PHENOLIC RESINS

POLYCARBONATE RESINS

POLYESTER RESINS

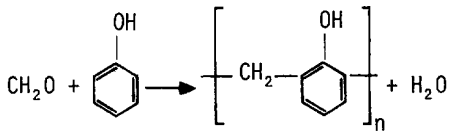
POLYIMIDE RESINS

POLYLITE
see POLYESTER

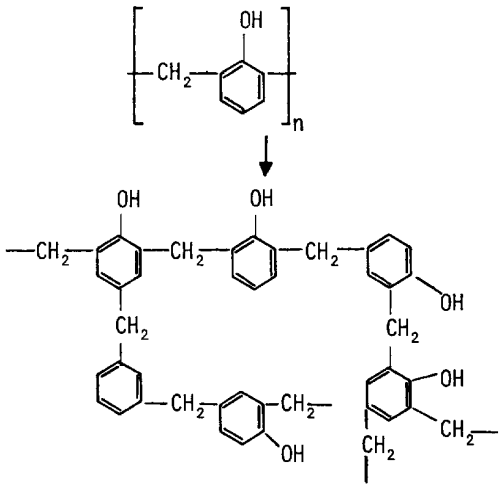
POLYURETHANE RESINS

Phenolic resins[19] are the product of the condensation of an aromatic alcohol with an aldehyde, particularly of phenol with formaldehyde. The reaction of phenol with formaldehyde may be acid- or base-catalysed.

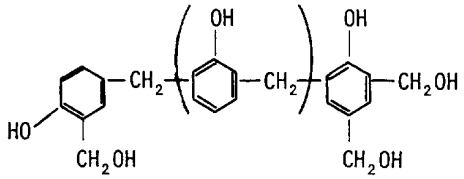
In the acid-catalysed reaction with equimolar amounts of phenol and formaldehyde, the primary product is a linear, low molecular weight polymer, often termed novolac:



The intermediate novolac may be cross-linked into the product resin by the addition of excess formaldehyde in a basic environment:



Under basic conditions the reaction of phenol with formaldehyde initially produces a low molecular weight, soluble polymer containing hydroxymethyl groups which can condense, on further heating, to the high molecular weight cross-linked polymer. At the intermediate stage the polymers are known as resoles:

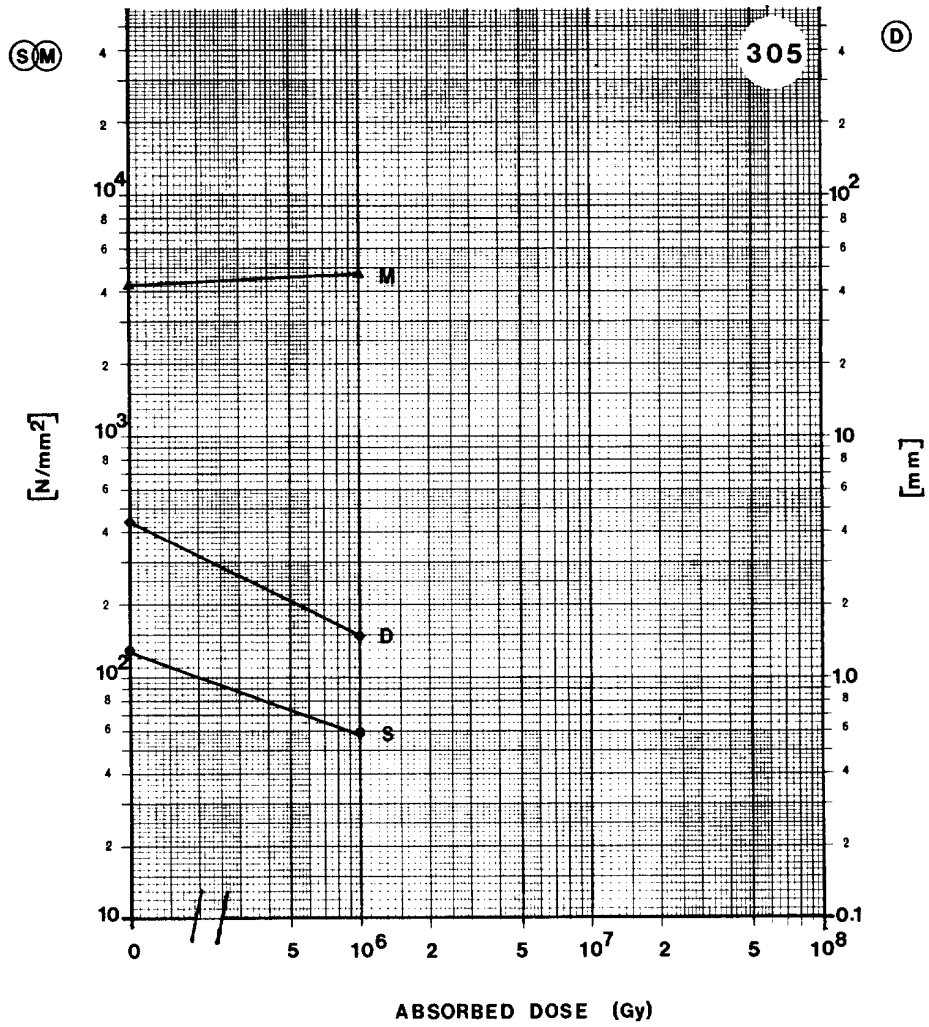


No.	Material and Supplier	Dose (Gy)	Ultimate flex. strength S (N/mm^2)	Deflexion at break D (mm)	Modulus of elasticity M (N/mm^2)
305	Phenolic resin + glass	0	129.5 ± 12.8	4.4 ± 0.4	$4.22 \pm 0.62 \times 10^3$
	Klockner-Müller	1×10^6	59.8 ± 23.5	1.5 ± 0.4	$4.75 \pm 0.90 \times 10^3$
309	RESOFIL 22	0	133.4 ± 3.9	5.2 ± 0.2	$7.93 \pm 0.10 \times 10^3$
		5×10^5	86.3 ± 8.8	2.1 ± 0.2	$8.65 \pm 0.27 \times 10^3$
		1×10^6	70.6 ± 4.9	1.6 ± 0.1	$8.66 \pm 0.40 \times 10^3$
	MICAFIL	5×10^6	47.0 ± 1.0	1.4 ± 0.1	$6.46 \pm 0.14 \times 10^3$

