PA66 unreinforced, flame retardant	FR7026V0F		
Zytel® PA66 glass reinforced, flame retardant	FR70G25GW		
	FR70G25V0	60 and up to 120	6
Zytel® PA66 glass reinforced	79G13L	120 and up to 180	5
	70G20HSL	60 and up to 120	6
	70G25HSL	60 and up to 120	6
	70G30HSL	60 and up to 120	6
	70G30PSR		
	70G33GRA BK*		
	70G35HSL	60 and up to 120	6
	70G50HSL		
	70G60HSL BK*		
Zytel® PA66 glass-bead reinforced	70GB40 HSL		
Zytel® PA66 mineral reinforced, flame retardant	FR70M30V0	60 and up to 120	6
	FR70M40GW		
Minlon® PA66 mineral reinforced	10B140		
	11C140	60 and up to 120	6
Zytel® PA66/6 unreinforced, flame retardant	FR7200V0F	60 and up to 120	6
Zytel® PA66/6 glass reinforced, flame retardant	FR72G25V0	60 and up to 120	6
Zytel® PA66/6 glass reinforced	74G30L NC010		
	74G33EHSL BK354		
Zytel® PA6 unreinforced	7300		
Zytel® PA6 glass reinforced	73G15, 73G20		
	73G30, 73G40		
	73G50		
Zytel® HTN high performance polyamide	HTN51G35HSL NC010	60 and up to 120	6
	HTN51G45HSL NC010	60 and up to 120	6
	HTNFR51G35L NC010	60 and up to 120	6
	HTN51G35HSLR NC010		
	HTN51G15HSL NC010		
	HTN52G35HSL NC010		
	HTNFR52G30BL NC010		
	HTNFR52G35BL NC010		
Zytel® PA612	151L	120 and up to 180	5
	153HSL	120 and up to 180	5
	158	120 and up to 180	5
	77G33L	120 and up to 180	5
	77G43L	120 and up to 180	5
Zytel®-Kevlar® SFC	70K20HSL		
Zytel® flexible nylon alloy	FN718		
Hytrel® TEEE	4056		
	G4078	60 and up to 120	6
	5556		
	7246		
Teflon® fluorinated resins	PTFE	240 and up to 300	3
	FEP	240 and up to 300	3
	PFA	240 and up to 300	3
Tefzel® fluorinated resins	ETFE	60 and up to 120	6
	HT2004	60 and up to 120	6
Surlyn® ionomer resins	8940		
	9020		
	9450		
	9720		
Vespel® polyimide resins	SP1		
	SP21		

For products or grades that do not appear on this table, please contact your DuPont representative for more information.

[1] Literature values.
[2] PLC = Performed level.
[3] Test plate, 4 mm thick for all Crastin® grades.

* Only available in black.
** Only available in natural colour.

Tracking resistance (Comparative tracking index) V (Volt)

Definition

Tracking is the current flowing on the surface of an insulator between two electrodes caused either through pollution or degradation of the insulator. Tracking resistance is the ability of an insulator to prevent such currents.

Arc tracking is affected by temperature, humidity, carbon particles, dirt, oil and other contaminants on the surface of the insulator. Changing the design of the plastic part can correct arc tracking problems, improving cleanliness or increasing the distance between the electrodes (creepage line).

Test description of DIN/IEC 60112, VDE 0303 part 1

This method of test indicates the relative resistance of solid electrical insulating materials to tracking for voltages up to 600 V when the surface is exposed under electric stress to water with the addition of contaminants.

Material which does not track at the highest test voltage may erode differently. The depth of erosion can be measured. Some materials may ignite during the test.

Specimen:	15 × 15 mm, thickness ≥ 3 mm (a larger specimen size is preferred)
Electrodes:	Pointed tips, 4 mm apart
Solution:	A-Ammoniumchloride
	B-Ammoniumchloride with wetting agent (more aggressive than A)
Usually recommended voltage steps:	175-250-300-375-500-600 V
Apparatus:	see Fig. 1–3

Tracking is considered to have occured during the test procedure if a current of 0,5 A circulates for more than 2 s, actuating an overcurrent relay.

Failure is also occurring if, while there is no current and the relay was not operated, the specimen is burning.

Significance

CTI Voltage at which no tracking occurs after 50 drops of solution A, provided that at 25 V lower no tracking occurs after 100 drops of solution A.

CTI-M Voltage at which no tracking occurs after 50 drops of solution B, provided that at 25 V lower no tracking occurs after 100 drops of solution B.

In case the value of tracking after 100 drops is lower than 25 V of that determined for 50 drops, the lower voltage is added in brackets, e.g. CTI 575 (525).

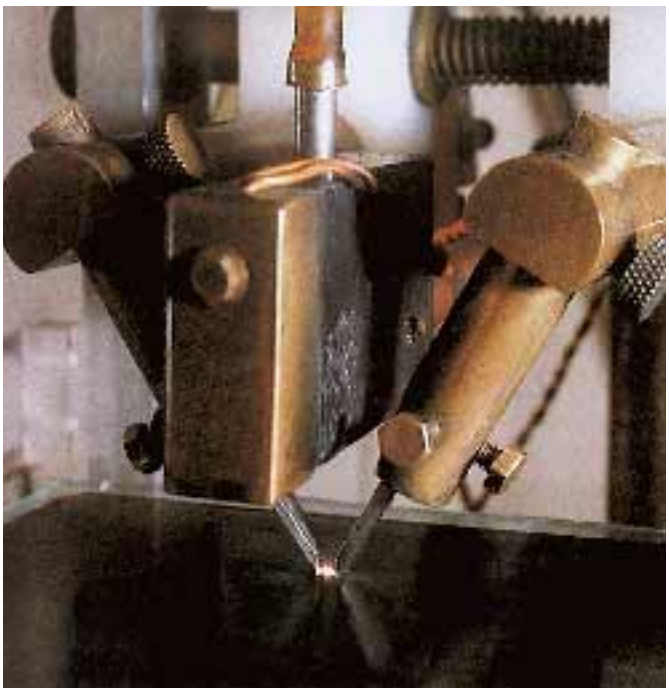
The higher the values the more resistant is the material.

Remark

Data for KB and KC obtained according to the old version of the standards may not be identical with those obtained according to the new standard giving CTI resp. CTI-M values because the standard did not simultaneously require the no tracking after 100 drops at 25 V lower testing.

Test description of UL 746 A and ASTM D 3638

See also chapter “How to read and interpret a UL yellow card’’, columna 12, page 61.



VDE 0303, part 1
DIN IEC 112
IEC 60112 “Comparative tracking index” (CTI)
CEE Publ. 24, paragraph 20 e
BS 3781 (Comparative tracking index)
NF C 26-220
ASTM D 3638 (CTI only)
UL 746 A, paragraph 24

Tracking resistance

Testing divices

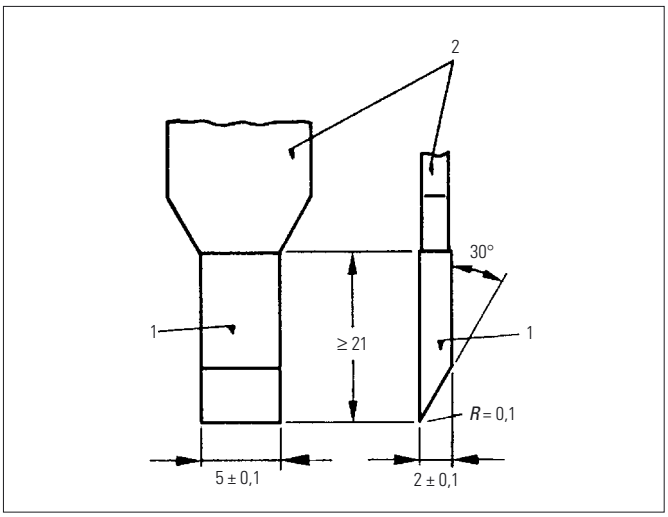


Fig. 1. **Electrode**[a)]

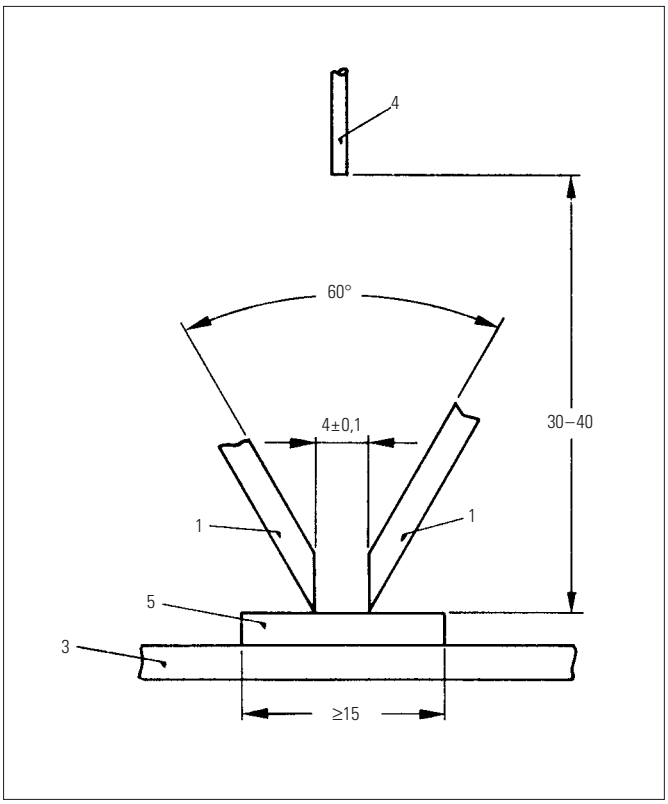
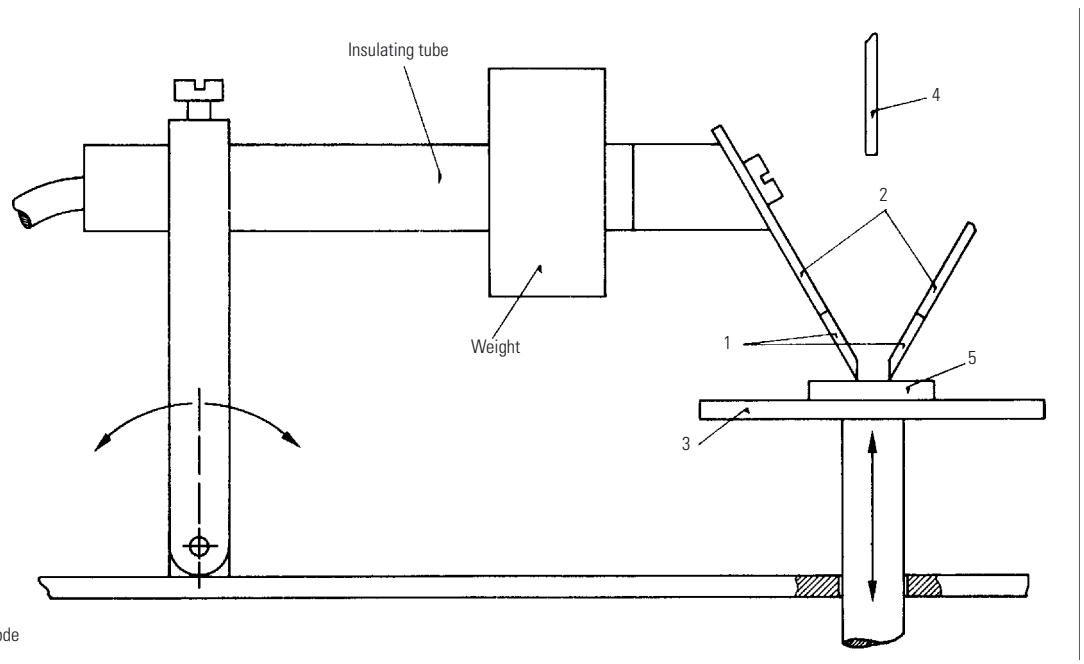


Fig. 2. **Electrode arrangement**[a)]



1 = Platinum electrode
2 = Brass extension
3 = Support
4 = Tip of dropping device
5 = Specimen

Fig. 3. **Example of test apparatus**[a)]

[a)] All dimensions are in millimetres

Tracking Resistance, IEC 60112 / UL 746 A

V (volt) thickness of specimens : >3 mm

		CTI		CTI-M
		IEC	UL 746 A PLC level	IEC
Crastin® PBT	S600F10, S620F20	>600	0	350
	ST820	>600	0	>600
	SK601	300	2	200
	SK602	350	2	200
	SK603	400	2	200
	SK605	450	1	200
	SK608	475	1	200
	SK609	500	1	200
	LW9020, LW9030	550	1	175
	T805	500	1	200
	SO653	300	2	200
	SO655	250	2	200
	HTI619	600	0	200
	S650FR	225	2	175
	S680FR	250	2	175
	T850FR	600	0	275
	SK641FR	225	2	175
	SK642FR, SK643FR, SK645FR	250	2	175
	CE7931	250	2	150
	SK673GW	250	2	175
	LW9020FR	350	2	175
	LW9020FR GY	325		
	LW9030FR	375	1	175
	LW9320FR	350		
	LW9330FR	375		
	LW9330FR GYB	350		
	T841FR	250	2	175
	T843FR	275		
	T845FR	325		
Delrin® POM	100, 107	>600	0	>600
	100P	600	0	
	111P			
	500, 507	>600	0	
	500P, 900P	600	0	
	511P, 911P			
	100ST, 100T, 500T, 570	600	0	600
	500AL			
	500AF, 500CL	>600	0	
Rynite® PET	520	250	3	
	530	250 (200)	3	200
	531			
	545	250	2	250
	555	200	3	
	935	325 [1]	2	
	940			
	FR515	275	2	
	FR530L	250 (200)	2	125
	FR543	250 (175)	3	125
	FR943	225	2	100
	GW520CS			
	GW525CS			
Zytel® PA66 unreinforced	101L	600	0	375 (325)
	101F	600	0	575 (475)
	103HSL	525 (425)	0	400 (350)
	103HSL BK080	525		400
	105F BK010		0	
	114L BK097	575 (525)	0	
	135F	600	0	475
	E42A		0	
	450	600 (590)	0	525 (475)
	490	600	0	475
	ST801 NC010, NC010 A	600	0	600
Zytel® PA66 unreinforced, flame retardant	FR7026V0F			
Zytel® PA66 glass reinforced, flame retardant	FR70G25GW FR70G25V0	325	2	150
Zytel® PA66 glass reinforced	79G13L	475	1	
	70G20HSL, 70G25HSL	400 (325)	1	
	70G30HSL	400 (325)	1	350
	74G33EHSL BK354	450		

		CTI		CTI-M
		IEC	UL 746 A PLC level	IEC
Zytel® PA66 miner. reinforced, flame retardant	FR70M30V0 FR70M40GW	325	2	250 [1]
Minlon® PA66 mineral reinforced	10B140	575		250 (200)
	11C140	550 (475)	1	300 (250)
Zytel® PA66/6 unreinforced, flame retardant	FR7200V0F	575	0	
Zytel® PA66/6 glass reinforced, flame retardant	FR72G25V0	325	2	150
	FR72G25V0 BK	275		150
Zytel® PA66/6 glass reinforced	74G30L NC010			
	74G33E BK354			
Zytel® HTN high performance polyamide	HTN51G35HSL NC010	600	0	300 (250)
	HTN51G45HSL NC010	600	0	250
	HTNFR51G35L NC010	500	1	225
	HTN51G15HSL NC010			
	HTN51G35HSLR NC010			
	HTN52G35HSL NC010			
	HTNFR52G30BL NC010			
	HTNFR52G35BL NC010			
Zytel® PA612	151L, 153HSL, 158	600	0	
	77G33L, 77G43L		0	
Hytrel® TEEE	5556	600	0	
	7246	600	0	575
Zenite® LCP	6130 WT010	150	4	100
	7130 WT010	150	4	100
	6330 NC010	150		100
Teflon® fluorinated resins	PTFE, FEP		0	
Vespel® polyimide resins	SP1, SP21		3	

[1] K_C, K_B values. * Only available in black.

Caution: Colours often significantly affect tracking values in one or the other way. Further information on this is available on request.

Ignition properties

°C

Self ignition temperature
Flash ignition temperature

Definition

Self-ignition temperature – the lowest initial temperature of air passing around the specimen at which, in the absence of an ignition source, the self-heating properties of the specimen lead to ignition or ignition occurs by itself, as indicated by an explosion, flame or sustained glow.

Flash-ignition temperature – the lowest initial temperature of air passing around the specimen at which a sufficient amount of combustible gas is evolved to be ignited by a small external pilot flame.

Test description

Laboratory determination of the self-ignition and flash-ignition temperatures of plastics using a hot-air ignition source.

ASTM D 1929	Procedure A	Procedure B
Specimen:		3 g resin
Temperature:	300°C/h (raise)	at 400°C (start T°)
Air flow rate:	25, 50, 100 mm/s	25 mm/s
Ignition time:		13 min. (without ignition)
Apparatus:		see Fig. 1

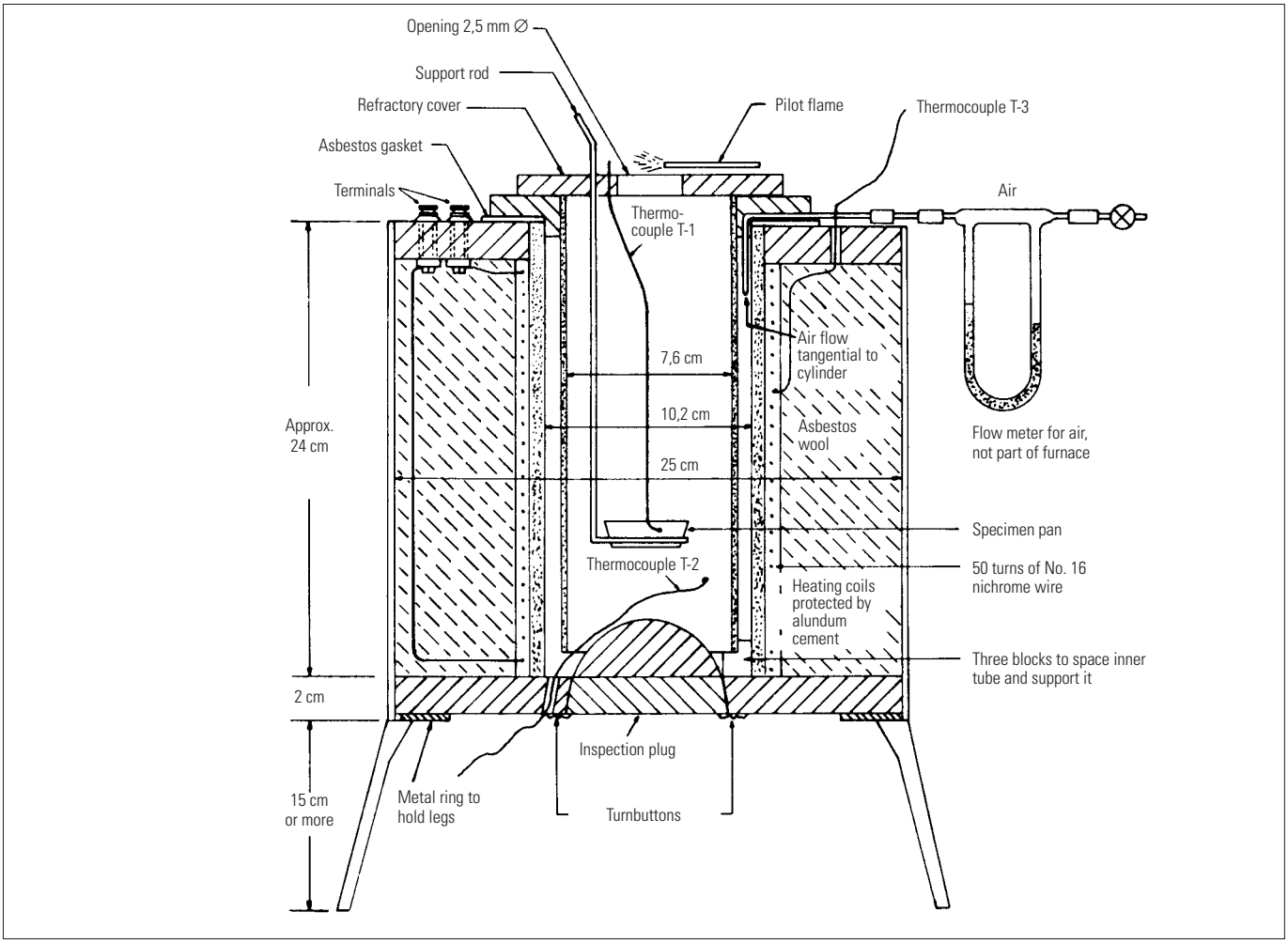


Fig. 1. **Cross section of hot-air ignition furnace assembly**

Ignition properties

°C

		Self ignition[1)]	Flash ignition[1)]
DELRIN® POM	100	375	325
	107	375	325
	111P		
	500	375	325
	500AL		
	500P	375	325
	507	375	325
	511P		
	900P	375	325
	911P		
	570	375	325
RYNITE® PET	FR530L		370
ZYTEL® PA66 unreinforced	101L	430	380
ZYTEL® PA66 mineral reinforced, flame retardant	FR70M30V0	365	
	FR70M40GW		
TEFLON® fluorinated resins	PTFE	620–675	>500
	FEP	635	590
	PFA		570
TEFZEL® fluorinated resins	ETFE	550–555	545–560

[1)] Test done by outside institutes, average values of one single batch.

