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COMPILATION OF RADIATION DAMAGE TEST DATA

PART I: Cable insulating materials

INDEX DES RÉSULTATS D'ESSAIS DE RADIORÉSISTANCE

I^re PARTIE: Matériaux d'isolation de câbles

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Abstract

This report summarizes radiation damage test data on commercially available organic cable insulation and jacket materials: ethylene-propylene rubber, Hypalon, neoprene rubber, polyethylene, polyurethane, polyvinylchloride, silicone rubber, etc. The materials have been irradiated in a nuclear reactor to integrated absorbed doses from 5×10^5 to 5×10^6 Gy. Mechanical properties, e.g. tensile strength, elongation at break, and hardness, have been tested on irradiated and non-irradiated samples. The results are presented in the form of tables and graphs, to show the effect of the absorbed dose on the measured properties.

Résumé

Ce rapport donne les résultats d'essais sur la résistance aux rayonnements ionisants de matériaux utilisés comme isolations et gaines de câbles électriques, tels que le caoutchouc éthylène propylène, l'Hypalon, le caoutchouc néoprène, le polyéthylène, le polyuréthane, le chlorure de polyvinyle, le caoutchouc silicone, etc. Ces matériaux ont été irradiés dans un réacteur nucléaire, à des doses absorbées de 5×10^5 à 5×10^6 Gy. La résistance à la traction, l'allongement à la rupture et la dureté ont été testés sur des échantillons irradiés et non irradiés. Les résultats sont présentés sous forme de tableaux et de graphiques qui montrent l'effet de la dose absorbée sur ces propriétés mécaniques.

PU-TP/kw-msv-mv-pe-mn-mg

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TABLE DES MATIÈRES

1. Introduction

Investigations on degradation of materials and components which are exposed to ionizing radiation have been carried out in the past in many different fields of applications, such as for nuclear reactors, fusion reactors, high-energy accelerators, medical and industrial irradiation facilities, space projects, etc. At the European Organization for Nuclear Research (CERN), radiation damage test studies have been concentrated on organic and inorganic materials, electronic components, and metals which are used in the construction and operation of high-energy accelerators. Apart from electronic components and devices, the organic materials are the ones most sensitive to radiation. As a consequence of this, a large number of radiation tests have been made on these materials and the results are extensively documented[1-10]. Design engineers are, however, often faced with the problem of finding the desired information quickly within the available literature. We therefore decided to publish our radiation damage test results on organic materials in the form of a catalogue with an alphabetic compilation of data. For clarity, this will be done in two volumes:

- The present volume, Part I, will contain organic cable insulating materials mainly consisting of thermoplastics and elastomers.
- The second part will contain thermosetting and thermoplastic resins with a main contribution of epoxies used for magnet coil insulations.

We first describe some characteristic properties of the materials represented here, and define our end-point criteria for selection of radiation-resistant materials. Then we list the tests and test methods, and give the irradiation conditions. In Section 5 we explain the presentation of the data. It must be noted that all data have been obtained from accelerated tests carried out after irradiation in a nuclear reactor, and all tests were made at ambient temperature. After long-time exposures and ageing in other environments, a variation from the presented data may be expected.

2. Materials, characteristic properties, and end-point criteria

With a few exceptions, which are marked in the catalogue, all test data presented here have been obtained, over the past six or seven years, from materials available commerically. In the meantime, some of them may not be on the

1. Introduction

Des essais sur la dégradation des matériaux due aux rayonnements ionisants ont été effectués dans plusieurs domaines d'application, par exemple autour des réacteurs nucléaires et de fusion, des accélérateurs à haute énergie, dans les installations d'irradiation industrielle ou médicale, dans les centres d'études spatiales, etc. A l'Organisation européenne pour la recherche nucléaire (CERN), les essais de radiorésistance ont été concentrés sur des matériaux organiques et inorganiques, des composants électroniques et des métaux qui sont utilisés pour la construction et l'opération des accélérateurs à haute énergie. A part les composants électroniques, les matériaux organiques sont parmi les plus sensibles aux rayonnements ionisants. Par conséquent, une grande quantité de ces matériaux ont été soumis à des essais d'irradiation, et les résultats peuvent être trouvés dans de nombreuses publications[1-10]. Toutefois, les ingénieurs rencontrent souvent des difficultés pour trouver facilement, dans la littérature, 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. Pour éviter une trop grande complexité, nous avons choisi de le présenter dans l'ordre alphabétique des noms anglais de ces matériaux. Une liste complète de traductions, dans l'ordre alphabétique des noms français, est donnée dans le tableau 3. Pour des raisons pratiques, et afin de maintenir une certaine clarté, ce catalogue sera composé de deux parties:

- Le présent volume, qui constitue la première partie, contient des matériaux utilisés comme isolants et pour les gaines de câbles électriques.
- La seconde partie comprendra des résines thermodurcissables et thermoplastiques dont la plupart sont des époxydes utilisées dans l'isolation de bobines d'aimants.

Nous donnons d'abord quelques propriétés caractéristiques des matériaux présentés dans ce catalogue; nous définissons les critères de dégradation de ces propriétés, qui servent à sélectionner les matériaux radiorésistants. Nous décrivons ensuite les méthodes d'essais, ainsi que les conditions d'irradiation. Dans le chapitre 5 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 market any longer; this is marked on the tables and graphs of the catalogue, whenever known. The most common representatives are:

Ethylene-propylene rubber
Halar®
Hypalon®
Kapton®
Neoprene®
Polyethylene
Cross-linked polyethylene
Polyurethane
Polyvinylchloride
Silicone rubber

The materials have been supplied in general in connection with offers from European cable manufacturers according to CERN specifications for control and power cables which have to operate in radiation environments. A list of firms supplying such materials is given in Appendix 3.

In Table 1 we summarize the mechanical, electrical, and physical properties of the materials, and give some indications of behaviour in the case of combustion.

It is evident that for selection and classification of materials according to their radiation resistance, not all of the properties listed in Table 1 can be tested, and we have to restrict ourselves to a few characteristic and representative ones. In our case the mechanical properties were chosen. We justify this by our own experience and that of others[4)] that, in general, the mechanical degradation of plastic insulating materials due to ionizing radiation occurs before the degradation of the electrical and physical properties. Also, no important change of flammability has been observed with radiation[9)].

Among the mechanical properties, the most radiation-sensitive parameter is the elongation at break, which above a certain threshold dose partially decreases with increasing radiation dose. We therefore selected the elongation at break for our definition of the end-point criterion for elastic cable insulating materials: *we consider a cable insulating material to be radiation resistant up to a dose at which the elongation at break is 100% or more.*

This is in some cases in contradiction to international norms[11)], which in general require that 50% of the initial value of the considered parameter must be maintained in order to fully guarantee in-service operation. From experience, however, our definition has in the past been shown to be realistic and is also recognized by many cable manufactures.

vieillissement sous d'autres conditions, on peut s'attendre à un changement dans les résultats que nous avons obtenus.

2. Les matériaux, leurs propriétés caractéristiques et les critères de dégradation de ces propriétés

A part quelques exceptions, qui sont indiquées dans le catalogue, tous les résultats donnés ont été obtenus, au cours des six ou sept dernières années, sur des matériaux disponibles dans le commerce. Il est possible que quelques-uns 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. Les plus courants de ces matériaux sont:

Caoutchouc éthylène propylène
Halar®
Hypalon®
Kapton®
Neoprene®
Polyéthylène
Polyéthylène réticulé
Polyuréthane
Chlorure de pclyvinyle
Caoutchouc silicone

En général, les matériaux ont été fournis par des fabricants de câbles européens, suivant des spécifications du CERN pour des câbles de contrôle ou de puissance qui doivent être utilisés en présence de rayonnements ionisants. Une liste des fabricants qui ont fourni les échantillons est donnée en appendice 3.

Le tableau 1 donne un résumé des propriétés mécaniques, électriques et physiques des matériaux, ainsi que quelques indications sur leur comportement en cas de combustion.

Il est évident que, pour la sélection et la classification des matériaux selon leur résistance aux rayonnements, on ne peut pas tester toutes les propriétés données dans le tableau 1, et qu'il faut se limiter à quelques-unes des plus représentatives. Dans le cas présent, nous avons choisi les propriétés mécaniques. Ce choix se justifie par notre propre expérience, et celle d'autres auteurs[4)], qui nous a appris que la dégradation, due à l'irradiation, des propriétés mécaniques des isolants plastiques intervient généralement avant celle de leurs propriétés électriques et physiques. Nous avons aussi trouvé que les rayonnements n'ont que peu d'effet sur l'inflammabilité de ces matériaux[9)].

Parmi les propriétés mécaniques, on trouve que l'allongement à la rupture diminue sensiblement au-dessus d'un seuil de dose de

3. Tests and test methods

Whenever possible, tests have been carried out according to international norms[11]. Sometimes exceptions had to be made for practical or technical reasons such as the example given in the previous section.

The samples, usually 5 per test, were cut from 2 to 3 mm thick plates molded from the respective materials. The following tests have been carried out:

i) Tensile tests, according to ISO Recommendation R37, on dumb-bell samples mainly of type S1 with an over-all length of 115 mm. The tests were carried out on an Instron machine and allowed the following parameters to be determined:
   - tensile strength
   - elongation at break.

ii) Hardness Shore A, C, or D, according to ISO Recommendations R868, carried out on a Wolpert apparatus.

iii) Oxygen Index test, according to ASTM D-2863. This gives an indication of the inflammability of the plastic material. The oxygen index is defined as the minimum percentage of oxygen, in a mixture with nitrogen, required to keep a sample burning. Test results are reported only from non-irradiated materials. Some results of the change of this parameter with radiation are given in Ref. 9. The test apparatus was made by Stanton Redcroft.