MATERIAL: PHENOLIC RESIN + GLASS

SUPPLIER: KLOCKNER-MÜLLER

Remarks: USED AT THE SPS FOR CABLE CONNECTION BOX



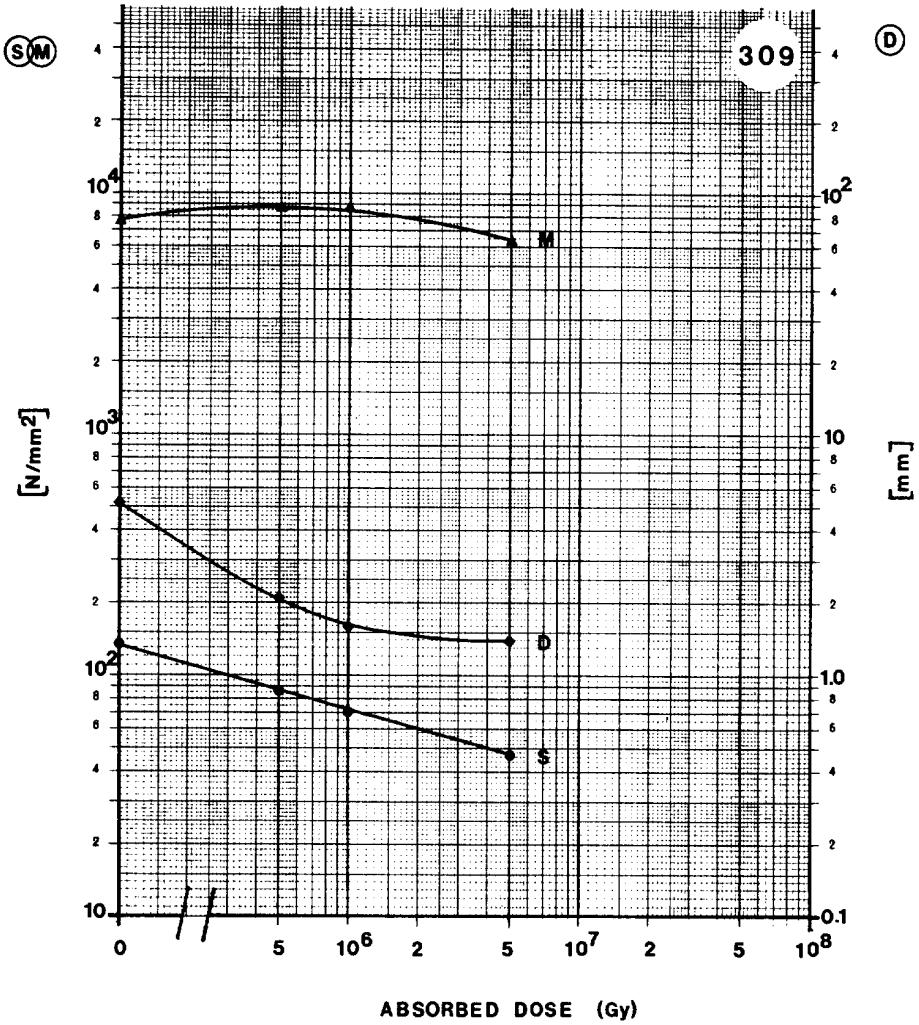
CURVE	PROPERTY	INITIAL VALUE	
S	Ultimate flexural strength	129.5	N/mm^2
D	Deflexion at break	4.4	mm
M	Modulus of elasticity	4.2×10^3	N/mm^2

PHENOLIC RESINS

MATERIAL: RESOFIL 22

SUPPLIER: MICAFIL

Remarks:



CURVE	PROPERTY	INITIAL VALUE	
S	Ultimate flexural strength	133.4	N/mm^2
D	Deflexion at break	5.2	mm
M	Modulus of elasticity	7.9×10^3	N/mm^2

In the polycondensation process of carbon acid with diolen, one obtains a thermoplastic polyester which can be presented by the following general formula[20]:

$$\left[-O-R-O-\overset{\overset{\displaystyle O}{\|}}{C}- \right]_n$$

with a mean molecular weight from 25,000 to 50,000. The base compounds that are most often used for this polycondensation are bisphenol A and phosgene or carbon acid ester.

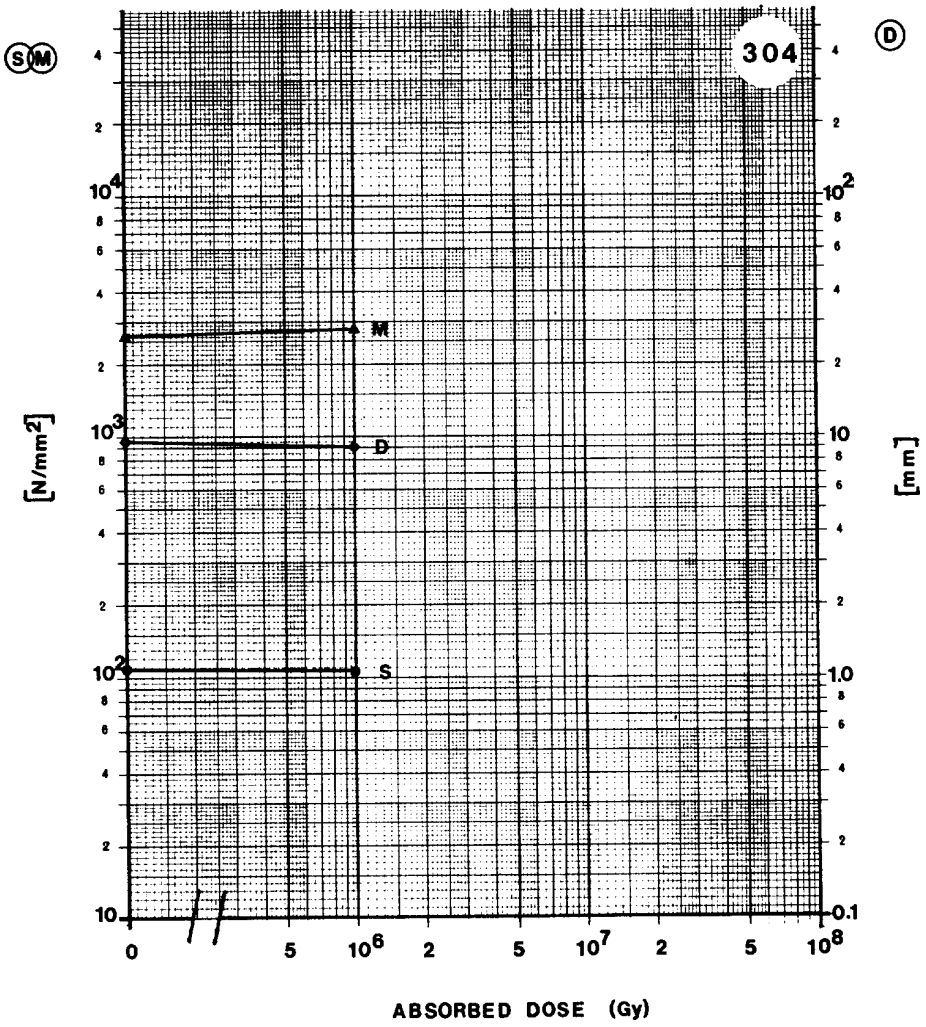
The most known representative of polycarbonates is MAKROLON (polycarbon ester of bisphenol A).

