BIRAKRIT

Epoxy fibre-glass laminate

see EPOXY RESINS

BISPHENOL A

Base product for epoxy resins

see EPOXY RESINS

DOBECKAN IF

trade name of Dr. Beck

see POLYURETHANE

DOBECKOT

trade name of Dr. Beck

see EPOXY RESINS

EPIKOTE

Trade name of SHELL for epoxy resins
154 see NOVOLAC
827 see NOVOLAC (VETRESIT)
828 see EPOXY RESINS

EPOXY RESINS

see also ARALDITE
see also NOVOLAC

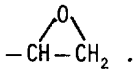
EPOXY RESIN + EPOXY NOVOLAC (50:50)

see NOVOLAC

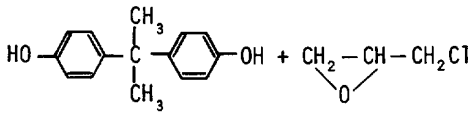
ETRONAX

Trade name of Elektro-ISOLA for laminated plastic of phenol resin with paper tissue
see POLYESTER

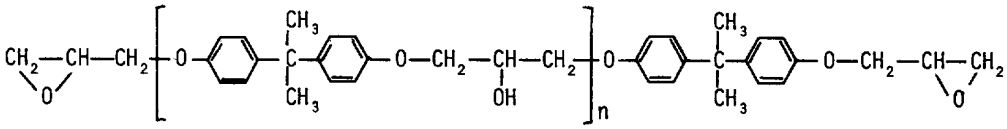
Epoxy resins[16-18]) are polymers containing two or more epoxy groups:



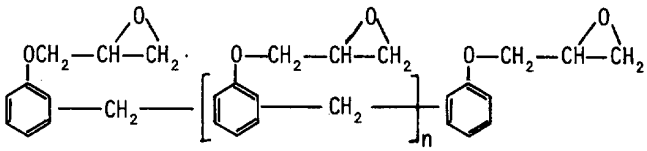
Depending on the base product, many different types of epoxy resins can be manufactured. The most common ones are prepared by the reaction of bisphenol A with epichlorohydrin:



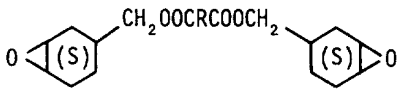
bisphenol A epoxy chlorohydrin



Another frequently used group of epoxy resins is based on novolac, which in reaction with epichlorohydrin gives a product which can be represented by the following formula:



A further commercially important group is that of the cyclo-aliphatic epoxy resins

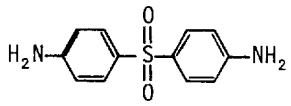


Cycloaliphatic epoxy resin

The epoxy resins in their thermoplastic or uncured state are converted or hardened into useful thermosets by reaction with a variety of hardeners.

The most widely used hardeners are either of the amine or acid anhydride type, e.g.:

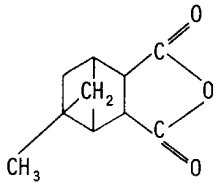
- diaminodiphenylsulfone (DDS)



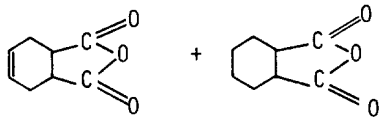
- diethylenetriamine

$$H_2N-CH_2-CH_2-NH-CH_2-CH_2-NH_2$$

- methyl nadic anhydride (MNA = NMA)

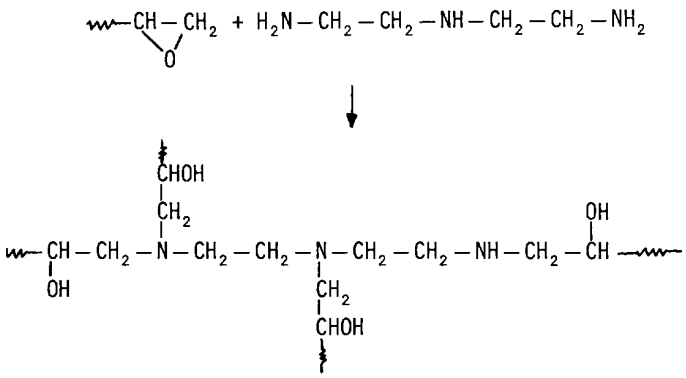


- mixture of tetra- and hexahydrophthalic-anhydride



The other types of hardeners used with epoxy resins are the polysulfides, tertiary amines, boron trifluoride complexes, etc.

The curing process for introducing cross-links into a polymer chain to form a resin can be represented by the reaction of the diethylene-triamine with the epoxide groups:



The cross-linking process can be speeded up by the addition of accelerators such as triamine

[dimethylbenzylamine $-CH_2-N(CH_3)_2$]

or polyalcohol

$$\left[\text{glycerin } HO-CH_2-\overset{\overset{\displaystyle OH}{|}}{CH}-CH_2-OH\right].$$

The other additives are flexibilizers, diluents, fillers. The fillers such as silica, Dolomite, aluminium oxide, glass tape, Mica, etc., may improve the mechanical strength and/or electrical properties. In many cases these fillers also increase the radiation resistance.

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)
113	Epoxy resin + anhydride hardener + Al_2O_3	0	122.6 ± 2.0	2.8 ± 0.2	$9.45 \pm 0.39 \times 10^3$
		5×10^6	89.3 ± 2.0	1.8 ± 0.1	$9.97 \pm 0.26 \times 10^3$
		1×10^7	81.4 ± 2.9	1.6 ± 0.0	$1.03 \pm 0.03 \times 10^4$
		2×10^7	60.8 ± 2.0	1.3 ± 0.0	$9.90 \pm 0.26 \times 10^3$
	BBC Mannheim	5×10^7	23.5 ± 1.0	1.0 ± 0.1	$6.32 \pm 0.98 \times 10^3$
114	Epoxy resin + anhydride hardener + quartz powder	0	117.7 ± 2.9	3.2 ± 0.1	$8.68 \pm 0.11 \times 10^3$
		5×10^6	90.2 ± 4.9	2.0 ± 0.1	$9.26 \pm 0.19 \times 10^3$
		1×10^7	82.4 ± 2.0	1.7 ± 0.1	$9.83 \pm 0.25 \times 10^3$
	BBC Mannheim	2×10^7	67.7 ± 1.0	1.3 ± 0.1	$1.00 \pm 0.02 \times 10^4$
156	DOBECKOT 500(100) + Hardener 700(30) 14 h 140 °C	0	127.5 ± 1.9	13.4 ± 0.3	$1.90 \pm 0.04 \times 10^3$
		5×10^6	too flexible for testing		
		1×10^7	93.2 ± 24.5	6.1 ± 3.4	$3.50 \pm 0.06 \times 10^3$
	Dr. BECK	3×10^7	23.5 ± 12.8	1.3 ± 0.7	$3.45 \pm 0.21 \times 10^3$
157	DOBECKOT 505(100) + Hardener 750(8) 24 h 25 °C	0	75.5 ± 1.0	9.4 ± 0.3	$2.19 \pm 0.15 \times 10^3$
		5×10^6	94.2 ± 3.9	5.8 ± 0.4	$3.25 \pm 0.00 \times 10^3$
		1×10^7	samples broken after irradiation		
	Dr. BECK	3×10^7			
158	DOBECKOT 556/05M(100) + Hardener 750(4) 24 h 25 °C	0	51.0 ± 3.9	1.9 ± 0.2	$5.14 \pm 0.36 \times 10^3$
		5×10^6	32.4 ± 1.9	1.3 ± 0.1	$4.69 \pm 0.16 \times 10^3$
		1×10^7	samples broken after irradiation		
	Dr. BECK	3×10^7			
161	BIRAKRIT - Epoxy fibre-glass laminate type 2370.4	0	546.4 ± 27.5	5.8 ± 0.1	$2.54 \pm 0.09 \times 10^4$
		5×10^6	573.9 ± 17.7	6.4 ± 0.2	$2.41 \pm 0.06 \times 10^4$
		1×10^7	568.0 ± 27.5	6.2 ± 0.3	$2.46 \pm 0.10 \times 10^4$
	UOP	5×10^7	104.0 ± 4.6	1.9 ± 0.1	$1.79 \pm 0.14 \times 10^4$
162	BIRAKRIT - Epoxy fibre-glass laminate type 2372.2	0	508.2 ± 46.1	6.0 ± 0.5	$1.93 \pm 0.20 \times 10^4$
		5×10^6	417.9 ± 89.3	4.6 ± 0.3	$2.00 \pm 0.21 \times 10^4$
		1×10^7	411.0 ± 93.2	4.4 ± 0.5	$2.09 \pm 0.27 \times 10^4$
	UOP	5×10^7	90.0 ± 20.6	2.5 ± 0.3	$1.14 \pm 0.23 \times 10^4$

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)
167	VETRONIT EPG 10	0	510.1 ± 21.6	7.9 ± 0.2	$2.78 \pm 0.13 \times 10^4$
		5×10^7	55.9 ± 5.9	4.0 ± 0.9	$1.46 \pm 0.28 \times 10^4$
	ISOLA	1×10^8	32.4 ± 6.9	2.6 ± 0.9	$8.12 \pm 2.61 \times 10^3$
168	VETRONIT EPG 11	0	350.2 ± 6.9	6.8 ± 0.1	$2.08 \pm 0.06 \times 10^4$
		5×10^7	48.1 ± 3.9	4.5 ± 0.6	$8.46 \pm 0.45 \times 10^3$
	ISOLA	1×10^8	37.3 ± 4.9	3.9 ± 0.6	$8.30 \pm 0.85 \times 10^3$
186	Epoxy, type EGS 102	0	538.6 ± 4.9	5.1 ± 0.1	$2.22 \pm 0.14 \times 10^4$
		1×10^7	184.4 ± 0	1.9 ± 0	$2.02 \pm 0 \times 10^4$
	Ferrozell	5×10^7	47.1 ± 3.9	1.0 ± 0.1	$9.34 \pm 1.75 \times 10^3$
193	ISOVAL 11 + charge 2569 (epoxy resin with glass)	0	364.9 ± 10.8	3.4 ± 0.3	$1.53 \pm 0.16 \times 10^4$
		1×10^6	220.7 ± 3.9	4.3 ± 0.5	$1.32 \pm 0.03 \times 10^4$
		3×10^6	236.4 ± 5.9	3.8 ± 0.3	$1.33 \pm 0.03 \times 10^4$
	ISOVOLTA	5×10^6	211.9 ± 7.8	3.7 ± 0.1	$1.19 \pm 0.03 \times 10^4$
229	DOBECKOT 502 + Hardener 710 cured at 160 °C	0	84.4 ± 17.7	5.3 ± 1.2	$3.79 \pm 0.13 \times 10^3$
		1×10^7	99.1 ± 12.8	6.1 ± 1.0	$4.11 \pm 0.27 \times 10^3$
	PLESSEY				
264	Epoxy 91-1892(100) + Curing Agent 91-1893(150) + DY 062(2.5)	0	125.6 ± 37.8	3.4 ± 1.1	$9.06 \pm 0.26 \times 10^3$
		5×10^6	13.8 ± 2.7	0.7 ± 0.0	$4.25 \pm 0.77 \times 10^3$
	2 h 80 °C + 3 h 100 °C	1×10^7	samples	broken after	irradiation
	LARS FOSS KEMI				