4. 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[12]. The 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 in this report the unit 'Gray' is used for the absorbed dose.

Test samples have been irradiated in the 7 MW ASTRA pool reactor at Seibersdorf (Austria). The irradiation position, called 'Ebene 1', is placed in the pool at about 26 cm distance from the reactor core. The characteristics of the irradiation container and of the radiation field were the following:

rayonnement. C'est pour cette raison que nous l'avons choisi pour notre définition du critère de fin de vie des isolants de câbles élastiques: *Nous considérons qu'un isolant de câbles est résistant aux rayonnements si, à une dose-seuil, l'allongement à la rupture est supérieur à 100% de la longueur initiale de l'échantillon.*

Cette définition est dans certains cas en contradiction avec les normes internationales[11] qui demandent en général que 50% de la valeur initiale du paramètre considéré soit maintenu pour garantir le service. Toutefois, à l'expérience, notre définition a prouvé qu'elle était plus proche de la réalité; de plus, elle est admise par de nombreux fabricants de câbles.

3. Essais et méthodes d'essais

Nous avons exécuté nos essais selon les normes internationales[11] dans tous les cas où cela était possible. Pour des raisons pratiques ou techniques, quelques exceptions étaient inévitables.

Les matériaux ont été fournis sous forme de plaques, de 2 à 3 mm d'épaisseur, dont cinq échantillons ont été en général coupés pour chaque essai. Nous avons effectué les tests suivants:

i) Traction, selon la recommandation ISO R37, sur des échantillons S1, d'une longueur de 115 mm. Les essais ont été faits sur une machine Instron et ont permis de déterminer les paramètres suivants:
   - Résistance à la traction,
   - Allongement à la rupture.

ii) Dureté Shore A, C ou D, selon la recommandation ISO R868, mesurée sur un appareil Wolpert.

iii) L'indice d'oxygène, selon la norme ASTM D-2863. L'indice d'oxygène est défini comme le pourcentage minimum d'oxygène qui est nécessaire, dans un mélange avec de l'azote, pour entretenir une flamme. Cette valeur permet de classer les matériaux plastiques selon leur inflammabilité. La valeur de l'indice d'oxygène est donnée, dans ce catalogue, pour les matériaux non irradiés seulement. Quelques résultats du changement de ce paramètre avec la radiation peuvent être trouvés dans la référence 9. L'appareil de mesure était fabriqué par Stanton Redcroft.

Dimensions of irradiation container:	diameter 60 mm; length 200 mm;
Fast neutron flux (E > 1 MeV):	2-3 × 10^{10}n/cm^2sec;
Thermal neutron flux:	3-4 × 10^{11}n/cm^2 sec;
Gamma dose rate:	~ 10^5Gy/h;
Irradiation medium:	air;
Irradiation temperature:	~ 30°C (max. 40°C).

The samples have been irradiated, with a few exceptions, to three different integrated neutron and gamma doses of 5 × 10^5 Gy, 1 × 10^6 Gy, and 5 × 10^6 Gy.

The thermal neutron flux and the fast neutron spectrum are determined by means of activation detectors. The gamma dose is measured with an ionization chamber made of magnesium and filled with CO_2 or argon. More details about the radiation conditions and dosimetry are given in Ref. 13.

5. Presentation of data

As mentioned in the Introduction, the data are presented in alphabetical order. Materials which can be found in this catalogue are summarized in Appendix 1. Appendix 2 gives the popular names used and the corresponding chemical names. Appendix 3 lists the firms and cable manufacturers who supplied test samples for this study, and Appendix 4 explains all abbreviations which occur in this volume.

The data are presented in alphabetical order and under each letter, if there is any representative of a material, the following information can be found:

- material names (trade names and/or chemical names);
- some general information on the material, e.g. properties and chemical structure, and radiation resistance if no detailed data are included in this catalogue;
- tables and graphs containing the radiation damage test data.

The tables contain:
- the name of the material (e.g. PE);
- internal code number;
- material type, e.g. insulator, jacket, reference number of the supplier, etc.;
- supplier of the material;
- tensile test results for the irradiated and non-irradiated material:
    - R = tensile strength in N/mm^2,
    - E = elongation at break in %;

4. Conditions d'irradiation et dosimétrie

Remarque importante: De nouvelles unités SI dans le domaine des rayonnements ionisants ont été introduites en 1975 [12]. L'unité SI pour la dose absorbée est le gray, 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 à trois doses intégrées, 5 × 10^5 Gy, 10^6 Gy et 5 × 10^6 Gy, au réacteur ASTRA, à Seibersdorf (Autriche). Il s'agit d'un réacteur piscine de 7 MW, et la position d'irradiation, appelée 'Ebene 1' se trouve à 26 cm de distance du coeur du réacteur. Les caractéristiques du container d'irradiation, ainsi que du champ de rayonnement, sont les suivantes:

Dimensions du container d'irradiation:	diamètre 60 mm, longueur 200 mm;
Flux de neutrons rapides (E > 1 MeV):	2-3 × 10^{10}n/cm^2sec;
Flux de neutrons thermiques:	3-4 × 10^{11}n/cm^2sec;
Débit de dose gamma:	10^5Gy/h;
Milieu d'irradiation:	air;
Température d'irradiation:	~ 30°C (max. 40° C).

Le flux des neutrons thermiques et rapides a été mesuré par des détecteurs à activation, et la dose de gammas par une chambre d'ionisation en magnésium, remplie de CO_2 ou d'argon. Plus de détails sur les conditions des irradiations et la dosimétrie peuvent être trouvés dans la référence 13.

5. Présentation des résultats

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 (voir tableau 3). L'appendice 2 donne les noms déposés des matériaux, avec leur nom chimique. L'appendice 3 présente une liste des commerçants et fabricants d'isolants qui ont fourni des échantillons pour les essais. L'appendice 4 explique les abréviations.

Sous chaque lettre de l'alphabet on peut trouver les informations suivantes:

- Nom du matériau (nom du commerce et/ou nom chimique) et sa formule chimique, si connue.

- hardness Shore A, C or D is specified for the irradiated and non-irradiated material, e.g. 58 D;
- oxygen index for non-irradiated material.

The graphs contain:
- R, E, and hardness plotted as a function of absorbed dose for the same materials as listed in the preceding tables;
- information on material, type, and supplier;
- remarks, if any (e.g. used for SPS vacuum pump supply cable SVH2);
- initial value of R, E, hardness, and oxygen index.

6. Classification of materials

In Table 2 we give a classification of the materials in decreasing order of radiation resistance. The aim of this table is to indicate to the user the order of magnitude of the doses up to which the various materials may be used. It appears from the table that for a large number of them the dose limit for application in radiation environment is around 10^6 Gy.

Acknowledgements

The present study was initiated by J.B. Adams with the start of the SPS program, and was originally carried out in collaboration with M. Van de Voorde and the ISR Division. The radiation damage test studies have been continuously supported by M. Crowley-Milling (SPS Division) and A.J. Herz (HS Division).

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.

We would also like to thank the European cable manufacturers who have supplied the test samples, both for their interest in the subject and for the useful discussions which we had with representatives of many of these firms.

The irradiations have been carried out by the Österreichische Studiengesellschaft für Atomenergie in Vienna. The good collaboration with A. Burtscher and J. Casta from the ASTRA reactor in Seibersdorf is acknowledged.

Most of the mechanical tests and oxygen index tests presented in this report have been carried out by P. Beynel. His enthusiasm was very much appreciated.

- Quelques informations sur la radiorésistance du matériau pour le cas où les données détaillées manquent.
- Les résultats des essais de radiorésistance des matériaux sous forme de tableaux et graphiques.

Les tableaux contiennent:
- Le nom du matériau (par exemple, Hypalon, PE);
- Un numéro de code interne;
- Le type de matériau, par exemple, isolant, gaine, numéro de référence du fournisseur, etc.;
- Le nom du fournisseur du matériau;
- Les résultats des essais de traction pour le matériau irradié et non irradié (R, résistance à la traction en N/mm^2; E, allongement à la rupture en %);
- La dureté Shore A, C ou D pour le matériau irradié et non irradié (par exemple, 58D);
- L'indice d'oxygène pour le matériau non irradié.

Les graphiques contiennent:

- La variation des paramètres R, E et de la dureté, en fonction de la dose absorbée pour les mêmes matériaux que ceux donnés dans les tableaux mentionnés ci-dessus;
- L'information sur le matériau (type, fournisseur, etc.);
- Des remarques, s'il y a lieu;
- Les valeurs de R, E, dureté et indice d'oxygène, pour le matériau non irradié.

6. Classification des matériaux

Dans le tableau 2, nous classons les matériaux dans l'ordre décroissant de leur tenue aux radiations. Le but de ce tableau est uniquement de donner une idée de l'ordre de grandeur de la dose jusqu'à laquelle les produits peuvent être utilisés. Il ressort de ce tableau que, pour un grand nombre des matériaux étudiés, l'utilisation soit limitée à une dose se situant autour de 10^6 Gy.