Caution: Colours often significantly affect tracking values in one or the other way. Further information on this is available on request.

For products or grades that do not appear on this table, please contact your DuPont representative for more information.

Ignition temperature, IEC 60829 method A
Ignition time, IEC 60829 method B

- Plastics are more or less resistant to ignition when in contact with a hot wire.

A. Ignition temperature

The glow wire device (p. 38) is used to compare the relative resistance of plastic insulators to ignition. It determines the minimum temperature of the glow wire at which, during the 30 seconds of contact time of the glow wire with the plastic, there is ignition.
Results are expressed as a temperature.

- Sample : 60 × 60 × 3 ± 0,2 mm.
- Conditioning : 48 hours at 23°C at 50% relative humidity.
- Test device: see Glow wire, p. 38.

Ignition temperatures according to Method A

DELRIN® 500	725°C
ZYTEL® 103HSL	725°C
ZYTEL® 70G30HSL	750°C

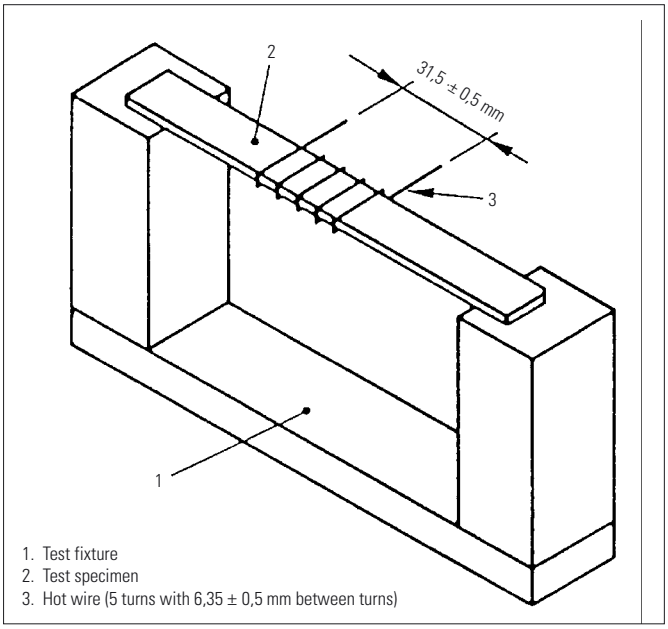
B. Ignition time

The relative ignition time of a plastic material is determined by winding a wire with a flowing current around a normalised sample and measuring the time that elapses until ignition occurs due to the heating of the wire.

This test is similar to the HWI (hot wire ignition) test carried out by the Underwriters' Laboratories described on page 60.

As a first approximation, the results listed on page 63 may be used.

- Sample: 125 ± 5 × 3 ± 0,3 × (3 ± 0,1 mm or the part thickness).
  5 samples are to be tested.
- Conditioning: 48 hours at 23°C and 50% relative humidity (after predrying).
- Hot wire: 5 turns with 6,35 ± 0,5 mm between turns.
- Heat applied: 0,26 W/mm of wounded sample.



1. Test fixture
2. Test specimen
3. Hot wire (5 turns with 6,35 ± 0,5 mm between turns)

Fig. 1. **Method B: Hot-wire coil ignition. Test apparatus (example)**

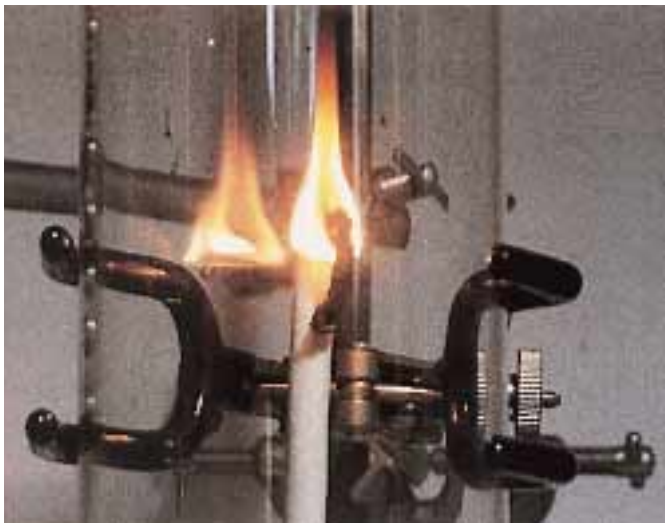
IEC 60829, methods A and B

Oxygen index

%

Definition

OI is the minimum concentration of oxygen in a flowing mixture of oxygen and nitrogen that will just support flaming combustion.



Test description

Samples:	70 to 150 mm × 6,5 × 3,0 mm
Number of samples:	10
Procedure:	Specimen clamped vertically, ignition on top. Constant increase of oxygen concentration.
Apparatus:	see Fig. 1

Significance

Usually the higher the value the more resistant a material will be to ignition and combustion.

Note: Normal atmosphere at sea level is 21% O_2.
Gas mixture temperature affects the OI value.

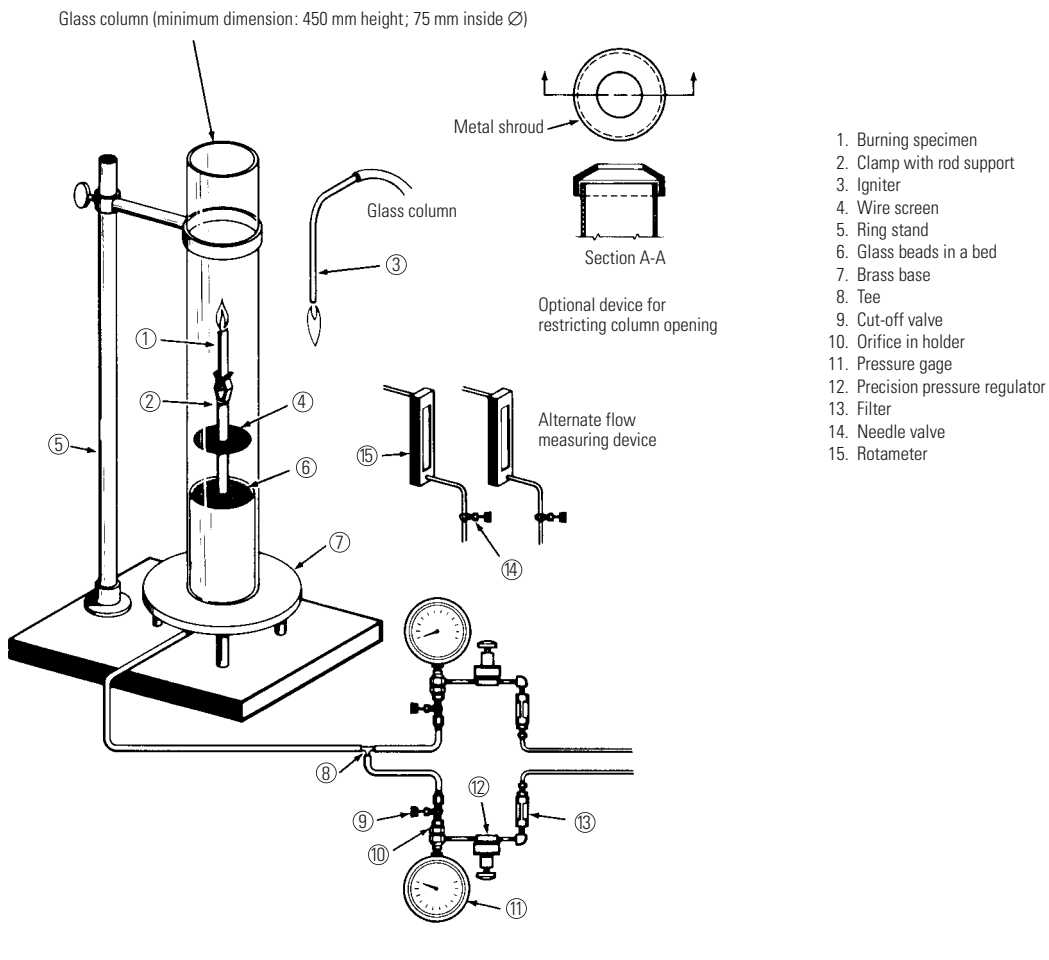


Fig. 1. **Typical equipement layout for measuring the oxygen index**

ISO 4589
ASTM D 2863
AFNOR T 51-071
BS 2782, part 1, method 141 B

Oxygen index, ASTM D 2863

		% O_2 [1]
Crastin® PBT	S600F10	22
	S620F20	22
	ST820	
	SK601	20
	SK602	19
	SK603	19
	SK605	19
	SK608	20
	SK609	20
	LW9020	19
	LW9030	19
	T805	19
	SO653	22
	SO655	22
	HTI619	21
	S650FR	30
	S680FR	30
	T850FR	29
	SK641FR	31
	SK642FR	31
	SK643FR	31
	SK645FR	31
	CE7931	33
	SK673GW	
	LW9020FR	27
	LW9030FR	27
	T841FR	30
	T843FR	30
	T845FR	30
Delrin® POM	100	
	107	
	100P	
	111P	
	500	15
	507	15
	500P	
	511P	
	900P	
	911P	
	100ST	
	100T	
	500T	
	500AL	
	500AF	
	500CL	
	570	
Rynite® PET	520	
	530	20
	545	20
	555	22
	935	
	940	
	FR515 BK	32
	FR530L	33
	FR543	35
	FR943	31
	530CS	
	936CS	
	GW520CS	
	GW525CS	
Zytel® PA 66 unreinforced	101L	28
	101F	28
	103HSL	28
	105F BK010	25
	114L BK097	22
	135F	26
	EFE1068	28
	408	21
	450	21
	490	21
	ST801	20
Zytel® PA66 unreinforced, flame retardant	FR7026V0F	
Zytel® PA66 glass reinforced, flame retardant	FR70G25GW	
	FR70G25V0	
Zytel® PA66 glass reinforced	79G13L	23
	70G20HSL	
	70G25HSL	
	70G30HSL	23
	70G30PSR	
	70G33GRA BK*	
	70G35HSL	
	70G50HSL	
	70G60HSL BK*	
Zytel® PA66 glass-bead reinforced	70GB40 HSL	
Zytel® PA66 mineral reinforced, flame retardant	FR70M30V0	43
	FR70M40GW	
Minlon® PA66 mineral rienforced	10B140	25
	11C140	31
Zytel® PA66/6 unreinforced, flame retardant	FR7200V0F	37
Zytel® PA66/6 glass reinforced, flame retardant	FR72G25V0	
Zytel® PA66/6 glass reinforced	74G30L NC010	
	74G33E BK354	
Zytel® PA6 unreinforced	7300	23
Zytel® PA6 glass reinforced	73G15	
	73G20	
	73G30	
	73G40	
	73G50	
Zytel® HTN high performance polyamide	HTN51G35HSL NC010	23
	HTN51G45HSL NC010	24
	HTNFR51G35L NC010	44
Zytel® PA612	151L	
	153HSL	
	158	25
	77G33L	
	77G43L	
Zytel®-Kevlar® SFC	70K20 HSL	
Zytel® flexible nylon alloy	FN718	
Hytrel® TEEE	4056	22
	G4078	
	5556	21
	7246	21
Zenite® LCP	3130L WT010	
	6130 WT010	38
	6330 NC010	
	7130 WT010	39
	7145L WT010	
Teflon® fluorinated resins	PTFE	>95
	FEP	>95
	PFA	>95
Tefzel® fluorinated resins	ETFE	30–32
	HT2004	30–32
Surlyn® ionomer resins	8940	
	9020	
	9450	
	9720	
Vespel® polyimide resins	SP1	53
	SP21	49

[1] Average value obtained from one single batch of dry as moulded samples.
* Only available in black. ** Only available in natural colour.

For products or grades that do not appear on this table, please contact your DuPont representative for more information.

Hot mandrel test

Scope

Insulating parts retaining live parts in position shall be resistant to abnormal heat and fire.

Test description

A mandrel at 300° C or 500° C is inserted by a force of 6 or 12 N into a conical hole in the part to be tested. Sparks of 6 mm length are produced close to the cone.

Apparatus: see Figure 1, page 29

CEE Publ. 3

CEE Publ. 10, part 1, paragraph 30 b, modification 3

CEE Publ. 11, part 1, paragraph 26 b (also run with mandrel of 500° C)

CEE Publ. 12, paragraph 18 d (also run with mandrel of 500° C)

CEE Publ. 17, paragraph 27 d

CEE Publ. 22, paragraph 26 a

CEE Publ. 24, paragraph 20 d

CEE Publ. 25, paragraph 23 b (also run with mandrel of 500° C)

CEE Publ. 32, paragraph 27 b

IEC 60309, part 1, paragraph 27.4

VDE 0470, paragraph 26

VDE 0625, paragraph 26

VDE 0630, part 1, paragraph 20 d

VDE 0730, part 1, paragraph 29

BS 3456, part 1, paragraph 30.2

BS 4491, paragraph 26.1.1

NF C 62-411, art. 3.21.2 (also run with mandrel of 500° C)

NF C 73-150, paragraph 30.2

NF C 73-200, paragraph 30.2

NF C 75-100, paragraph 27 b

Neither the sample nor any gasses produced during heating shall be ignited by the sparks.

A **more severe testing method** by the Hot mandrel test has been published in **Modification 3** (Sept. 75) of **CEE publ. 10, part 1, paragraph 30 b by adding the following sentences:**

“However, if the sample starts to soften or to melt during the test, a force just sufficient to keep the sample in contact with the mandrel is applied to the sample in horizontal direction.”

Further:

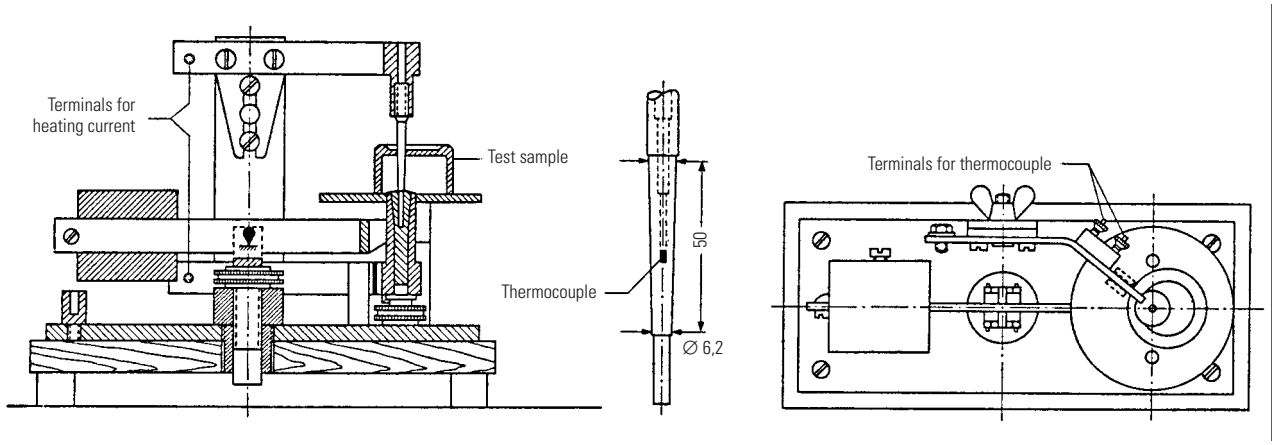
“Sparks of 6 mm length are produced at the upper surface of the sample where the mandrel protrudes **and the sample is in contact with the mandrel.”**

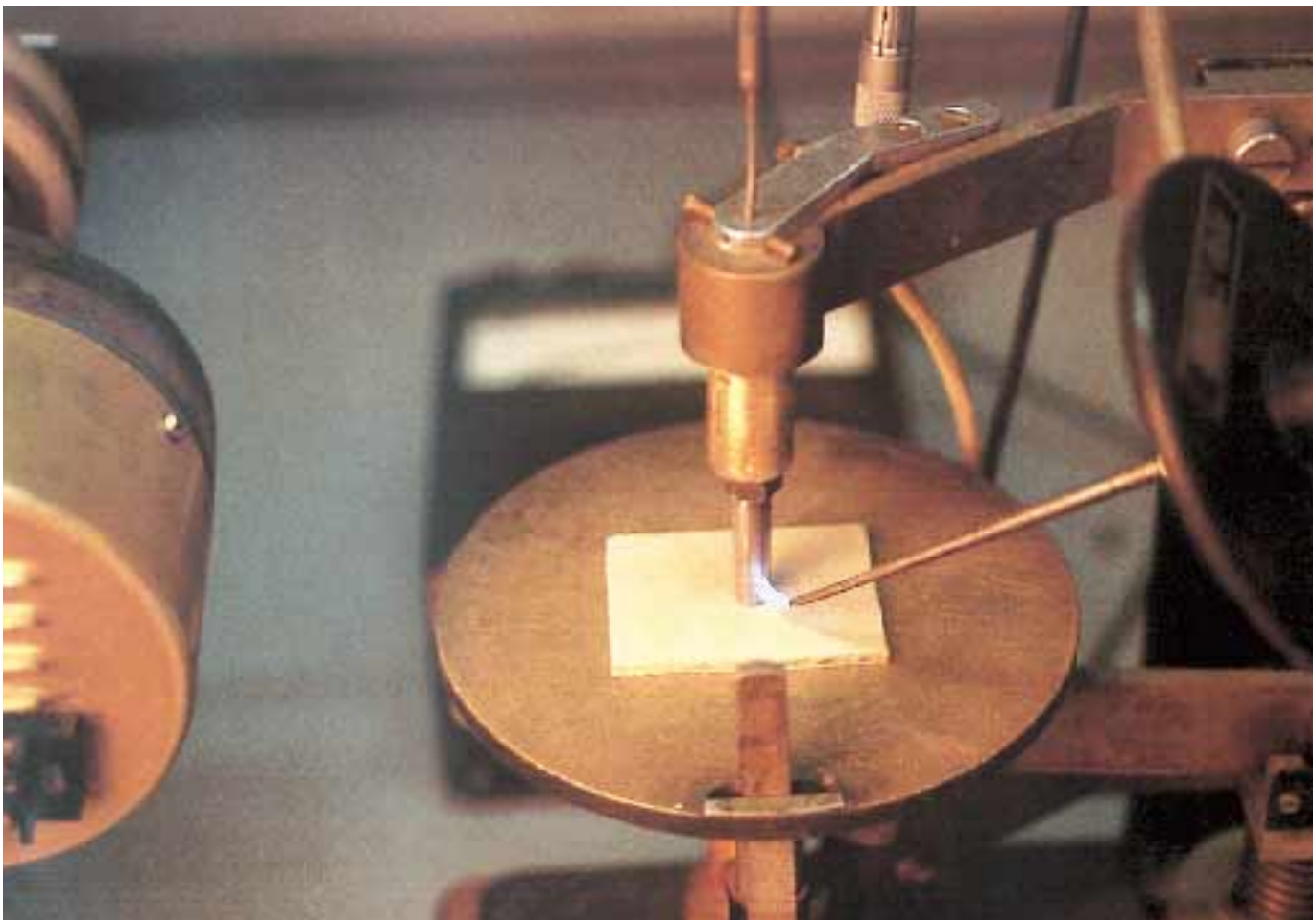
Other standards are limiting penetration of the hot mandrel in the samples to 5 mm maximum to pass the test.

Note: VDE / Germany will always apply the modified CEE test method whenever the Hot mandrel test is required, although the corresponding VDE standard might not have been revised yet accordingly.

Hot mandrel test

Dimensions in millimetres





Hot mandrel test (acc. to CEE publ. 10, modif. 3) **+ Pass / – Failure**

	3 mm thick	300°C	500°C*
DELRIN® POM	100	+	
	107	+	
	500P	+	
RYNITE® PET	530	+	
	545	+	
	FR530L	+	+
ZYTEL® PA66 unreinforced	101L	+	
	103HSL	+	
	114L BK097	+	
	ST801	+	
ZYTEL® PA66 glass reinforced, flame retardant	FR70G25GW		
ZYTEL® PA66 glass reinforced	70G30HSL	+	
ZYTEL® PA66 mineral reinforced, flame retardant	FR70M30V0	+	+
	FR70M40GW	+	+
MINLON® PA66 mineral reinforced	10B140	+	+
	11C140	+	+
ZYTEL® PA66/6 unreinforced, flame retardant	FR7200V0F	+	

+ = Passes test requirements
– = Does not pass test requirements

* Average value of one single batch; according to CEE publ. 10, Modif. 3, there is no limitation to the penetration of the mandrel (which is sometimes the case) that moves horizontally to maintain the contact.