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)
279	Epoxy 91-1892(100) + Hardener 91-1893(150) + DY 040(25) + DY 062(2.5)	0	99.1 ± 8.8	5.0 ± 0.5	$3.88 \pm 0.09 \times 10^3$
		5×10^6	14.7 ± 2.9	1.0 ± 0.3	$2.86 \pm 0.47 \times 10^3$
	LARS FOSS KEMI				
293 (a) (173)	SAMICANIT epoxy resin + glass + Mica	0	160.6 ± 18.6	1.1 ± 0.1	$6.26 \pm 0.55 \times 10^4$
		1×10^8	183.5 ± 11.2	1.1 ± 0.1	$7.34 \pm 0.18 \times 10^4$
	ISOLA				
306 (b)	SAMICATHERM 366.28.02 Epoxy resin + Mica + glass tape	0	224.6 ± 7.8	1.0 ± 0.0	$3.41 \pm 0.02 \times 10^4$
		1×10^7	58.8 ± 5.9	1.3 ± 0.1	$5.88 \pm 1.19 \times 10^3$
		3×10^7	44.2 ± 3.9	1.5 ± 0.2	$5.05 \pm 1.21 \times 10^3$
	ISOLA	1×10^8	17.7 ± 2.9	1.5 ± 0.0	$1.83 \pm 0.40 \times 10^3$
307 (b)	SAMICATHERM CR 5.56.4 Epoxy resin + Mica + glass tape	0	176.6 ± 11.8	0.9 ± 0.1	$2.76 \pm 0.09 \times 10^4$
		1×10^7	54.9 ± 2.9	1.3 ± 0.1	$5.82 \pm 0.66 \times 10^3$
		5×10^7	42.2 ± 6.9	1.4 ± 0.3	$4.71 \pm 1.22 \times 10^3$
	ISOLA	1×10^8	35.3 ± 2.9	1.4 ± 0.2	$3.88 \pm 0.81 \times 10^3$
313 (b)	Epoxy resin + Mica + glass tape	0	299.2 ± 19.6	2.3 ± 0.1	$2.71 \pm 0.08 \times 10^4$
		5×10^6	36.7 ± 4.1	1.0 ± 0.1	$7.56 \pm 2.13 \times 10^3$
		1×10^7	6.7 ± 1.0	1.6 ± 0.2	$8.48 \pm 2.18 \times 10^2$
	CIBA-GEIGY	2.5×10^7	25.1 ± 3.6	7.4 ± 1.5	$5.48 \pm 1.85 \times 10^2$
317	Epoxy urethane resin	0	70.6 ± 6.9	4.6 ± 0.9	$3.09 \pm 0.26 \times 10^3$
		5×10^5	72.6 ± 11.8	4.7 ± 0.9	$3.13 \pm 0.36 \times 10^3$
		1×10^6	57.9 ± 20.6	3.6 ± 1.0	$3.13 \pm 0.42 \times 10^3$
	LRCE	5×10^6	9.3 ± 0.0	1.2 ± 0.0	$1.09 \pm 0.0 \times 10^3$

(a) No graph.

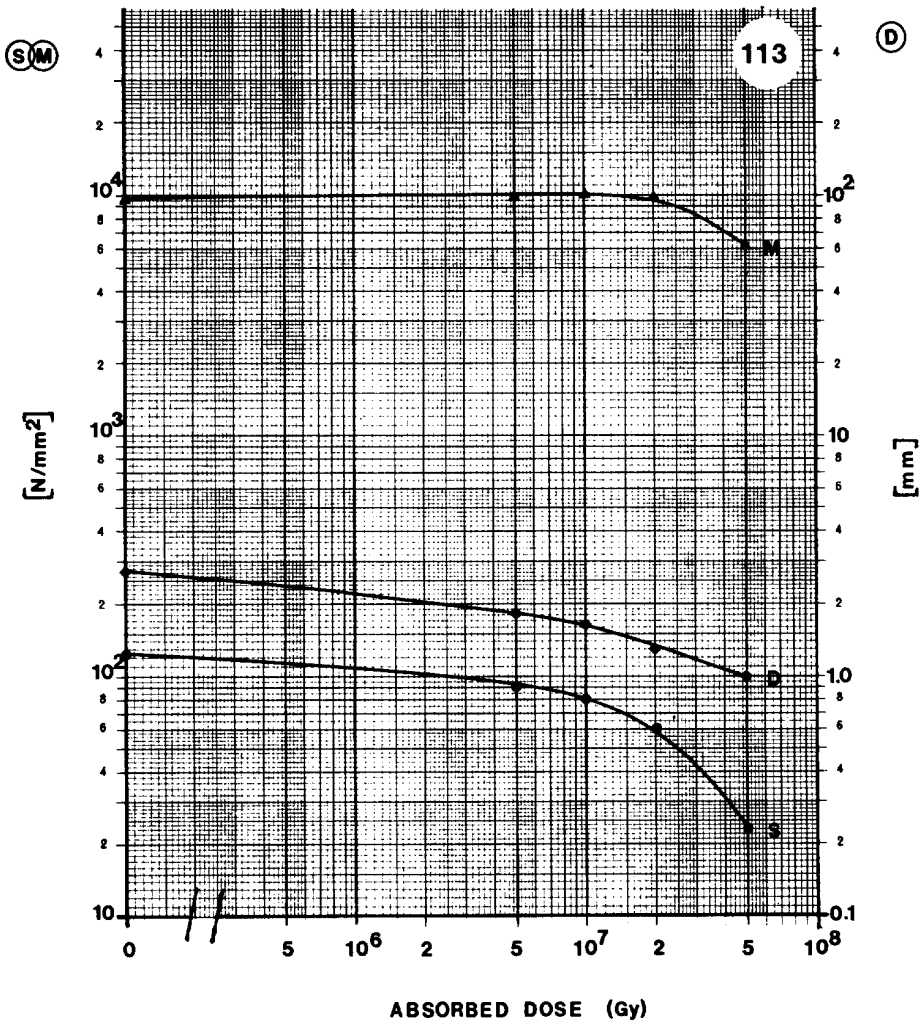
(b) Damage from water during irradiation.

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)
318	Epoxy urethane resin	0	78.3 ± 14.5	4.8 ± 1.6	$3.27 \pm 0.10 \times 10^3$
		5×10^5	68.6 ± 8.7	4.1 ± 0.4	$3.26 \pm 0.38 \times 10^3$
		1×10^6	52.0 ± 17.8	3.3 ± 1.2	$3.59 \pm 0.12 \times 10^3$
	LRCE	5×10^6	13.1 ± 9.6	1.2 ± 0.7	$1.71 \pm 0.40 \times 10^3$
319	Epoxy resin	0	43.4 ± 7.1	4.2 ± 1.3	$2.95 \pm 0.75 \times 10^3$
	IR 5003 special	5×10^5	58.9 ± 1.4	4.1 ± 0.8	$3.71 \pm 0.76 \times 10^3$
		1×10^6	37.8 ± 6.2	4.6 ± 1.5	$3.06 \pm 0.47 \times 10^3$
	LRCE	5×10^6	31.8 ± 11.1	3.4 ± 1.1	$2.11 \pm 0.59 \times 10^3$

MATERIAL: EPOXY RESIN + ANHYDRIDE HARDENER + AL_2O_3

SUPPLIER: BBC MANNHEIM

Remarks:



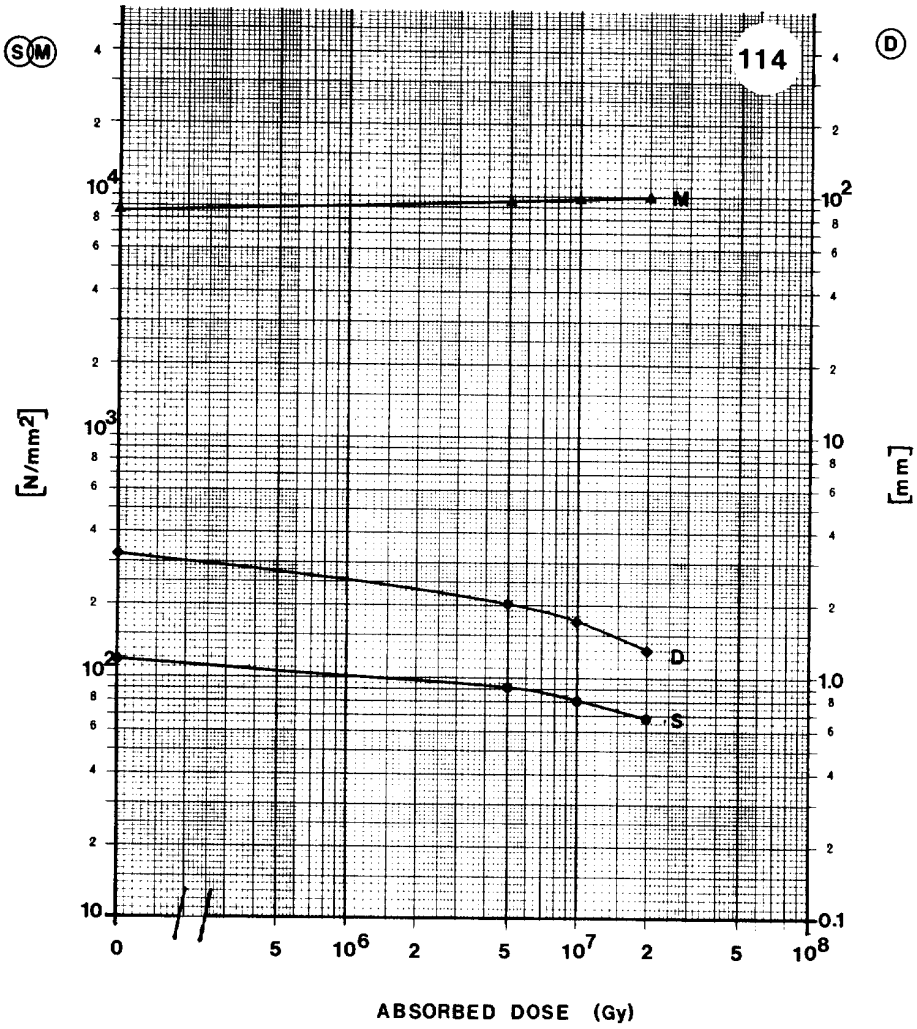
CURVE	PROPERTY	INITIAL VALUE	
S	Ultimate flexural strength	122.6	N/mm^2
D	Deflexion at break	2.8	mm
M	Modulus of elasticity	9.5×10^3	N/mm^2