Remerciements

Cette étude a été lancée par J. Adams, avec le début du programme SPS; initialement, elle a été effectuée en collaboration avec M. Van de Voorde et la Division ISR. Les études de dégradation des matériaux due au rayonnement ont été constamment soutenues par M. Crowley-Milling, Division SPS, et A.J. Herz, Division HS.

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Nous remercions particulièrement K. Goebel pour l'intérêt qu'il a montré pour cette étude et pour de nombreuses suggestions et discussions, ainsi que pour la révision de ce rapport.

Nous tenons aussi à remercier les fabricants de câbles européens qui ont fourni des échantillons d'essais; nous avons eu des discussions utiles avec les représentants de nombreuses firmes.

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.

La plupart des essais mécaniques et les mesures de l'indice d'oxygène 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 présentation de ce document.

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Table 1

Main characteristics of some materials

	PROPERTIES	EAR	EPR / EPDM std	EPR / EPDM f	EVA	HALAR	HYPALON	KAPTON	NEOPRENE	PUR	PVC std	PVC f	PE / XLPE	$XLPE_f$	SILICONE	TEFLON PTFE	TEFLON FEP	TEFZEL
PHYSICAL	Specific gravity (g/cm^3)	1.09	0.86		0.94		1.18	1.42	1.1-1.6	1.1-1.3	1.15-1.5		0.91-0.96		1.2-1.5	2.1-2.3		1.70
	Water absorption (%)				< 0.01			1.3	3-4	0.6-0.8			< 0.01		0.5-2.4	0	0.01	0.03
	Thermal conductivity (kcal/m.h.°C)												0.28					
	Thermal coefficient of expansion (10^{-5}/°C)								60-75				16-30		15-16			
ELECTRICAL	Dielectric constant at 1 kHz		2.6-4.0	3.2-4.5	4.2-5.3	2.6	7.5	3.5		6.0	4-8	5-6	2.2-4.5	2.7-4.5	3.0	2.1		2.6
	Loss factor at 1 kHz		0.02-0.004		0.05	0.001	0.1	0.003		0.005	0.07-0.08	0.07-0.08	0.05-0.0003	0.02-0.002	0.004	0.0002	0.0007	0.005
	Resistivity (Ωm)		10^{11}-10^{15}		10^{14}-10^{15}	10^{13}	10^{11}-10^{12}	10^{16}		10^{11}-10^{13}	10^{11}-10^{13}	10^{11}-10^{13}	10^{15}-10^{16}	10^{12}-10^{15}	10^{13}	10^{16}		10^{14}
	Dielectric strength (kV/mm)		15-30		20	20	15	160-280		15	15-20	15-20	15-25	15-27	28			16
MECHANICAL	Ultimate tensile strength (N/mm^2)	11.7-22	3.9-8.8		10-15	29.4	12.8	118-168	9.8-13.7	24.5-34.3	14.7-19.6	14.7-19.6	12.3-17.7	13.7-19.6	5.9-8.8	12-27	20-22	44.2
	Ultimate elongation (%)	270-500	250-550		320-600	200	300-500	50-70	250-400	400-600	250-270	190-270	600-650 / 200-350	200-350	400-600	100-800	300	200
	Hardness Shore D		15-36		32-40	85			20	30-40	44-60	46-60	32-55	46-60		55		75
	Abrasion resistance compared to PVC		worse		same to worse	good	same to better	better	better	better		same	same to worse	better	worse	good		good
	Chlorine content (g/kg)	0	0		0	2	90-200	0	100-200	0	250-270	110-300	0	40-110	0	0		
COMBUSTION	Toxic gases a) CO_2		m				l		l	m	m	m	m	m	l	l		
	HCl		o			h	l		m	o	h	h	o	m	o	o		
	SO_2		l				m		l	o	o	o	o	o	o	o		
	HF		o			h	o		o	o	o	o	o	o	o	l		
	HCN		o				o		o	l	o	o	o	o	o	o		
	Hydrocarbon		h				m		m	m	m	m	m	m	l	o		
	Max. temperature (°C) permanently	140-150	85-90			150-180	90	200	80	70	70		70 / 85-90		150	350	200	135
	t < 4 h		160-180				190		180	100	100-120		90-180	160-180	250			200
	t < 4 s		250								160		150	250				
	Oxygen index	20-25	18-21	23-31	18-22	50	25-35	50-90	25-35	19-22	24-26	28-35	18-20	23-30	24-35	95		30
	Fume production b)		h			l	h	l	h	m	h	h	h	h	l	l		l

a) toxic gas content
b) fume production
} l = low; m = medium; h = high; o = nothing; all gases contain CO

Std = standard material, f = special flame-retardant material.

Table 2

Classification of materials according to their radiation resistance

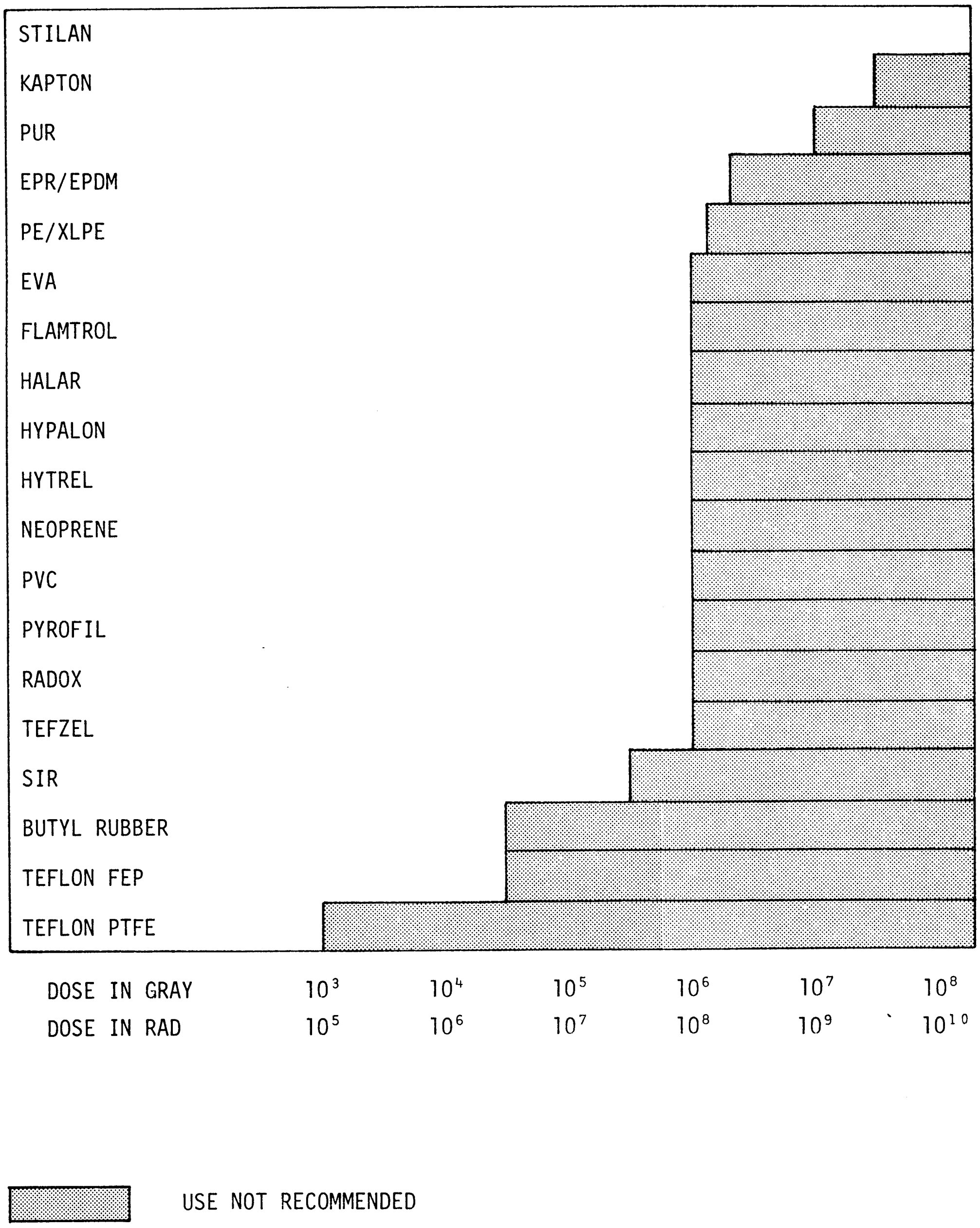


Tableau 3

Noms, en ordre alphabétique, de tous les matériaux cités dans ce volume, avec le titre sous lequel on peut les trouver dans le catalogue.