No.	Material and Supplier	Dose (Gy)	Ultimate flex. strength S (N/mm^2)	Deflexion at break D (mm)	Modulus of elasticity M (N/mm^2)
304	MAKROLON	0	108.9 ± 3.9	9.5 ± 0.2	$2.60 \pm 0.11 \times 10^3$
	Klockner-Müller	1×10^6	105.9 ± 2.0	9.0 ± 0.5	$2.81 \pm 0.10 \times 10^3$

MATERIAL: MAKROLON

SUPPLIER: KLOCKNER-MULLER

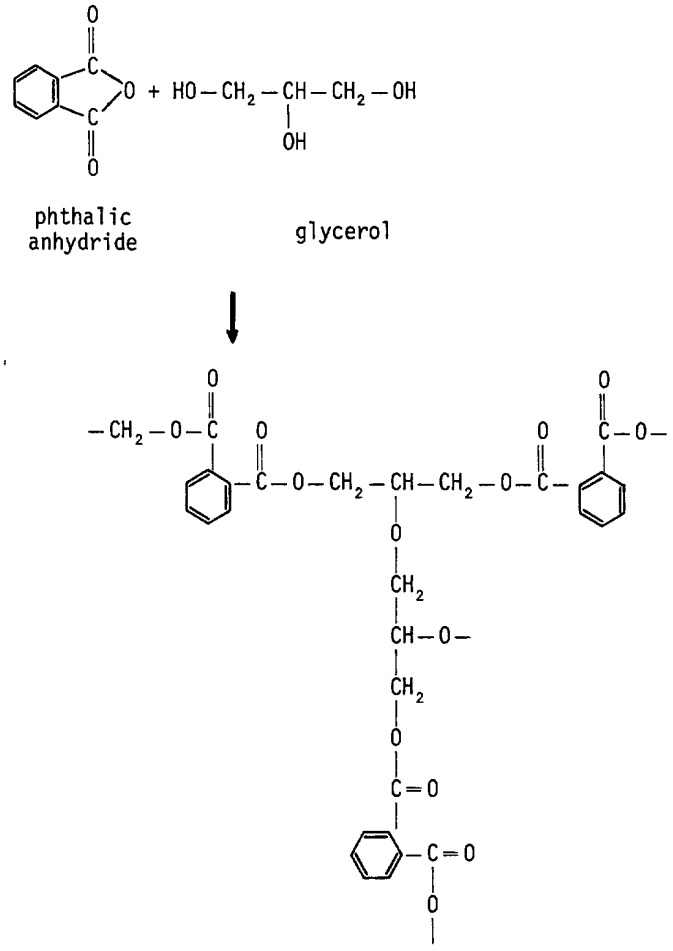
Remarks: USED AT THE SPS FOR CABLE CONNECTION BOX



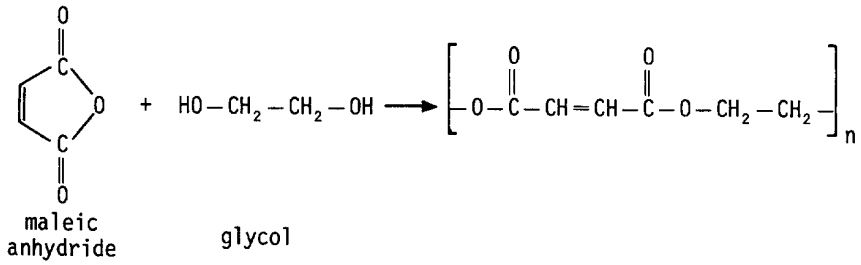
CURVE	PROPERTY	INITIAL VALUE	
S	Ultimate flexural strength	108.9	N/mm^2
D	Deflexion at break	9.5	mm
M	Modulus of elasticity	2.6×10^3	N/mm^2

These are polymers[19]) obtained by the condensation of compounds containing carboxyl and hydroxyl groups. There are two kinds of polyester: alkyd resins and unsaturated polyesters.

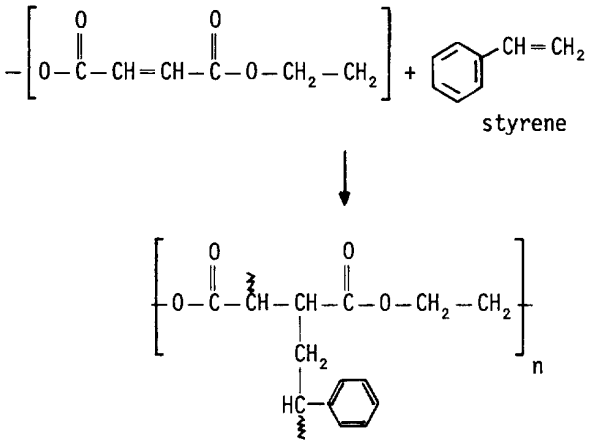
Polyester resins prepared by the reactions of trials with dibasic acids or their derivatives are usually termed alkyd resins:



The unsaturated polyesters are generally prepared by the reacting of unsaturated dibasic acid (or derivatives) with dihydric alcohols:



This linear unsaturated polyester may then be cross-linked into resins by dissolving in a vinyl-type active monomer (styrene, dialkyl phthalate):



