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Compilation of radiation damage test data, pt 2: thermosetting and thermoplastic resins

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Les chapitres 1 à 4 sont traduits en français

Appendix 1: Names of materials presented in this catalogue
Appendix 2: Trade name with corresponding chemical name for basic components
Appendix 3: Firms which supplied test samples contained in this volume
Appendix 4: Abbreviations of used commercial symbols

Alphabetic compilation of data:

A - ARALDITE F CY 205 (view: TIFF or GIF or PDF)

ARALDITE CY 222 - ARALDITE MY 720 (view: TIFF or GIF or PDF)

B - EPOXY RESINS (view: TIFF or GIF or PDF)

I - O (view: TIFF or GIF or PDF)

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1. Introduction

At the European Organization for Nuclear Research (CERN), radiation damage test studies have been carried out on a large variety of organic and inorganic materials, electronic components, metals, etc., which are used in the construction and operation of high-energy accelerators. Since apart from electronic components the organic materials are amongst those the most sensitive to radiation, a large amount of radiation damage test data have been published[1-11]. Nevertheless, design engineers are often faced with the problem of quickly finding the desired information. We therefore decided to publish our radiation damage test results on organic materials in a catalogue, with an alphabetic compilation of data. Up to now, two volumes of the catalogue are available.

Part I[12] contains information on commercially available cable insulating materials such as ethylene-propylene rubber, Hypalon, Neoprene-rubber, polyethylene, polyvinylchloride, etc. A detailed list of materials which can be found in Part I is given in Appendix 1.

The present part, Part II, contains thermosetting and thermoplastic resins*) with exception of cable insulating materials. The main contribution of data in this part is from epoxy resins, which are used for the insulation of large magnet coils.

We first describe some characteristic properties of the materials and the test methods, and define the end-point criterion for the selection of radiation-resistant materials. Then we give the irradiation conditions, and in Section 4 we explain the presentation of the data.

It must be noted that all data have been obtained after accelerated irradiations in a nuclear reactor, and all tests were carried out under ambient environmental conditions. After long-term exposure and ageing in other environments, a variation from the presented data may be expected.

*) Thermosetting materials have the property of becoming permanently hard and rigid when heated or cured, whereas thermoplastic resins may be remelted and cooled time after time without undergoing any appreciable chemical change.

1. Introduction

A l'Organisation européenne pour la recherche nucléaire (CERN), des essais de radiorésistance ont été effectués sur un grand nombre de matériaux organiques et inorganiques, des composants électroniques, des métaux, etc., qui sont utilisés pour la construction et l'opération des accélérateurs à haute énergie. Mis à part les composants électroniques, les matériaux organiques sont parmi les plus sensibles aux rayonnements ionisants; une grande quantité de résultats sur ce sujet peut donc être trouvée dans la littérature[1-11]. Toutefois, les ingénieurs rencontrent souvent des difficultés pour trouver facilement l'information voulue. C'est pour cette raison que nous avons décidé de publier nos résultats d'essais de radiorésistance des matériaux organiques sous forme de catalogue alphabétique. Ceci a été fait en deux parties:

La première partie[12] concerne des matériaux utilisés comme isolants et gaines de câbles électriques: le caoutchouc éthylène-propylène, l'Hypalon, le caoutchouc Néoprène, le polyéthylène, le chlorure de polyvinyle, etc. Une liste complète des matériaux présentés dans cette première partie peut être trouvée dans l'appendice 1.

Le présent volume, qui constitue la seconde partie, contient des résines thermodurcissables et thermoplastiques*), dont la plupart sont des époxydes utilisés dans l'isolation de bobinés d'aimants.

Nous donnons d'abord quelques propriétés caractéristiques des matériaux, les méthodes d'essais utilisées, et nous définissons les critères de dégradation de propriétés qui servent à sélectionner les matériaux radiorésistants. Nous décrivons ensuite les conditions d'irradiation et, dans la section 4, nous expliquons la présentation des données.

Il faut noter que tous les résultats ont été obtenus par des irradiations accélérées dans un réacteur nucléaire, et que tous les essais ont été faits à température ambiante. Après une longue période d'irradiation et un vieillissement sous d'autres conditions, on peut s'attendre à un changement dans les résultats que nous avons obtenus.

*) Les matériaux thermodurcissables se transforment pendant la cuisson en des produits réfractaires et non solubles, tandis que les produits thermoplastiques ramollissent si l'on augmente la température et durcissent de nouveau si on l'abaisse.

2. Materials, characteristic properties, test methods, and end-point criterion

Most materials listed in this catalogue have been supplied during the construction period of the CERN 400 GeV Super Proton Synchrotron (SPS) by European firms which were involved in offers and/or supply of organic resins to be used in high radiation areas. A list of these firms is given in Appendix 3. Apart from epoxy resins, which represent the largest group of materials, also polyesters, phenolics, polyurethanes, and silicones were included in the radiation damage test studies. Some materials may not be on the market any longer; this is marked in the tables and graphs of the catalogue whenever known.

Some characteristic physical, mechanical, and electrical properties of thermosetting resins are summarized in Table 1 [9]. These values may serve only as a general indication since they depend on numerous parameters such as composition and quantity of base resin, hardener, accelerator, filler, and other additives, as well as on cure conditions, etc.

The determination of the degradation of the materials due to ionizing radiation is based on the mechanical properties. This we justify by our own experience and that of others [4] that, in general, the mechanical degradation of organic insulating materials occurs before the degradation of the electrical and other physical properties.

Whenever possible, the tests have been carried out according to international norms [13]. Sometimes exceptions had to be made for practical or technical reasons, e.g. sample size, dose rate during irradiation, etc. The test samples, usually five per test, have been cut from 4 to 6 mm thick plates molded from the respective materials.

Flexion tests were performed on an Instron testing machine, where the force at rupture and the maximum deflection at break were determined. From these measurements the ultimate flexural strength and the tangent modulus of elasticity were calculated.

The testing method was a three-point loading system utilizing a centre load on the supported sample according to ASTM norm D790. The distance between the two supports was 67.0 mm and the speed of the central point was 2 mm/min.

As end-point criterion for the definition of the radiation resistance of non-flexible plastic insulating materials we require that *at a given dose D the ultimate flexural strength of the material is above 50% of its initial value at zero dose.*

2. Les matériaux, leurs propriétés caractéristiques, les méthodes d'essais et les critères de dégradation de propriétés

La plupart des matériaux de ce catalogue ont été fournis pendant la construction, au CERN, du Super-Synchrotron à Protons de 400 GeV, par des firmes européennes qui ont été engagées dans des offres ou des fournitures de résines organiques. Une liste de ces firmes est donnée dans l'appendice 3. A part les résines époxydes, qui recouvrent la plupart des matériaux, nous avons aussi inclus dans l'étude des résines polyestères, phénoliques, polyuréthanes et silicones. Il est possible que quelques-uns des matériaux ne soient plus sur le marché, et nous l'avons noté dans les tableaux et les graphiques, pour les cas où nous l'avons su.

Le tableau 1 donne un résumé des quelques propriétés mécaniques, électriques et physiques des résines thermodurcissables [9]. Ces valeurs peuvent seulement servir d'indication générale, puisqu'elles dépendent de nombreux paramètres tels que la composition et la quantité de la résine de base, du durcisseur et de l'accélérateur, ainsi que les charges et d'autres additifs.

Pour la détermination de la dégradation des matériaux due aux rayonnements ionisants, nous avons choisi pour les essais les propriétés mécaniques. Ce choix se justifie par notre propre expérience, et celle d'autres auteurs [4], qui nous ont appris que la dégradation, due à l'irradiation, des propriétés mécaniques des matières plastiques intervient généralement avant celle de leurs propriétés électriques et de leurs autres propriétés physiques.

Nous avons exécuté nos essais selon les normes internationales [13] dans tous les cas où cela était possible. Pour des raisons pratiques ou techniques, quelques exceptions étaient inévitables, par exemple dimension d'échantillons, débit de dose pendant l'irradiation, etc.

Les matériaux ont été fournis sous forme de plaques de 4 à 6 mm d'épaisseur, dans lesquelles, en général, cinq échantillons ont été coupés pour chaque essai.

Des essais de flexion ont été effectués sur une machine Instron qui ont permis de déterminer la force ainsi que la déflexion à la rupture. Ensuite nous avons calculé la résistance à la flexion et le module d'élasticité.

La méthode d'essai était un système d'appui à trois points: on applique la force sur le point central, selon la norme ASTM D790. La distance entre les deux points d'appui était de 67,0 mm, et la vitesse d'avancement du point central était de 2 mm/min.

3. Irradiation conditions and dosimetry

Important remark: New special names of SI units in the field of ionizing radiation have been adopted in 1975 on the recommendation of the International Commission on Radiation Units and Measurements[14]. This new SI unit for the absorbed dose of interest here is the Gray (Gy), whereby

$$1\ \text{Gy} = 1\ \text{J/kg} = 100\ \text{rad}.$$

Please note that all units for absorbed dose in this report are in Gray.

Test samples have been irradiated to three different doses between 5×10^6 and 1×10^8 Gy at the ASTRA reactor in Seibersdorf (Austria). This is a 7 MW pool reactor, and the irradiation position 11 is situated in the reactor core. The characteristics of the irradiation container and the radiation field are the following:

Dimensions of irradiation container:	diameter 46 mm; length 300 mm;
Fast neutron flux (E > 1 MeV):	$2\text{-}3 \times 10^{12}$ n/cm^{2}sec;
Thermal neutron flux:	$4\text{-}5 \times 10^{12}$ n/cm^{2}sec;
Gamma dose rate:	$1\text{-}2 \times 10^6$ Gy/h;
Irradiation medium:	water;
Irradiation temperature:	30-40°C.

The thermal neutron flux and the fast neutron spectrum are determined by means of activation detectors and the gamma dose rate is measured calorimetrically. More details about the irradiation conditions and dosimetry are given elsewhere[15].

4. Presentation of data

The data are presented in alphabetical order, and under each letter (if there are any materials) the following information can be found:

- Material name, trade name, and/or chemical name and chemical formula if known;
- Tables and graphs containing the radiation damage test data.

The tables contain:

- The material name (e.g. Silicone);
- An internal code number;
- The material type, composition, cure condition if known, and the supplier of the material;
- Flexion test results for the irradiated and non-irradiated material:
  ultimate flexural strength in N/mm^2,
  deflection at break in mm,
  modulus of elasticity in N/mm^2.

Comme critère de dégradation de propriétés pour la définition de la radiorésistance de matériaux isolants non flexibles, nous exigeons qu'à *une dose-seuil D la résistance de flexion du matériel soit au-dessus de 50% de sa valeur initiale à dose zéro.*

3. Conditions d'irradiation et dosimétrie

Remarque importante: De nouvelles unités SI dans le domaine des rayonnements ionisants ont été introduites en 1975[14]. L'unité SI pour la dose absorbée est le Gray (Gy), tel que

$$1\ \text{Gy} = 1\ \text{J/kg} = 100\ \text{rad}.$$

Il faut noter que dans ce rapport toutes les valeurs pour la dose absorbée sont données en Gray.

Les échantillons ont été irradiés en général à trois doses intégrées entre 5×10^6 et 1×10^8 Gy dans le réacteur ASTRA, à Seibersdorf (Autriche). Il s'agit d'un réacteur piscine de 7 MW et la position d'irradiation N° 11 se trouve dans le coeur du réacteur. Les caractéristiques du container d'irradiation, ainsi que du champ de rayonnement, sont les suivantes:

Dimensions du container d'irradiation:	46 mm de diamètre, 300 mm de longueur;
Flux de neutrons rapides (E > 1 MeV):	$2\text{-}3 \times 10^{12}$ n/cm^{2}sec;
Flux de neutrons thermiques:	$4\text{-}5 \times 10^{12}$ n/cm^{2}sec;
Débit de dose gamma:	$1\text{-}2 \times 10^6$ Gy/h;
Milieu d'irradiation:	eau;
Température d'irradiation:	30-40 °C.

Le flux des neutrons thermiques et rapides a été mesuré par des détecteurs à activation, et le débit de dose gamma par un calorimètre. Plus de détails sur les conditions d'irradiation et la dosimétrie peuvent être trouvés dans la référence 15.

4. Présentation des résultats

Les matériaux au sujet desquels on peut trouver des résultats sont classés alphabétiquement en anglais; sous chaque lettre on peut trouver les informations suivantes:

- Nom du matériau, nom commercial et/ou nom chimique et formule chimique si connue;
- Les résultats d'essais de radiorésistance de matériaux sous forme de tableaux et graphiques.

Les tableaux contiennent:

- Le nom du matériau (par exemple, silicone);
- Un numéro de code interne;

The arithmetic mean value and standard deviation is given.

The graphs contain:

- The ultimate flexural strength S, the deflection at break D, and the modulus of elasticity M as a function of absorbed dose for the same materials as listed in the tables above;
- Information on the material, composition, and supplier;
- Remarks, if any (e.g. used for SPS dipole magnets);
- Initial values of S, D, and M.

All materials which can be found in this catalogue are listed in Appendix 1. Appendix 2 gives the used trade names and corresponding chemical names. Appendix 3 lists the firms which supplied test samples for this study, and Appendix 4 explains the used commercial symbols for chemical compounds.

- Le type de matériau, sa composition, les conditions de cuisson si connues, et le fournisseur du matériau;
- Les résultats des essais de flexion pour le matériau irradié et non irradié:
  - résistance à la flexion en N/mm^2,
  - déflection à la rupture en mm,
  - module d'élasticité en N/mm^2.

  La valeur de la moyenne arithmétique et la déviation standard sont données.

Les graphiques contiennent:

- La variation des propriétés mécaniques en fonction de la dose absorbée pour les mêmes matériaux que ceux donnés dans les tableaux expliqués ci-dessus;
- L'information sur le matériau, sa composition, le fournisseur;
- Des remarques, s'il y a lieu;
- Les valeurs des propriétés mécaniques pour le matériau non irradié.

La liste des matériaux pour lesquels nous donnons des résultats constitue l'appendice 1. Pour y retrouver facilement un matériau dont on ne connaît le nom qu'en français, nous avons préparé une liste de traductions dans le tableau 2.

L'appendice 2 donne les noms déposés ou noms de commerce des matériaux, avec leur nom chimique. L'appendice 3 présente une liste des firmes qui ont fourni des échantillons pour les essais, et l'appendice 4 explique les symboles commerciaux utilisés pour les composés chimiques.

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Our particular thanks are due to K. Goebel for his interest in this work and for many useful discussions and suggestions, as well as for the revision of this report.

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We would like to thank the firms which have supplied the test samples, both for their interest in this subject and for useful discussions which we had with their representatives.

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Les irradiations ont été effectuées au réacteur ASTRA, à Seibersdorf, en Autriche, qui fait partie de l'Österreichische Studiengesellschaft für Atomenergie. Nous avons apprécié la bonne collaboration que nous ont offerte A. Burtscher et J. Casta.

L'organisation des essais mécaniques, leur exécution, et l'analyse des résultats ont été effectués par P. Beynel. Son enthousiasme et l'intérêt qu'il a porté à ce travail ont été précieux.

Nous voudrions enfin exprimer notre appréciation de l'effort et de l'attention que le Service de dactylographie de rapports scientifiques a apportés à la préparation de ce document.

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Table 1

Characteristic properties of thermosetting materials

PROPERTIES / POLYMERS		EPOXY RESINS					
		BISPHENOL A			EPOXY NOVOLAC		
		NO FILLER	GLASS	MINERAL	NO FILLER	GLASS	MINERAL
SPECIFIC GRAVITY (g/cm^3)	ASTM D792	1.15	2.0 - 2.1	1.8 - 2.0	1.2	1.97	1.7
WATER ABSORPTION (%)	D570	0.1 – 0.2	0.02 – 0.08	0.30 – 0.80	–	0.04 – 0.06	0.11 – 0.20
THERMAL CONDUCTIVITY (kcal/m.h.°C)	D325	0.15 – 0.45	1	–	–	–	–
THERMAL COEFFICIENT OF EXPANSION (10^{-5}/°C)	D696	6	0.6	–	3	–	–
TENSILE STRENGTH (kg/cm^2)	D638	700 – 800	3500 – 4000	700	700	3500 – 4000	380
ELONGATION (%)	D638	4.4	–	–	2 – 5	–	–
TENSILE MODULUS (10^4 kg/cm^2)	D638	3.5	30	10 – 15	3.5	21 – 22	–
FLEXURAL STRENGTH (kg/cm^2)	D790	800 – 1300	3600	1500 – 1700	600 – 1000	3900	700 – 800
IMPACT STRENGTH (notched) (kgcm/cm)	D256	1.1 – 2.7	6.4 – 8.2	2.2 – 2.7	2.7	7.0 – 9.2	2.2 – 2.7
VOLUME RESISTIVITY (Ω cm)	D257	6.1 10^{15}	–	1.5 10^{15}	2.1 – 10^{14}	–	1.4 – 5.5 10^{14}
DIELECTRIC STRENGTH (kV/mm)	D149	> 16	18 – 22	15 – 16	–	–	12 – 16
POWER FACTOR at 10^6 cycl/s	D150	0.032	0.024	0.013	0.029	0.015	–
DIELECTRIC CONSTANT at 10^6 cycl/s	D150	3.4	4.7 – 4.8	4.1 – 4.6	3.5	5.1	4.3 – 4.8
HEAT DISTORTION TEMPERATURE (°C)	D648	110	–	–	150 – 200	–	–

Table 1 (contd.)

PROPERTIES \ POLYMERS		PHENOLICS						POLYIMIDES	
		NO FILLER	WOOD FLOUR	ASBESTOS	FIBRE AND FABRIC	MINERAL	NYLON	UNFILLED	GLASS
SPECIFIC GRAVITY (g/cm^3)	ASTM D792	1.30 - 1.32	1.29 - 1.51	1.78 - 2.00	1.3 - 1.4	1.5 - 1.9	1.2 - 1.5	1.47	1.90
WATER ABSORPTION (%)	D570	0.30 - 0.40	0.70 - 1.20	0.03 - 0.30	0.50 - 1.6	0.04 - 0.25	0.25 - 0.4	0.68	0.20
THERMAL CONDUCTIVITY (kcal/m.h.°C)	D325	-	0.15 - 0.45	0.15 - 0.25	0.3	0.3	-	0.60	-
THERMAL COEFFICIENT OF EXPANSION (10^{-5}/°C)	D696	4.3	3.6	-	3	1.8	-	5.4	1.5
TENSILE STRENGTH (kg/cm^2)	D638	140 - 630	385 - 630	210 - 490	315 - 630	140 - 595	315 - 630	740	2100
ELONGATION (%)	D638	~5	~5	~5	~5	4 - 9		< 1.5	< 1
TENSILE MODULUS (10^4 kg/cm^2)	D638	1.4 - 3.1	4.9 - 14.0	11 - 20.0	5.6 - 10.0	9.5 - 21.0	2.8 - 14.0	3.2	28 - 30
FLEXURAL STRENGTH (kg/cm^2)	D790	840 - 1000	600	450 - 770	490 - 1100	560 - 840	420 - 910	1000	3500
IMPACT STRENGTH (notched) (kgcm/cm)	D256	2.7 - 4.3	1 - 2.8	0.8 - 16	2 - 36	0.97 - 3.9	1.4 - 2.8	5	17
VOLUME RESISTIVITY (Ω cm)	D257	$2.5\ 10^{10} - 10^{12}$	$10^9 - 10^{13}$	$10^8 - 10^{13}$	$10^8 - 10^{12}$	$10^{10} - 10^{14}$	$10^{11} - 10^{14}$	$10^{16} - 10^{17}$	$9.2\ 10^{15}$
DIELECTRIC STRENGTH (kV/mm)	D149	10 - 16	0.6 - 10	0.4 - 10	0.4 - 7	3 - 16	1 - 11	22	-
POWER FACTOR at 10^6 cycl/s	D150	0.04 - 0.05	0.015 - 0.06	0.03 - 0.25	0.03 - 0.08	0.007 - 0.08	0.15 - 0.2	0.005	0.0055
DIELECTRIC CONSTANT at 10^6 cycl/s	D150	4-9.7 (10^3c/s)	3.9 - 6.5	5 - 6	4.8 - 7	4 - 6	3.7 - 4.5	3.4	4.7
HEAT DISTORTION TEMPERATURE (°C)	D648	150 - 180	130 - 180	-	250	180 - 200	-	300	350

Table 1 (contd.)

PROPERTIES \ POLYMERS	ASTM	POLYESTERS				POLYURETHANES	SILICONES	
		α CELLULOSE	MINERAL	GLASS	NO FILLER		GLASS	MINERAL
SPECIFIC GRAVITY (g/cm^3)	D792	1.35 - 1.40	1.70 - 2.20	1.20 - 2.00	1.20 - 1.40	1.21	1.88	1.88 - 2.8
WATER ABSORPTION (%)	D570	0.01 - 1	–	0.1 - 2	0.03 - 0.4	0.30 - 0.90	0.10 - 0.30	0.05 - 0.22
THERMAL CONDUCTIVITY (kcal/m.h.°C)	D325	–	–	1.8 - 2.2	0.15	–	0.27	0.50
THERMAL COEFFICIENT OF EXPANSION (10^{-5}/°C)	D696	–	–	2	7	–	6	5
TENSILE STRENGTH (kg/cm^2)	D638	420 - 500	210 - 460	420 - 900	350 - 810	450 - 600	280 - 560	175 - 310
ELONGATION (%)	D638	–	–	0.3 - 0.5	1.7 - 2.6	$>$	<3	<3
TENSILE MODULUS (10^4 kg/cm^2)	D638	–	9.8 - 19.0	4.2 - 12.0	2.8 - 4.6	3.3 - 8.4	14.7 - 17.5	8.7 - 15.9
FLEXURAL STRENGTH (kg/cm^2)	D790	700 - 840	175 - 630	840 - 1500	450 - 910	–	910 1330	490 700
IMPACT STRENGTH (notched) (kgcm/cm)	D256	1.6 - 2.5	1 - 4	40 - 54	1.6 - 10	>5.4	50	2
VOLUME RESISTIVITY (Ω cm)	D257	$>10^{14}$	$>10^{14}$	$10^{12}-10^{15}$	2.7 10^{14} 2 10^{15}	6 $10^{12}-10^{14}$	3 10^{14}	10^{14}
DIELECTRIC STRENGTH (kV/mm)	D149	10 - 14	10 - 17	6 - 14	10 - 17	20	10 - 11	11 - 16
POWER FACTOR at 10^6 cycl/s	D150	0.03 - 0.05	0.013 - 0.04	1.1 - 0.04	0.01 - 0.03	0.03 - 0.05	0.003 - 0.02	0.002 - 0.01
DIELECTRIC CONSTANT at 10^6 cycl/s	D150	3.5 - 5.5	4.5 - 7.0	4.5 - 6.0	3.0 - 4.01	3.3 - 3.9	4.35	3.4 - 4.5
HEAT DISTORTION TEMPERATURE (°C)	D648	–	–	200	50 - 200	–	>450	270 - 450

Tableau 2

Noms, en ordre alphabétique,
de tous les matériaux cités dans ce volume, avec leur traduction en anglais.

Les noms en italiques sont des marques de fabrique,
ou des noms déposés, pour lesquels nous ne donnons pas de traduction.

En français	En anglais
Araldite B	
Araldite D	
Araldite F	
Araldite F + epoxy Novolac	
Birakrit	
Cevolit	
Crystic	
Dobeckan IF	
Dobeckot	
Epikote	
Etronax	
Isoval	
Kerimid	
Kinel	
Macrolon	
Novolac	
Orlitherm	
Polylite	
Résines époxydes	Epoxy resins
Résines époxydes + Novolac	Epoxy resins + Novolac
Résines phénoliques	Phenolic resins
Résines de polycarbonate	Polycarbonate resins
Résines de polyester	Polyester resins
Résines de polyimide	Polyimide resins
Résines polyuréthanes	Polyurethane resins
Résines silicones	Silicone resins
Resofil	
Ryton	
Samicanit	
Samicatherm	
Veridur	
Vetresit	
Vetronit	

APPENDIX 1

Names, in alphabetical order, of all materials presented in this catalogue.
The main entries are in romans,
the names in italics appear as cross-references.

Volume 1: Cable insulating materials (Ref. 12)

BUTYL RUBBER
CHLOROSTOP
CHLOROSULFONATED POLYETHYLENE (CSP)
CROSS-LINKED POLYETHYLENE (XLPE)
DESMOPAN
ETHYL-ACRYLATE RUBBER (EAR)
ETHYLENE-PROPYLENE DIENE RUBBER (EPDM)
ETHYLENE-PROPYLENE RUBBER (EPR)
ETHYLENE VINYL-ACETATE (EVA)
FLAMTROL
FLUOROPOLYMER
HALAR
HYPALON
HYTREL
KAPTON
LUPOLEN
NEOPRENE
NORDEL
POLYCHLOROPRENE
POLYETHYLENE (PE)
POLYURETHANE (PUR)
POLYVINYLCHLORIDE (PVC)
PYROFIL
RADOX
SEMICONDUCTING POLYETHYLENE
SILICONE RUBBER
SILYTHENE
STILAN
TEFLON
TEFZEL
VITON
XLPE

Volume 2: Thermoplastic and thermosetting resins (present report)

ARALDITE B
ARALDITE D
ARALDITE F and other ARALDITE resins
ARALDITE F + EPOXY NOVOLAC
BIRAKRIT
CEVOLIT
CRYSTIC
DOBECKAN IF
DOBECKOT
EPIKOTE
EPOXY RESINS
EPOXY RESINS + EPOXY NOVOLAC
ETRONAX
ISOVAL
KERIMID
KINEL
MACROLON
NOVOLAC
ORLITHERM
PHENOLIC RESINS
POLYCARBONATE RESINS
POLYESTER RESINS
POLYIMIDE RESINS
POLYLITE
POLYURETHANE RESINS
RESOFIL
RYTON
SAMICANIT
SAMICATHERM
SILICONE RESINS
VERIDUR
VETRESIT
VETRONIT

APPENDIX 2

Trade name with corresponding chemical name for basic components

Trade name	Chemical name
ARALDITE	Epoxy resin
BIRAKRIT	Epoxy resin
CEVOLIT	Polyester
CRYSTIC	Polyester
DOBECKAN IF	Polyurethane
DOBECKOT	Epoxy resin
EPIKOTE	Epoxy resin
ETRONAX	Phenolic
ISOVAL	Epoxy resin
KERIMID	Polyimide
KINEL	Polyimide
MAKROLON	Polycarbonate
ORLITHERM	Epoxy resin
POLYLITE	Polyester
RESOFIL	Phenolic
RYTON	Polyphenyl sulfide
SAMICANIT	Epoxy resin
SAMICATHERM	Epoxy resin
VERIDUR	Silicone resin
VETRESIT	Epoxy resin (Novolac)
VETRONIT	Epoxy resin

APPENDIX 3

Firms which supplied test samples contained in this volume

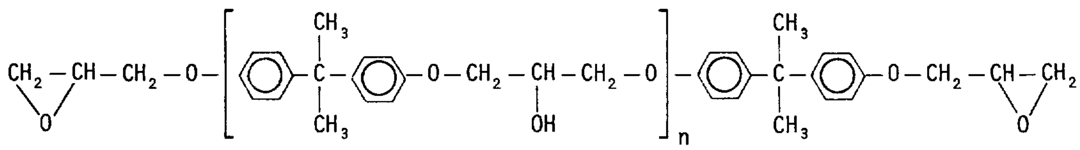
Firm	Material
ALSTHOM Belfort, France	Araldite MY745; Epoxy Novolac
BBC, Brown, Boveri & Company Baden, Switzerland	Araldite CY205, CY222, MY720, Silicone
BBC, Brown, Boveri & Company Mannheim, West Germany	Epoxy, Polyester, Polyurethane
Cellpack AG Wohlen/Aargau, Switzerland	Polyester
CIBA-GEIGY Basel, Switzerland	Araldite B, Araldite CY205, MY745, Epoxy Novolac
DOW Chemical Europe SA Horgen, Switzerland	Epoxy Novolac
Dr. Beck (new name BASF Farben + Fasern AG) Hamburg, West Germany	Epoxy, Polyurethane
Elektro-ISOLA A/S Vejle, Denmark	Polyester
Ferrozell-Geschw. Sachs & Co. mbH Augsburg, West Germany	Epoxy
Gummi Maag Zürich, Switzerland	Polyester
Hazemeyer Hengelo, Netherlands	Polyester
ISOLA, Fabrique Suisse d'Isolants Breitenbach, Switzerland	Epoxy, Epoxy Novolac, Polyimide, Silicone
ISOVOLTA Vienna, Austria	Epoxy
Klöckner-Müller AG Lausanne, Switzerland	Polycarbonate
LARS FOSS KEMI A/S (new name SADOFOSS) Fredensborg, Denmark	Epoxy
LINTOTT Engineering Ltd. Horsham, Sussex, England	Araldite F, MY720, MY740
LRCE, Laboratoire de Recherches, Contrôles et Expertises Genève, Switzerland	Epoxy
MICAFIL Zürich, Switzerland	Araldite CY222, Epoxy Novolac, Phenolic, Polyester

APPENDIX 4

Abbreviations of used commercial symbols

BF_3MEA Boron trifluoride monoethylamine: $BF_3{-}NH_2{-}CH_2{-}CH_3$

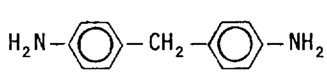
CT 200 (CIBA-GEIGY), Araldite B, solid, unmodified epoxy resin based on Bisphenol A:



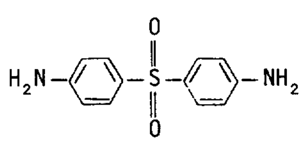
n ≙ 2

CY 205 (CIBA-GEIGY)	Liquid, unmodified epoxy resin based on Bisphenol A	Chemical formula see CT 200 (n ≙ 0.15)
208	" modified " " " " " "	
221	" " " " " " " "	
222	" " " " " " " "	

DDM (CIBA-GEIGY) Hardener - 4,4'-Diaminodiphenylmethane (methylenedianiline MDA):

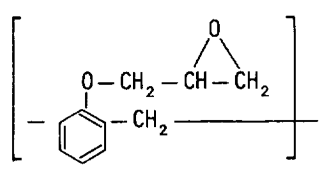


DDS Hardener - Diaminodiphenyl sulphone:

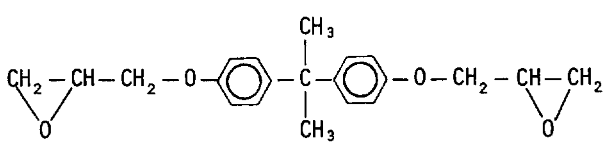


DEN (DOW) Dow Epoxy Novolac

431, 438 } Polyglycidyl ether of phenol formaldehyde novolac

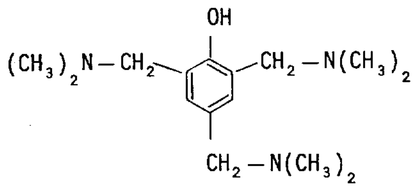


DGEBA Diglycidyl ether of Bisphenol A:

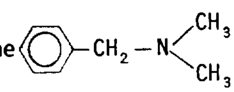


Firm	Material
Phillips Petroleum Company Bruxelles, Belgium	Ryton
PLESSEY COMPANY Ltd. Ilford, Essex, England	Araldite MY740
RHÔNE-POULENC Genève, Switzerland	Polyimide
SHAMBAN, Rubeli Guigoz Lausanne, Switzerland	Polyimide
SHELL CHEMIE Zürich, Switzerland	Epoxy Novolac
SIN, Schweizerisches Institut für Nuklear-forschung Villigen, Switzerland	Araldite D
SNPE, Société Nationale de Poudres et Explosifs Paris, France	Polyester
UOP, Bisterfeld & Stolting GmbH Egerpohl/Wipperfürth, West Germany	Epoxy

DMP 30 Accelerator - 2,4,6-tris[N,N-(dimethylamino)methyl]phenol



DX 126 (SHELL) }
DX 127 (SHELL) } curing agent - anhydride

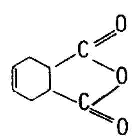
DY 040 (CIBA-GEIGY) flexibilizer - polypropyleneglycol
061 accelerator - aminophenol
062 accelerator - benzyldimethylamine 

063 accelerator
064 accelerator - aminophenol
065 accelerator unmodified sodium alkoxide
067 accelerator modified "

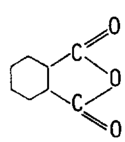
EP (SHELL) EPIKOTE
154 } Polyglycidyl ether of phenol formaldehyde novolac
827 } (Chemical formula see DEN)
828 Diglycidyl ether of Bisphenol A (see DGEBA)

EPN (CIBA-GEIGY) Epoxy Phenol Novolac
1138 } Polyglycidyl ether of phenol formaldehyde novolac
1139 } (Chemical formula see DEN)

HT 903 (CIBA-GEIGY) Acid anhydride hardener, solid, modified

Tetrahydrophthalic anhydride 

HT 907 (CIBA-GEIGY) Acid anhydride hardener, solid, unmodified

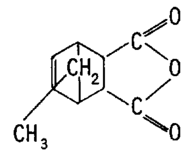
Hexahydrophthalic anhydride 

HT 972 (CIBA-GEIGY) Amine hardener, solid, unmodified (see DDM)

HY 905 (CIBA-GEIGY) Acid anhydride hardener, liquid, modified
Hexahydrophthalic anhydride (see HT 907)

HY 906 (CIBA-GEIGY) Acid anhydride hardener, liquid, unmodified

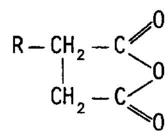
Methyl nadic anhydride (MNA)



HY 956 (CIBA-GEIGY) Amine hardener, liquid, modified
Triethylenetetramine $H_2N \mathrm{[}CH_2-CH_2-NH\mathrm{]}_2\, CH_2-CH_2-NH_2$

HY 964 (CIBA-GEIGY) Acid anhydride hardener

Dodecenyl succinic anhydride



$R = C_{12}H_{23}$

MDA Hardener
Methylenedianiline (see DDM)

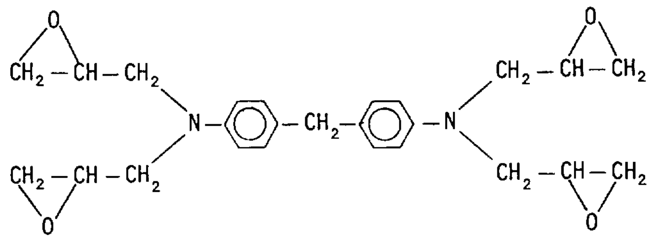
MNA Hardener
Methyl nadic anhydride (formula see HY 906)

MY 720 (CIBA-GEIGY) Liquid, unmodified, epoxy resin
Tetrafunctional glycidyl compound of diamines (TGDM)

MY 740 (CIBA-GEIGY) Liquid, unmodified epoxy resin based on Bisphenol A
(see CY 205)

MY 745 (CIBA-GEIGY) Liquid, modified epoxy resin based on Bisphenol A
(see CY 208, 221 and 222)

TGDM N,N'-tetraexpoxypropyl-4,4'-methylene-dianiline



XB 2687 (CIBA-GEIGY) Accelerator, liquid modified, replacement for DY 063
Amine-phenol salt

ALPHABETIC COMPILATION OF DATA

ARALDITE

Trade name of CIBA-GEIGY for epoxy resins,
see also EPOXY RESINS

ARALDITE B
ARALDITE D
ARALDITE F and similar epoxy resins based on Bisphenol A

ARALDITE MY 720

ARALDITE F + EPOXY NOVOLAC (50:50)

see NOVOLAC

Base resin

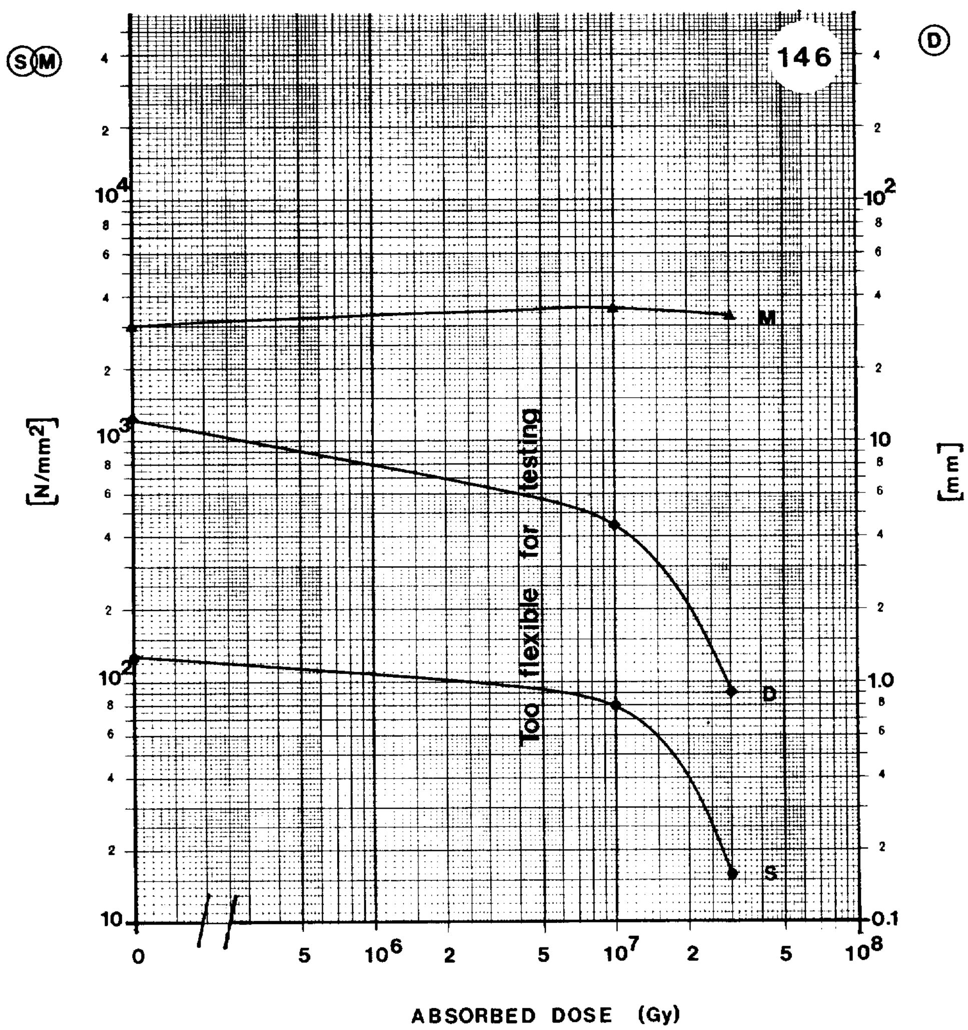
CT 200 - Solid, unmodified epoxy resin based on Bisphenol A

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)
146	CT 200(100) + HT 903(30)	0	126.5 ± 3.9	12.1 ± 0.4	$2.91 \pm 0.07 \times 10^3$
	2 h 110 °C + 14 h 140 °C	5×10^6	too flexible for testing		
		1×10^7	81.4 ± 13.7	4.5 ± 0.7	$3.48 \pm 0.08 \times 10^3$
	CIBA-GEIGY	3×10^7	15.7 ± 1.0	0.9 ± 0.1	$3.31 \pm 0.30 \times 10^3$
147	CT 200(100) + HT 903(30) + + Silica(200)	0	140.3 ± 4.9	3.4 ± 0.1	$9.64 \pm 0.93 \times 10^3$
	2 h 110 °C + 14 h 140 °C	5×10^6	74.6 ± 1.9	1.4 ± 0.0	$1.07 \pm 0.16 \times 10^4$
		1×10^7	68.7 ± 2.9	1.2 ± 0.1	$1.05 \pm 0.02 \times 10^4$
	CIBA-GEIGY	3×10^7	28.5 ± 3.9	0.7 ± 0.1	$8.22 \pm 0.39 \times 10^3$
148	CT 200(100) + HT 903(30) + + Dolomite(200)	0	76.5 ± 5.9	1.6 ± 0.1	$9.42 \pm 0.29 \times 10^3$
	2 h 110 °C + 14 h 140 °C	5×10^6	74.6 ± 3.9	1.5 ± 0.1	$8.78 \pm 2.26 \times 10^3$
		1×10^7	57.9 ± 7.8	1.1 ± 0.1	$9.91 \pm 0.34 \times 10^3$
	CIBA-GEIGY	3×10^7	41.2 ± 2.9	1.3 ± 0.1	$7.71 \pm 0.27 \times 10^3$

MATERIAL: CT 200(100) + HT 903(30)

SUPPLIER: CIBA-GEIGY

Remarks:



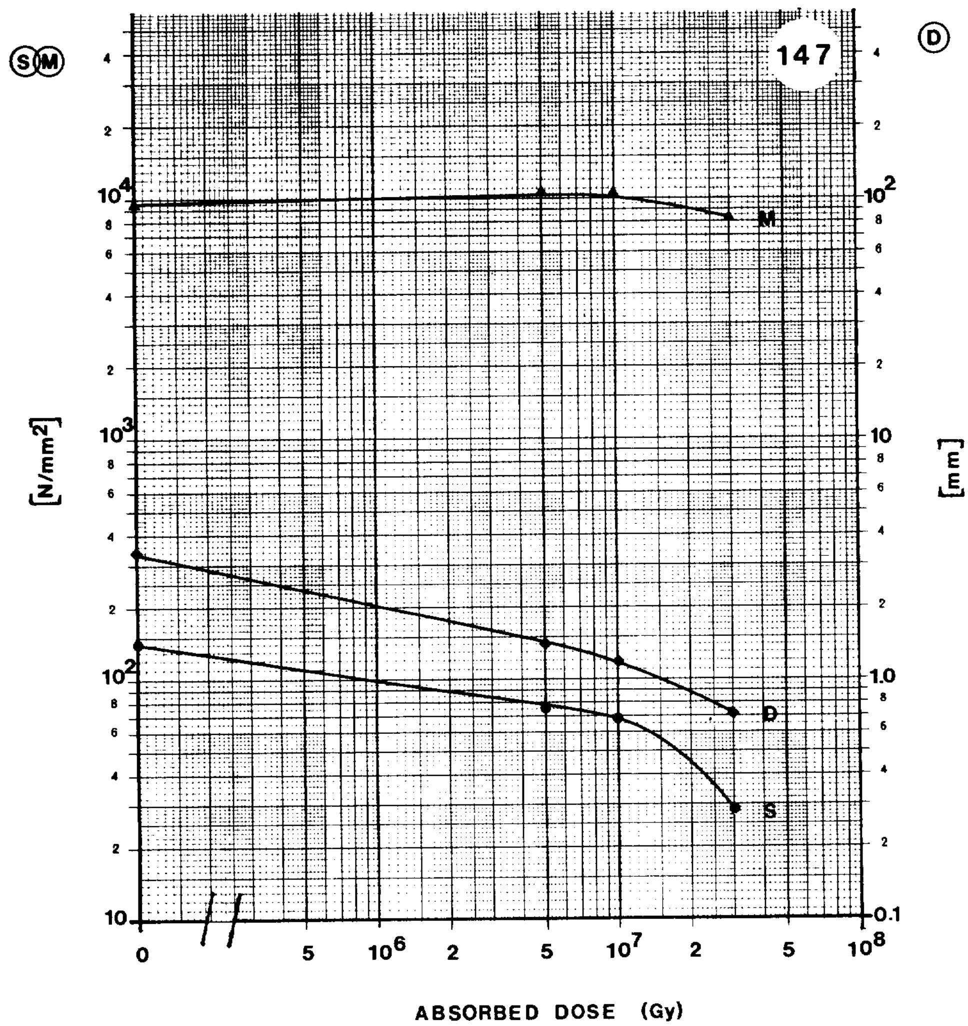
CURVE	PROPERTY	INITIAL VALUE	
S	Ultimate flexural strength	126.5	N/mm^2
D	Deflexion at break	12.1	mm
M	Modulus of elasticity	2.9×10^3	N/mm^2

ARALDITE B

MATERIAL: CT 200(100) + HT 903(30) + Silica(200)

SUPPLIER: CIBA-GEIGY

Remarks:

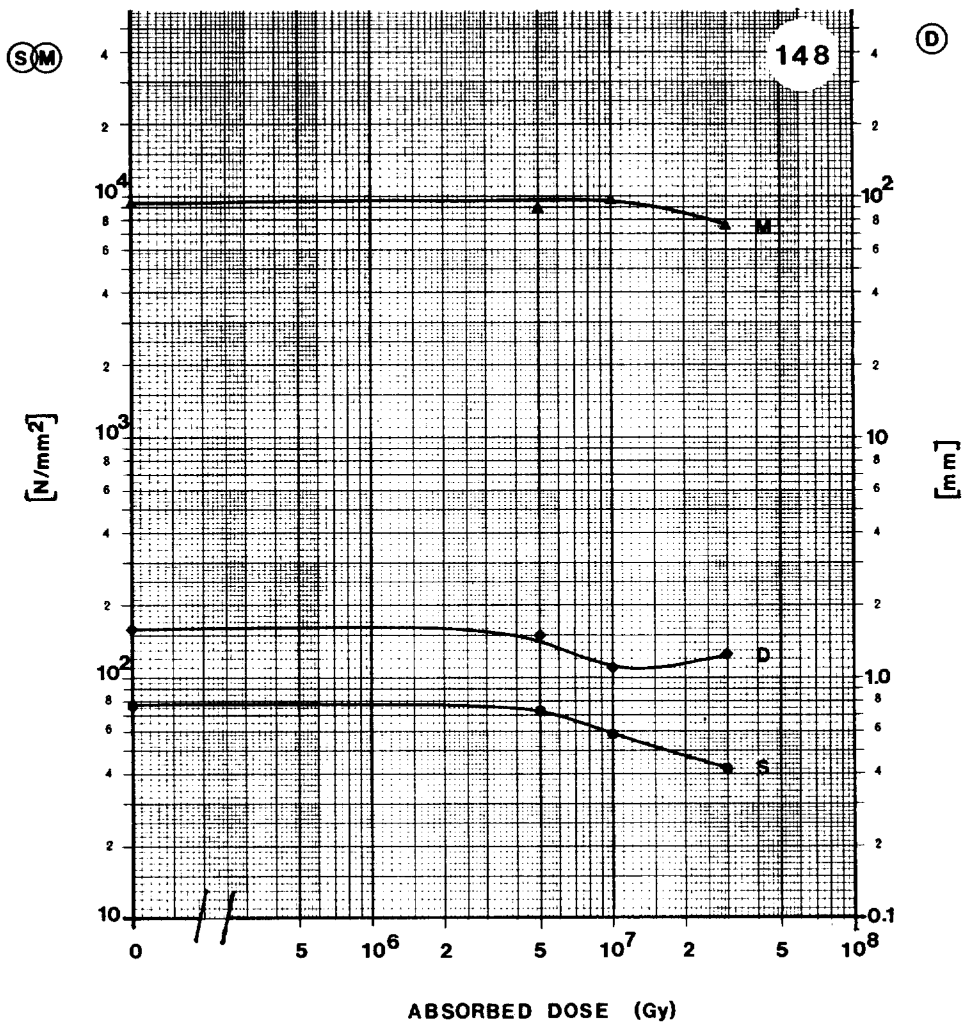


CURVE	PROPERTY	INITIAL VALUE	
S	Ultimate flexural strength	140.3	N/mm^2
D	Deflexion at break	3.4	mm
M	Modulus of elasticity	9.6×10^3	N/mm^2

MATERIAL: CT 200(100) + HT 903(30) + DOLOMITE(200)

SUPPLIER: CIBA-GEIGY

Remarks:



CURVE	PROPERTY	INITIAL VALUE	
S	Ultimate flexural strength	76.5	N/mm^2
D	Deflexion at break	1.6	mm
M	Modulus of elasticity	9.4×10^3	N/mm^2

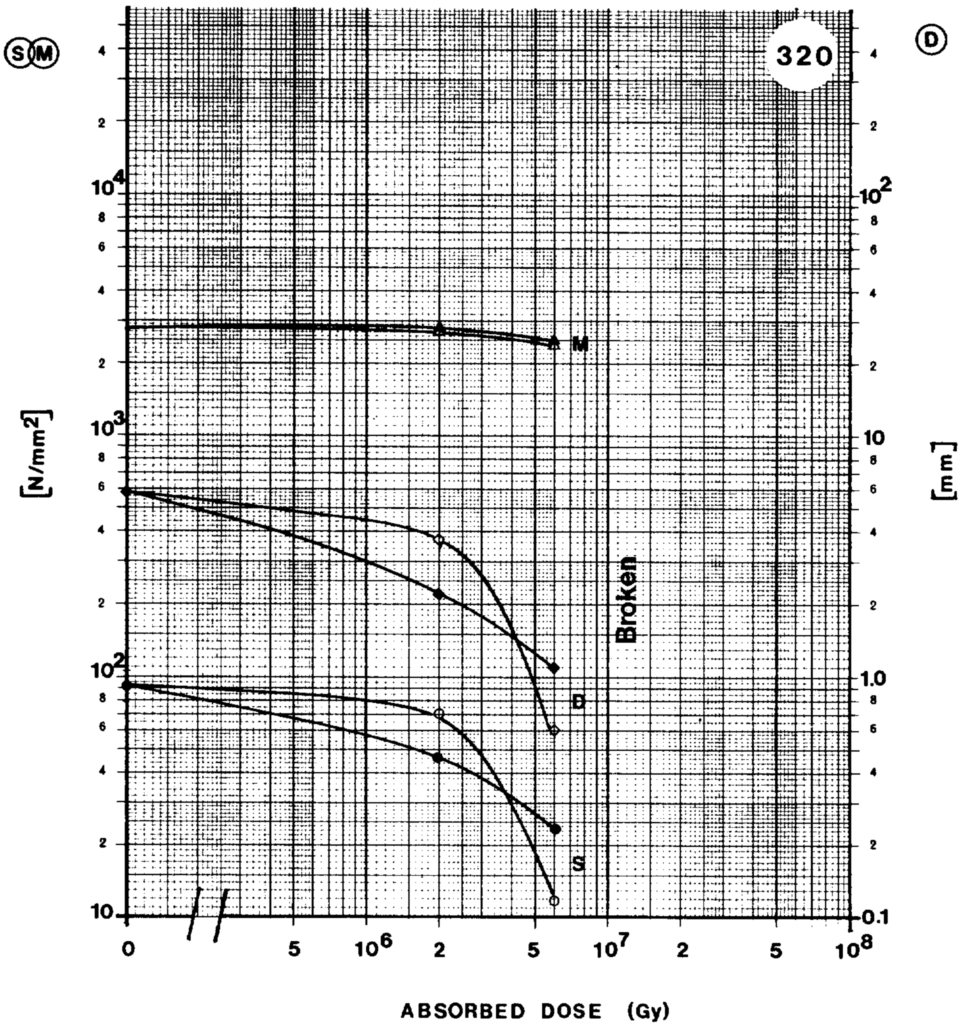
No.	Material and Supplier	Dose (Gy)	Ultimate flex. strength S (N/mm²)	Deflexion at break D (mm)	Modulus of elasticity M (N/mm²)
320	ARALDITE D + HY 956	0	92.2 ± 12.8	5.9 ± 1.6	$2.78 \pm 0.05 \times 10^3$
	(Cured at ambient temp.)	2×10^6	46.1 ± 31.4	2.2 ± 1.7	$2.82 \pm 0.27 \times 10^3$
		6×10^6	23.5 ± 10.8	1.1 ± 0.6	$2.44 \pm 0.38 \times 10^3$
		2×10^7	samples broken after irradiation		
	*)	2×10^6	69.7 ± 32.4	3.7 ± 2.3	$2.78 \pm 0.09 \times 10^3$
	*)	6×10^6	11.8 ± 3.9	0.6 ± 0.2	$2.33 \pm 0.12 \times 10^3$
	SIN *)	2×10^7	samples broken after irradiation		
321	ARALDITE D + HY 956 filled with cotton	0	91.2 ± 3.9	5.3 ± 1.1	$3.82 \pm 0.09 \times 10^3$
	(Cured at ambient temp.)	2×10^6	21.6 ± 3.9	1.1 ± 0.3	$2.84 \pm 0.06 \times 10^3$
		6×10^6	22.6 ± 3.9	1.3 ± 0.4	$2.25 \pm 0.32 \times 10^3$
		2×10^7	samples broken after irradiation		
	*)	2×10^6	36.3 ± 9.8	2.1 ± 0.8	$2.52 \pm 0.41 \times 10^3$
	*)	6×10^6	26.5 ± 9.8	1.4 ± 0.5	$2.75 \pm 0.34 \times 10^3$
	SIN *)	2×10^7	1.9 ± 0.0	0.4 ± 0.1	$5.20 \pm 1.84 \times 10^2$

*) Irradiated in vacuum

MATERIAL: ARALDITE D + HY 956

SUPPLIER: SIN

Remarks: USED FOR INJECTOR TRIM COILS AT SIN



Open symbols: irradiated in vacuum
Full symbols: irradiated in air

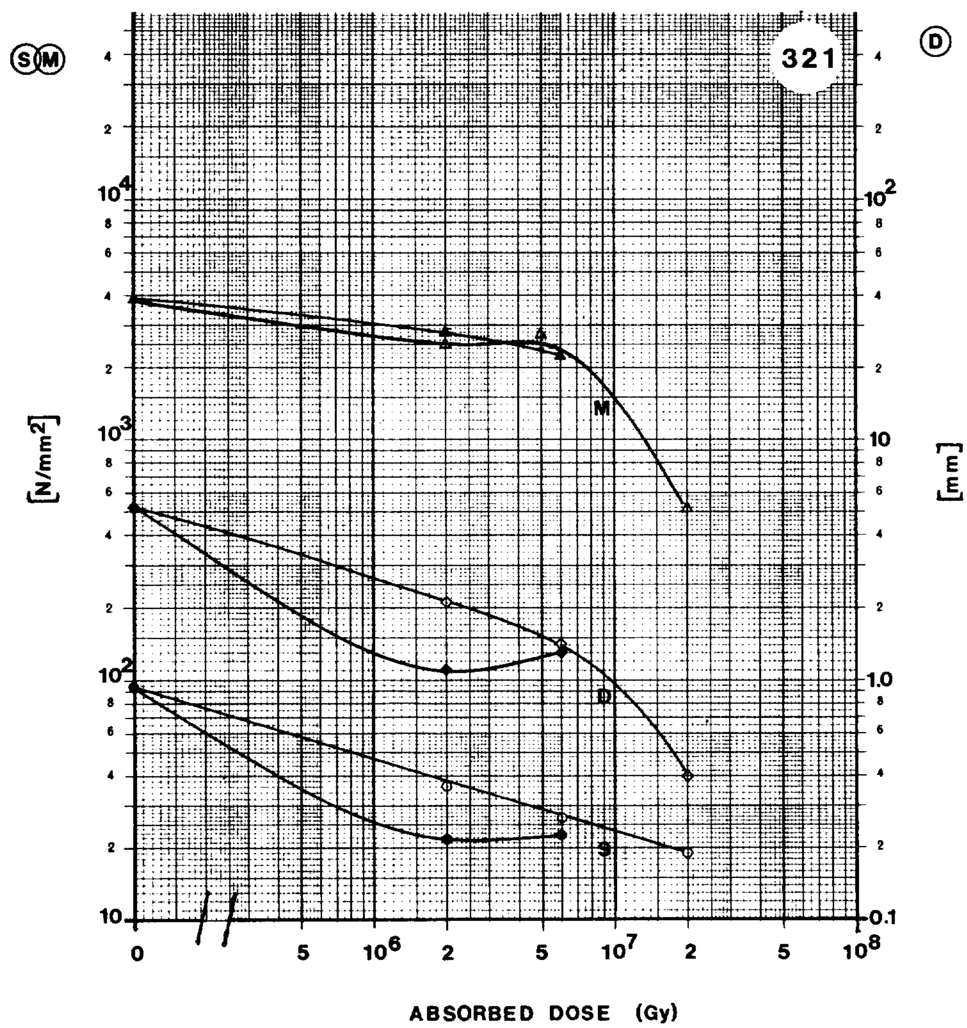
CURVE	PROPERTY	INITIAL VALUE	
S	Ultimate flexural strength	92.2	N/mm^2
D	Deflexion at break	5.9	mm
M	Modulus of elasticity	2.8×10^3	N/mm^2

ARALDITE D

MATERIAL: ARALDITE D + HY 956 FILLED WITH COTTON

SUPPLIER: SIN

Remarks: USED FOR INJECTOR TRIM COILS AT SIN



Open symbols: irradiated in vacuum
Full symbols: irradiated in air

CURVE	PROPERTY	INITIAL VALUE	
S	Ultimate flexural strength	91.2	N/mm^2
D	Deflexion at break	5.3	mm
M	Modulus of elasticity	3.8×10^3	N/mm^2