EPOXY RESINS

MATERIAL: EPOXY RESIN + ANHYDRIDE HARDENER + QUARTZ POWDER

SUPPLIER: BBC MANNHEIM

Remarks:

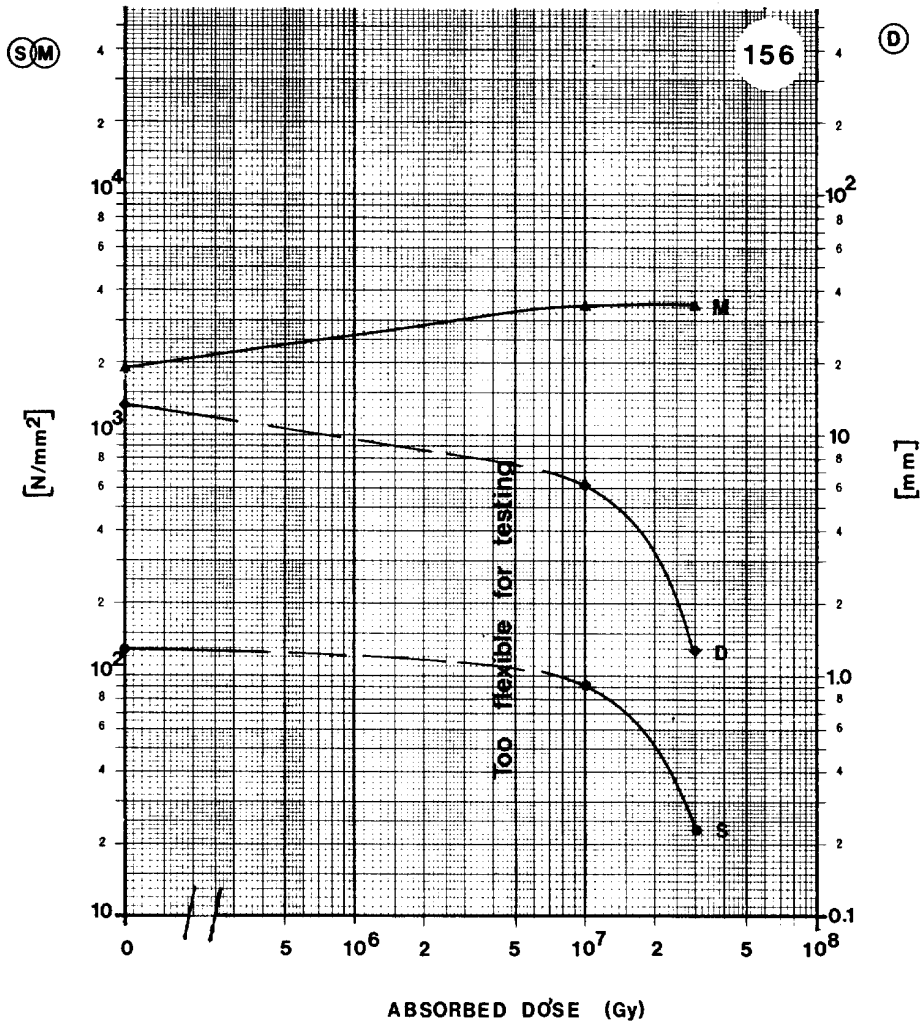


CURVE	PROPERTY	INITIAL VALUE	
S	Ultimate flexural strength	117.7	N/mm^2
D	Deflexion at break	3.2	mm
M	Modulus of elasticity	8.7×10^3	N/mm^2

MATERIAL: DOBECKOT 500(100) + HARDENER 700(30)

SUPPLIER: DR. BECK

Remarks:



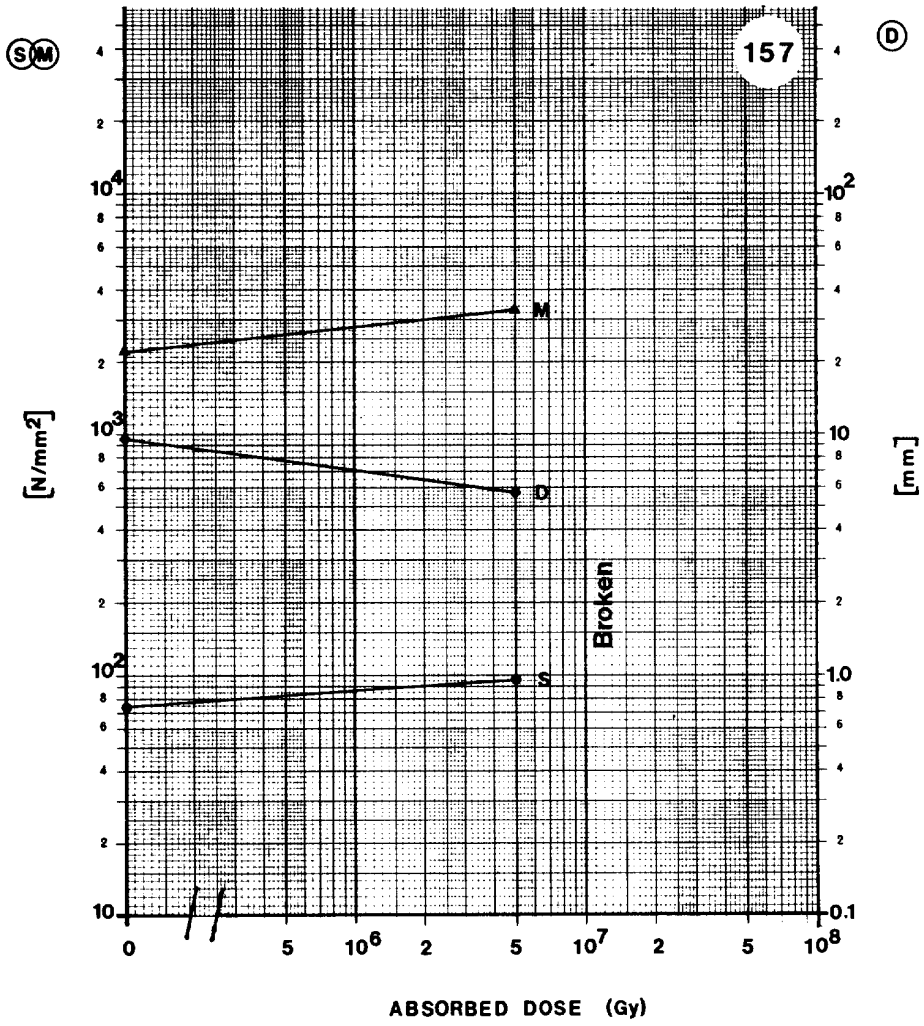
CURVE	PROPERTY	INITIAL VALUE	
S	Ultimate flexural strength	127.5	N/mm^2
D	Deflexion at break	13.4	mm
M	Modulus of elasticity	1.9×10^3	N/mm^2

EPOXY RESINS

MATERIAL: DOBECKOT 505(100) + HARDENER 750(8)

SUPPLIER: DR. BECK

Remarks:

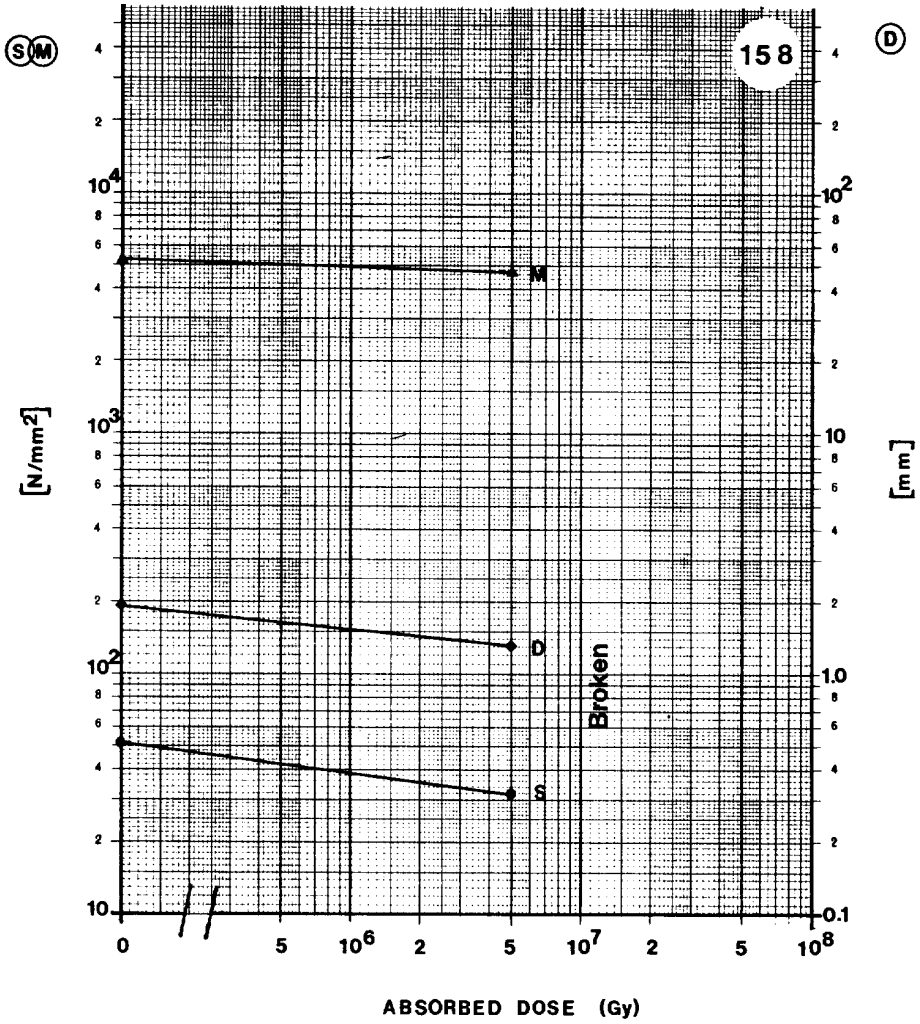


CURVE	PROPERTY	INITIAL VALUE	
S	Ultimate flexural strength	75.5	N/mm^2
D	Deflexion at break	9.4	mm
M	Modulus of elasticity	2.2×10^3	N/mm^2