For products or grades that do not appear on this table, please contact your DuPont representative for more information.

Flammability classifications HB, V-2, V-1, V-0, 5V, 5VA, 5VB

according to UL 94

Scope

The UL 94 test enables to compare plastic materials in terms of their burning behaviour. It gives indication either on the relative speed of burning, or on their ability to extinguish or not to propagate fire.

A. HB (Horizontal Burning)

Test description according to UL

Sample size:	125 ± 5 × 13 ± 0,2 mm
Thickness:	± 0,8; ± 1,6; ± 3,2; ± 6… Bar having marked lines at 25 and 100 mm from end
Pretreatment:	48 h / 23°C / 50% RH
Burner:	Bunsen 9,5 mm ∅, 100 mm length
Flame height:	25 ± 2 mm
Contact time:	30 s
Gas:	Technical grade methane or earthgas having heat capacity of 37 MJ/m^3
Apparatus:	see Figure 1 (Fig. 2.1 from UL 94)

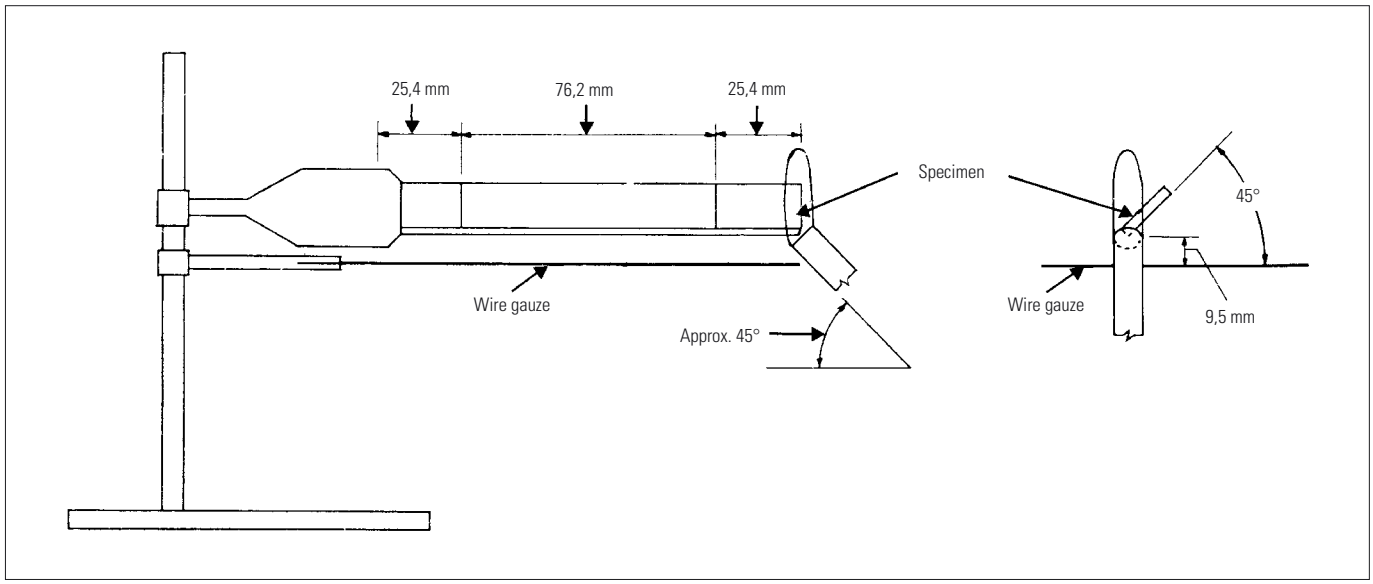


Fig. 1. **Horizontal burning test for 94 HB classification**

The HB rating is given if the **burn rate,** measured between the 2 marks, does not exceed:

- 38,1 mm/min. for 3,2 mm testbar thickness;
- 63,5 mm/min. for <3,2 mm testbar thickness;

In both cases, the testbar must stop burning before reaching the 100 mm mark.

B. V (Vertical Burning)

V-2
V-1
V-0

Test description according to UL

Sample size:	125 ± 5 × 13 ± 0,2 mm
Thickness:	± 0,8; ± 1,6; ± 3,2; ± 6…
Pretreatment:	On two sets of samples 1. One set of 5 test bars conditioned for 48 h at 23°C, 50% RH; 2. Another set of 5 test bars conditioned for 168 h at 70°C (RH not defined).
Burner:	Bunsen 9,5 mm ∅, 100 mm length
Flame height:	25 ± 2 mm
Gas:	Technical grade methane or earthgas having heat capacity of 37 MJ/m^3
Number of flame applications	2 × 10 s
Apparatus:	see Figures 2 + 3 (Fig. 4.1 of UL 94)

Classification:	UL V-0	V-1	V-2
Max. burning time single specimen	≤10 s	≤30 s	≤30 s
Max. burning time total of 5 specimens	≤50 s	≤250 s	≤250 s
Dripping ignition of cotton	no	no	yes
Afterglow	≤30 s	≤60 s	≤60 s
Afterglow ignition of cotton	none	none	yes

Thus, in total, a flame is applied 2 times on 5 test bars, which gives **10 values** per set of test bar; **2 sets,** differently conditioned, are checked which gives **a total of 20 values** per material.

A one time retesting of a set of 5 test bars is allowed if only one testbar exceeds the single burn time or if the total burn time of one set exceeds the required value by not more than 5 s. (V-0 = 55 s; V-1, V-2 = 255 s).

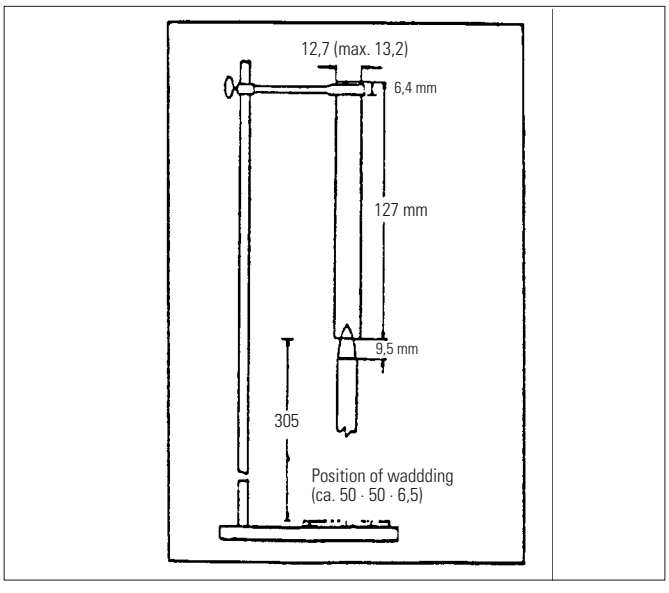


Fig. 2. **Burning test for solid specimens according to UL 94 (1976)**

C. Vertical burning test 5V, 5 VA, 5VB

Test description according to UL

Specimen size:	Bars: 127 × 12,7 mm (thickness as specified on yellow card) Plaques: 152 3 152 mm (idem)
Pretreatment:	On two sets of samples 1. 5 bars or 3 plaques conditioned for 48 hours at 23°C, 50% R.H. 2. 5 bars or 3 plaques conditioned for 168 hours at 70°C
Burner:	Bunsen 9,5 mm diameter, 100 mm length
Flame height:	127 mm (inner blue core 38 mm)
Gas:	Technical grade methane or earthgas having a heat capacity of 37 MJ/m^3
Samples positioning:	Bars: vertical Plaques: horizontal
Contact time:	5 × 5 seconds with intervals of 5 seconds (bars and plaques).
Apparatus:	see Figure 3

5V classification

1. No flaming or glowing – 60 s after the last flame application.
2. No dripping at all.
3. No significant destruction of the sample in the flame area.

A one time retesting of a set of test specimens is allowed if only 1 testbar fails.

5VA classification (bars and plaques)

1. No flaming or glowing – 60 s after the last flame application.
2. No ignition of the cotton by dripping particles.
3. No holes in plaques.

A one time retesting of a set of test specimens is allowed if only 1 testbar fails.

5VB classification (bars and plaques)

1. No flaming or glowing – 60 s after the last flame application.
2. No ignition of the cotton by dripping particles.
3. A hole in the plaque is acceptable.

A one time retesting of a set of test specimens is allowed if only 1 testbar fails.

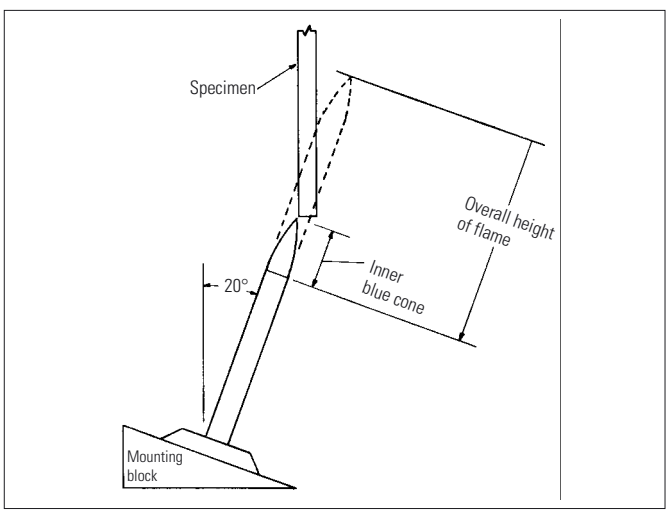


Fig. 3. **Vertical burning test for UL 94-5 V classification**

Flammability classification, UL 94[1)]

		UL rating at minimum thickness (mm)						
		HB	V-2	V-1	V-0	5V	5VA	5VB
Crastin® PBT	S600F10, S620F20	1,5						
	ST820							
	SK601, SK602	1,5						
	SK603, SK605, SK609	0,75						
	LW9020, LW9030	1,5						
	T805	0,75						
	SO653	1,5						
	SO655	0,75						
	HTI619	1,5						
	S650FR, S680FR				0,75			
	T850FR				1,5			
	SK641FR, SK642FR				1,5			
	SK643FR, SK645FR				0,75			
	CE7931				1,5			
	SK673GW							
	LW9020FR, LW9030FR				1,5			
	T841FR, T843FR, T845FR				1,5			
Delrin® POM	100, 107, 100P, 111P	0,75						
	500, 507, 500P, 511P	0,75						
	500AL, 500CL, 500T	0,75						
	900P, 911P	0,75						
	570	1,5						
Rynite® PET	520, 415HP, 935	0,75						
	530, 545, 555, 408	0,75						
	FR515				0,86[4)]			
	FR530L, FR943				0,35[3)]			
	FR543				0,81[3)]			
	GW520CS							
	GW525CS							
Zytel® PA66 unreinforced	101L, 101F, 103HSL		0,71					
	105F BK010		0,71					
	114L BK097	0,81						
	135F		0,71					
	408, 450, 490	0,81						
	ST801	0,81						
Zytel® PA66 unreinforced, flame retardant	FR7026V0F							
Zytel® PA66 glass reinforced, flame retardant	FR70G25GW							
	FR70G25V0				0,5			
Zytel® PA66 glass reinforced	79G13L	1,5						
	70G20HSL, 70G25HSL	0,71						
	70G30HSL	0,75						
	70G30PSR	0,81						
	70G35HSL	0,71						
Zytel® PA66 glass-bead reinforced	70GB40HSL	0,75						
Zytel® PA66 mineral reinforced, flame retardant	FR70M30V0				1,5[4)]		1,5[3)]	
	FR70M40GW		0,75					
Minlon® PA66 mineral reinforced	10B140							
	11C140	0,81[4)]						
Zytel® PA66/6 unreinforced, flame retardant	FR7200V0F				0,45			
Zytel® PA66/6 glass reinforced, flame retardant	FR72G25V0				0,5			
Zytel® PA66/6 glass reinforced	74G30L NC010							
	74G33EHSL BK354							
Zytel® PA6 unreinforced	7335F	1,5						
Zytel® PA6 glass reinforced	73G15, 73G20, 73G30, 73G50	1,5						
Zytel® HTN high performance polyamide	HTN51G35HSL NC010, HTN51G45HSL NC010	0,85						
	HTNFR51G35L NC010				0,81			
	HTN51G15HSL NC010	0,8						
	HTN51G35HSLR NC010							
	HTN52G35HSL NC010	0,75						
	HTNFR52G35BL NC010, HTNFR52G30BL NC010				0,75			
Zytel® PA 612	151L NC010		0,86					
	77G33L, 77G43L	0,71						
Zenite® LCP	3130L WT010							
	6130 WT010				0,38			
	6330 NC010				0,75			
	7130 WT010				0,89			
Hytrel® TEEE	4056, 5556, 7246	1,5						
Teflon® fluorinated resins	PTFE				0,076			
	FEP				0,86			
	PFA				0,81			
Tefzel® fluorinated resins	ETFE				1,57			
	HT2004							
Surlyn® ionomer resins	8940, 9020, 9450, 9720							
Vespel® polyimide resins	SP1					1,7		
	SP21					1,6		

[1)] UL yellow cards are available.
[2)] DuPont test results.
[3)] NC, BK.
[4)] All colours.
[5)] NC, BK, GY.

* Only available in black. ** Only available in natural colour.

Table for information only. For actual classification, please consult the most recent UL Yellow Cards.
For products or grades that do not appear on this table, please contact your DuPont representative for more information.

Flammability classifications BH 1, BH 2, BH 3; FH 1, FH 2, FH 3; FV 0, FV 1, FV 2

according to IEC 60707

Scope

The methods of test refer to solid electrical materials and are intended to serve as a preliminary indication of their behaviour when exposed to an ignition source.

Tests make it possible to distinguish between the different degrees of flammability of materials.

The horizontal position of test specimes (BH and FH) is suitable to evaluate extent of burning and/or velocity of flame propagation, i.e. burning rate.

The vertical position (FV) is suitable to evaluate extent of burning after extinction of flame.

This test is very close to the UL 94 for part of it.

IEC 60707 FV 2 is close to UL 94 V-2
FV 1 is close to UL 94 V-1
FV 0 is close to UL 94 V-0

One will thus refer to the UL 94 values published in this brochure to have a close if not identical value to the one obtained according to the IEC 60707 **FV** method.

A. Incandescent bar burning "BH"

Test description according to IEC/HD: BH 1, BH 2, BH 3

Sample size:	length 125 ± 5 mm width 10,0 ± 0,2 mm thickness 4,0 ± 0,2 mm Specimens are marked 25 mm and 100 mm from ignition end
Ignition source:	silicon carbide rod, 8 mm ∅, 100 mm long with contact force on test specimen 0,3 N
Temperature:	955 ± 15° C by alternating current
Contact time:	3 min.
Apparatus:	see Fig. 1, page 31

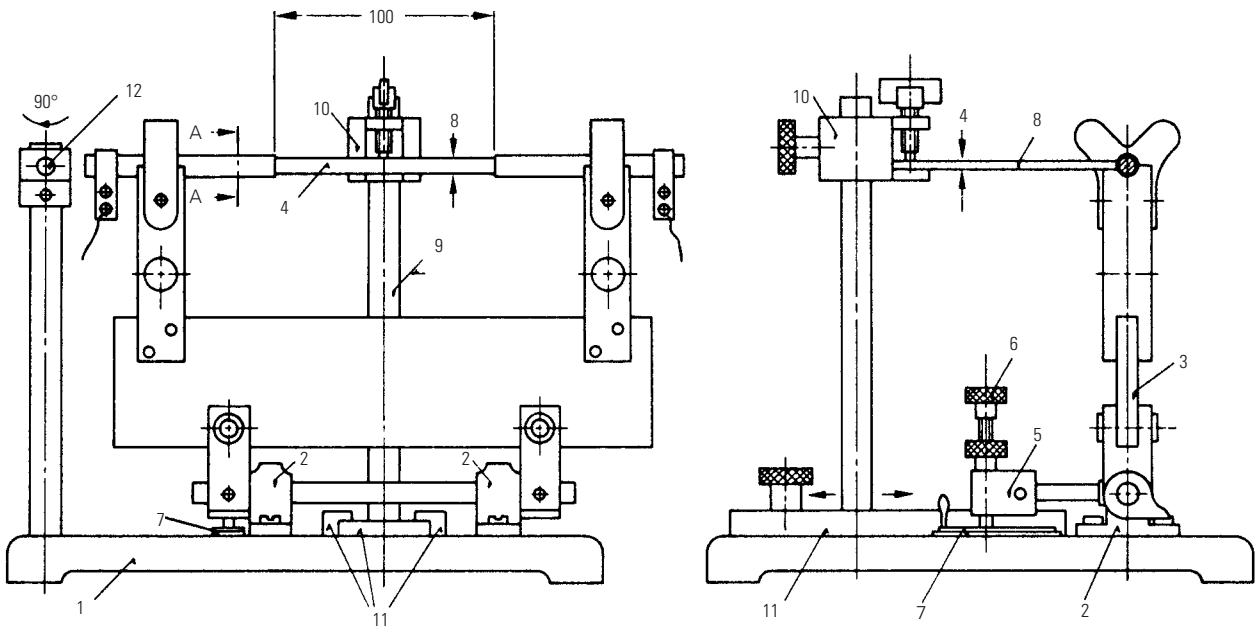
Significance

BH 1: No visible flame during test.

BH 2: Flame ceases before 100 mm mark is reached. Length of burnt area is added, e.g. BH 2–70.

BH 1: flame raches 100 mm, mark. Burning rate is given, e.g. BH 3–30 mm/min.

Dimensions in millimetres



1 = Base plate
2 = Bearings
3 = Holder
4 = Incandescent bar
5 = Counterweight
6 = Stop screw
7 = Pivoting plate
8 = Test specimen
9 = Holder for specimen
10 = Clamp
11 = Sliding base
12 = Pivoting metal rod

Section A-A

Method BH: Incandescent bar – Horizontal specimen: test unit

IEC 60707
EN/HD 441

B. Horizontal burning "FH"

Test description

Specimen:	length 125 ± 5 mm width 13,0 ± 0,3 mm thickness 3,0 ± 0,2 mm Specimens are marked 25 mm and 100 mm from ignition end
Ignition source:	Bunsen 9,5 mm ∅, 100 mm length
Flame height:	25 ± 2 mm
Contact time:	30 s
Gas:	Technical grade methane or natural gas having heat content of approx. 37 MJ/m³
Apparatus:	see Fig. below

Significance

FH 1: No visible flame during test.

FH 2: Flame ceases before 100 mm mark.
Length of burnt area is added, i.e. FH 2–70 mm

FH 3: Flame reaches 100 mm mark. Burning rate is given, e.g. FH 3–30 mm / min.

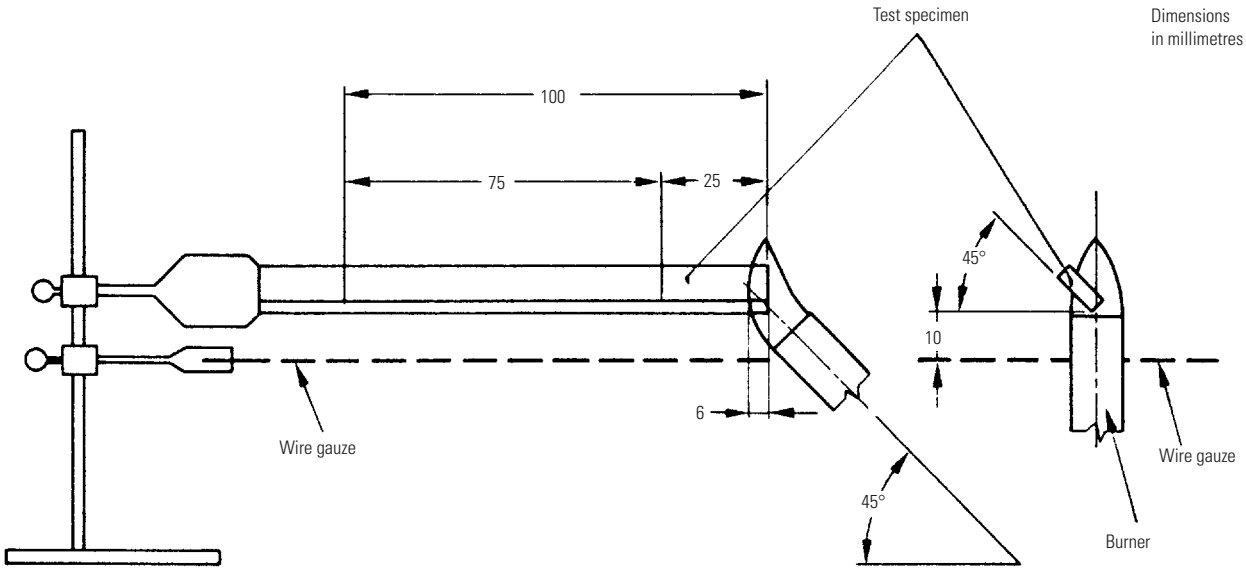
C. Vertical burning "FV"

Test description

Sample size:	same as for FH
Ignition source:	same as for FH
Flame height:	20 ± 2 mm
Contact time:	see UL 94 p. 28
Gas:	same as FH
Apparatus:	**see UL 94,** Fig. 2 for vertical burning, p. 32

Test results

		Thickness 3,2 mm
DELRIN®	500	FH 3
ZYTEL®	70G30HSL	FH 3
	103HSL	FH 2



Method FH: Flame – Horizontal test specimen

Flammability classifications 0.6HB, 0.6V-0, 0.6V-1, 0.6V-2

according to C.S.A. C22.2, No. 0.6

F-5 – Test E: Horizontal burning test for classifying materials as 0.6HB (similar to UL 94 HB rating).