ARALDITE F and similar epoxy resins based on Bisphenol A

Base resins

CY 205 - liquid, unmodified epoxy resin based on Bisphenol A = ARALDITE F

CY 222 - liquid, modified epoxy resin based on Bisphenol A

MY 740 - liquid, unmodified epoxy resin based on Bisphenol A

MY 745 - liquid, modified epoxy resin based on 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)
97	Magnet coil resin Orlitherm® (Base: DGEBA + MNA + + other components)	0	97.1 ± 16.7	5.8 ± 1.7	$3.53 \pm 0.11 \times 10^3$
		5.6×10^6	64.7 ± 10.8	3.6 ± 0.6	$3.51 \pm 0.06 \times 10^3$
		1.1×10^7	52.9 ± 14.7	3.0 ± 0.8	$3.55 \pm 0.13 \times 10^3$
		2.2×10^7	39.2 ± 6.8	2.0 ± 0.4	$3.75 \pm 0.15 \times 10^3$
	BBC Baden	5.6×10^7	7.9 ± 1.0	1.0 ± 0.1	$2.26 \pm 0.21 \times 10^3$
99	Magnet coil resin Orlitherm® reinforced with fibre-silanized woven glass tape type 1 and mica-paper tape	0	224.6 ± 11.7	5.0 ± 0.5	$2.96 \pm 0.74 \times 10^4$
		1.1×10^7	191.3 ± 2.9	5.2 ± 0.4	$7.99 \pm 0.54 \times 10^3$
		3.1×10^7	130.4 ± 5.9	4.6 ± 0.5	$8.00 \pm 0.50 \times 10^3$
		6.3×10^7	84.4 ± 14.7	3.9 ± 0.5	$5.85 \pm 0.49 \times 10^3$
	BBC Baden	1.0×10^8	54.9 ± 1.9	3.2 ± 0.2	$4.59 \pm 1.01 \times 10^3$
131	ARALDITE F(100) + MNA(80) + + DMNA(0.5) + filler	0	312.9 ± 2.9	9.0 ± 0.3	$1.57 \pm 0.05 \times 10^4$
		1×10^7	287.4 ± 11.8	8.9 ± 0.1	$1.45 \pm 0.02 \times 10^4$
		2×10^7	301.2 ± 8.8	10.2 ± 0.3	$1.51 \pm 0.02 \times 10^4$
	Rutherford Workshop	5×10^7	222.7 ± 2.9	9.8 ± 0.4	$1.09 \pm 0.05 \times 10^4$
132	ARALDITE F + MNA + filler	0	436.5 ± 55.9	6.8 ± 0.8	$2.42 \pm 0.07 \times 10^4$
		5×10^6	392.4 ± 28.5	6.3 ± 0.5	$2.24 \pm 0.13 \times 10^4$
		1×10^7	402.2 ± 54.0	6.8 ± 1.0	$2.19 \pm 0.22 \times 10^4$
		2×10^7	365.9 ± 53.0	6.4 ± 0.6	$2.35 \pm 0.22 \times 10^4$
	LINTOTT	5×10^7	230.5 ± 17.7	5.1 ± 0.8	$1.74 \pm 0.08 \times 10^4$
149	CY 205(100) + HY 964(130) + + DY 040(20) + DY 064(0.5) 40 h 75 °C	0	71.6 ± 0.98	8.4 ± 0.4	$2.12 \pm 0.05 \times 10^3$
		5×10^6	49.6 ± 30.4	6.2 ± 5.3	$2.14 \pm 0.05 \times 10^3$
		1×10^7	56.9 ± 3.9	5.2 ± 0.5	$2.18 \pm 0.01 \times 10^3$
	CIBA-GEIGY	3×10^7	samples	broken after	irradiation
150	CY 205(100) + HY 964(130) + + DY 040(20) + DY 064(0.5) + + Silica 40 h 75 °C	0	83.4 ± 2.9	2.4 ± 0.3	$8.36 \pm 0.37 \times 10^3$
		5×10^6	56.9 ± 4.9	1.1 ± 0.1	$9.98 \pm 0.39 \times 10^3$
		1×10^7	42.2 ± 3.9	0.9 ± 0.1	$9.40 \pm 0.29 \times 10^3$
	CIBA-GEIGY	3×10^7	samples	broken after	irradiation

No.	Material and Supplier	Dose (Gy)	Ultimate flex. strength S (N/mm²)	Deflexion at break D (mm)	Modulus of elasticity M (N/mm²)
151	CY 205(100) + HY 964(130) + + DY 040(20) + DY 064(0.5) + + Dolomite	0	40.2 ± 1.9	1.2 ± 0.4	7.53 ± 0.55 × 10^3
		5 × 10^6	50.0 ± 3.9	1.2 ± 0.1	8.10 ± 0.38 × 10^3
	40 h 75°C	1 × 10^7	23.5 ± 3.9	1.2 ± 0.0	3.90 ± 0.67 × 10^3
	CIBA-GEIGY	3 × 10^7	9.8 ± 2.9	0.7 ± 0.0	3.12 ± 0.83 × 10^3
169	CY 205(100) + HY 905(100) + + DY 040(10) + Silica(400) + + DY 061(1)	0	51.0 ± 3.9	1.4 ± 0.1	1.02 ± 0.02 × 10^4
		5 × 10^6	50.0 ± 2.0	1.3 ± 0.0	1.27 ± 0.25 × 10^4
		1 × 10^7	29.4 ± 2.0	0.9 ± 0.1	1.10 ± 0.07 × 10^4
	CIBA-GEIGY	5 × 10^7	27.8 ± 4.9	1.1 ± 0.1	8.13 ± 1.20 × 10^3
170	CY 205(100) + HY 905(100) + + DY 040(10) + Dolomite(400) + + DY 061(1)	0	55.9 ± 3.9	1.4 ± 0.1	1.06 ± 0.03 × 10^4
		5 × 10^6	51.0 ± 3.9	1.4 ± 0.1	1.02 ± 0.02 × 10^4
		1 × 10^7	51.0 ± 1.0	1.6 ± 0.0	9.38 ± 0.56 × 10^3
	CIBA-GEIGY	5 × 10^7	32.4 ± 4.9	1.6 ± 0.1	5.40 ± 0.42 × 10^3
172	CY 205(100) + HY 905(110) + + CY 208(10) + XB 2687(0.8)	0	93.2 ± 14.7	8.3 ± 1.8	1.60 ± 0.01 × 10^3
		5 × 10^6	48.1 ± 2.9	6.7 ± 0.4	1.49 ± 0.03 × 10^3
		1 × 10^7	60.8 ± 12.7	4.9 ± 0.9	3.37 ± 0.10 × 10^3
	CIBA-GEIGY	3 × 10^7	samples	broken after	irradiation
175	Magnet coil resin Orli-therm® reinforced with a fibre-silanized woven glass tape type 1	0	510.1 ± 11.8	5.2 ± 0.1	1.91 ± 0.07 × 10^4
		1 × 10^7	364.9 ± 5.9	4.2 ± 0.4	1.91 ± 0.01 × 10^4
		5 × 10^7	285.5 ± 13.7	3.4 ± 0.2	1.85 ± 0.06 × 10^4
	12 h 165 °C BBC Baden	1 × 10^8	169.7 ± 22.6	2.7 ± 0.4	1.56 ± 0.14 × 10^4
176	Magnet coil resin Orli-therm® reinforced with glass woven tape type 2 with a special silane finish	0	450.3 ± 24.5	5.2 ± 0.3	1.64 ± 0.07 × 10^4
		1 × 10^7	419.9 ± 18.6	5.0 ± 0.1	1.62 ± 0.05 × 10^4
		5 × 10^7	387.5 ± 55.9	5.2 ± 0.5	1.61 ± 0.01 × 10^4
	12 h 165 °C BBC Baden	1 × 10^8	281.5 ± 28.5	4.9 ± 0.3	1.44 ± 0.01 × 10^4
202	ARALDITE F(100) + HY 905(100) + DY 040(10) + DY 062(0.5)	0	121.6 ± 8.8	12.6 ± 4.4	3.71 ± 0.26 × 10^3
	4 h 80 °C + 6 h 120 °C	5 × 10^6	88.3 ± 9.8	4.6 ± 0.4	3.80 ± 0.16 × 10^3
	CIBA-GEIGY	1 × 10^7	70.6 ± 11.8	3.7 ± 0.6	3.75 ± 0.10 × 10^3

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)
223	ARALDITE F(200) + HT 972(54)	0	too flexible for testing		
	4 h 80 °C	5×10^6	119.7 ± 7.8	14.7 ± 0.5	$3.57 \pm 0.09 \times 10^3$
		1×10^7	100.0 ± 4.9	4.9 ± 0.3	$3.85 \pm 0.05 \times 10^3$
	CERN Workshop	5×10^7	21.6 ± 11.8	1.0 ± 0.5	$4.04 \pm 0.29 \times 10^3$
224 (a)	ARALDITE F(200) + HT 972(54)	0	too flexible for testing		
	24 h 80 °C	5×10^6	131.5 ± 0.0	12.5 ± 1.2	$3.56 \pm 0.08 \times 10^3$
		1×10^7	105.0 ± 20.6	6.8 ± 3.9	$3.82 \pm 0.23 \times 10^3$
	CERN Workshop	5×10^7	broken		
225 (a)	ARALDITE F(200) + HT 972(54)	0	too flexible for testing		
	4 h 100 °C	5×10^6	137.3 ± 2.0	12.2 ± 0.6	$3.63 \pm 0.09 \times 10^3$
		1×10^7	118.7 ± 29.4	7.4 ± 4.1	$3.88 \pm 0.05 \times 10^3$
	CERN Workshop	5×10^7	broken		
226	ARALDITE F(200) + HT 972(54)	0	130.5 ± 4.0	10.9 ± 0.8	$3.07 \pm 0.05 \times 10^3$
	24 h 100 °C	5×10^6	136.4 ± 3.9	11.9 ± 0.2	$3.80 \pm 0.11 \times 10^3$
		1×10^7	132.4 ± 9.8	10.4 ± 2.6	$3.74 \pm 0.03 \times 10^3$
	CERN Workshop	5×10^7	broken		
227	ARALDITE F(200) + HT 972(54)	0	125.6 ± 1.6	12.3 ± 1.9	$3.02 \pm 0.12 \times 10^3$
	4 h 120 °C	5×10^6	140.3 ± 15.7	13.8 ± 0.9	$3.58 \pm 0.05 \times 10^3$
		1×10^7	128.5 ± 6.9	13.4 ± 1.7	$3.61 \pm 0.08 \times 10^3$
	CERN Workshop	5×10^7	broken		
228	ARALDITE F(200) + HT 972(54)	0	110.8 ± 1.6	9.0 ± 0.3	3.01 0.07 10^3
	24 h 120 °C	5×10^6	131.5 ± 7.8	13.8 ± 1.0	3.54 0.25 10^3
		1×10^7	136.4 ± 14.7	11.3 ± 5.2	3.60 0.07 10^3
	CERN Workshop	5×10^7	broken		
241 (a)	CY 205(100) + HY 906(80) + + DY 064(1) 3 h 150 °C + 15 h 180 °C CIBA-GEIGY	0	120.5 ± 27.9	8.7 ± 2.9	$3.18 \pm 0.06 \times 10^3$

(a) No graph.

No.	Material and Supplier	Dose (Gy)	Ultimate flex. strength S (N/mm²)	Deflexion at break D (mm)	Modulus of elasticity M (N/mm²)
242 (a)	CY 205(100) + HY 905(100) + + DY 061(0.5) 12 h 90 °C CIBA-GEIGY	0	114.0 ± 15.2	5.8 ± 0.9	$3.86 \pm 0.09 \times 10^3$
252 (a)	CY 205 + HY 905 + DY 040 + + DY 061 CIBA-GEIGY	0	103.3 ± 3.4	5.7 ± 0.3	$3.64 \pm 0.16 \times 10^3$
275	Magnet coil resin Orlitherm® reinforced with glass woven tape type 2 with a special silane finish and mica-paper tape 5 h 135 °C + 6 h 160 °C BBC Baden	0 5×10^6 1×10^7 5×10^7	264.9 ± 9.8 215.8 ± 14.7 227.6 ± 10.8 64.7 ± 0.0	1.8 ± 0.1 5.1 ± 0.4 5.5 ± 0.3 4.5 ± 0.0	$2.56 \pm 0.07 \times 10^4$ $6.82 \pm 0.50 \times 10^3$ $6.84 \pm 0.44 \times 10^3$ $1.80 \pm 0.00 \times 10^3$
276	Magnet coil resin Orlitherm® reinforced with a fibre-silanized woven glass tape type 3 5 h 135 °C + 6 h 160 °C BBC Baden	0 5×10^6 5×10^7	563.1 ± 25.5 467.9 ± 58.9 259.0 ± 28.5	4.8 ± 0.2 4.5 ± 0.1 3.2 ± 0.0	$2.22 \pm 0.14 \times 10^4$ $2.15 \pm 0.29 \times 10^4$ $1.76 \pm 0.15 \times 10^4$
277	Magnet coil resin Orlitherm® reinforced with a fibre-silanized woven glass tape type 3 and mica-paper tape 5 h 135 °C + 6 h 160 °C BBC Baden	0 5×10^6 5×10^7	223.7 ± 19.6 160.9 ± 11.8 38.3 ± 6.9	7.8 ± 0.4 7.9 ± 1.4 7.0 ± 0.3	$6.02 \pm 0.99 \times 10^3$ $3.93 \pm 0.13 \times 10^3$ $7.02 \pm 2.54 \times 10^2$
294 (a)	CERN 800 MeV Booster magnet coil resin CIBA-GEIGY	0	122.6 ± 32.7	2.8 ± 1.0	$3.43 \pm 0.04 \times 10^3$

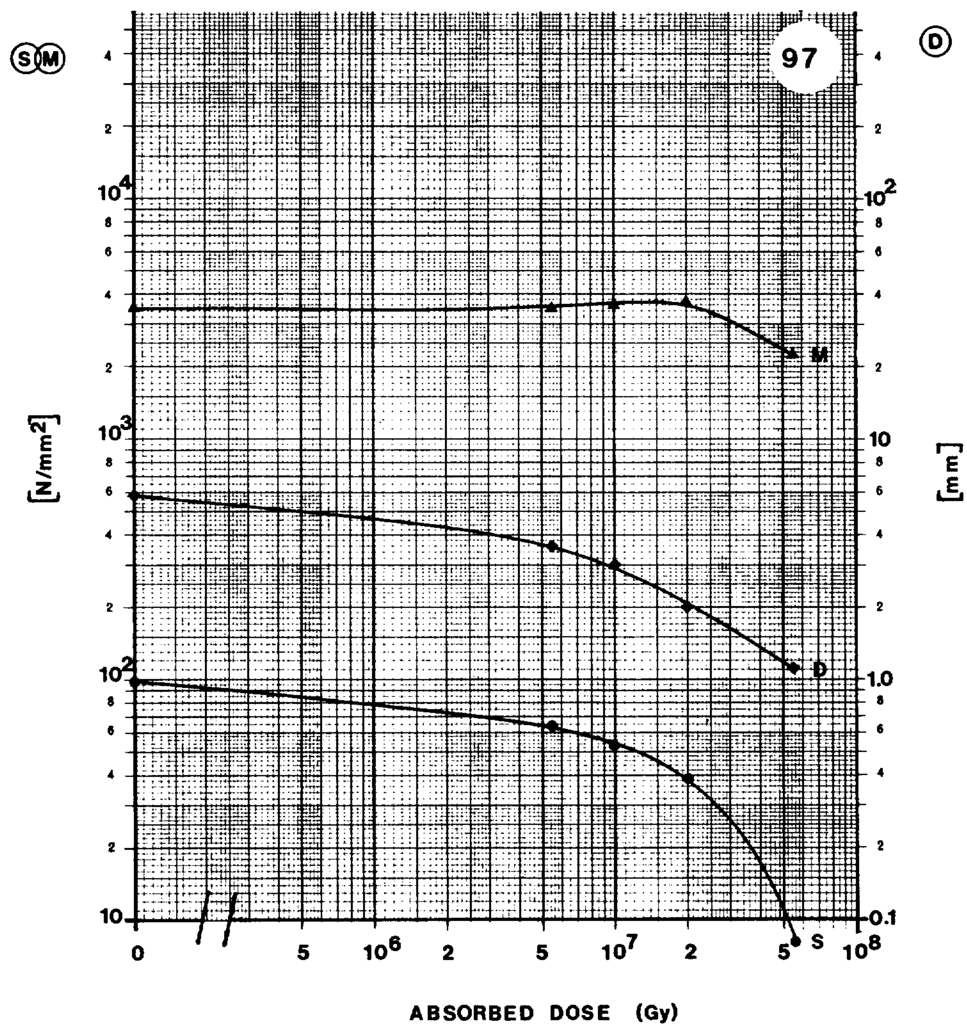
(a) No graph.

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)
300	CY 205(100) + HY 905(100) + + DY 061(1)	0	144.2 ± 10.8	13.1 ± 0.9	$3.57 \pm 0.29 \times 10^3$
	8 h 80 °C + 8 h 130 °C	5×10^6	109.9 ± 15.7	7.4 ± 1.2	$3.93 \pm 0.10 \times 10^3$
		1×10^7	59.8 ± 12.8	3.7 ± 0.7	$4.14 \pm 0.16 \times 10^3$
	CIBA-GEIGY	2.5×10^7	12.8 ± 2.0	1.1 ± 0.1	$3.22 \pm 0.16 \times 10^3$
301	CY 205(100) + HY 906(80) + + DY 064(1)	0	116.7 ± 25.5	10.9 ± 2.9	$3.22 \pm 0.17 \times 10^3$
	24 h 150 °C	5×10^6	141.3 ± 25.5	12.2 ± 1.0	$3.67 \pm 0.09 \times 10^3$
		1×10^7	55.9 ± 15.7	3.4 ± 1.0	$4.15 \pm 0.19 \times 10^3$
		2.5×10^7	43.1 ± 12.8	2.6 ± 0.7	$4.21 \pm 0.25 \times 10^3$
	CIBA-GEIGY	5×10^7	8.8 ± 2.0	0.7 ± 0.2	$3.42 \pm 0.00 \times 10^3$
303	Magnet coil resin Orlitherm® reinforced with a sandwich tape built up of a fibre-silanized woven glass tape type 3 and a polyimide film	0	379.6 ± 44.7	4.7 ± 0.2	$1.76 \pm 0.23 \times 10^4$
	16 h 140 °C	1×10^7	385.4 ± 5.7	4.4 ± 0.2	$1.96 \pm 0.02 \times 10^4$
	BBC Baden	5×10^7	236.2 ± 4.3	3.4 ± 0.9	$1.62 \pm 0.07 \times 10^4$
311	CY 205(100) + HY 906(80) + + DY 061(0.5) + Silica	0	96.1 ± 2.9	1.6 ± 0.0	$9.28 \pm 0.09 \times 10^3$
		5×10^6	67.7 ± 1.96	1.4 ± 0.1	$9.15 \pm 0.17 \times 10^3$
		1×10^7	64.5 ± 3.9	1.3 ± 0.1	$9.16 \pm 0.16 \times 10^3$
	CIBA-GEIGY	5×10^7	30.6 ± 0.98	0.6 ± 0.0	$7.48 \pm 0.34 \times 10^3$
312	CY 205(100) + HY 906(80) + + DY 061(0.5)	0	64.9 ± 5.9	3.0 ± 0.2	$3.35 \pm 0.07 \times 10^3$
		5×10^6	68.7 ± 5.9	2.9 ± 0.3	$3.67 \pm 0.04 \times 10^3$
		1×10^7	50.0 ± 2.9	2.0 ± 0.1	$3.81 \pm 0.08 \times 10^3$
	CIBA-GEIGY	2.5×10^7	32.6 ± 7.8	1.3 ± 0.3	$3.93 \pm 0.13 \times 10^3$

MATERIAL: Magnet coil resin Orlitherm®
(Base: DGEBA + MNA + other components)

SUPPLIER: BBC Baden

Remarks:



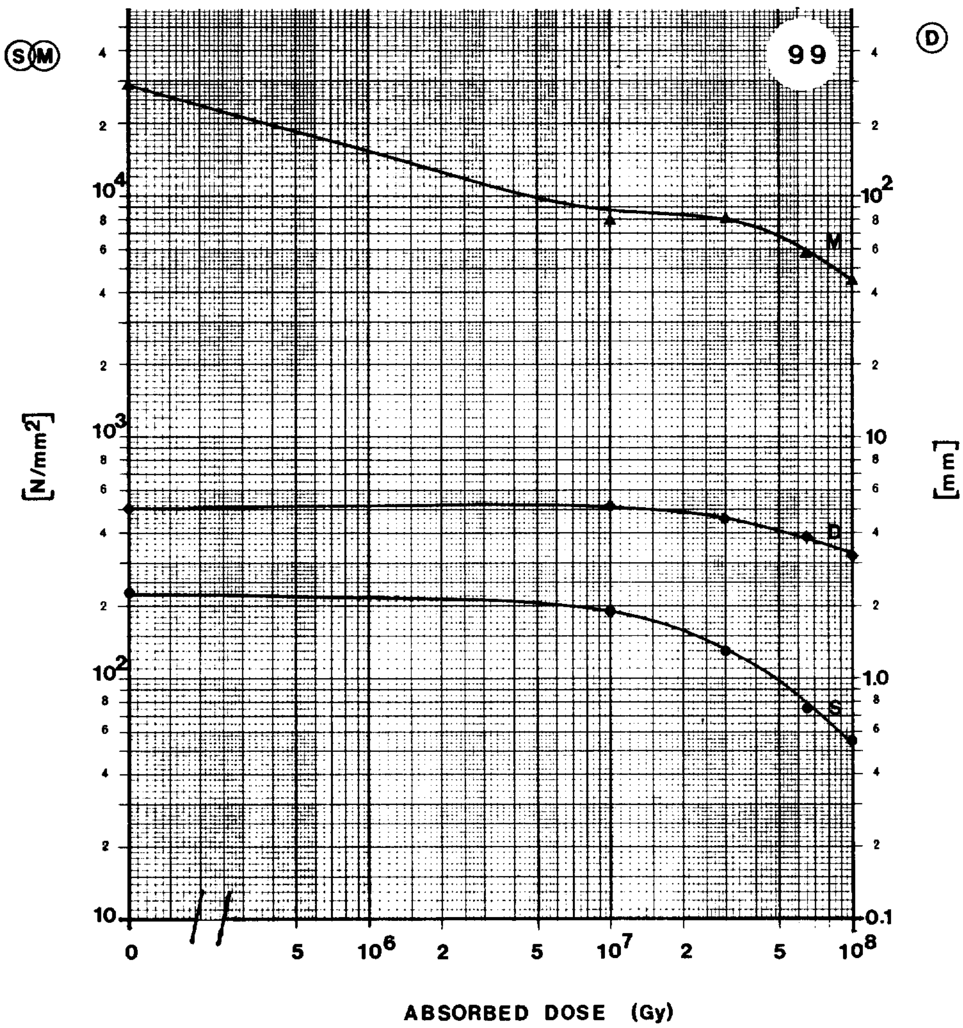
CURVE	PROPERTY	INITIAL VALUE
S	Ultimate flexural strength	97.1 N/mm²
D	Deflexion at break	5.8 mm
M	Modulus of elasticity	3.5×10^3 N/mm²

ARALDITE F
CY205

MATERIAL: MAGNET COIL RESIN ORLITHERM® REINFORCED WITH FIBRE-SILANIZED WOVEN GLASS TAPE TYPE 1 AND MICA-PAPER TAPE

SUPPLIER: BBC BADEN

Remarks:



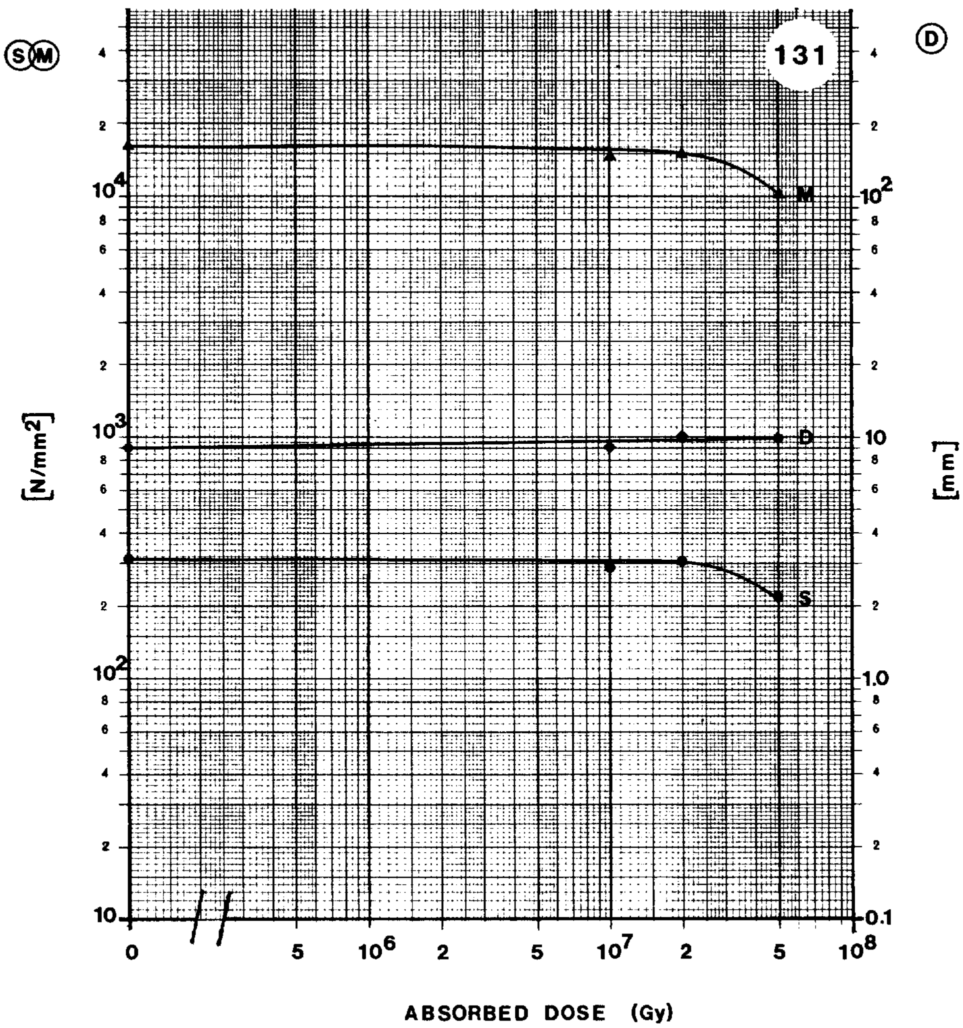
CURVE	PROPERTY	INITIAL VALUE	
S	Ultimate flexural strength	224.6	N/mm^2
D	Deflexion at break	5.0	mm
M	Modulus of elasticity	2.9×10^4	N/mm^2

MATERIAL: CY 205(100) + HY 964(130) + DY 040(20) + DY 064(0.5) + DOLOMIE

MATERIAL: ARALDITE F(100) + MNA(80) + DMNA(0.5) + FILLER

SUPPLIER: RUTHERFORD WORKSHOP

Remarks:



CURVE	PROPERTY	INITIAL VALUE	
S	Ultimate flexural strength	312.9	N/mm^2
D	Deflexion at break	9.0	mm
M	Modulus of elasticity	1.6×10^4	N/mm^2

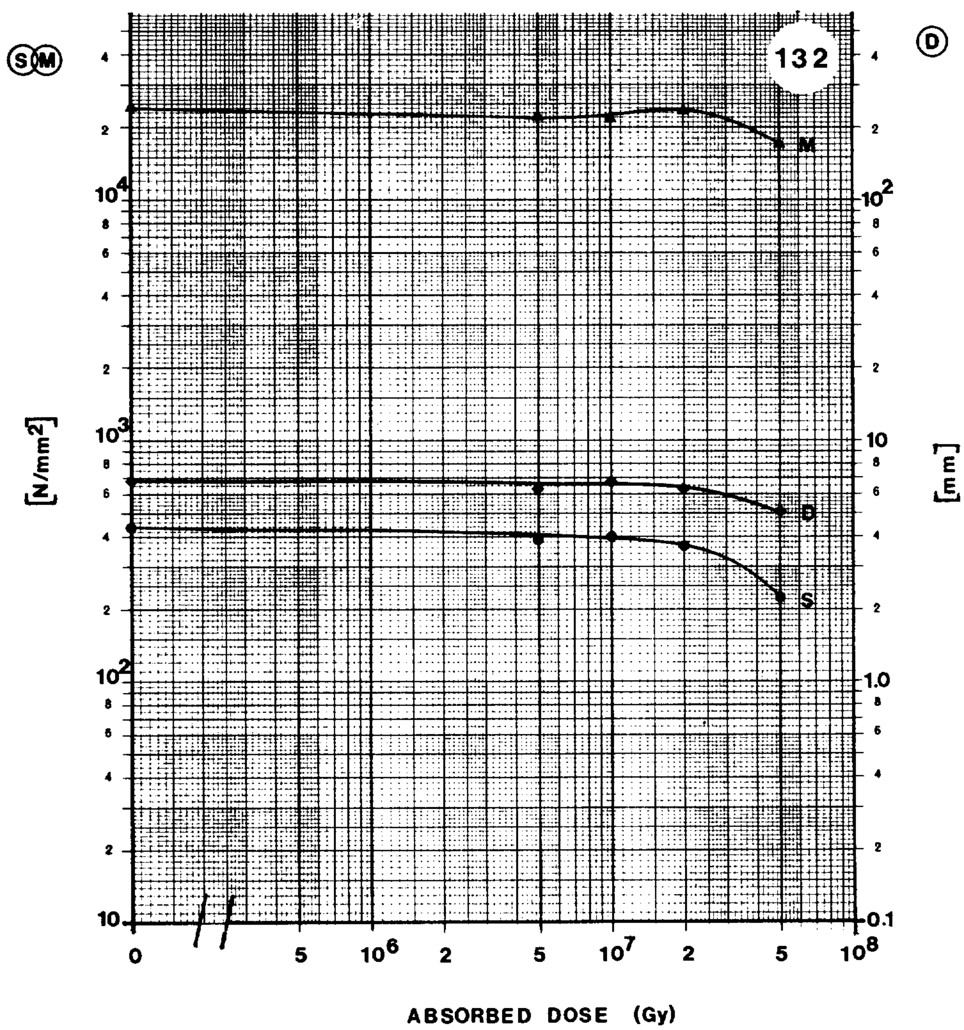
ARALDITE F
CY205

MATERIAL: CY 205(100) + HY 964(130) + DY 040(20) + DY 064(0.5) + Dolomie

MATERIAL: ARALDITE F + MNA + FILLER

SUPPLIER: LINTOTT

Remarks:

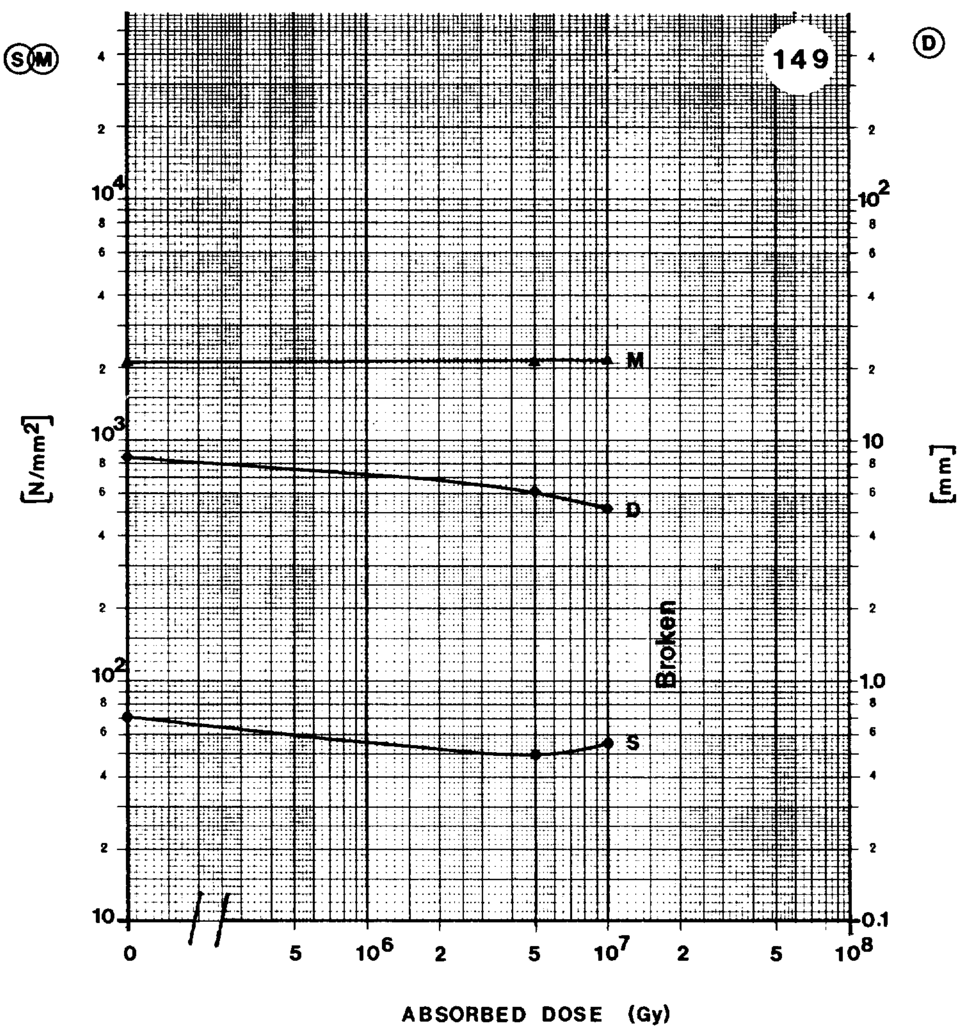


CURVE	PROPERTY	INITIAL VALUE	
S	Ultimate flexural strength	436.5	N/mm^2
D	Deflexion at break	6.8	mm
M	Modulus of elasticity	2.4×10^4	N/mm^2

MATERIAL: CY 205(100) + HY 964(130) + DY 040(20) + DY 064(0.5)

SUPPLIER: CIBA-GEIGY

Remarks:



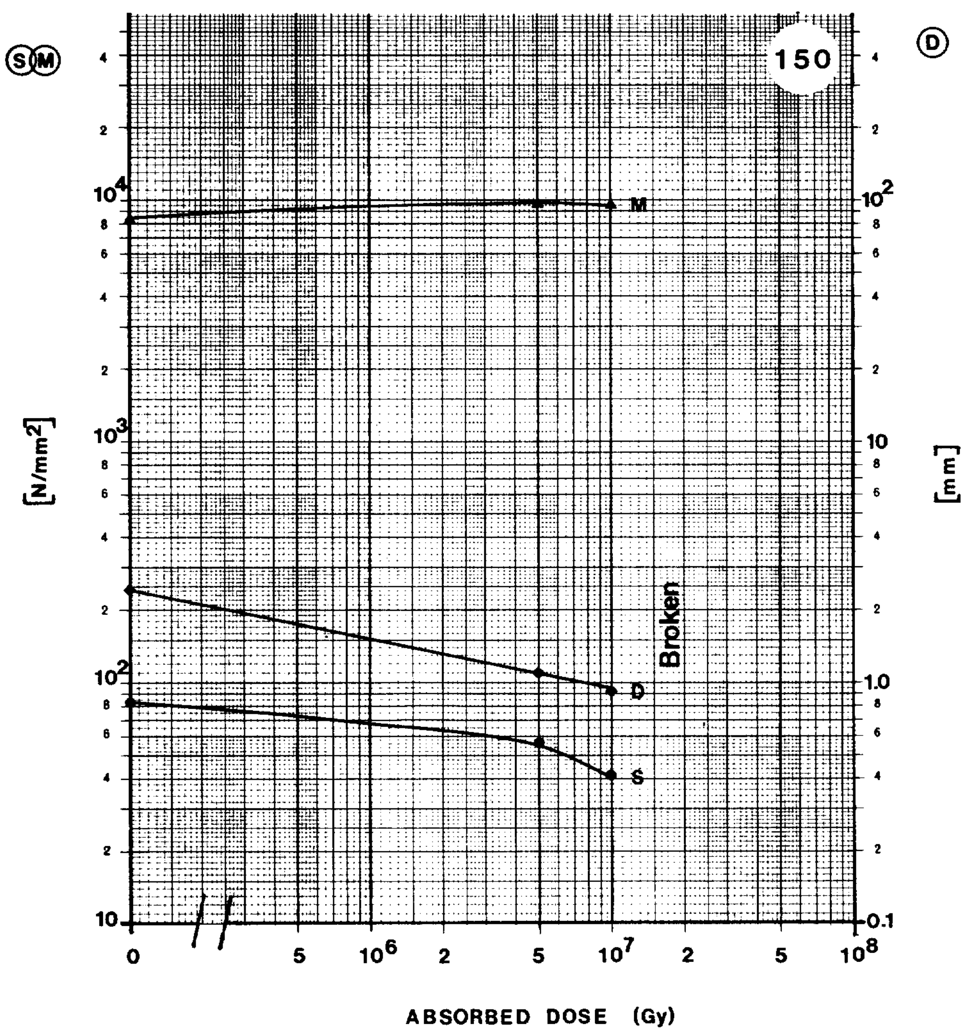
CURVE	PROPERTY	INITIAL VALUE	
S	Ultimate flexural strength	71.6	N/mm^2
D	Deflexion at break	8.4	mm
M	Modulus of elasticity	2.1×10^3	N/mm^2

ARALDITE F
CY205

MATERIAL: CY 205(100) + HY 964(130) + DY 040(20) + DY 064(0.5) + Silica

SUPPLIER: CIBA-GEIGY

Remarks: Used for SPS high-voltage resistor



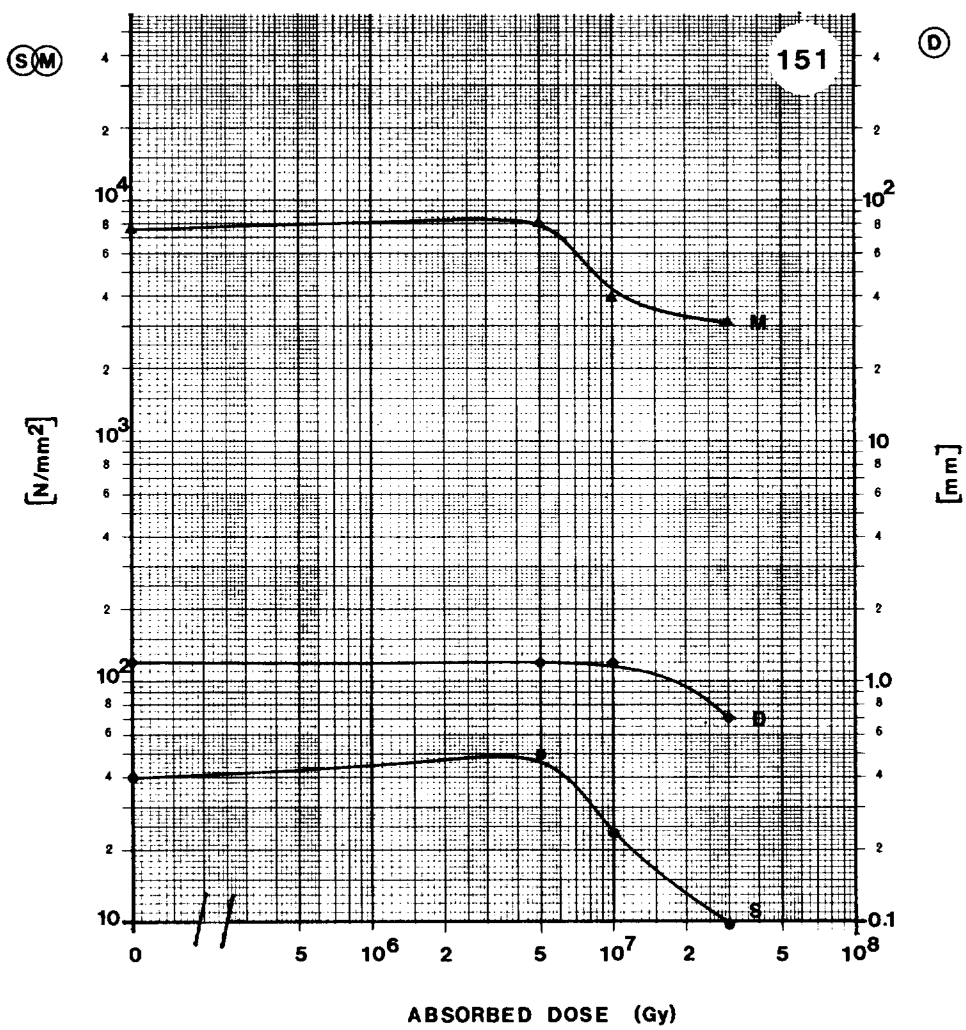
CURVE	PROPERTY	INITIAL VALUE	
S	Ultimate flexural strength	83.4	N/mm²
D	Deflexion at break	2.4	mm
M	Modulus of elasticity	8.4 × 10³	N/mm²

ARALDITE F CY205

MATERIAL: CY 205(100) + HY 964(130) + DY 040(20) + DY 064(0.5) + Dolomite

SUPPLIER: CIBA-GEIGY

Remarks:



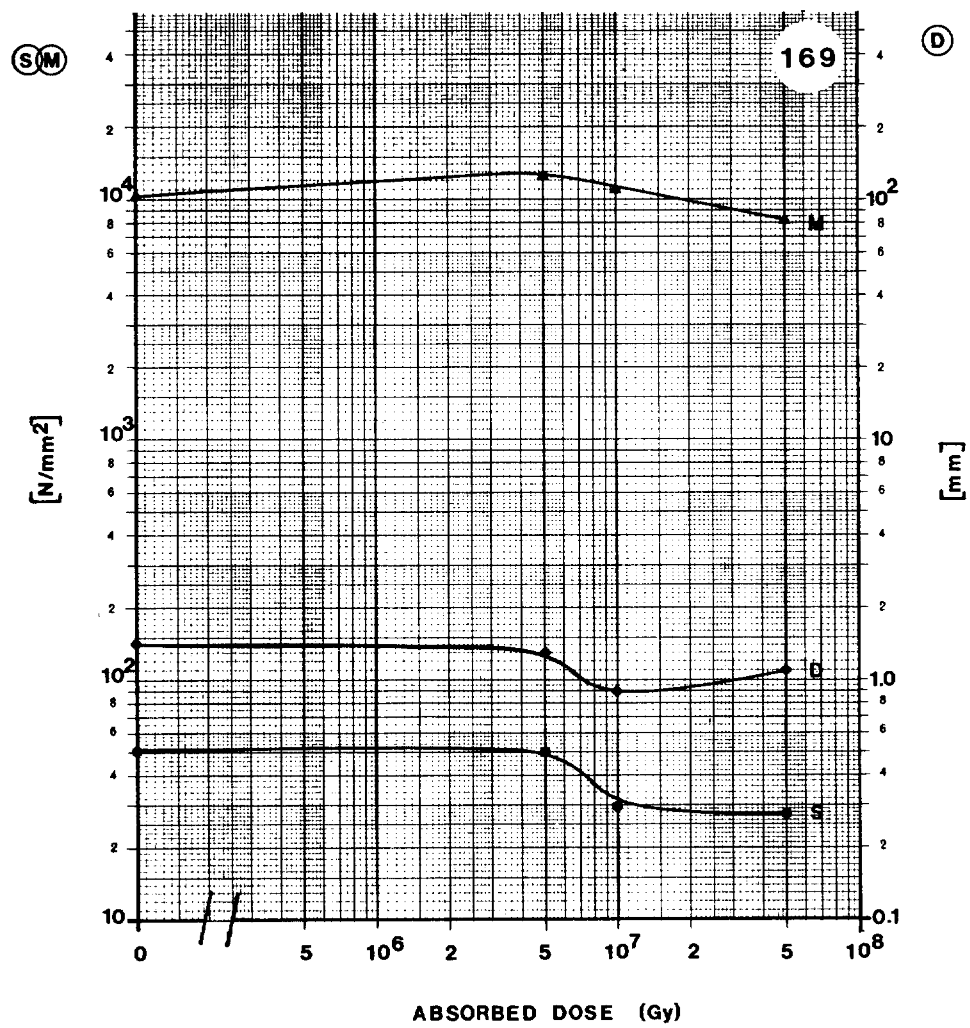
CURVE	PROPERTY	INITIAL VALUE	
S	Ultimate flexural strength	40.2	N/mm²
D	Deflexion at break	1.2	mm
M	Modulus of elasticity	7.5×10^3	N/mm²

ARALDITE F
CY205

MATERIAL: CY 205(100) + HY 905(100) + DY 040(10) + Silica(400) + DY 061(1)

SUPPLIER: CIBA-GEIGY

Remarks:

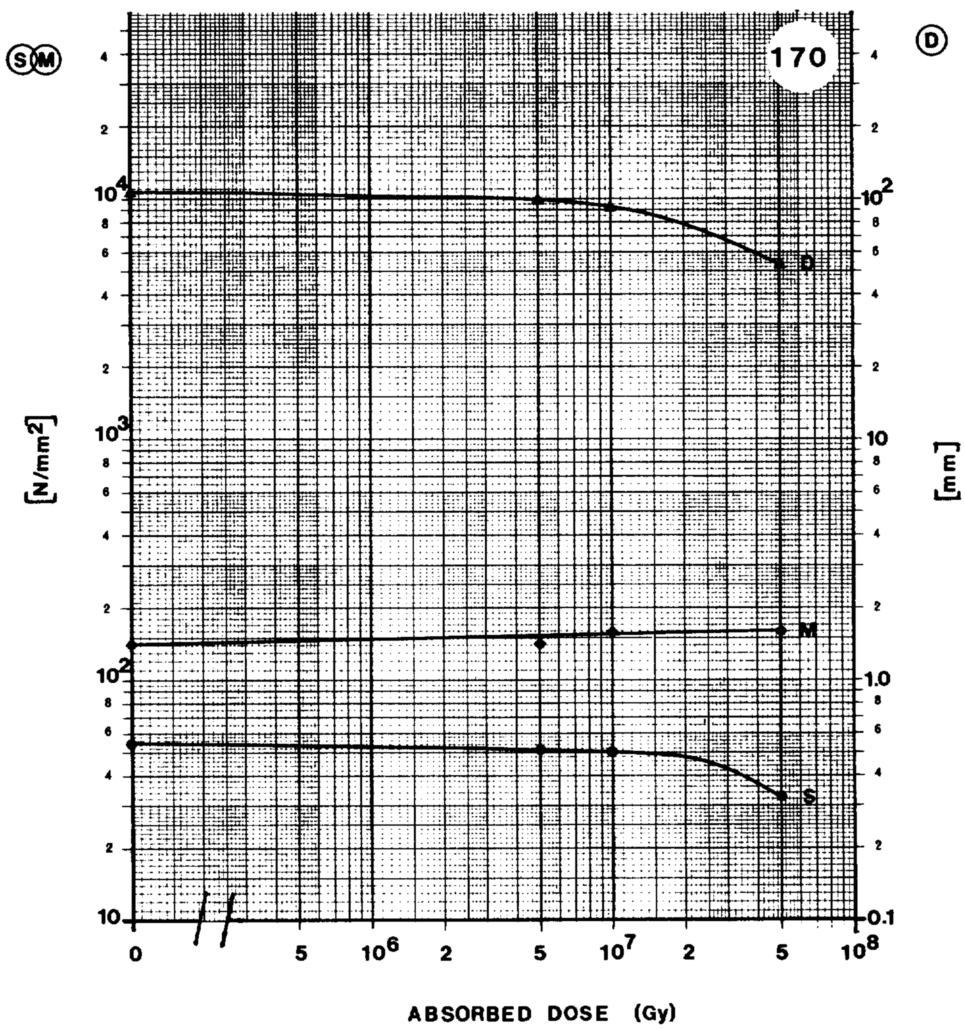


CURVE	PROPERTY	INITIAL VALUE	
S	Ultimate flexural strength	51.0	N/mm^2
D	Deflexion at break	1.4	mm
M	Modulus of elasticity	1.0×10^4	N/mm^2

MATERIAL: CY 205(100) + HY 905(100) + DY 040(10) + DOLOMITE(400) + DY 061(1)

SUPPLIER: CIBA-GEIGY

Remarks:



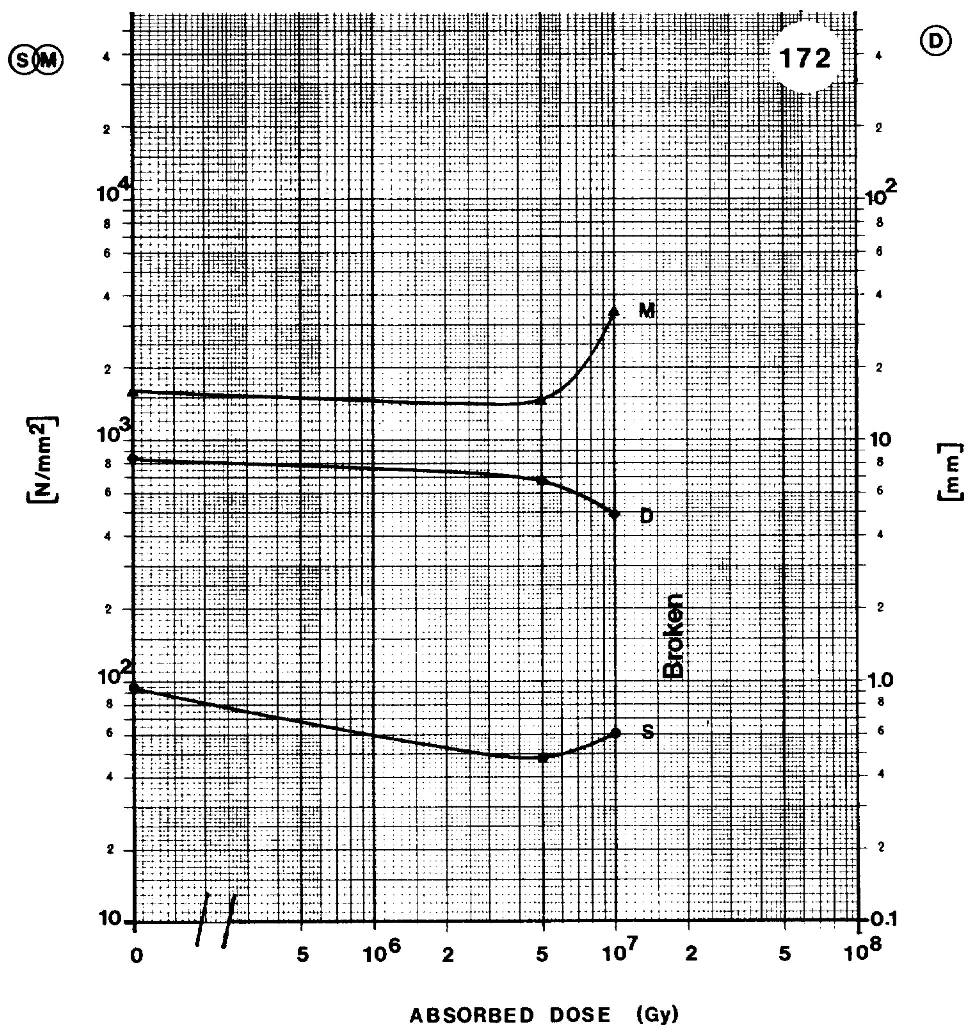
CURVE	PROPERTY	INITIAL VALUE	
S	Ultimate flexural strength	55.9	N/mm^2
D	Deflexion at break	1.4	mm
M	Modulus of elasticity	1.1×10^4	N/mm^2

ARALDITE F
CY205

MATERIAL: CY 205(100) + HY 905(110) + CY 208(10) + XB 2687(0.8)

SUPPLIER: CIBA-GEIGY

Remarks:



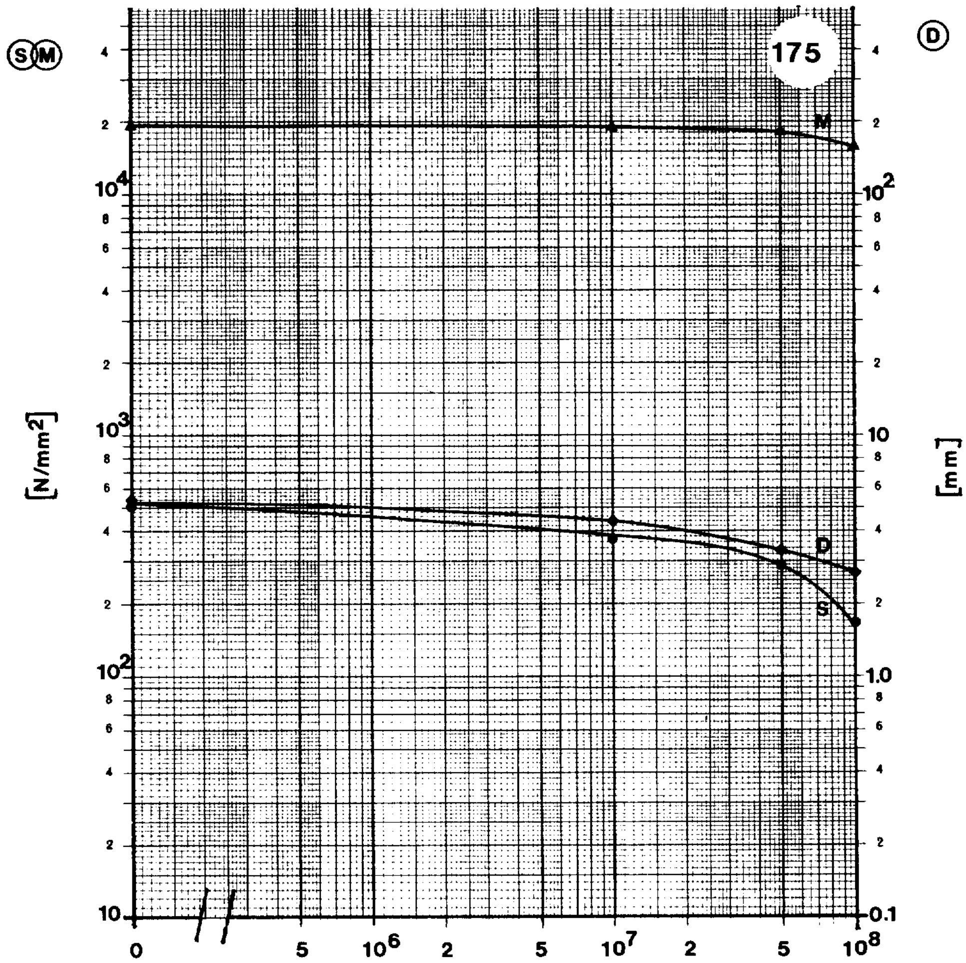
CURVE	PROPERTY	INITIAL VALUE	
S	Ultimate flexural strength	93.2	N/mm^2
D	Deflexion at break	8.3	mm
M	Modulus of elasticity	1.6×10^3	N/mm^2

ARALDITE F
CY205

MATERIAL: MAGNET COIL RESIN ORLITHERM® REINFORCED WITH A FIBRE-SILANIZED WOVEN GLASS TAPE TYPE 1

SUPPLIER: BBC BADEN

Remarks:



ABSORBED DOSE (Gy)