MATERIAL: DOBECKOT 556/05M(100) + HARDENER 750(4)

SUPPLIER: DR. BECK

Remarks:

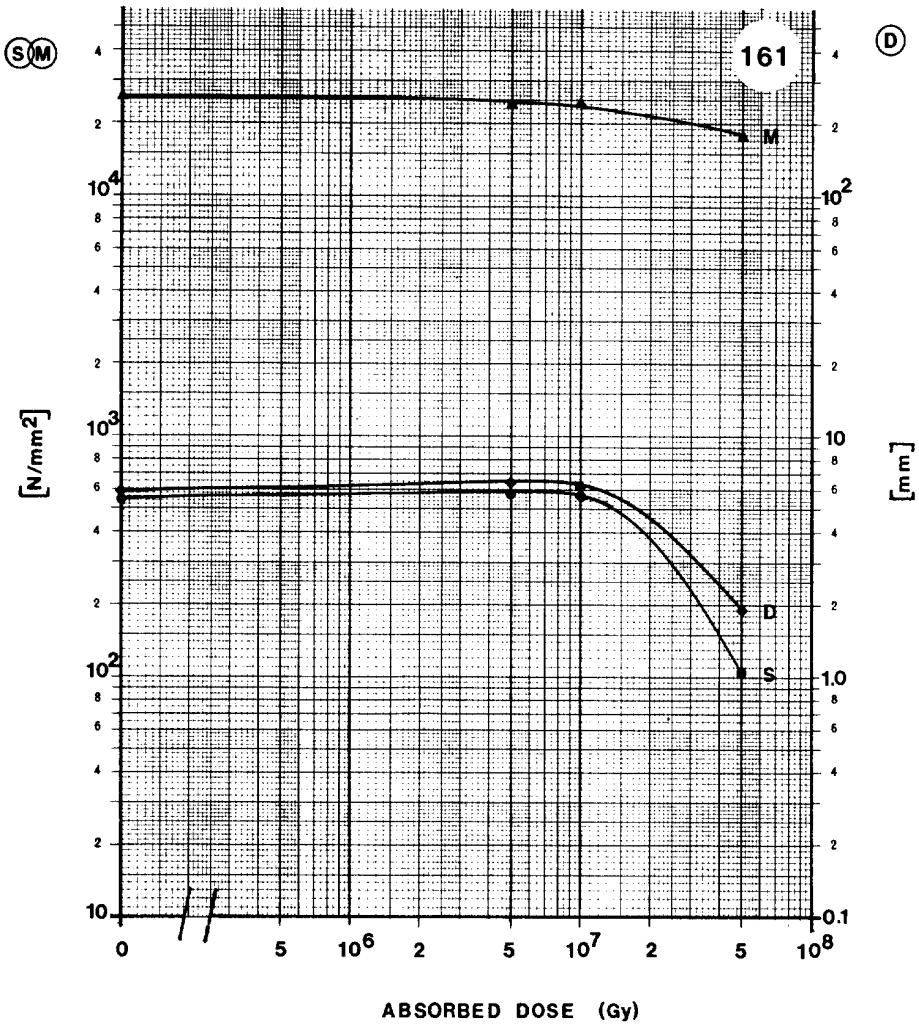


CURVE	PROPERTY	INITIAL VALUE	
S	Ultimate flexural strength	51.0	N/mm^2
D	Deflexion at break	1.9	mm
M	Modulus of elasticity	5.1×10^3	N/mm^2

MATERIAL: BIRAKRIT - EPOXY FIBRE-GLASS LAMINATE TYPE 2370.4

SUPPLIER: UOP

Remarks:

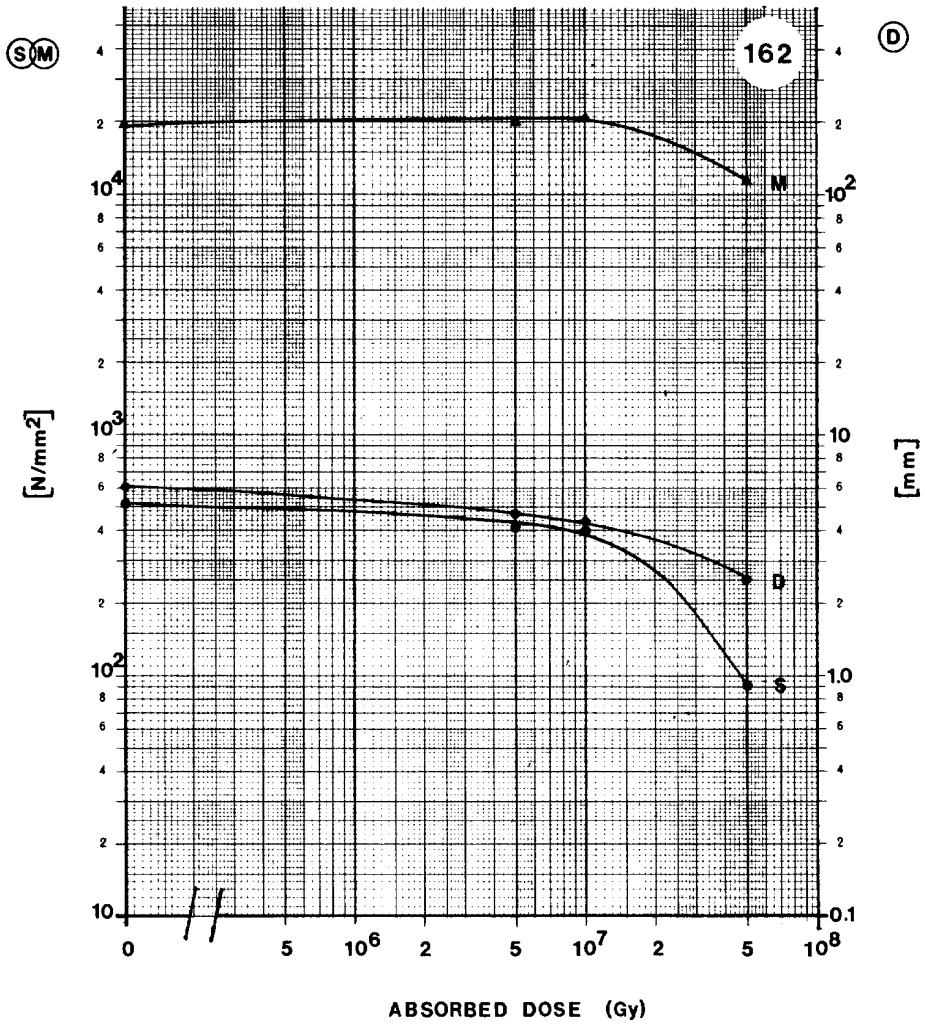


CURVE	PROPERTY	INITIAL VALUE	
S	Ultimate flexural strength	546.4	N/mm^2
D	Deflexion at break	5.8	mm
M	Modulus of elasticity	2.5×10^4	N/mm^2

MATERIAL: BIRAKRIT - EPOXY FIBRE-GLASS LAMINATE TYPE 2372.2

SUPPLIER: UOP

Remarks:

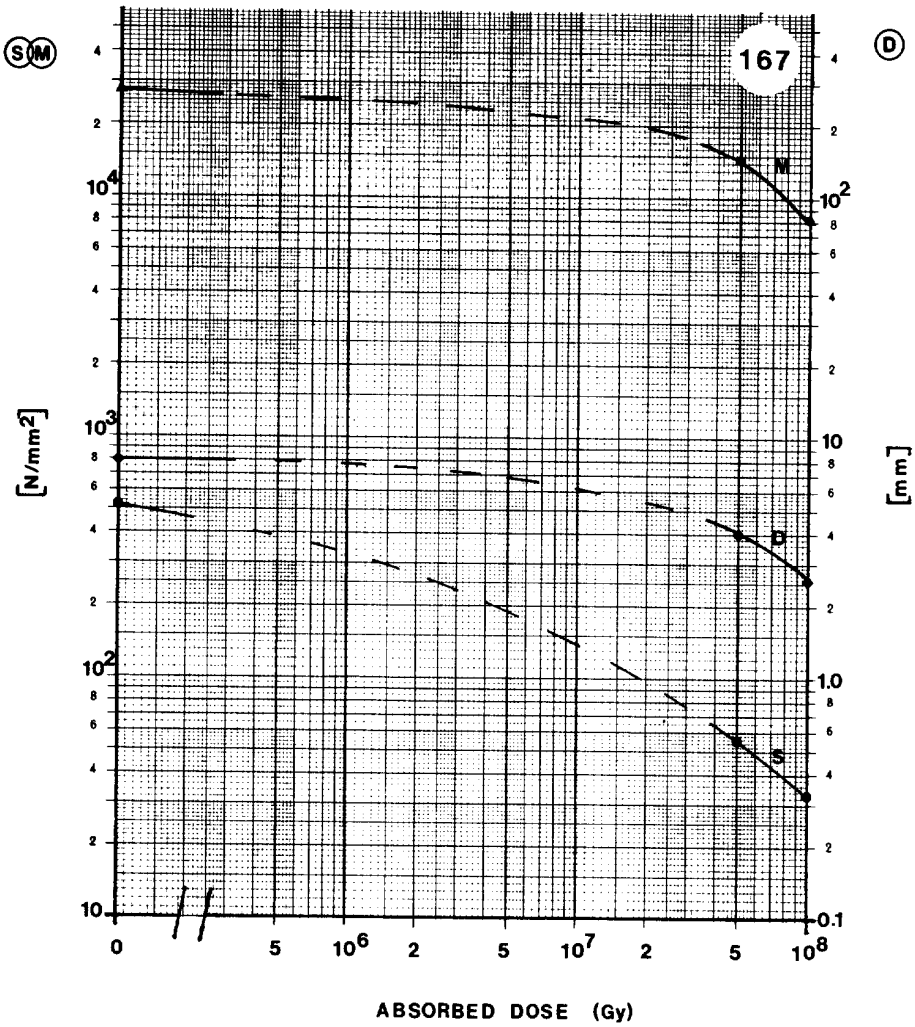


CURVE	PROPERTY	INITIAL VALUE	
S	Ultimate flexural strength	508.2	N/mm^2
D	Deflexion at break	6.0	mm
M	Modulus of elasticity	1.9×10^4	N/mm^2