No.	Material and Supplier	Dose (Gy)	Ultimate flex. strength S (N/mm^2)	Deflexion at break D (mm)	Modulus of elasticity M (N/mm^2)
106	Polyester - Epoxy resin compound	0	84.4 ± 2.9	5.3 ± 0.4	$3.40 \pm 0.09 \times 10^3$
		5×10^6	63.8 ± 5.9	3.6 ± 0.3	$3.49 \pm 0.04 \times 10^3$
		1×10^7	46.1 ± 2.0	2.9 ± 0.1	$3.19 \pm 0.07 \times 10^3$
		2×10^7	samples broken	after irradiation	
	BBC Mannheim	5×10^7			
109 (a)	Polyesterimide resin + glass fibre	0	432.6 ± 13.7	4.0 ± 0.1	$2.27 \pm 0.03 \times 10^4$
	BBC Mannheim				
180	Polyester CRYSTIC 196 LV	0	89.3 ± 11.8	6.4 ± 1.1	$6.08 \pm 0.70 \times 10^3$
		1×10^7	81.4 ± 5.9	8.5 ± 0.2	$3.62 \pm 0.35 \times 10^3$
	Gummi Maag	5×10^7	78.5 ± 4.9	6.7 ± 0.8	$3.37 \pm 0.43 \times 10^3$
182	Polyester CRYSTIC 384 + glass fibre 60%	0	158.9 ± 14.7	5.5 ± 0.2	$6.13 \pm 0.59 \times 10^3$
		1×10^7	118.7	4.7	5.44×10^3
	Gummi Maag	5×10^7	58.8 ± 5.9	3.3 ± 0.2	$3.01 \pm 0.29 \times 10^3$
184	Polyester isophthalic + taffeta material	0	466.0 ± 8.8	5.1 ± 0.2	$2.09 \pm 0.12 \times 10^4$
		1×10^7	449.3	4.6	1.73×10^4
	SNPE	5×10^7	118.7 ± 11.8	2.3 ± 0.5	$1.35 \pm 0.07 \times 10^4$
187	Polyester 65% + glass 35%	0	94.2 ± 7.8	5.5 ± 0.7	$4.32 \pm 0.13 \times 10^3$
		5×10^6	79.5 ± 10.8	6.9 ± 0.5	$3.06 \pm 0.20 \times 10^3$
		1×10^7	52.9 ± 13.7	5.4 ± 0.7	$2.66 \pm 0.43 \times 10^3$
	MICAFIL	5×10^7	41.2 ± 8.8	6.4 ± 1.4	$1.64 \pm 0.13 \times 10^3$

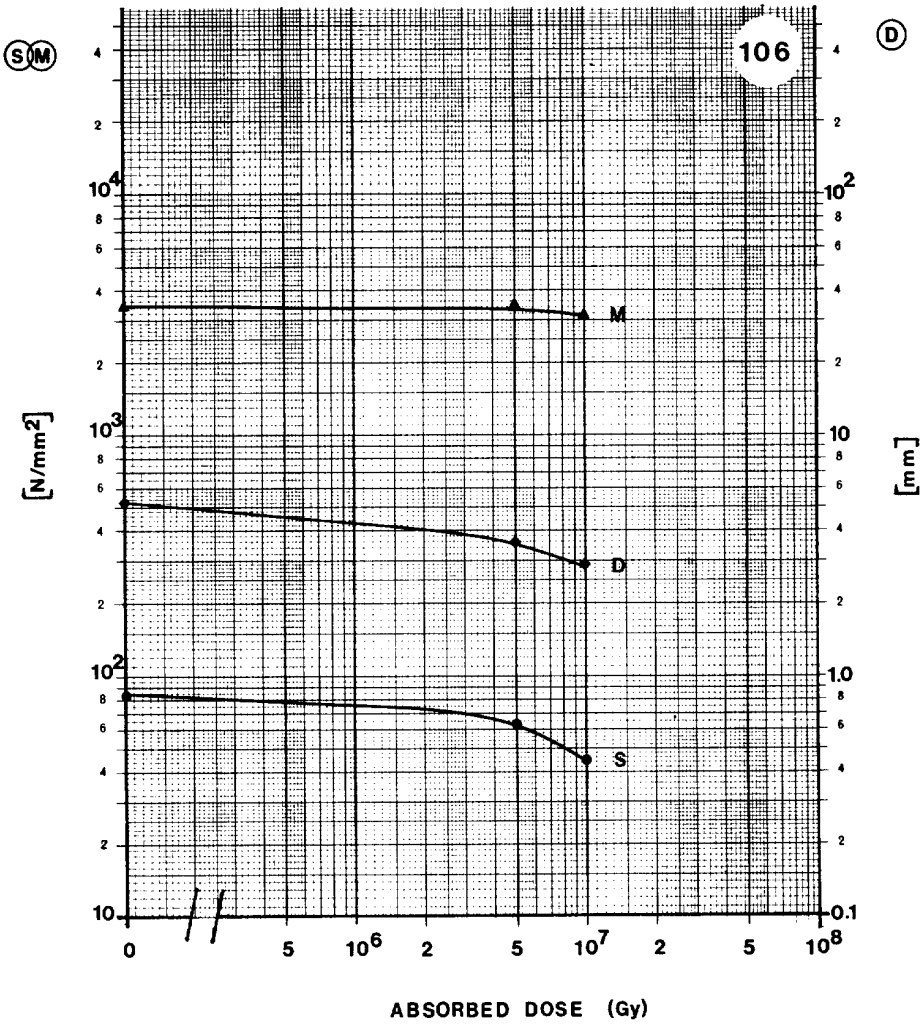
(a) No graph.