Specimens for this test are first conditioned in accordance with C22.2 No. 0.6, C1 9.2.3. This flame test uses a 25 mm blue flame that is applied to specimens (outlined in C22.2 No. 0.6, C1 9.2) for 30 seconds or until the specimen burns to the 25 mm mark if it is prior to 30 seconds, and then removed. The time for burning to occur between the 25 mm and 100 mm mark is recorded and the burn rate is calculated.

Materials classified as 0.6HB shall

a. not have a burning rate greater than 38 mm/min. over a 76 mm span for samples having a thickness of 3,0 to 3,2 mm;

b. not have a burning rate exceeding 76 mm/min. over a 76 mm span for specimens having a thickness less than 3,0 mm;

c. cease to burn before the flame reaches the 100 mm reference mark.

Ratings
0.6HB = slow burning rating granted;
0.6HF = failed test.

F-6 – Test F: Vertical burning test for classifying materials as 0.6V-0, 0.6V-1, 0.6V-2 (similar to UL 94 V-0, V-1, V-2 Ratings).

Two sets of specimens are conditioned according to the specifications in C22.2 No. 0.6, C1 10.2.3.

A 19 mm blue flame is applied to a sample for 10 seconds, removed, and reapplied for another 10 seconds when flaming ceases.

Ratings
0.6V-0 = V-0 rating granted;
0.6V-1 = V-1 rating granted;
0.6V-2 = V-2 rating granted;
0.6V-F = failed test.

Flammability classification CSA C22.2, No. 0.6, 0.6HB, 0.6V-2, 0.6V-1, 0.6V.0 ratings

		Thickness (mm)	Rating Test E	Test F
Crastin® PBT	S600F10			
	S620F20			
	ST820			
	SK601			
	SK602			
	SK603			
	SK605			
	SK608			
	SK609			
	LW9020			
	LW9030			
	T805			
	SO653			
	SO655			
	HTI619			
	S650FR		0,6 HB	
	S680FR			
	T850FR			
	SK641FR			
	SK642FR			
	SK643FR			
	SK645FR			
	CE7931			
	SK673GW			
	LW9020FR			
	LW9030FR			
	T841FR			
	T843FR			
	T845FR			
Delrin® POM	100	0,750	0,6 HB	
	107	0,750	0,6 HB	
	100P		0,6 HB	
	111P			
	500		0,6 HB	
	507		0,6 HB	
	500P		0,6 HB	
	511P			
	900P		0,6 HB	
	911P			
	100ST		0,6 HB	
	100T		0,6 HB	
	500T		0,6 HB	
	500AL			
	500AF		0,6 HB	
	500CL		0,6 HB	
	570			
Rynite® PET	520		0,6 HB	
	530		0,6 HB	
	545		0,6 HB	
	555		0,6 HB	
	935		0,6 HB	
	FR515			0,6 V0
	FR530L			0,6 V0
	FR543			0,6 V0
	FR943			0,6 V0
	530CS			
	936CS			
	GW520CS			
	GW525CS			
Zenite® LCP	3130L WT			
	6130 WT			
	6330 NC			
	7130L WT			
Zytel® PA66 unreinforced	101L	0,750		0,6 V2
	101F	0,780		
	103HSL	0,870		
	105F BK010			
	114L BK097			
	135F			

		Thickness (mm)	Rating Test E	Test F
Zytel® PA66 unreinforced (continued)	E42A			
	408			
	450			
	490			
	ST801		0,6 HB	
Zytel® PA66 unreinforced, flame retardant	FR7026V0F			
Zytel® PA66 glass reinforced, flame retardant	FR70G25GW			
	FR70G25V0			
Zytel® PA66 glass reinforced	79G13L			
	70G20HSL			
	70G25HSL			
	70G30HSL			
	70G30PSR			
	70G33GRA BK*			
	70G35HSL			
	70G50HSL			
	70G60HSL BK*			
Zytel® PA66 glass-bead reinforced	70GB40HSL			
Zytel® PA66 mineral reinforced, flame retardant	FR70M30V0	0,780		0,6 V0
	FR70M40GW			
Minlon® PA66 mineral reinforced	10B140			
	11C140			
Zytel® PA66/6 unreinforced, flame retardant	FR7200 V0F			
Zytel® PA66/6 glass reinforced, flame retardant	FR72G25V0			
Zytel® PA66/6 glass reinforced	74G30L NC010			
	74G33EHSL BK354			
Zytel® PA6 unreinforced	7300			
Zytel® PA6 glass reinforced	73G15			
	73G20			
	37G30			
	73G40			
	73G50			
Zytel® PA612	151L			
	153HSL			
	158			
	77G33L			
	77G43L			
Zytel®-Kevlar® SFC	70K20HSL			
Zytel® flexible nylon alloy	FN718			
Hytrel® TEEE	4056			
	G4078	1,560	0,6 HB	
	5556			
	7246			
Teflon® fluorinated resins	PTFE			
	FEP			
	PFA			
Tefzel® fluorinated resins	ETFE			
	HT2004			
Surlyn® ionomer resins	8940			
	9020			
	9450			
	9720			
Vespel® polyimide resins	SP1			
	SP21			

* Only available in black. ** Only available in natural colour.

Table for information only. For actual classification, please consult the most recent CSA documents.
For products or grades that do not appear on this table, please contact your DuPont representative for more information.

Glow wire test / IEC 60695-2-1 / 0, 1, 2, 3 °C

- **Glow Wire Test** applicable to devices or sub-assemblies or parts of it
- **Glow Wire Flammability Index "GWFI"** measured on material plates
- **Glow Wire Ignition Temperature "GWIT"** measured on material plates

Scope

1. Glow Wire Test

Components or parts may, under faulty or overload conditions, reach a temperature such that they are unduly affected or such that they will ignite parts in their vicinity. The glow wire test simulates thermal stresses which may be produced by such sources of heat or ignition, for example glowing elements or overloaded resistors, for short periods, in order to simulate the fire hazard. It is applied to devices or parts of them.

2. Glow Wire Flammability Index: "GWFI"

The "GWFI" of a material is determined by applying the glow wire test to material plates under similar conditions that apply to the actual devices or parts of it. This permits a comparison to be made of the materials in terms of their extinguishing capabilities.

3. Glow Wire Ignition Temperature: "GWIT"

The "GWIT" of a material is determined by applying the glow wire test to material plates under similar conditions that apply to the actual devices or parts of it. This permits a comparison to be made of the materials in terms of their relative resistance to ignition.

Test description

	Glow wire test	GWFI	GWIT
Sample	Complete equipment sub-assembly or part of it	Plates 60 × 60 × e mm e = thickness	Plates 60 × 60 × e mm e = thickness
Conditioning	24 hours 15°C ≤ Temperature ≤ 35°C 45% ≤ RH ≤ 75%	48 hours at 23°C 50% RH	
Glow wire	see Fig. 1		
Glow wire temperature	550, 650, 750, 850, 960	500, 550, 600, 650, 700, 750, 800, 850, 900, 960	
Force	0,8 to 1,2 N 2 N (HE60E01)	0,8 to 1,2 N	0,8 to 1,2 N
Time of glow wire contact	30 s	30 s	30 s
No. of contacts	1	3 successive	3 successive
Apparatus	see Fig. 2	see Fig. 2	see Fig. 2

Significance

GWIT: is defined as the maximum glow wire temperature, at which there is no ignition of the plate, for 3 successive applications, and to which one adds 25 K. That is, GWIT = Maximum temperature without ignition +25K. For example: A product that passes the GWIT at 825°C with a 3 mm thickness will be rated GWIT 850/3.

GWFI: The GWFI is the highest temperature of the glow wire, applied three successive times to the plate and on each occasion the plate extinguishes in a maximum of 30 seconds after the glow wire withdrawal, and it does not ignite the wrapping tissue under the test plate.

VDE 0471, part 2-1
DIN IEC 695-2-1
IEC 60695-2-1
NF C 20-455
BS 5733 § 32.4
CEE (031-SEC) F 142 E
BS 1313 § 23
HE 60-E-01 (EDF)
AS 2420

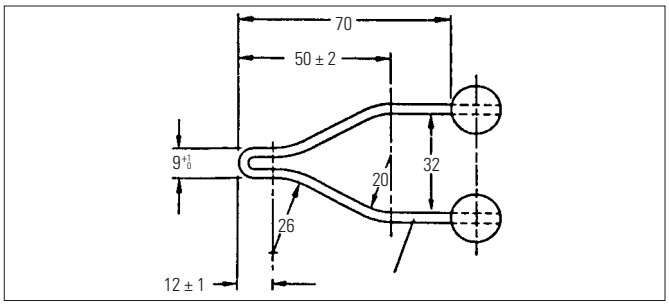
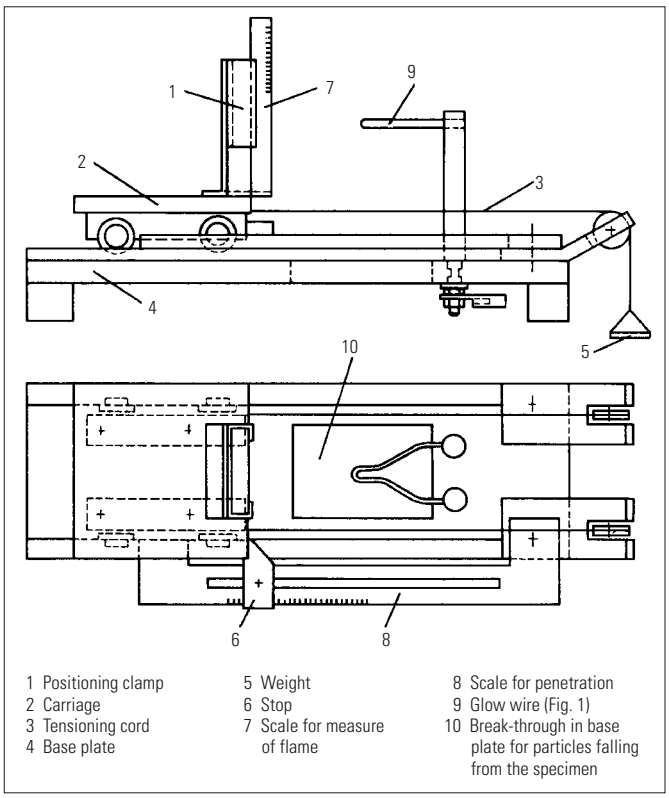


Fig. 1. **Glow-wire**



1 Positioning clamp
2 Carriage
3 Tensioning cord
4 Base plate
5 Weight
6 Stop
7 Scale for measure of flame
8 Scale for penetration
9 Glow wire (Fig. 1)
10 Break-through in base plate for particles falling from the specimen

Fig. 2. **Test equipment**

Device Glow Wire Test:

Unless otherwise specified by the standard for the device, the specimen is considered to have withstood the Glow Wire Test at a given temperature if either:

– there is no flame or glowing of the specimen.
– the specimen flames and the layer below flames extinguish in a maximum of 30 seconds after removal of the glow wire. The layer below should not be totally burned. If the layer below is wrapping tissue, it should not ignite.

Many standards refer to the Glow Wire Test and differences may exist compared to the IEC test method. Please contact a DuPont represententive if you have any doubt about the validity of the results you obtained according to the IEC 60695-2-1 or by using other standards glow wire test methods.

- Some specifications specify a maximum flame height of 30 mm to pass the test.
- The HN60-E-01 specifies an extinction time of maximum 5 seconds.

For more information please contact your local representative.

Glow Wire Flammability Index : "GWFI" **°C**

		1 mm	2 mm	3 mm	6,4 mm
Crastin® PBT	S600F10, S620F20			750	
	ST820		700	700	
	SK602, SK603, SK605			750	
	SK608, SK609			750	
	LW9020, LW9030			650	
	T805			750	
	SO653, SO655, HTI619			750	
	S650FR, S680FR T850FR	960		960	
	SK641FR, SK642FR			960	
	SK643FR, SK645FR	960		960	
	CE7931, SK673GW			960	
	LW9020FR, LW9030FR	960		960	
	T841FR, T843FR, T845FR	960		960	
Delrin® POM	100, 107, 100P	550	550	550	
	111P				
	500, 507	550	550	550	
	500P, 900P	550	550	550	
	511P				
	911P				
	100ST, 100T, 500T	550	550	550	
	500AL				
	500CL			550	
	500AF, 570			600	
Rynite® PET	520	650	650	750	
	530	650	750	750	960
	545	750	750	850	960
	FR530L	960 (0,8 mm)	960 (2,2 mm)	960 (3,2 mm)	
		960 (1,2 mm)	960		
	FR543 NC010, FR943 NC010	960			
	530CS			750 (3,2 mm)	
	936CS	750 (0,8 mm)			
	GW520CS				
	GW525CS	850 (0,8 mm)	960	960	960
Zytel® PA66 unreinforced	101L	850 (1,6 mm)	960	960	
	101F	750	960	960	
	E103HSL	850	960	960	
	105F BK010	960*	960*	960*	
	114L BK097	650	650	650	
	135F	850	850	960	
	408	650*	650*	650*	
	450	675*	650*	650*	
	490	700*	700*	700*	
	ST801			650	650
Zytel® PA66 unreinforced, flame retardant	FR7026V0F				
Zytel® PA66 glass reinforced, flame retardant	FR70G25GW				
	FR70G25V0	850 (1,6 mm)	960		
Zytel® PA66 glass reinforced	79G13L			650 (2,5 mm)	
	70G20HSL	650*	650*	750	
	70G25HSL	650	650	750	
	70G30HSL	650*	650*	750*	
	70G60HSL BK**	700	700	850	
Zytel® PA66 glass-bead reinforced	70GB40HSL				
Zytel® PA66 mineral reinforced, flame retardant	FR70M30V0	960 (at 1,2, 1,5 and 2,5 mm)			
	FR70M40GW	960 (at 1,2 mm)			
Minlon® PA66 mineral reinforced	10B140			750 (3,2 mm)	
	11C140			650 (3,1 mm)	
	EFE6091 BK				
Zytel® PA66/6 unreinforced, flame retardant	FR7200V0F	960 (at 0,8, 1,6 and 3,2 mm)			
Zytel® PA66/6 glass reinforced, flame retardant	FR72G25V0	960 (1,6 and 3,2 mm)			
Zytel® PA6 unreinforced	7300, 7335F	800 (1,6 mm)		850	
Zytel® PA6 glass reinforced	73G15				
	73G30HSL BK	700	700	700	
	73G40, 73G50				
Zytel® HTN high performance polyamide	HTN51G35HSL NC010	750			
	HTN51G45HSL NC010	750			
	HTNFR51G35L NC010	960			
	HTN51G15HSL NC010	750	800	960	
	HTN51G35HSLR NC010	750	800	960	
	HTN52G35HSL NC010	750	750	960	
	HTNFR52G35BL NC010	960	960	960	
	HTNFR52G30BL NC010	960	960	960	
Zytel® PA612	151L		960		
Hytrel® TEEE	4056	775	750	750	
Zenite® LCP	6130 WT010, 7130 WT010, 7145 WT010	960	960	960	
	6330 NC010	960	960	960	
Teflon® fluorinated resins	PTFE701N	960			
	FEP, PFA	960			
Tefzel® fluorinated resins	ETFE200	960			
Surlyn® ionomer resins	8940, 9020, 9450, 9720				
Vespel® polyimide resins	SP1, SP21				

* DuPont Laboratory test results. ** Only available in black. *** Only available in natural colour

For products or grades that do not appear on this table, please contact your DuPont representative for more information.

Flammability with needle burner

Scope

Parts of insulating material or of other combustible material which are liable to propagate flames inside the equipment may be ignited by flames produced by a failing component. Under certain conditions, for example a faulty current flowing over a tracking path, overloading of components or parts and bad connections, flames may also occur; such flames may impinge upon combustible parts in the vicinity. The needleflame test is a test to simulate the effect of small flames, which may result form faulty conditions within the equipment, in order to assess by a simulation technique the fire hazard.

Test description for IEC 60695-2-2 / VDE 0860 / DIN IEC 695-2-2 / NF C 20-456

Specimen size:	Complete equipment, sub-assembly or component
Pretreatment:	IEC – 24 h / 23°C / 50% RH
Gas:	Butane
Flame length:	12 ± 1 mm injection needle
Orifice:	0,5 ± 0,1 mm ∅
Flame contact time:	1. VDE / DIN = 10 s 2. IEC / NFC = 5, 10, 20, 30, 60, 120 s contact by flame tip, depending on the relevant device specification.
Apparatus:	see Figure 1

Significance

VDE / DIN: After removal of flame, sample shall not burn or glow longer than 30 s. If 30 s are not exceeded, once more flame contact for 1 minute. If again 30 s are not exceeded, once more flame contact for 2 minutes.

Flame must extinguish within 30 s and droppings shall never ignite a 10 mm thick sheet of plywood from pine, placed 20 mm below specimen, which is covered with tissue paper (ISO R 135) of 12–25 g/m^2 weight.

IEC / NFC: The test is successfully passed if, after removal of the flame tip (5, 10, 20, 30, 60 or 120 seconds later), one of the following four situations applies:

- if the specimen does not ignite;
- if flames or burning or glowing particles falling from the specimen do not spread fire to the surrounding parts or 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;
- if the extent of burning specified in the relevant specification has not been exceeded.