MATERIAL: VETRONIT EPG 10

SUPPLIER: ISOLA

Remarks:

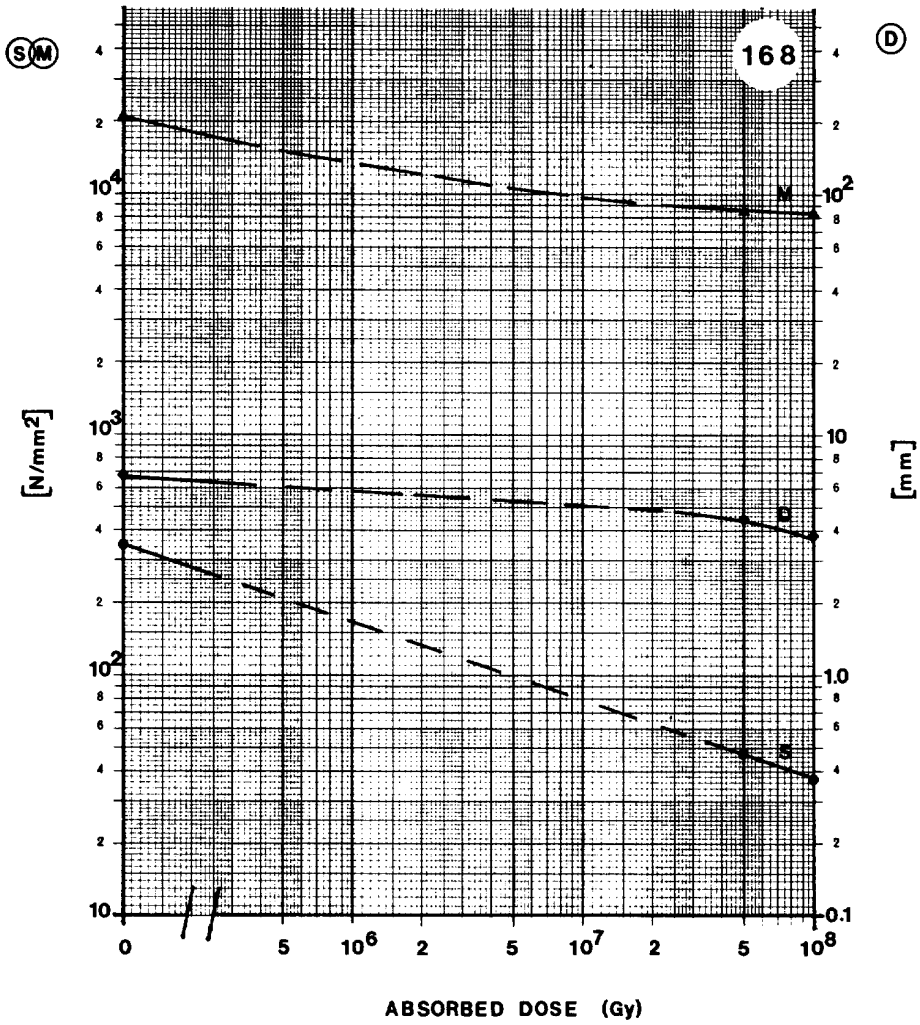


CURVE	PROPERTY	INITIAL VALUE	
S	Ultimate flexural strength	510.1	N/mm^2
D	Deflexion at break	7.9	mm
M	Modulus of elasticity	2.8×10^4	N/mm^2

MATERIAL: VETRONIT EPG 11

SUPPLIER: ISOLA

Remarks:



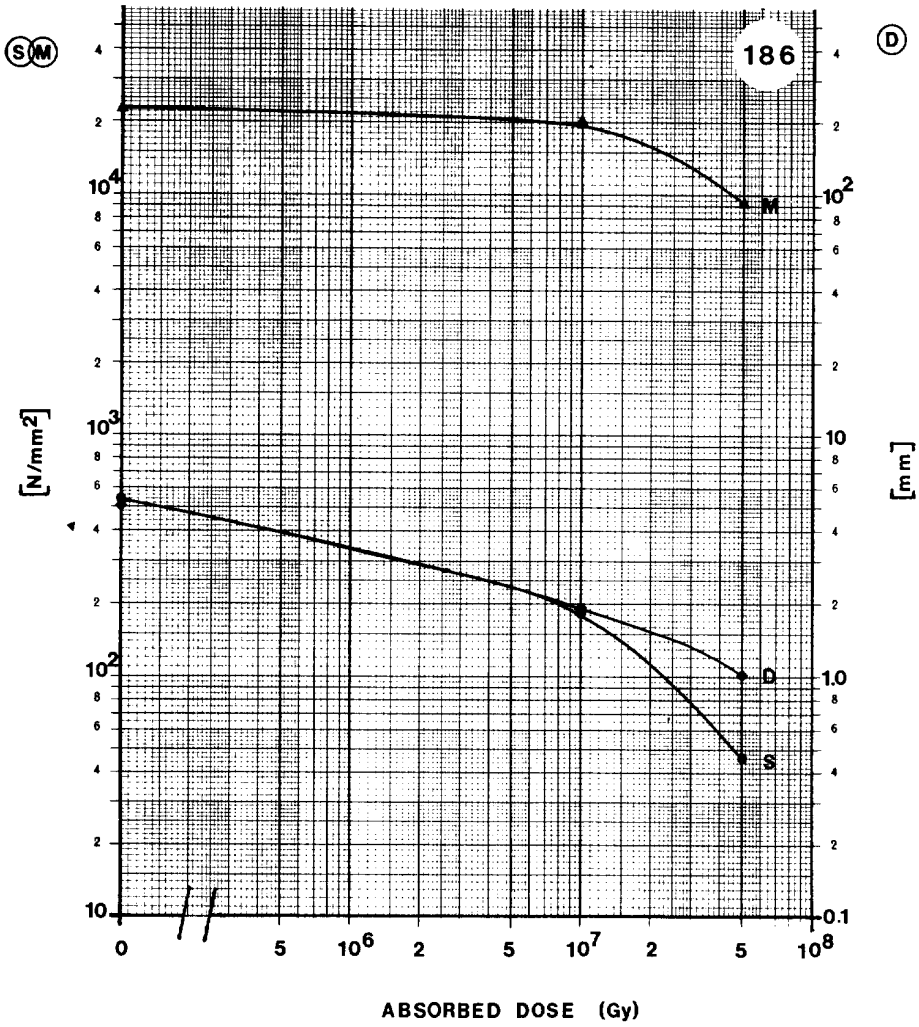
CURVE	PROPERTY	INITIAL VALUE	
S	Ultimate flexural strength	350.2	N/mm^2
D	Deflexion at break	6.8	mm
M	Modulus of elasticity	2.1×10^4	N/mm^2

EPOXY RESINS

MATERIAL: EPOXY, TYPE EGS 102

SUPPLIER: FERROZELL

Remarks:

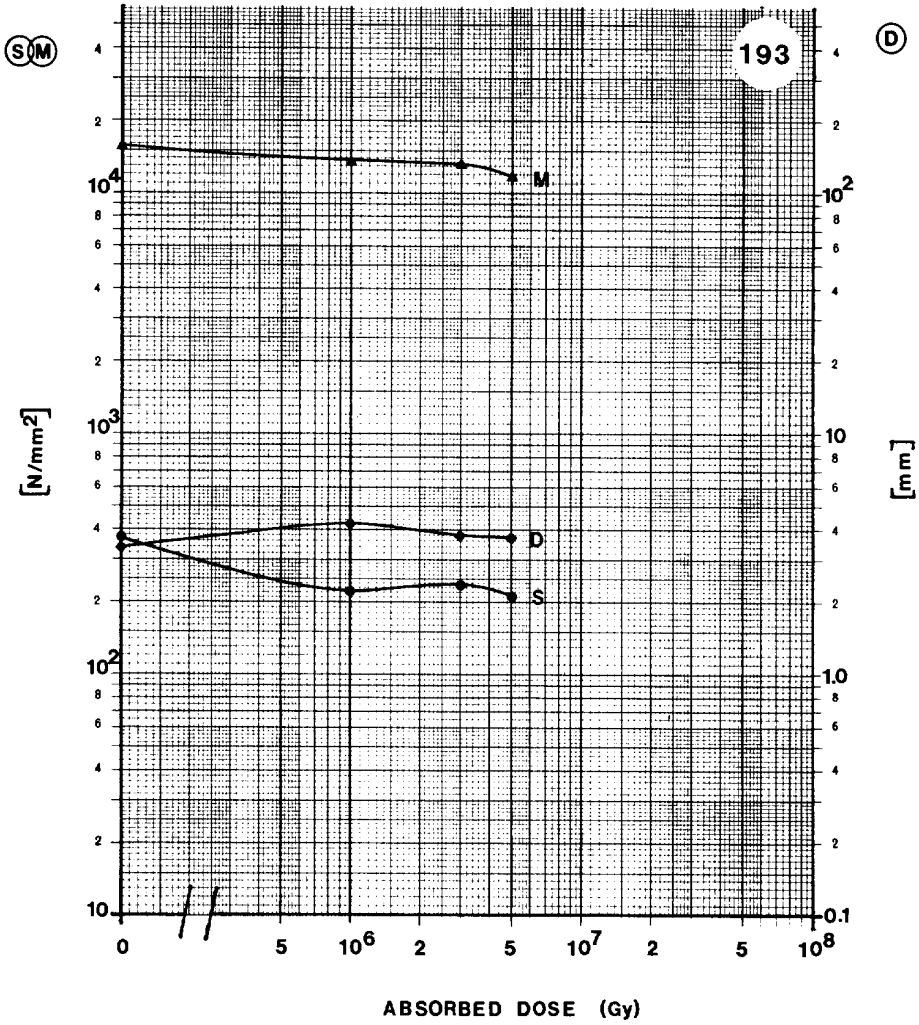


CURVE	PROPERTY	INITIAL VALUE	
S	Ultimate flexural strength	538.6	N/mm²
D	Deflexion at break	5.1	mm
M	Modulus of elasticity	2.2 × 10⁴	N/mm²