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

En français	Titre anglais
Caoutchouc butyle	Butyl rubber
Caoutchouc d'acrylique d'éthylène	EAR
Caoutchouc éthylène-propylène	EPR
Caoutchouc éthylène-propylène diène	EPDM
Caoutchouc silicone	Silicone rubber
Chlorostop	
Chlorure de polyvinyle	PVC
Desmopan	
Ethylène-acétate de vinyle	EVA
Flamtrol	
Fluoropolymère	
Halar	
Hypalon	
Hytrel	
Kapton	
Lupolen	
Neoprene	
Nordel	
Polychloroprène	Polychloroprene
Polyéthylène	PE
Polyéthylène chlorosulfonisé	Chlorosulfonated PE
Polyéthylène réticulé (PRC)	XLPE
Polyéthylène semi-conducteur	Semiconducting PE
Polyuréthane	PUR
Pyrofil	
Radox	
Silythene	
Stilan	
Teflon	
Tefzel	
Viton	

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 (present report)

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

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 and popular names,
and corresponding chemical names

CHLOROSTOP	Polyvinylchloride
DESMOPAN	Polyurethane
FLAMTROL	Polyolefin
HALAR	Copolymer of ethylene and chlorotrifluoroethylene
HYPALON	Chlorosulfonated polyethylene
HYTREL	Copolymer of polyethylene terephthalate and polyalkenglykolen
KAPTON	Polyimide
LUPOLEN	Polyethylene
NEOPRENE	Polychloroprene
NORDEL	Ethylene-propylene diene rubber
PYROFIL	Basis EPDM
RADOX	Polyolefin
SILYTHENE	Polyethylene
STILAN	Polyarylene
TEFLON PTFE	Polytetrafluoroethylene
TEFLON FEP	Copolymer of tetrafluoroethylene and hexafluoropropylene
TEFZEL	Copolymer of ethylene and tetrafluoroethylene
VITON	Copolymer of vinylidene fluoride and hexafluoropropylene

APPENDIX 3

Firms and cable manufacturers who supplied test samples contained in this catalogue

Firm	Material
AEG Telefunken Kabelwerke AG Mönchengladbach, West Germany	EVA, PUR
Alfacavi SPA Quattordio, Italy	EPR
Allied Chemical International SA Haasrode, Belgium	Halar
Aumann & Co. Zurich, Switzerland	PVC, Silicone rubber
BICC Wrexham, England	EPR, Hypalon, PE, PVC_f, XLPE
Cablexport Milan, Italy	(see Pirelli)
Câbles de Lyon Lyons, France	PE, PVC_f, XLPE
Dätwyler Altdorf, Switzerland	EPDM, PVC_f, XLPE
Dolder Basle, Switzerland	EPDM, Hypalon, Hytrel
DRAKA KABEL Amsterdam, The Netherlands	EPDM, Hypalon, PUR, PVC, Silicone rubber
Felten & Guilleaume Kabelwerke Cologne, West Germany	EPR, Hypalon, Neoprene, PE, PVC
FILECA Ste-Geneviève, France	PUR, PVC_f
Filotex Draveil, France	PVC_f
Gummi Maag Zürich, Switzerland	Viton
Huber & Suhner AG Zürich, Switzerland	EPDM, EPR, PE, PVC, PVC_f, Radox
IKO Kabelfabrik AB Grimsas, Sweden	PE, PVC, XLPE
Kabel-Metall Hannover, West Germany	EAR, EVA, EPR, PE, PUR, PVC, PVC_f
Leonische Drahtwerke AG Nürnberg, West Germany	PE, PVC

Firm	Material
Liljeholmens Kabelfabrik (new name ASEA KABEL AB) Stockholm, Sweden	EPR, PVC_f
Norsk Elektrisk Kabelfabrik Oslo, Norway	PE, PVC
Pirelli Milan, Italy	EPDM, EPR, Hypalon, Neoprene, PE, PVC, PVC_f, XLPE
Reliance Cords & Cables Ltd. London, England	PE
Rheinkabel Cologne, Germany	PUR
Siemens Munich, West Germany	PE
Sieverts Kabelwerk Sundbyberg, Sweden	PVC, PVC_f, XLPE
SIKA Zurich, Switzerland	Hypalon, PVC
SILEC Paris, France	EPR, Neoprene, PE, PVC_f, XLPE
Sprecher & Schuh AG Aarau, Switzerland	PE
Thomson-Brandt Bohain, France	PE, PVC_f, XLPE

APPENDIX 4

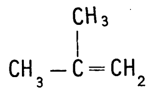
Abbreviations

BASF	Badische Anilin-und Sodafabrik AG, Ludwigshafen
CSP	chlorosulfonated polyethylene
E	elongation at break
EAR	ethyl-acrylate rubber
EPDM	ethylene-propylene diene rubber
EPR	ethylene-propylene rubber
EVA	ethylene vinyl-acetate
Gy	Gray (dose unit)
H	hardness
PE	polyethylene
PRC	polyéthylène réticulé
PUR	polyurethane
PVC	polyvinylchloride
PVC_f	polyvinylchloride flame retardant
R	tensile strength
SIR	silicone rubber
XLPE	cross-linked polyethylene

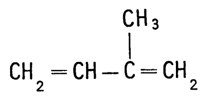
ALPHABETIC COMPILATION OF DATA

BUTYL RUBBER

A typical formulation comprises 97 parts of isobutylene (2-methylpropene)



and 3 parts of isoprene (2-methylbutadiene)



copolymerized in the presence of aluminium chloride. The general characteristics of a butyl rubber compound may be summarized as follows:

Dielectric constant at 1 kHz	7-10
Resistivity (Ω cm)	10^{12}-10^{14}
Dielectric strength (kV/mm)	6-20
Ultimate tensile strength (N/mm^2)	17-21
Ultimate elongation (%)	500-900
Hardness Shore A	40-90
Abrasion resistance compared to PVC	good

The material is not recommended for use in radiation areas. It is severely damaged above 5×10^4 Gy.

CHLOROSTOP

see PVC

CHLOROSULFONATED POLYETHYLENE (CSP)

see HYPALON

CROSS-LINKED POLYETHYLENE

see XLPE

DESMOPAN

trade name of Bayer

$$\left[\left(R-NH-\underset{\underset{O}{\parallel}}{C}-O-\text{polychain}-O-\underset{\underset{O}{\parallel}}{C}-NH-\right)_n\right]-NCO$$

see POLYURETHANE

EAR

ethyl-acrylate rubber

EPDM

ethylene-propylene diene rubber

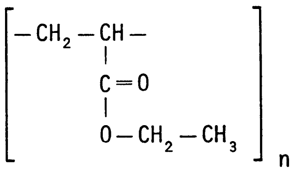
EPR

ethylene-propylene rubber

EVA

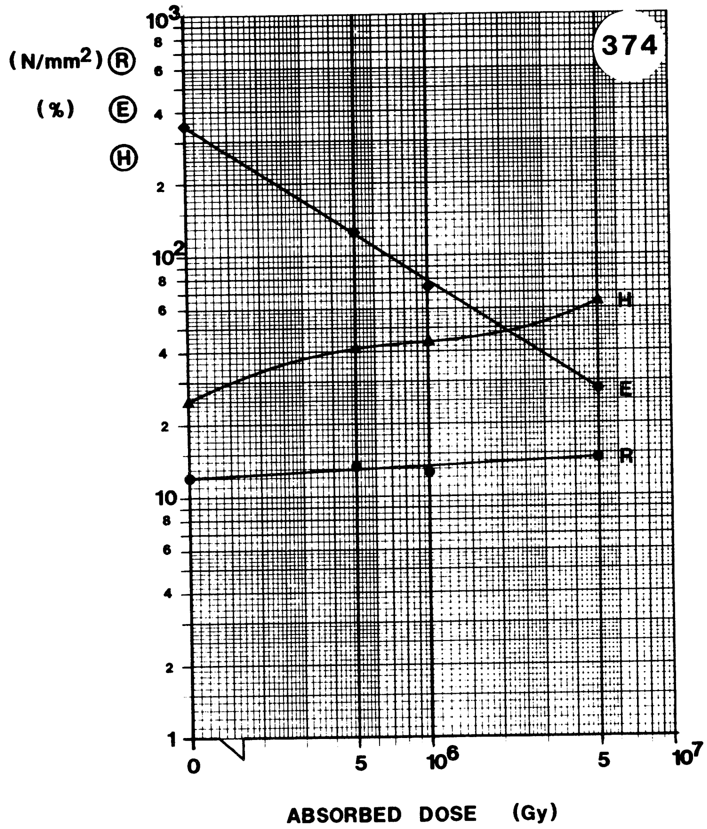
ethylene vinyl-acetate

ETHYL-ACRYLATE RUBBER



For general characteristics, see Table 1 in Section 2.