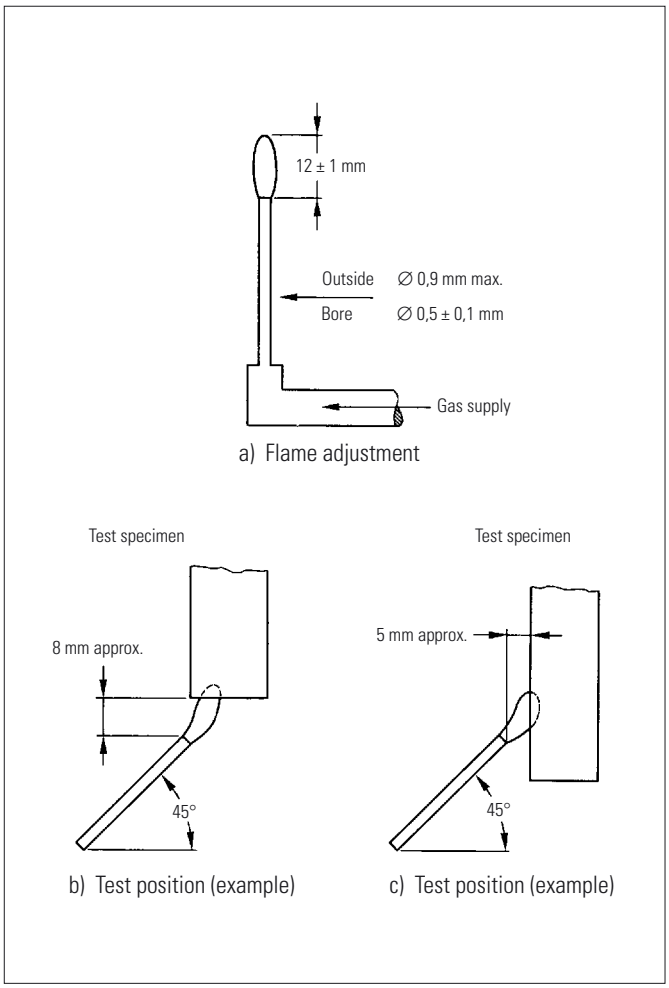


Fig. 1. **Needle burner**

IEC 60695-2-2
VDE 0860
DIN 57860
DIN IEC 695, part 2-2 / VDE 0471, part 2-2
NF C 20-456

Flammability with needle burner[1)] **+ Pass / – Failure**

	Grade	Thickness in mm[2)]	Pos. B/C[3)]	Flame Exp. Time (s)	Pass +/–	Comments
Crastin® PBT	S600F10, S620F20					
	ST820					
	SK601, SK602, SK603, SK605, SK608, SK609					
	LW9020, LW9030					
	T805					
	SO653, SO655					
	HTI619					
	S650FR,S680FR					
	T850FR					
	SK641FR, SK642FR, SK643FR					
	SK645FR					
	CE7931	4	B/C	120	+ + +	
	SK673GW					
	LW9020FR, LW9030FR					
	T841FR, T843FR, T845FR					
Delrin® POM	All grades	2,3			– – –	
Rynite® PET	520, 530, 545, 555, 935					
	FR515 NC010	3,2	B/C	120	+ + +	
		2,2	B/C	120	+ + +	
		1,2	B/C	120	+ + +	
	FR530L NC010	3,2	B/C	120	+ + +	
		2,2	B/C	120	+ + +	
		1,2	B/C	120	+ + +	
	FR543 NC010	3,2	B/C	120	+ + +	
		2,2	B/C	120	+ + +	
		1,2	B/C	120	+ + +	
	FR945 NC010	3,2	B/C	120	+ + +	
		2,2	B/C	120	+ + +	
		1,2	B/C	120	+ + +	
	FR946 NC010	3,2	B/C	120	+ + +	
		2,2	B/C	120	+ + +	
		1,2	B/C	120	+ + +	
	GW520CS, GW525CS	3,2	B/C	120	+ + +	
		2,2	B/C	120	+ + +	
		1,2	B/C	120	+ + +	
Zytel® PA66 unreinforced	101L, 101F, 103HSL	2,3		30	+ + +	
	105F BK, 114L, 135F, E42A					
	408, 450, 490, ST801	2,3		30	+ + +	
Zytel® PA66 unreinforced, flame retardant	FR7026V0F					
Zytel® PA66 glass reinforced, flame retardant	FR70G25GW					
	FR70G25V0					
Zytel® PA66 glass reinforced	79G13L, 70G20HSL					
	70G25HSL, 70G30HSL					
	70G30PSR					
	70G33GRA BK*					
	70G35HSL, 70G50HSL					
	70G60HSL BK*					
Zytel® PA66 glass-bead reinforced	70GB40HSL					
Zytel® PA66 mineral reinforced, flame retardant	FR70M30V0	3,2	B/C	120	+ + +	Glowing
	FR70M40GW	2,2	B/C	120	+ + +	self
		1,2	B/C	120	+ + +	extinguish
Minlon® PA66 mineral reinforced	10B140, 11C140					
Zytel® PA66/6 unreinforced, flame retardant	FR7200V0F					
Zytel® PA66/6 glass reinforced, flame retardant	FR72G25V0					
Zytel® PA66/6 glass reinforced	74G30L					
	74G33EHSL BK354					
Zytel® PA6 unreinforced	7300					
Zytel® PA6 glass reinforced	73G15, 73G20, 37G30, 73G40, 73G50					
Zytel® PA612	151L, 153HSL, 158, 77G33L, 77G43L					
Zytel®-Kevlar® SFC	70K20HSL					
Hytrel® TEEE	4056, G4078, 5556, 7246					
Teflon® fluorinated resins	PTFE	3,0		120	+ + +	
	PTFE, PFA					
Tefzel® fluorinated resins	ETFE, HT2004					
Surlyn® ionomer resins	8940, 9020, 9450, 9720					
Vespel® polyimide resins	SP1, SP21					

+ + + = passed requirements.
– – – = did not pass requirements.

* Only available in black.
** Only available in natural colour.

[1)] Tested at DuPont.
[2)] All samples of 2,2 and 1,2 mm thickness have been machined on both sides.
[3)] Pos. B/C means the position of the flame to the sample "B" being the most critical (underneath the sample).

For products or grades that do not appear on this table, please contact your DuPont representative for more information.

Rate of burning, ASTM D 635

If you are interested in specific test results for a DuPont resin, please contact your local representative.

Scope

Small-scale laboratory screening for comparing relative rate of burning and/or extent and time of burning of self-supporting plastics. Should not be used as a fire-hazard test method.

Test description for ASTM D 635 (rate of burning and/or extent and time of burning of self-supporting plastics in a horizontal position)

Specimen size:	12,7 × 125 mm Thickness 3 to 12 mm Bars having marked lines at 25 and 100 mm from end
Burner:	Bunsen, blue flame
Flame height:	25 mm
Flame contact:	30 s on horizontal bar
Apparatus:	in draftfree chamber (see Fig. 1)

Significance

Burning rate – if two or more specimens have burned to the 100 mm gage mark, the average burning rate is given in cm/min.

ATB (= Average Time of Burning) =

$$\frac{\sum (t - 30\ s)}{\text{number of specimens}}$$

AEB (= Average Extent of Burning) =

$$\frac{\sum (100\ mm\text{-unburned length})}{\text{number of specimens}}$$

ASTM D 635

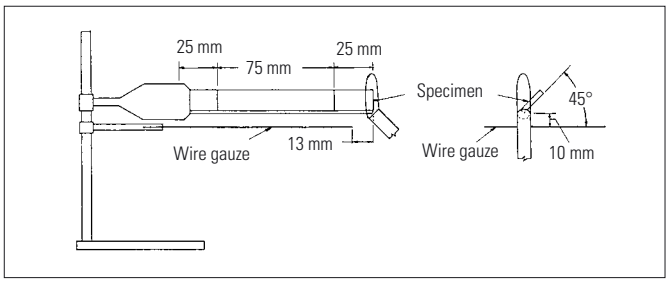


Fig. 1. **Test apparatus**

Rate of Burning, ASTM D 635 (Samples are 1,6 mm thick)

	Grade	cm/min	ATB s	AEB mm
CRASTIN® PBT	S600F10	2,6	*	*
	S620F20	2,6	*	*
	ST820	4,6	*	*
	SK601	3,7	*	*
	SK602	3,7	*	*
	SK603			
	SK605			
	SK608	2,5	*	*
	SK609	2,4	*	*
	LW9020	5,0	*	*
	LW9030	5,0	*	*
	T805	3,5	*	*
	SO653	2,7	*	*
	SO655	2,7	*	*
	HTI619	4,9	*	*
	S650FR	*	< 5	< 5
	S680FR	*	< 5	< 5
	T850FR	*	< 5	< 5
	SK641FR	*	< 5	< 5
	SK642FR	*	< 5	< 5
	SK643FR	*	< 5	< 5
	SK645FR	*	< 5	< 5
	CE7931	*	< 5	< 5
	SK673GW			
	LW9020FR	*	< 5	< 5
	LW9030FR	*	< 5	< 5
	T841FR	*	< 5	< 5
	T843FR	*	< 5	< 5
	T845FR	*	< 5	< 5
TEFLON®	PTFE		< 5	5
	FEP		< 5	5
	PFA		< 5	10
TEFZEL®	ETFE		< 5	10

< 5 means average is below 2,5.

Properties marked with a * are not applicable for this material.

For products or grades that do not appear on this table, please contact your DuPont representative for more information.

ASTM D 635
DIN 53438, part 1, 2, 3
BS 2782, 508A
ISO 1210
ISO 1326 (for film only)
ATS-1000.001

Rate of burning, DIN 53438

Scope

Small-scale laboratory screening for comparing relative rate of burning and/or extent and time of burning of self-supporting plastics. Should not be used as a fire-hazard test method.

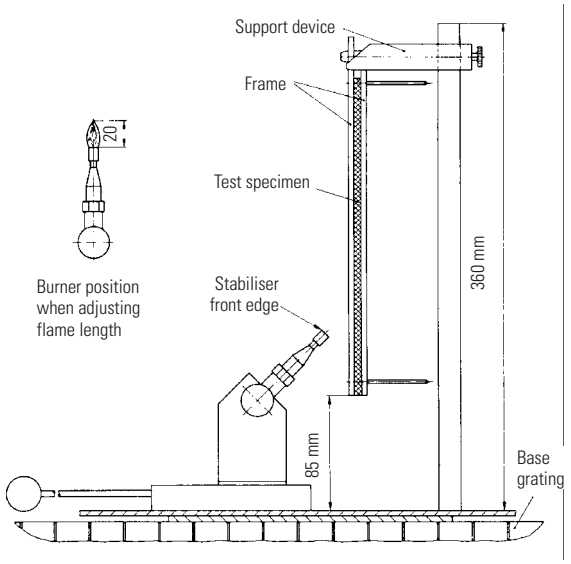
Test description for DIN 53438 (reaction against a flame of a burner)

	Part 2 Method K (edgeing flame action)	Part 3 Method F (surface flame action)
Specimen:	190 × 190 mm	230 × 90 mm
Thickness:	acc. relevant application	acc. relevant application
Marked line:	150 mm from lower end	40 and 140 m from lower end
Burner:	Bunsen	
Flame height:	20 mm at 45° on vertical bar	
Flame contact:	15 s	
Gas:	Propane	
Apparatus:	Draftfree chamber (see Fig. 1)	
Flame contact area:	see Fig. 2	see Fig. 3

Significance	Class	Class
Flame does reach upper mark, i.e. flame extinguishes before	K1/…mm*	F1/…mm*
Flame reaches upper mark in 20 s or more	K2/…mm*	F2/…mm*
Flame reaches upper mark in less than 20 s	K3/…mm*	F3/…mm*

* Thickness of tested sample

DIN 53438



Burner according to DIN 50051. This must be inclinable 45° from the vertical in the direction of the test specimen. It must be fitted with a guide allowing it to be mored horizontally towards the test specimen. Propane according to DIN 51662 should be used as the heating gas.

Combustion chamber according to DIN 50050. This should if possible be installed in a fume chamber. Particular attention should be given to the exhaust ventilation requirements of DIN 50050, February 1977 edition, Section 2.2.

Fig. 1. **Test set-up (schematic)**

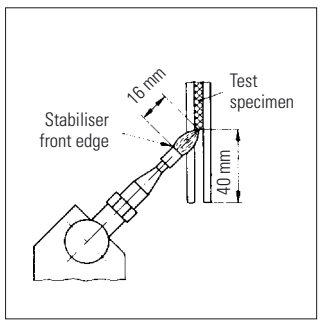


Fig. 2.

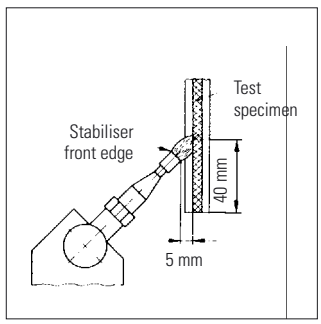


Fig. 3.

Smoke density

Scope

Laboratory method of comparing optical density of fumes produced by plastics when exposed to radiant heat while flaming or smoldering.

Test description

Specimen:	ASTM	– 25 × 25 × 6,2 mm	
	NF	– granules of resin, components etc.	
	UTE	– 76 × 76 × ≤25,4 mm	
Combustion:	ASTM	– NBS chamber	(Fig. 1)
	NF	– oven	(Fig. 2)
	UTE	– oven	(Fig. 3)

Significance

ASTM: Smoke density rating in %, measured by light absorption vs. time.

NF / UTE: Specific optical density D_s is measured with time.

$$D_s(t) = D(t)\,\frac{V}{s \cdot l}$$

V = chamber volume
s = sample exposed surface

$$\frac{V}{s \cdot l} = 132$$

l = optical distance (between bulb and optical cell)

$$D(t) = \log \frac{\Phi_0}{\Phi(t)}$$

Φ_0 = emitted light flux
$\Phi(t)$ = incident light flux at time t

D_m = maximum specific optical density reached during the test

${}^tD_m$ = time to reach D_m

VOF_4 = Accumulation of smokes during the first 4 minutes

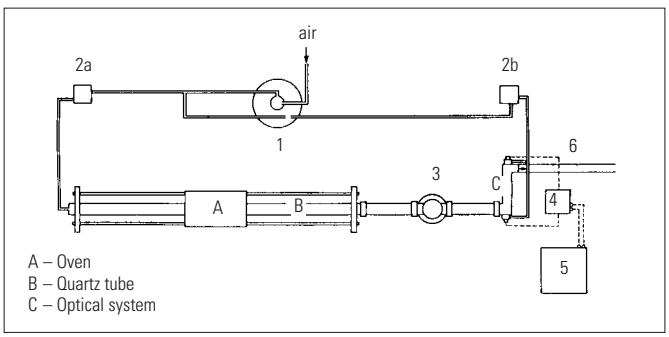
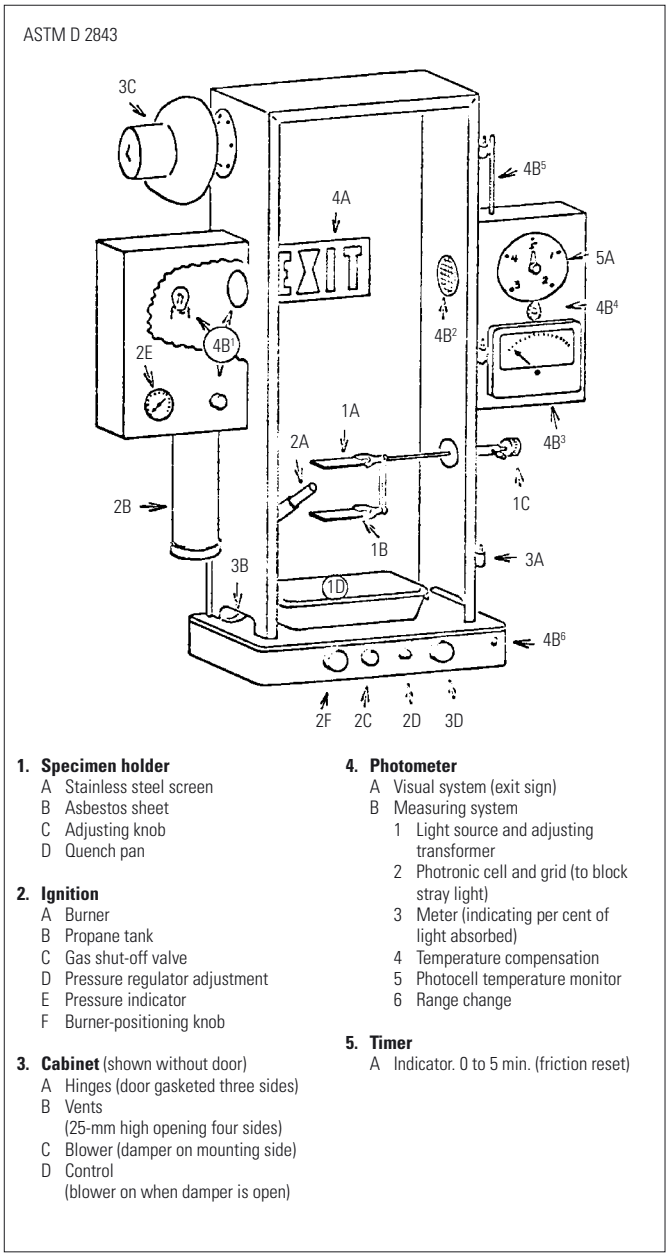


Fig. 2. **NF T 51-073**

ASTM D 2843
NF T 51-073
UTE C 20-452



1. Specimen holder
- A Stainless steel screen
- B Asbestos sheet
- C Adjusting knob
- D Quench pan

2. Ignition
- A Burner
- B Propane tank
- C Gas shut-off valve
- D Pressure regulator adjustment
- E Pressure indicator
- F Burner-positioning knob

3. Cabinet (shown without door)
- A Hinges (door gasketed three sides)
- B Vents (25-mm high opening four sides)
- C Blower (damper on mounting side)
- D Control (blower on when damper is open)

4. Photometer
- A Visual system (exit sign)
- B Measuring system
  - 1 Light source and adjusting transformer
  - 2 Photronic cell and grid (to block stray light)
  - 3 Meter (indicating per cent of light absorbed)
  - 4 Temperature compensation
  - 5 Photocell temperature monitor
  - 6 Range change

5. Timer
- A Indicator. 0 to 5 min. (friction reset)

Fig. 1. **Schematic diagram of smoke chamber**

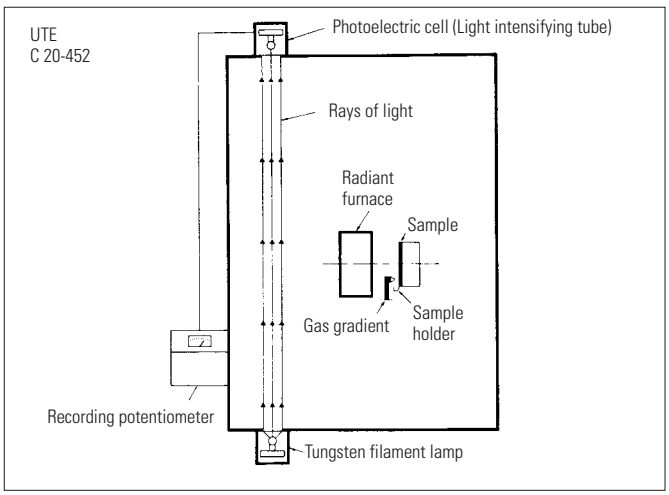


Fig. 3. **Schematic diagram of test chamber**

Smoke density

Smoke density, ASTM D 2843		% [1]
ZYTEL®	101L	<1
	151	<1

Specific optical density at max. smoke accumulation

		D_m [2]	
		RF	R
ZYTEL®	101L	26	13
	151	27	37

RF = Radiant source and flaming gas jets
R = Radiant source only
[1] Literature data
[2] Data from Flammability Handbook for Plastics, C. J. Hilado, Union Carbide Corp.

Smoke density, UTE C 20-452

	D_m	t_{D_m}	VOF_4
ZYTEL® 101 F NC-10	67/29*	20/11*	7,2/11,8*

* Sample flaming

Smoke compositions

Scope

Smoke compositions of melting or burning plastic is determined, in normalised conditions, to evaluate their respective toxicity. Different methods are used mainly by the aircraft and the underground transportation industries.

Test description

Samples of materials are usually pyrolised at different temperatures (400°C, 600°C, 800°C) and one measures the quantities of toxic gases generated per weight unit of the considered material. Commonly searched gases are:

CO, CO_2, SO_2, HCN, HC1, HBr, NO, NO_2, HF, H_2S.

Results

Considering the cost of these tests they are only run when needed. Please contact the local Du Pont respensentative if you need further information.

UTE C 20-452
ATS 1000.001/5

Aviation regulatory flame tests

Scope

Flame test applied to construction materials in the aircraft industry for the determination of their field of application.

Test description for FAR* 25853 (b) and ATS-1000.001/4

(Vertical Burning Test)

Specimen:	330 × 57 mm
Thickness:	2 mm or thinnest of application
Conditioning:	24 hours at 21°C / 50% RH
Burner:	Bunsen, 9,5 mm
Flame height:	38 mm
Contact time:	12 s
Gas:	temperature of flame must give 850°C
Apparatus:	see Fig. 1 +2
Flame contact area:	The one resulting of the burner position, vertical, 19 mm below the lower edge of the sample.

Classification

Product specimen passes test if:

– burned length is < 203 mm (measured from bottom of sample);

– burning after flame removal is ≤ 15 s;

– drippings do not burn more than 5 s after falling.