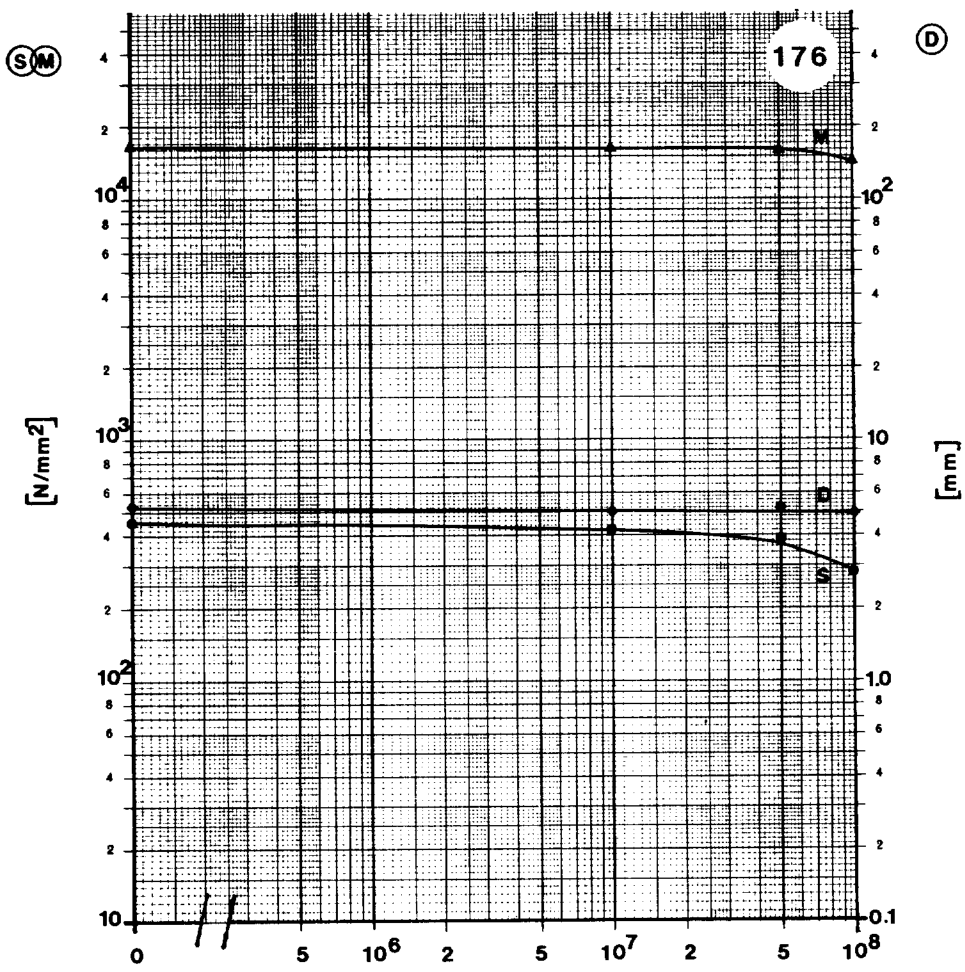
CURVE	PROPERTY	INITIAL VALUE	
S	Ultimate flexural strength	510.1	N/mm^2
D	Deflexion at break	5.2	mm
M	Modulus of elasticity	1.9×10^4	N/mm^2

ARALDITE F
CY205

MATERIAL: Magnet coil resin Orlitherm® reinforced with glass woven tape type 2 with a special silane finish

SUPPLIER: BBC Baden

Remarks:



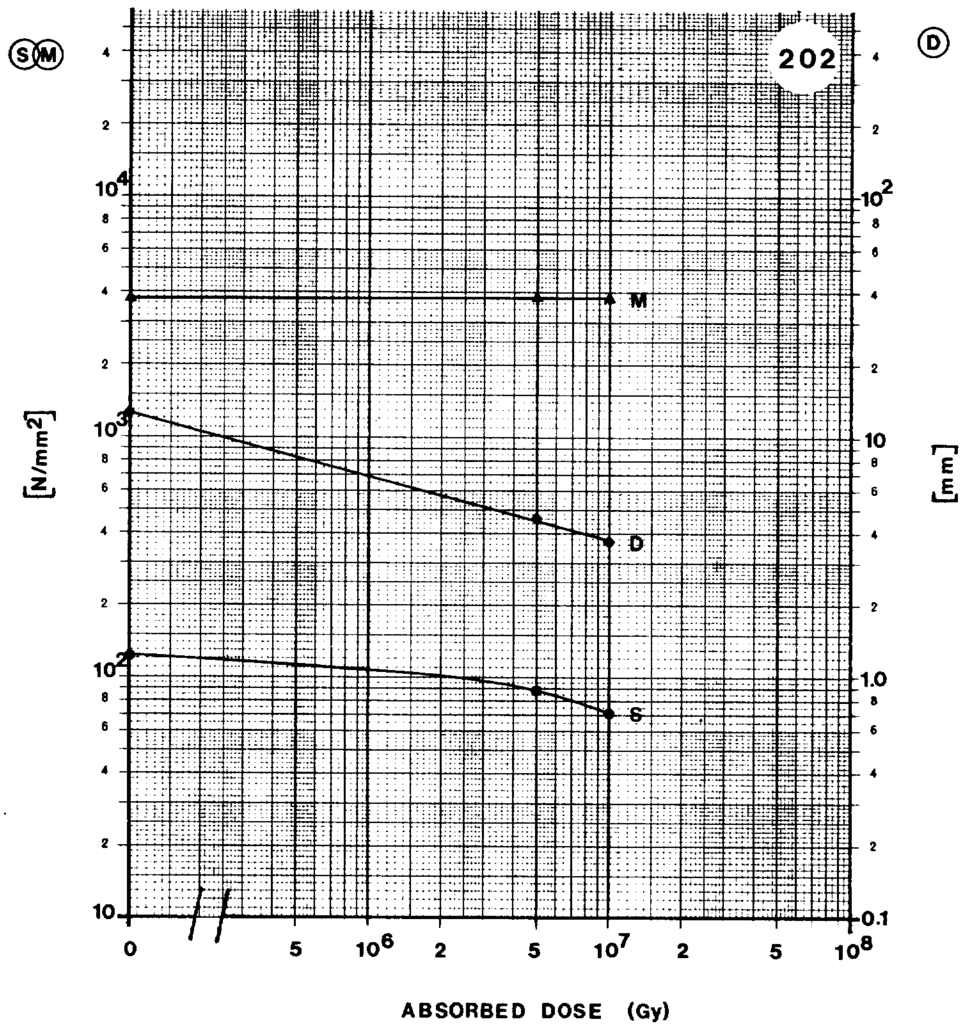
CURVE	PROPERTY	INITIAL VALUE	
S	Ultimate flexural strength	450.3	N/mm^2
D	Deflexion at break	5.2	mm
M	Modulus of elasticity	1.6×10^4	N/mm^2

ARALDITE F
CY205

MATERIAL: ARALDITE F(100) + HY 905(100) + DY 040(10) + DY 062(0.5)

SUPPLIER: CIBA-GEIGY

Remarks:



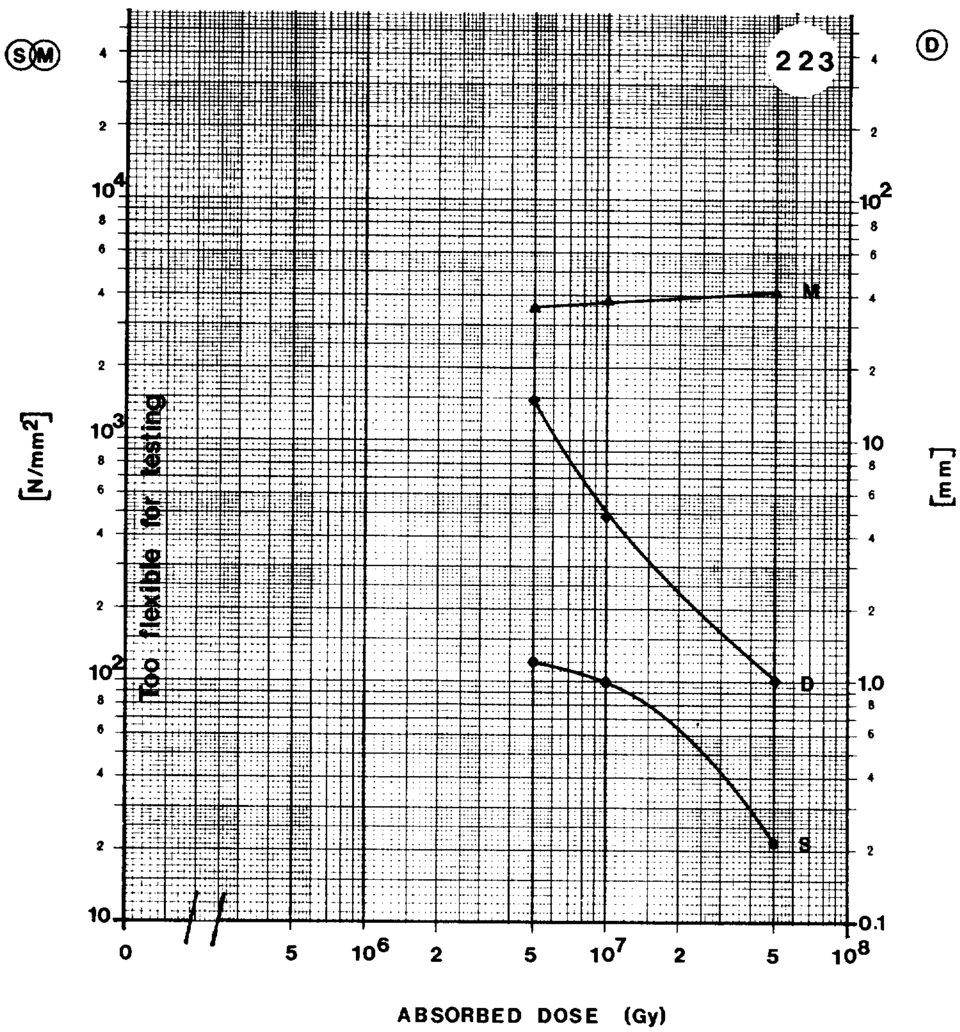
CURVE	PROPERTY	INITIAL VALUE	
S	Ultimate flexural strength	121.6	N/mm²
D	Deflexion at break	12.6	mm
M	Modulus of elasticity	3.7×10^3	N/mm²

ARALDITE F
CY205

MATERIAL: ARALDITE F(200) + HT 972(54)

SUPPLIER: CERN WORKSHOP

Remarks:

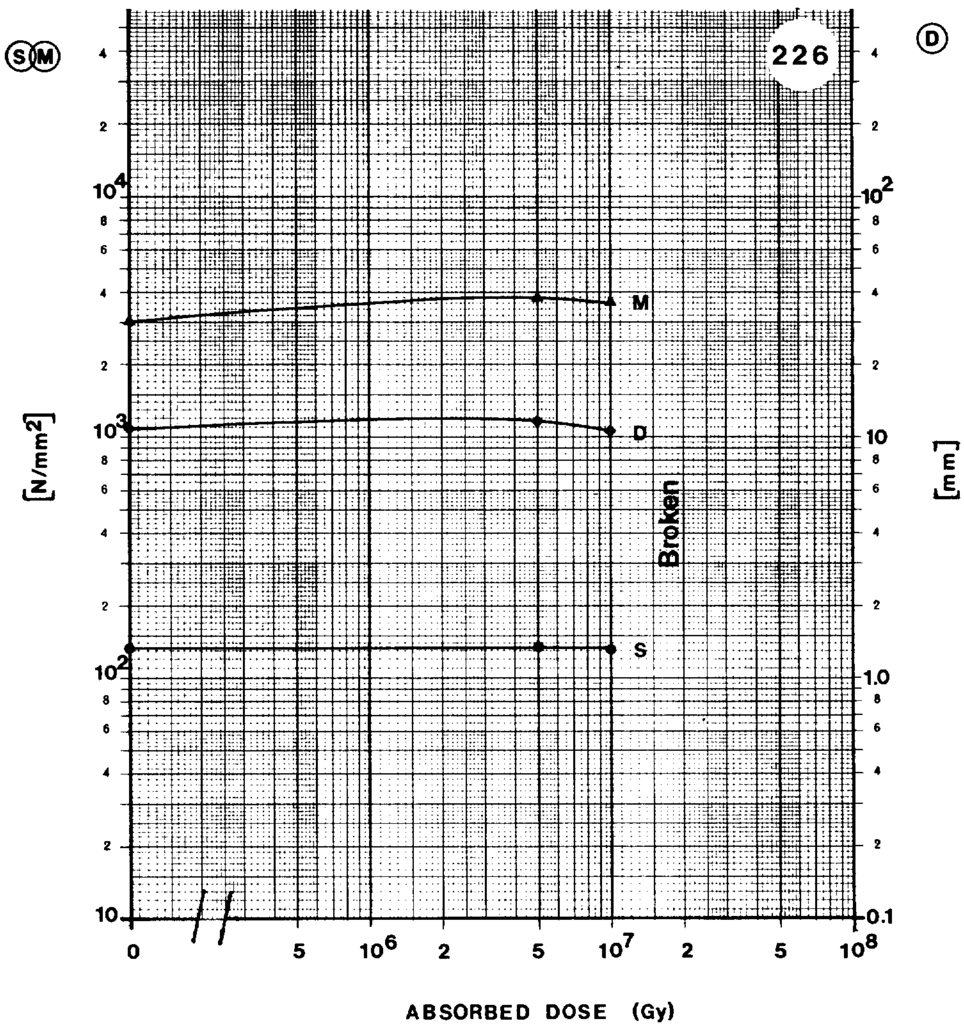


CURVE	PROPERTY	INITIAL VALUE	
S	Ultimate flexural strength	-	N/mm^2
D	Deflexion at break	-	mm
M	Modulus of elasticity	-	N/mm^2

MATERIAL: ARALDITE F(200) + HT 972(54)

SUPPLIER: CERN WORKSHOP

Remarks:



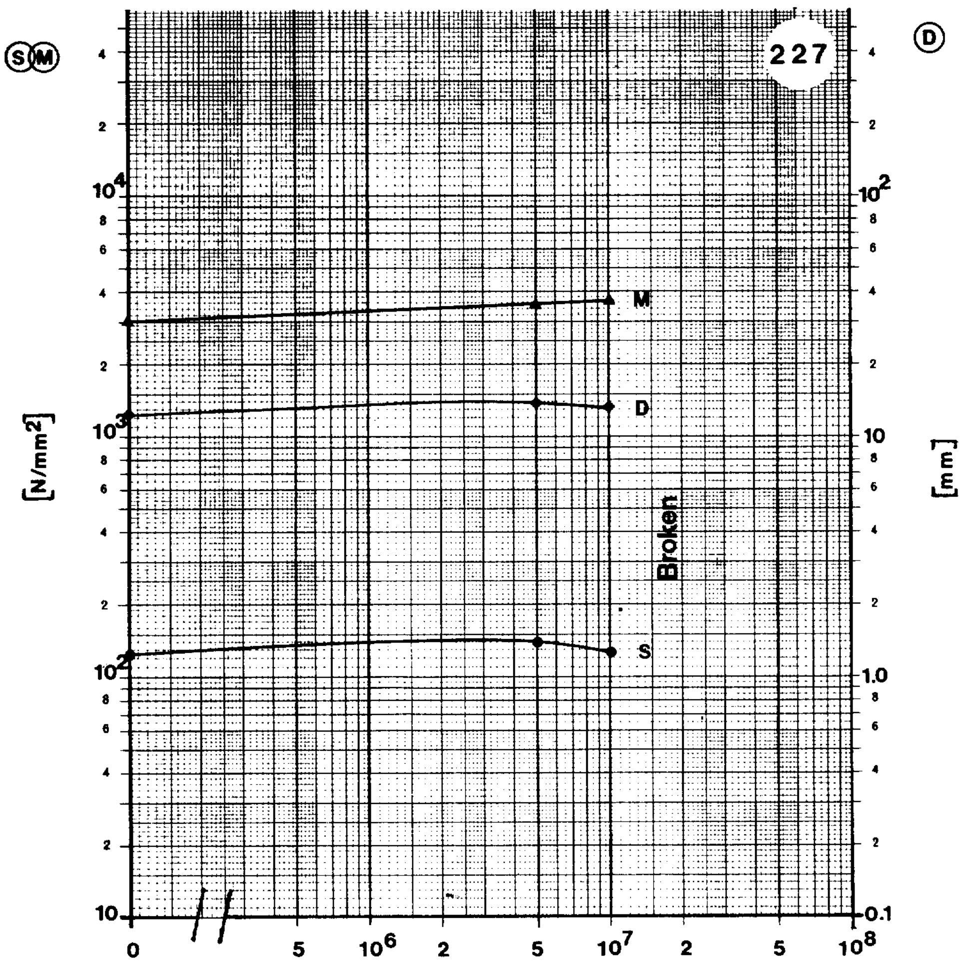
CURVE	PROPERTY	INITIAL VALUE	
S	Ultimate flexural strength	130.5	N/mm^2
D	Deflexion at break	10.9	mm
M	Modulus of elasticity	3.1×10^3	N/mm^2

ARALDITE F
CY205

MATERIAL: ARALDITE F(200) + HT 972(54)

SUPPLIER: CERN WORKSHOP

Remarks:

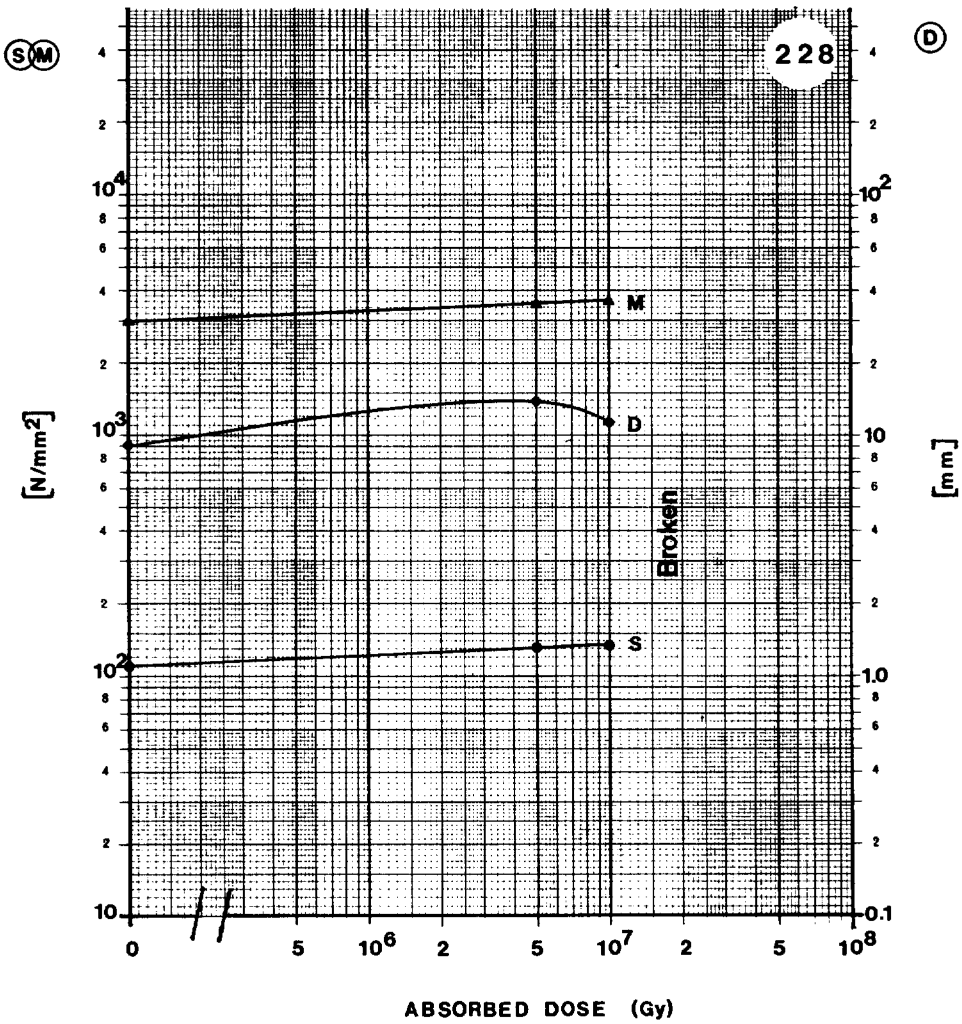


CURVE	PROPERTY	INITIAL VALUE	
S	Ultimate flexural strength	125.5	N/mm^2
D	Deflexion at break	12.3	mm
M	Modulus of elasticity	3.0×10^3	N/mm^2

MATERIAL: ARALDITE F(200) + HT 972(54)

SUPPLIER: CERN WORKSHOP

Remarks:



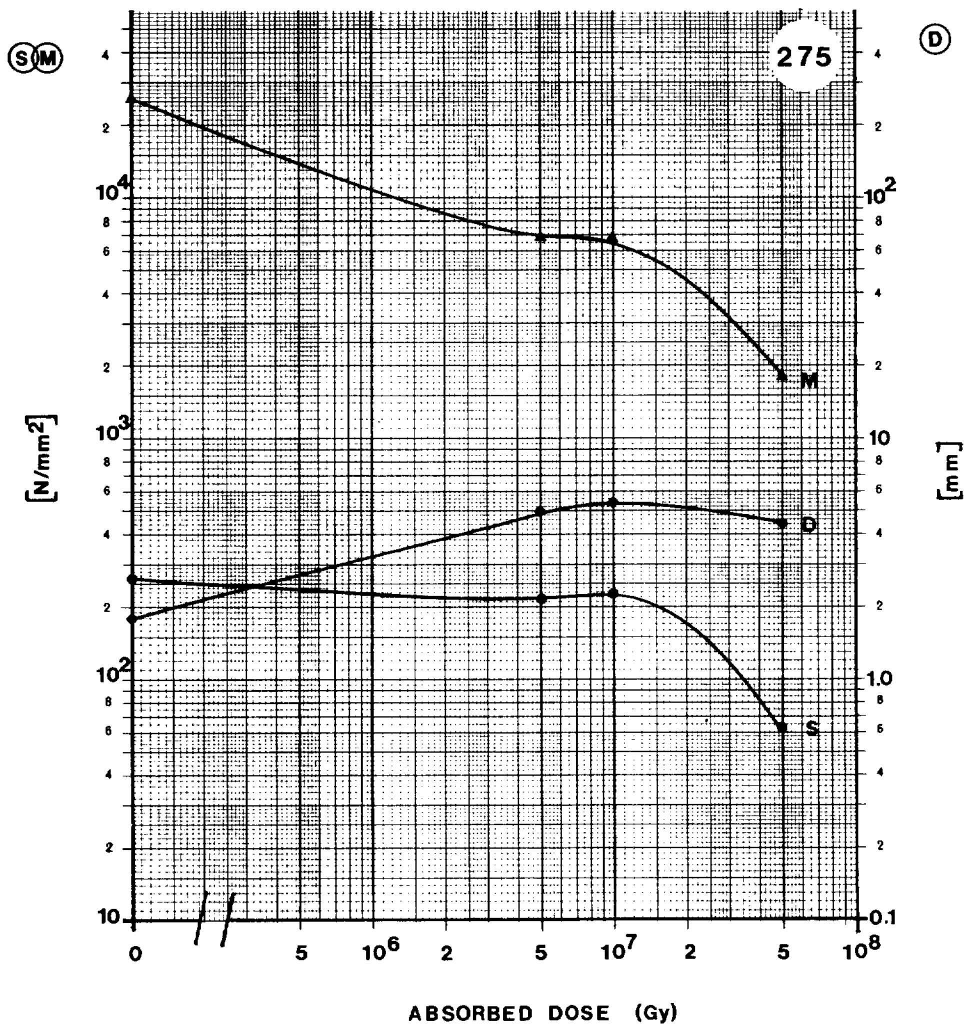
CURVE	PROPERTY	INITIAL VALUE	
S	Ultimate flexural strength	110.8	N/mm^2
D	Deflexion at break	9.0	mm
M	Modulus of elasticity	3.0×10^3	N/mm^2

ARALDITE F
CY205

MATERIAL: MAGNET COIL RESIN ORLITHERM® REINFORCED WITH GLASS WOVEN TAPE TYPE 2 WITH A SPECIAL SILANE FINISH AND MICA-PAPER TAPE

SUPPLIER: BBC BADEN

Remarks:



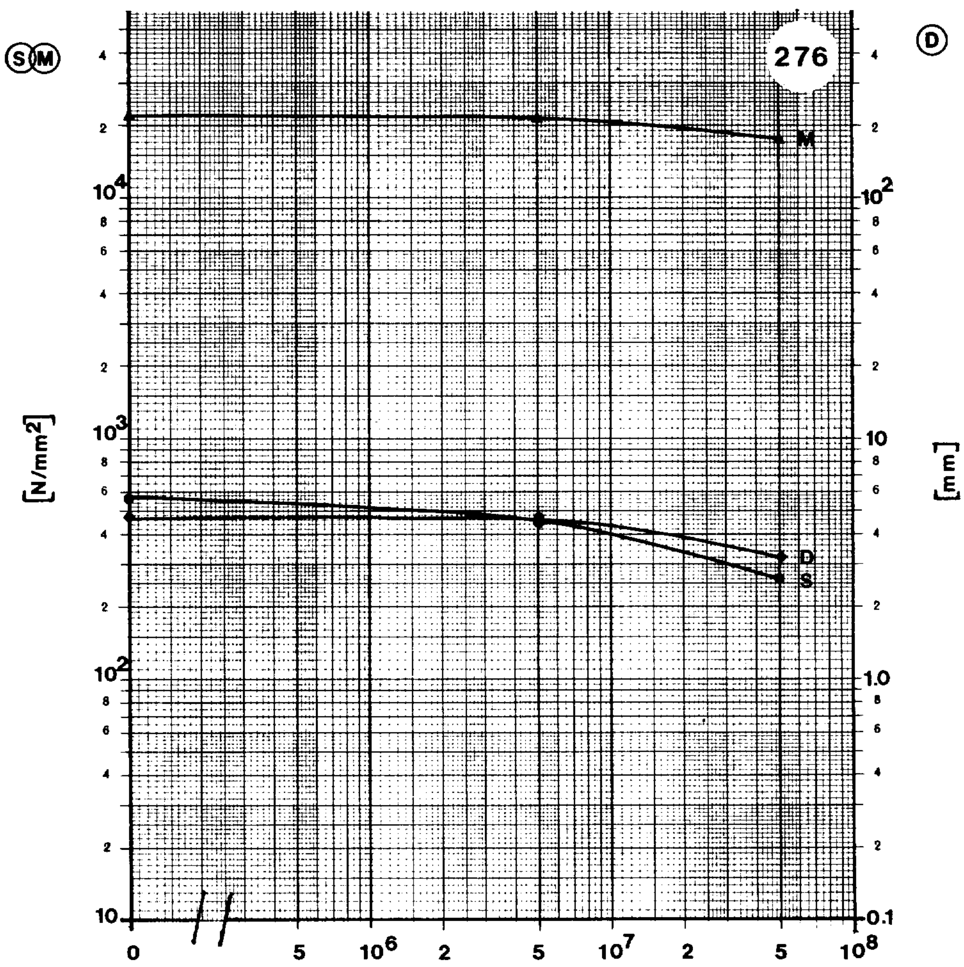
CURVE	PROPERTY	INITIAL VALUE
S	Ultimate flexural strength	264.9 N/mm^2
D	Deflexion at break	1.8 mm
M	Modulus of elasticity	2.6×10^4 N/mm^2

ARALDITE F
CY205

MATERIAL: Magnet coil resin Orlitherm® reinforced with a fibre-silanized woven glass tape type 3

SUPPLIER: BBC Baden

Remarks:



ABSORBED DOSE (Gy)

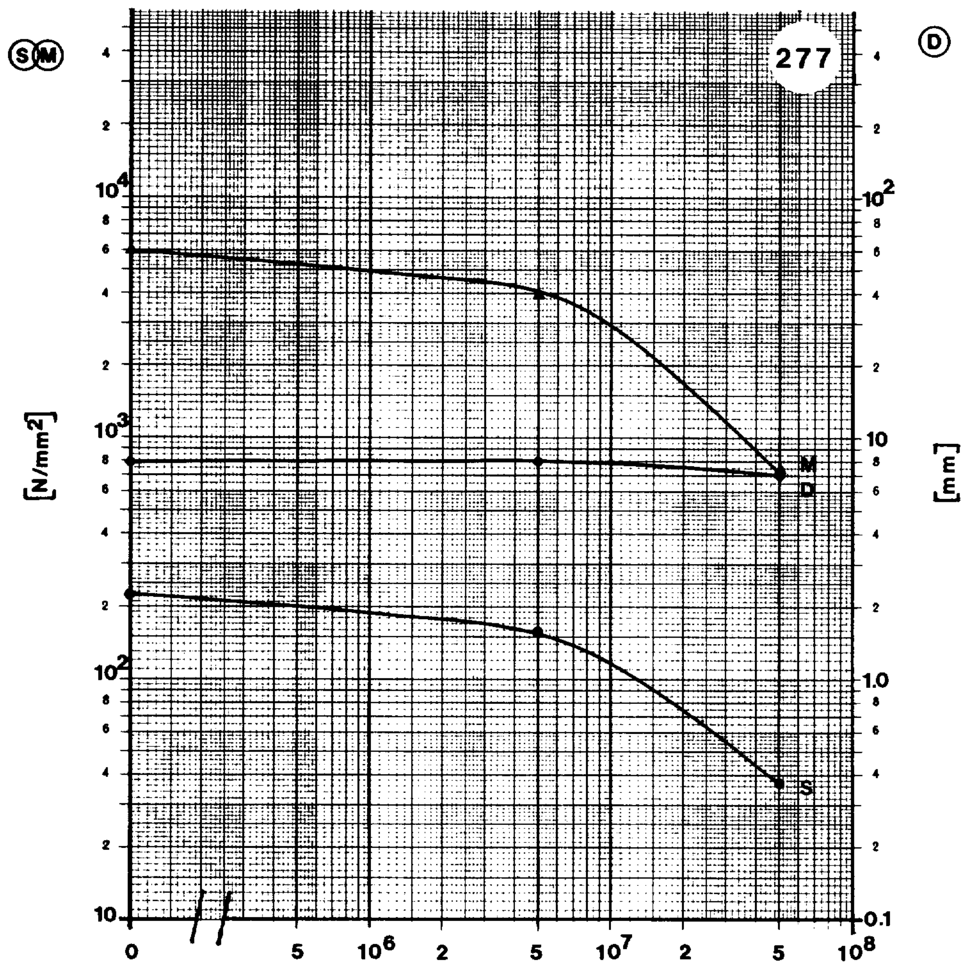
CURVE	PROPERTY	INITIAL VALUE	
S	Ultimate flexural strength	563.1	N/mm^2
D	Deflexion at break	4.8	mm
M	Modulus of elasticity	2.2×10^4	N/mm^2

ARALDITE F
CY205

MATERIAL: Magnet coil resin Orlitherm® reinforced with a fibre-silanized woven glass tape type 3 and mica-paper tape

SUPPLIER: BBC Baden

Remarks:

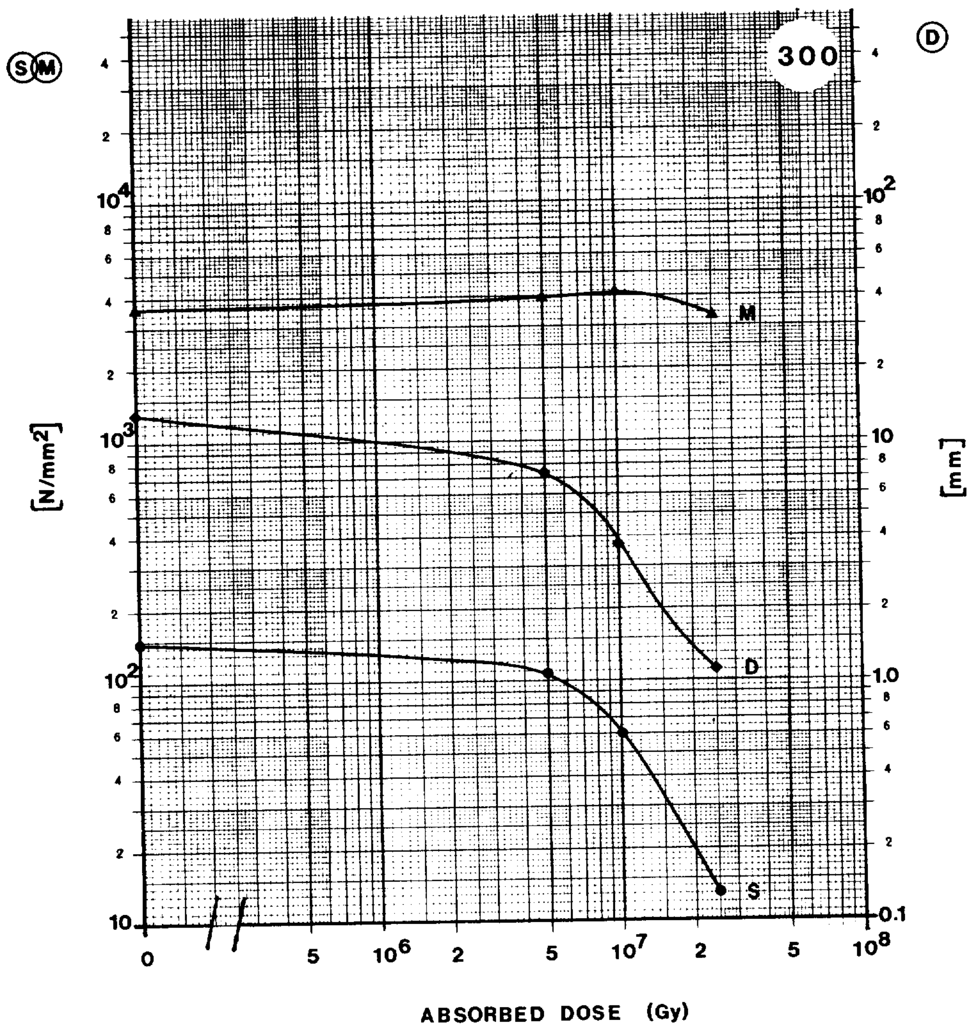


CURVE	PROPERTY	INITIAL VALUE	
S	Ultimate flexural strength	223.7	N/mm^2
D	Deflexion at break	7.8	mm
M	Modulus of elasticity	6.0×10^3	N/mm^2

MATERIAL: CY 205(100) + HY 905(100) + DY 061(1)

SUPPLIER: CIBA-GEIGY

Remarks:



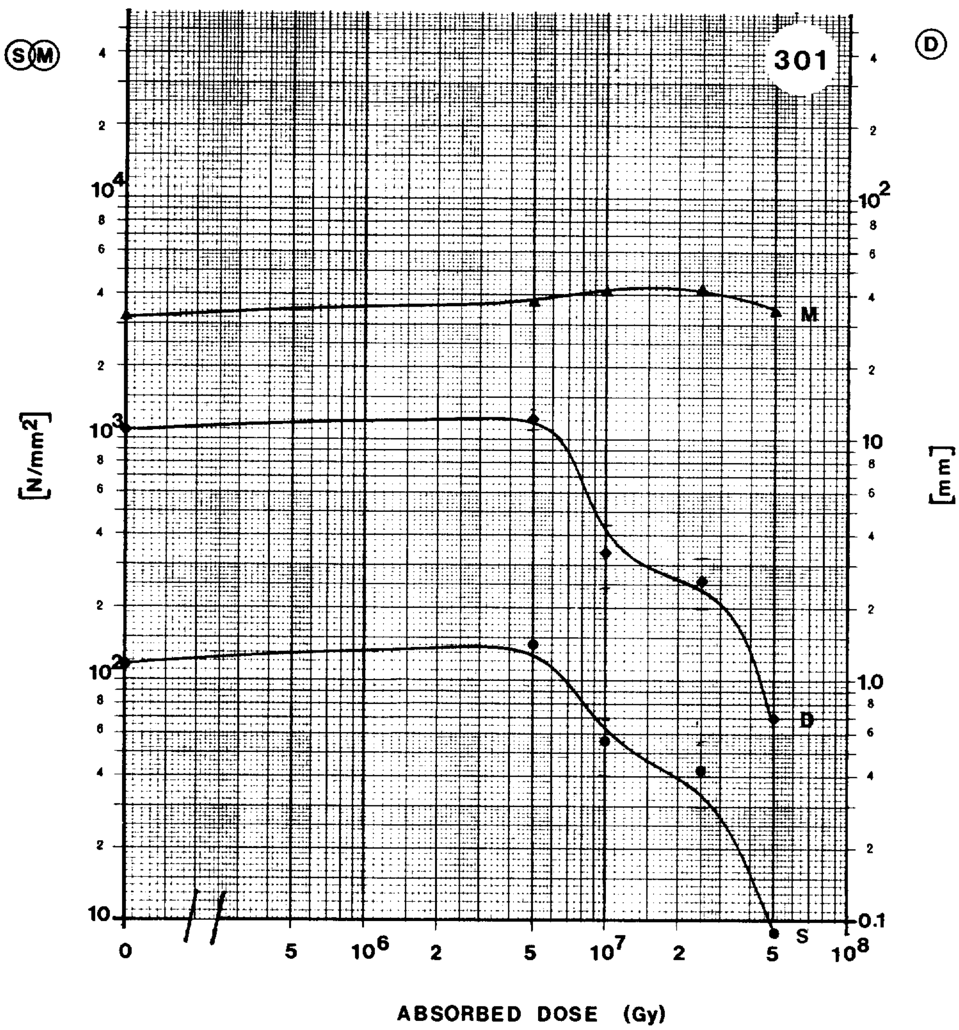
CURVE	PROPERTY	INITIAL VALUE	
S	Ultimate flexural strength	144.2	N/mm^2
D	Deflexion at break	13.1	mm
M	Modulus of elasticity	3.6×10^3	N/mm^2

ARALDITE F
CY205

MATERIAL: CY 205(100) + HY 906(80) + DY 064(1)

SUPPLIER: CIBA-GEIGY

Remarks:



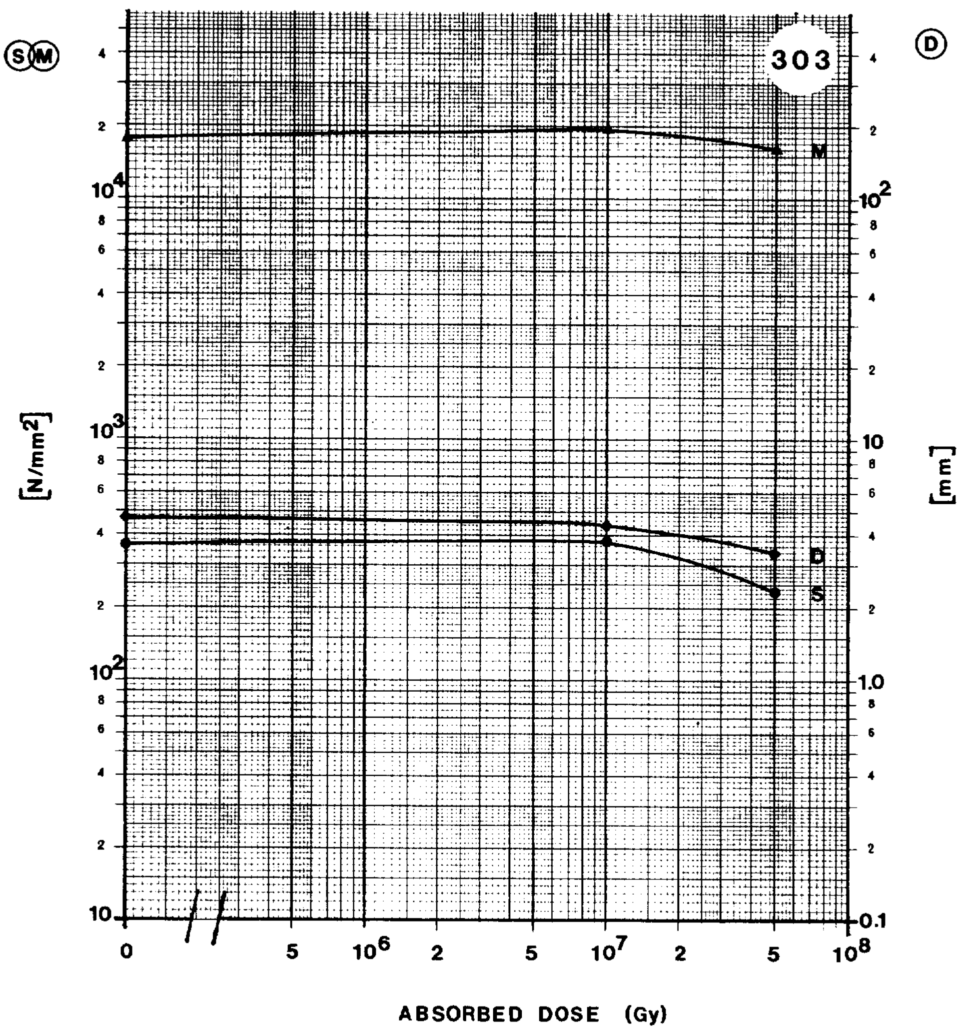
CURVE	PROPERTY	INITIAL VALUE	
S	Ultimate flexural strength	116.7	N/mm^2
D	Deflexion at break	10.9	mm
M	Modulus of elasticity	3.2×10^3	N/mm^2

ARALDITE F
CY205

MATERIAL: Magnet coil resin Orlitherm® reinforced with a sandwich tape built up of a fibre-silanized woven glass tape type 3 and a polyimide film

SUPPLIER: BBC Baden

Remarks:

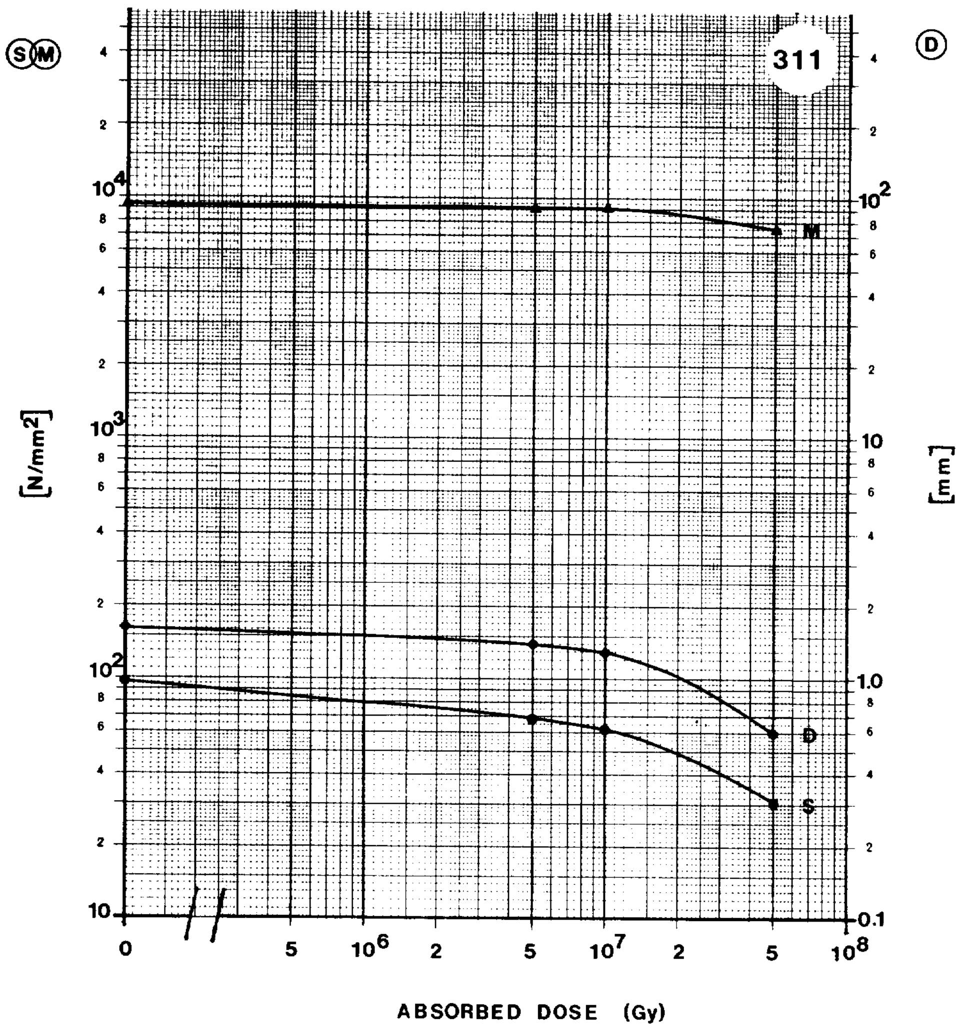


CURVE	PROPERTY	INITIAL VALUE	
S	Ultimate flexural strength	379.6	N/mm^2
D	Deflexion at break	4.7	mm
M	Modulus of elasticity	1.8×10^4	N/mm^2

MATERIAL: CY 205(100) + HY 906(80) + DY 061(0.5) + SILICA

SUPPLIER: CIBA-GEIGY

Remarks: USED FOR PS (SC) - LF AND LG MAGNET COILS



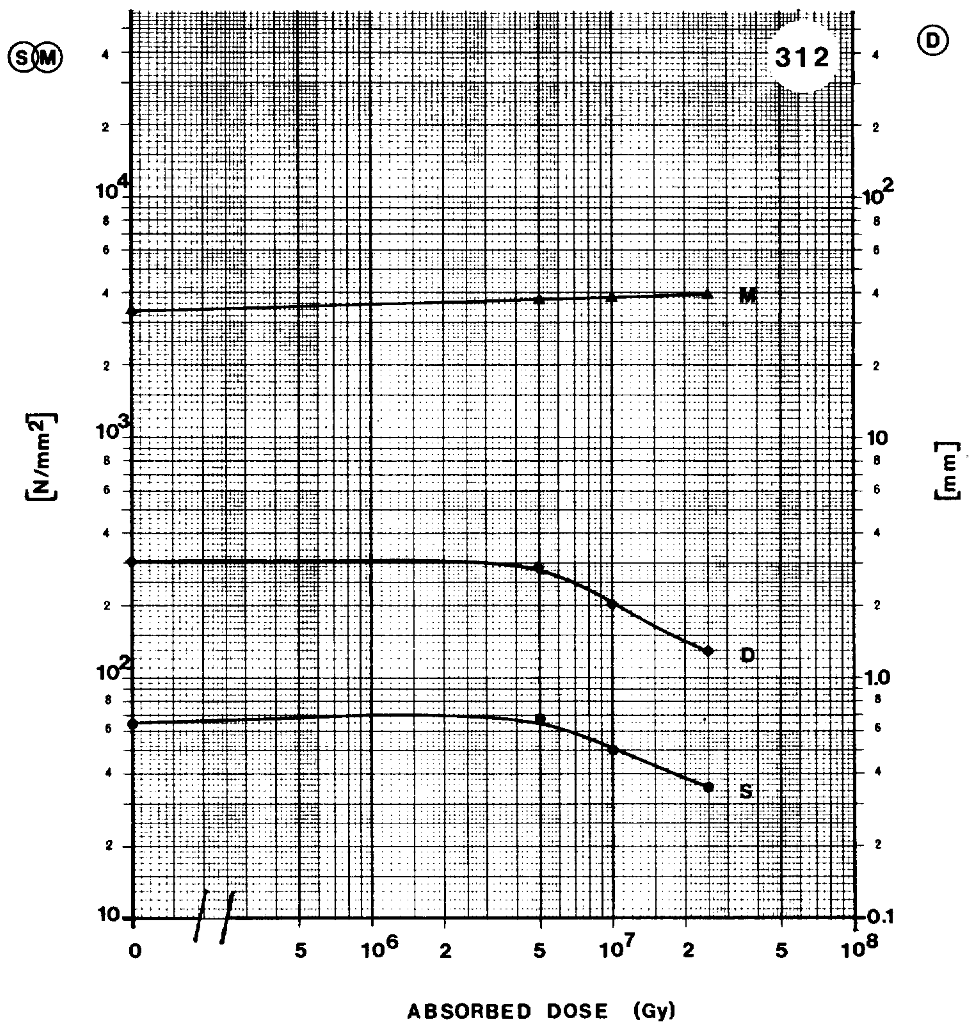
CURVE	PROPERTY	INITIAL VALUE	
S	Ultimate flexural strength	96.1	N/mm^2
D	Deflexion at break	1.6	mm
M	Modulus of elasticity	9.3×10^3	N/mm^2

ARALDITE F
CY205

MATERIAL: CY 205(100) + HY 906(80) + DY 061(0.5)

SUPPLIER: CIBA-GEIGY

Remarks: Used for PS (SC) - LF and LG magnet coils



CURVE	PROPERTY	INITIAL VALUE	
S	Ultimate flexural strength	64.9	N/mm^2
D	Deflexion at break	3.0	mm
M	Modulus of elasticity	3.4×10^3	N/mm^2

No.	Material and Supplier	Dose (Gy)	Ultimate flex. strength S (N/mm²)	Deflexion at break D (mm)	Modulus of elasticity M (N/mm²)
103 (a)	CY 222 + HY 920 (Pure resin)	0	too flexible for testing		
		5×10^6			
		1×10^7			
		3×10^7	15.7 ± 2.0	5.4 ± 3.6	$8.04 \pm 1.32 \times 10^2$
	BBC Baden	5×10^7	12.8 ± 1.0	1.4 ± 0.3	$1.66 \pm 0.13 \times 10^3$
104	CY 222 + HY 920 + 70% glass (cut ǁ to fibre)	0	88.3 ± 8.8		$6.87 \pm 1.31 \times 10^3$
		1×10^7	114.8 ± 4.9		$1.02 \pm 0.09 \times 10^4$
		3×10^7	89.3 ± 6.9		$8.34 \pm 0.46 \times 10^3$
		6×10^7	69.7 ± 3.9		$8.44 \pm 0.50 \times 10^3$
	BBC Baden	1×10^8	61.8 ± 6.9	3.8 ± 3.5	$6.07 \pm 2.45 \times 10^3$
105	CY 222 + HY 920 + MICA	0	91.2 ± 5.9	1.6 ± 0.1	$1.87 \pm 0.26 \times 10^4$
		1×10^7	108.9 ± 2.0	3.4 ± 0.2	$1.97 \pm 0.36 \times 10^4$
		3×10^7	52.0 ± 2.9	2.6 ± 0.5	$4.27 \pm 0.34 \times 10^3$
		6×10^7	33.4 ± 3.9	2.3 ± 0.2	$2.99 \pm 0.27 \times 10^3$
	MICAFIL	1×10^8	36.3 ± 3.9	2.8 ± 0.4	$2.90 \pm 0.26 \times 10^3$

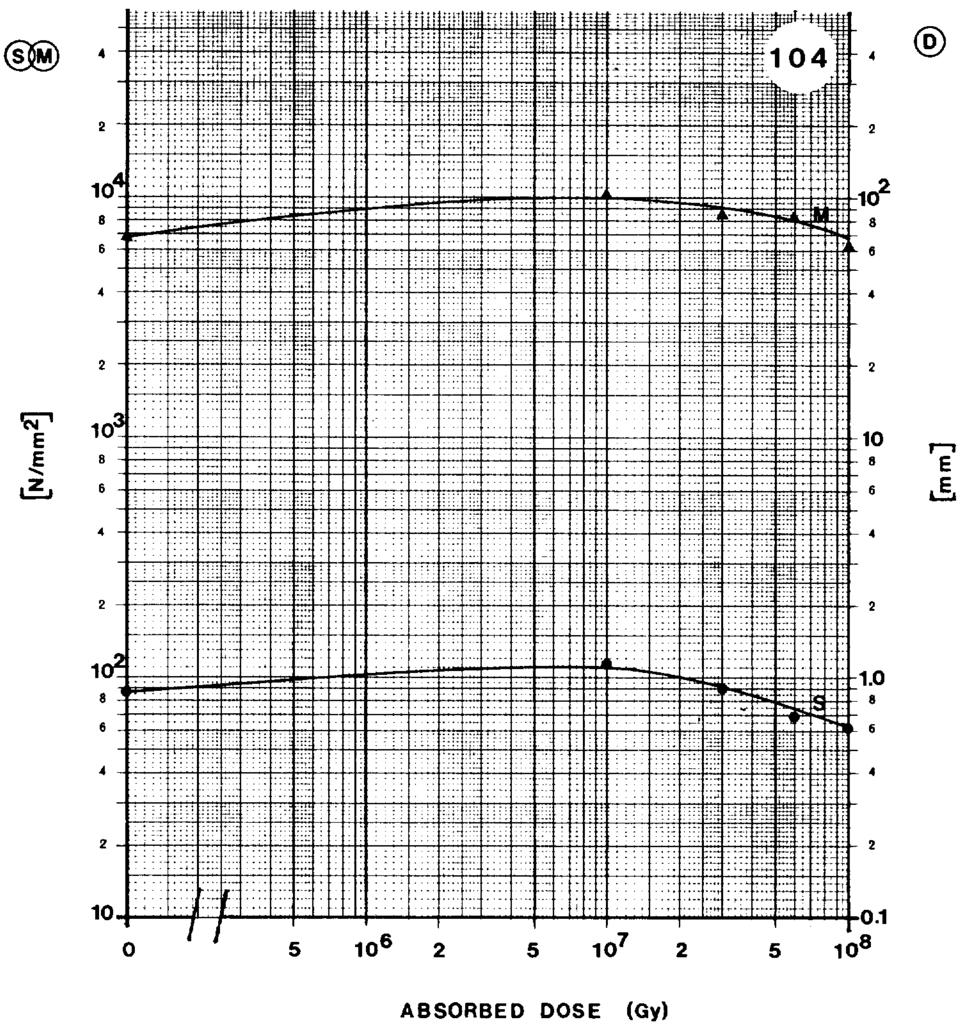
(a) No graph

ARALDITE
CY222

MATERIAL: CY 222 + HY 920 + 70% GLASS

SUPPLIER: BBC BADEN

Remarks:



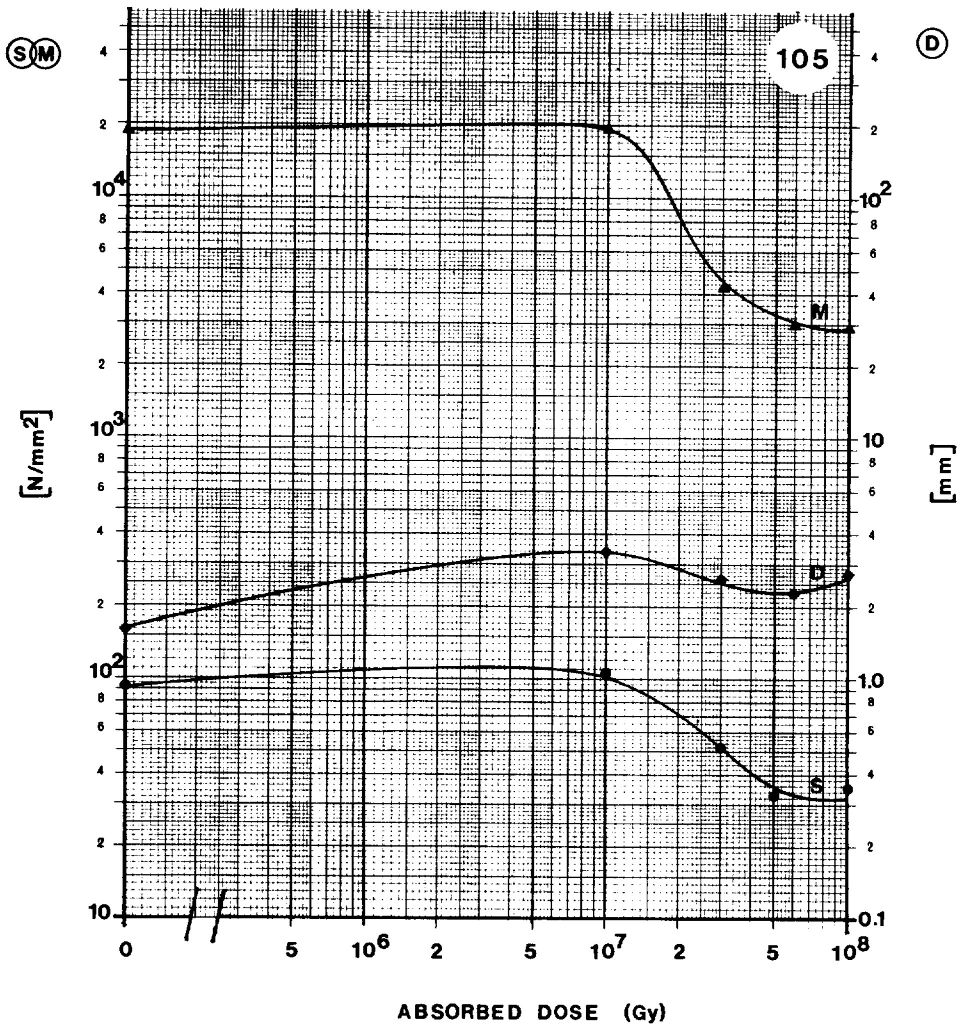
CURVE	PROPERTY	INITIAL VALUE	
S	Ultimate flexural strength	88.3	N/mm^2
D	Deflexion at break		mm
M	Modulus of elasticity	6.8×10^3	N/mm^2

ARALDITE
CY 222

MATERIAL: CY 222 + HY 920 + MICA

SUPPLIER: MICAFIL

Remarks:



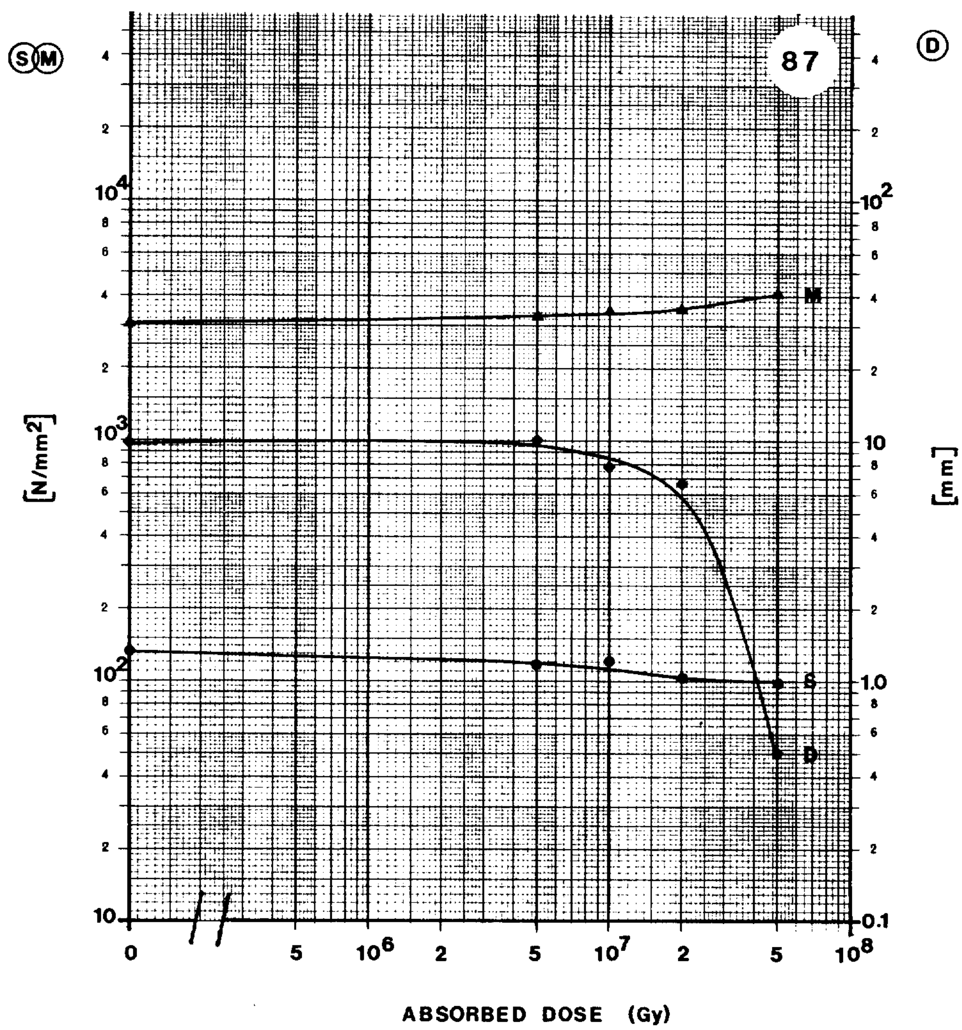
CURVE	PROPERTY	INITIAL VALUE	
S	Ultimate flexural strength	91.2	N/mm^2
D	Deflexion at break	1.6	mm
M	Modulus of elasticity	1.8×10^4	N/mm^2

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)
87	MY 740 + HY 906 + DY 063	0	130.5 ± 18.6	9.9 ± 3.1	$3.08 \pm 0.08 \times 10^3$
		5×10^6	115.8 ± 5.9	10.0 ± 2.0	$3.34 \pm 0.27 \times 10^3$
		1×10^7	121.6 ± 31.4	7.7 ± 2.2	$3.48 \pm 0.18 \times 10^3$
		2×10^7	103.0 ± 42.2	6.7 ± 3.0	$3.48 \pm 0.12 \times 10^3$
	LINTOTT	5×10^7	9.8 ± 2.9	0.5 ± 0.2	$4.10 \pm 0.25 \times 10^3$
143	MY 740(100) + MNA(80) + + DMP 30(0.5) + glass	0	283.5 ± 7.8	7.2 ± 0.2	$1.58 \pm 0.04 \times 10^4$
		3×10^7	263.9 ± 23.5	9.2 ± 0.2	$1.38 \pm 0.16 \times 10^4$
	PLESSEY	5×10^7	197.2 ± 12.8	9.1 ± 0.4	$1.02 \pm 0.06 \times 10^4$
144	MY 740(100) + MNA(80) + + DMP 30(0.5)	0	89.3 ± 10.8	6.3 ± 0.9	$3.77 \pm 0.15 \times 10^3$
		1×10^7	84.4 ± 25.5	6.4 ± 2.4	$3.96 \pm 0.22 \times 10^3$
	PLESSEY	3×10^7	27.5 ± 23.5	1.9 ± 1.7	$3.68 \pm 0.04 \times 10^3$

MATERIAL: MY 740 + HY 906 + DY 063

SUPPLIER: LINTOTT

Remarks:



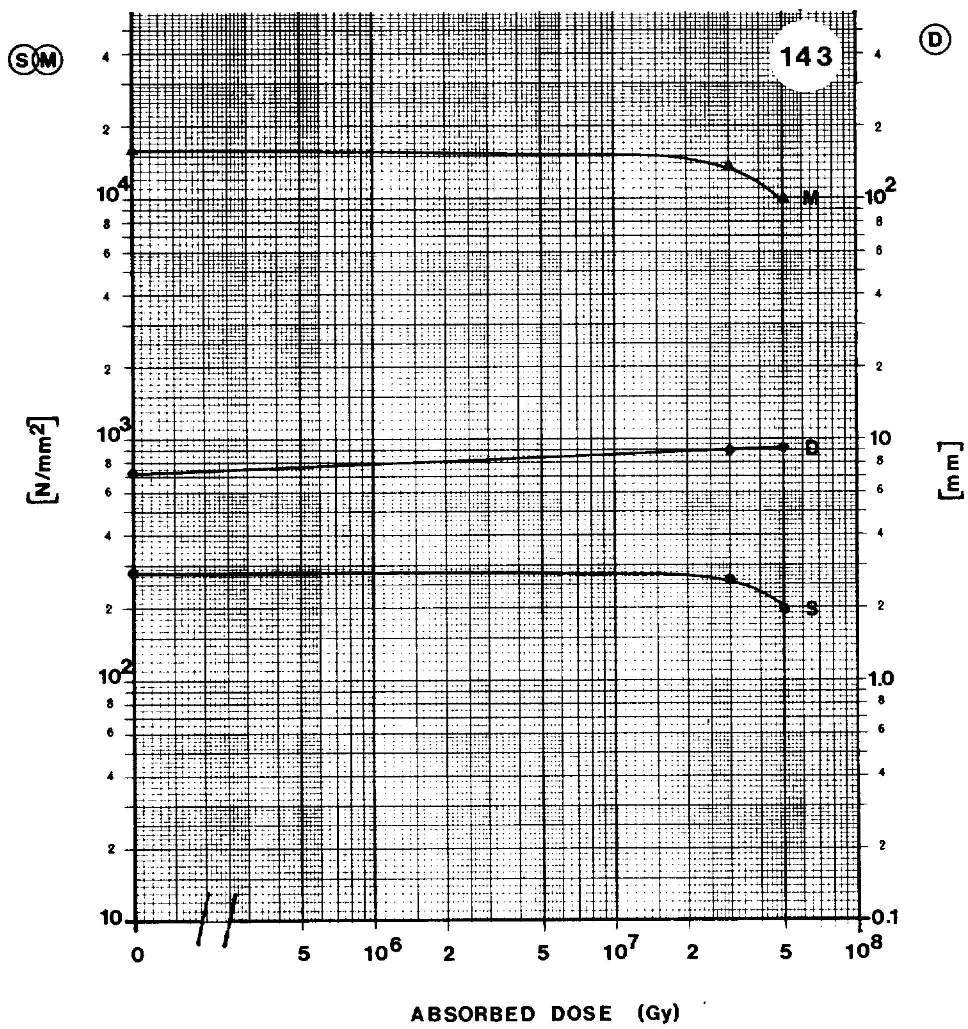
CURVE	PROPERTY	INITIAL VALUE
S	Ultimate flexural strength	130.5 N/mm^2
D	Deflexion at break	9.9 mm
M	Modulus of elasticity	3.1×10^3 N/mm^2

ARALDITE
MY 740

MATERIAL: MY 740(100) + MNA(80) + DMP 30(0.5) + GLASS

SUPPLIER: PLESSEY

Remarks:

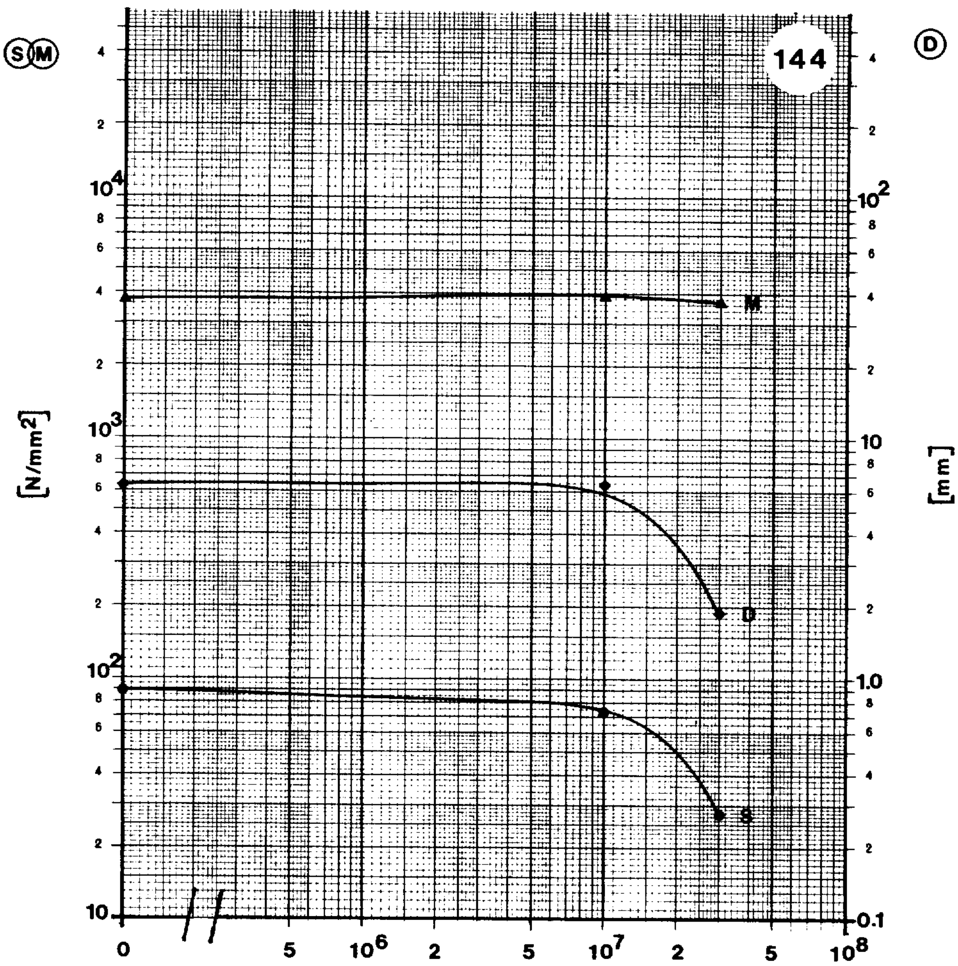


CURVE	PROPERTY	INITIAL VALUE	
S	Ultimate flexural strength	283.5	N/mm^2
D	Deflexion at break	7.2	mm
M	Modulus of elasticity	1.6×10^4	N/mm^2

MATERIAL: MY 740(100) + MNA(80) + DMP 30(0.5)

SUPPLIER: PLESSEY

Remarks:



ABSORBED DOSE (Gy)

CURVE	PROPERTY	INITIAL VALUE	
S	Ultimate flexural strength	89.3	N/mm^2
D	Deflexion at break	6.3	mm
M	Modulus of elasticity	3.8×10^3	N/mm^2

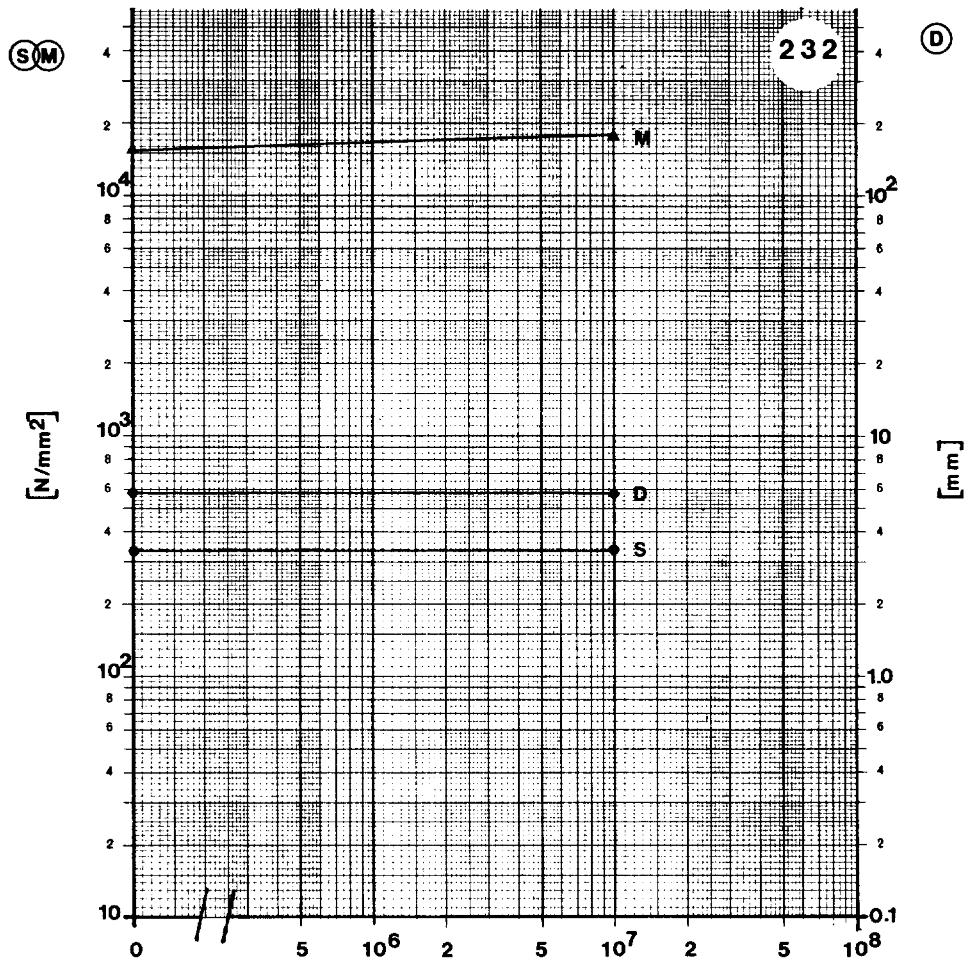
No.	Material and Supplier	Dose (Gy)	Ultimate flex. strength S (N/mm²)	Deflexion at break D (mm)	Modulus of elasticity M (N/mm²)
232	MY 745 + HY 906 + XB 2687 + + glass ALSTHOM	0	333.5 ± 56.9	5.9 ± 0.5	$1.53 \pm 0.15 \times 10^4$
		1×10^7	336.5 ± 27.5	5.8 ± 0.7	$1.77 \pm 0.13 \times 10^4$
240 (a)	MY 745(100) + HY 906(90) + + XB 2687(1.5) 12 h 125 °C CIBA-GEIGY	0	118.8 ± 10.0	6.5 ± 0.8	$3.64 \pm 0.07 \times 10^3$
298	MY 745(100) + HY 906(90) + + XB 2687(1.5) 5 h 110 °C + 16 h 125 °C CIBA-GEIGY	0	100.4 ± 37.3	8.3 ± 4.0	$3.68 \pm 0.04 \times 10^3$
		5×10^6	118.8 ± 32.4	11.2 ± 4.1	$3.65 \pm 0.12 \times 10^3$
		1×10^7	100.0 ± 44.1	7.0 ± 3.5	$4.08 \pm 0.10 \times 10^3$
		2.5×10^7	48.1 ± 17.7	2.9 ± 1.1	$4.20 \pm 0.21 \times 10^3$
		5×10^7	13.7 ± 2.9	1.2 ± 0.4	$3.42 \pm 0.00 \times 10^3$
299	MY 745(100) + HY 906(90) + + XB 2687(1.5) 24 h 125 °C CIBA-GEIGY	0	107.7 ± 20.6	7.9 ± 2.0	$3.84 \pm 0.15 \times 10^3$
		5×10^6	114.9 ± 34.3	9.3 ± 3.3	$3.76 \pm 0.12 \times 10^3$
		1×10^7	68.7 ± 21.6	4.4 ± 1.3	$4.02 \pm 0.16 \times 10^3$
		2.5×10^7	36.3 ± 8.8	2.2 ± 0.5	$4.25 \pm 0.24 \times 10^3$
		5×10^7	8.8 ± 1.96	0.6 ± 0.2	$3.21 \pm 0.00 \times 10^3$

(a) No graph.

MATERIAL: MY 745 + HY 906 + XB 2687 + GLASS

SUPPLIER: ALSTHOM

Remarks: RESIN USED FOR SPS DIPOLE MAGNETS



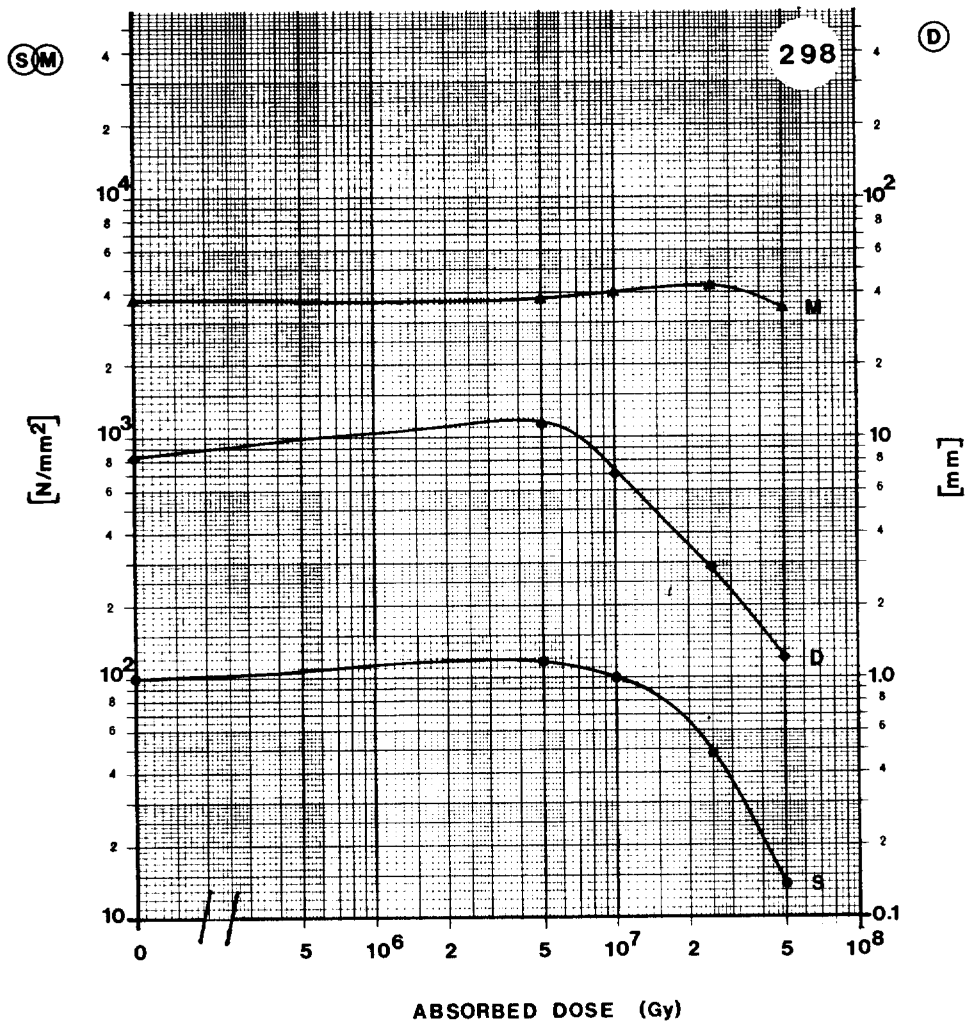
CURVE	PROPERTY	INITIAL VALUE	
S	Ultimate flexural strength	333.5	N/mm^2
D	Deflexion at break	5.9	mm
M	Modulus of elasticity	1.5×10^4	N/mm^2

ARALDITE MY 745

MATERIAL: MY 745(100) + HY 906(90) + XB 2687(1.5)

SUPPLIER: CIBA-GEIGY

Remarks: Resin used for SPS dipole magnets

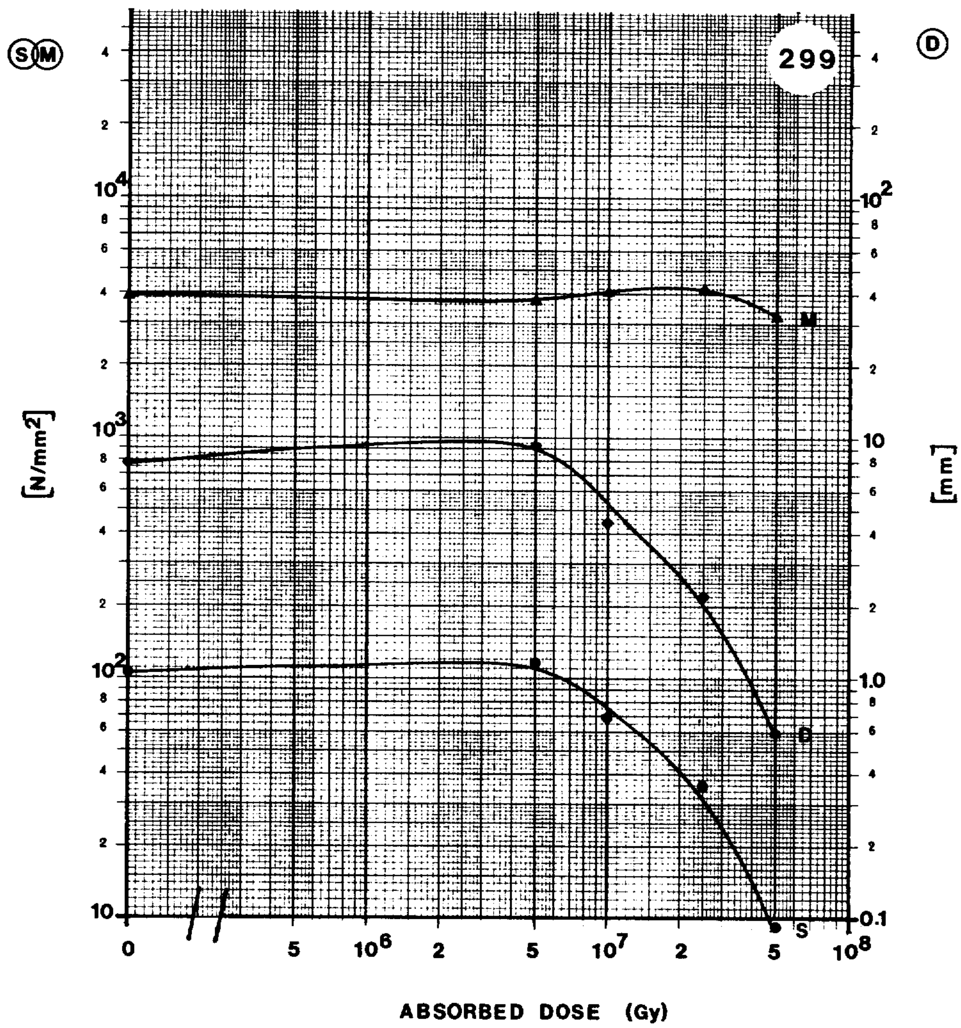


CURVE	PROPERTY	INITIAL VALUE	
S	Ultimate flexural strength	100.4	N/mm^2
D	Deflexion at break	8.3	mm
M	Modulus of elasticity	3.7×10^3	N/mm^2

MATERIAL: MY 745(100) + HY 906(90) + XB 2687(1.5)

SUPPLIER: CIBA-GEIGY

Remarks:



CURVE	PROPERTY	INITIAL VALUE	
S	Ultimate flexural strength	107.7	N/mm^2
D	Deflexion at break	7.9	mm
M	Modulus of elasticity	3.8×10^3	N/mm^2

Base resin

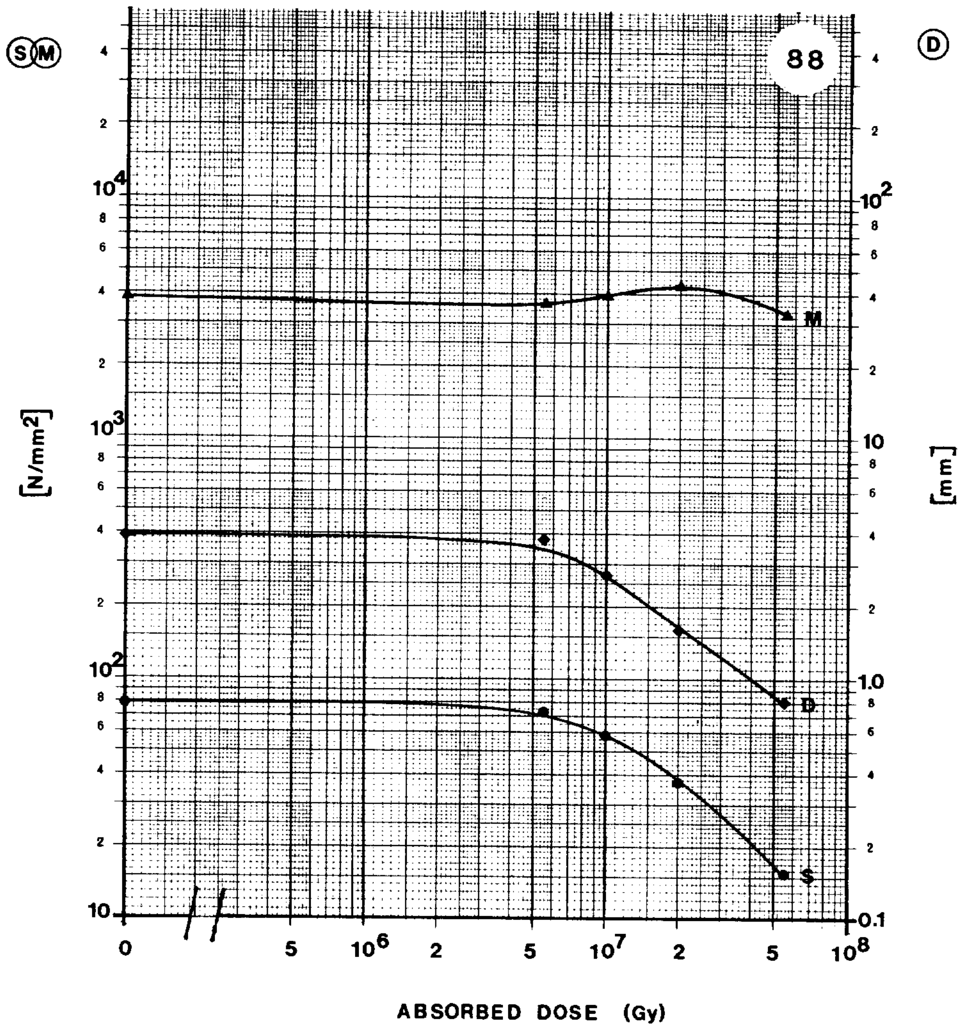
liquid unmodified epoxy resin based on TGDM

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)
88	MY 720 + HY 906	0	79.5 ± 11.8	3.9 ± 0.5	$3.87 \pm 0.15 \times 10^3$
		5.5×10^6	73.6 ± 20.6	3.8 ± 1.1	$3.61 \pm 0.64 \times 10^3$
		1×10^7	58.9 ± 20.6	2.7 ± 0.9	$3.94 \pm 0.39 \times 10^3$
		2.3×10^7	37.3 ± 6.9	1.6 ± 0.2	$4.42 \pm 0.79 \times 10^3$
	LINTOTT	5.5×10^7	15.7 ± 6.9	0.8 ± 0.2	$3.26 \pm 0.44 \times 10^3$
101	Magnet coil resin type B reinforced with fibre-silanized glass tape type 1 (Base: TGDM + MNA + other components)	0	421.8 ± 83.4	3.5 ± 0.4	$2.77 \pm 0.13 \times 10^4$
	(cut ‖ to fibre)	1.2×10^7	478.8 ± 5.9	3.7 ± 0.2	$2.79 \pm 0.12 \times 10^4$
	BBC Baden	3.6×10^7	451.3 ± 23.5	3.5 ± 0.1	$2.75 \pm 0.20 \times 10^4$
		7.2×10^7	337.5 ± 33.4		$2.55 \pm 0.10 \times 10^4$

MATERIAL: MY 720 + HY 906

SUPPLIER: LINTOTT

Remarks:



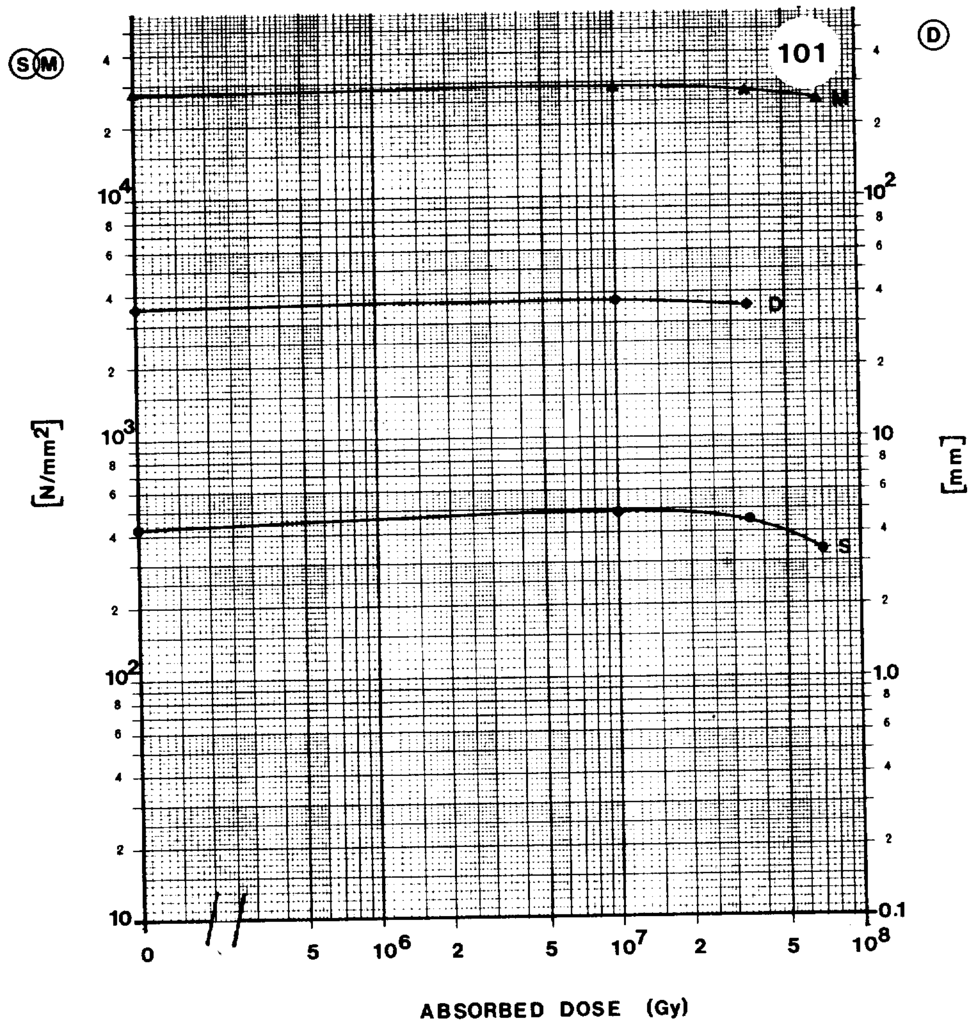
CURVE	PROPERTY	INITIAL VALUE	
S	Ultimate flexural strength	79.5	N/mm^2
D	Deflexion at break	3.9	mm
M	Modulus of elasticity	3.9×10^3	N/mm^2

ARALDITE
MY 720

MATERIAL: Magnet coil resin type B reinforced with fibre-silanized glass tape type 1 (Base: TGDM + MNA + + other components)

SUPPLIER: BBC Baden

Remarks:



CURVE	PROPERTY	INITIAL VALUE	
S	Ultimate flexural strength	421.8	N/mm^2
D	Deflexion at break	3.5	mm
M	Modulus of elasticity	2.8×10^4	N/mm^2

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)

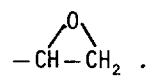
see NOVOLAC

ETRONAX

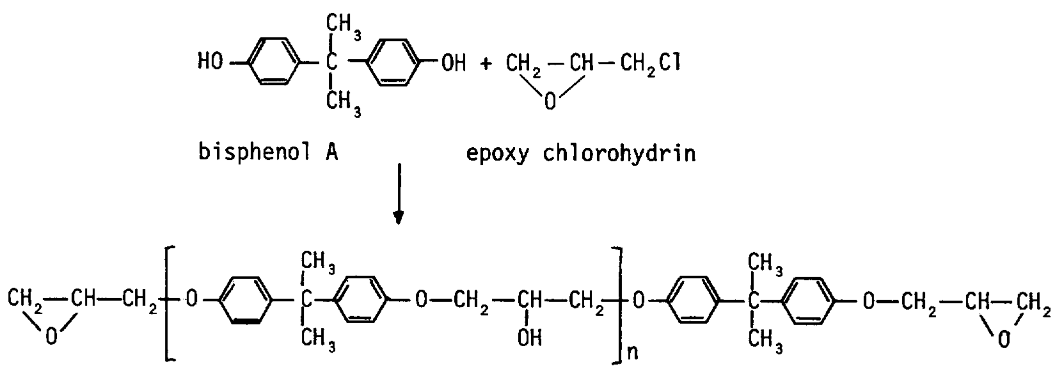
Trade name of Elektro-ISOLA for laminated plastic of phenol resin with paper tissue

see POLYESTER

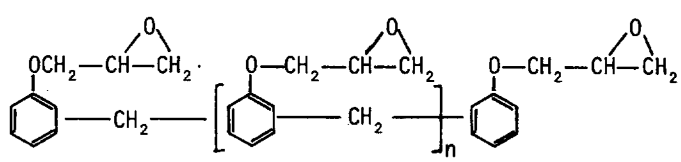
Epoxy resins[16-18] are polymers containing two or more epoxy groups:



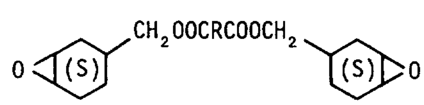
Depending on the base product, many different types of epoxy resins can be manufactured. The most common ones are prepared by the reaction of bisphenol A with epichlorohydrin:



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

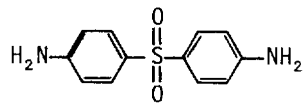


Cycloaliphatic epoxy resin

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.:

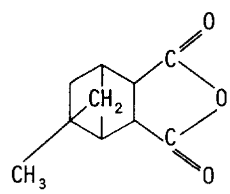
- diaminodiphenylsulfone (DDS)



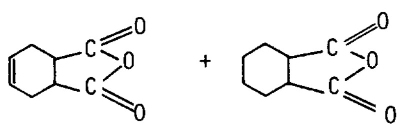
- diethylenetriamine

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

- methyl nadic anhydride (MNA = NMA)

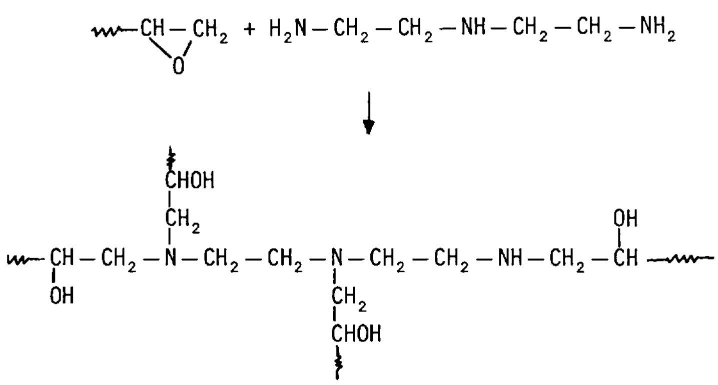


- mixture of tetra- and hexahydrophthalic-anhydride

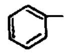


The other types of hardeners used with epoxy resins are the polysulfides, tertiary amines, boron trifluoride complexes, etc.

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

$$\left[\text{glycerin } HO-CH_2-\underset{}{\overset{OH}{\overset{|}{C}}}H-CH_2-OH\right].$$

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/mm²)	Deflexion at break D (mm)	Modulus of elasticity M (N/mm²)
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)	0	127.5 ± 1.9	13.4 ± 0.3	$1.90 \pm 0.04 \times 10^3$
	14 h 140 °C	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)	0	75.5 ± 1.0	9.4 ± 0.3	$2.19 \pm 0.15 \times 10^3$
	24 h 25 °C	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)	0	51.0 ± 3.9	1.9 ± 0.2	$5.14 \pm 0.36 \times 10^3$
	24 h 25 °C	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	$3.79 \pm 0.13 \times 10^3$
	PLESSEY	1×10^7	99.1 ± 12.8	6.1 ± 1.0	$4.11 \pm 0.27 \times 10^3$
264	Epoxy 91-1892(100) + Curing Agent 91-1893(150) + DY 062(2.5)	0	125.6 ± 37.8	3.4 ± 1.1	$9.06 \pm 0.26 \times 10^3$
	2 h 80 °C + 3 h 100 °C	5×10^6	13.8 ± 2.7	0.7 ± 0.0	$4.25 \pm 0.77 \times 10^3$
	LARS FOSS KEMI	1×10^7	samples	broken after	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)
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	$6.26 \pm 0.55 \times 10^4$
	ISOLA	1×10^8	183.5 ± 11.2	1.1 ± 0.1	$7.34 \pm 0.18 \times 10^4$
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.

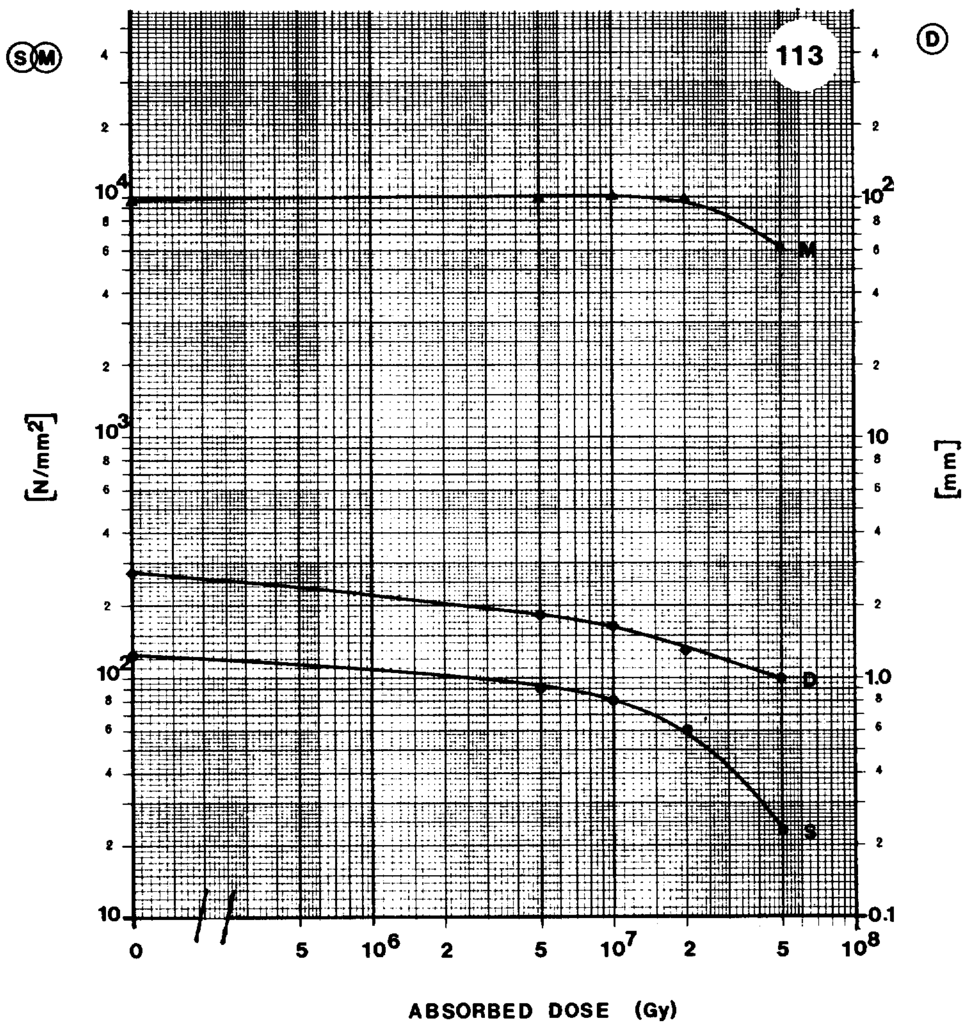
(b) Damage from water during irradiation.

No.	Material and Supplier	Dose (Gy)	Ultimate flex. strength S (N/mm²)	Deflexion at break D (mm)	Modulus of elasticity M (N/mm²)
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:

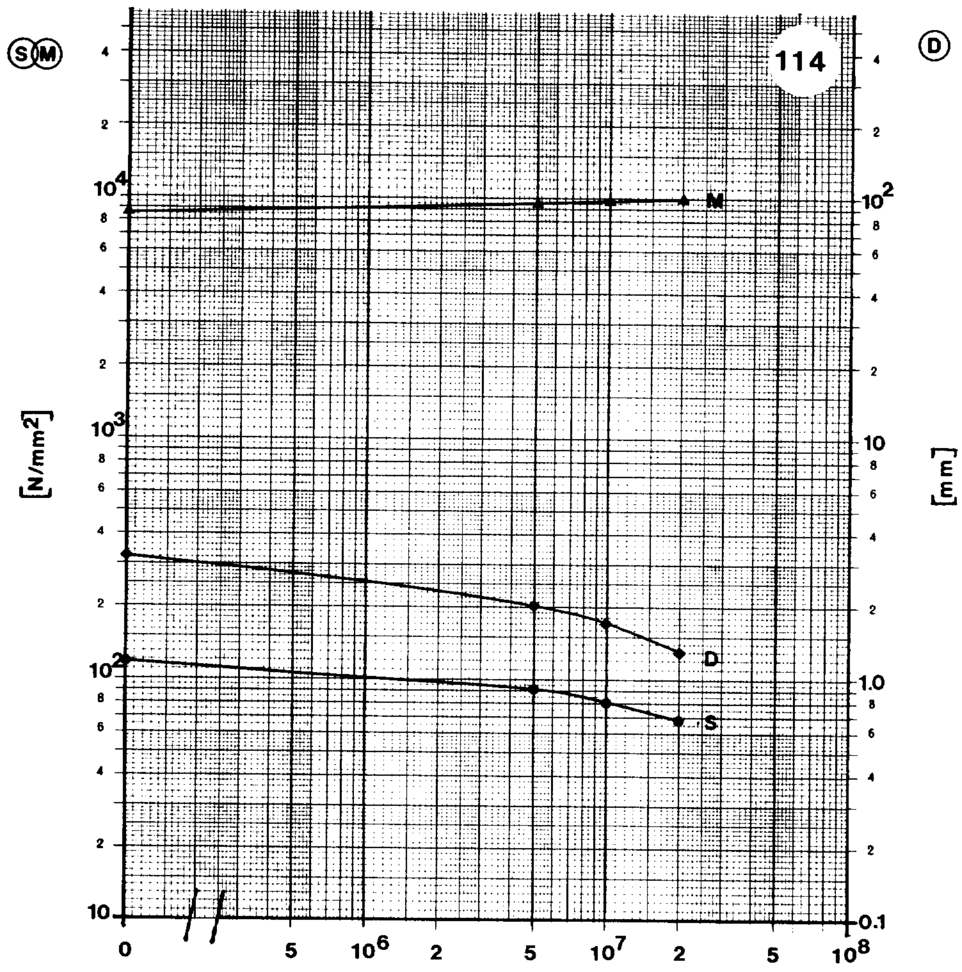


CURVE	PROPERTY	INITIAL VALUE	
S	Ultimate flexural strength	122.6	N/mm²
D	Deflexion at break	2.8	mm
M	Modulus of elasticity	9.5×10^3	N/mm²

MATERIAL: Epoxy resin + anhydride hardener + quartz powder

SUPPLIER: BBC Mannheim

Remarks:

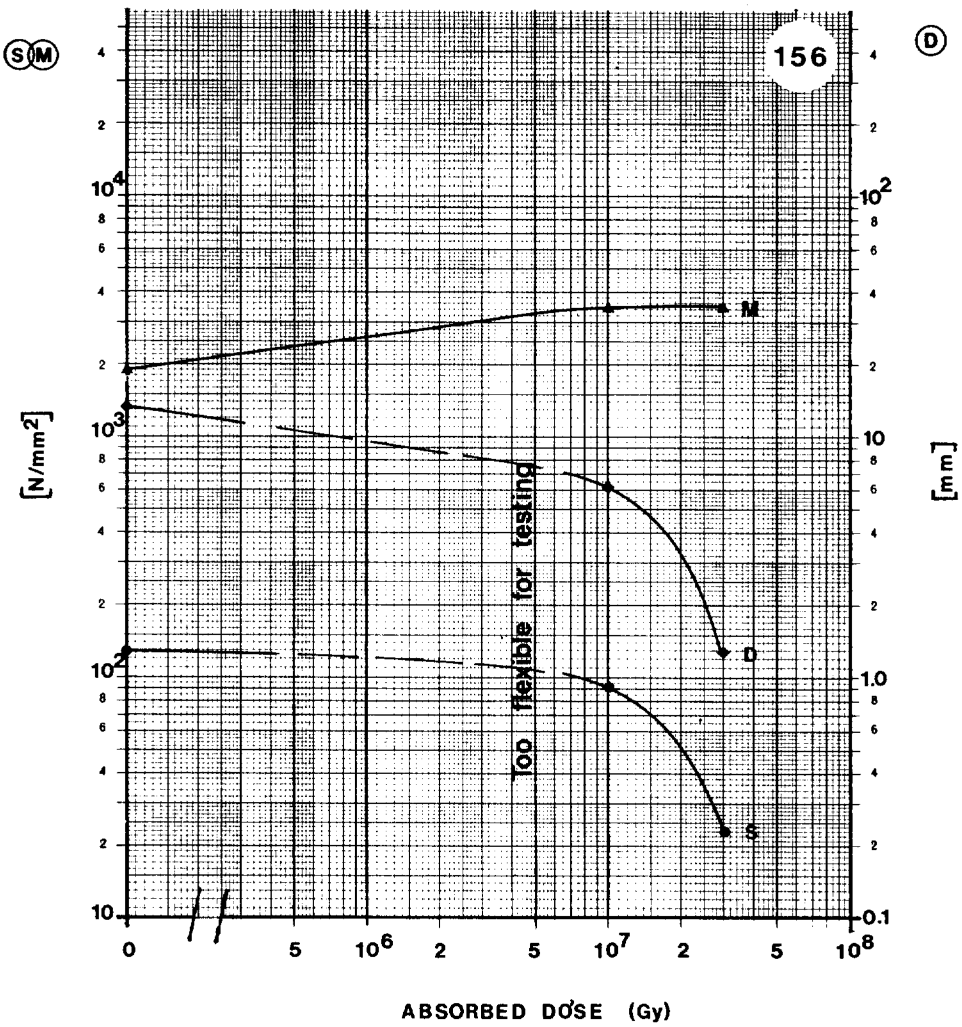


CURVE	PROPERTY	INITIAL VALUE	
S	Ultimate flexural strength	117.7	N/mm²
D	Deflexion at break	3.2	mm
M	Modulus of elasticity	8.7 × 10³	N/mm²

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

SUPPLIER: DR. BECK

Remarks:

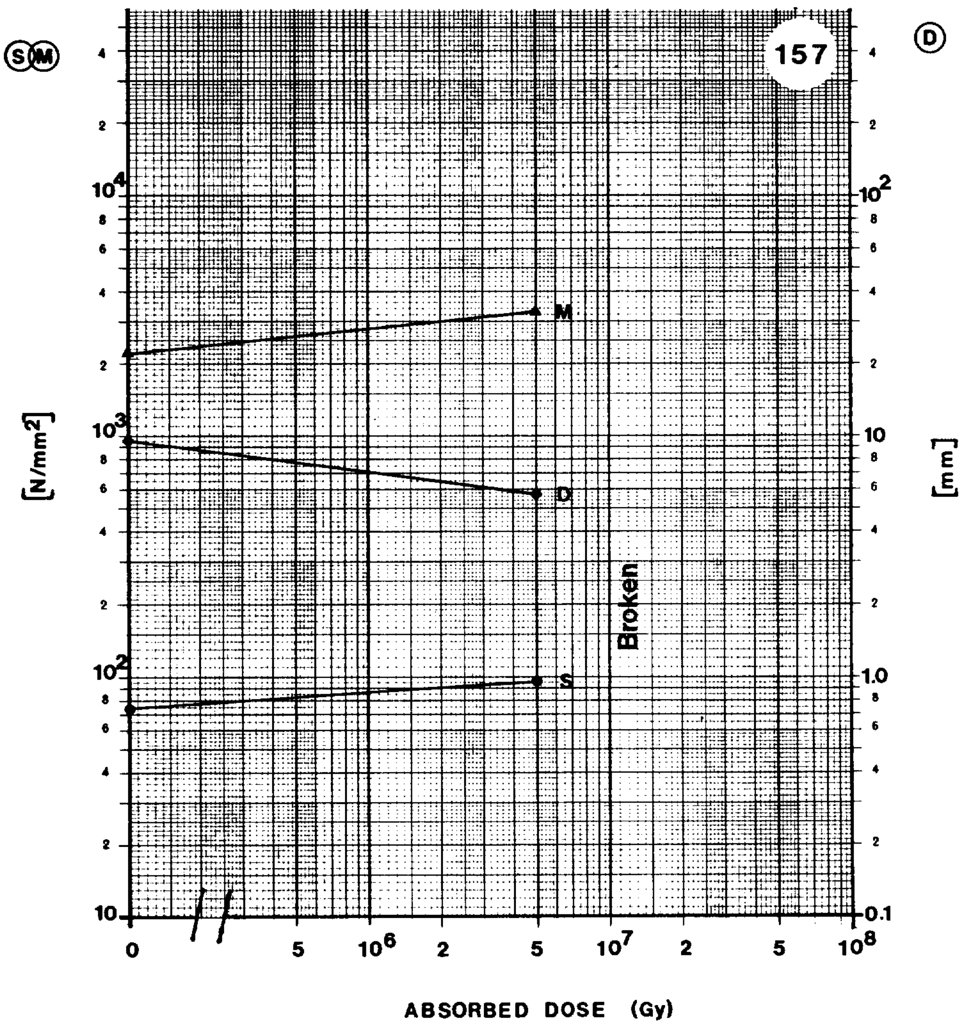


CURVE	PROPERTY	INITIAL VALUE	
S	Ultimate flexural strength	127.5	N/mm^2
D	Deflexion at break	13.4	mm
M	Modulus of elasticity	1.9×10^3	N/mm^2

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

SUPPLIER: DR. BECK

Remarks:

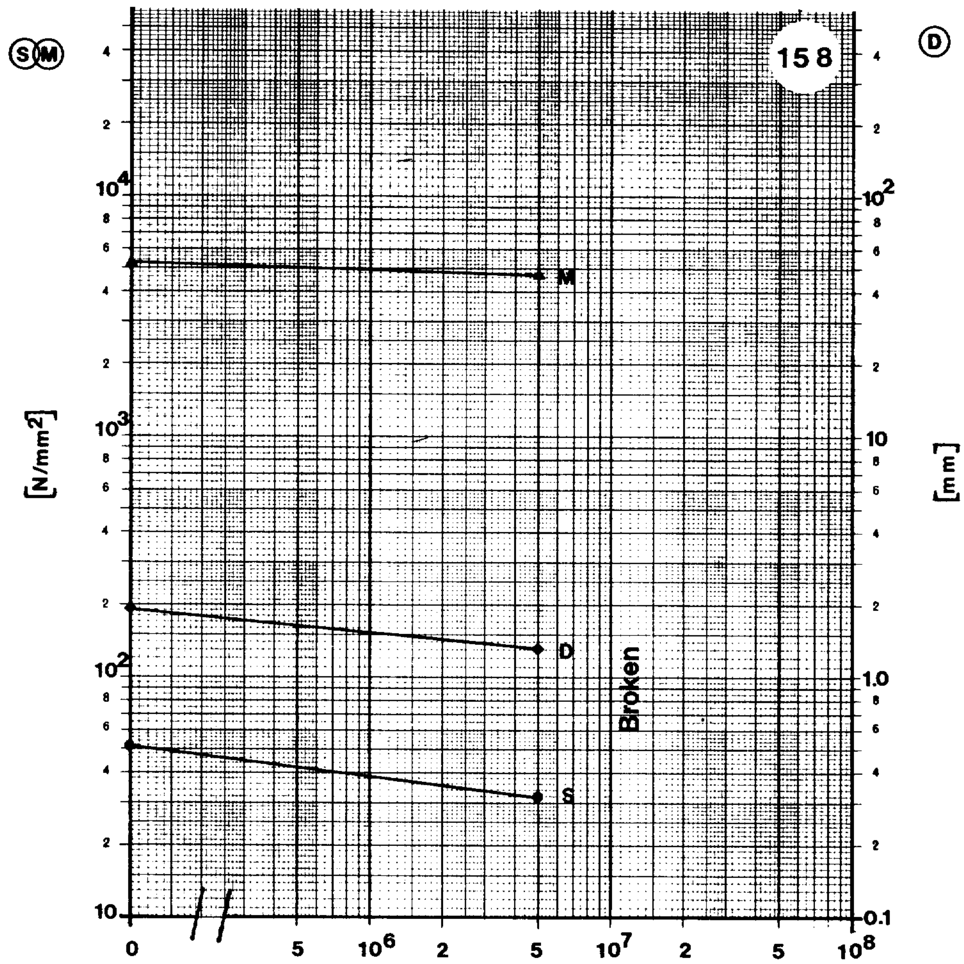


CURVE	PROPERTY	INITIAL VALUE	
S	Ultimate flexural strength	75.5	N/mm²
D	Deflexion at break	9.4	mm
M	Modulus of elasticity	2.2 × 10³	N/mm²

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

SUPPLIER: DR. BECK

Remarks:



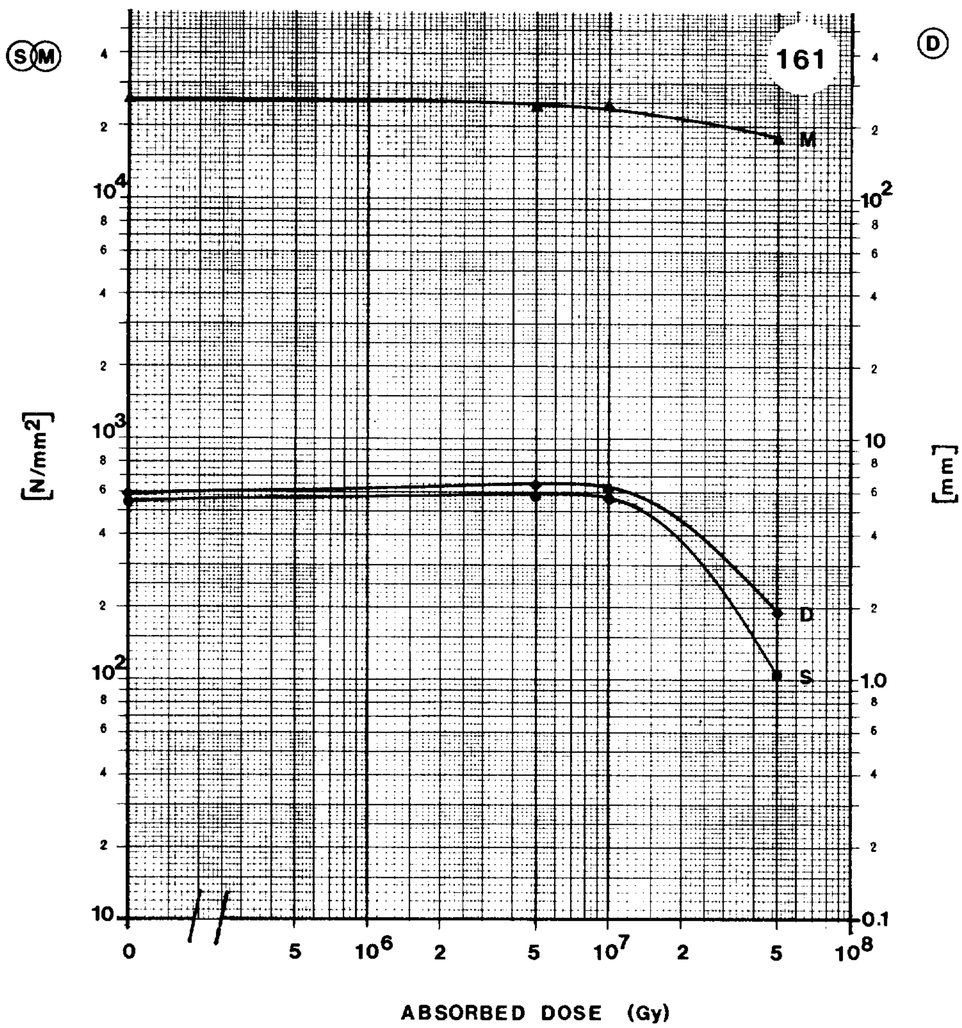
ABSORBED DOSE (Gy)