MATERIAL: ISOVAL 11 + CHARGE 2569 (EPOXY RESIN WITH GLASS)

SUPPLIER: ISOVOLTA

Remarks:



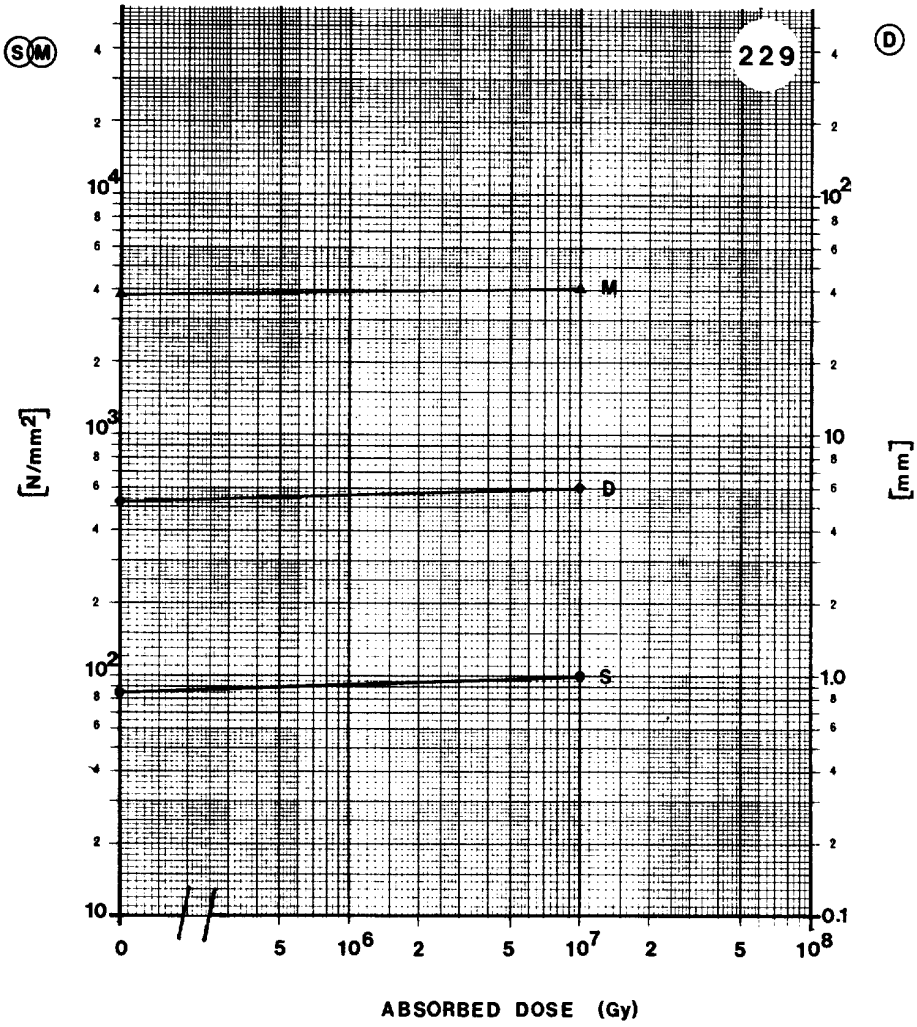
CURVE	PROPERTY	INITIAL VALUE	
S	Ultimate flexural strength	364.9	N/mm^2
D	Deflexion at break	3.4	mm
M	Modulus of elasticity	1.5×10^4	N/mm^2

EPOXY RESINS

MATERIAL: DOBECKOT 502 + HARDENER 710

SUPPLIER: PLESSEY

Remarks: USED FOR SPS QUADRUPOLE COILS

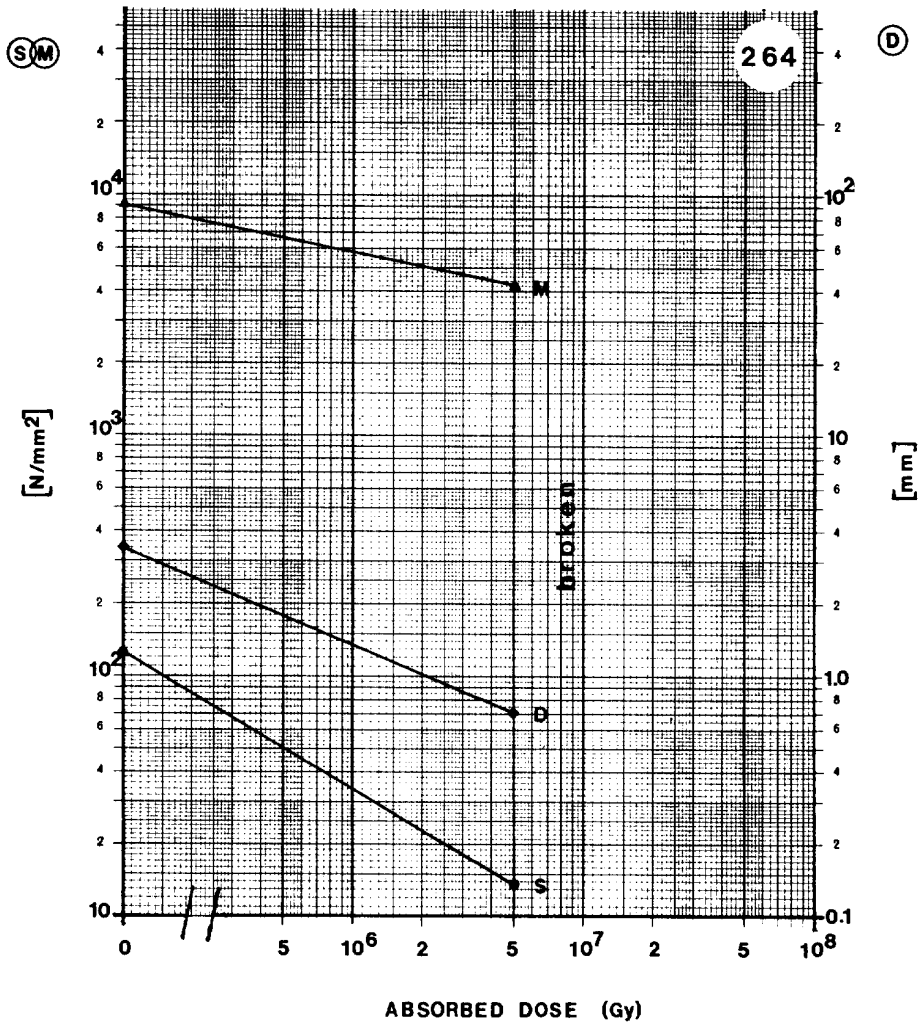


CURVE	PROPERTY	INITIAL VALUE	
S	Ultimate flexural strength	84.4	N/mm^2
D	Deflexion at break	5.3	mm
M	Modulus of elasticity	3.8×10^3	N/mm^2

MATERIAL: EPOXY 91-1892(100) + CURING AGENT 91-1893(150) + DY 062(2.5)

SUPPLIER: LARS FOSS KEMI

Remarks:



CURVE	PROPERTY	INITIAL VALUE	
S	Ultimate flexural strength	125.6	N/mm^2
D	Deflexion at break	3.4	mm
M	Modulus of elasticity	9.1×10^3	N/mm^2

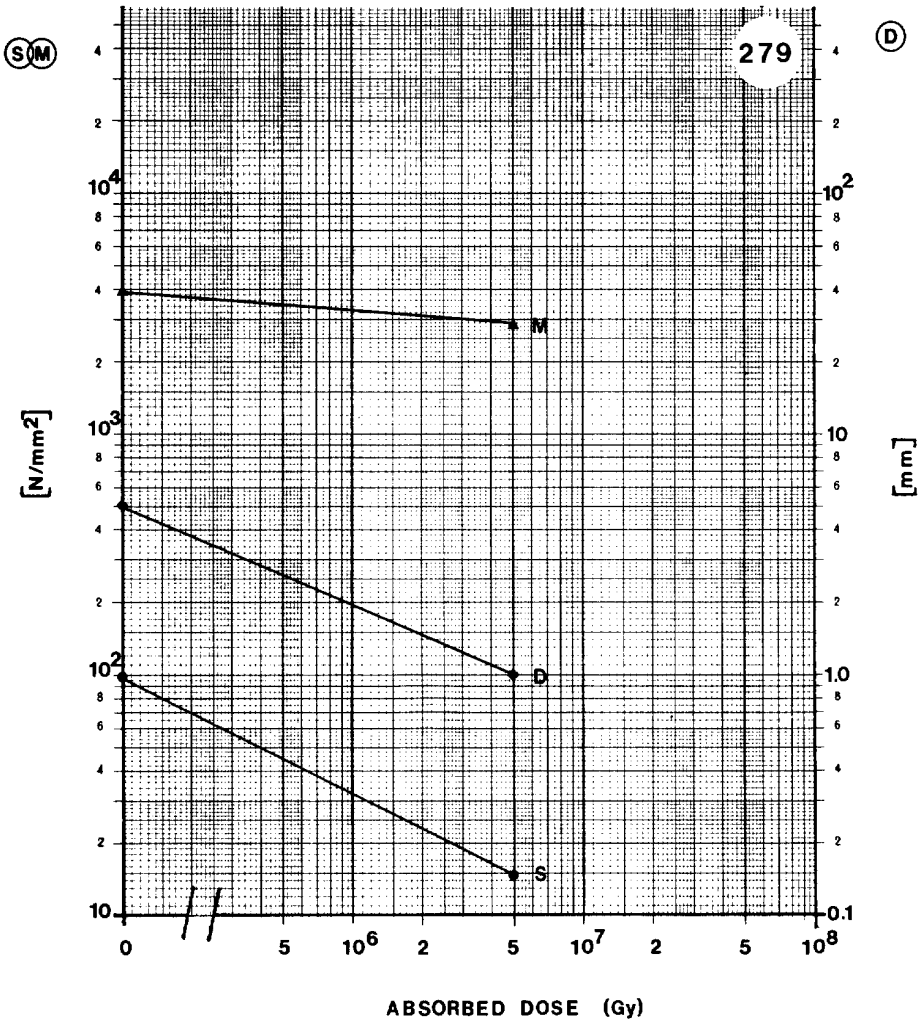
EPOXY RESINS

MATERIAL: SAMICATHERM 366.28.02 - EPOXY RESIN + MICA + GLASS TAPE

MATERIAL: EPOXY 91-1892(100) + HARDENER 91-1893(150) + DY 040(25) + + DY 062(2.5)