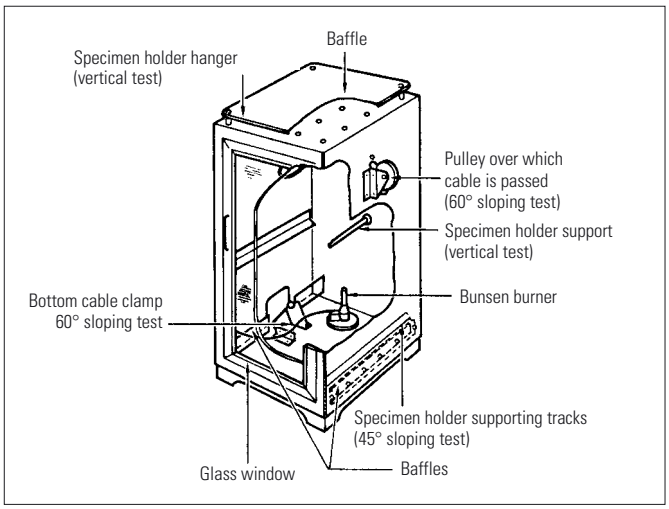


Fig. 1. **General assembly view – chamber for vertical and inclined tests**

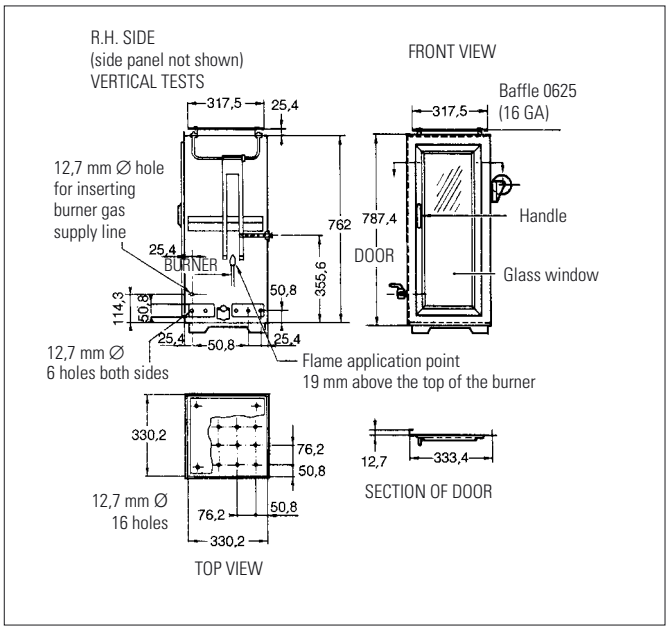


Fig. 2. **Chamber for vertical and inclined tests**

FAR 25853 (b)

	Resin passes requirements[1)]
RYNITE® FR530	+
ZYTEL® FR70M30V0	+

[1)] Thickness 2 mm

FAR 25853 (b)
ATS-1000.001/4

* US Federal Aviation Regulation

Flammability test for automotive materials

Scope

To measure the burning rate of materials, components, parts and portions of components, composites and substitute plaques, determining their possible use in automotive applications.

Test description

	Width	Length	Thickness
FMVSS* No. 302	100 mm	355 mm	as used in application. Usually tested in 1 mm thickness
ISO 3795	a) 3–60 mm	a) 356 mm	as used in application or <13 mm
	b) 60–100 mm	b) min. 138 mm	Usually tested in 1 mm thickness
DIN 75200	identical with ISO 3795		
VW TL 1010	identical with FMVSS No. 302		
Renault D451333	identical with FMVSS No. 302		
PSA D471333	identical with FMVSS No. 302		

Classifications

Category	Definition
DNI	**Does not ignite** The material does not support combustion during or after ignition.
SE	**Self-extinguished** The material ignited but did not burn to the timing zone (A).
SE / NBR	**Self-extinguished / No burn rate** The material stops burning before it has burned for 60 seconds from the start of timing, and has not burned more than 50 mm from the point where timing was started.

Classifications (continued)

Category	Definition
SE / B	**Self-extinguished / with maximum burn rate of 100 mm per minute** Material ignites but stops burning before flame reaches specified end point. Burn rate calculated from formula below. $B = 60 \times \frac{D}{T}$ B = Burn rate in mm / min. D = Distance the flame travels in mm T = Time in seconds for the flame to travel "D" in mm
B	**Maximum burn rate of 100 mm / min.** Calculated from same formula above (see Fig. below).

Pretreatment:	24 h / 23°C / 50 % RH
Burner:	Bunsen
Flame height:	38 mm
Flame contact:	15 s

Note

The rate of burning changes with the wall thickness. With some resins a relation between burning rate, shape and resin pigmentation can be noticed. The rate of burning is also definitely influenced by the test method and by moulding conditions of the part. The materials, grades and pigmentation normally used for materials in the motor vehicle industry meet the requirements for wall thickness of 0,5 to 1 mm.

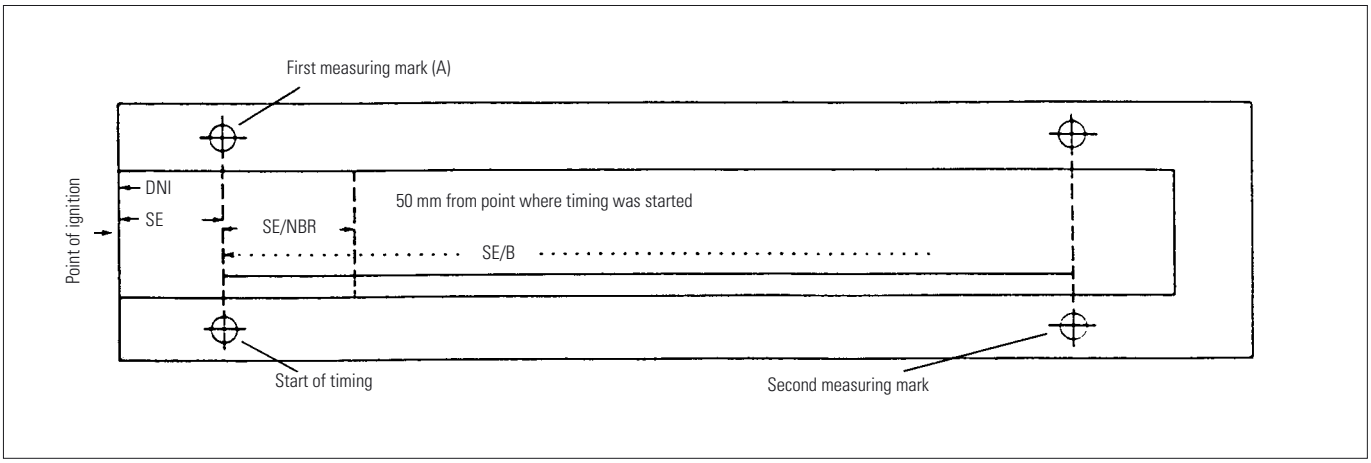


Fig. 1. **Determination of burn rate according to FMVSS No. 302**

FMVSS-302
ISO 3795
DIN 75200

* FMVSS-302 (Federal Motor Vehicle Safaty Standard / USA, contained in 49 CFR 571.302)

Flammability according to FMVSS No. 302[1)]

mm/min.

(full code : 49 CFR 571.302)		Colour	Average burn rate (mm/min.)
Crastin® PBT	S600F10	NC010	SE
	ST820	NC010	B38
	SK601	NC010	B36
	SK602	NC010	B30
	SK603, SK605	NC010	B28
	SK608	BK851	B62
	SK609	NC010	B27
	LW9020	NC10	B38
		BK851	B70
	LW9030	NC10	B42
		BK851	B80
	T805	NC010	B38
Delrin® POM	100	NC010	B43
		BK402	B40
	100P	NC010	B17
		BK402	B20
	100KM	NC000	B34
	100T	NC010	B38
	107	NC010	B34
	111P		
	500	NC010	B50
		BK402	B30
		RD401	B43
	500P	NC010	B15
	507	NC010	B39
		RD602	B32
		BK601	B37
	900P	BK602	B12
	100ST	NC010	B60
	500AL	NC010	B28
	500AF	NC010	B54
	500T	NC010	B48
		BK602	B55
	500CL	NC010	B31
		BK601	B41
	510GR	NC000	B46
	520MP	NC010	B37
	525GR	NC000	B49
	511P	NC010	B22
	570	NC000	B58
	577	BK000	B57
	1700P	NC010	B29
	127UV	BK701	B26
	527UV	BK701	B27
	900SP (DE8903)	NC010	B30
	911P		
	927UV	BK701	B27
Rynite® PET	520	NC010	B26
	530	NC010	B24
		BK503	B41
	545	NC010	SE/NBR
		BK504	SE/NBR
	935	NC010	B24
Zytel® PA66 unreinforced	101L	NC010	SE
		BKB80	SE
	101F	NC010	SE
		BKB09	SE
	101F	BK	SE
	105F	BK010	SE
	EFE1068	NC010	SE
		BK381	SE
	103HSL	NC010	SE
		BKB80	SE
	114L	BK097	B26
	135F	NC010	SE
	135F	BK	SE
	E42A	NC/BK/RD	SE
	E50	GY	SE
	408	NC010	B37
	408HS	BK009	B31
	408HS	BK010	B51
	450	NC010	B28
		BK010	B32
	490	NC010A	B35
	ST801	NC010	B32
		BK010	B38
	EFE4162HSL	BK152	B33
Zytel® PA66 unreinforced, flame retardant	FR7026V0F	NC010	SE
Zytel® PA66 glass reinforced	79G13L	NC010	B67
		BK039	B48
	70G13	BK031	B24

(full code : 49 CFR 571.302)		Colour	Average burn rate (mm/min.)
Zytel® PA66 glass reinforced (continued)	70G20HSL	NC010	B25
		BK039B	B26
	70G25HSL	NC010	SE/32
	70G30HSL	NC010	B28
		BK039B	B32
Zytel® PA66 glass reinforced	70G30HSL	YLB178	B8
		BK099	SE/B9
		BK186	B23
	70GB40HSL	BK351	SE
	70G30PSR	NC010	B22
	70G33HS1L	NC010	SE/B20
		BK031	B35
	70G33GRA	BK350	SE/B20
	70G35HSL	NC010	B42
	70G35HSLA4	BK267	B25
	70G43L	NC010	SE/B27
	70G43HSL	BK099	SE/B26
	70G60HSL	BK	SE/B30
	80G14	NC010	B36
		BKB085	B26
	80G33HS1L	NC010	SE/B15
	80G33HS1L	BK104	SE
Zytel® PA66/6 glass reinforced	72G30HSL	BK170	B31
	74G30L	NC010	
	74G33EHSL	BK354	
Zytel® PA6 unreinforced	7300, 7335F	NC010	SE
	7300T	NC010	SE/B27
Zytel® PA6 glass reinforced	73G15	NC010	B23
	73G15THSL	BK240	B38
	73G20L	NC010	B22
	73G30HSL	NC010	B50
		BK261	B45
	73G30T	NC010	B40
	73G30W	BK282	B43
	73G40	BK270	B44
Zytel® PA612	151L	NC010	SE
Zytel®-Kevlar® SFC	70K20HSL	NC010	SE
		BK284	SE
Zytel® flexible nylon alloy	FN718	NC010	B25
Zytel® HTN high performance polyamide	HTN51G35HSL	NC010	B23
	HTN51G45HSL	NC010	B29
	HTN51G15HSL	NC010	
	HTN51G35HSLR	NC010	
	HTN52G35HSL	NC010	
	HTNFR52G30BL	NC010	
	HTNFR52G35BL	NC010	
Zytel® DMX	61G15H	NC010	SE
	61G30H		
	ST601H	NC010	B14
Minlon® PA66 mineral reinforced	10B140	NC010	B31
		BK061	B31
	11C140	NC010	B38
		BKB86	B50
	13MM	GY282	B33
	14D1	BK113	B31
	21B1	BK143	B36
	23B1	BKB114	SE/B26
		NC010	B39
	EFE6053	BK210	B28
	EFE6091	BK	B51
	EFE6096	GY90A	B35
Minlon® PA6 mineral reinforced	73GM30HSL	BK261	B38
Hytrel® TEEE	4056	NC	SE/B34
		BK	SE
	4275	BK	B36
	4774, 4778	NC010	B33
	5526	NC010	SE/B30
	5555	HS	SE/NBR
	5556	NC	SE
		BK	SE
	5612	BK	B34
	6356	NC010	B32
		BK	SE/B36
	7246	NC	SE/B20
		BK	SE/B23
	8238	NC	DNI
	G3548L	NC	SE/B48
	G4074	BK	B45
	DYM100	BKB254	SE
	DYM500, DYM600	BK320	SE/NBR
Teflon® fluorinated resins	PTFE	NC010	DNI
	FEP, PFA	NC	DNI
Tefzel® fluorinated resins	ETFE	NC	DNI

For products or grades that do not appear on this table, please contact your DuPont representative for more information.

** Only available in natural colour.

* Only available in black.

[1)] All tests are done on specimens of 1 mm thickness.

“M” classification for construction and transportation NF P 92-507

Scope

This combination of tests is applied in France for the fire resistance classification of the materials to be used in the construction and transportation industries.

Test description

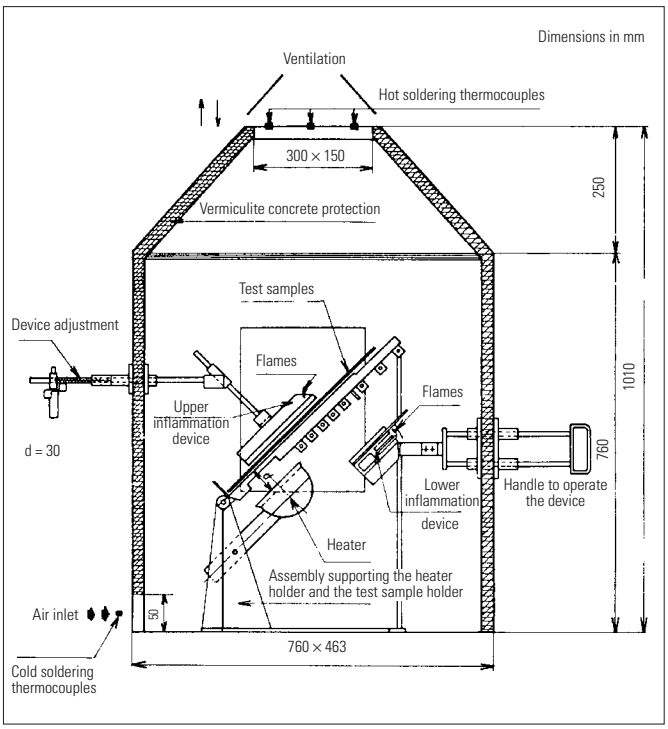
- Given results have to be achieved in defined testing procedures to be classified in a given category. Among the applied test one finds for rigid materials:
  - NF P 92-501 test applied on plates (300 × 400 mm × e = part thickness).
  - NF P 92-505 test applied on plates (70 × 70 mm × e = part thickness).

Classification

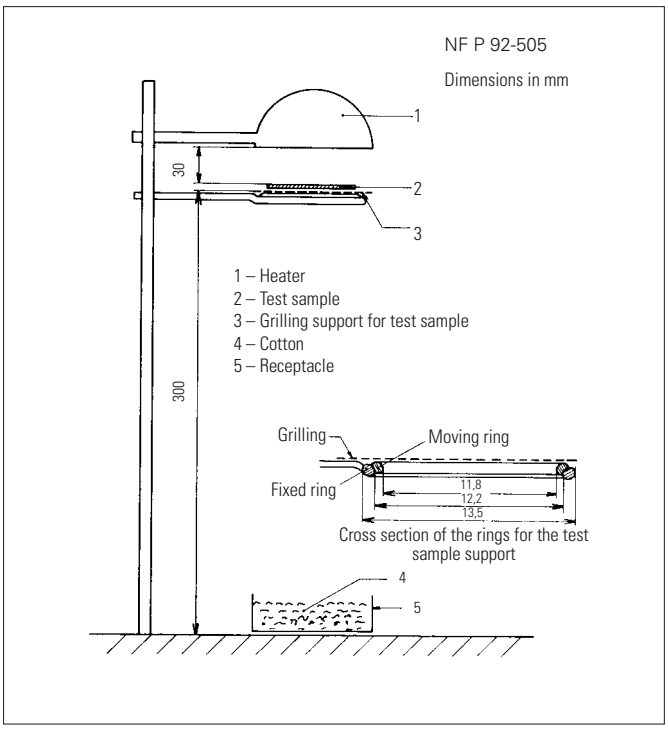
- This classification[1)] rates materials in 5 categories:
  M_0: incombustible
  M_1: non-flammable
  M_2: burns with difficulty
  M_4: easily flammable
  M_5: very easily flammable
- For small electrical parts the glow wire can alternatively be used to classify the parts in the following way:
  - to be M_0, part should pass the glow wire test at 960° C and extinguish in 5 s max.
    M_2, part should pass the glow wire test at 850° C and extinguish in 5 s max.
    M_3, part should pass the glow wire test at 750° C and extinguish in 5 s max.

Classification for small electrical parts according to Ministerial order of Dec. 22, 1981, laying down equivalents.

[1)] Used in the building industry in France



Box for flammability test (NF P 92-501)



Additional test for fusible material

“M” classification, NF P 92-507 Test results

PLATES, 300 × 400 mm	6,0 mm	3,0 mm	•	2,0 mm	1,5 mm	1,0 mm
RYNITE® FR530 NC010		M_2	M_0	–	–	–
ZYTEL® FR70M30V0 NC010		M_2	M_0	–	–	–

• Classification for small electrical parts according to Ministerial order of Dec. 22, 1981, laying down equivalents

NF P 92-507
NF P 92-501
NF P 92-505

"I/F" classification for transportation

NF F16.101

Scope

This combination of tests is applied in France for the ignition resistance and fumes classification of non-metallic electrical components used in the underground transportation industry.

Test description

1. Ignition

The ignition characteristics of a material is determined by a combination of the glow wire test (GWT, see page 38) and the oxygen index (O.I., see page 26). However, the GWT is a more severe version : no flame observed at all for the better ratings or no flame after withdrawal of the glow wire. Once the O.I. <28, the glow wire test is no longer done.

Table 1 Result of tests

Class	O.I.	Glow wire
I0	≥70	No ignition at 960°C
I1	≥45	No ignition at 960°C
I2	≥32	No ignition at 850°C
I3	≥28	Ignition does not persist at 850°C after glow wire is withdrawn
I4	≥20	
NC[1]	<70	

[1] NC: Non-classified.

The material under test is classified according to Table 1.

2. Fume composition

The parameters tested are:

Fume opacity and analysis of pyrolysis as well as combustion gases. All 3 parameters are used to calculate a "smoke index" (S.I.) which in turn determines the "fume class" F as per table 2.

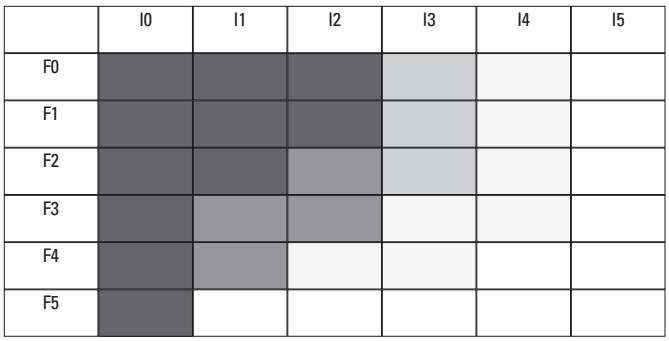
Table 2

Class	Value of S.I.
F0	≤5
F1	≤20
F2	≤40
F3	≤80
F4	≤120
F5	>120

Classification

Each material will eventually receive an I/F rating, the smaller the number the better. Unfortunately, good I and good F ratings are difficult to achieve: low I values frequently mean addition of FR packages which in turn leads to high F values.

Consequently and depending on the requirement of the application four (4) overall I/F performance classes were defined as per the scheme below :



Performance class 1, least demanding

Performance class 2

Performance class 3

Performance class 4, most demanding

According to our experience, underground transportation requires a I2/F2 classification or better.

Testing Institute

Because of the complexity of the testing, DuPont contracts the SNPE Institute in France for an official test report.

"I/F" test results according to NF F16.101

Resin	I rating	F rating
Zytel® XA374GY30D	3	3
Zytel® FR72G25V0	2	4
Zytel® FR7200V0F	3	2
Zytel® 490 NC010	4	2
Zytel® FR7026V0F		
Zytel® FR70G25V0		

Resin	I rating	F rating
Minlon® 11C140 NC010	4	2
Zytel® EFE1068 NC010	4	2
Zytel® 408 NC010	4	2
Zenite® 6130 WT010	2	1
Zenite® 7130 WT010	2	1

“PT”, “GPT”, “GET” Classification according to MIL-M-24519 military specification for the US Ministry of Defense

To be qualified in a class defined in the MIL-M-24519 specifications, thermoplastic polyesters have to show properties’ values within the ranges defined for each class. 19 properties are considered including mechanical, electrical properties, flame resistance, toxicity, heat resistance, water absorption and dimensional stability.

A recognised unfilled PBT will be classified “PT-F”. A recognised reinforced PBT will be classified “GPT” followed by the glass fibre content, e.i. GPT-30F.

A recognised reinforced PET will be classified “GET” followed by the glass fibre content, e.i. GET-30F.

RYNITE® FR530 is classified GET-30F

Government designation	Manufacturer’s designation	Test or qualification reference	Manufacturer’s name (address on last page)
Type GET-30F	RYNITE® FR530* RYNITE® RE9009*	US Testing Co., Inc. Rpts. 66417 and 83415; Detroit Testing Lab Rpt. 208563-1; and Inplant Rpt. 822481A and 822481B	E.I. du Pont de Nemours & Co., Inc.
Type GPT-30F	CRASTIN® SK645FR	Springborn Testing Institute Inc. Rpt. 1781.20	E.I. du Pont de Nemours & Co. Inc.