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:

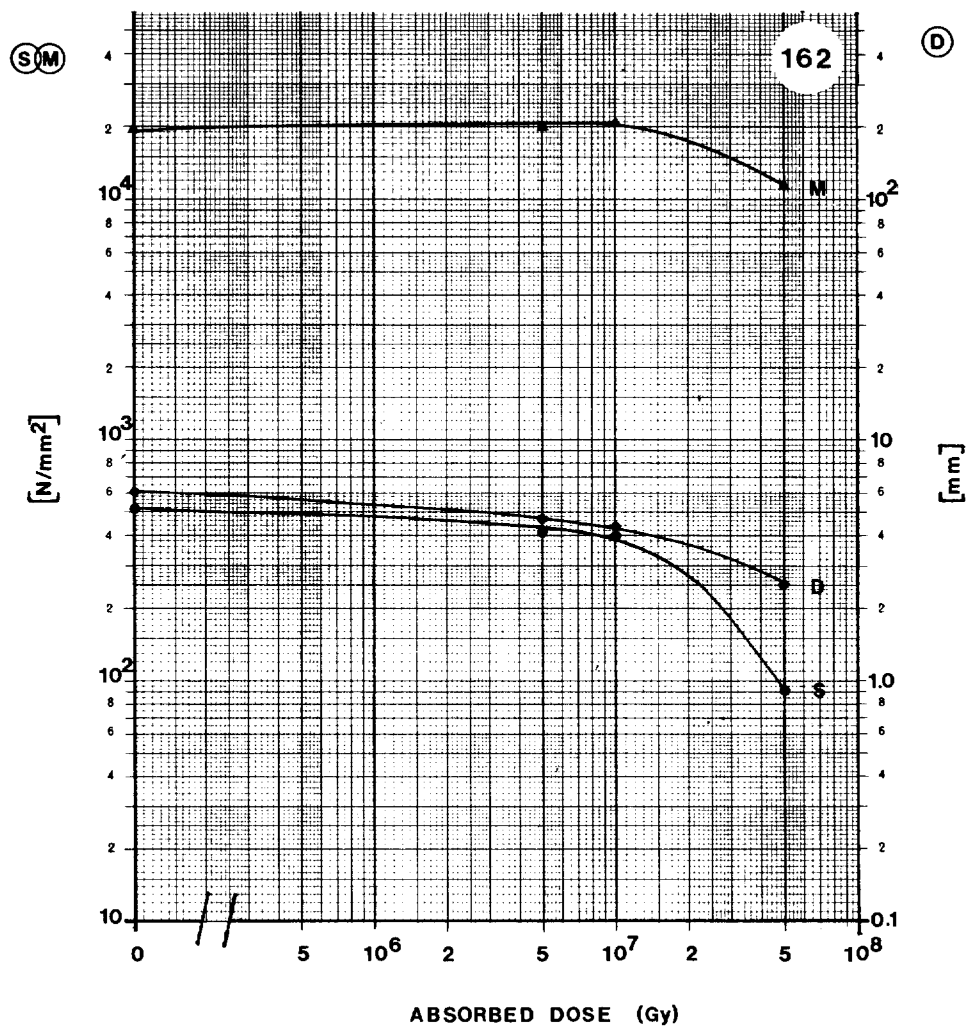


CURVE	PROPERTY	INITIAL VALUE	
S	Ultimate flexural strength	546.4	N/mm^2
D	Deflexion at break	5.8	mm
M	Modulus of elasticity	2.5×10^4	N/mm^2

MATERIAL: BIRAKRIT - EPOXY FIBRE-GLASS LAMINATE TYPE 2372.2

SUPPLIER: UOP

Remarks:

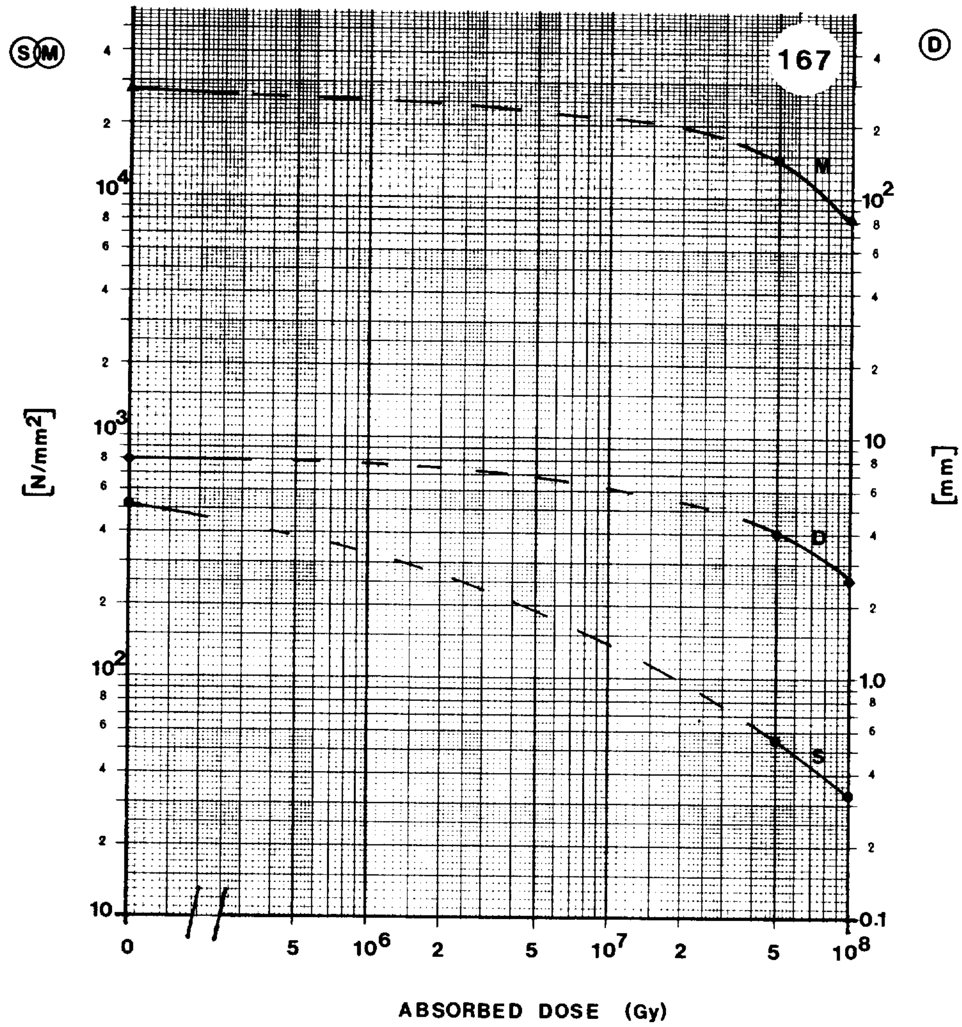


CURVE	PROPERTY	INITIAL VALUE	
S	Ultimate flexural strength	508.2	N/mm^2
D	Deflexion at break	6.0	mm
M	Modulus of elasticity	1.9×10^4	N/mm^2

MATERIAL: VETRONIT EPG 10

SUPPLIER: ISOLA

Remarks:

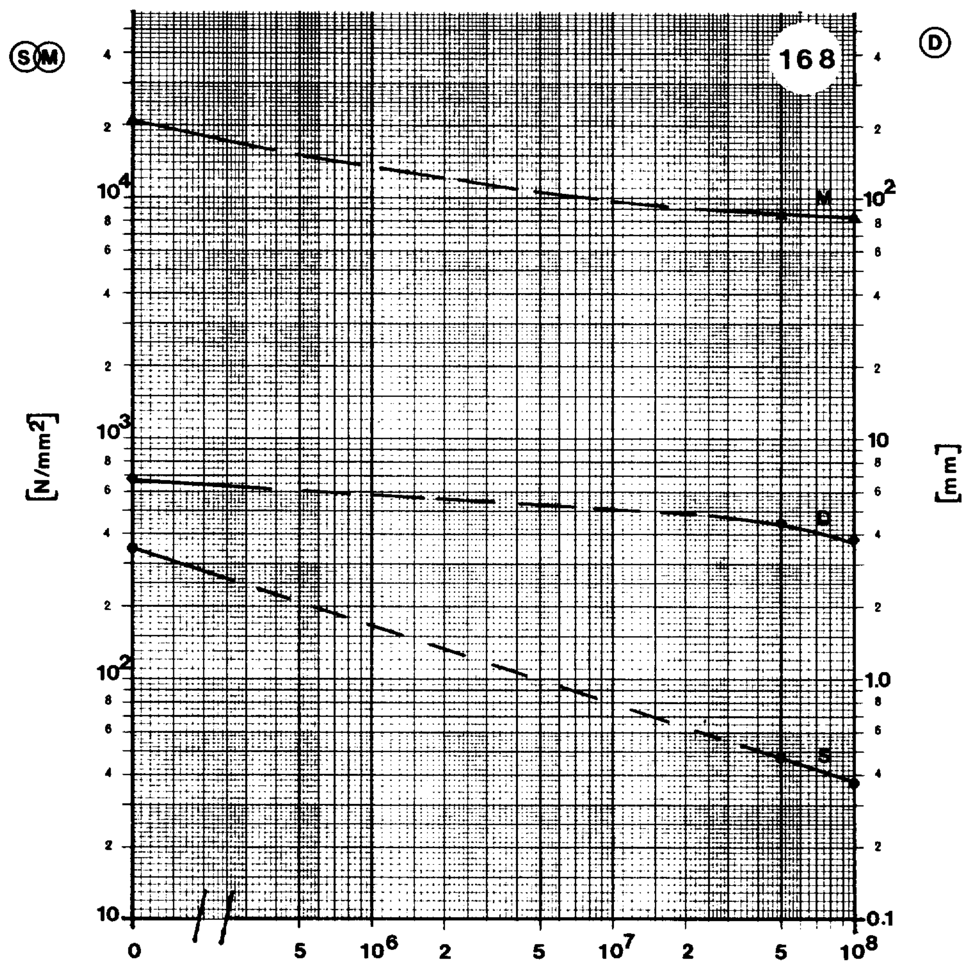


CURVE	PROPERTY	INITIAL VALUE	
S	Ultimate flexural strength	510.1	N/mm^2
D	Deflexion at break	7.9	mm
M	Modulus of elasticity	2.8×10^4	N/mm^2

MATERIAL: VETRONIT EPG 11

SUPPLIER: ISOLA

Remarks:



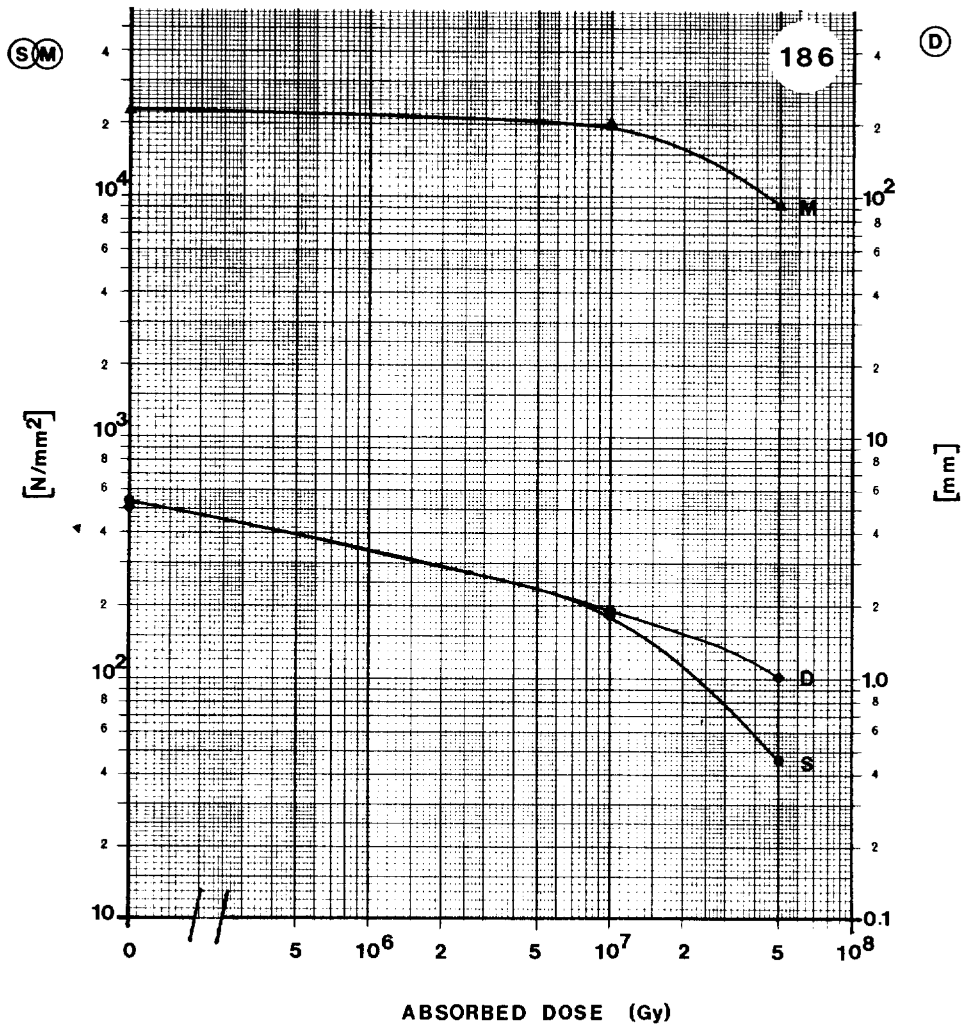
ABSORBED DOSE (Gy)

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

MATERIAL: Epoxy, type EGS 102

SUPPLIER: FERROZELL

Remarks:

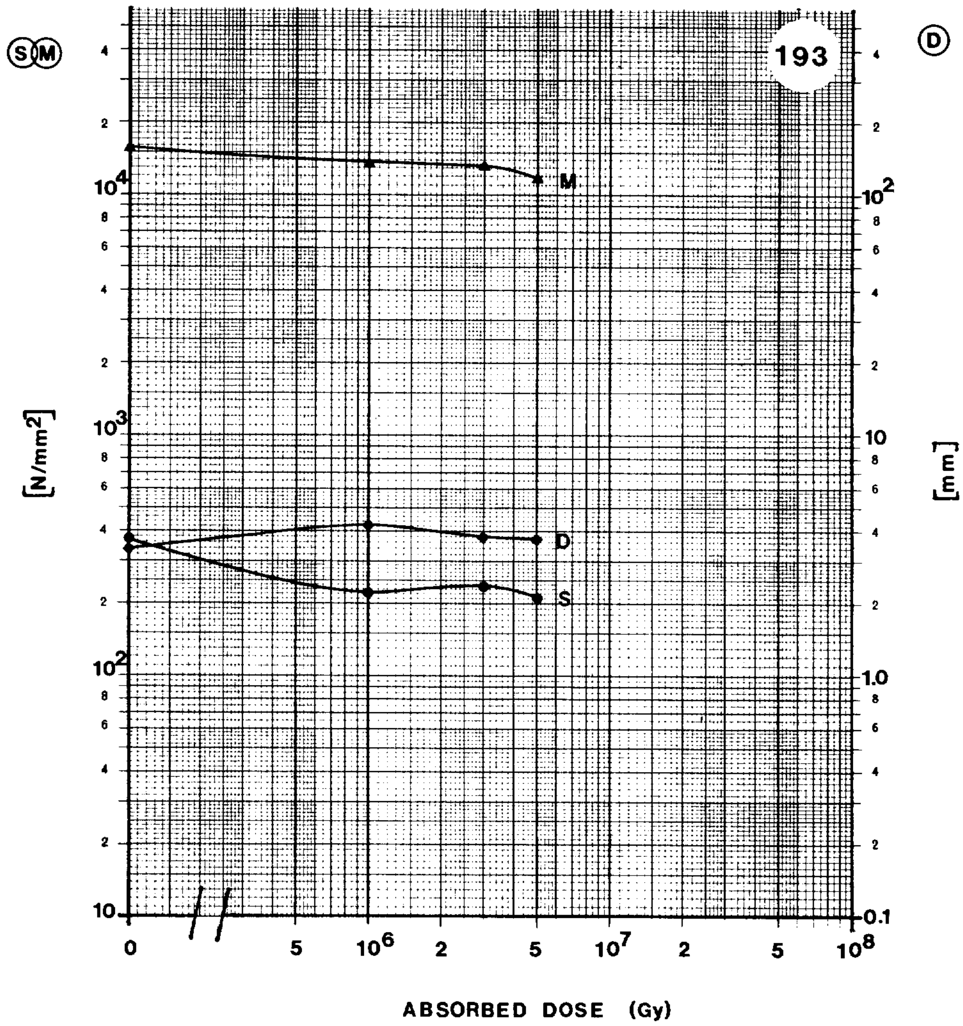


CURVE	PROPERTY	INITIAL VALUE	
S	Ultimate flexural strength	538.6	N/mm^2
D	Deflexion at break	5.1	mm
M	Modulus of elasticity	2.2×10^4	N/mm^2

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

SUPPLIER: ISOVOLTA

Remarks:

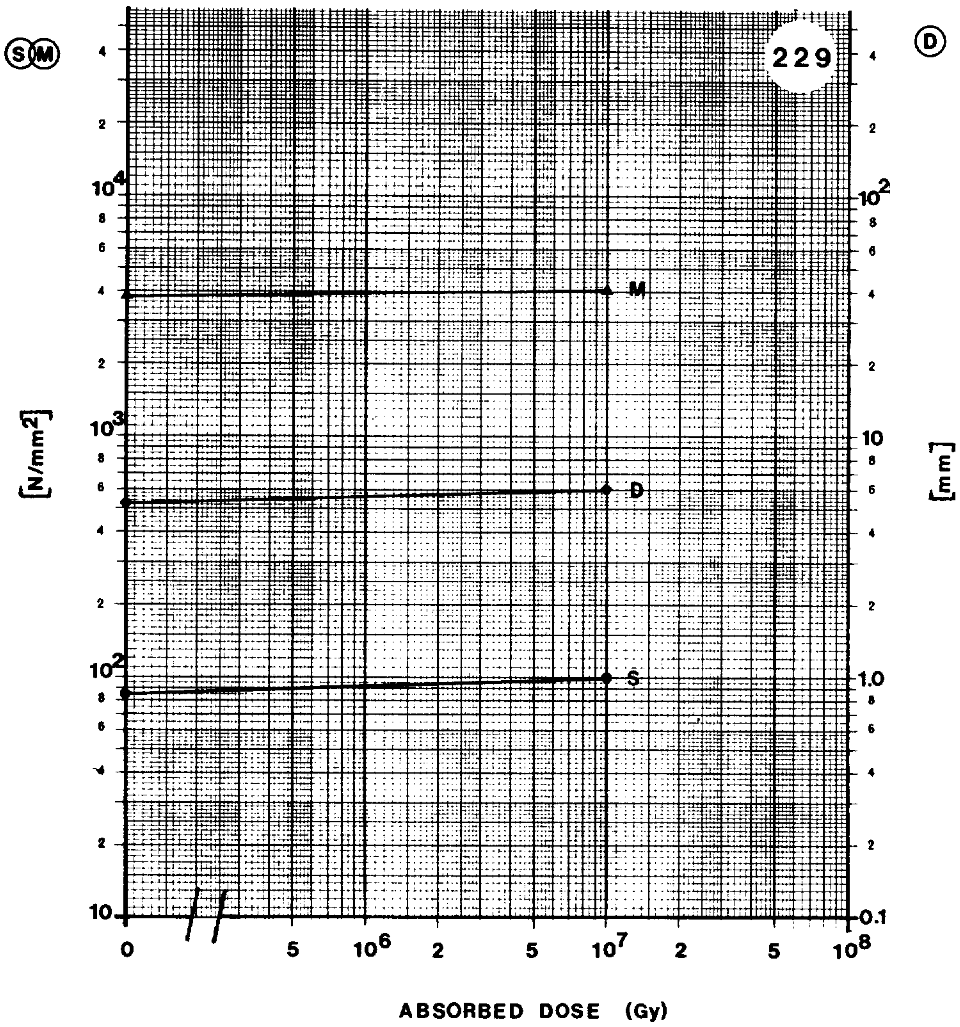


CURVE	PROPERTY	INITIAL VALUE	
S	Ultimate flexural strength	364.9	N/mm^2
D	Deflexion at break	3.4	mm
M	Modulus of elasticity	1.5×10^4	N/mm^2

MATERIAL: DOBECKOT 502 + HARDENER 710

SUPPLIER: PLESSEY

Remarks: USED FOR SPS QUADRUPOLE COILS

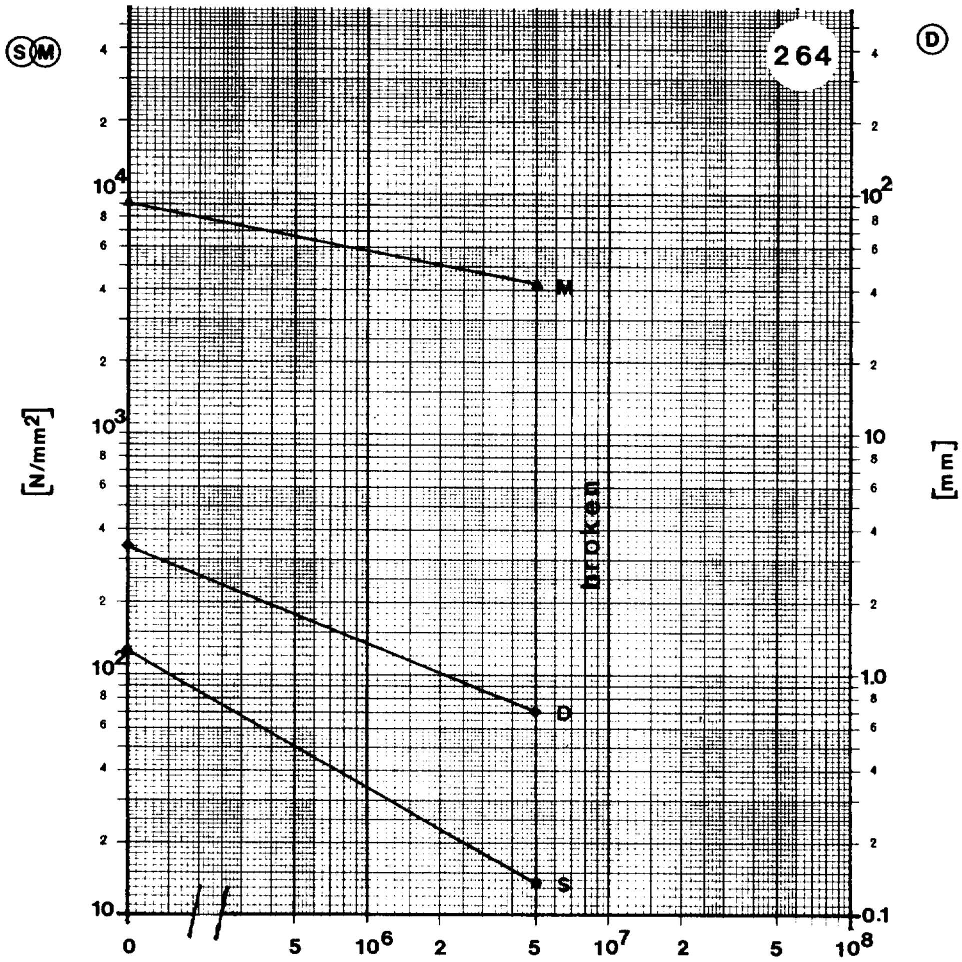


CURVE	PROPERTY	INITIAL VALUE	
S	Ultimate flexural strength	84.4	N/mm^2
D	Deflexion at break	5.3	mm
M	Modulus of elasticity	3.8×10^3	N/mm^2

MATERIAL: Epoxy 91-1892(100) + Curing Agent 91-1893(150) + DY 062(2.5)

SUPPLIER: LARS FOSS KEMI

Remarks:



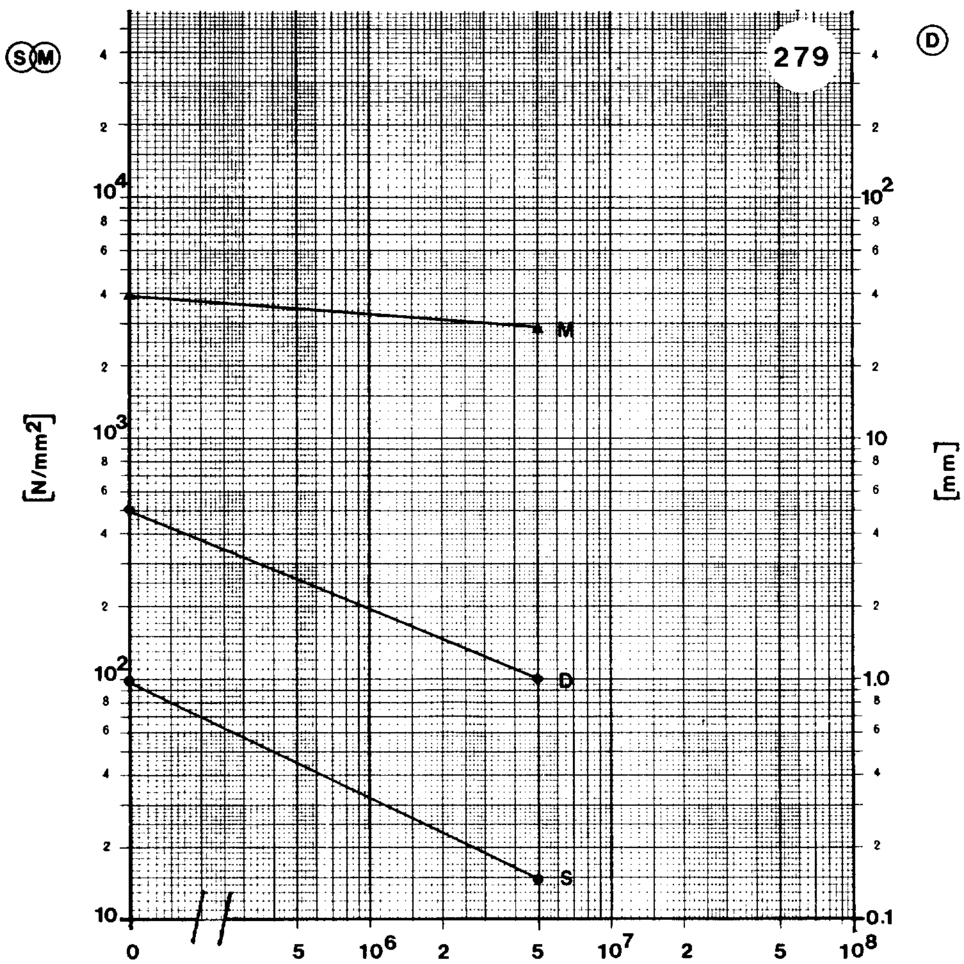
CURVE	PROPERTY	INITIAL VALUE	
S	Ultimate flexural strength	125.6	N/mm^2
D	Deflexion at break	3.4	mm
M	Modulus of elasticity	9.1×10^3	N/mm^2

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:

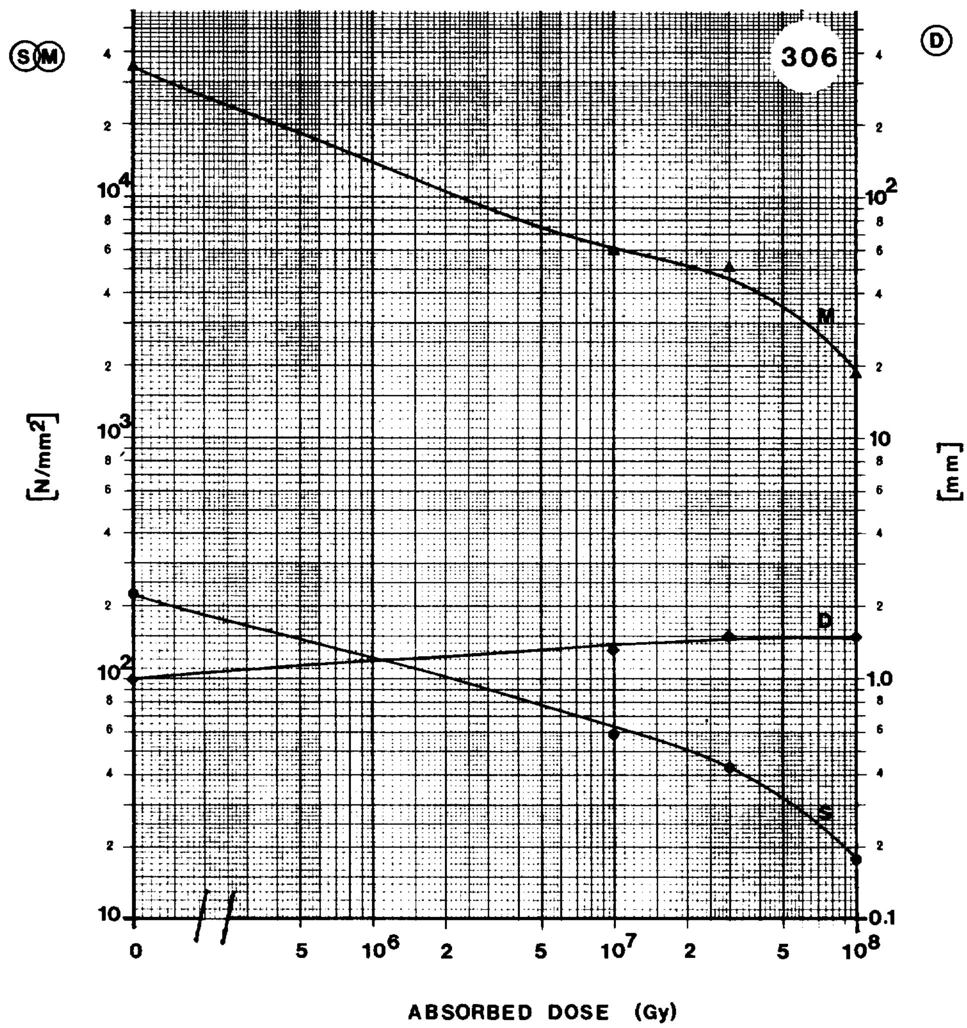


CURVE	PROPERTY	INITIAL VALUE	
S	Ultimate flexural strength	99.1	N/mm^2
D	Deflexion at break	5.0	mm
M	Modulus of elasticity	3.9×10^3	N/mm^2

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

SUPPLIER: ISOLA

Remarks:

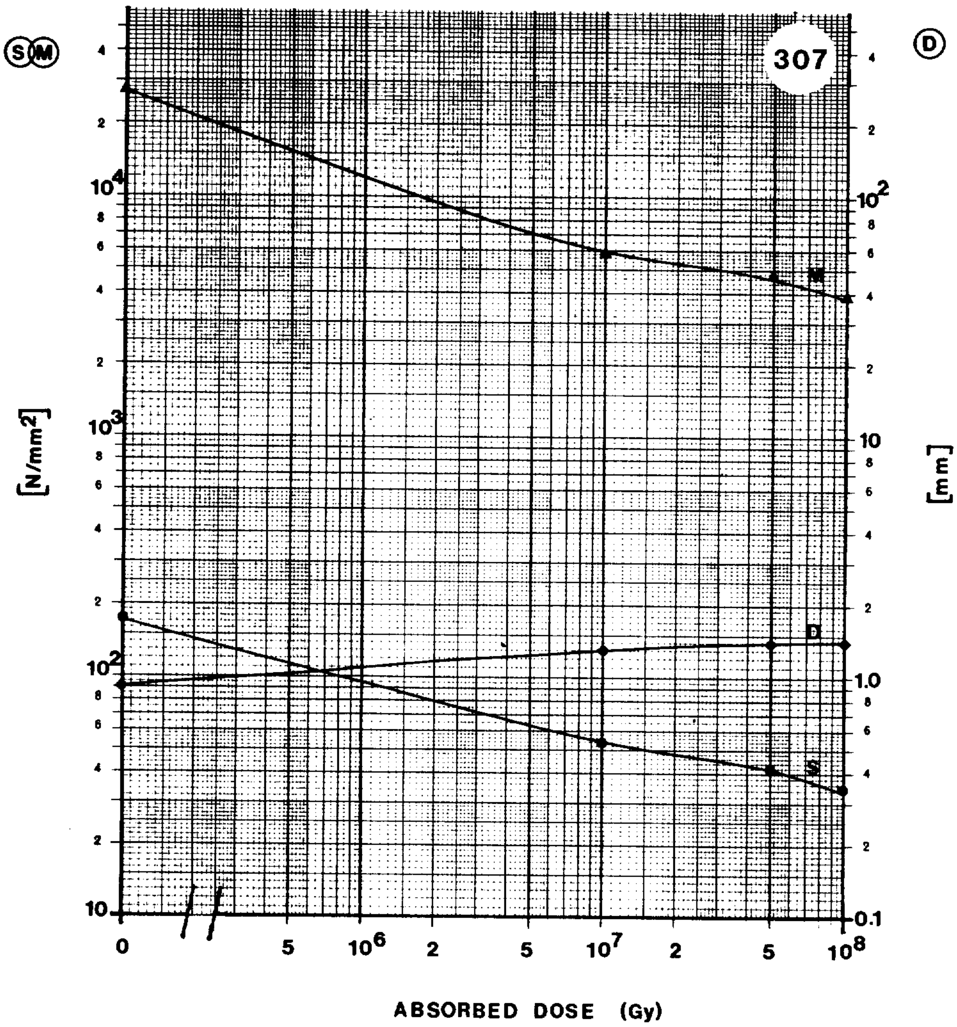


CURVE	PROPERTY	INITIAL VALUE	
S	Ultimate flexural strength	224.6	N/mm^2
D	Deflexion at break	1.0	mm
M	Modulus of elasticity	3.4×10^4	N/mm^2

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

SUPPLIER: ISOLA

Remarks:

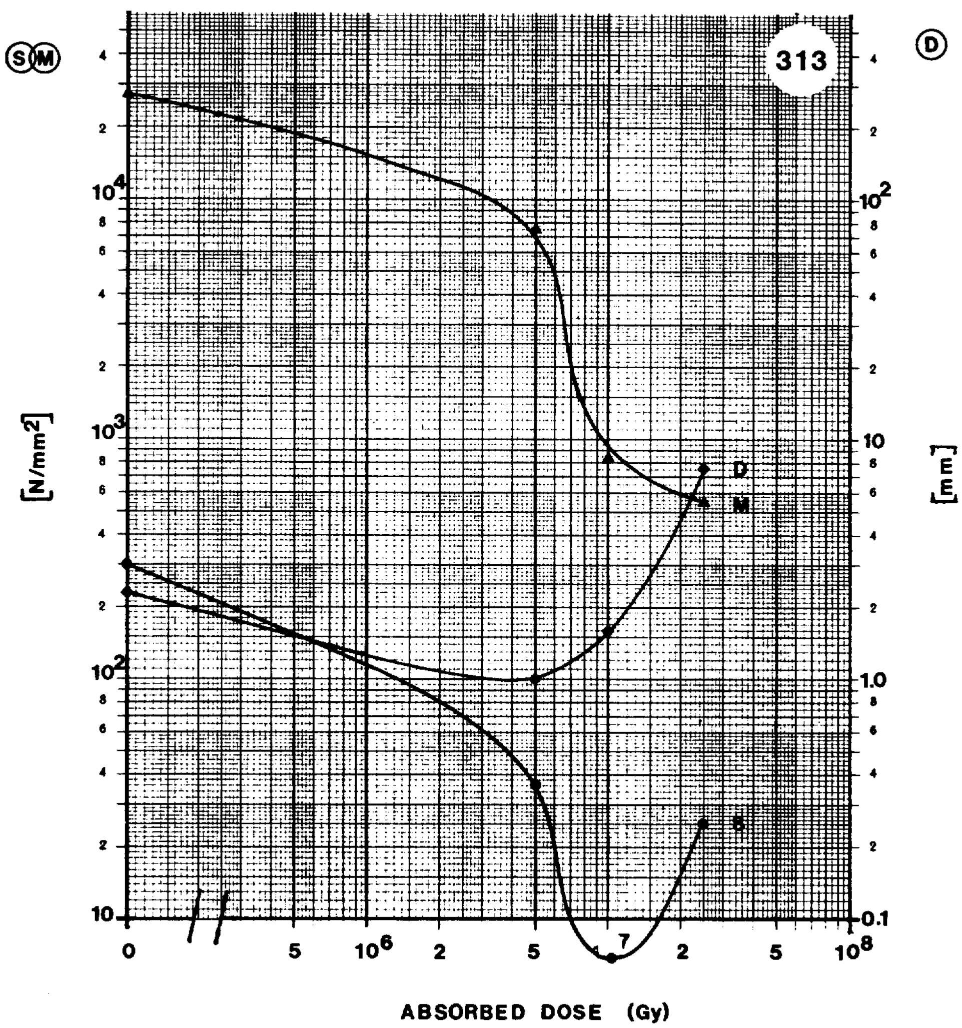


CURVE	PROPERTY	INITIAL VALUE	
S	Ultimate flexural strength	176.6	N/mm^2
D	Deflexion at break	0.9	mm
M	Modulus of elasticity	2.8×10^4	N/mm^2

MATERIAL: EPOXY RESIN + MICA + GLASS TAPE

SUPPLIER: CIBA-GEIGY

Remarks:

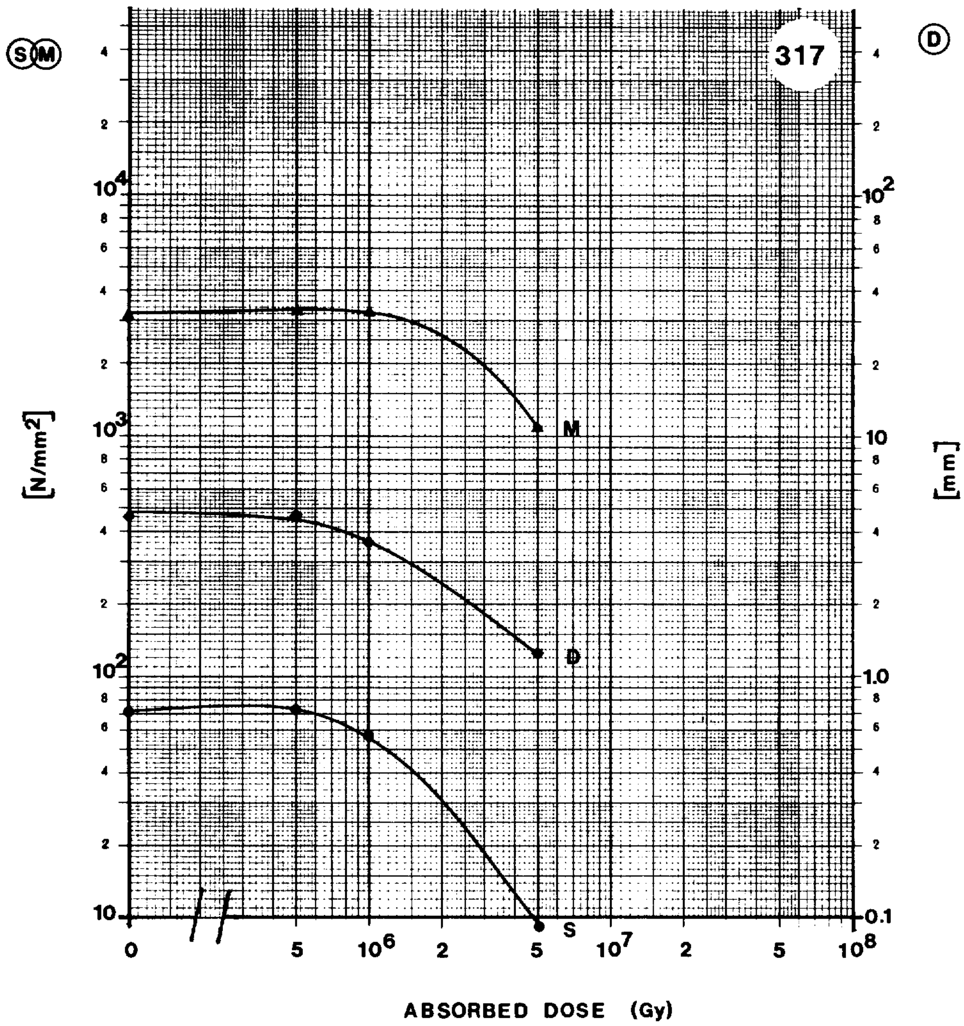


CURVE	PROPERTY	INITIAL VALUE	
S	Ultimate flexural strength	299.2	N/mm^2
D	Deflexion at break	2.3	mm
M	Modulus of elasticity	2.7×10^4	N/mm^2

MATERIAL: Epoxy urethane resin (Experimental product 1)

SUPPLIER: LRCE

Remarks: Used for anchorage

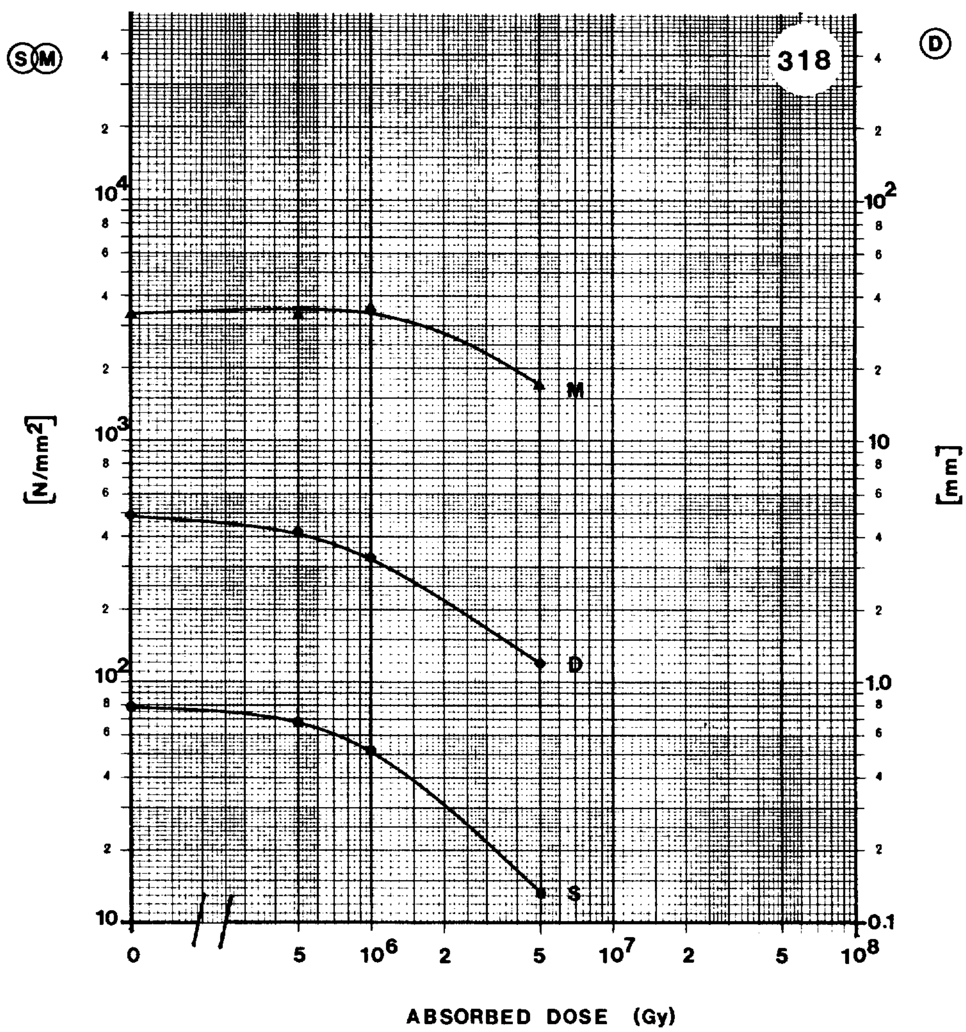


CURVE	PROPERTY	INITIAL VALUE	
S	Ultimate flexural strength	70.6	N/mm^2
D	Deflexion at break	4.6	mm
M	Modulus of elasticity	3.1×10^3	N/mm^2

MATERIAL: EPOXY URETHANE RESIN (EXPERIMENTAL PRODUCT 2)

SUPPLIER: LRCE

Remarks: USED FOR ANCHORAGE

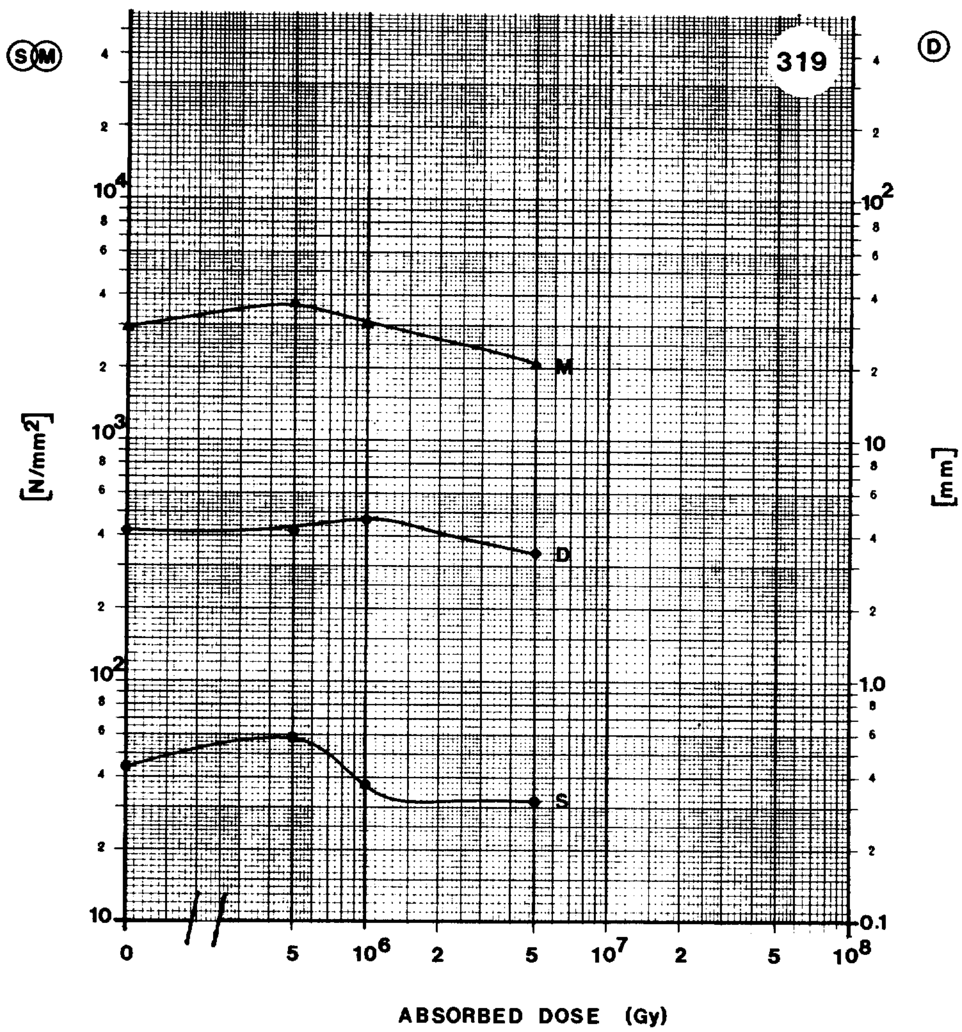


CURVE	PROPERTY	INITIAL VALUE	
S	Ultimate flexural strength	78.3	N/mm^2
D	Deflexion at break	4.8	mm
M	Modulus of elasticity	3.3×10^3	N/mm^2

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

ISOVAL

see EPOXY RESINS

KEREMID

Trade name of Rhône-Poulenc

see POLYIMIDE

KINEL

Trade name of Rhône-Poulenc

Product on a polyimide basis filled with glass fibre or graphite

see POLYIMIDE

MAKROLON

Trade name of Bayer

see POLYCARBONATE

NOVOLAC

EPOXY-NOVOLAC RESINS

see also EPOXY RESINS

Base resins

CIBA-GEIGY	DOW	SHELL
EPN 1138	DEN 438	EPIKOTE (EP) 154
EPN 1139	DEN 431	

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)
89	EPN 1138(50) + MY 745(50) + + CY 221(20) + HY 905(120) + + DY 063(0.3)	0	131.5 ± 24.5	9.3 ± 3.2	$3.55 \pm 0.15 \times 10^3$
	24 h 120 °C	6×10^6	92.2 ± 6.9	4.6 ± 0.3	$3.75 \pm 0.13 \times 10^3$
	Type ISR	1×10^7	68.7 ± 22.6	3.5 ± 1.2	$3.56 \pm 0.07 \times 10^3$
		2×10^7	62.8 ± 13.7	3.0 ± 0.7	$3.88 \pm 0.08 \times 10^3$
	ALSTHOM	6×10^7	6.9 ± 0.3	0.7 ± 0.1	$1.90 \pm 0.24 \times 10^3$
90	EPN 1139(100) + HY 906(87.5) X157/2505(0.5)	0	130.5 ± 23.5	6.7 ± 2.4	$3.98 \pm 0.05 \times 10^3$
	24 h 120 °C	5×10^6	103.0 ± 13.7	5.5 ± 0.9	$3.63 \pm 0.15 \times 10^3$
		1×10^7	107.9 ± 6.9	6.0 ± 0.5	$3.55 \pm 0.13 \times 10^3$
		2×10^7	59.8 ± 26.5	2.9 ± 1.5	$3.73 \pm 0.18 \times 10^3$
	ALSTHOM	5×10^7	28.2 ± 6.3	1.2 ± 0.2	$4.05 \pm 0.17 \times 10^3$
92	DEN 438 + MNA	0	83.4 ± 19.6	4.7 ± 1.2	$3.17 \pm 0.11 \times 10^3$
		5×10^6	70.6 ± 13.7	3.7 ± 0.7	$3.36 \pm 0.15 \times 10^3$
		1×10^7	83.4 ± 19.6	4.0 ± 1.6	$4.00 \pm 0.89 \times 10^3$
		2×10^7	61.8 ± 12.8	3.0 ± 0.6	$3.73 \pm 0.06 \times 10^3$
	DOW	5×10^7	18.6 ± 11.8	1.1 ± 0.4	$3.19 \pm 0.90 \times 10^3$
93	DEN 431 + MDA	0	92.2 ± 6.9	6.4 ± 0.8	$2.87 \pm 0.10 \times 10^3$
		5×10^6	118.7 ± 6.9	9.0 ± 1.8	$3.46 \pm 0.18 \times 10^3$
		1×10^7	129.5 ± 4.9	8.9 ± 2.0	$3.63 \pm 0.11 \times 10^3$
		2×10^7	127.5 ± 26.5	9.1 ± 3.7	$3.85 \pm 0.09 \times 10^3$
	DOW	5×10^7	40.2 ± 15.7	1.6 ± 0.7	$3.85 \pm 0.10 \times 10^3$
94	EPIKOTE 154 + MNA + glass tape	0	441.4 ± 18.6	5.5 ± 0.6	$1.85 \pm 0.10 \times 10^4$
		5×10^6	394.4 ± 12.7	5.2 ± 0.5	$1.77 \pm 0.06 \times 10^4$
		1×10^7	270.8 ± 44.2	3.6 ± 0.9	$1.82 \pm 0.10 \times 10^4$
		2×10^7	308.0 ± 21.6	4.1 ± 0.3	$1.85 \pm 0.11 \times 10^4$
	MICAFIL	5×10^7	234.5 ± 3.9	3.0 ± 0.2	$1.95 \pm 0.16 \times 10^4$
95	EPIKOTE 154 + DDS + glass fabric	0	430.6 ± 11.8	4.5 ± 0.1	$2.53 \pm 0.13 \times 10^4$
		5×10^6	387.5 ± 15.7	5.0 ± 0.6	$2.47 \pm 0.04 \times 10^4$
		1×10^7	317.8 ± 12.8	4.3 ± 0.8	$2.27 \pm 0.09 \times 10^4$
		2×10^7	264.8 ± 6.9	4.1 ± 0.2	$2.05 \pm 0.06 \times 10^4$
	MICAFIL	5×10^7	165.8 ± 4.9	3.6 ± 0.4	$1.49 \pm 0.11 \times 10^4$

No.	Material and Supplier	Dose (Gy)	Ultimate flex. strength S (N/mm²)	Deflexion at break D (mm)	Modulus of elasticity M (N/mm²)
96	EPIKOTE 154 + DDM + glass fabric	0	351.2 ± 14.7	3.6 ± 0.4	$1.97 \pm 0.16 \times 10^4$
		5×10^6	361.0 ± 10.8	3.7 ± 0.2	$2.16 \pm 0.06 \times 10^4$
		1×10^7	329.6 ± 12.7	3.7 ± 0.1	$2.06 \pm 0.19 \times 10^4$
		2×10^7	310.9 ± 3.9	3.6 ± 0.9	$1.98 \pm 0.12 \times 10^4$
	MICAFIL	5×10^7	207.0 ± 5.9		$1.63 \pm 0.11 \times 10^4$
116	Epoxy Novolac 438 + HY 906 + + glass fabric	0	458.1 ± 74.6	4.1 ± 0.2	$2.41 \pm 0.23 \times 10^4$
		5×10^6	457.1 ± 60.0	4.0 ± 0.1	$2.46 \pm 0.17 \times 10^4$
		1×10^7	446.4 ± 54.0	4.1 ± 0.3	$2.53 \pm 0.27 \times 10^4$
		2×10^7	345.0 ± 33.0	4.2 ± 0.3	$2.27 \pm 0.17 \times 10^4$
	ISOLA	5×10^7	187.4 ± 50.0	2.5 ± 0.4	$1.63 \pm 0.40 \times 10^4$
117 (a)	Epoxy Novolac 438 + MNA + + glass Samica ISOLA	0	316.9 ± 9.8	1.1 ± 0.1	$5.81 \pm 0.14 \times 10^4$
118 (a)	Epoxy Novolac 438 + BF_3MEA complex + glass Samica ISOLA	0	316.9 ± 9.8	1.1 ± 0.1	$5.67 \pm 0.14 \times 10^4$
121	Epoxy Novolac 431 + MNA + + accelerator	0	464.0 ± 74.6	7.2 ± 0.5	$2.44 \pm 0.30 \times 10^4$
		5×10^6	434.6 ± 66.7	7.3 ± 0.1	$2.45 \pm 0.15 \times 10^4$
		1×10^7	365.9 ± 60.8	6.4 ± 0.5	$2.35 \pm 0.15 \times 10^4$
		2×10^7	260.0 ± 27.5	6.1 ± 1.2	$1.77 \pm 0.27 \times 10^4$
	ISOLA	6×10^7	180.5 ± 31.4	5.6 ± 0.8	$1.52 \pm 0.18 \times 10^4$
122	Epoxy Novolac 431 + BF_3MEA complex	0	363.9 ± 15.7	6.1 ± 0.3	$2.35 \pm 0.14 \times 10^4$
		5×10^6	383.6 ± 5.9	6.7 ± 0.4	$2.51 \pm 0.74 \times 10^4$
		1×10^7	373.8 ± 36.3	6.8 ± 0.2	$2.40 \pm 0.23 \times 10^4$
		2×10^7	145.2 ± 24.5	4.2 ± 0.6	$1.82 \pm 0.69 \times 10^4$
	ISOLA	6×10^7	121.6 ± 26.5	3.1 ± 0.5	$6.43 \pm 2.34 \times 10^3$
123	EPN 1138(50) + MY 745(50) + + HY 905(103) + XB 2687(0.25)	0	118.7 ± 21.6	8.4 ± 3.1	$3.30 \pm 0.05 \times 10^3$
	24 h 120 °C	5×10^6	114.8 ± 21.6	9.8 ± 3.4	$3.34 \pm 0.12 \times 10^3$
		1×10^7	78.5 ± 8.8	4.3 ± 0.4	$3.45 \pm 0.13 \times 10^3$
	ALSTHOM	2×10^7	53.0 ± 6.9	2.8 ± 0.3	$3.51 \pm 0.06 \times 10^3$

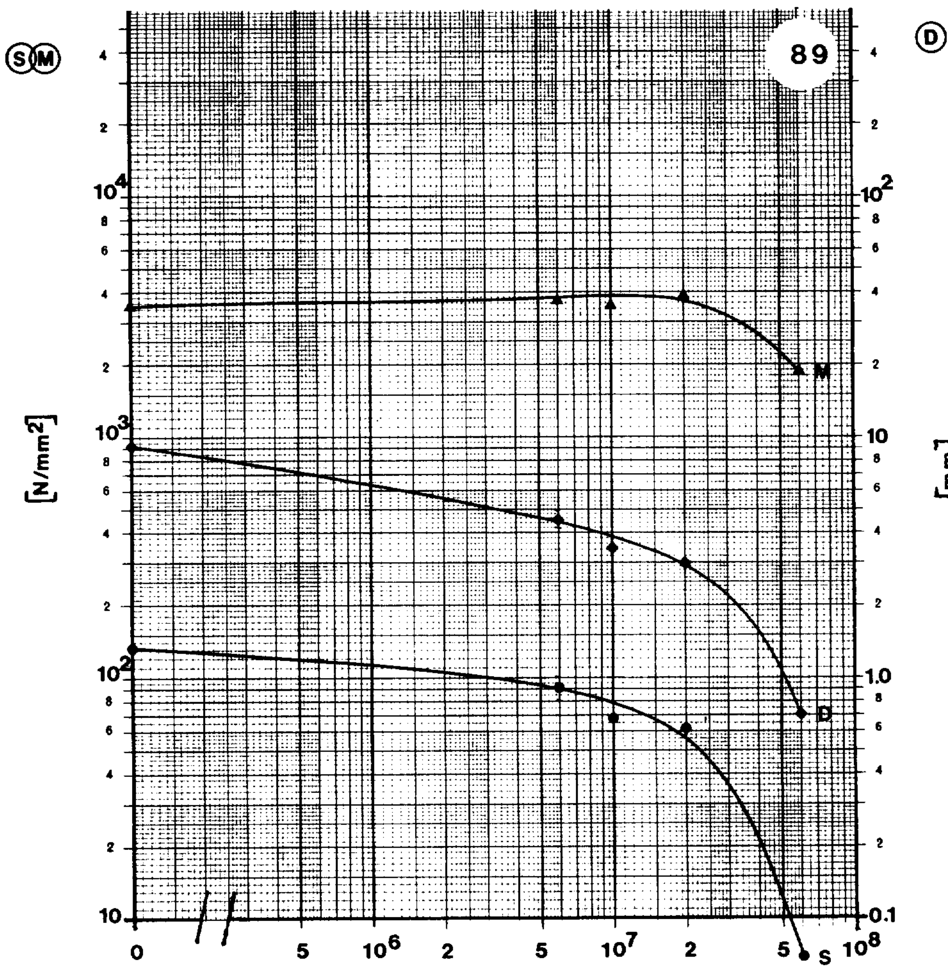
(a) No graph.