No.	Material and Supplier	Dose (Gy)	Ultimate flex. strength S (N/mm^2)	Deflexion at break D (mm)	Modulus of elasticity M (N/mm^2)
189	CEVOLIT 1413 (polyester resin + glass fibre)	0	301.2 ± 5.9	5.2 ± 0.3	$1.33 \pm 0.01 \times 10^4$
		5×10^6	167.8 ± 4.9	3.6 ± 0.3	$1.11 \pm 0.04 \times 10^4$
		1×10^7	129.5 ± 11.8	3.1 ± 0.1	$1.02 \pm 0.06 \times 10^4$
	CELLPACK AG	5×10^7	111.8 ± 12.8	3.3 ± 0.4	$9.25 \pm 0.65 \times 10^3$
190	G-ETRONAX PM (polyester laminate + 40% glass fibre)	0	197.2 ± 17.7	5.0 ± 0.3	$1.00 \pm 0.26 \times 10^4$
		5×10^6	229.5 ± 19.6	5.6 ± 0.2	$9.84 \pm 0.43 \times 10^3$
		1×10^7	206.0 ± 12.8	5.7 ± 0.0	$8.74 \pm 0.32 \times 10^3$
	Elektro-ISOLA	5×10^7	118.7 ± 3.9	5.1 ± 0.6	$5.79 \pm 0.33 \times 10^3$
271	Polyester + glass	0	163.8 ± 57.9	5.2 ± 0.8	$1.10 \pm 0.28 \times 10^4$
	Hazemeyer	1×10^6	188.3 ± 64.7	5.4 ± 1.0	$1.20 \pm 0.21 \times 10^4$

MATERIAL: POLYESTER - EPOXY RESIN COMPOUND

SUPPLIER: BBC MANNHEIM

Remarks:



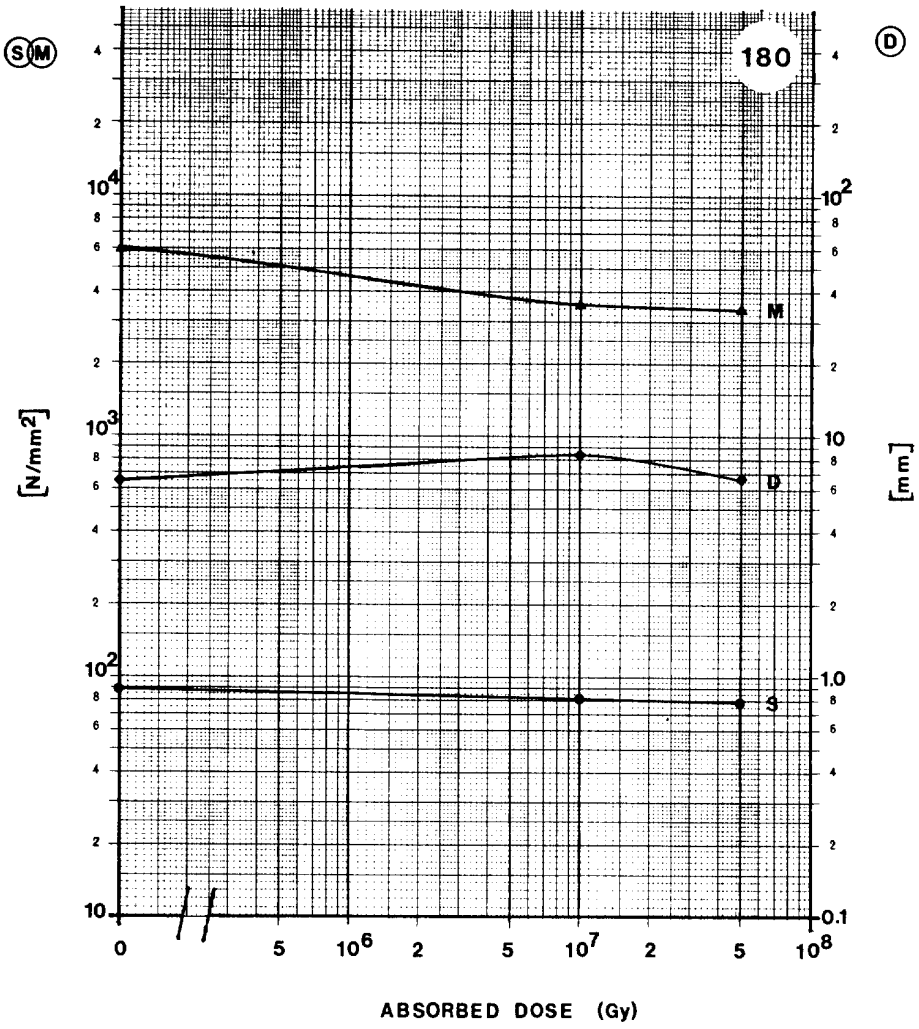
CURVE	PROPERTY	INITIAL VALUE	
S	Ultimate flexural strength	84.4	N/mm^2
D	Deflexion at break	5.3	mm
M	Modulus of elasticity	3.4×10^3	N/mm^2

POLYESTER

MATERIAL: POLYESTER CRYSTIC 196 LV

SUPPLIER: GUMMI MAAG

Remarks:

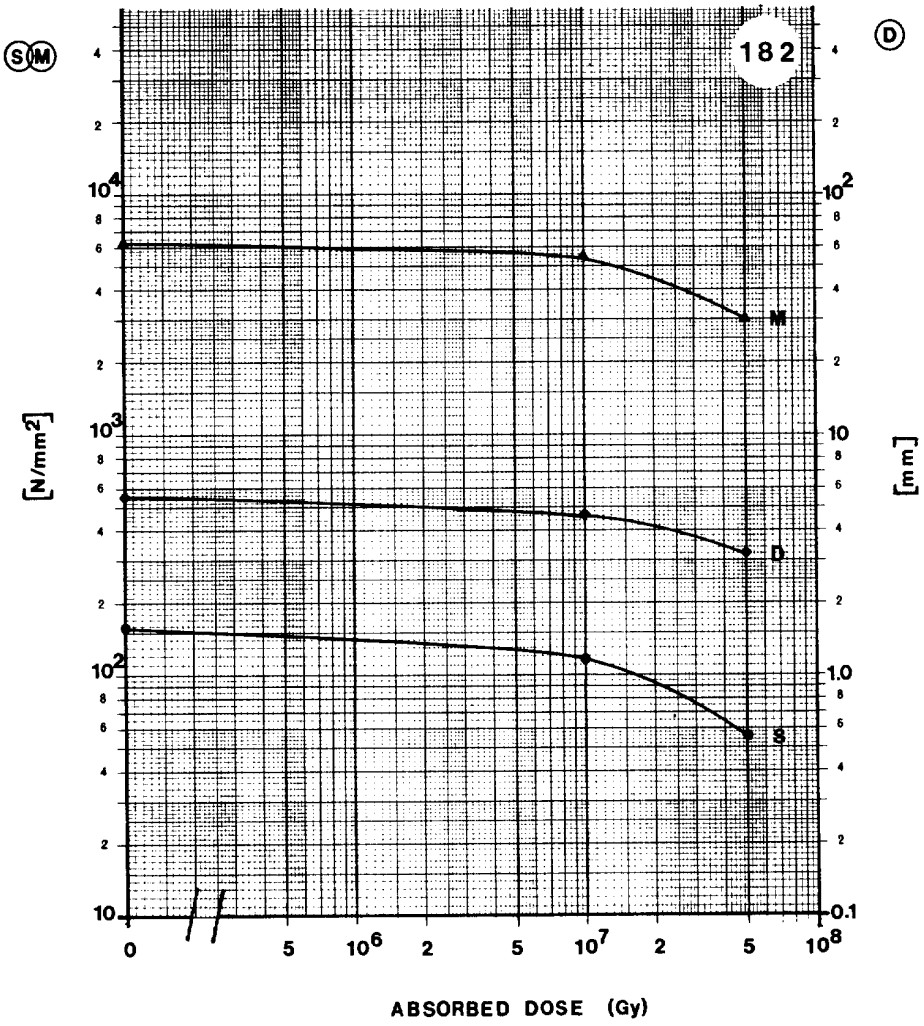


CURVE	PROPERTY	INITIAL VALUE	
S	Ultimate flexural strength	89.3	N/mm^2
D	Deflexion at break	6.4	mm
M	Modulus of elasticity	6.1×10^3	N/mm^2

MATERIAL: POLYESTER CRYSTIC 384 + GLASS FIBRE 60%

SUPPLIER: GUMMI MAAG

Remarks:



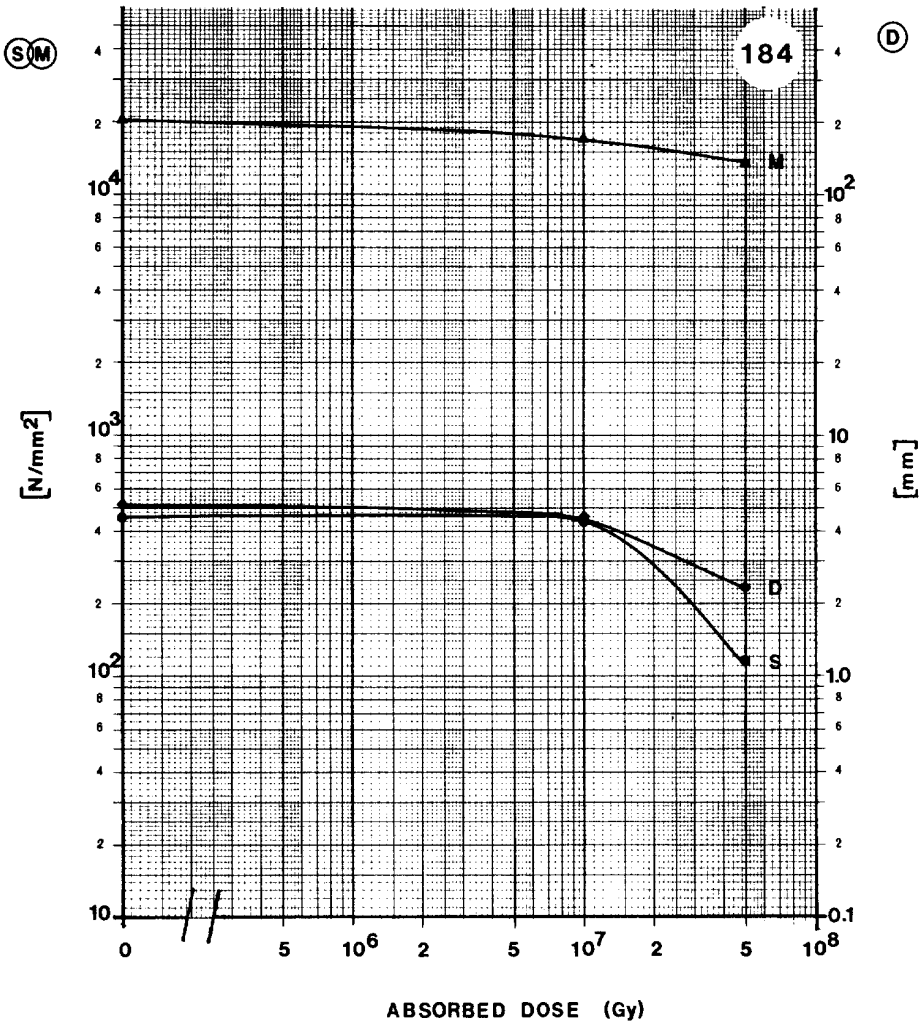
CURVE	PROPERTY	INITIAL VALUE	
S	Ultimate flexural strength	158.9	N/mm^2
D	Deflexion at break	5.5	mm
M	Modulus of elasticity	6.1×10^3	N/mm^2

POLYESTER

MATERIAL: POLYESTER ISOPHTHALIC + TAFFETA MATERIAL

SUPPLIER: SNPE

Remarks:

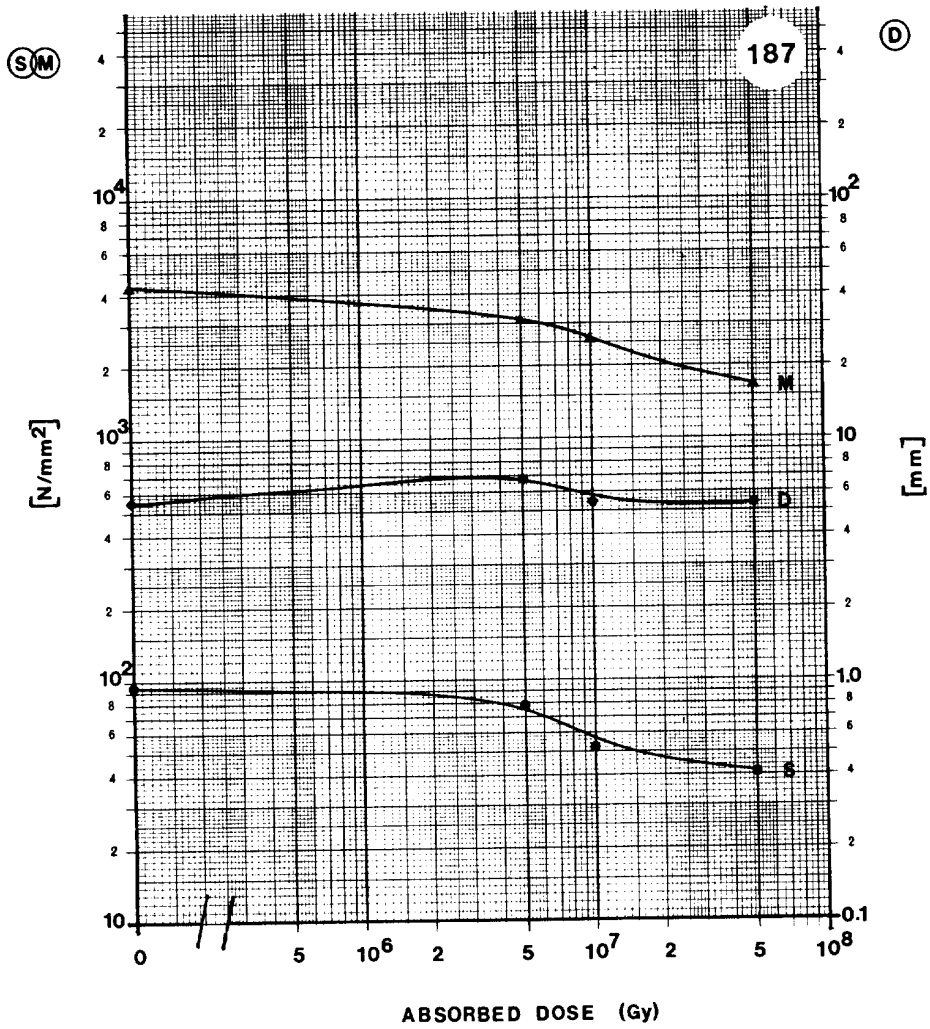


CURVE	PROPERTY	INITIAL VALUE	
S	Ultimate flexural strength	466.0	N/mm^2
D	Deflexion at break	5.1	mm
M	Modulus of elasticity	2.1×10^4	N/mm^2

MATERIAL: POLYESTER 65% + GLASS 35%

SUPPLIER: MICAFIL

Remarks:

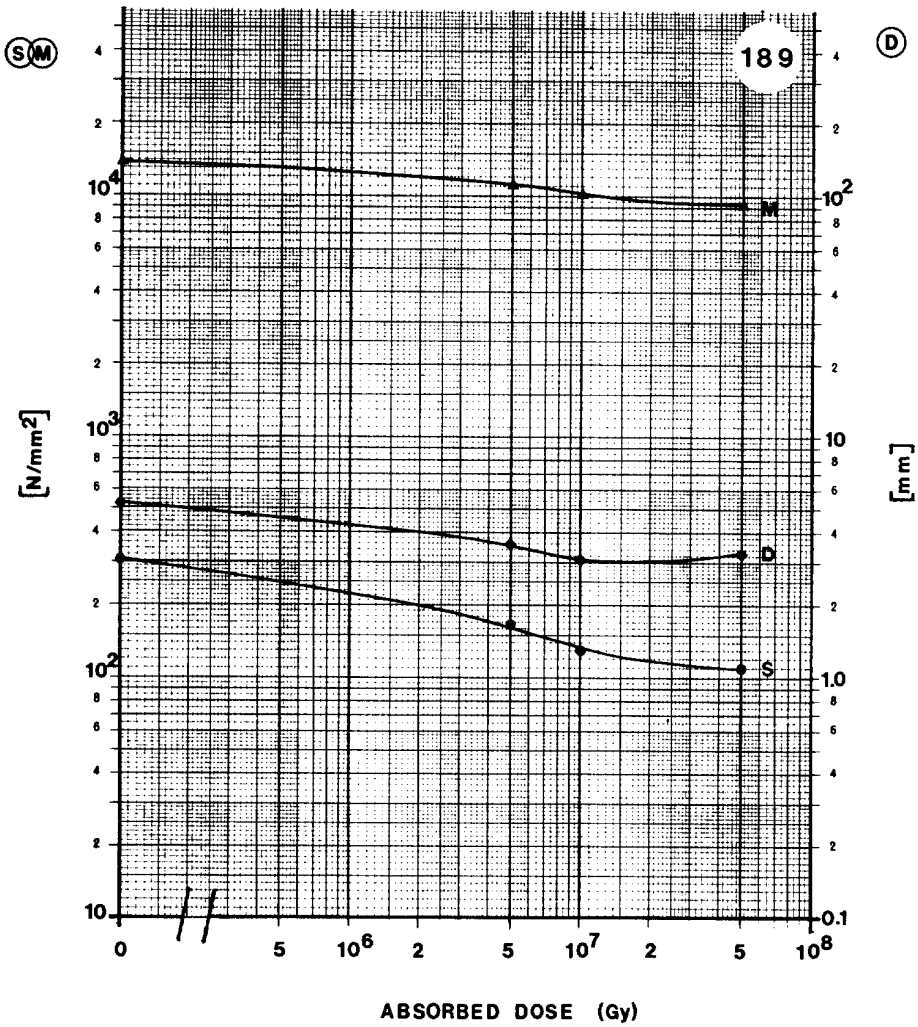


CURVE	PROPERTY	INITIAL VALUE	
S	Ultimate flexural strength	94.2	N/mm^2
D	Deflexion at break	5.5	mm
M	Modulus of elasticity	4.3×10^3	N/mm^2

MATERIAL: CEVOLIT 1413 (POLYESTER RESIN + GLASS FIBRE)

SUPPLIER: CELLPACK

Remarks:

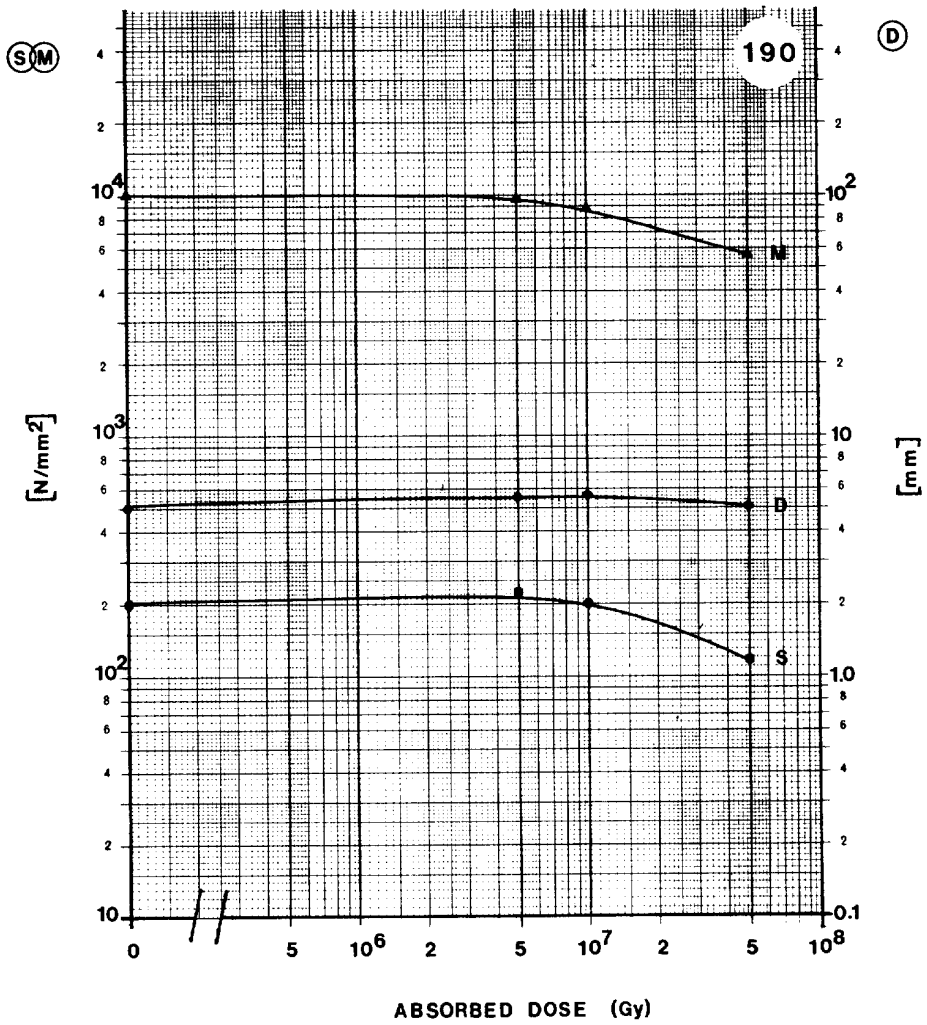


CURVE	PROPERTY	INITIAL VALUE	
S	Ultimate flexural strength	301.2	N/mm^2
D	Deflexion at break	5.2	mm
M	Modulus of elasticity	1.3×10^4	N/mm^2

MATERIAL: G-ETRONAX PM (POLYESTER LAMINATE + 40% GLASS FIBRE)

SUPPLIER: ELEKTRO-ISOLA

Remarks:



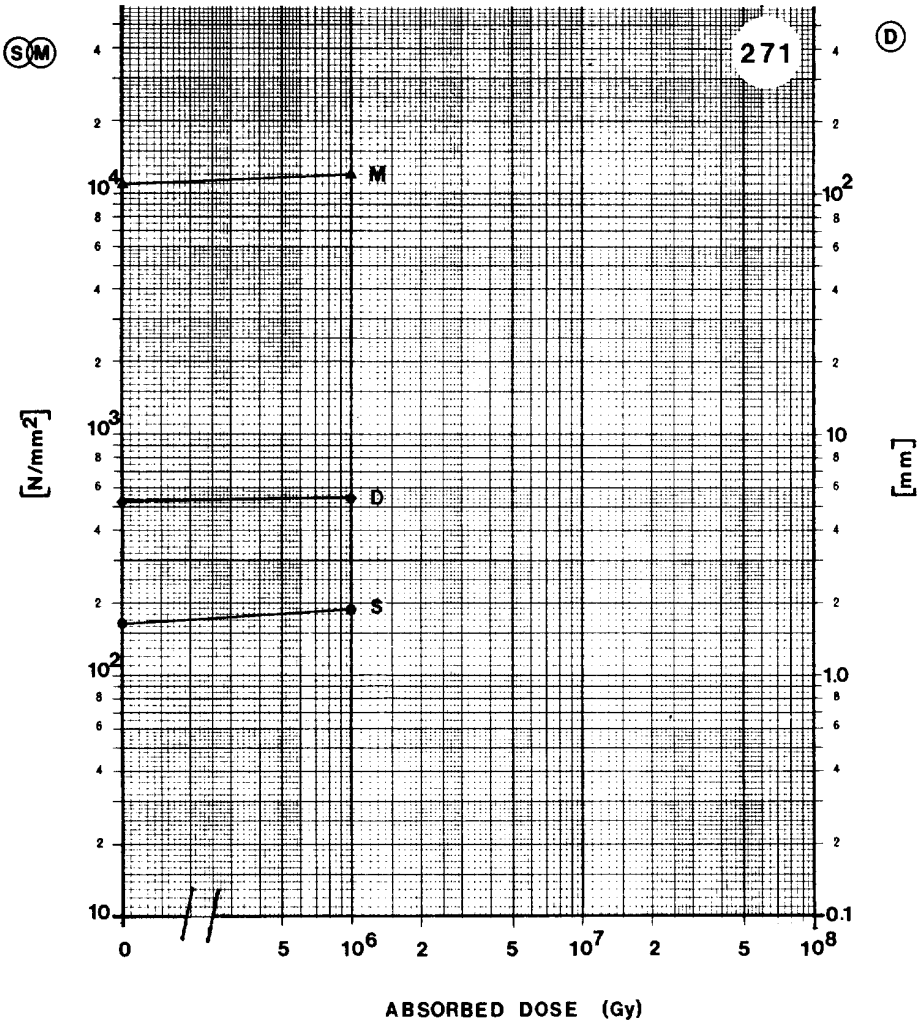
CURVE	PROPERTY	INITIAL VALUE	
S	Ultimate flexural strength	197.2	N/mm^2
D	Deflexion at break	5.0	mm
M	Modulus of elasticity	1.0×10^4	N/mm^2

POLYESTER

MATERIAL: POLYESTER + GLASS

SUPPLIER: HAZEMEYER, PART OF HOLEC SWITCHGEAR

Remarks: USED AT THE SPS FOR CABLE CONNECTION BOX



CURVE	PROPERTY	INITIAL VALUE	
S	Ultimate flexural strength	163.8	N/mm^2
D	Deflexion at break	5.2	mm
M	Modulus of elasticity	1.1×10^4	N/mm^2