Manufacturer’s name, address and plant

E.I. du Pont de Nemours & Co., Inc.
Polymer Products Department
Barley Mill Plaza, Building #22
P.O. Box 80022
Wilmington, Delaware 19880
Plant: Washington Works
Parkersburg, WV
USA

* Rating obtained for material produced in U.S.A.

COR1, COR2, COR3, COR4 classification for plastic materials used in telecommunications equipments (France) DEC 26-0611

Significance
Plastic materials are pre-classified in view of their use in telecommunication equipments. According to the type of device the plastic material will have to achieve a given rating COR1, COR2, COR3 or COR4.

The rating is based on three test results:

- Flash ignition point: F.I.P. (p. 23)
- Limiting oxygen index: L.O.I. (p. 26)
- Corrosivity: C.O.R. (p. 58)

Rating	C.O.R.	L.O.I.	F.I.P.
C.O.R. 1	<5%	L.O.I. ≥ 27%	≥350°C
C.O.R. 2	5% ≤ C.O.R. <10%	27% ≤ L.O.I. <35%	≥400°C
		L.O.I. > 35%	≥350°C
C.O.R. 3	10% ≤ C.O.R. <15%	27% ≤ L.O.I. <35%	≥450°C
		L.O.I. > 35%	≥400°C
C.O.R. 4	15% ≤ C.O.R. <20%	27% ≤ L.O.I. <35%	≥500°C
		35% ≤ L.O.I. <50%	≥450°C
		L.O.I. ≥ 50%	
	C.O.R. > 20%		FORBIDDEN

P.S. Domestic telecommunication equipment will have to comply with the following criteria:

F.I.P.	L.O.I.	UL 94
≥350°C	≥27%	V-0

Please refer to the relevant page for test results.

Class 1, 2, 3, 4, classification for plastic material used in telecommunication equipment (U.K.) M147A

Significance

Plastic materials are pre-classified in view of their use in telecommunication equipments. According to the type of device the plastic material must achieve a minimal L.O.I. (limited oxygen index) value. (See also page 26).

Class 1	Class 2	Class 3	Class 4
L.O.I. ≥27	25≤ L.O.I. <27	22≤ L.O.I. <25	L.O.I. <22
• STOPS burning after removal of ignition source	• Burns vertically • Does NOT burn downwards, horizontally	• Burns vertically • Burns horizontally • Does NOT burn downwards	• Others

Class	Oxygen index	Typical usage	Examples of allowed usage
1	27 or above	High volume materials Large vertical surfaces Long vertical runs of material In situations where there are ignition hazards	Dust covers for relays etc. Equipment rack covers Cabling ducting Encapsulating resins for resistors Cases and potting resins for capacitors Tag blocks Printed wiring board sockets
2	25 or above, but less than 27	Low ignition hazard items	Gears, pulleys, latches, brackets, busbar covering
3	22 or above, but less than 25	Very low usage items	Certain labels
4	Less than 22	Normally prohibited, except for very low usage items in zero ignition situations	Canned components Gears in metal cases

Hot ball pressure test

°C

Scope

External parts of insulating material, the deterioration of which might cause the appliances to become unsafe, shall be sufficiently resistant to heat.

Test descripton

A ball of 5 mm diameter is pressed at 20 N for 1 hour against the surface of the sample at 80 ± 3 or 125 ± 5°C, or at a temperature which is 40 ± 2°C in excess of the temperature rise of the relevant part, whichever is the higher.

Apparatus: see Figure 1 and Illustration.

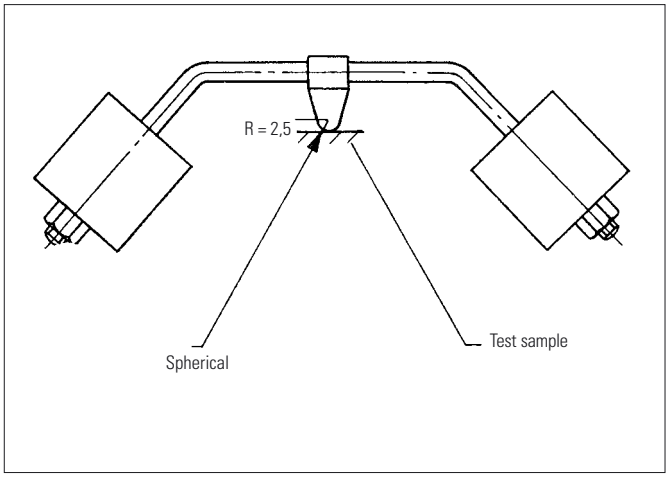


Fig. 1. **Hot ball pressure test apparatus**

Significance

After the ball is removed, the sample is cooled within 10 seconds to room temperature by immersion in cold water.

The diameter of the impression caused by the ball shall not exceed 2 mm. The rating is given as the maximum temperature at which the impression reaches, but does not exceed 2 mm.

VDE	0470, paragraph 4
VDE	0623, part 1
VDE	0625, paragraph 23
VDE	0630, paragraph 20 b
VDE	0720, part 1, paragraph 30
VDE	0730, part 1, paragraph 30 a
CEE	Publ. 10, part 1, paragraph 30 a
CEE	Publ. 11, part 1, paragraph 26 a
CEE	Publ. 12, paragraph 18 c
CEE	Publ. 17, paragraph 27 c
CEE	Publ. 20, paragraph 27 a, b
CEE	Publ. 24, paragraph 20 c
CEE	Publ. 25, paragraph 23 a
IEC	60309, part 1, paragraph 27.3
BS	3456, part 1, paragraph 30.1 and 30.2
BS	3676, paragraph 27 a, b
BS	3955, part 3, paragraph 21.1
BS	5733, paragraph 29.2
NF C	61-303, art. 51, paragraph 3
NF C	62-411, art. 3.21.1
NF C	73-150, paragraph 30.1
NF C	73-200, paragraph 30.1
NF C	75-100, paragraph 27 a
HN	60-E-01, paragraph 5

Hot ball pressure test °C

	Grade	Passed 125°C	Passed 165°C	Maximal temperature passed, °C
CRASTIN® PBT	S600F10, S620F20			180
	ST820			
	SK601			
	SK602, SK603, SK605, SK608			210
	SK609			220
	LW9020, LW9030			180
	T805			200
	SO653, SO655			190
	HTI619			210
	S650FR, S680FR			190
	T850FR			180
	SK641FR			
	SK642FR, SK643FR, SK645FR			210
	SK673GW			210
	CE7931			210
	LW9020FR, LW9030FR			180
	T841FR, T843FR, T845FR		*	170

Hot ball pressure test (continued) **°C**

	Grade	Passed 125°C	Passed 165°C	Maximal temperature passed, °C
Delrin® POM	100, 107	*	*	
	100P			
	111P			
	500	*	*	165
	507, 500P, 900P			
	511P, 911P			
	100ST	*		
	500T	*	*	170
Rynite® PET	520, 530, 545, 555, 935	*	*	235/245[1)]
	FR515			235
	FR530L	*	*	230/245[1)]
	FR943			200
	530CS	*	*	245
	936CS	*	*	240
	GW520CS			
	GW525CS			
Zytel® PA66 unreinforced	101L, 101F, 103HSL	*	*	200
	105F BK010, 114L BK097			
	135F	*	*	200
	E42A			
	408, 490	*		
	450	*	*	220
	ST801	*		
Zytel® PA66 unreinforced, flame retardant	FR7026V0F			
Zytel® PA66 glass reinforced, flame retardant	FR70G25V0, FR70G25GW			
Zytel® PA66 glass reinforced	79G13L			
	70G20HSL, 70G25HSL			
	70G30HSL	*	*	250
	70G30PSR, 70G33GRA BK**			
	70G35HSL	*	*	250
	70G50HSL, 70G60HSL BK**			
Zytel® PA66 glass-bead reinforced	70GB40HSL			
Zytel® PA66 mineral reinforced, flame retardant	FR70M30V0			
	FR70M40GW			
Minlon® PA66 mineral reinforced	10B140	*	*	250
	11C140	*		
Zytel® PA66/6 unreinforced, flame retardant	FR7200V0F	*	*	200
Zytel® PA66/6 glass reinforced, flame retardant	FR72G25V0			
Zytel® PA66/6 glass reinforced	74G30L NC010			
	74G33EHSL BK354			
Zytel® PA6 unreinforced, toughened	7300			
Zytel® PA6 glass reinforced	73G15, 73G20, 73G30, 73G40, 73G50			
Zytel® PA6 mineral and glass reinforced, flame retardant				
Zytel® HTN high performance polyamide	HTN51G35HSL, HTN51G45HSL	*	*	280
	HTNFR51G35L	*	*	270
	HTN51G15HSL	*	*	280
	HTNFR51G35HSLR	*	*	270
	HTN52G35HSL	*	*	280
	HTNFR52G30BL	*	*	270
	HTNFR52G35BL	*	*	280
Zytel® PA612	151L	*	*	200
Zytel® transparent	330 NC010	110		110
Zytel®-Kevlar® SFC	70K20HSL	*	*	250
Hytrel® TEEE	4056			
	G4078			
	5556, 7246			
Zenite® LCP	7130, 7140	*	*	300
	3130L WT010	*	*	
	6130 WT010	*	*	
	6330 NC010	*	*	
	7130 WT010	*	*	
Teflon® fluorinated resins	PTFE, PFA			
Tefzel® fluorinated resins	ETFE			
	HT2004			
Surlyn® ionomer resins	8940, 9020, 9450, 9720			
Vespel® polyimide resins	SP1, SP21			

[1)] Depending on moulding conditions or annealing. ** Only available in black. *** Only available in natural colour.

For products or grades that do not appear on this table, please contact your DuPont representative for more information.

Deflection temperature under flexural load

Scope

Give an indication on the maximum short term temperature a polymer can withstand under load.

Test description

A bar of rectangular cross section is tested as a simple beam under a load (1,8 or 0,45 MPa) applied at its centre to give maximum fibre stresses. The test is done in a heat transfer medium provided with a means of raising the temperature at 2 ± 0,2°C/min. The temperature is recorded as the deflection temperature under flexural load of the test specimen.

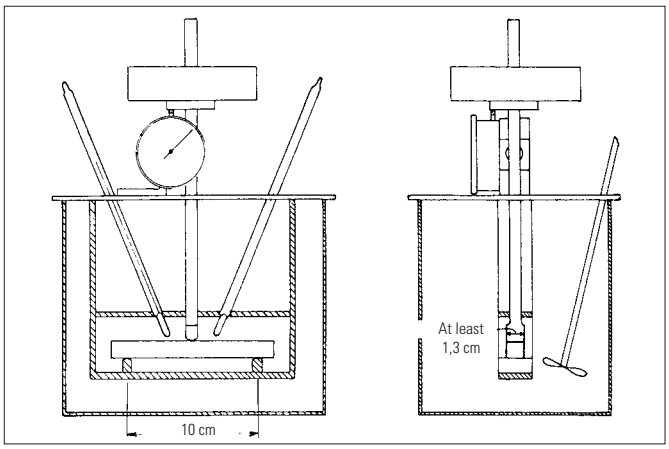


Fig. 1. **Apparatus for deflection temperature test**

Deflection temperature under flexural load, ASTM D 648, DIN 53461, ISO 75 **°C**

		0,45 MPa DAM	1,8 MPa DAM
Crastin® PBT	S600F10, S620F20	160	60
	ST820	105	48
	SK601	215	185
	SK603	220	204
	SK605	220	205
	SK609	222	215
	LW9020	215	172
	LW9030	215	182
	T805	205	190
	SO653	185	70
	SO655	212	99
	HTI619	220	200
	S650FR	160	65
	S680FR	175	64
	T850FR	167	60
	SK642FR	218	203
	SK643FR	220	205
	SK645FR	220	210
	CE7931	221	210
	SK673GW	220	205
	LW9020FR	215	175
	LW9030FR	220	190
	T841FR	200	183
	T843FR	204	188
	T845FR	205	192
Delrin® POM**	100, 107, 500, 507	170	115
	100ST	145	70
	111P	170	115
	500T	165	90
	500AL	170	115
	500AF	168	105
	500CF	170	105
	511P	170	115
	570	174	158
Rynite® PET	520		220
	530		224
	545		226
	555		229
	935		200
	940		225
	FR515		200
	FR530L, FR543		225
	FR943		220
	530CS		225
	936CS		210
	GW520CS		
	GW525CS		235

DIN 53461
ISO 75
ASTM D 648

		0,45 MPa DAM	1,8 MPa DAM
Zytel® PA66 unreinforced**	101L, 101F, 103HSL	225	80
	105F BK010	210	80
	114L BK097	205	75
	135F	210	85
	408	210	65
	450, 490	210	65
	ST801	210	65
Zytel® PA66 unreinforced, flame retardant	FR7026V0F		
Zytel® PA66 glass reinforced, flame retardant	FR70G25GW		
	FR70G25V0		240
Zytel® PA66 glass reinforced	79G13L		240
	70G20HSL, 70G25HSL		250
	70G30HSL, 70G35HSL		250
Zytel® PA66 mineral reinforced, flame retardant	FR70M30V0	240	200
	FR70M40GW		
Minlon® PA66 mineral reinforced	10B140	240	210
	11C140	220	145
Zytel® PA66/6 unreinforced, flame retardant	FR7200V0F	195	75
	FR7026V0F		
Zytel® PA66/6 glass reinforced, flame retardant	FR72G25V0	240	215
	FR70G20V0		
Zytel® PA66/6 glass reinforced	74G30L NC010	250	225
	74G33EHSL BK354	250	235
Zytel® HTN high performance polyamide	HTN51G35HSL	276	264
	HTN51G45HSL	276	264
	HTNFR51G35L	270	255
Zytel® PA612	151L, 153HSL, 158	180	90
	77G33L	215	200
	77G43L	215	205
Zytel®-Kevlar® SFC	70K20HSL		
Hytrel® TEEE	4056	50	
	G4078		
	5556	70	70
	7246	115	50
Zenite® LCP	3130L WT010		230
	6130 WT010	277	265
	6140L WT010		280
	6330 NC010		245
	7130 WT010		295
	7145L WT010		300
Surlyn® ionomer resins	8940	44	
	9020	40	
	9450	41	
	9720	43	
Vespel® polyimide resins	SP1, SP21		360

* Only available in black.
** Annealed.

For products or grades that do not appear on this table, please contact your DuPont representative for more information.

Electrolytic corrosion[1)]

Scope

Electrical insulating materials at high atmospheric humidity and under the influence of electric stress may cause corrosion of metal parts in contact with them. Such electrolytic corrosion is dependent upon the composition of the insulating material and the character of the metal; it is influenced by temperature, relative humidity, nature of the voltage and time of exposure. Direct voltage produces much more rapid and extensive corrosion than alternating voltage. Corrosion is more pronounced at the positive electrode (anode).

Electrolytic corrosion may cause open-circuit failure in electrical conductors and devices. It may promote low resistance leakage paths across or through electrical insulation and the products of corrosion may otherwise interfere with the operation of electrical devices, i.e. it may prevent operation of contacts, etc. Thus, electronic equipment operating under conditions of high humidity and temperature may be particularly subject to failure from electrolytic corrosion. The selection of insulating materials which do not produce electrolytic corrosion is particularly important for such applications.

Classification

Evaluation of the positive and negative pole foils is done by the aid of a magnifying glass (2,5×) by describing corrosion index given in the table.

Corrosion index table

- **Cathode foil**

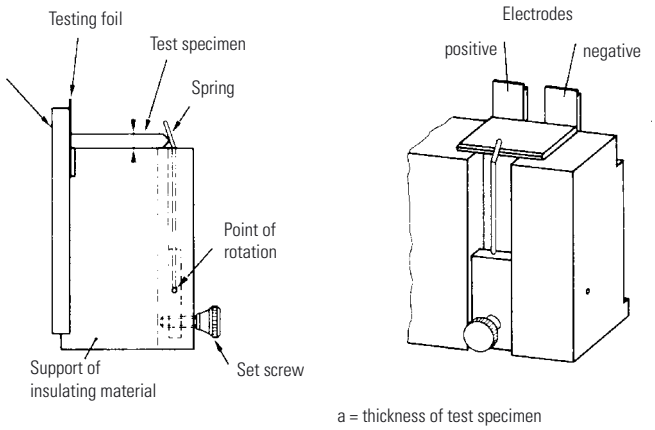
1. No change
1.2 Slight change in form of spots or fine stripes
1.4 Increased discolouration (brown)
1.6 Black discolouration in form of small spots together with discolouration as under 1.4
1.8 As 1.6 but increased number of black spots
2. Mainly black discolouration in form of meeting spots
3. Complete discolouration of contact area to cathode (–)
4. Complete discolouration in excess of contact area to cathode.

- **Anode foil**

A No change
AN Slight discolouration and marks
AB Slight red discolouration
B Significant red discolouration and/or green spots

Test description

Specimen:	4 mm thickness, bar 200 × 10 mm or plate
Metal foil:	MS 63 F 45 or MS 63 F 55 10 mm width, 0,1 mm thick
Exposure:	40°C/93 ± 2% RH
Voltage:	100 ± 5 V
Exposure time:	4 days
Apparatus:	see Fig. 1



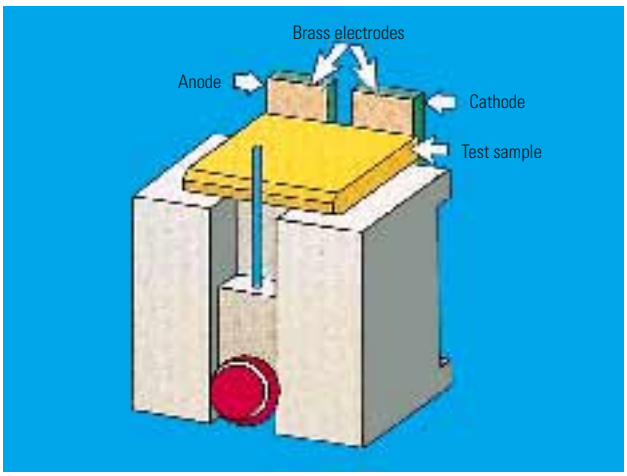


Fig. 1. **Device for testing cut surface of insulating materials**

[1)] Determined by outside institutes

VDE 0303, part 6
IEC 426
DIN 53489

Test results

RYNITE®	FR530 NC010	A-1
CRASTIN®	S600F10, S650FR	A-1
	T845FR	A-1
	T850FR	A-1.2
	SK645FR	A-1.2
	HTI668FR	A-1.2
ZYTEL® PA66 unreinforced	101L NC010	AN-1.2
	ST801 NC010	A-1.2
ZYTEL® PA66 mineral reinforced, flame retardant	FR70M30V0 NC010	A-1.4
ZYTEL® PA66 unreinforced, flame retardant	FR7200V0F	AB-1.6
	FR7026V0F	
ZYTEL® PA66/6 glass reinforced, flame retardant	FR70G25V0F	
	FR72G25V0F	
ZYTEL® PA612	151	AN-1.2
ZENITE® Liquid Crystal Polymer	7130 WT010	
	7145L WT010	

Corrosivity of decomposition products (C.O.R.)

Scope

The corrosiveness of combustion products is determined from the increase in electrical resistance of a standard copper circuit board after combustion of the sample and condensation of the effluents on the cooled circuit.