No.	Material and Supplier	Dose (Gy)	Ultimate flex. strength S (N/mm²)	Deflexion at break D (mm)	Modulus of elasticity M (N/mm²)
124	EPN 1139(100) + HY 905(97.5) + XB 2687(0.2)	0	124.6 ± 38.3	8.3 ± 3.7	$3.49 \pm 0.27 \times 10^3$
	24 h 120 °C	6×10^6	127.5 ± 36.3	8.3 ± 3.2	$3.67 \pm 0.06 \times 10^3$
		1×10^7	78.5 ± 2.9	4.0 ± 0.2	$3.58 \pm 0.14 \times 10^3$
		2.5×10^7	60.8 ± 7.8	3.2 ± 0.4	$3.58 \pm 0.14 \times 10^3$
	ALSTHOM	5.5×10^7	9.8 ± 2.9	0.6 ± 0.2	$3.27 \pm 0.35 \times 10^3$
154	EP 154(50) + EP 828(50) + + DX 126(60) + DX 127(22) + + accelerator	0	145.2 ± 18.6	11.5 ± 2.1	$3.04 \pm 0.04 \times 10^3$
		5×10^6	113.8 ± 2.0	10.2 ± 2.2	$3.27 \pm 0.06 \times 10^3$
	4 h 80 °C + 4 h 150 °C	1×10^7	81.4 ± 26.5	5.0 ± 2.1	$3.46 \pm 0.01 \times 10^3$
	SHELL	3×10^7	45.1 ± 14.7	2.6 ± 0.9	$3.33 \pm 0.05 \times 10^3$
155	EP 154(50) + EP 828(50) + + DX 126(60) + DX 127(22) + Silica(300) + accelerator	0	86.3 ± 6.9	1.7 ± 0.1	$9.63 \pm 0.00 \times 10^3$
		5×10^6	50.0 ± 2.0	0.9 ± 0.0	$1.05 \pm 0.04 \times 10^4$
	4 h 80 °C + 4 h 150 °C	1×10^7	41.2 ± 1.0	0.8 ± 0.0	$1.03 \pm 0.03 \times 10^4$
	SHELL	3×10^7	37.3 ± 2.0	0.8 ± 0.0	$9.12 \pm 0.48 \times 10^3$
203	EPN 1138(100) + HY 906(95) + + DY 062(0.5)	0	130.5 ± 19.6	8.7 ± 2.2	$3.52 \pm 0.05 \times 10^3$
	2.5 h 80 °C + 12 h 160 °C	5×10^6	115.8 ± 19.6	7.1 ± 1.8	$3.88 \pm 0.17 \times 10^3$
	CIBA-GEIGY	1×10^7	122.6 ± 7.8	7.2 ± 0.7	$3.95 \pm 0.04 \times 10^3$
297	EPN 1138(50) + MY 745(50) + + CY 221(20) + HY 905(120) + + XB 2687(0.3)	0	124.2 ± 24.5	12.4 ± 3.7	$3.73 \pm 0.25 \times 10^3$
	24 h 120 °C	5×10^6	91.9 ± 8.8	6.4 ± 0.6	$3.80 \pm 0.13 \times 10^3$
		1×10^7	68.9 ± 11.8	4.5 ± 0.9	$4.01 \pm 0.09 \times 10^3$
		2.5×10^7	13.7 ± 0.3	1.2 ± 0.4	$3.26 \pm 0.04 \times 10^3$
	CIBA-GEIGY	5×10^7	2.1 ± 0.0	0.7 ± 0.0	$5.27 \pm 0.00 \times 10^2$
810	VETRESIT 14; EPIKOTE 827 + + DDS + glass tissue	0	445.4 ± 3.9	4.2 ± 0.1	$2.36 \pm 0.04 \times 10^4$
		1×10^7	371.8 ± 13.7	4.6 ± 0.3	$2.33 \pm 0.03 \times 10^4$
		3×10^7	134.4 ± 19.6	2.0 ± 0.3	$1.64 \pm 0.07 \times 10^4$
		6×10^7	43.2 ± 17.7	1.1 ± 0.2	$1.10 \pm 0.19 \times 10^4$
	MICAFIL	1×10^8	67.7 ± 6.9	1.8 ± 0.1	$1.05 \pm 0.10 \times 10^4$

MATERIAL: EPN 1138(50) + MY 745(50) + CY 221(20) + HY 905(120) + DY 063(0.3)

SUPPLIER: ALSTHOM

Remarks: PREPARED FOR ISR MAGNETS AND USED SINCE THEN

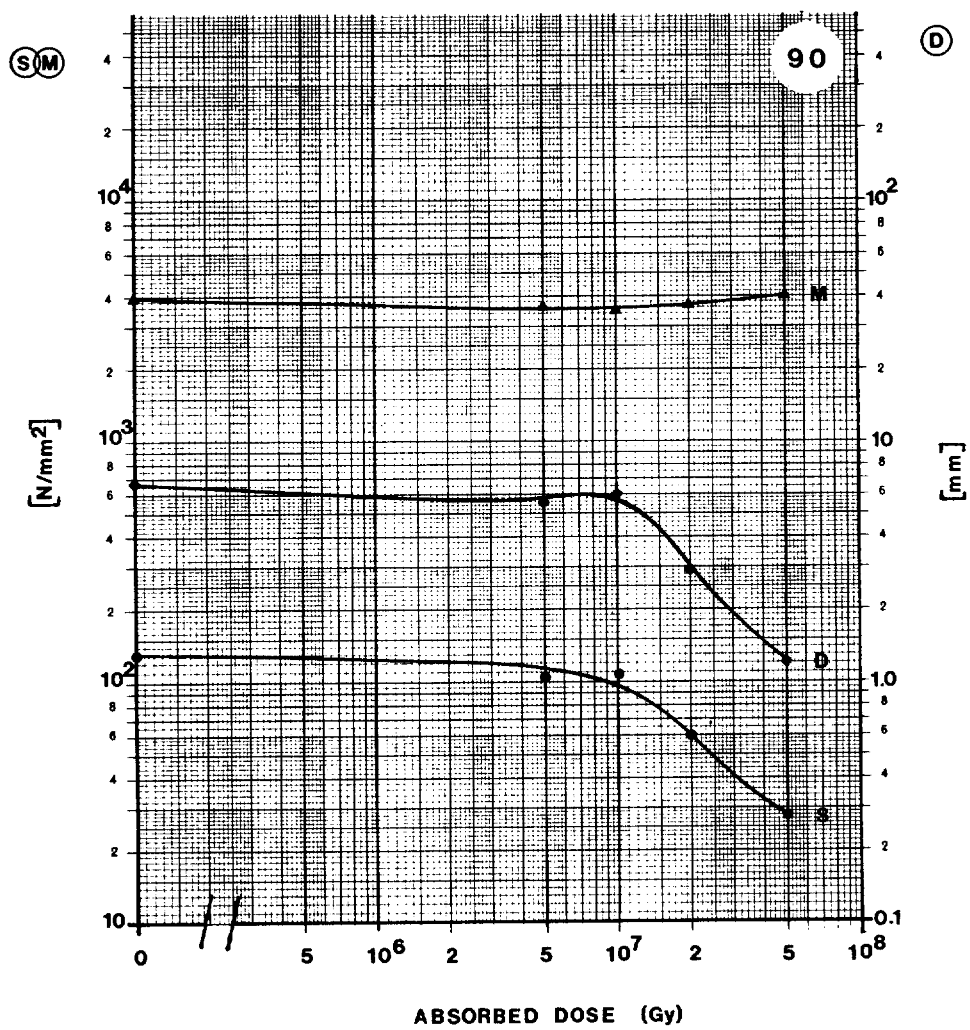


CURVE	PROPERTY	INITIAL VALUE	
S	Ultimate flexural strength	131.5	N/mm^2
D	Deflexion at break	9.3	mm
M	Modulus of elasticity	3.6×10^3	N/mm^2

MATERIAL: EPN 1139(100) + HY 906(87.5) + X157/2505(0.5)

SUPPLIER: ALSTHOM

Remarks:

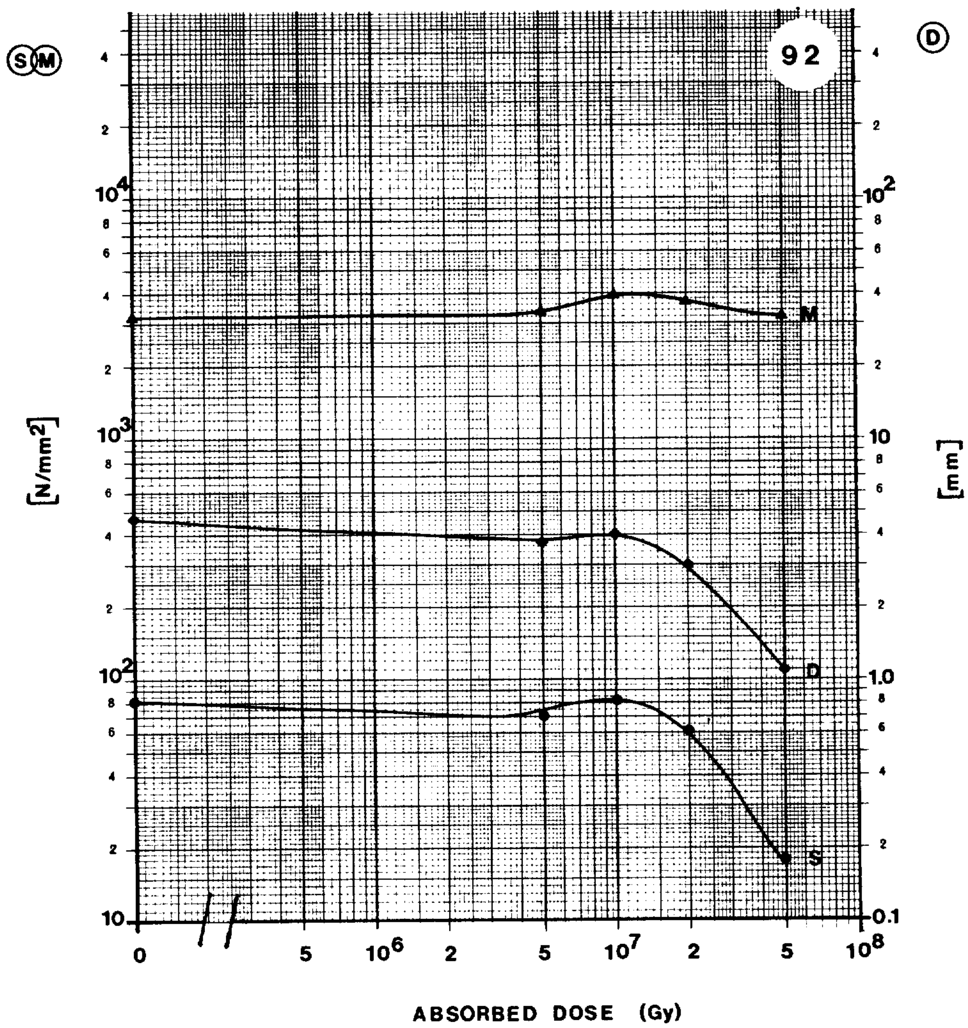


CURVE	PROPERTY	INITIAL VALUE	
S	Ultimate flexural strength	130.5	N/mm^2
D	Deflexion at break	6.7	mm
M	Modulus of elasticity	4.0×10^3	N/mm^2

MATERIAL: DEN 438 + MNA

SUPPLIER: DOW

Remarks:

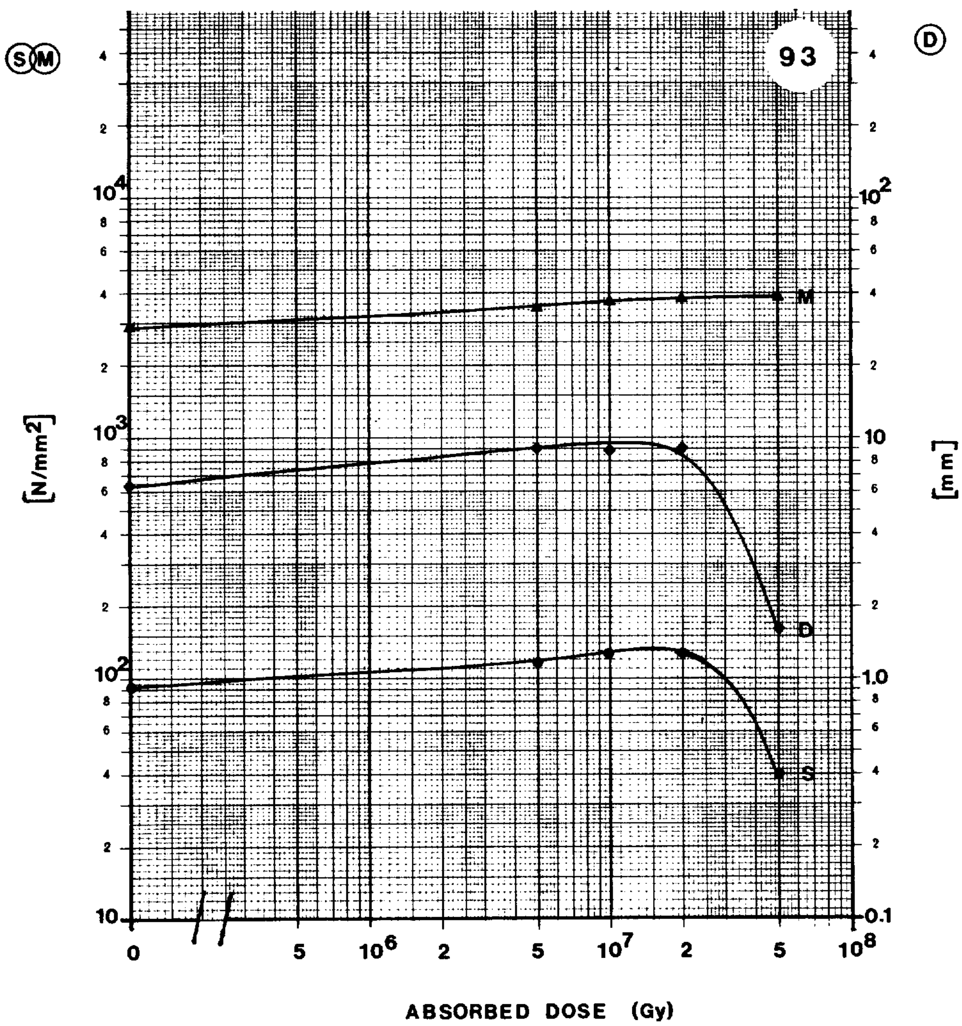


CURVE	PROPERTY	INITIAL VALUE	
S	Ultimate flexural strength	83.4	N/mm^2
D	Deflexion at break	4.7	mm
M	Modulus of elasticity	3.2×10^3	N/mm^2

MATERIAL: DEN 431 + MDA

SUPPLIER: DOW

Remarks:

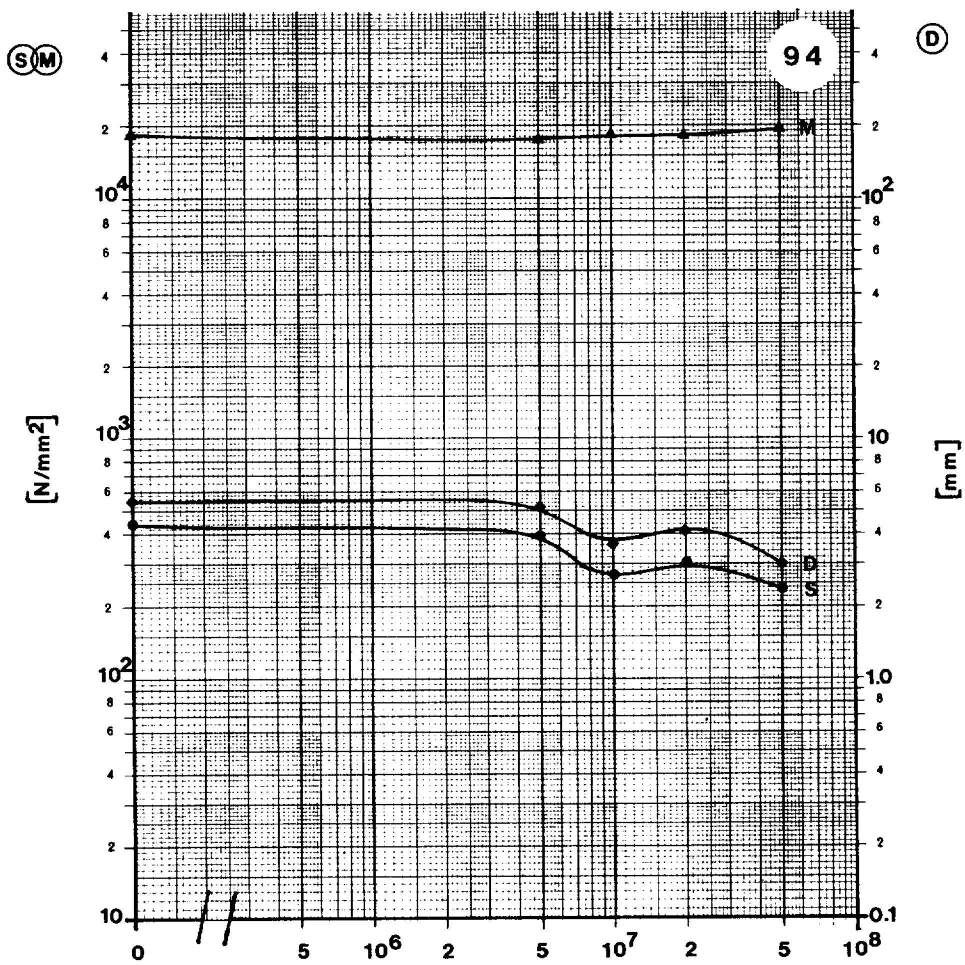


CURVE	PROPERTY	INITIAL VALUE	
S	Ultimate flexural strength	92.2	N/mm^2
D	Deflexion at break	6.4	mm
M	Modulus of elasticity	2.9×10^3	N/mm^2

MATERIAL: EPIKOTE 154 + MNA + GLASS TAPE

SUPPLIER: MICAFIL

Remarks:

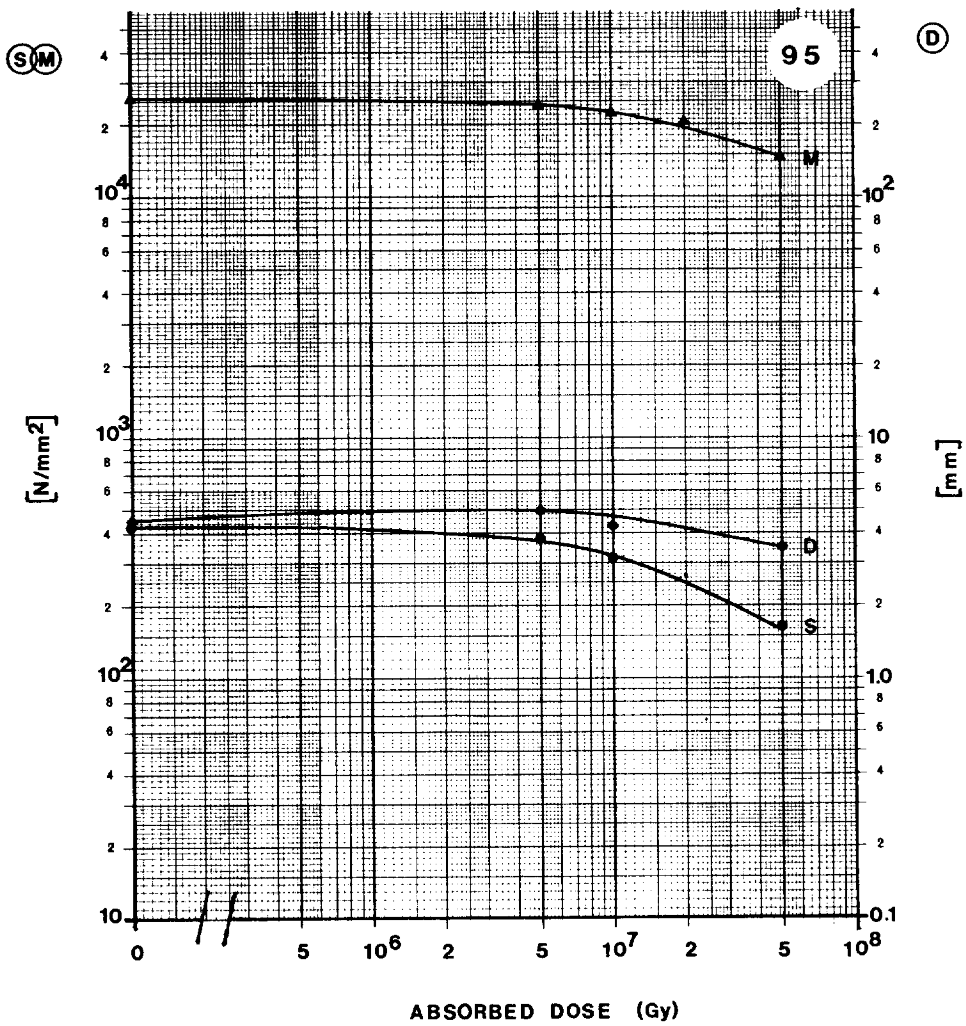


CURVE	PROPERTY	INITIAL VALUE	
S	Ultimate flexural strength	441.4	N/mm^2
D	Deflexion at break	5.5	mm
M	Modulus of elasticity	1.9×10^4	N/mm^2

MATERIAL: EPIKOTE 154 + DDS + GLASS FABRIC

SUPPLIER: MICAFIL

Remarks:

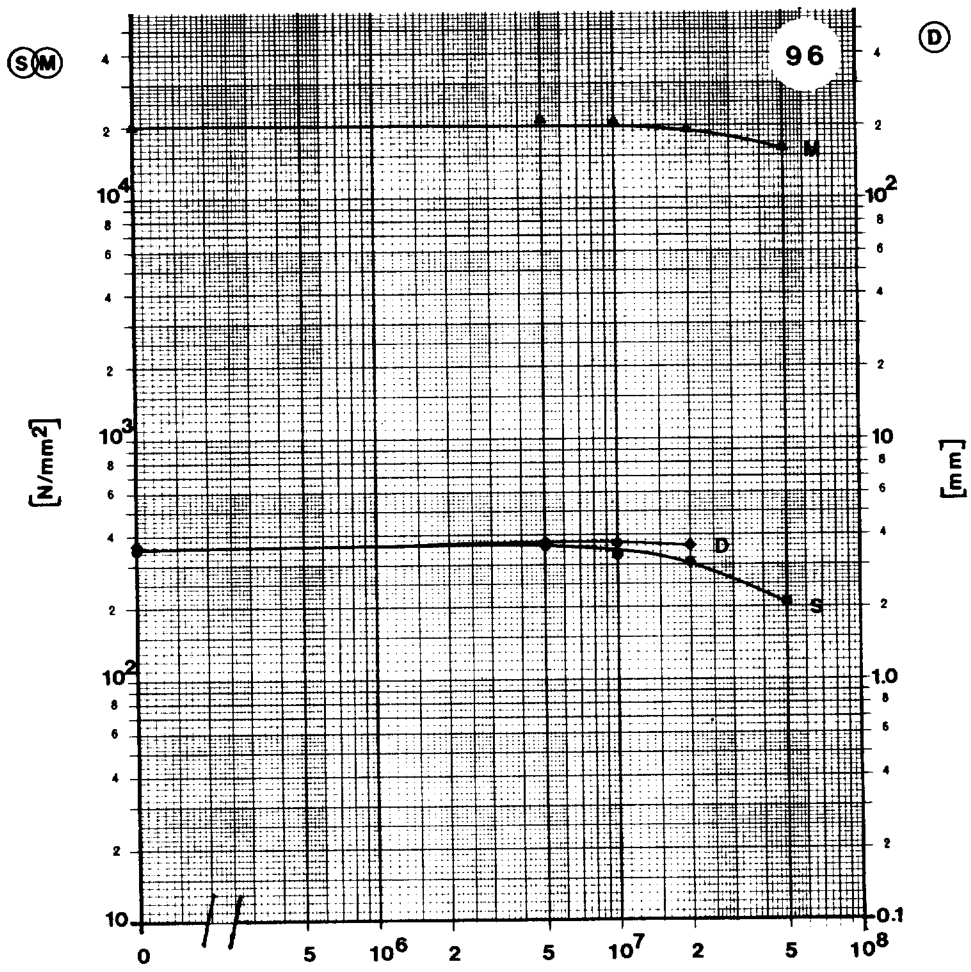


CURVE	PROPERTY	INITIAL VALUE	
S	Ultimate flexural strength	430.6	N/mm^2
D	Deflexion at break	4.5	mm
M	Modulus of elasticity	2.5×10^4	N/mm^2

MATERIAL: EPIKOTE 154 + DDM + GLASS FABRIC

SUPPLIER: MICAFIL

Remarks:

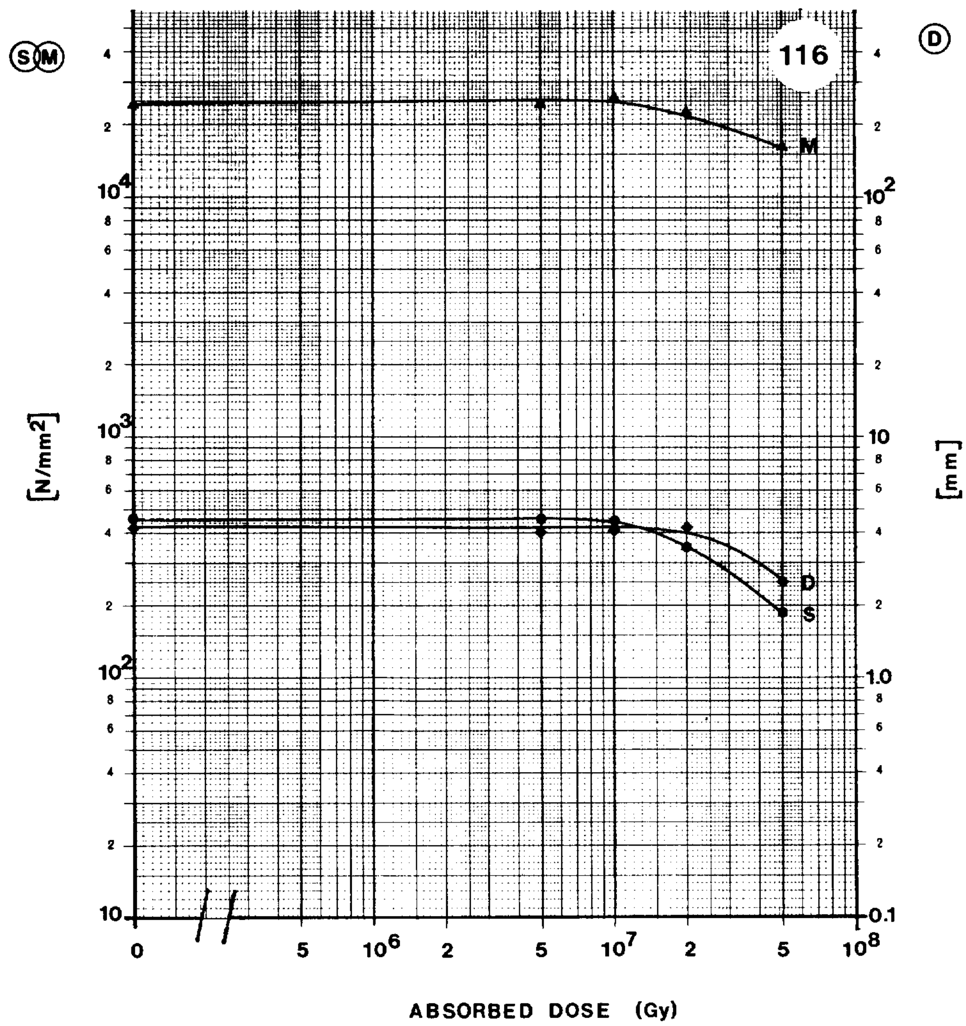


CURVE	PROPERTY	INITIAL VALUE	
S	Ultimate flexural strength	351.2	N/mm^2
D	Deflexion at break	3.6	mm
M	Modulus of elasticity	2.0×10^4	N/mm^2

MATERIAL: Epoxy Novolac 438 + HY 906 + glass fabric

SUPPLIER: ISOLA

Remarks:

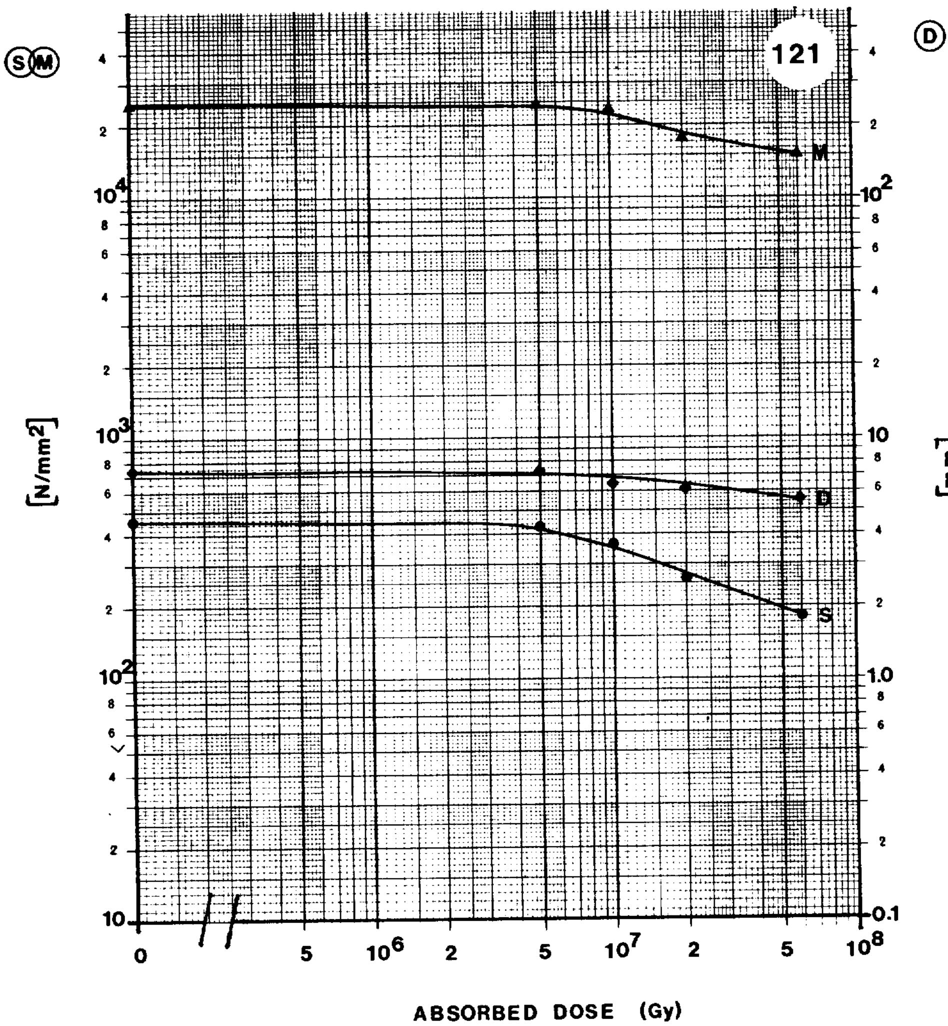


CURVE	PROPERTY	INITIAL VALUE	
S	Ultimate flexural strength	458.1	N/mm^2
D	Deflexion at break	4.1	mm
M	Modulus of elasticity	2.4×10^4	N/mm^2

MATERIAL: Epoxy Novolac 431 + MNA + accelerator

SUPPLIER: ISOLA

Remarks:

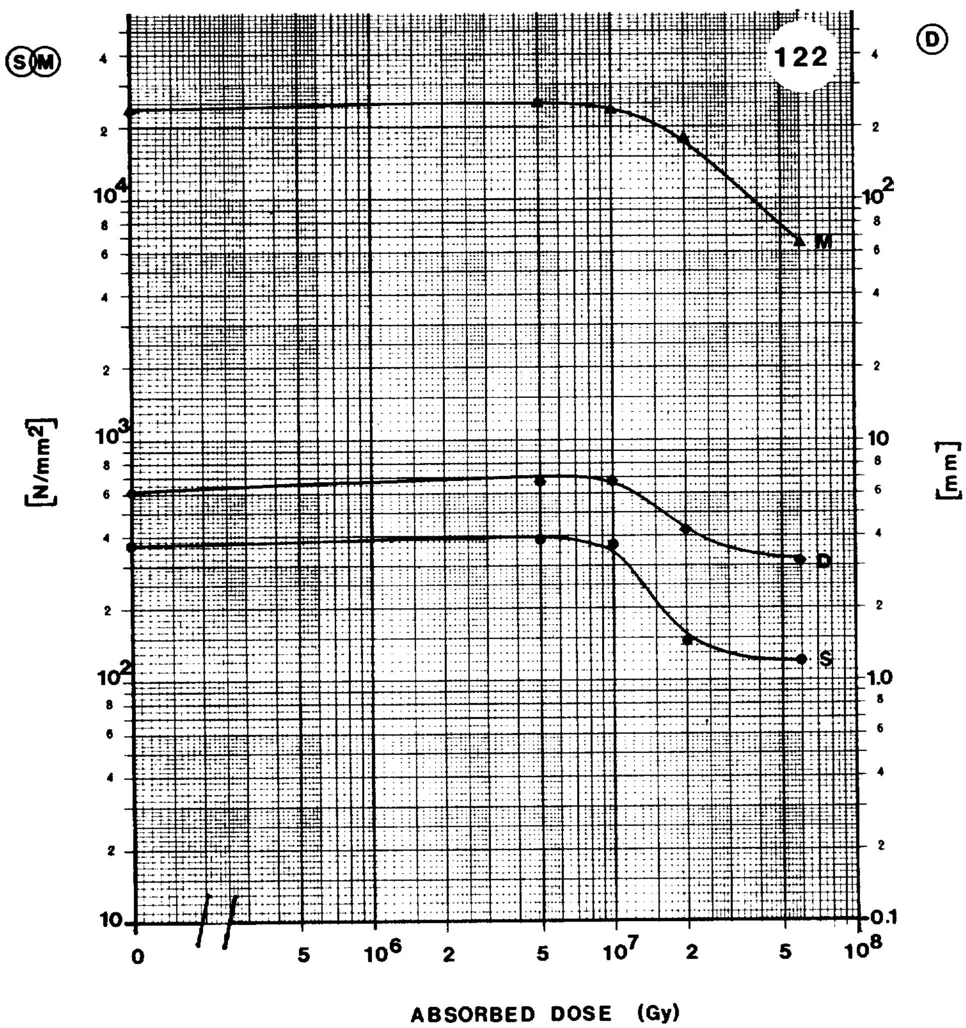


CURVE	PROPERTY	INITIAL VALUE	
S	Ultimate flexural strength	464.0	N/mm^2
D	Deflexion at break	7.2	mm
M	Modulus of elasticity	2.4×10^4	N/mm^2

MATERIAL: EPOXY NOVOLAC 431 + BF_3 MEA COMPLEX

SUPPLIER: ISOLA

Remarks:

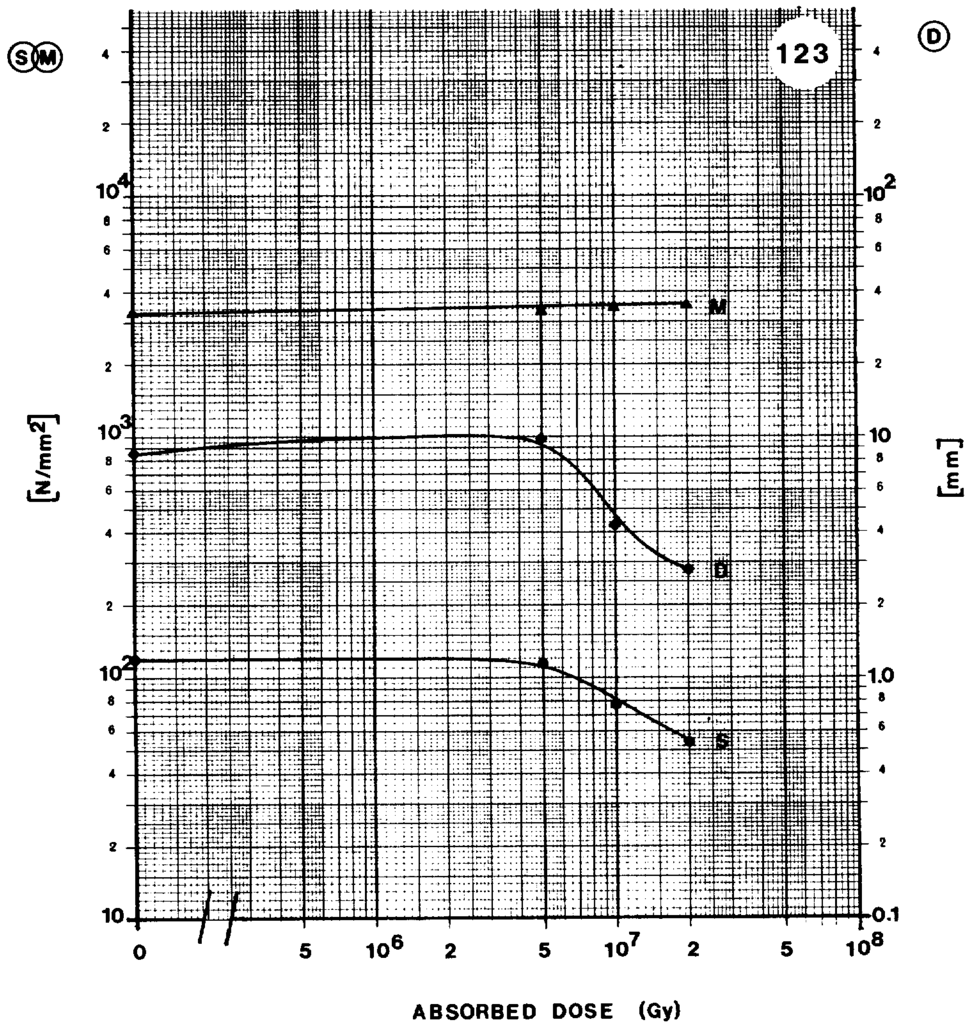


CURVE	PROPERTY	INITIAL VALUE	
S	Ultimate flexural strength	363.9	N/mm^2
D	Deflexion at break	6.1	mm
M	Modulus of elasticity	2.4×10^4	N/mm^2

MATERIAL: EPN 1138(50) + MY 745(50) + HY 905(103) + XB 2687(0.25)

SUPPLIER: ALSTHOM

Remarks: ISR RESIN WITHOUT FLEXIBILIZER

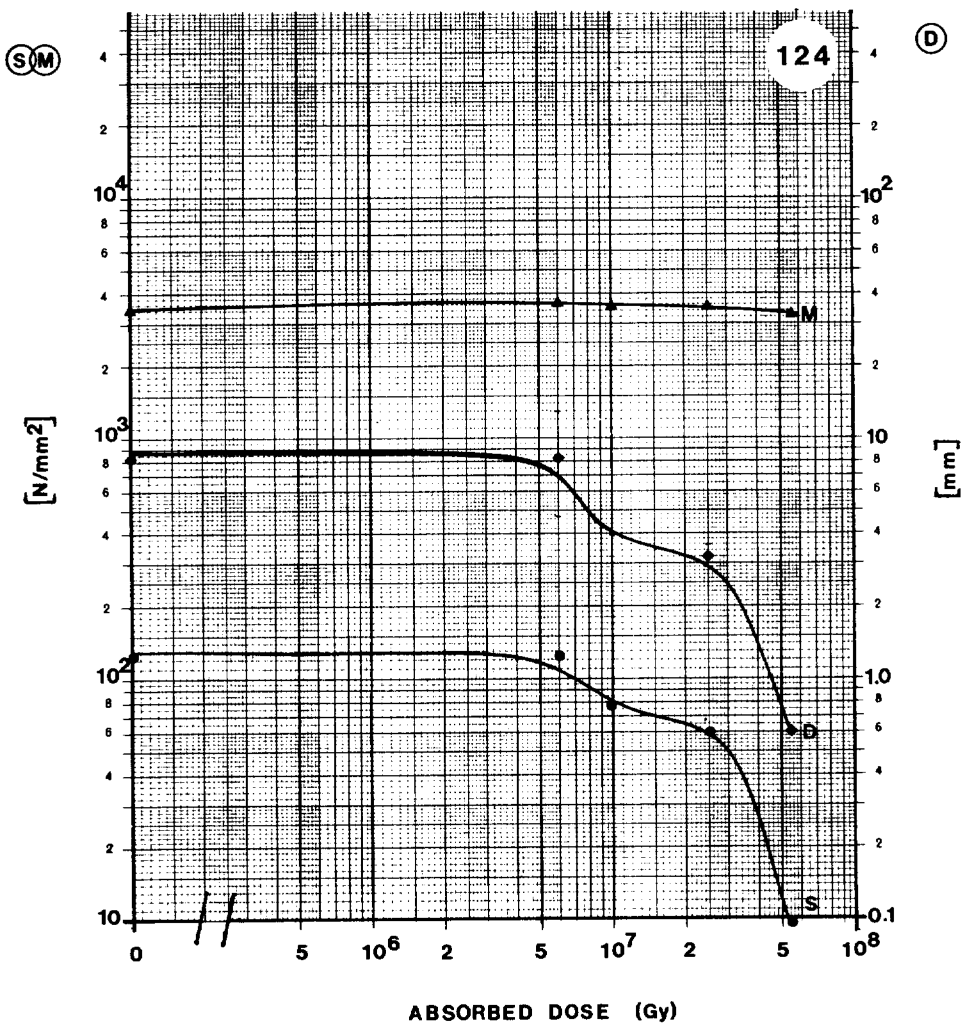


CURVE	PROPERTY	INITIAL VALUE	
S	Ultimate flexural strength	118.7	N/mm^2
D	Deflexion at break	8.4	mm
M	Modulus of elasticity	3.3×10^3	N/mm^2

MATERIAL: EPN 1139(100) + HY 905(97.5) + XB 2687(0.2)

SUPPLIER: ALSTHOM

Remarks:

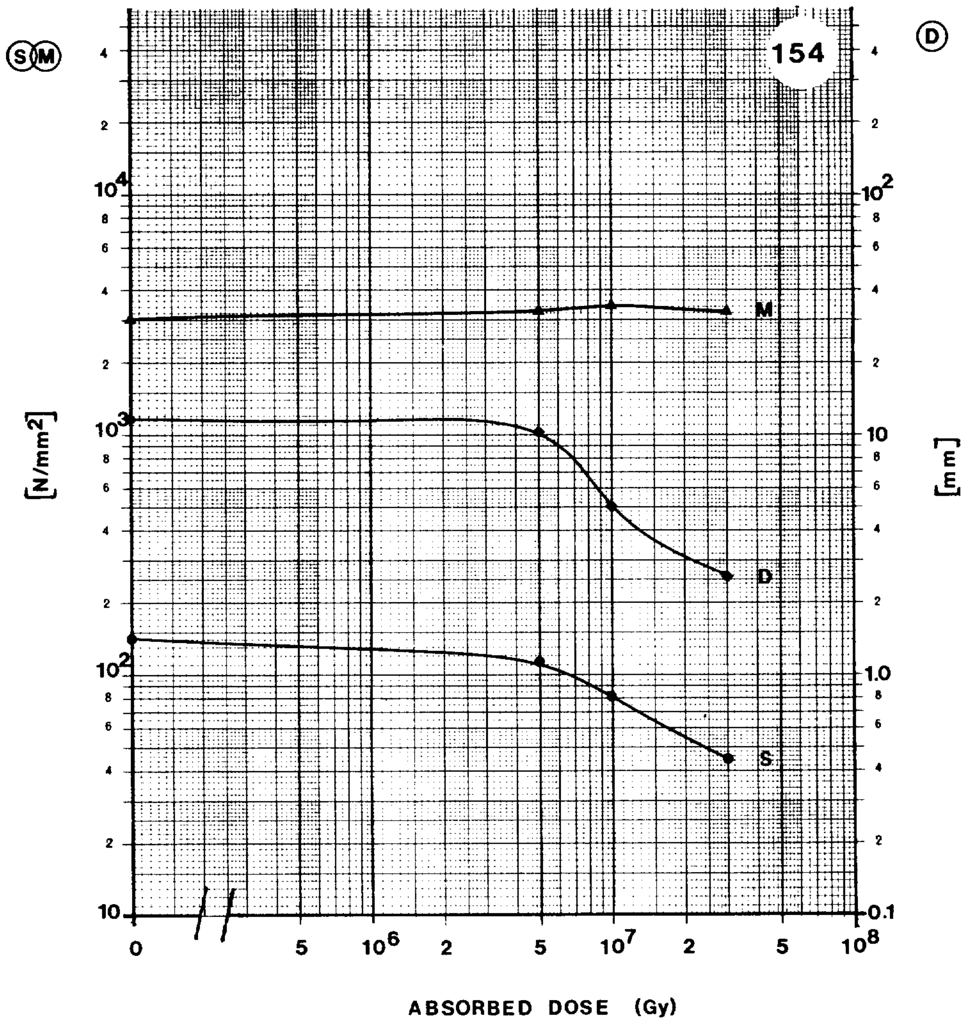


CURVE	PROPERTY	INITIAL VALUE	
S	Ultimate flexural strength	124.6	N/mm^2
D	Deflexion at break	8.3	mm
M	Modulus of elasticity	3.5×10^3	N/mm^2

MATERIAL: EP 154(50) + EP 828(50) + DX 126(60) + DX 127(22) + ACCELERATOR

SUPPLIER: SHELL

Remarks:

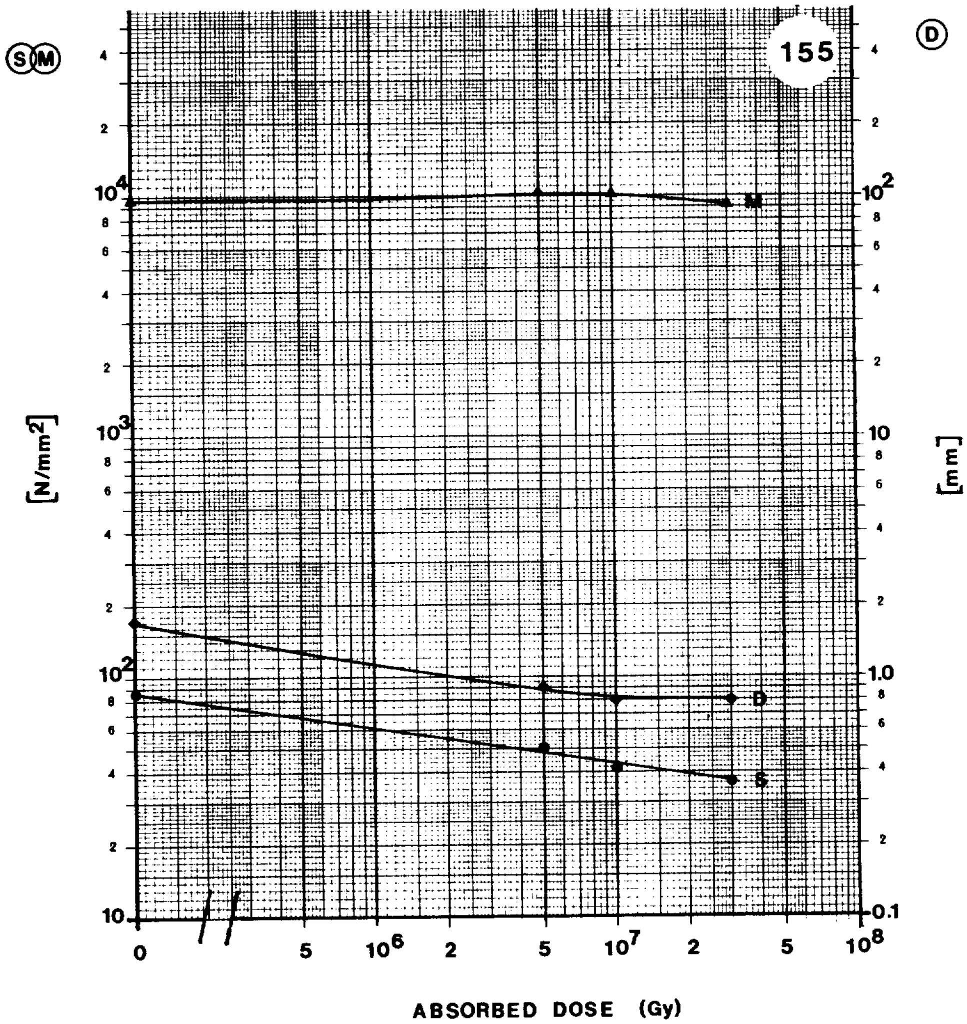


CURVE	PROPERTY	INITIAL VALUE	
S	Ultimate flexural strength	145.2	N/mm^2
D	Deflexion at break	11.5	mm
M	Modulus of elasticity	3.0×10^3	N/mm^2

MATERIAL: EP 154(50) + EP 828(50) + DX 126(60) + DX 127(22) + + SILICA(300) + ACCELERATOR

SUPPLIER: SHELL

Remarks:

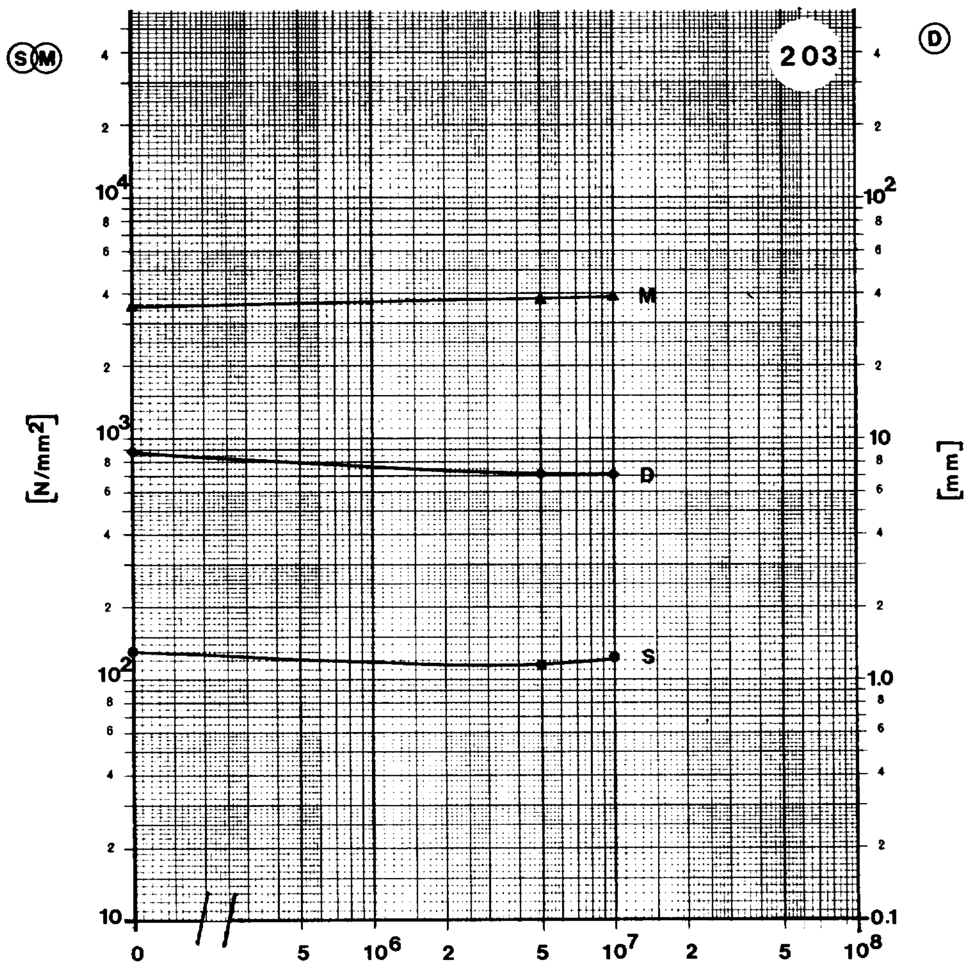


CURVE	PROPERTY	INITIAL VALUE	
S	Ultimate flexural strength	86.3	N/mm^2
D	Deflexion at break	1.7	mm
M	Modulus of elasticity	9.6×10^3	N/mm^2

MATERIAL: EPN 1138(100) + HY 906(95) + DY 062(0.5)

SUPPLIER: CIBA-GEIGY

Remarks:

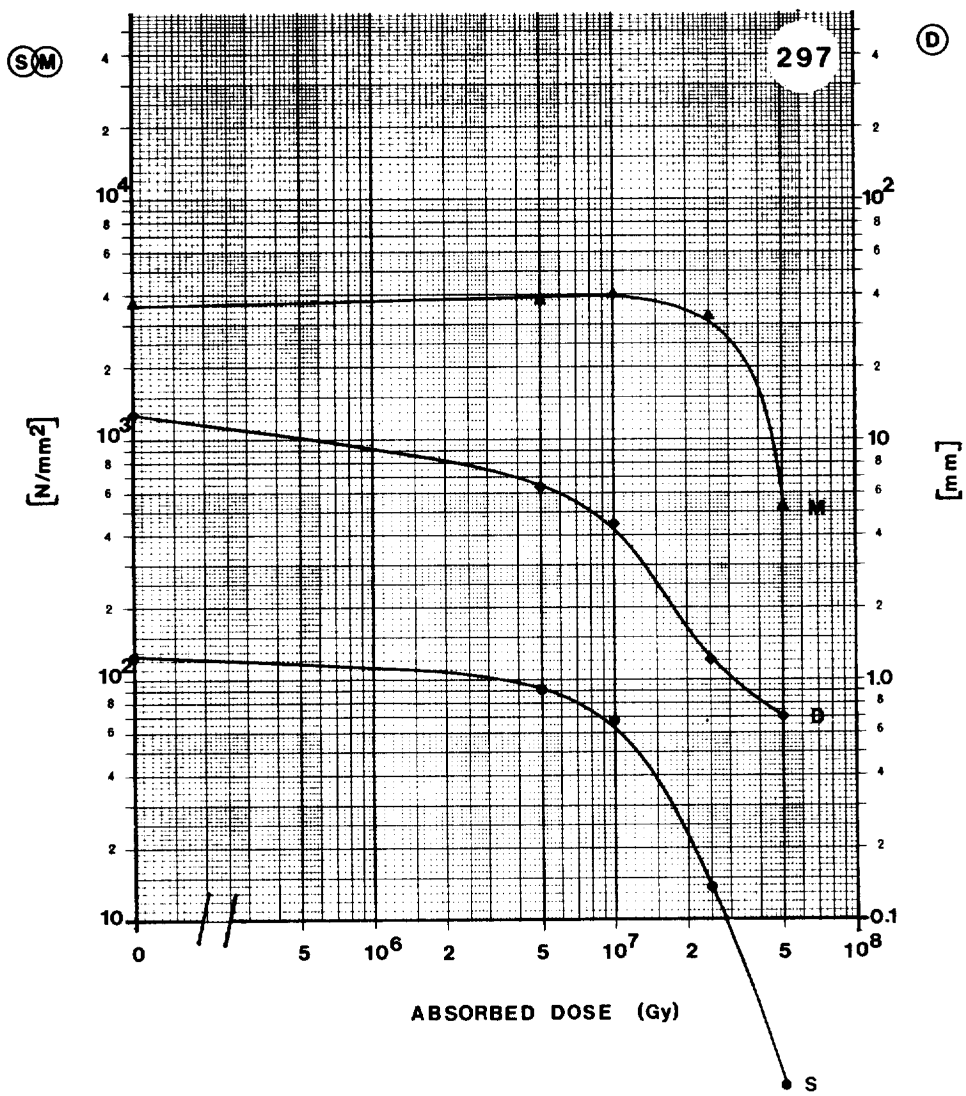


CURVE	PROPERTY	INITIAL VALUE	
S	Ultimate flexural strength	130.5	N/mm^2
D	Deflexion at break	8.7	mm
M	Modulus of elasticity	3.5×10^3	N/mm^2

MATERIAL: EPN 1138(50) + MY 745(50) + CY 221(20) + HY 905(120) + + XB 2687(0.3)

SUPPLIER: CIBA-GEIGY

Remarks:

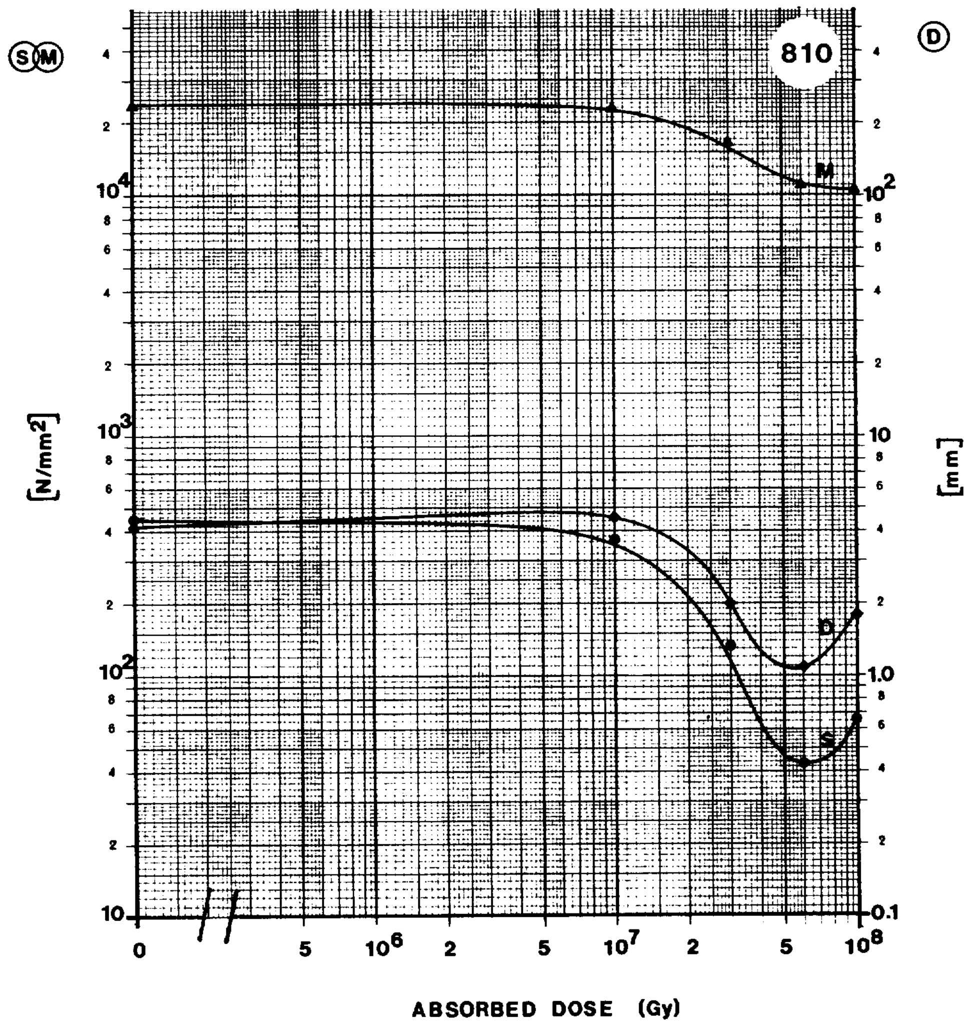


CURVE	PROPERTY	INITIAL VALUE	
S	Ultimate flexural strength	124.2	N/mm^2
D	Deflexion at break	12.4	mm
M	Modulus of elasticity	3.7×10^3	N/mm^2

MATERIAL: VETRESIT 14; EPIKOTE 827 + DDS + GLASS TISSUE

SUPPLIER: MICAFIL

Remarks:



CURVE	PROPERTY	INITIAL VALUE	
S	Ultimate flexural strength	445.4	N/mm^2
D	Deflexion at break	4.2	mm
M	Modulus of elasticity	2.4×10^4	N/mm^2

ORLITHERM

Trade name of BBC Baden
for epoxy resins based on DGEBA with MNA
see ARALDITE F

PHENOLIC RESINS

POLYCARBONATE RESINS

POLYESTER RESINS

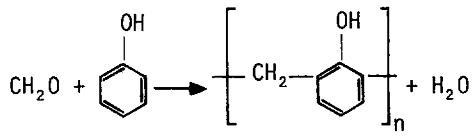
POLYIMIDE RESINS

POLYLITE
see POLYESTER

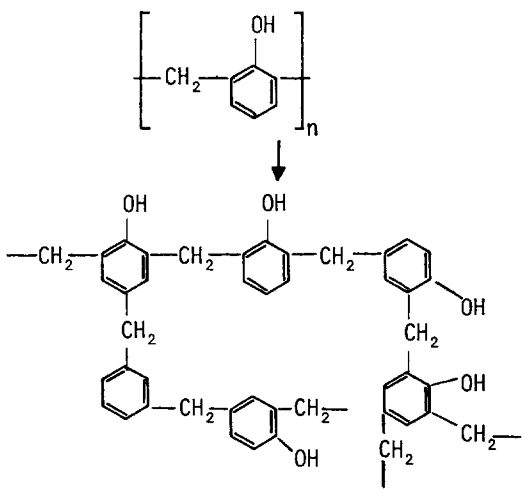
POLYURETHANE RESINS

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.