SUPPLIER: LARS FOSS KEMI

Remarks:

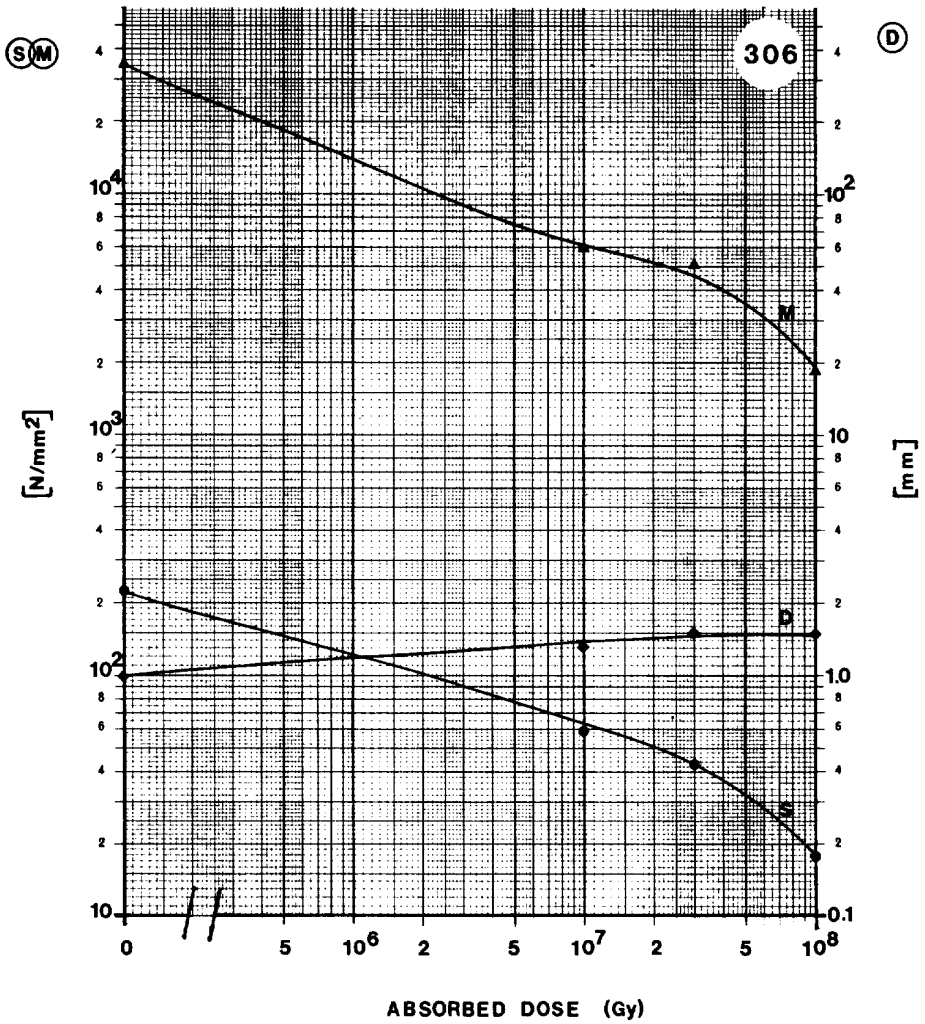


CURVE	PROPERTY	INITIAL VALUE	
S	Ultimate flexural strength	99.1	N/mm^2
D	Deflexion at break	5.0	mm
M	Modulus of elasticity	3.9×10^3	N/mm^2

MATERIAL: SAMICATHERM 366.28.02 - EPOXY RESIN + MICA + GLASS TAPE

SUPPLIER: ISOLA

Remarks:

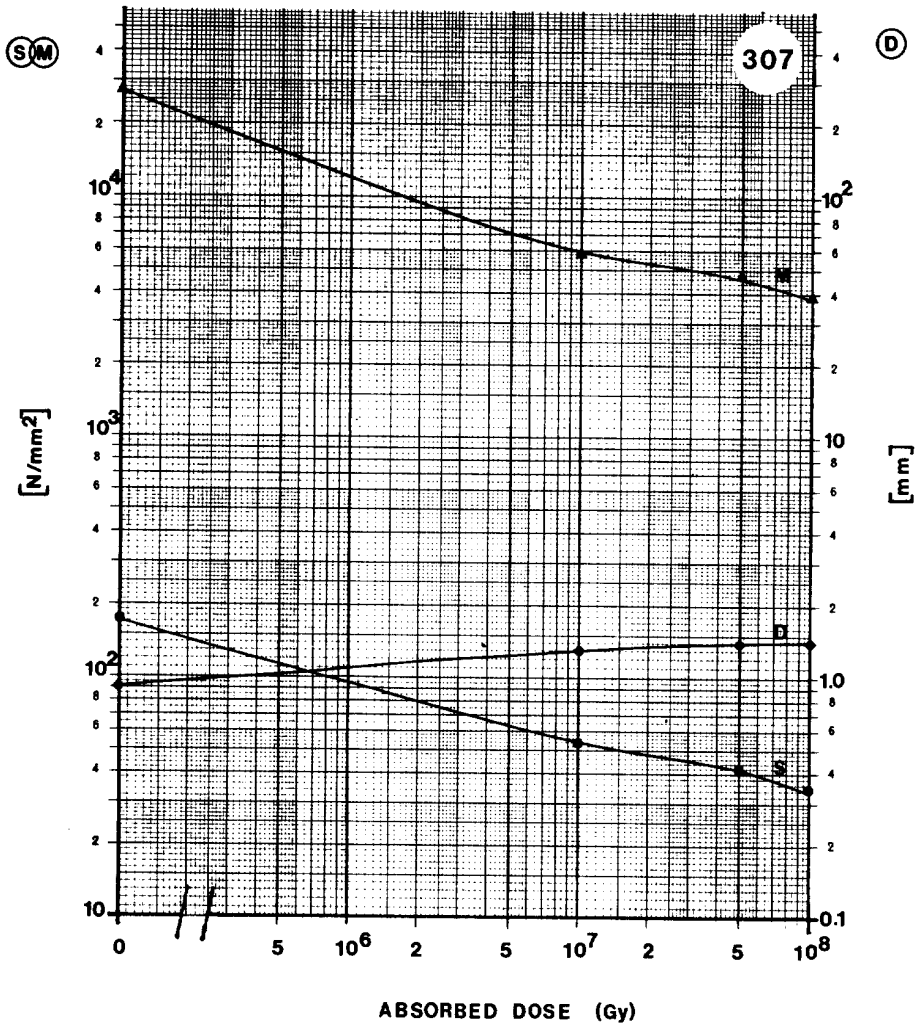


CURVE	PROPERTY	INITIAL VALUE	
S	Ultimate flexural strength	224.6	N/mm²
D	Deflexion at break	1.0	mm
M	Modulus of elasticity	3.4 × 10⁴	N/mm²

MATERIAL: SAMICATHERM CR 5.56.4 - EPOXY RESIN + MICA + GLASS TAPE

SUPPLIER: ISOLA

Remarks:

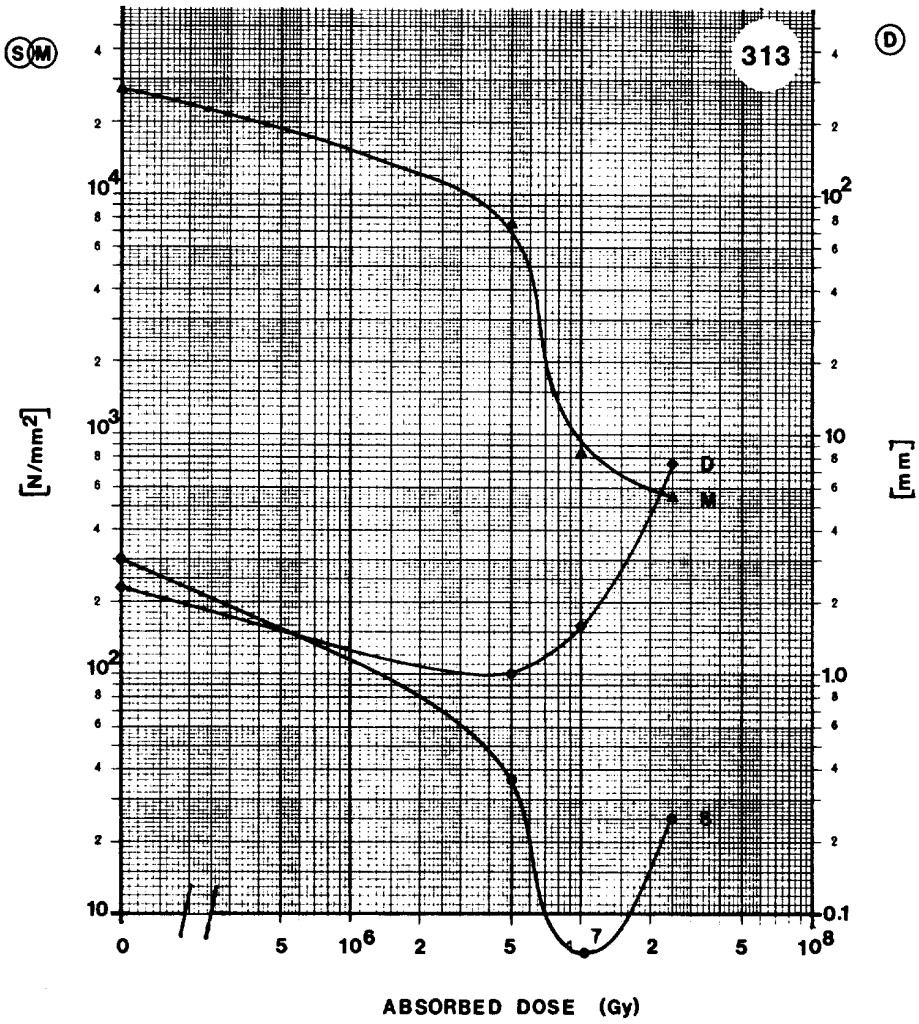


CURVE	PROPERTY	INITIAL VALUE	
S	Ultimate flexural strength	176.6	N/mm^2
D	Deflexion at break	0.9	mm
M	Modulus of elasticity	2.8×10^4	N/mm^2

MATERIAL: EPOXY RESIN + MICA + GLASS TAPE

SUPPLIER: CIBA-GEIGY

Remarks:



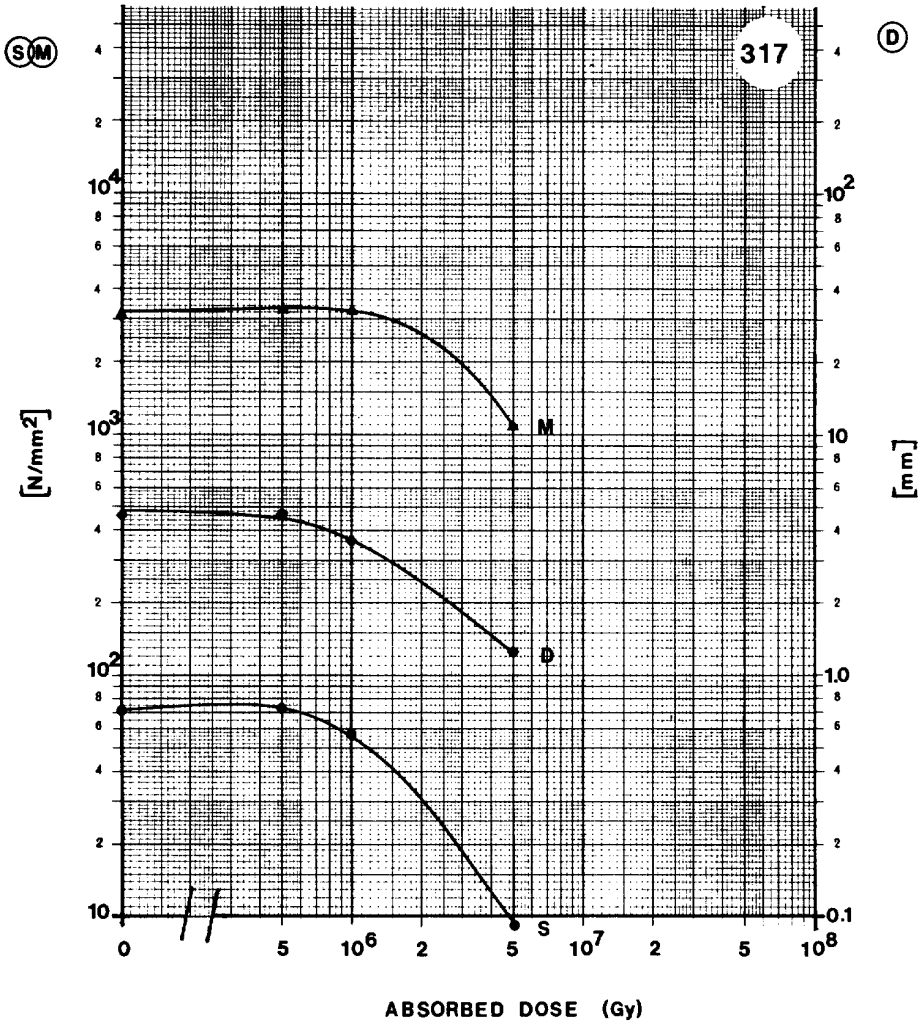
CURVE	PROPERTY	INITIAL VALUE	
S	Ultimate flexural strength	299.2	N/mm^2
D	Deflexion at break	2.3	mm
M	Modulus of elasticity	2.7×10^4	N/mm^2

EPOXY RESINS

MATERIAL: EPOXY URETHANE RESIN (EXPERIMENTAL PRODUCT 1)

SUPPLIER: LRCE

Remarks: USED FOR ANCHORAGE

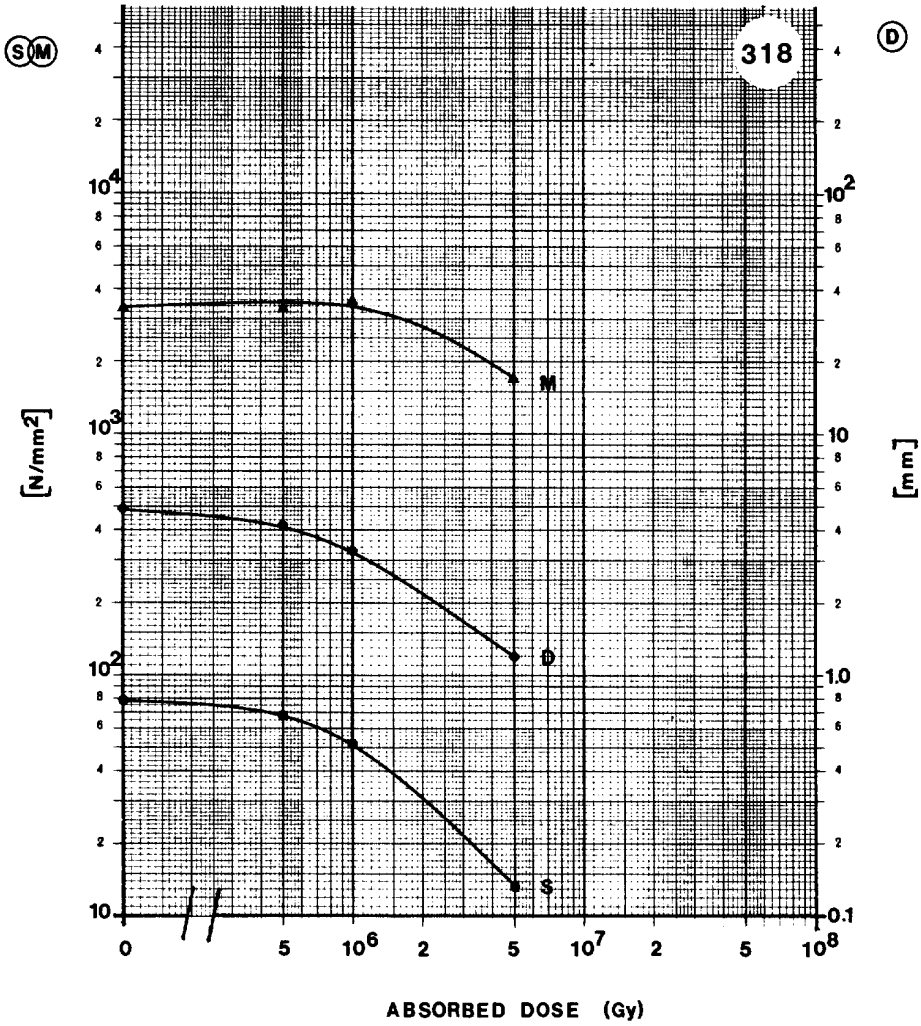


CURVE	PROPERTY	INITIAL VALUE	
S	Ultimate flexural strength	70.6	N/mm^2
D	Deflexion at break	4.6	mm
M	Modulus of elasticity	3.1×10^3	N/mm^2

MATERIAL: EPOXY URETHANE RESIN (EXPERIMENTAL PRODUCT 2)

SUPPLIER: LRCE

Remarks: USED FOR ANCHORAGE



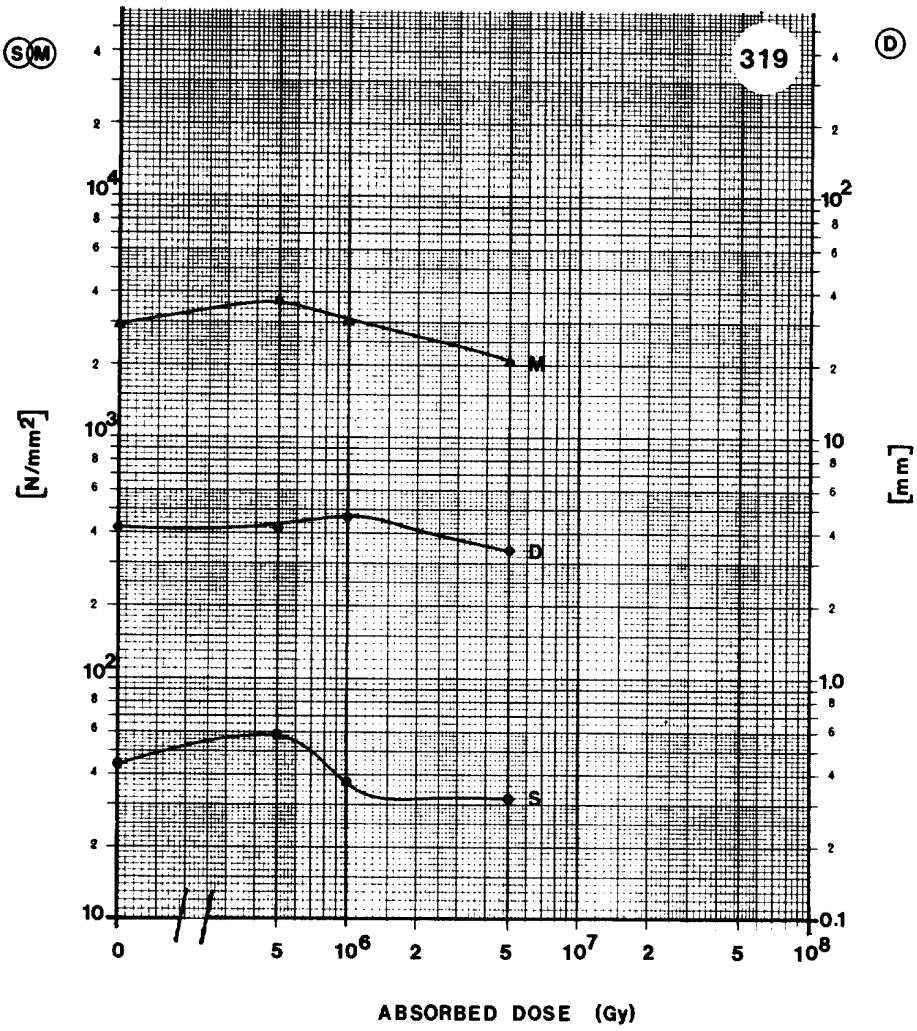
CURVE	PROPERTY	INITIAL VALUE	
S	Ultimate flexural strength	78.3	N/mm^2
D	Deflexion at break	4.8	mm
M	Modulus of elasticity	3.3×10^3	N/mm^2

EPOXY RESINS

MATERIAL: EPOXY RESIN, IR 5003 SPECIAL

SUPPLIER: LRCE

Remarks: USED FOR ANCHORAGE



CURVE	PROPERTY	INITIAL VALUE	
S	Ultimate flexural strength	43.4	N/mm^2
D	Deflexion at break	4.2	mm
M	Modulus of elasticity	2.9×10^3	N/mm^2