No.	Type	Supplier	Dose (Gy)	Traction R (N/mm²)	Traction E (%)	Hardness H	Oxygen index (%)
374	Jacket	Kabel-Metall	0	12.0	355	25 D	25.5
			5×10^5	13.1	124	41 D	
			1×10^6	12.6	74	44 D	
			5×10^6	14.5	28	64 D	



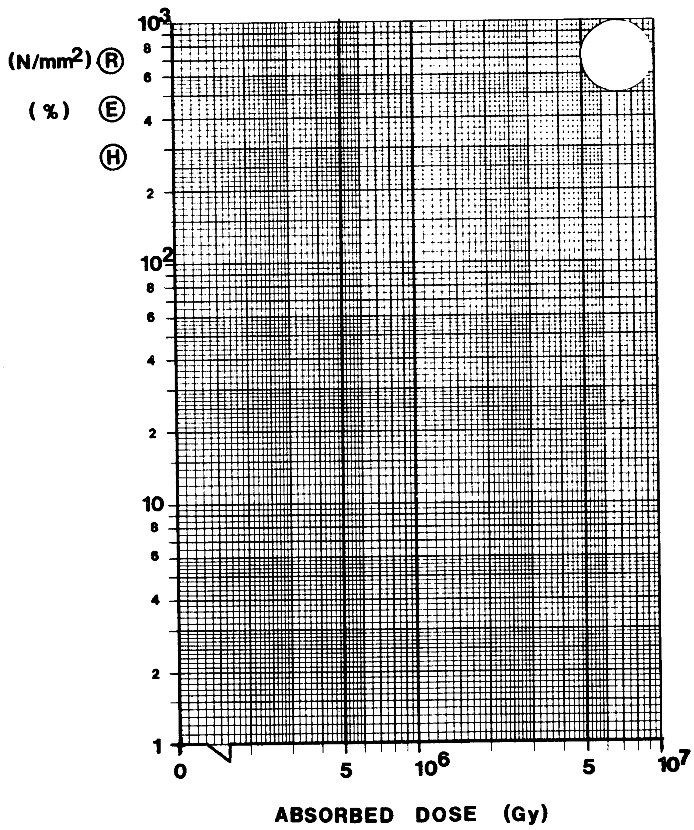
MATERIAL: EAR

TYPE: Jacket

SUPPLIER: Kabel-Metall

Remarks:

CURVE	PROPERTY	INITIAL VALUE
R	Tensile strength	12.0 N/mm2
E	Elong. at break	355 %
H	Hardness	25 Shore D
	Oxygen index	25.5



MATERIAL:

TYPE:

SUPPLIER:

Remarks:

CURVE	PROPERTY	INITIAL VALUE
R	Tensile strength	N/mm2
E	Elong. at break	%
H	Hardness	Shore C,D
	Oxygen index	

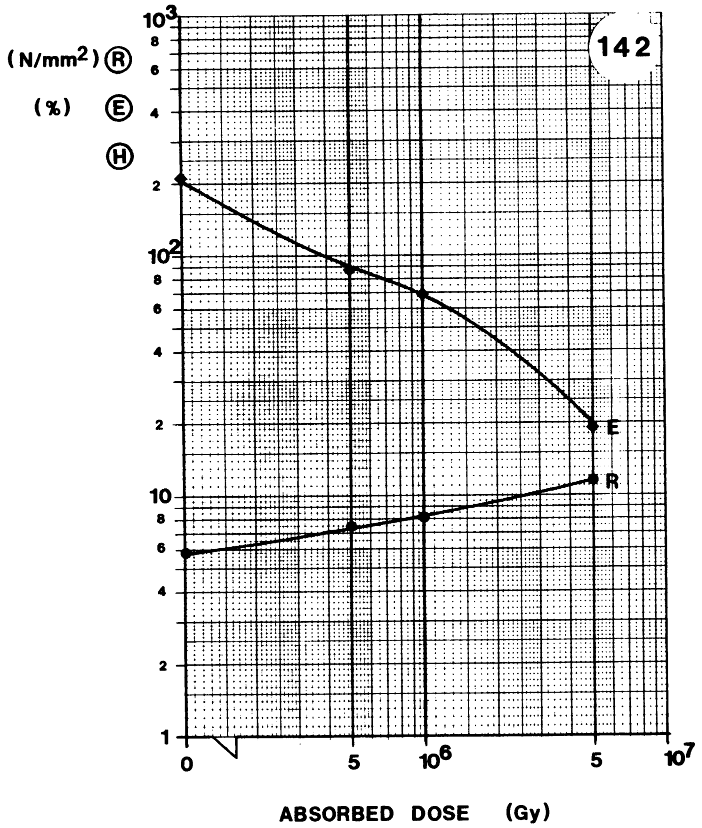
ETHYLENE-PROPYLENE DIENE RUBBER

Ethylene-propylene containing 1-2% of radical of diene. Properties almost identical to those of EPR.

For general characteristics, see Table 1 in Section 2.

No.	Type	Supplier	Dose (Gy)	Traction R (N/mm²)	Traction E (%)	Hardness H	Oxygen index (%)
142	3205 A	DRAKA	0	5.7	210		19.7
			5×10^5	7.3	88		
			1×10^6	8.0	69		
			5×10^6	11.5	19		
194	High-voltage insulator	Pirelli	0	7.0	419		
			5×10^5	6.0	165		
			1×10^6	5.5	86		
			5×10^6	5.5	25	63 C	
195	Medium-voltage insulator	Pirelli	0	7.9	522		
			5×10^5	5.3	249		
			1×10^6	3.9	116		
			5×10^6	5.0	14	66 D	
196	Low-voltage insulator	Pirelli	0	5.2	472		
			5×10^5	2.4	207		
			1×10^6	4.6	95		
			5×10^6	8.4	9		
293	Insulator (4-5571)	Dätwyler	0	12.3	184	26.5 D	23.5
			5×10^5	12.5	119	26 D	
			1×10^6	12.4	96	27.5 D	
			5×10^6	9.1	41	28 D	
303	Nordel, insulating compound	Dolder	0	7.0	416	51 A	18.5
			5×10^5	6.2	166	61 A	
			1×10^6	6.5	146	66 A	
			5×10^6	6.2	51	80 A	
304	Nordel, insulating compound	Dolder	0	14.4	364	27.5 D	18.5
			5×10^5	12.8	185	27 D	
			1×10^6	10.7	96	26 D	
			5×10^6	7.6	32	30 D	

No.	Type	Supplier	Dose (Gy)	Traction R (N/mm²)	Traction E (%)	Hardness H	Oxygen index (%)
305	Nordel, flame retardant	Dolder	0	11.0	190	24.5 D	29.0
			5×10^5	10.1	134	25 D	
			1×10^6	9.9	79	25 D	
			5×10^6	9.4	33	37 D	
306	Nordel, flame retardant	Dolder	0	10.9	217	21 D	28.5
			5×10^5	9.2	136	23 D	
			1×10^6	9.1	91	22.5 D	
			5×10^6	7.9	43	32 D	
338	Basis EPDM-PE, jacket (4-9302-3-13)	Dätwyler	0	5.1	135	37 D	30.0
			5×10^5	7.1	63	43 D	
			1×10^6	8.3	54	45 D	
			5×10^6	11.9	29	53 D	
339	Pyrofil, basis EPDM, insulator (4-5571-2)	Dätwyler	0	10.5	154	27 D	24.0
			5×10^5	10.0	100	31 D	
			1×10^6	9.8	78	31 D	
			5×10^6	8.0	37	32 D	
340	Pyrofil, basis EPDM, jacket (KECM 156/4)	Dätwyler	0	9.4	122	28 D	27.0
			5×10^5	10.8	82	31.5 D	
			1×10^6	9.4	62	30 D	
			5×10^6	9.3	28	36 D	
347	(T 2245/18)	Huber & Suhner	0	6.9	560	17 D	30.0
			5×10^5	3.3	272	17 D	
			1×10^6	2.8	162	18 D	
			5×10^6	4.4	41	27.5 D	



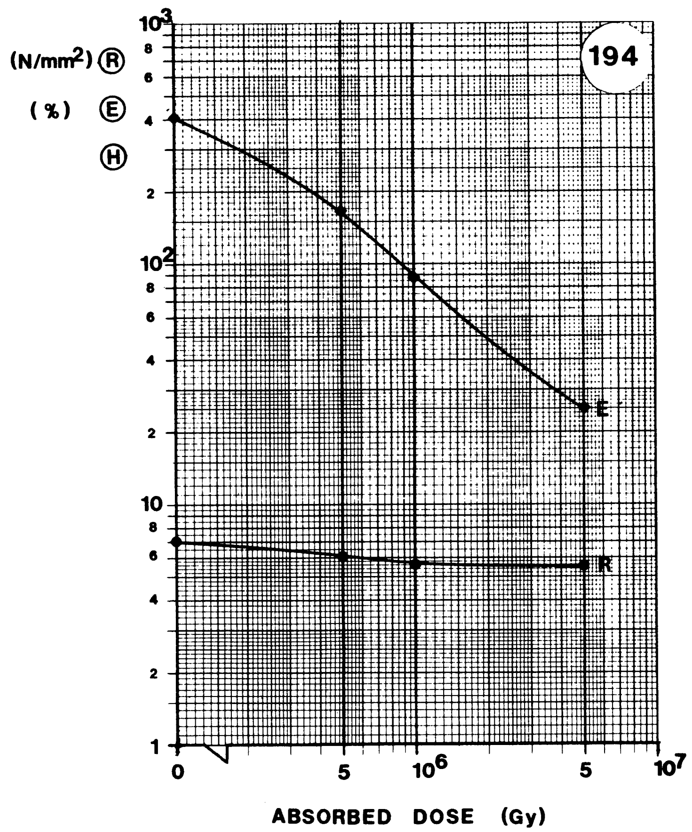
MATERIAL: EPDM

TYPE:

SUPPLIER: DRAKA

Remarks:

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	5.7	N/mm2
E	Elong. at break	210	%
H	Hardness	-	Shore C,D
	Oxygen index	19.7	