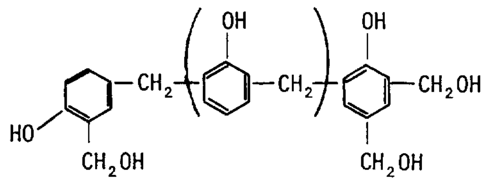
In the acid-catalysed reaction with equimolar amounts of phenol and formaldehyde, the primary product is a linear, low molecular weight polymer, often termed novolac:



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:

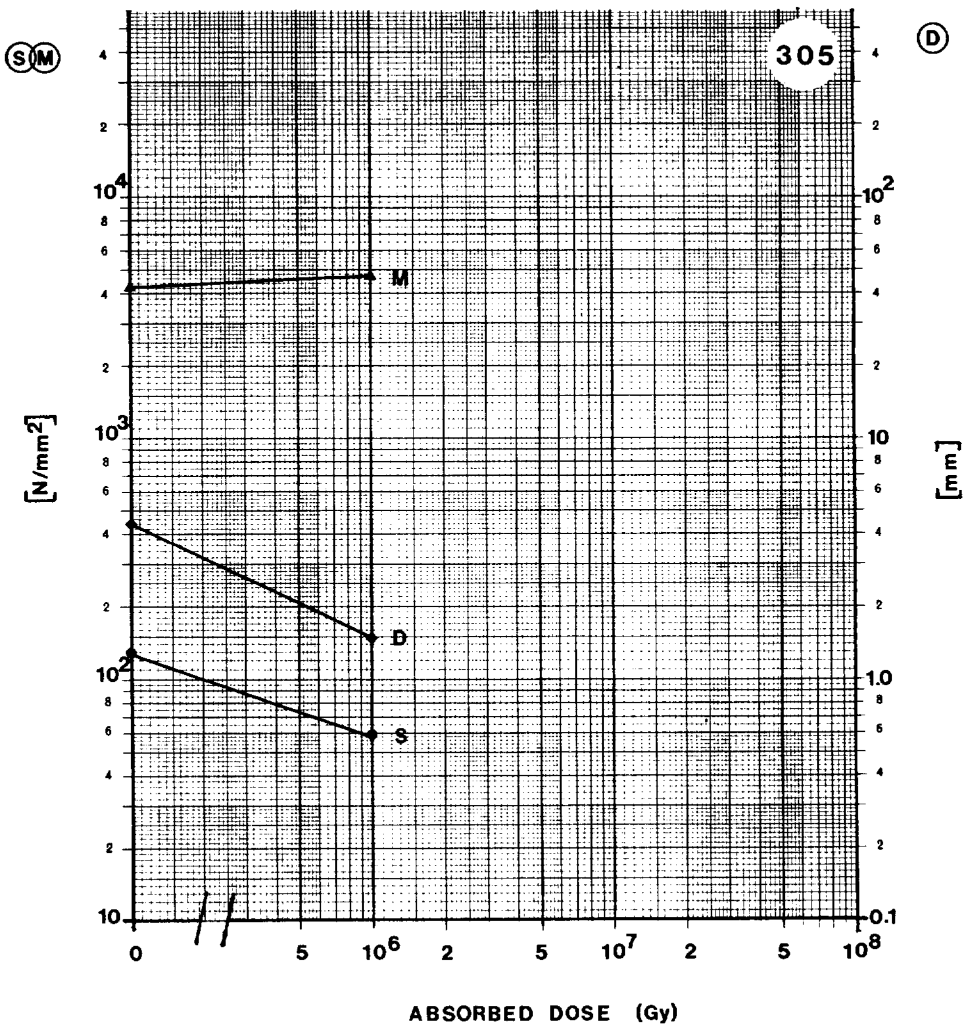


No.	Material and Supplier	Dose (Gy)	Ultimate flex. strength S (N/mm^2)	Deflexion at break D (mm)	Modulus of elasticity M (N/mm^2)
305	Phenolic resin + glass	0	129.5 ± 12.8	4.4 ± 0.4	$4.22 \pm 0.62 \times 10^3$
	Klockner-Müller	1×10^6	59.8 ± 23.5	1.5 ± 0.4	$4.75 \pm 0.90 \times 10^3$
309	RESOFIL 22	0	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

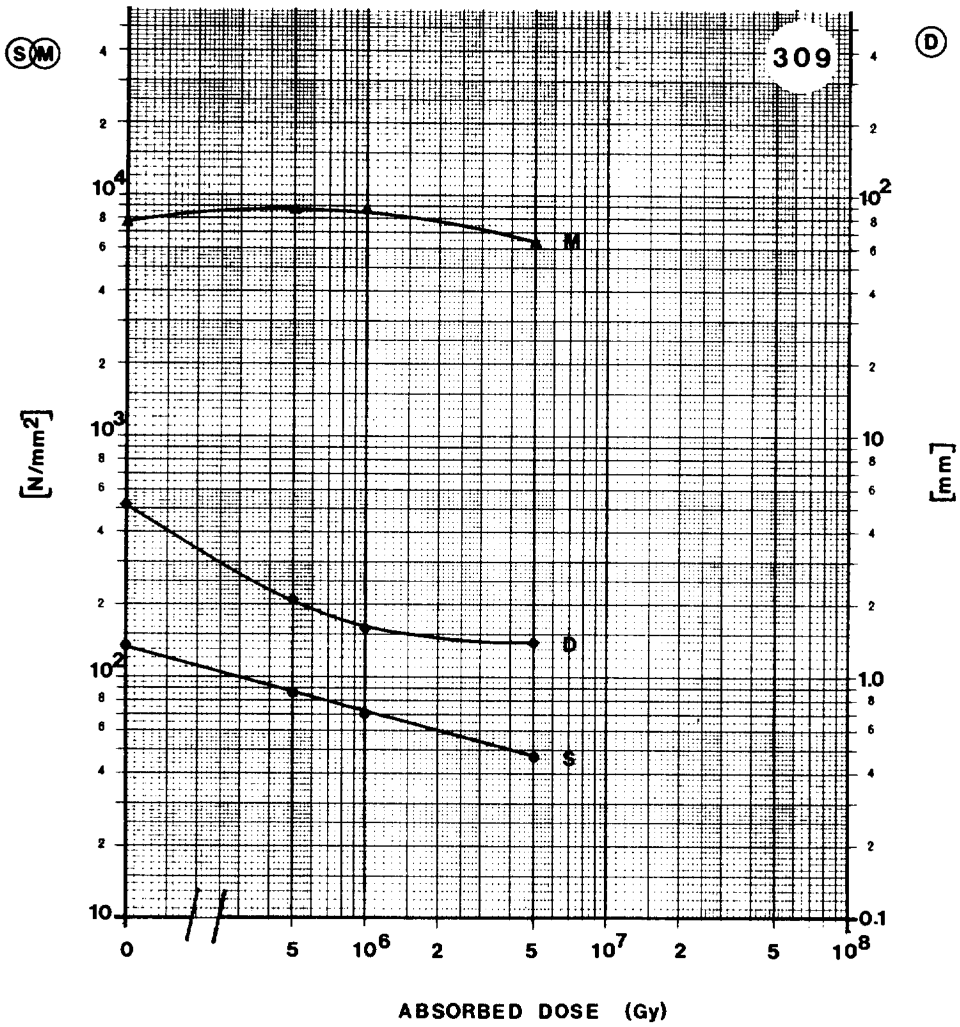


CURVE	PROPERTY	INITIAL VALUE	
S	Ultimate flexural strength	129.5	N/mm^2
D	Deflexion at break	4.4	mm
M	Modulus of elasticity	4.2×10^3	N/mm^2

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.

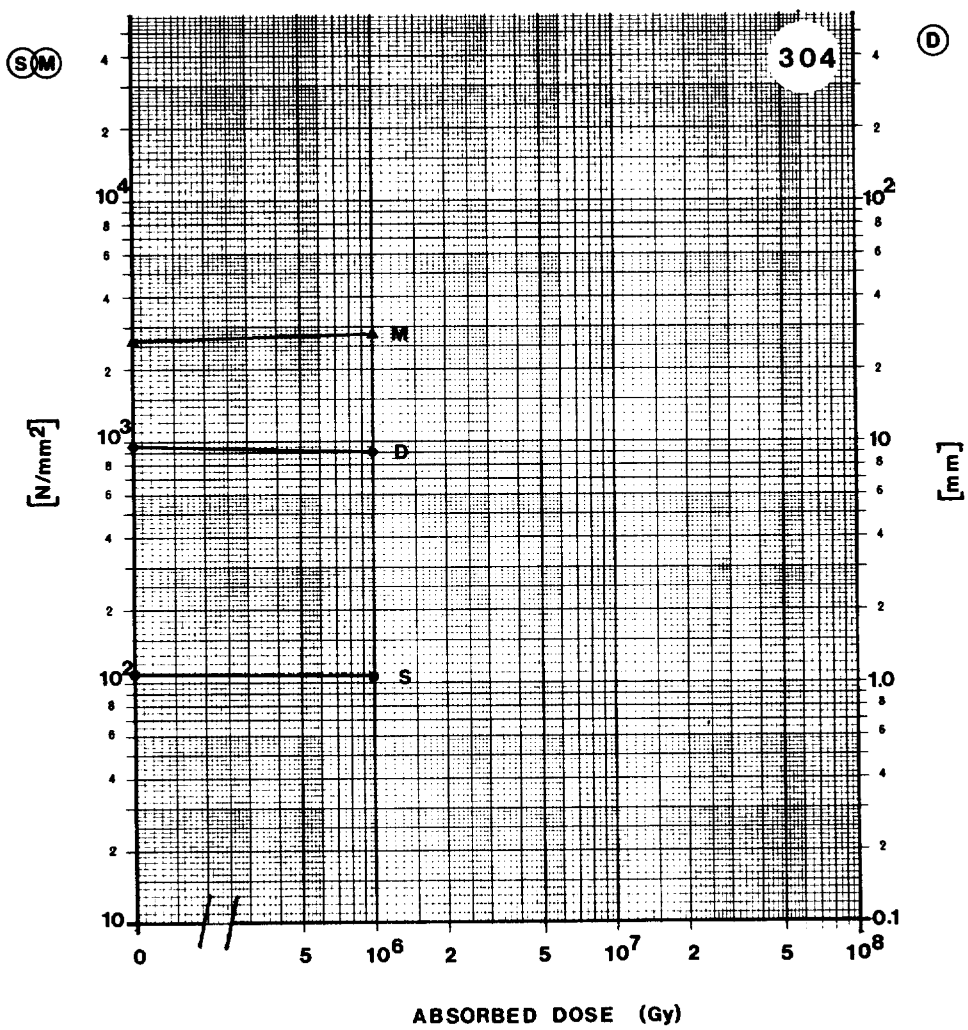
The most known representative of polycarbonates is MAKROLON (polycarbon ester of bisphenol A).

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

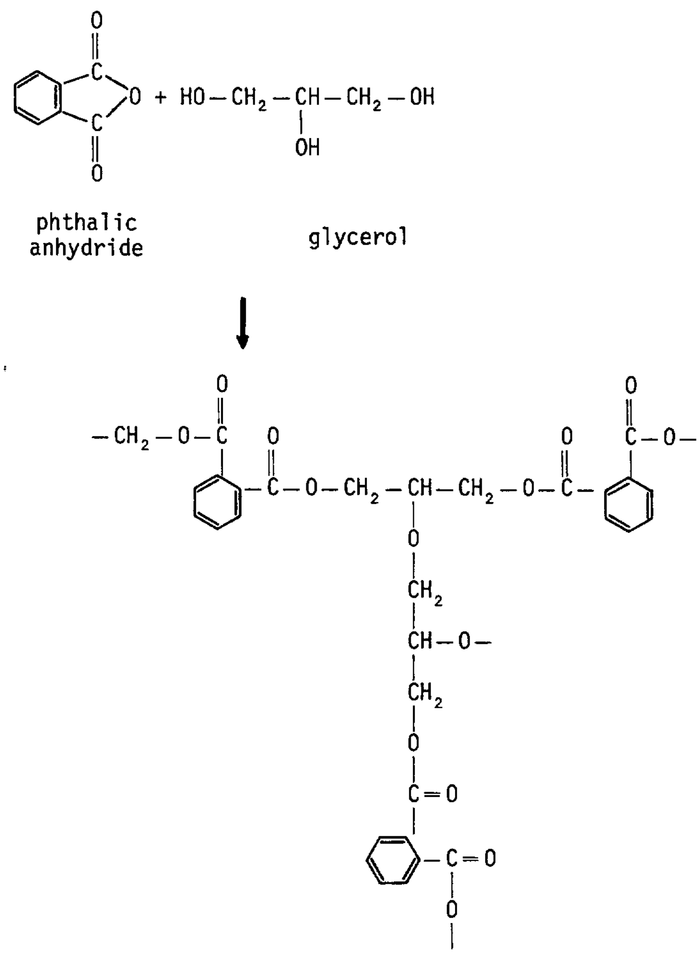
Remarks: USED AT THE SPS FOR CABLE CONNECTION BOX



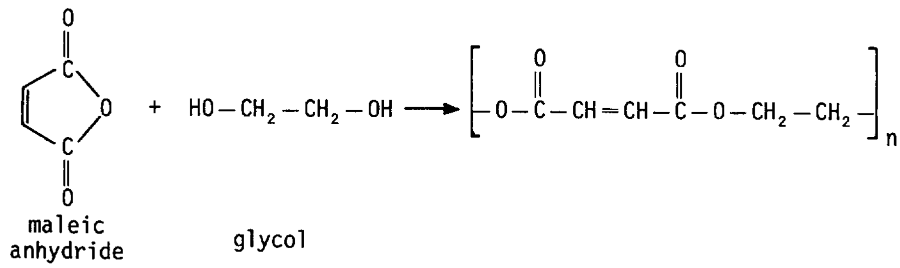
CURVE	PROPERTY	INITIAL VALUE	
S	Ultimate flexural strength	108.9	N/mm^2
D	Deflexion at break	9.5	mm
M	Modulus of elasticity	2.6×10^3	N/mm^2

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.

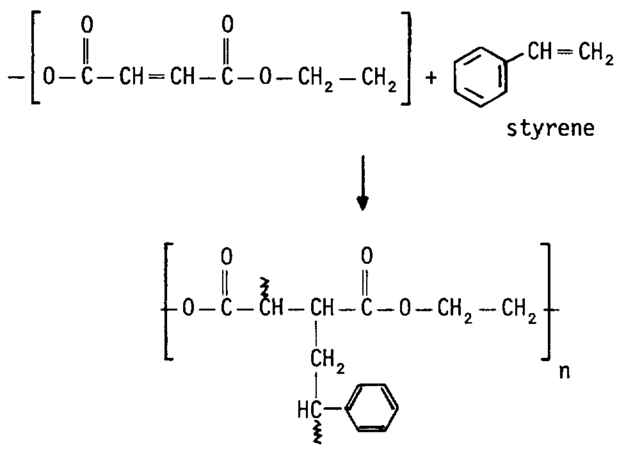
Polyester resins prepared by the reactions of trials with dibasic acids or their derivatives are usually termed alkyd resins:



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/mm²)	Deflexion at break D (mm)	Modulus of elasticity M (N/mm²)
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 BBC Mannheim	0	432.6 ± 13.7	4.0 ± 0.1	$2.27 \pm 0.03 \times 10^4$
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	$1.64 \pm 0.13 \times 10^3$

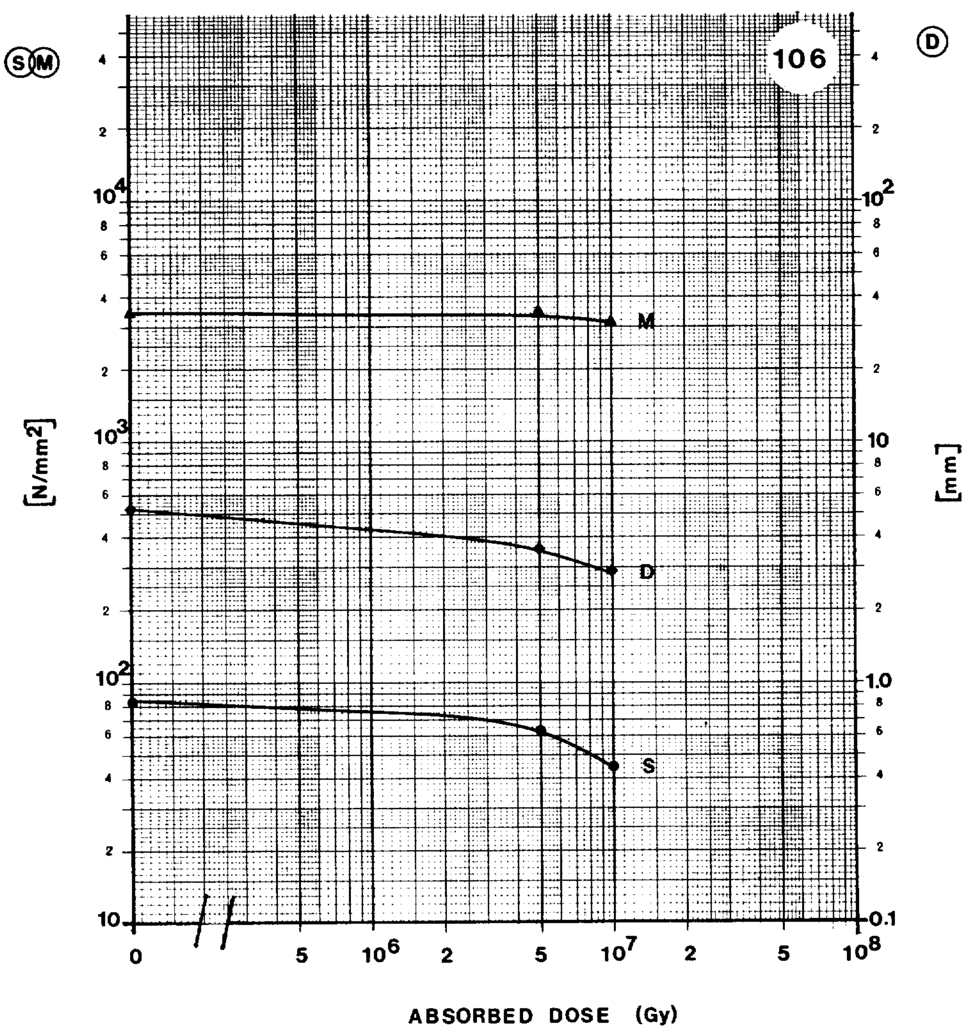
(a) No graph.

No.	Material and Supplier	Dose (Gy)	Ultimate flex. strength S (N/mm²)	Deflexion at break D (mm)	Modulus of elasticity M (N/mm²)
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:

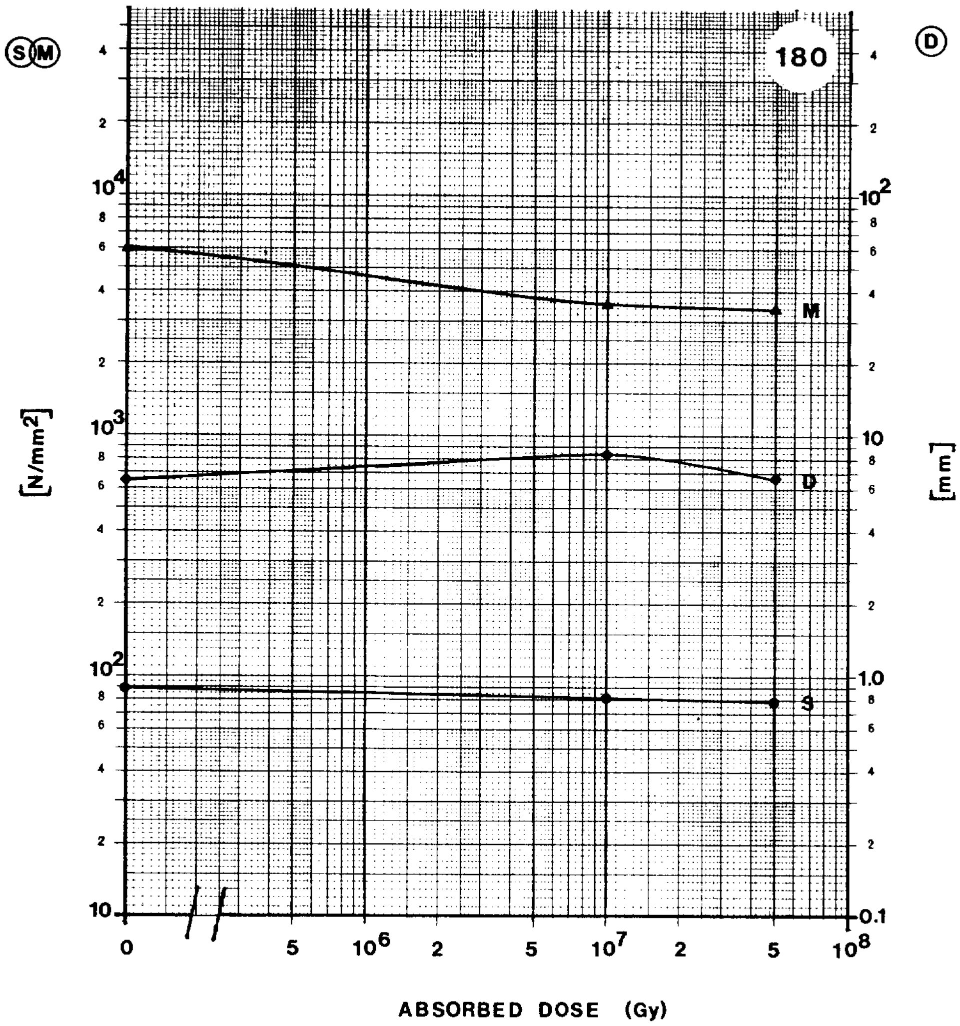


CURVE	PROPERTY	INITIAL VALUE	
S	Ultimate flexural strength	84.4	N/mm^2
D	Deflexion at break	5.3	mm
M	Modulus of elasticity	3.4×10^3	N/mm^2

MATERIAL: POLYESTER CRYSTIC 196 LV

SUPPLIER: GUMMI MAAG

Remarks:

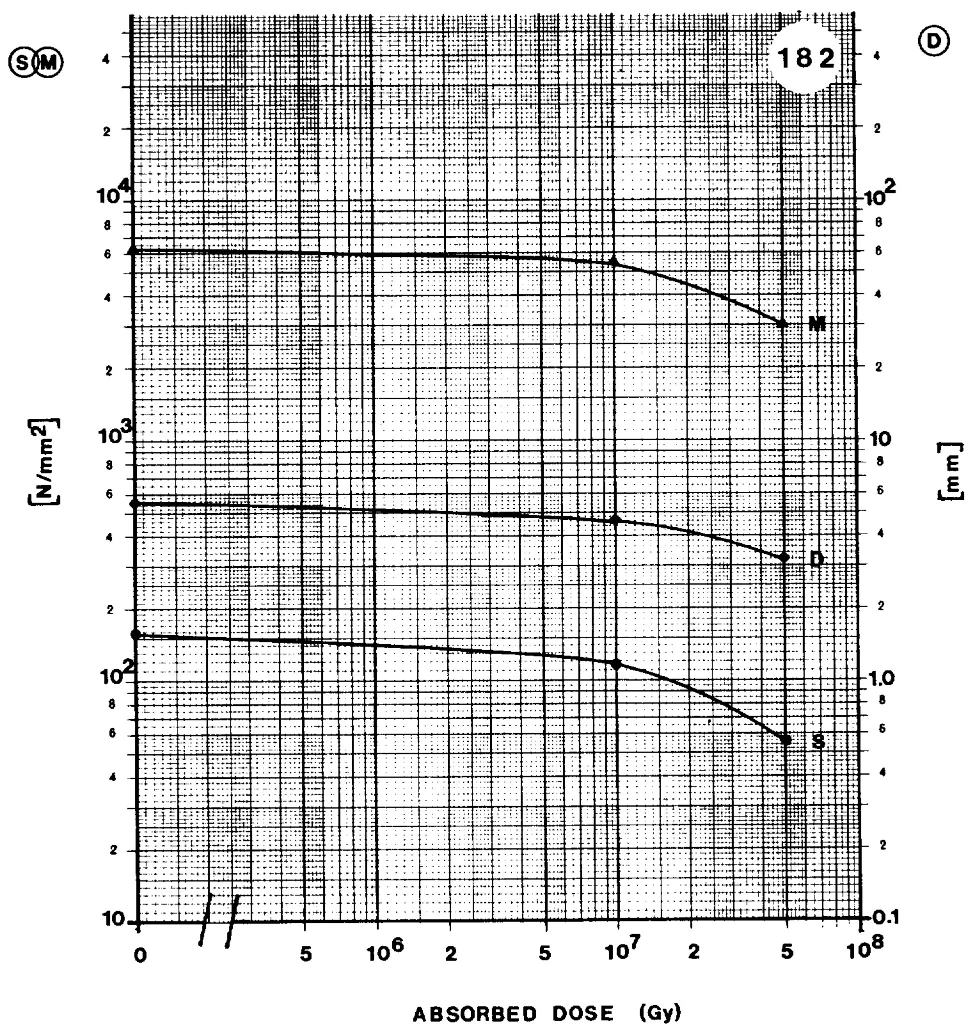


CURVE	PROPERTY	INITIAL VALUE	
S	Ultimate flexural strength	89.3	N/mm^2
D	Deflexion at break	6.4	mm
M	Modulus of elasticity	6.1×10^3	N/mm^2

MATERIAL: POLYESTER CRYSTIC 384 + GLASS FIBRE 60%

SUPPLIER: GUMMI MAAG

Remarks:

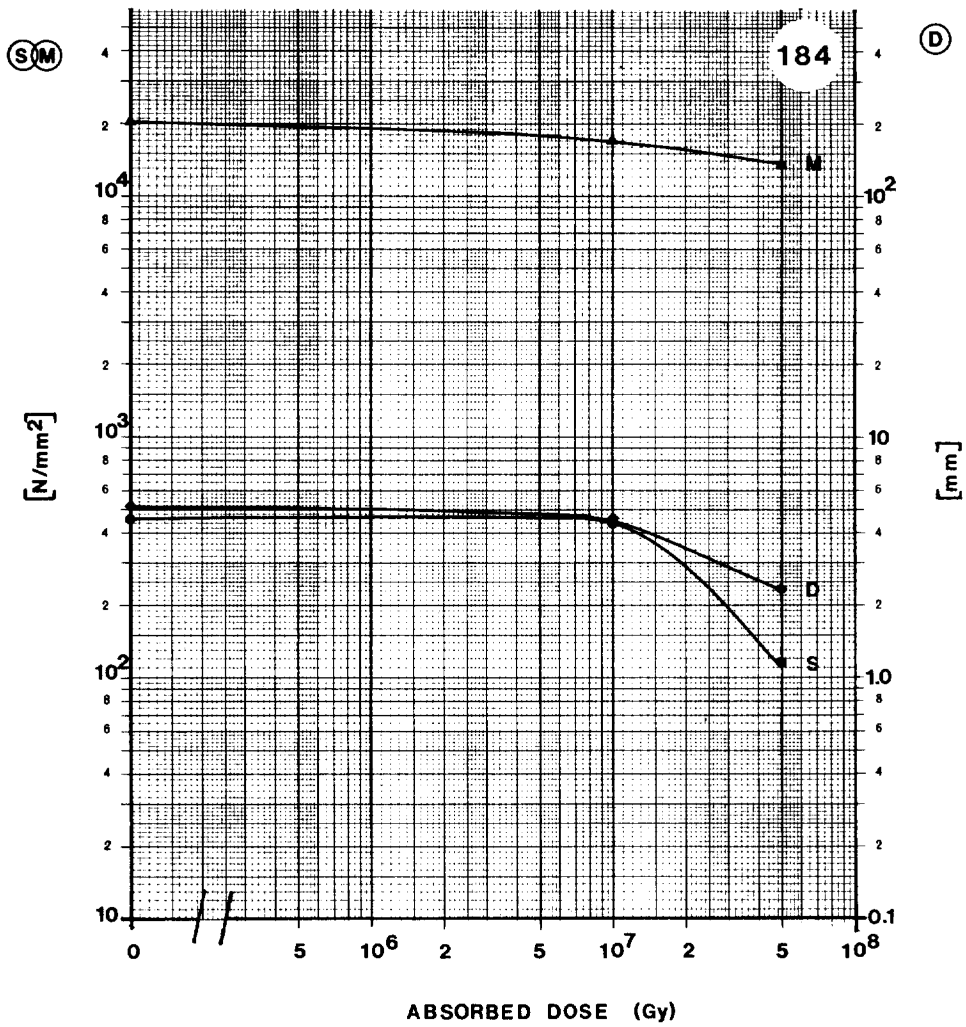


CURVE	PROPERTY	INITIAL VALUE	
S	Ultimate flexural strength	158.9	N/mm^2
D	Deflexion at break	5.5	mm
M	Modulus of elasticity	6.1×10^3	N/mm^2

MATERIAL: POLYESTER ISOPHTHALIC + TAFFETA MATERIAL

SUPPLIER: SNPE

Remarks:

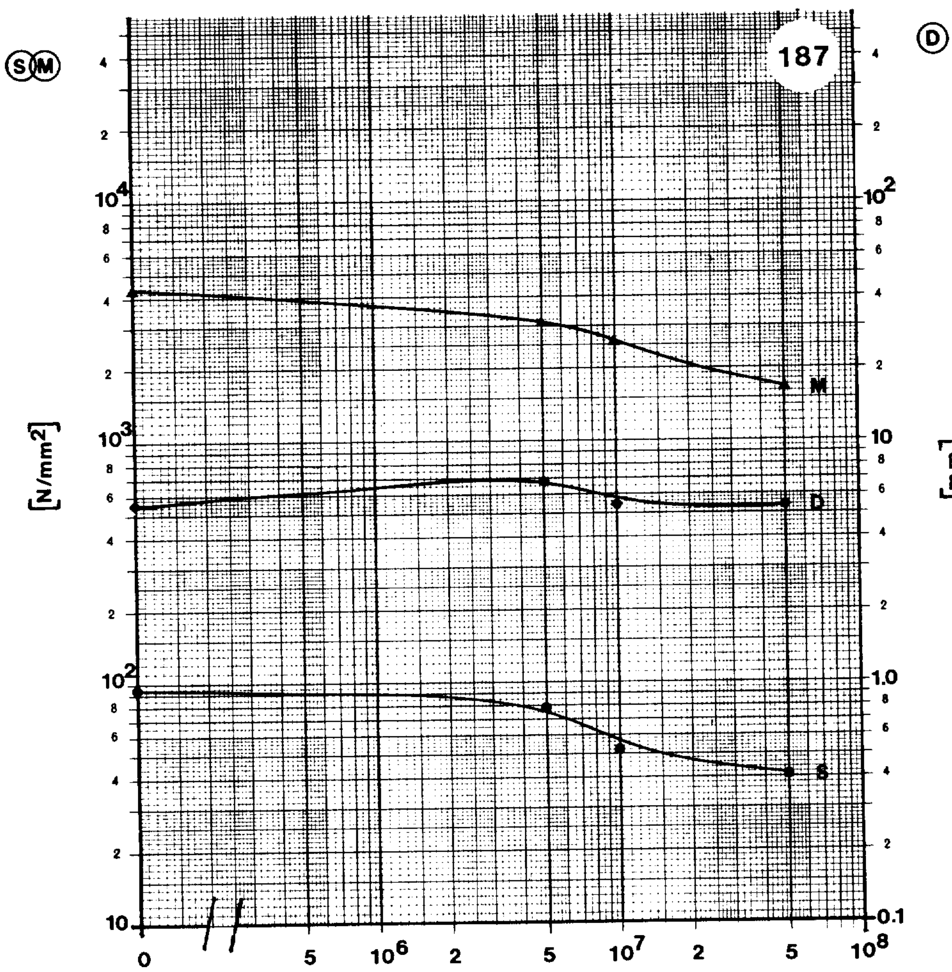


CURVE	PROPERTY	INITIAL VALUE	
S	Ultimate flexural strength	466.0	N/mm^2
D	Deflexion at break	5.1	mm
M	Modulus of elasticity	2.1×10^4	N/mm^2

MATERIAL: POLYESTER 65% + GLASS 35%

SUPPLIER: MICAFIL

Remarks:

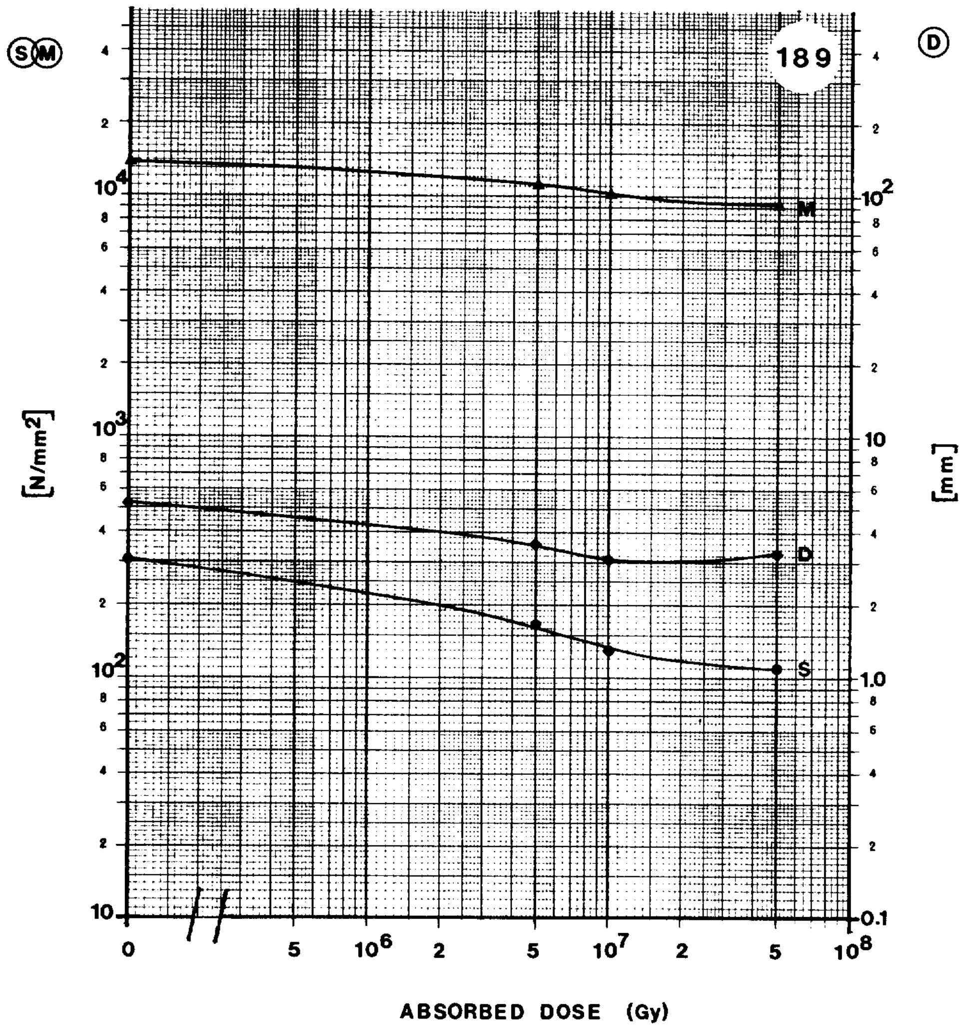


CURVE	PROPERTY	INITIAL VALUE	
S	Ultimate flexural strength	94.2	N/mm^2
D	Deflexion at break	5.5	mm
M	Modulus of elasticity	4.3×10^3	N/mm^2

MATERIAL: CEVOLIT 1413 (POLYESTER RESIN + GLASS FIBRE)

SUPPLIER: CELLPACK

Remarks:

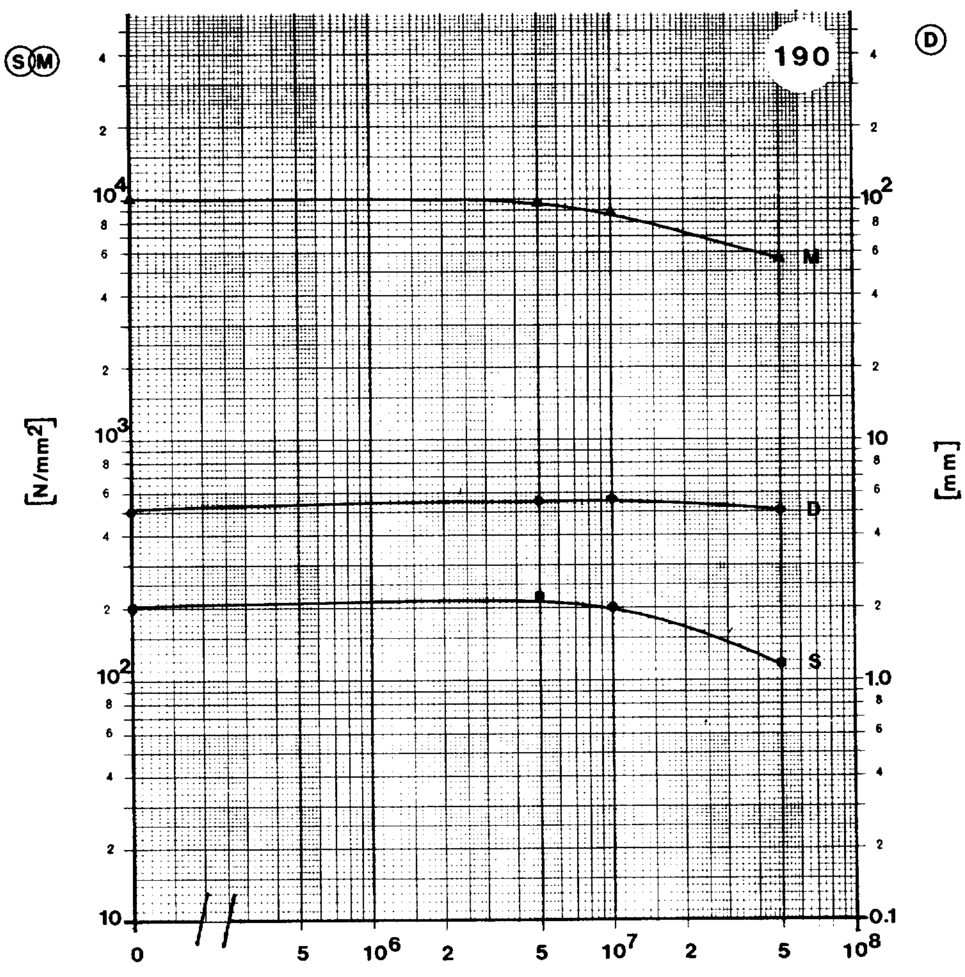


CURVE	PROPERTY	INITIAL VALUE	
S	Ultimate flexural strength	301.2	N/mm^2
D	Deflexion at break	5.2	mm
M	Modulus of elasticity	1.3×10^4	N/mm^2

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

SUPPLIER: ELEKTRO-ISOLA

Remarks:

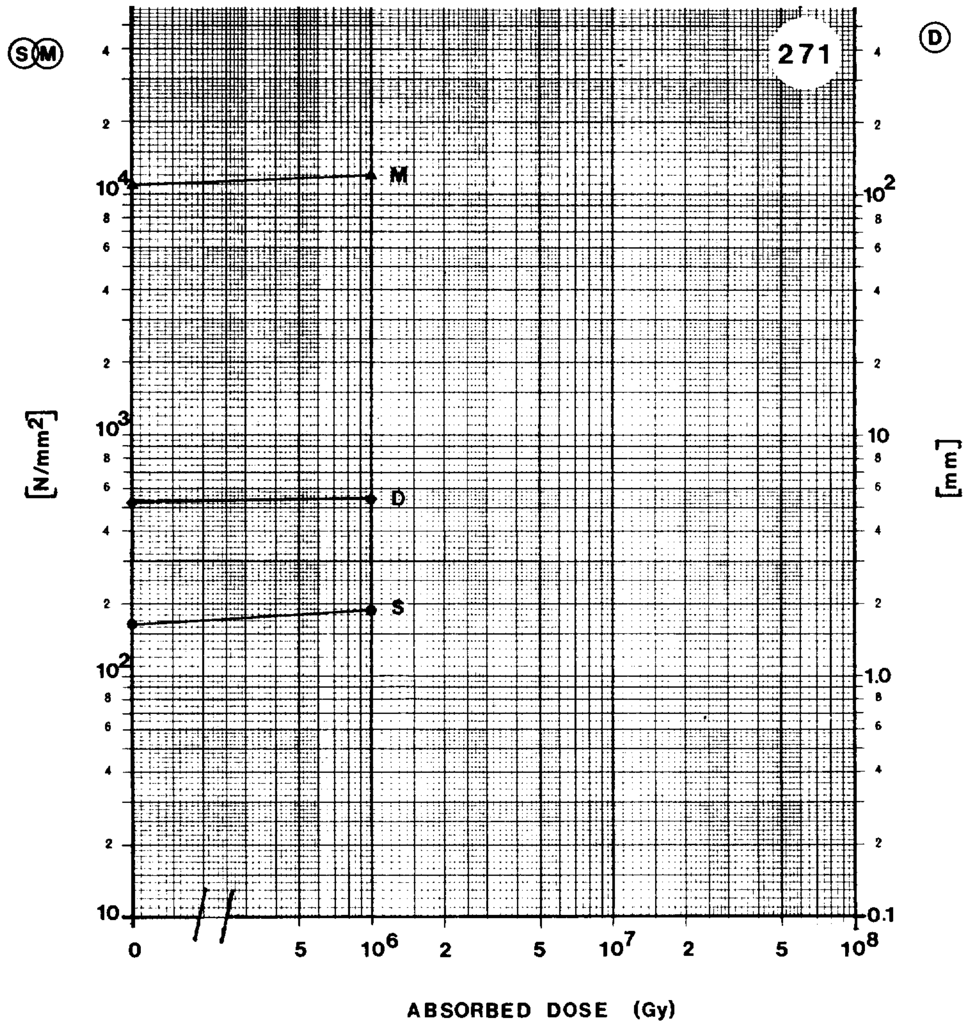


CURVE	PROPERTY	INITIAL VALUE
S	Ultimate flexural strength	197.2 N/mm^2
D	Deflexion at break	5.0 mm
M	Modulus of elasticity	1.0×10^4 N/mm^2

MATERIAL: Polyester + glass

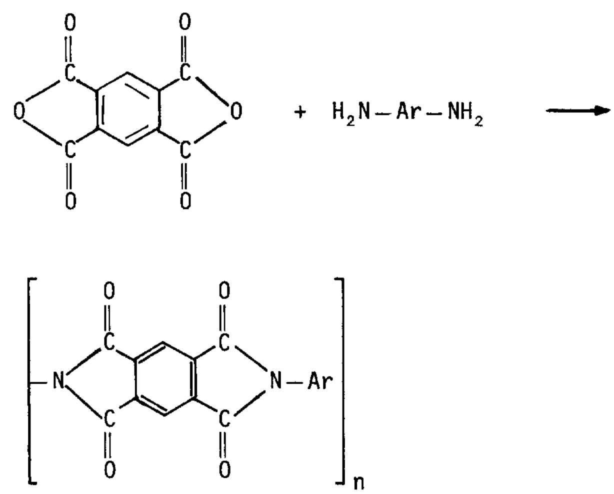
SUPPLIER: Hazemeyer, part of Holec Switchgear

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

The polyimides[16] are prepared from aromatic dianhydrides and aromatic diamines, e.g.:



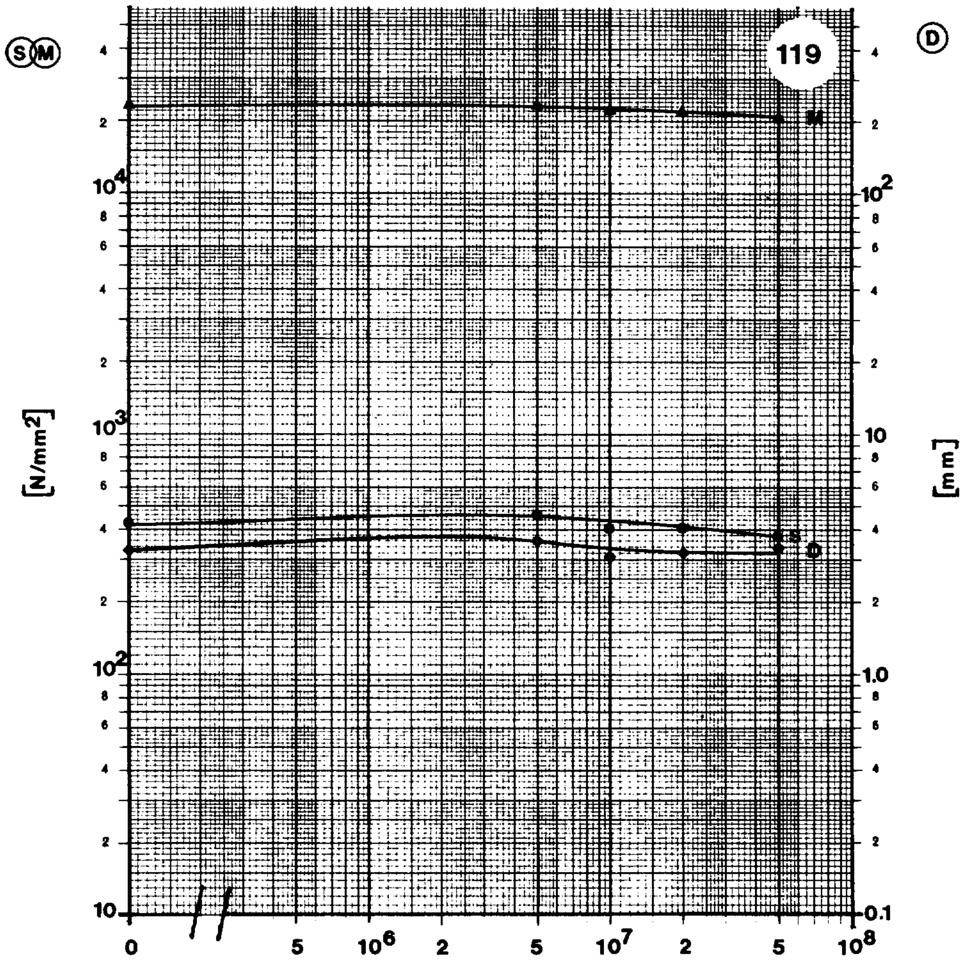
where Ar is m- or p-phenylene, biphenylnaphthylene, etc.