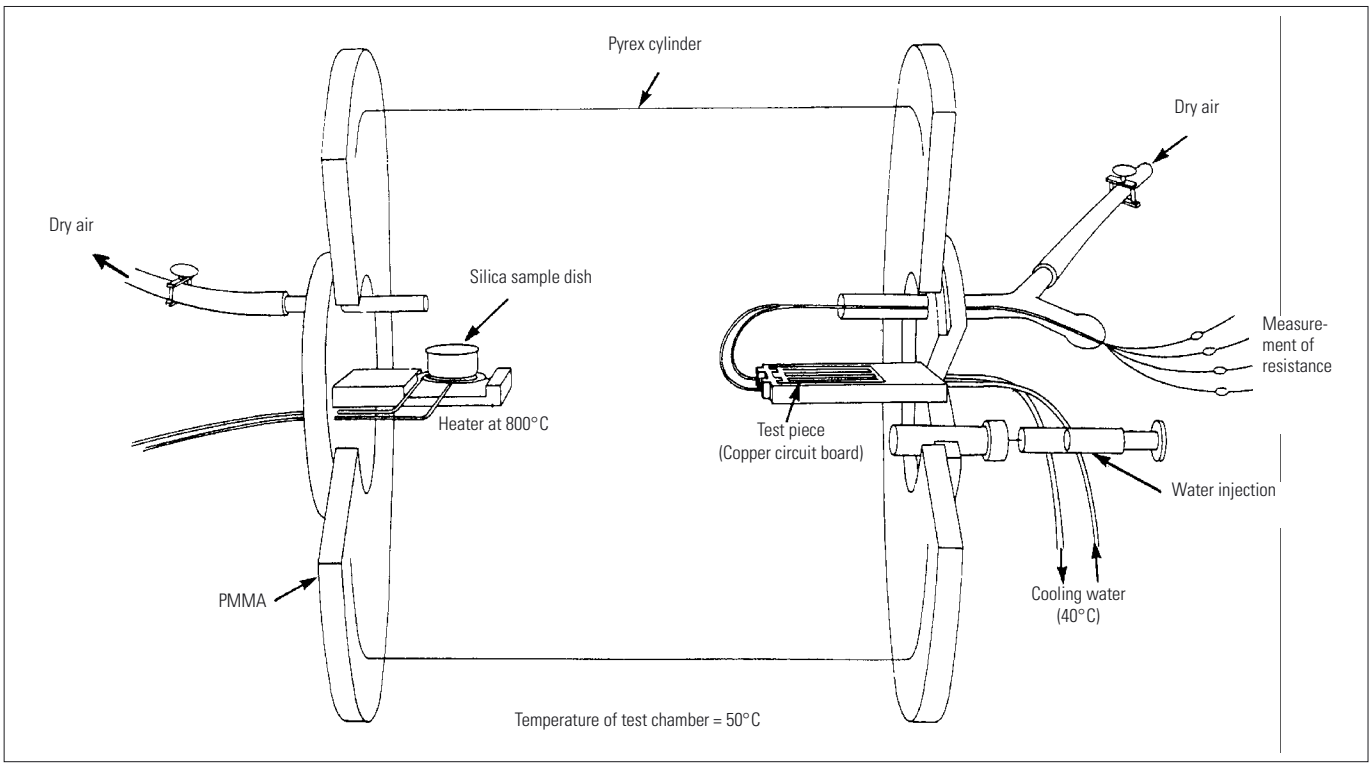
Test description

– 600 mg of sample is co-combusted with 100 mg polyethylene on an Inconel resistance heater at 800°C in a thermostatted chamber at high relative humidity.

– The combustion products are condensed out on to a copper printed circuit board.

– The corrosive effect is assessed by determining the relative increase in the electrical resistance of the PCB after one hour exposure.

CNET corrosivity chamber



The corrosivity (C.O.R.) is expressed in %

$$C.O.R. = \frac{R_f - R_i}{R_i}$$

R_f = final resistance

R_i = initial resistance

Some values are available. The test is not yet final and one should contact DuPont if specific product values are requested.

CNET (French National Telecommunications Laboratory)
Ref: DEC 26-0611
Test under development

How to read and interpret a UL (Underwriters Laboratories Inc.) Yellow Card

The UL (Underwriters Laboratories Inc.) classification system for plastic materials is the most widely used, even outside the USA, the main reason being that it is the only classification system listing **plastic materials.**
The listing is according to temperature, flammability and electrical properties. Very important is the fact that the famous V-0, V-1, V-2, HB, 5VA and 5VB flammability classification according to UL 94 (column 3) is only **one** of a total of nine properties. The remaining eight properties can be as important.

QMFZ2 November 11, 1999
Component – Plastics

E I DUPONT DE NEMOURS & CO INC **E41938**
WILMINGTON DE 19880

Material Designation: **101(fl)+, 101F(fl)+, 101L(fl)+, E101(fl)+, E101L(fl)+,132F(fl)+, 133L(fl)+, 135F(fl)+**

Product Description: Polyamide 66 (PA66), designated "Zytel" furnished in the form of pellets.

Color	Min. Thk. mm	Flame Class	HWI	HAI	RTI Elec	RTI Imp	RTI Str
ALL	0.71	V-2	4	0	130	75	85
	1.5	V-2	3	0	130	75	85
	3.0	V-2	2	0	130	75	85
	6.0	V-2	2	0	130	75	85
					CTI: 0	**HVTR**: 0	**D495**: 6

(fl) – Suitable for outdoor use with respect to exposure to Ultraviolet Light, Water Exposure and Immersion in accordance with UL 746C.
+ – Virgin and Regrind from 1% to 50% by weight inclusive, have the same basic material characteristics.
NOTE – Material designations that are colour pigmented may be followed by suffix letters and numbers.

Report Date: 07/29/1996 Underwriters Laboratories Inc.® 324299-147

Following columns are on the UL card.

Material designation

Column 1 – Colours
2 – Thickness
3 – Flammability rating acc. UL 94
4 – Hot wire ignition in sec. (HWI)
5 – High amperage ignition (HAI)
6, 7, 8 – Relative temperature indexes (RTI):
6 – Electrical
7 – Mechanical with impact
8 – Mechanical without impact

Comparative tracking index (CTI) ASTM D 3638, UL 746 A
High voltage track rate (HVTR)
Arc resistance ASTM D 495, UL 746 A

Material designation
Identifies the resin grade. Note that quite a number of different grades can be listed together.

Column 1:
Colours
Refers to colours with "BK" and "ALL" meaning as pigmented by DuPont, cube blends included.

Column 2:
Thickness
Shows the minimum thickness in mm for which a given rating was obtained. The thickness usually ranges from 0,35 mm up to 6,0 mm.

Column 3:
Flammability classification according to UL 94
This is the best known of all UL ratings. UL 94 refers to the testing methods used by Underwriters Laboratories Inc. UL 94 rates different plastics according to the **ease of extinguishment** after the ignition flame has been removed **(for details and results see pages 31–33).**

Column 4:
Hot Wire Ignition (HWI), UL 746 A (seconds)
Objective is to judge the **ease of ignition** of a plastic part which is in contact with a heat source (not an open flame). The test simulates the case that the **plastic part is in contact with an overheated electrical wire.**

A wire is wound around a test bar (length = 125 mm, width = 12,5 mm, thickness as indicated on yellow card) and then the wire is heated up to 930°C (6,7 A leading to 0,26 W/mm heat generation) recording the time (s) until the sample ignites. Five test bars are tested at least. The test bars are conditioned for 40 h, at 23°C, 50% RH.

Hot wire ignition (HWI) performance is expressed as the mean number of seconds needed either to ignite standard specimens or to burn through the specimens without ignition. The specimens are wrapped with resistance wire that dissipates a specified level of electrical energy.

See table next page

* Performance level classes (PLC) are added for HWI, HAI, HVAR, HVTR and CTI

HWI range – mean ignition time (IT in sec.)	Assigned PLC on UL card
120 ≤ IT	0
60 ≤ IT < 120	1
30 ≤ IT < 60	2
15 ≤ IT < 30	3
7 ≤ IT < 15	4
0 ≤ IT < 7	5

Column 5:

High amperage arc ignition (HAI), UL 746 A (number of arcs)

This test simulates the situation that an **arc occurs between two electrodes** under **low voltage** but a **high current,** e.g. the two connector pins of a plug. The arc is created on the surface of the plastic resin sample.

The test specimen is a test bar (length 127 mm, width 12,7 mm, thickness as specified on the yellow card). Two copper electrodes are placed onto the sample between which an arc is developed on the test sample surface with a short circuit current of **32,5 A** (at 240 V, 60 Hz) and a power factor of 0,5.

Forty complete arcs per minute are created by approaching the moving electrode to the fixed one until the arc occurs and then moving mobile electrode away with a speed of 250 mm / sec.

A minimum of three test specimens are subjected to the test. No test sample condition is specified.

High current arc iginition (HAI) performance is expressed as the number of arc rupture exposures (standardized as to electrode type and shape and electrical circuit) which are necessary to ignite the 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 on UL card
120 ≤ NA	0
60 ≤ NA < 120	1
30 ≤ NA < 60	2
15 ≤ NA < 30	3
0 ≤ NA < 15	4

Column 6, 7 and 8:

Relative temperature index (RTI) UL 746 B (°C)

These values give an indication of the **long term behaviour** of a plastic resin in respect to selected properties.

Three different values are given for:
– electrical properties
– mechanical properties with impact
– mechanical properties without impact

Column 6:

Electrical properties

This column shows the **upper use temperature** in °C related to **electrical material properties.** The criterion is the temperature at which after 60 000 h (7 years) the **most sensitive electrical property** drops to **50% of its initial value.** Normally only dielectric strength is tested. In other words, this property has at least 50% of its inital value after 7 years of continuous exposure to the temperature indicated.

Column 7:

Mechanical properties with impact

This column shows the **upper use temperature** in °C for **impact related mechanical properties.** The criterion is the temperature at which after 60 000 h (7 years) the **most sensitive impact property** drops to **50% of its initial value.**

Normally measured are:
– tensile impact (tested on unfilled resins only)
– lzod impact (tested on filled resins only).

Column 8:

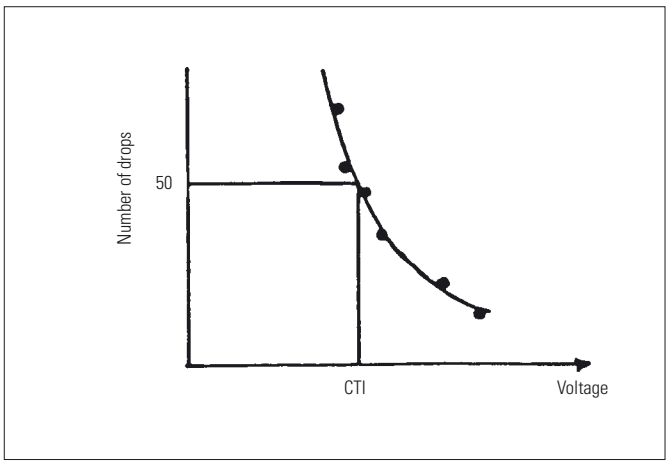
Mechanical properties without impact

This column shows the **upper use temperature** in °C for **non impact related mechanical properties.** The criterion is the temperature at which after 60 000 h (7 years) the **most sensitive non impact related mechanical property** drops to **50% of its initial value.** Normally only tensile strength is measured.

Comparative tracking index (CTI)
ASTM D 3638 / UL 746 A (volts)

This test simulates the case that a **current develops** due to a **surface contamination of the plastic insulator in between two conductors.**

Onto a test specimen (length 127 mm, width 12,7 mm, thickness normally 3 mm, or as shown on the yellow card) two electrodes are placed at a distance of 4 mm.



The following test procedure is run on 5 specimens each:
– A given voltage is applied to the two electrodes.
– A 0,1% ammonium choride solution is dropped in between both electrodes at a rate of 2 drops / minute until tracking occurs.
– The tracking is defined by a current increase from almost 0 Ampere to 1 Ampere together with a voltage decrease.
– The average number of drops / voltage relation is plotted into the graph shown above.

The selection of the voltage should be done in a way that at least 2 test values (= voltages at which tracking occurs) need less than 50 drops of the solution, and 2 test values need more than 50 drops.

A curve is then drawn based upon the (at least) 4 test values. The shape of the curve reflects the UL experience with the (number of drops/voltage) relationship of plastics.

The CTI value is defined as the voltage which leads to tracking at 50 drops.

See also Tracking resistance, page 20.

Comparative tracking index (CTI) is expressed as that voltage which causes tracking on a material after 50 drops of 0,1% ammonium chloride solution have fallen. The results of testing the nominal 3 mm thickness are considered representative of the material's performance in any thickness.

CTI range – tracking index (TI in volts)	Assigned PLC on UL card
600 ≤ TI	0
400 ≤ TI < 600	1
250 ≤ TI < 400	2
175 ≤ TI < 250	3
100 ≤ TI < 175	4
0 ≤ TI > 100	5

For further information and results see pages 20-22.

Please refer to the latest edition of UL yellow cards for classification.

Please contact your DuPont representative for the relevant UL yellow cards.

High voltage tracking rate (HVTR), UL 746 A classification according to number of tracking rates (mm/min.)
This test is designed to determine the ability of a material to withstand **repeated high-voltage low-current arcing** at is surface without forming a conductive path.

Onto the test specimen (length 127 mm, width 12,7 mm, thickness normally 3,2 mm or as shown on the yellow card) two electrodes are placed at a distance of 4 mm. **5200 V** at 60 Hz are applied to the electrodes. As soon as an arc occurs **(max. current = 2,36 milliamp.),** the electrodes are separated until the arc extinguishes. Then the electrodes are again moved closer together until the arc is reestablished. This procedure is carried out for a **total testing time of 2 minutes,** except if the tracking length (= distance between electrodes) is ≥ 50,8 mm.

Tested are 3 test bars, conditioned for **40 h at 23 °C, 50% RH.**

The tracking rate number shown on the yellow card is the classification according to the tracking length in mm/min. (Fig. see under arc resistance, p. 18).

High voltage arc tracking rate (HVTR) is denoted as the rate, mm/min., at which 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 (3 mm) thickness are considered representative of the material's performance in any thickness.

HVTR range – tracking rate (mm/min.)	Assigned PLC on UL card
0 ≤ TR ≤ 10	0
10 ≤ TR ≤ 25	1
25 ≤ TR ≤ 80	2
80 ≤ TR ≤ 150	3
150 ≤ TR	4

High voltage, low current, dry arc resistance ASTM D 495 / UL 746 A (seconds)
This test simulates the creation of a conductive path on the resin surface when subjected to **high voltage between two electrodes.** This may happen if two high voltage conductors are separated by a plastic insulator.

Onto a test specimen (length 127 mm, width 12,7 mm, thickness normally 3,2 mm or as shown on yellow card) two electrodes are placed at a distance of 6,35 mm. 15 000 V are applied to the electrodes, which will create an arc on the test sample surface.

The following conditions are applied stepwise:

for	a current of	is applied in the cycle		test-time
60 s	10 mA	¼ s on	1¾ s off	0–60 s
60 s	10 mA	¼ s on	1¾ s off	60–120 s
60 s	10 mA	¼ s on	1¼ s off	120–180 s
60 s	10 mA	continuous		180–240 s
60 s	20 mA	continuous		140–300 s
60 s	30 mA	continuous		300–360 s
60 s	40 mA	continuous		360–420 s

Thus, from second 0 to 180 the arc is lit and extinguished with an increasing frequency.

Failure of the part occurs:
– when a current occurs between the two electrodes
– if the test sample ignites.

Arc resistance (D 495) according to ASTM D 495 is expressed as the number of seconds that a material resists the formation of a surface conducting path when subjected to an intermittently occurring arc of high voltage, low current characteristics. The results of testing the nominal 3 mm thickness are considered representative of the material's performance in any thickness.

D 495 range – mean time of arc resistance (TAR in sec.)	Assigned PLC on UL card
420 ≤ TAR	0
360 ≤ TAR < 420	1
300 ≤ TAR < 360	2
240 ≤ TAR < 300	3
180 ≤ TAR < 240	4
120 ≤ TAR > 180	5
60 ≤ TAR > 120	6
0 ≤ TAR > 60	7

For results see page 19.

How to read and interpret a CSA card (CSA C22.2, No. 0.6-M 1982)

The CSA card similarly to the UL yellow card rates polymeric materials according to a number of standardised tests. These tests are covering flame resistance, electrical, mechanical and thermal ageing properties. Some of the tests are identical to those of the UL yellow card, but more generally they differ sufficiently so that one should not be attempted to derive CSA results from the UL yellow cards.

I. Main polymer flammability tests performed in accordance with C22.2 No. 0.6*

F-1 – Test A: 127 mm flame test

This is a general purpose high intensity flame test using five 15 s applications of a 127 mm flame with an inner blue cone of 38 mm. The flame is not reapplied if the sample flames beyond the 15 s rest interval and is to be reapplied if flaming ceases provided it is not more than 30 s from when the flame was last removed.

Ratings

A00 = no holes; no cotton ignition.
A00I = no holes; cotton ignition.
A25 = hole less than 0,25 inch (6,35 mm); no cotton ignition.
A25I = hole less than 0,25 inch (6,35 mm); cotton ignition.
A++ = hole more than 0,25 inch (6,35 mm); no cotton ignition.
A++I = hole more than 0,25 inch (6,35 mm); cotton ignition.

If 2 out 3 specimens droop from the top edge more than 25 mm, it will be indicated via a "technical comment".

F-2 – Test B: Flame test for combustion-resistant materials

This test and observations are simular to Test A; however a flame is not to be reapplied if the sample flames beyond the 5 s rest intervals and is to be reapplied if flaming ceases provided it is 30 s or less from when the flame was last removed.

Ratings

Same as Test A but with the prefix B, e.g. B00
B00I
etc.

F-3 – Test C: Horizontal/Vertical flame test for combustion-resistant materials

This test consists of applying the same flame as in A and B five times for 5 s with no reapplication permitted if the sample flames beyond the 5 s rest inverval and is reapplied after flaming has ceased if not more than 60 s have elapsed since the flame was last removed. Two sets of three specimens shall be tested, three vertical and three horizontal. The same observations as in Test A are noted by the flammability technician.

Ratings

P = passed test
F = failed test

F-4 – Test D: Horizontal burning flame test

Test D uses a 19 mm yellow flame that is applied to a horizontal sample mounted above surgical cotton. The burner is placed below the sample for 30 s, removed for 60 s, and then reapplied for an additional 30 s. Similar observations to Test A are noted for the first and second applications.

Ratings

Same as Test A but with prefix D, e.g. D00
D00I
etc.

F-5 – Test E: Horizontal burning test for classifying materials as 0.6HB(similar to UL 94 HB rating)

Specimens for this test are first conditioned in accordance with C22.2 No. 0.6, C1 9.2.3. This flame test uses a 25 mm blue flame that is applied to specimens (outlined in C22.2 No. 0.6, C1 9.2) for 30 seconds or until the specimen burns to the 25 mm mark if it is prior to 30 seconds, and then removed. The time for burning to occur between the 25 mm and 100 mm mark is recorded and the burn rate is calculated.

Materials classified as 0.6HB shall:

a. not have a burning rate greater than 38 mm/min. over a 76 mm span for specimens having a thickness of 3,0 to 3,2 mm;
b. not have a burning rate exceeding 76 mm/min. over a 76 mm span for specimens having a thickness less than 3,0 mm;
c. cease to burn before the flame reaches the 100 mm reference mark.

Ratings

0.6HB = slow burning rating granted
0.6HF = failed test.

For test results see p. 37.

F-6 – Test F:

Vertical burning test for classifying materials as 0.6V-0, 0.6V-1, 0.6V-2 (similar to UL 94 V-0, V-1, V-2 Ratings).

Two sets of specimens are conditioned according to the specifications in C22.2 No. 0.6, C1 10.2.3.

A 19 mm blue flame is applied to a sample for 10 seconds, removed, and reapplied for another 10 seconds when flaming ceases.

Ratings

0.6V-0 = V-0 rating granted
0.6V-1 = V-1 rating granted
0.6V-2 = V-2 rating granted
0.6V-F = failed test.

For test results see p. 37.

* The prefix 0.6 shown with the ratings, e.g. 0.6HB refers to the CSA Standard on flame tests C22.2 No. 0.6

F-9 – Test I: Hot wire ignition test
This test is designed to determine if nonmetallic enclosure materials will resist ignition when subjected to contact with a hot wire. A 20% chromium, 80% nickel wire providing 65W, at approx 9.8 to 9.9V, is used to produce a temperature near 600°C. This voltage is applied until ignition occurs or 60 s have elapsed. A material is deemed to pass if it does not ignite while in contact with the hot wire for 15 s.

Ratings
HWI-25 = passed test; ignition occurred at 25 s (max. 60 s)
HWI-2F = failed test; ignition occurred less than 15 s

PS: This test is different from the UL yellow card HWI.

II. Main electrical tests performed in accordance with C22.2 No. 0.11

Arc resistance (ASTM D-495)
This test measures the number of seconds required to form a conductive path by decomposition at the surface of the plastic material using high voltage and low current.

(See pages 18–19, 60–61).

Dielectric test
The dielectric test determines the breakdown voltage required to rupture or puncture a path through the polymer by electrical discharge, thermal, or intrinsic breakdown. **(See pages 10–12).**

Comparative Tracking Index (CTI)
The comparative tracking index provides an indication of the relative track resistance of the material when it is exposed to up to 600 V.

A fire or shock hazard may develop within electrical equipment as a result of the electrical tracking of insulating material that is exposed to various contaminating environments and surface conditions. The comparative tracking index provides a comparison of the performance of insulating materials under wet and contaminated conditions. **(See p. 20).**

High Current Arc Ignition (HAI)
This method determines a material's ability to resist ignition when exposed to an arcing electrical source. **(See p. 60).**

High voltage arc ignition
The purpose of this test is to determine the susceptibility of the test material to ignition or to form visible carbonized conducting paths over its surface when subjected to high voltage, low current arcing.

Relative thermal or temperature index as per UL description p. 59
Material temperature limits are established by relative comparisons of a critical physical property having an acceptable long-term field-service history under varied conditions and applications. A basic knowledge of the material's end use is necessary. **(See p. 60).**

Please refer to the latest edition of UL/CSA cards for classification.

Please contact your DuPont representative for the relevant UL/CSA cards.

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