No.	Material and Supplier	Dose (Gy)	Ultimate flex. strength S (N/mm²)	Deflexion at break D (mm)	Modulus of elasticity M (N/mm²)
119	Polyimide + glass fibre	0	426.7 ± 71.6	3.3 ± 0.6	2.31 ± 0.11 × 10^4
		5 × 10^6	464.0 ± 83.4	3.6 ± 0.7	2.33 ± 0.06 × 10^4
		1 × 10^7	406.1 ± 102.0	3.1 ± 0.8	2.23 ± 0.20 × 10^4
		2 × 10^7	409.1 ± 84.4	3.2 ± 0.8	2.22 ± 0.22 × 10^4
	ISOLA	5 × 10^7	379.6 ± 50.0	3.4 ± 0.8	2.09 ± 0.11 × 10^4
152	KINEL 5.502	0	67.7 ± 7.8	2.1 ± 0.6	5.82 ± 0.07 × 10^3
	6 h 180 °C + 2 h 200 °C	5 × 10^6	63.7 ± 4.9	2.1 ± 0.2	5.83 ± 0.16 × 10^3
		1 × 10^7	53.0 ± 5.9	1.8 ± 0.3	5.90 ± 0.12 × 10^3
	Rhône-Poulenc	3 × 10^7	53.0 ± 6.9	2.1 ± 0.2	5.27 ± 0.48 × 10^3
197	KINEL 5.504	0	375.7 ± 18.6	2.1 ± 0.2	2.03 ± 0.03 × 10^4
		5 × 10^7	263.9 ± 1.0	2.9 ± 0.2	1.73 ± 0.06 × 10^4
	Rhône-Poulenc	1 × 10^8	193.3 ± 8.8	1.9 ± 0.1	1.35 ± 0.03 × 10^4
198	KERIMID 601 (glass fibre 181 E)	0	503.3 ± 42.5	5.0 ± 0.9	3.05 ± 0.28 × 10^4
		1 × 10^7	537.3 ± 16.7	5.3 ± 0.1	2.97 ± 0.13 × 10^4
		5 × 10^7	747.1 ± 159.5	5.3 ± 0.4	3.34 ± 0.31 × 10^4
	Rhône-Poulenc	1 × 10^8	143.6 ± 11.8	3.7 ± 0.2	9.22 ± 0.41 × 10^3
314	Polyimide + glass	0	108.9 ± 11.8	0.5 ± 0.1	2.06 ± 0.10 × 10^4
	Compound 17287	5 × 10^5	51.0 ± 0.8	0.6 ± 0.0	8.74 ± 0.13 × 10^3
	Shamban	1 × 10^6	55.9 ± 1.0	0.7 ± 0.0	8.85 ± 0.11 × 10^3
315	Polyamide-imide	0	144.9 ± 33.3	8.0 ± 4.0	4.25 ± 0.11 × 10^3
	Compound 17286	5 × 10^5	165.8 ± 9.2	8.7 ± 1.7	4.36 ± 0.15 × 10^3
	Shamban	1 × 10^6	145.2 ± 16.7	7.3 ± 2.0	4.06 ± 0.13 × 10^3
316	Polyimide	0	36.7 ± 4.2	2.8 ± 0.4	6.61 ± 0.47 × 10^3
	Compound 17242	5 × 10^5	49.6 ± 5.9	1.4 ± 0.2	7.20 ± 0.35 × 10^3
	Shamban	1 × 10^6	53.9 ± 0.4	1.4 ± 0.1	7.75 ± 0.13 × 10^3

MATERIAL: POLYIMIDE + GLASS FIBRE

SUPPLIER: ISOLA

Remarks:



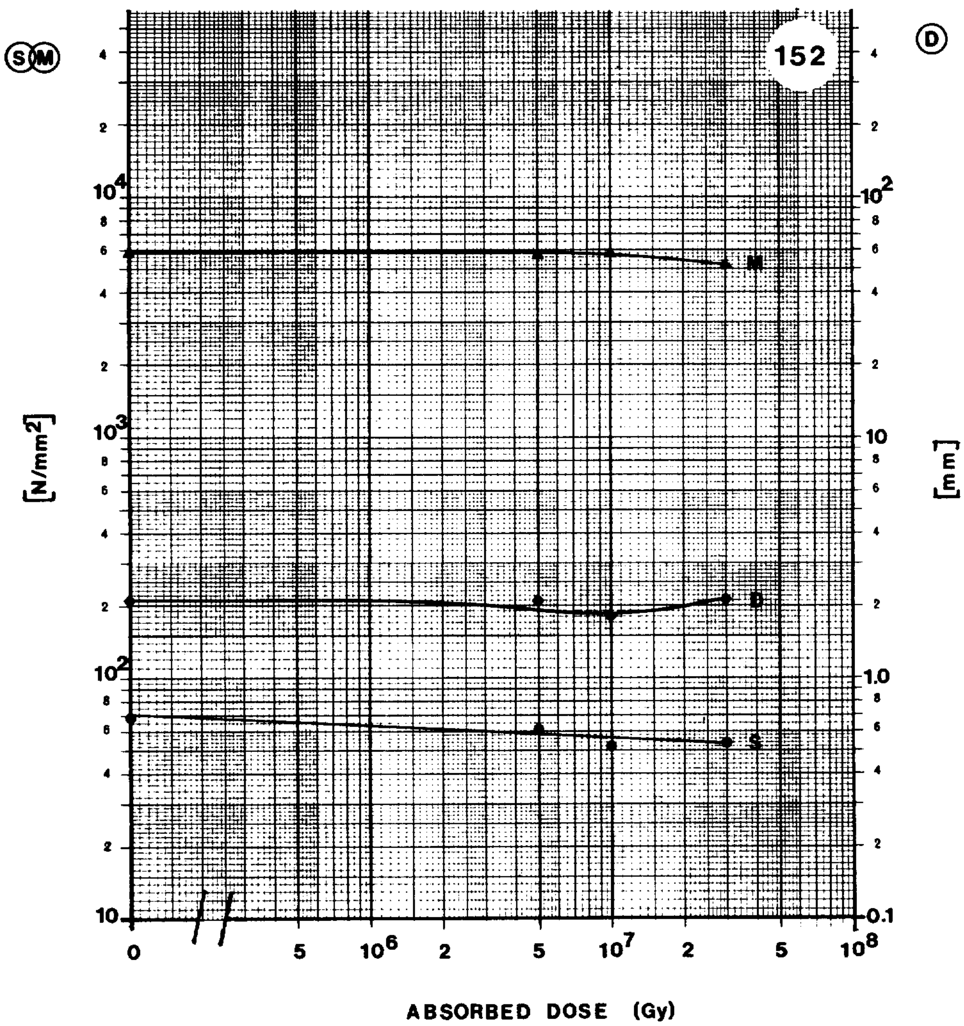
ABSORBED DOSE (Gy)

CURVE	PROPERTY	INITIAL VALUE	
S	Ultimate flexural strength	426.7	N/mm^2
D	Deflexion at break	3.3	mm
M	Modulus of elasticity	2.3×10^4	N/mm^2

MATERIAL: KINEL 5.502

SUPPLIER: RHÔNE-POULENC

Remarks: NO LONGER COMMERCIALLY AVAILABLE

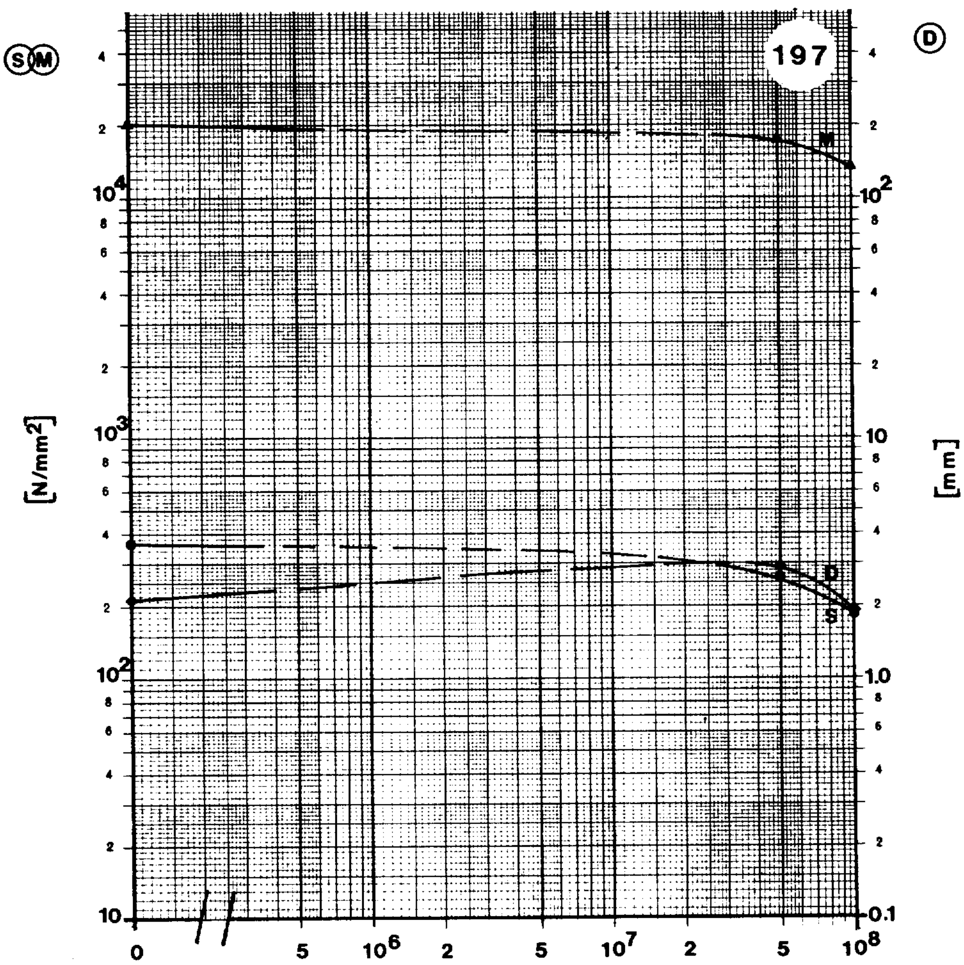


CURVE	PROPERTY	INITIAL VALUE	
S	Ultimate flexural strength	67.7	N/mm^2
D	Deflexion at break	2.1	mm
M	Modulus of elasticity	5.8×10^3	N/mm^2

MATERIAL: KINEL 5.504

SUPPLIER: RHÔNE-POULENC

Remarks:



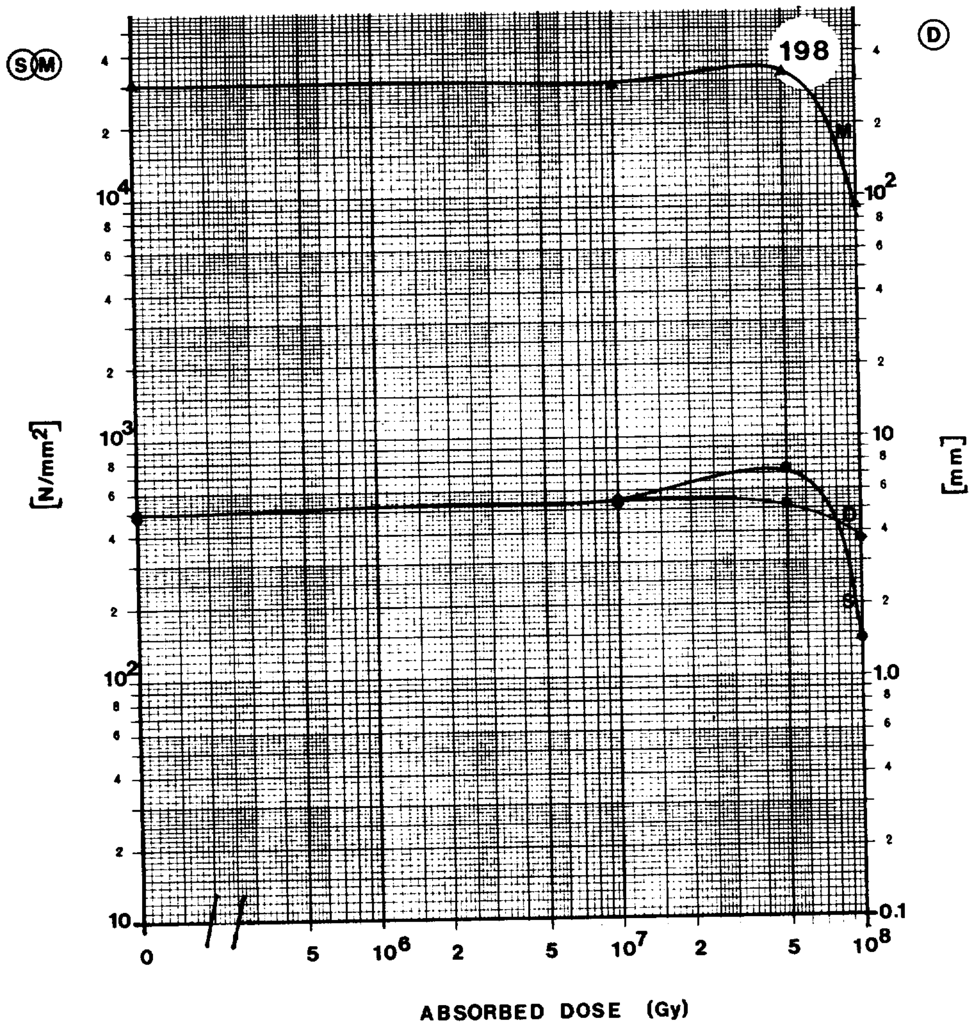
ABSORBED DOSE (Gy)

CURVE	PROPERTY	INITIAL VALUE	
S	Ultimate flexural strength	375.7	N/mm^2
D	Deflexion at break	2.1	mm
M	Modulus of elasticity	2.0×10^4	N/mm^2

MATERIAL: KERIMID 601 (GLASS FIBRE 181 E)

SUPPLIER: RHÔNE-POULENC

Remarks:

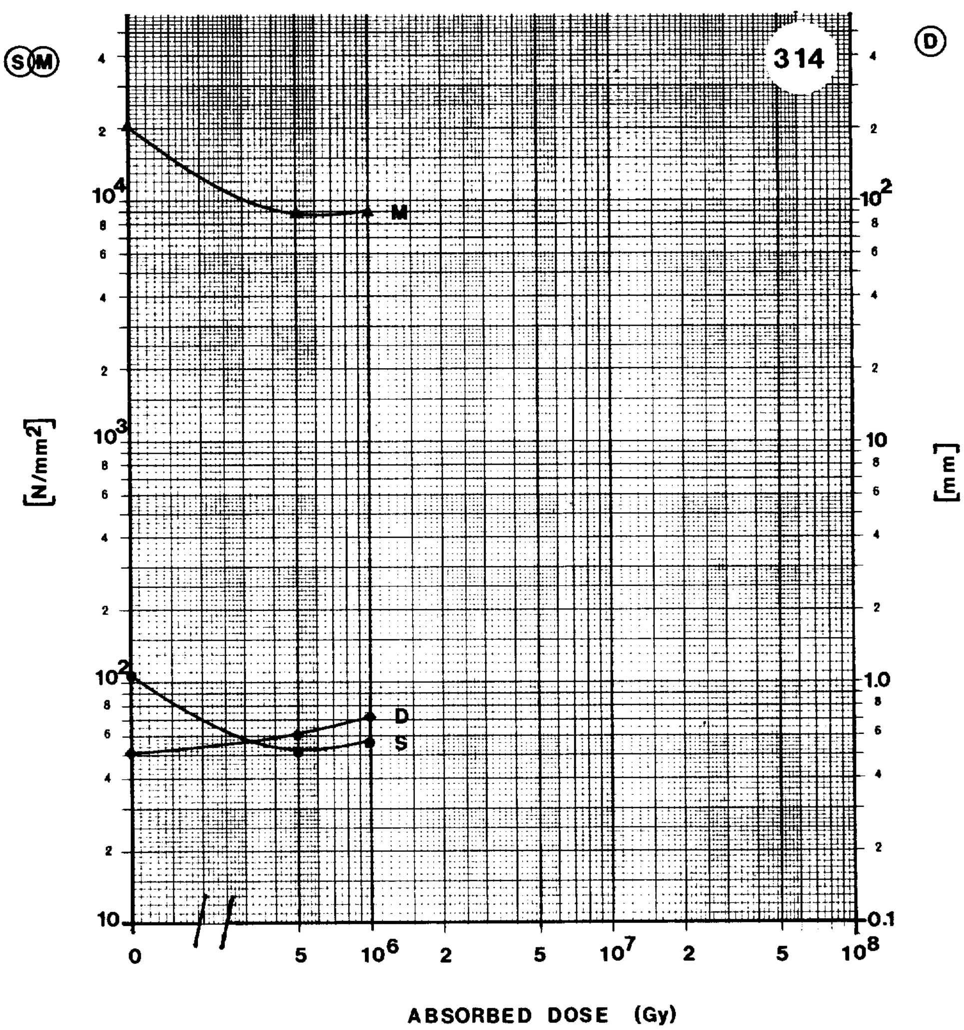


CURVE	PROPERTY	INITIAL VALUE	
S	Ultimate flexural strength	503.3	N/mm^2
D	Deflexion at break	5.0	mm
M	Modulus of elasticity	3.1×10^4	N/mm^2

MATERIAL: POLYIMIDE + GLASS; COMPOUND 17287

SUPPLIER: SHAMBAN

Remarks: USABLE FOR SEALS

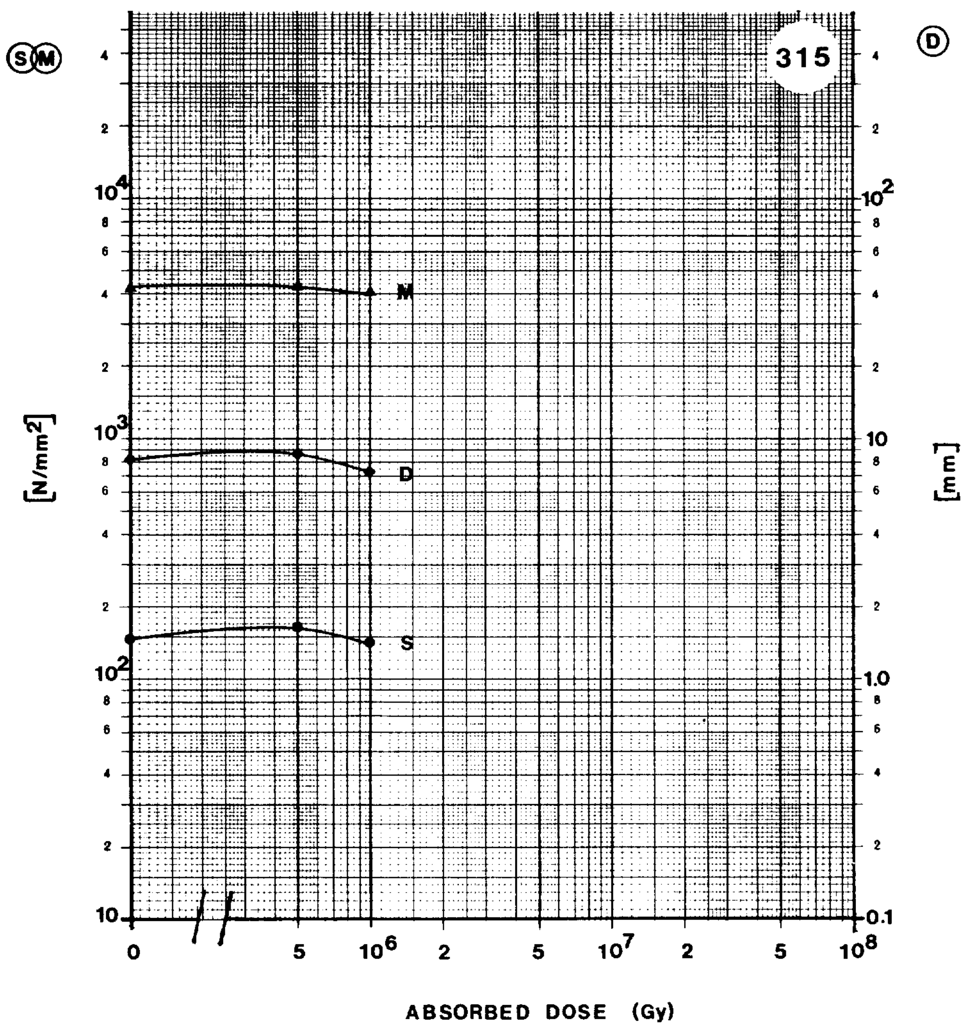


CURVE	PROPERTY	INITIAL VALUE	
S	Ultimate flexural strength	108.9	N/mm^2
D	Deflexion at break	0.5	mm
M	Modulus of elasticity	2.1×10^4	N/mm^2

MATERIAL: POLYAMIDE-IMIDE; COMPOUND 17286

SUPPLIER: SHAMBAN

Remarks: USABLE FOR SEALS

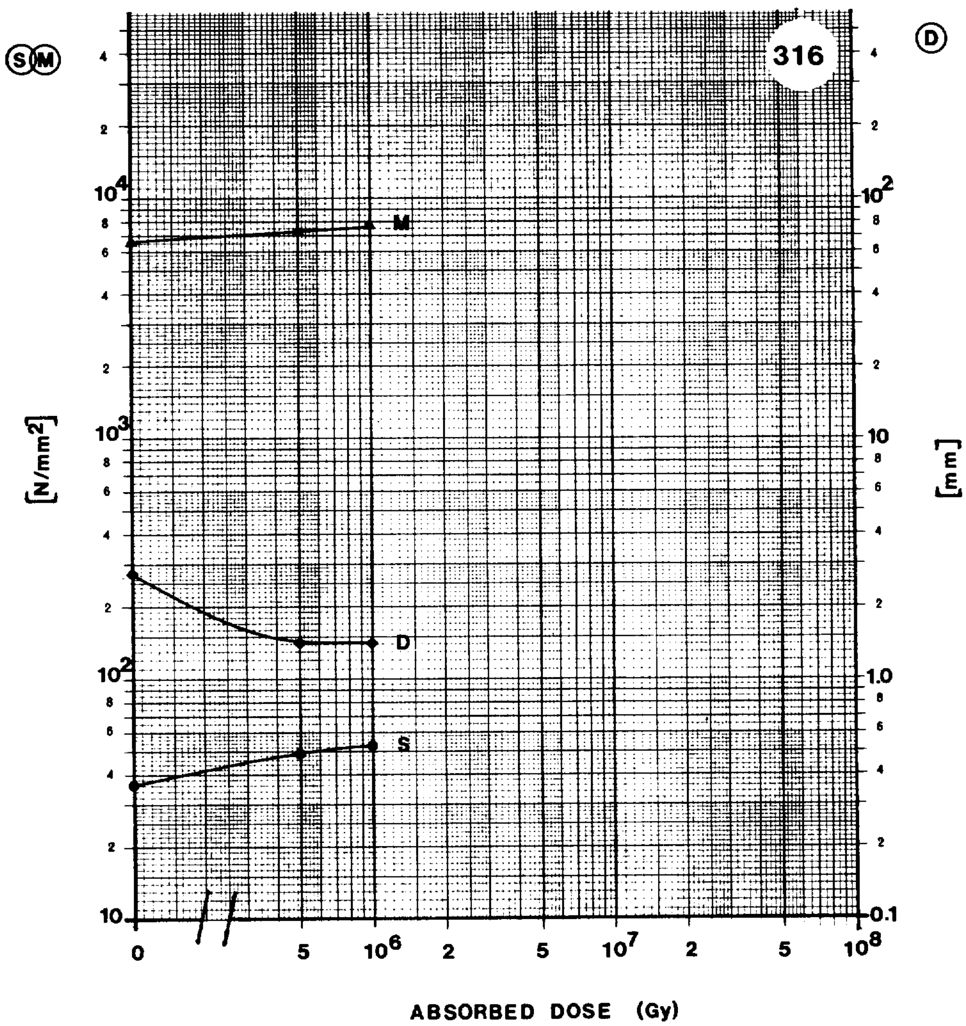


CURVE	PROPERTY	INITIAL VALUE
S	Ultimate flexural strength	144.9 N/mm^2
D	Deflexion at break	8.0 mm
M	Modulus of elasticity	4.3×10^3 N/mm^2

MATERIAL: Polyimide; compound 17242

SUPPLIER: Shamban

Remarks: Usable for seals



CURVE	PROPERTY	INITIAL VALUE	
S	Ultimate flexural strength	36.7	N/mm^2
D	Deflexion at break	2.8	mm
M	Modulus of elasticity	6.6×10^3	N/mm^2

Isocyanate resins[4], commonly known as polyurethanes, are formed by the reaction of compounds containing two or more active hydrogen groups, such as hydroxyl, amino, or carboxyl groups, with diisocyanates (O=C=N—R—N=C=O).

The principal compounds are polyesters and polyethers. Highly branched polyesters give rigid polyurethanes.

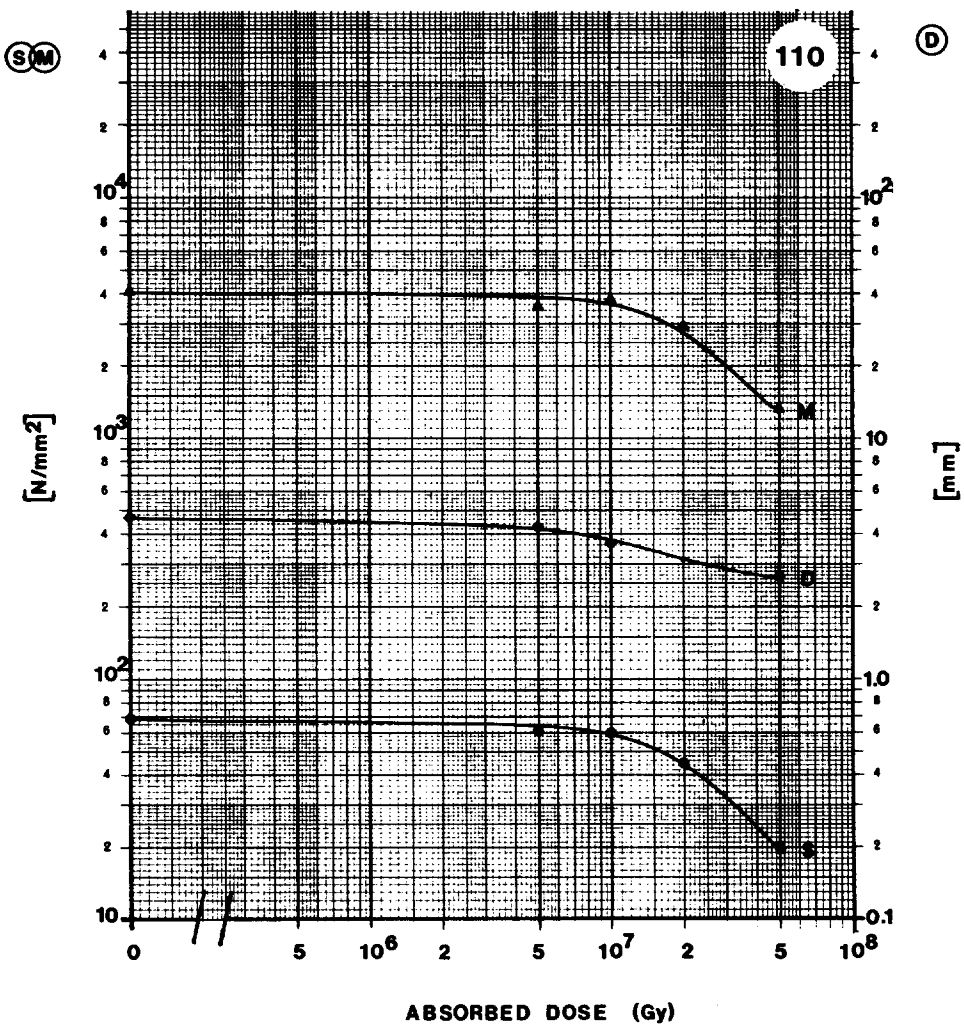
No.	Material and Supplier	Dose (Gy)	Ultimate flex. strength S (N/mm^2)	Deflexion at break D (mm)	Modulus of elasticity M (N/mm^2)
110	Polyurethane + $CaCO_3$	0	67.7 ± 1.0	4.6 ± 0.1	$4.04 \pm 0.09 \times 10^3$
		5×10^6	60.8 ± 2.9	4.3 ± 0.5	$3.50 \pm 0.05 \times 10^3$
		1×10^7	59.8 ± 5.9	3.7 ± 0.5	$3.82 \pm 0.19 \times 10^3$
		2×10^7	45.1 ± 6.9	3.1 ± 0.5	$2.94 \pm 0.18 \times 10^3$
	BBC Mannheim	5×10^7	19.6 ± 1.0	2.7 ± 0.1	$1.35 \pm 0.05 \times 10^3$
111	Polyurethane + Al_2O_3	0	65.7 ± 3.9	3.3 ± 0.2	$4.17 \pm 0.10 \times 10^3$
		5×10^6	53.0 ± 1.9	3.8 ± 0.2	$3.01 \pm 0.09 \times 10^3$
		1×10^7	49.0 ± 2.9	3.3 ± 0.2	$3.11 \pm 0.09 \times 10^3$
		2×10^7	43.2 ± 1.9	3.7 ± 0.2	$2.33 \pm 0.05 \times 10^3$
	BBC Mannheim	5×10^7	22.5 ± 1.0	2.9 ± 0.1	$1.37 \pm 0.13 \times 10^3$
112	Polyurethane + $CaCO_3$ + flexibilizer	0	32.4 ± 1.0		$1.62 \pm 0.06 \times 10^3$
		5×10^6	56.9 ± 1.0		$3.16 \pm 0.09 \times 10^3$
		1×10^7	60.8 ± 5.9	3.4 ± 0.8	$3.29 \pm 0.00 \times 10^3$
	BBC Mannheim	2×10^7	61.8 ± 1.0	3.0 ± 0.1	$3.39 \pm 0.05 \times 10^3$
159 (a)	DOBECKAN IF 200/25(100) + IF 200(Hardener) (35)	0	too flexible	for testing	
	24 h 25 °C	5×10^6			
		1×10^7	20.6 ± 3.9	2.1 ± 0.3	$1.82 \pm 0.17 \times 10^3$
	Dr. BECK	3×10^7	19.6 ± 2.9	1.3 ± 0.2	$1.84 \pm 0.07 \times 10^3$
160 (a)	DOBECKAN IF 1642/1(100) + IF 200(Hardener) (27)	0	too flexible	for testing	
	24 h 25 °C	5×10^6			
		1×10^7	31.4 ± 6.9	4.0 ± 0.8	$1.54 \pm 0.11 \times 10^3$
	Dr. BECK	3×10^7	22.6 ± 7.8	1.9 ± 1.0	$1.51 \pm 0.19 \times 10^3$

(a) No graph.

MATERIAL: Polyurethane + $CaCO_3$

SUPPLIER: BBC Mannheim

Remarks:

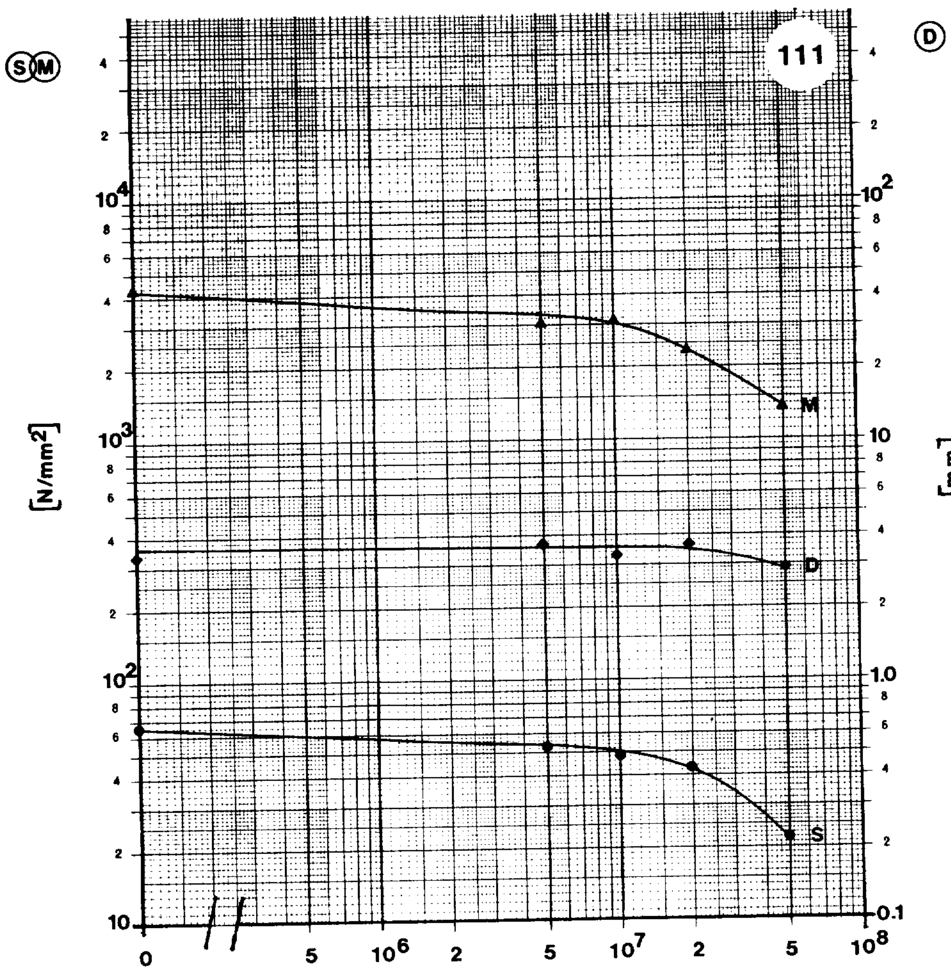


CURVE	PROPERTY	INITIAL VALUE	
S	Ultimate flexural strength	67.7	N/mm²
D	Deflexion at break	4.6	mm
M	Modulus of elasticity	4.0×10^3	N/mm²

MATERIAL: Polyurethane + Al_2O_3

SUPPLIER: BBC Mannheim

Remarks:

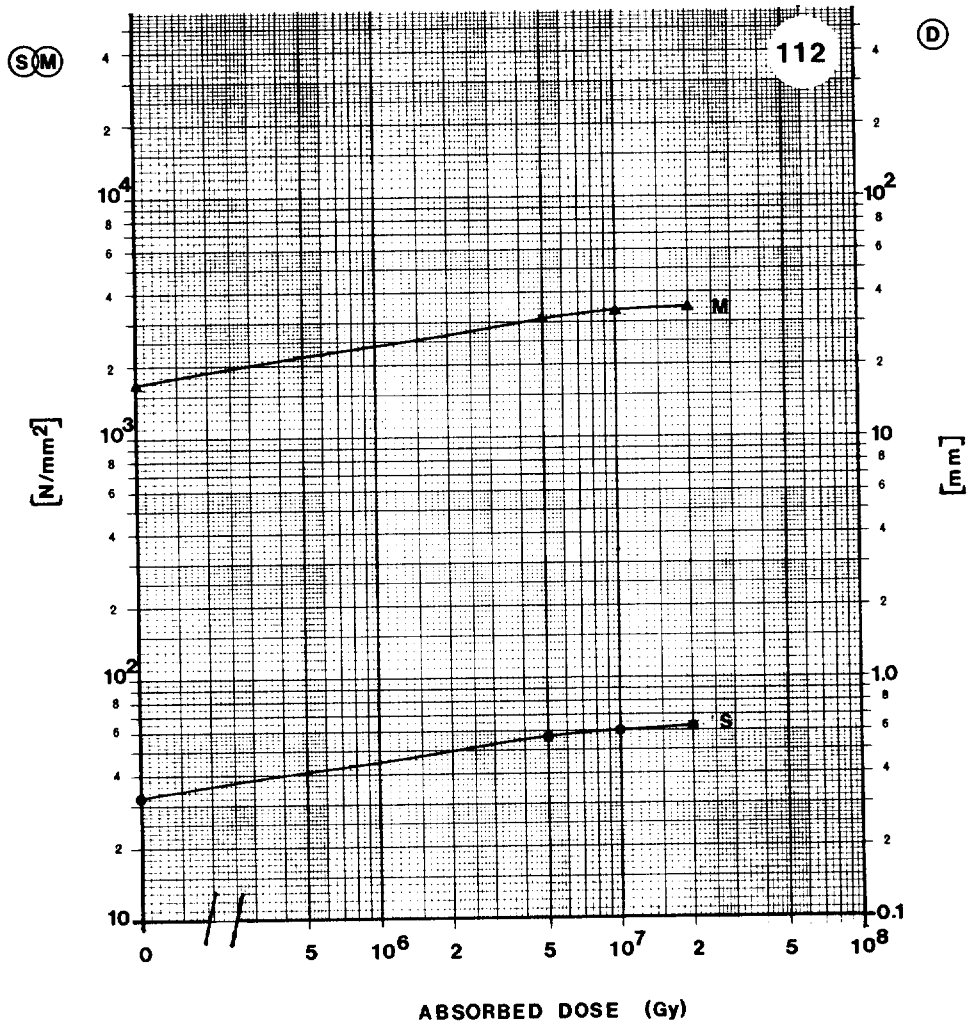


CURVE	PROPERTY	INITIAL VALUE	
S	Ultimate flexural strength	65.7	N/mm^2
D	Deflexion at break	3.3	mm
M	Modulus of elasticity	4.2×10^3	N/mm^2

MATERIAL: Polyurethane + $CaCO_3$ + flexibilizer

SUPPLIER: BBC Mannheim

Remarks:



CURVE	PROPERTY	INITIAL VALUE	
S	Ultimate flexural strength	32.4	N/mm^2
D	Deflexion at break	-	mm
M	Modulus of elasticity	1.6×10^3	N/mm^2

RESOFIL

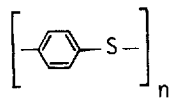
see PHENOLIC RESINS

RYTON

Polyphenylene sulfide

Ryton PPS*) is the trade name of Phillips Petroleum Company (USA) for polyphenyl sulfide.

Polyphenyl sulfide is a crystalline aromatic polymer consisting of para-substituted benzene rings connected by a single sulfur atom:



This polymer has a high thermal stability (melting point 288 °C), an outstanding chemical resistance.

*) This information is taken from a Phillips Petroleum Co. brochure.

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)
171	RYTON PPS	0	205.0 ± 4.9	3.4 ± 0.1	$1.31 \pm 0.02 \times 10^4$
	*)	5×10^6	200.1 ± 3.9	3.3 ± 0.1	$1.31 \pm 0.03 \times 10^4$
		1×10^7	199.5 ± 3.9	3.3 ± 0.1	$1.29 \pm 0.02 \times 10^4$
		5×10^6	205.0 ± 3.9	3.7 ± 0.0	$1.25 \pm 0.02 \times 10^4$
	**)	1×10^7	207.9 ± 3.9	3.7 ± 0.0	$1.27 \pm 0.02 \times 10^4$
	Phillips Petroleum	5×10^7	196.2 ± 3.9	3.4 ± 0.0	$1.25 \pm 0.02 \times 10^4$
310	RYTON PPS	0	202.1 ± 3.9	2.0 ± 0.1	$1.21 \pm 0.02 \times 10^4$
		5×10^6	208.9 ± 3.9	2.1 ± 0.1	$1.23 \pm 0.02 \times 10^4$
		1×10^7	205.5 ± 6.9	2.0 ± 0.1	$1.24 \pm 0.02 \times 10^4$
	Phillips Petroleum	5×10^7	201.1 ± 0.0	2.0 ± 0.0	$1.22 \pm 0.00 \times 10^4$

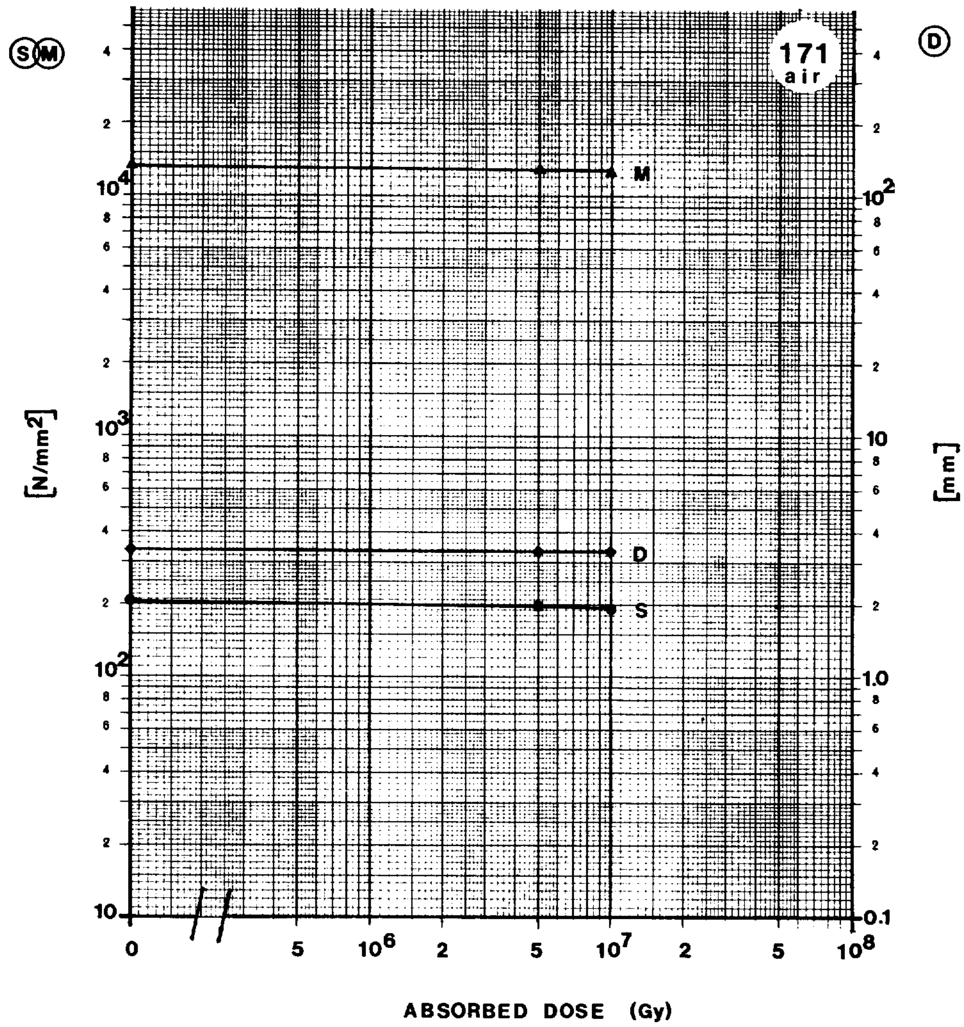
*) Irradiated in air

**) Irradiated in water

MATERIAL: RYTON PPS

SUPPLIER: Phillips Petroleum

Remarks:

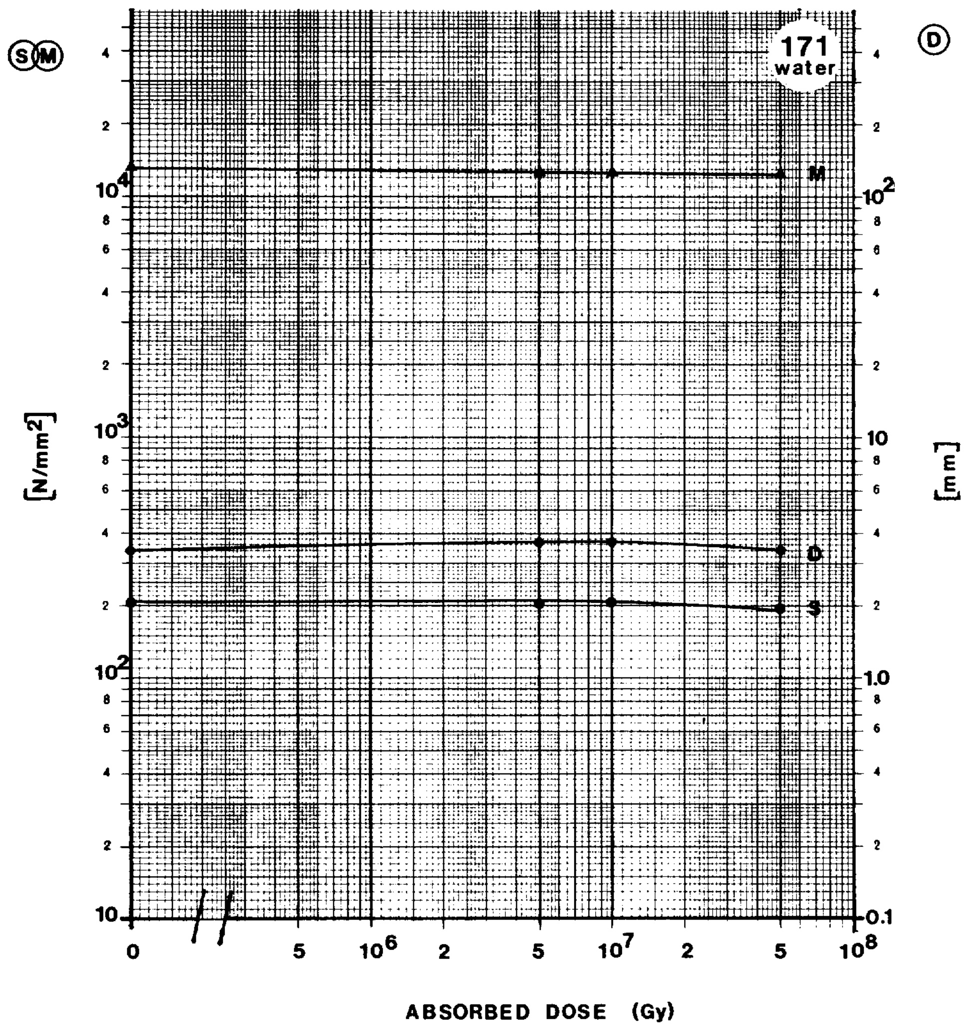


CURVE	PROPERTY	INITIAL VALUE	
S	Ultimate flexural strength	205.0	N/mm^2
D	Deflexion at break	3.4	mm
M	Modulus of elasticity	1.3×10^4	N/mm^2

MATERIAL: RYTON PPS

SUPPLIER: Phillips Petroleum

Remarks:

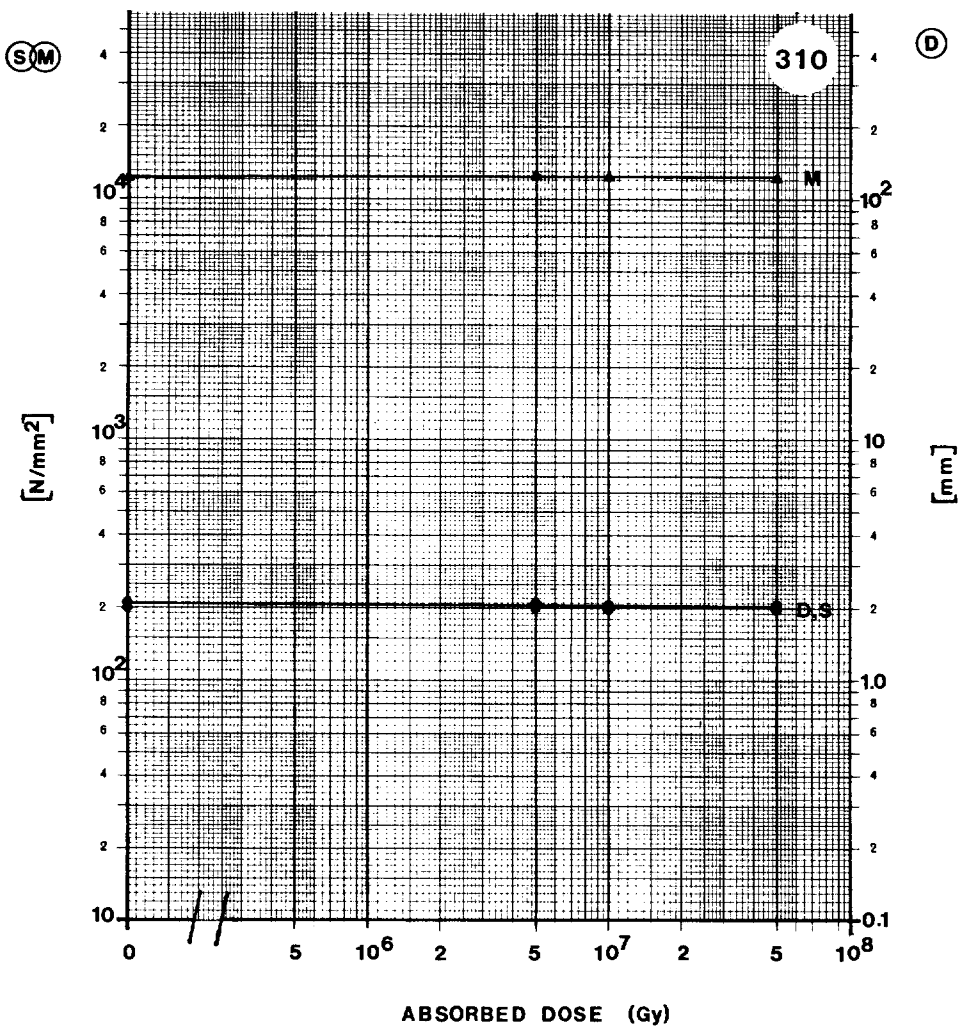


CURVE	PROPERTY	INITIAL VALUE	
S	Ultimate flexural strength	205.0	N/mm^2
D	Deflexion at break	3.4	mm
M	Modulus of elasticity	1.3×10^4	N/mm^2

MATERIAL: RYTON PPS

SUPPLIER: PHILLIPS PETROLEUM

Remarks:

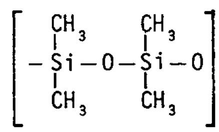


CURVE	PROPERTY	INITIAL VALUE	
S	Ultimate flexural strength	202.1	N/mm^2
D	Deflexion at break	2.0	mm
M	Modulus of elasticity	1.2×10^4	N/mm^2

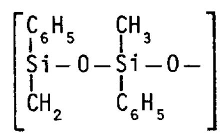
SAMICANIT, SAMICATHERM
see EPOXY RESINS

SILICONE RESINS

Silicone resins[16,20] for technical applications are in general cross-linked polymethylsiloxane:



or polymethylphenylsiloxane:

 .

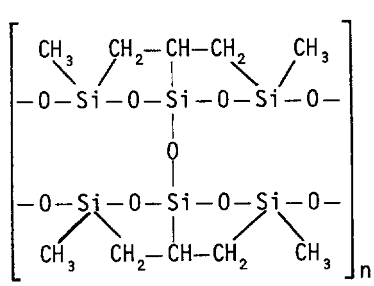
The elasticity and resistance to temperature increase with the content of the phenyl group.

The cross-linked (thermoset) polymer can be prepared using one of three different methods:

1) Hydrolizing dimethyldichlorosilane followed by air oxidization.
2) Co-condensing the product of a mixture of dimethyldichlorosilane and silicon tetrachloride.
3) Methylation of silicon tetrachloride followed by hydrolysis.

A typical reaction to produce a silicone resin is

$$x\ (CH_3)_2SiCl_2 + y\ CH_3SiCl_3 + z\ H_2O \longrightarrow$$

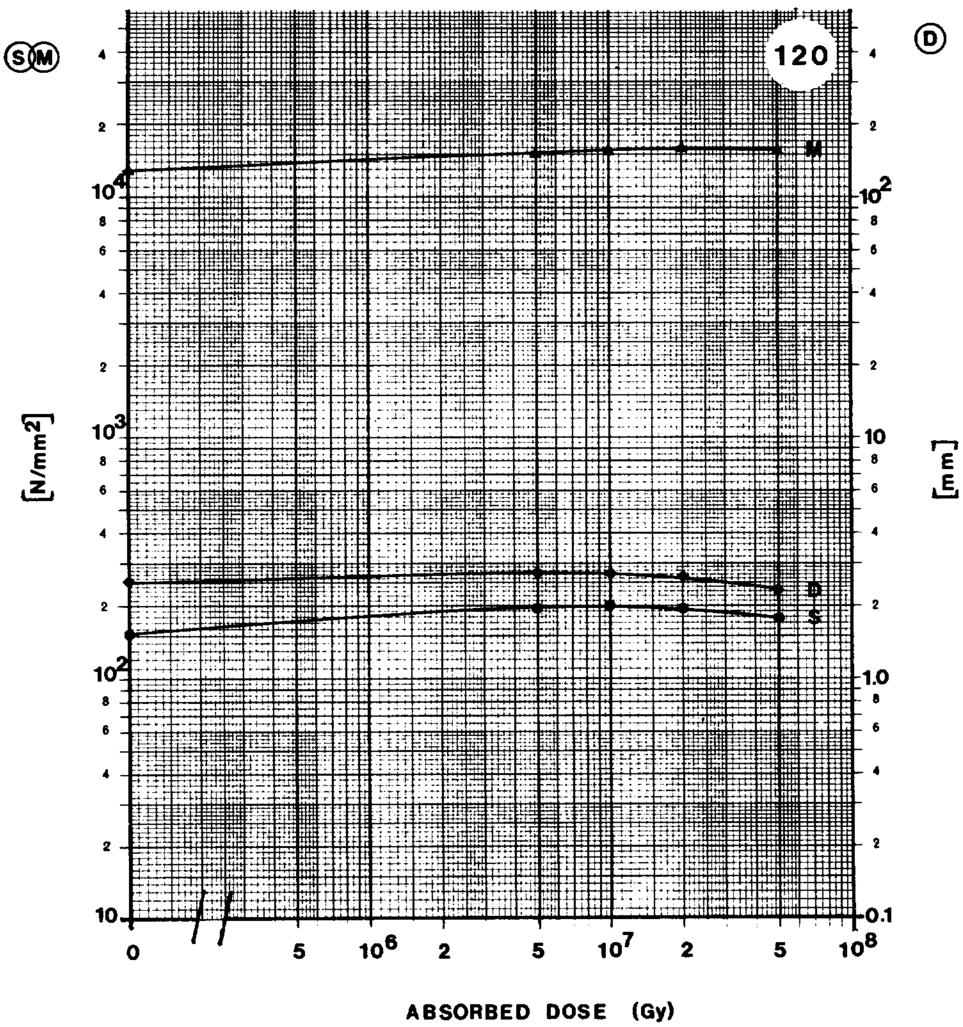
 + w HCl

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)
120	Silicone resin + glass fibre	0	152.0 ± 5.9	2.5 ± 0.2	$1.29 \pm 0.01 \times 10^4$
		5×10^6	198.2 ± 11.8	2.7 ± 0.2	$1.50 \pm 0.11 \times 10^4$
		1×10^7	200.1 ± 26.5	2.7 ± 0.1	$1.55 \pm 0.03 \times 10^4$
		2×10^7	194.2 ± 7.8	2.6 ± 0.2	$1.59 \pm 0.03 \times 10^4$
	ISOLA	5×10^7	178.5 ± 11.8	2.3 ± 0.2	$1.58 \pm 0.03 \times 10^4$
195	Solventless silicone resin Veridur® reinforced with a thermally sized glass-woven tape BBC Baden	0	109.8 ± 20.6	2.3 ± 0.3	$1.38 \pm 0.17 \times 10^4$
		5×10^7	96.1 ± 0.0	2.7 ± 0.1	$1.33 \pm 0.22 \times 10^4$

MATERIAL: SILICONE RESIN + GLASS FIBRE

SUPPLIER: ISOLA

Remarks:

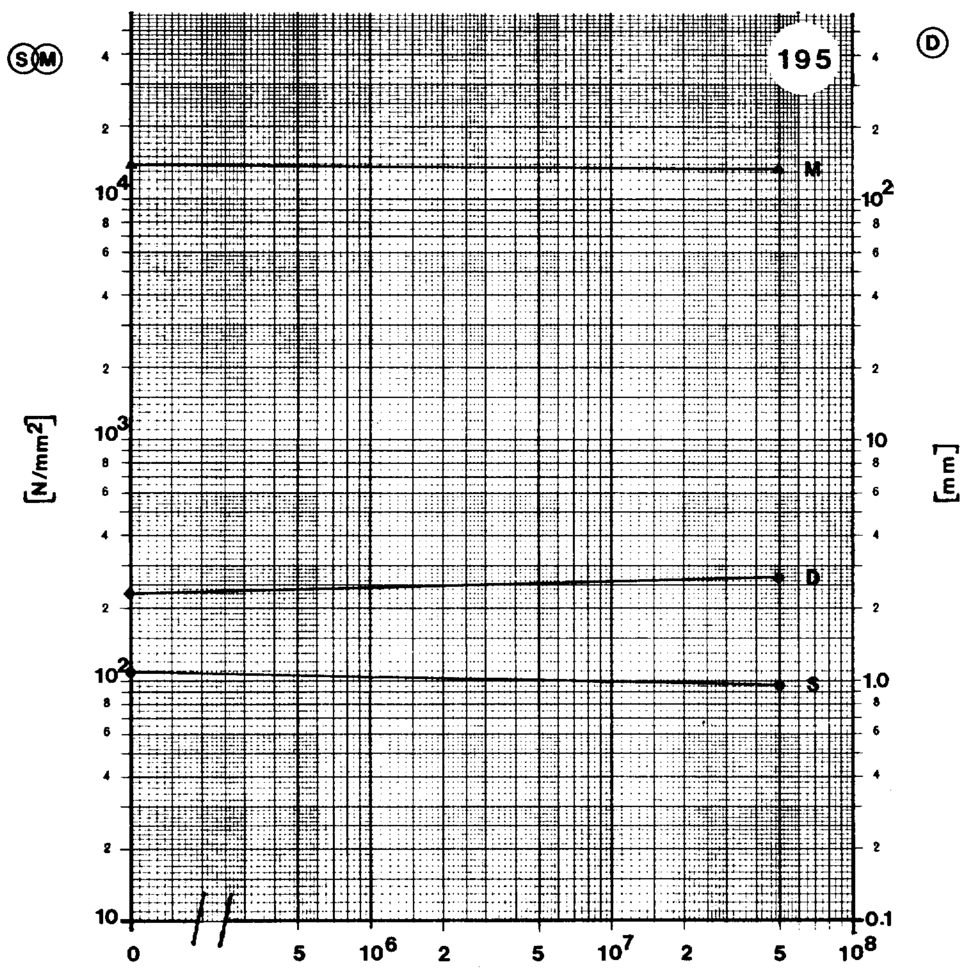


CURVE	PROPERTY	INITIAL VALUE	
S	Ultimate flexural strength	152.0	N/mm^2
D	Deflexion at break	2.5	mm
M	Modulus of elasticity	1.3×10^4	N/mm^2

MATERIAL: SOLVENTLESS SILICONE RESIN VERIDUR® REINFORCED WITH A THERMALLY SIZED GLASS-WOVEN TAPE

SUPPLIER: BBC BADEN

Remarks:



CURVE	PROPERTY	INITIAL VALUE	
S	Ultimate flexural strength	109.8	N/mm^2
D	Deflexion at break	2.3	mm
M	Modulus of elasticity	1.4×10^4	N/mm^2

VERIDUR

Trade name of BBC Baden
see SILICONE RESIN

VETRESIT

Trade name of MICAFIL
see NOVOLAC

VETRONIT

see EPOXY RESINS