MATERIAL: EPDM

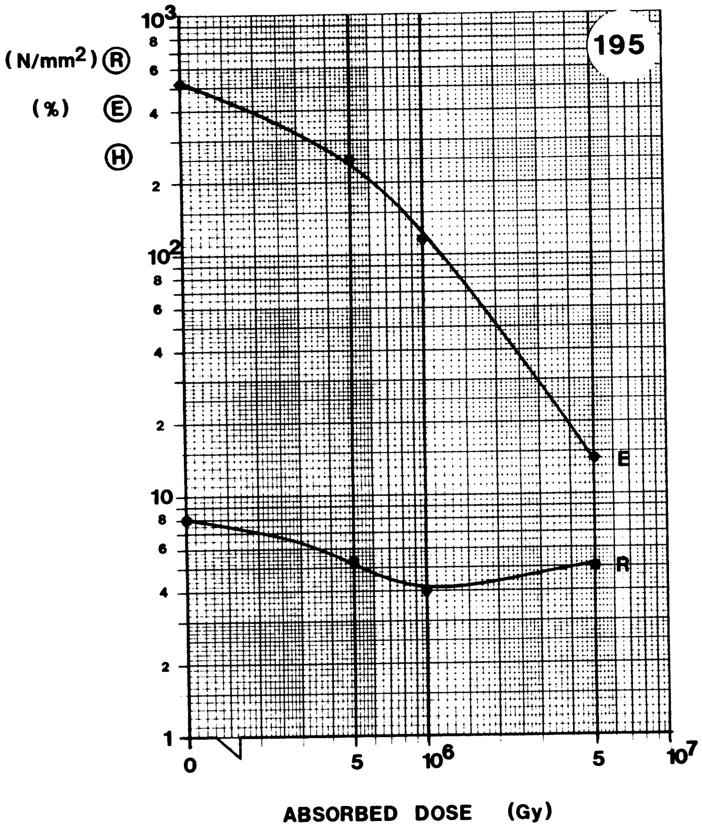
TYPE: High-voltage insulator

SUPPLIER: Pirelli

Remarks:

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	7.0	N/mm2
E	Elong. at break	419	%
H	Hardness	-	Shore C,D
	Oxygen index	-	

EPDM



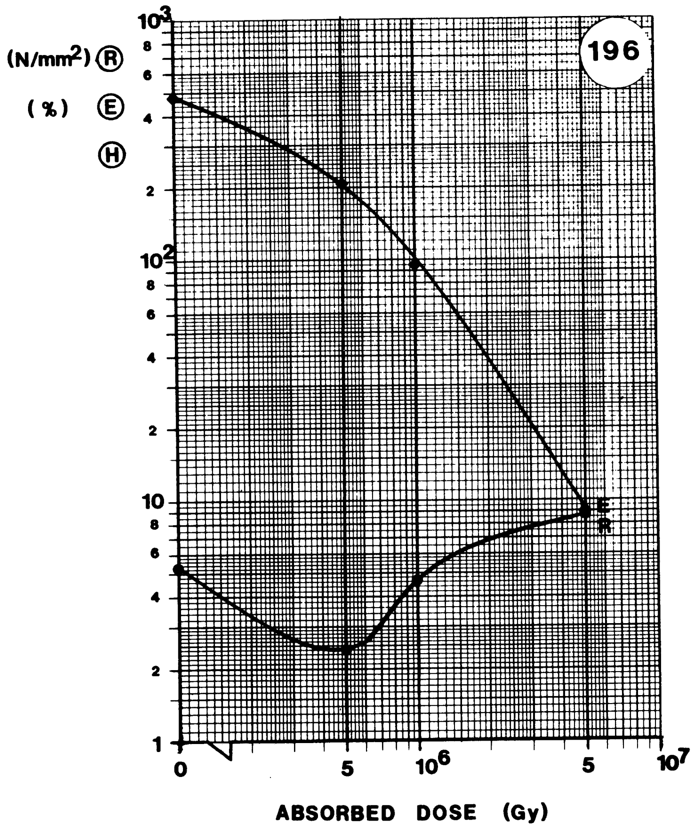
MATERIAL: EPDM

TYPE: Medium-voltage insulator

SUPPLIER: Pirelli

Remarks:

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	7.9	N/mm^2
E	Elong. at break	522	%
H	Hardness	-	Shore C,D
	Oxygen index	-	



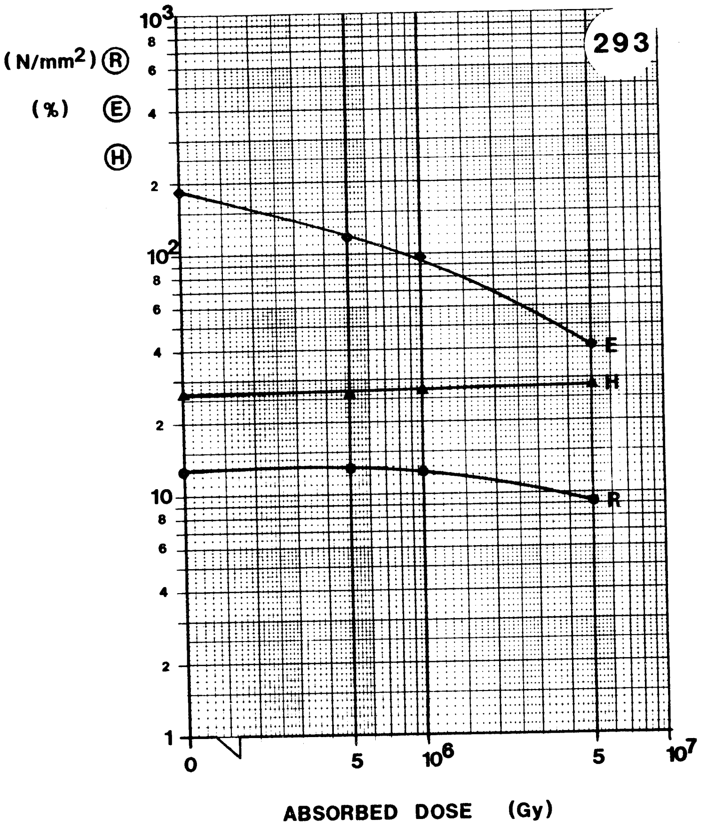
MATERIAL: EPDM

TYPE: Low-voltage insulator

SUPPLIER: Pirelli

Remarks:

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	5.2	N/mm^2
E	Elong. at break	472	%
H	Hardness	-	Shore C,D
	Oxygen index	-	



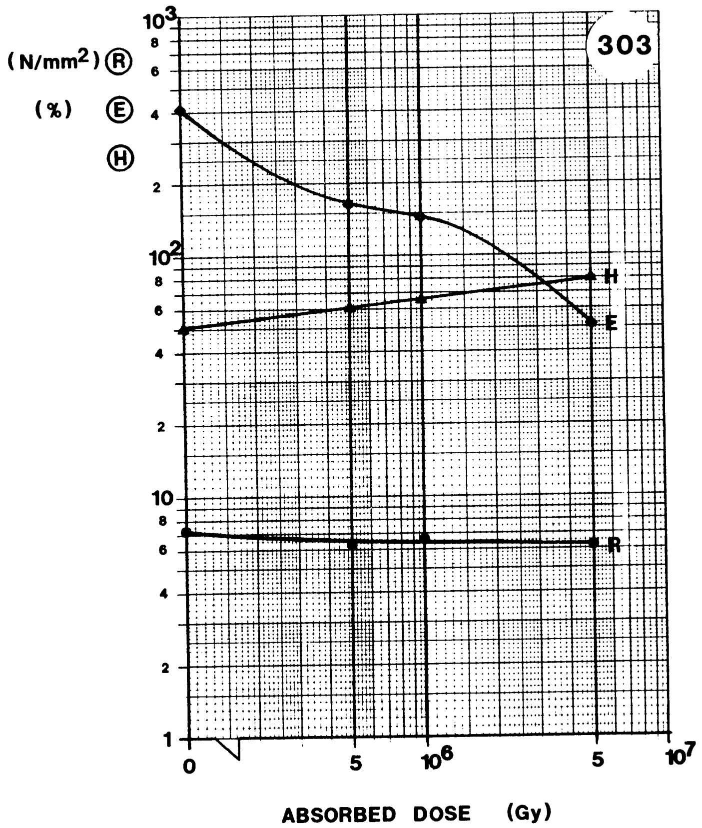
MATERIAL: EPDM

TYPE: Insulator

SUPPLIER: Dätwyler

Remarks:

CURVE	PROPERTY	INITIAL VALUE
R	Tensile strength	12.3 N/mm^2
E	Elong. at break	184 %
H	Hardness	26.5 Shore D
	Oxygen index	23.5



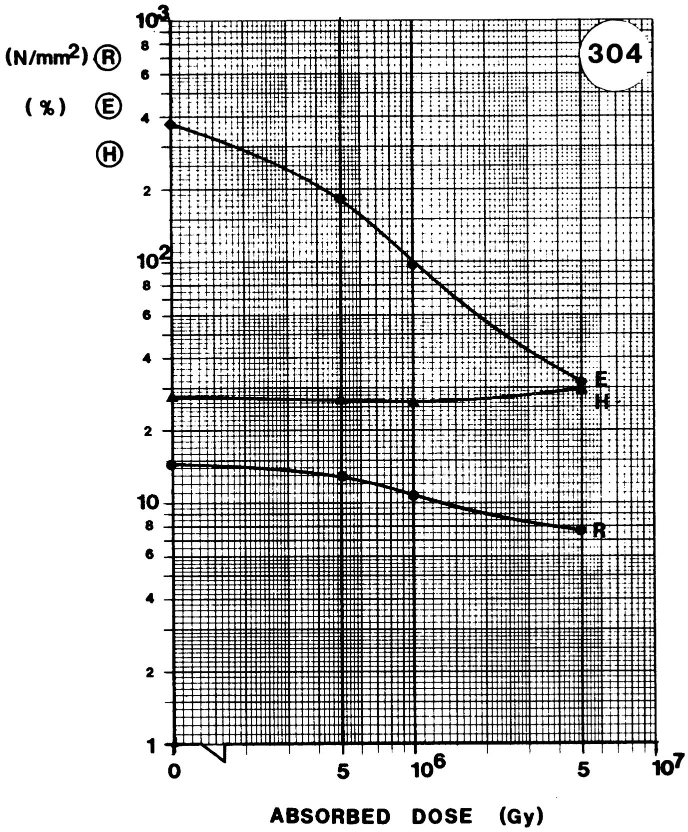
MATERIAL: EPDM

TYPE: Nordel, insulating compound

SUPPLIER: Dolder

Remarks:

CURVE	PROPERTY	INITIAL VALUE
R	Tensile strength	7.0 N/mm^2
E	Elong. at break	416 %
H	Hardness	51 Shore A
	Oxygen index	18.5



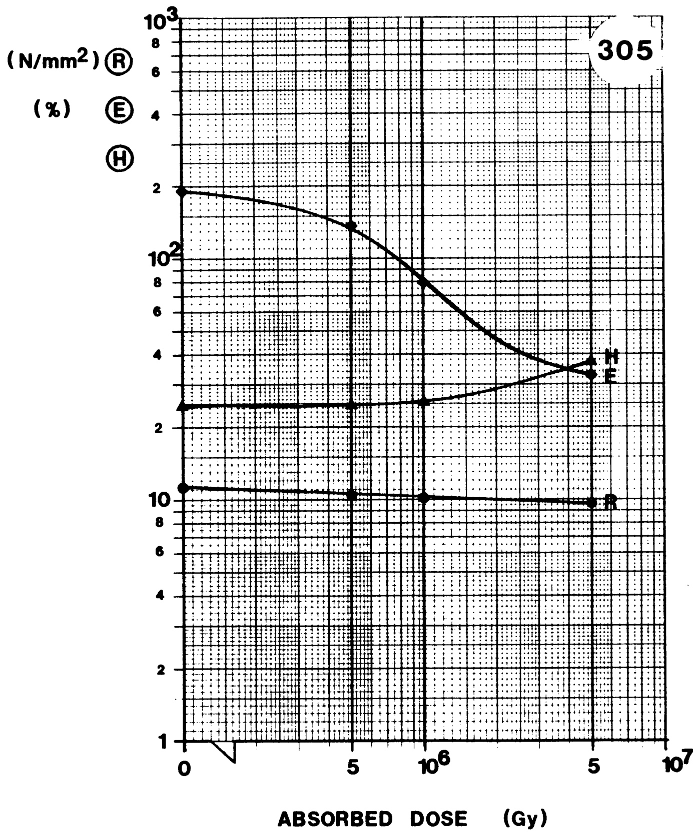
MATERIAL: EPDM

TYPE: Nordel, insulating compound

SUPPLIER: Dolder

Remarks:

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	14.4	N/mm^2
E	Elong. at break	364	%
H	Hardness	27.5	Shore D
	Oxygen index	18.5	



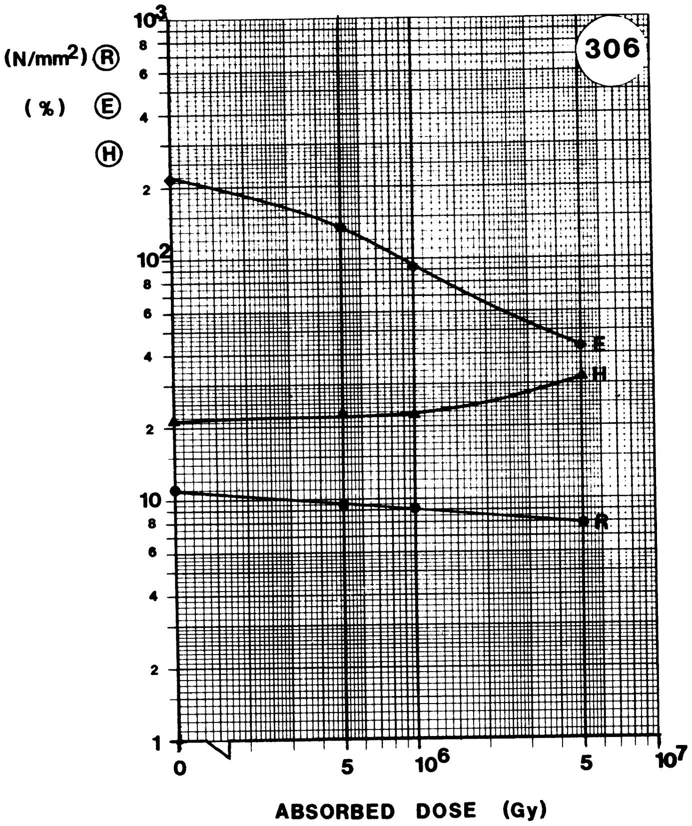
MATERIAL: EPDM

TYPE: Nordel, flame retardant

SUPPLIER: Dolder

Remarks:

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	11.0	N/mm^2
E	Elong. at break	190	%
H	Hardness	24.5	Shore D
	Oxygen index	29	



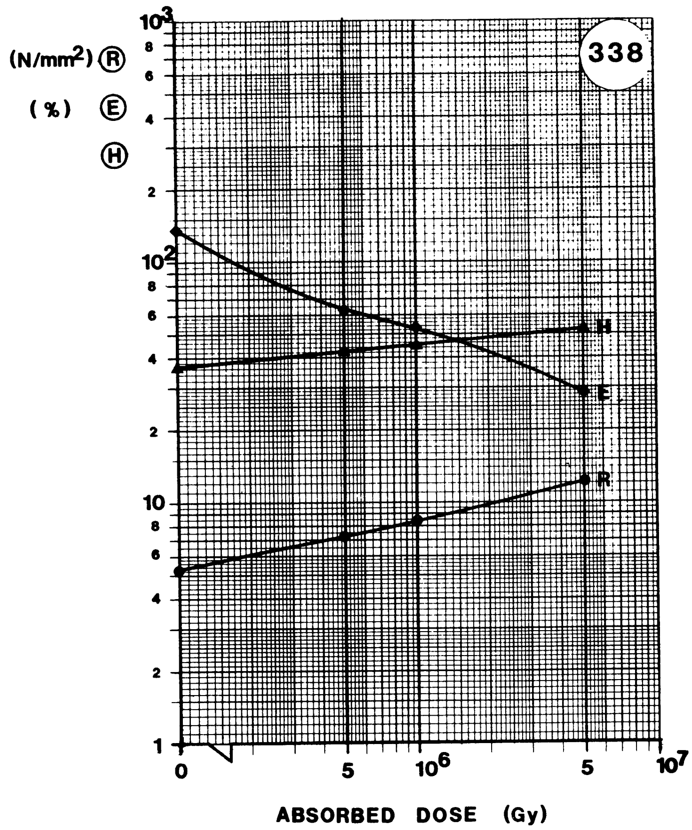
MATERIAL: EPDM

TYPE: Nordel, flame retardant

SUPPLIER: Dolder

Remarks:

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	10.9	N/mm2
E	Elong. at break	217	%
H	Hardness	21	Shore D
	Oxygen index	28.5	



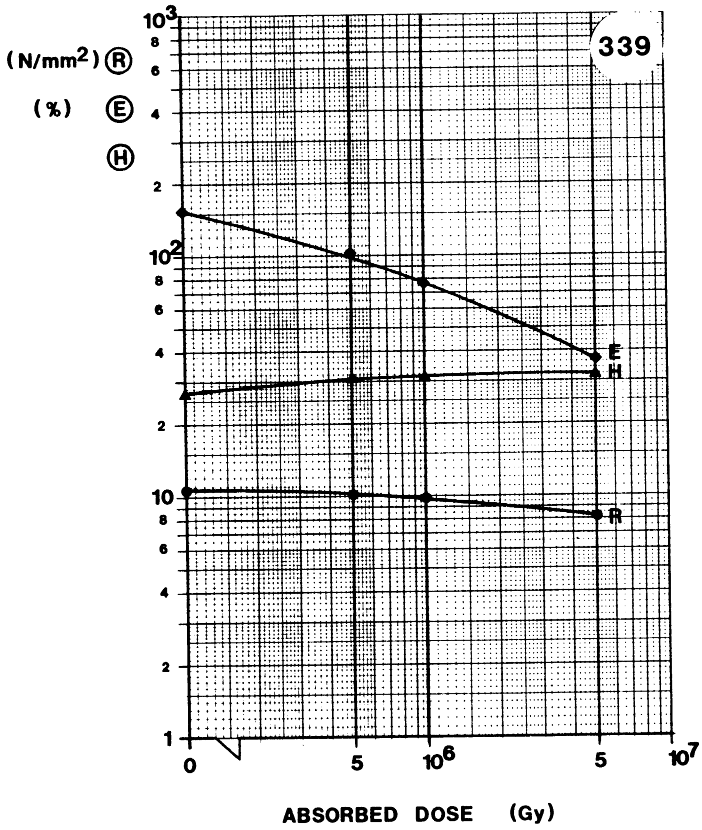
MATERIAL: EPDM

TYPE: Basis EPDM-PE, jacket

SUPPLIER: Dätwyler

Remarks:

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	5.1	N/mm2
E	Elong. at break	135	%
H	Hardness	37	Shore D
	Oxygen index	30	



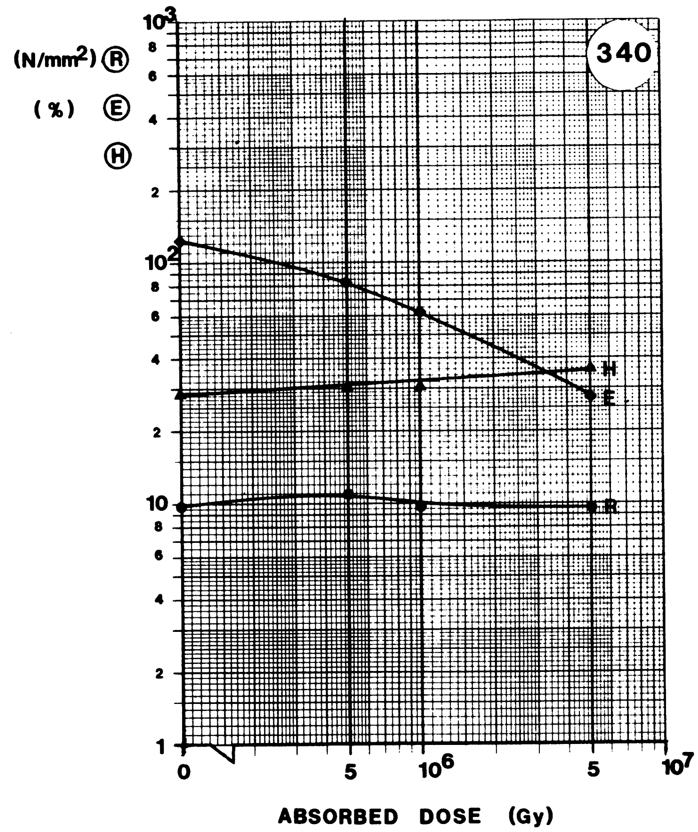
MATERIAL: EPDM

TYPE: PYROFIL, INSULATOR

SUPPLIER: DÄTWYLER

Remarks:

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	10.5	N/mm^2
E	Elong. at break	154	%
H	Hardness	27	Shore D
	Oxygen index	24	



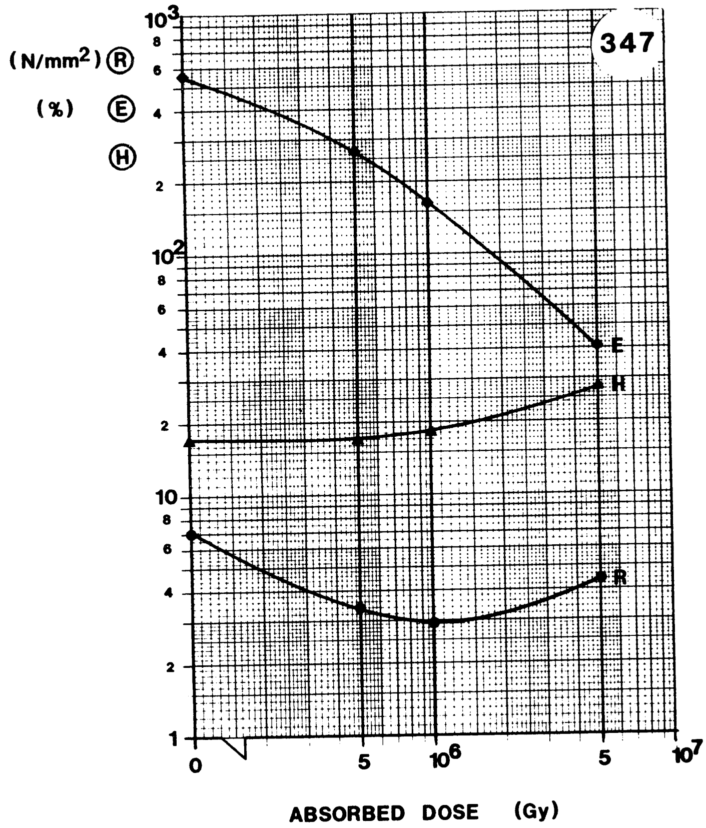
MATERIAL: EPDM

TYPE: PYROFIL, JACKET

SUPPLIER: DÄTWYLER

Remarks:

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	9.4	N/mm^2
E	Elong. at break	122	%
H	Hardness	28	Shore D
	Oxygen index	27	



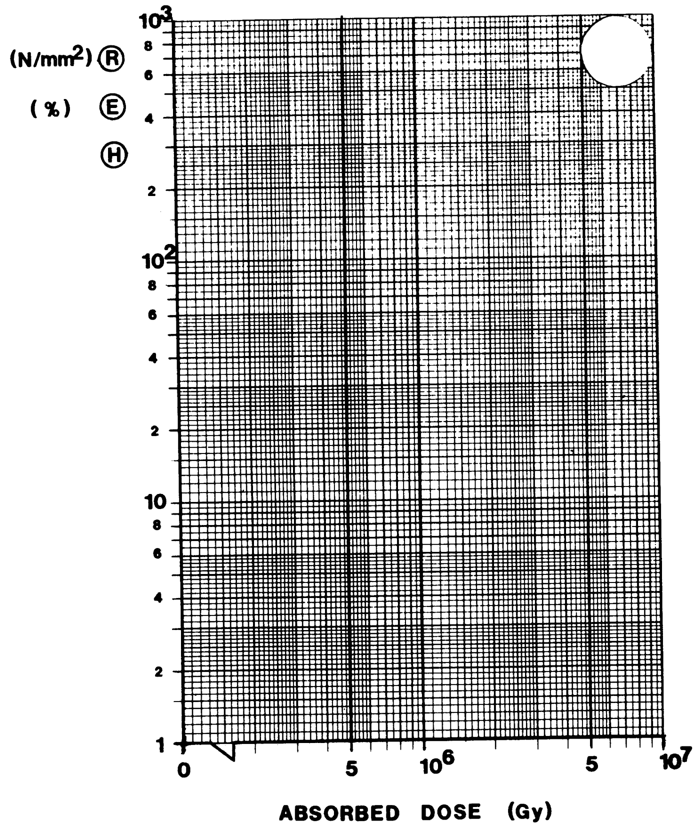
MATERIAL: EPDM

TYPE:

SUPPLIER: Huber & Suhner

Remarks:

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	6.9	N/mm2
E	Elong. at break	560	%
H	Hardness	17	Shore D
	Oxygen index	30	



MATERIAL:

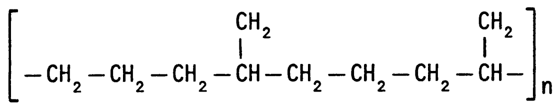
TYPE:

SUPPLIER:

Remarks:

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength		N/mm2
E	Elong. at break		%
H	Hardness		Shore C,D
	Oxygen index		

ETHYLENE-PROPYLENE RUBBER

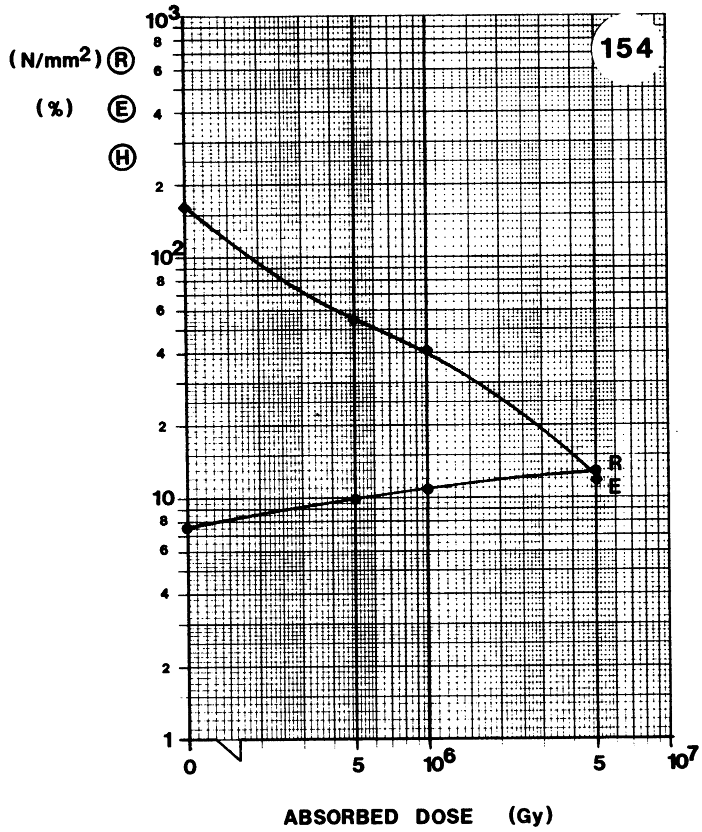


For general characteristics, see Table 1 in Section 2.

No.	Type	Supplier	Dose (Gy)	Traction R (N/mm²)	Traction E (%)	Hardness H	Oxygen index (%)
154	(DS 7)	Kabel-Metall	0	7.4	162		
			5×10^5	9.7	56		
			1×10^6	10.7	41		
			5×10^6	12.6	12		
170	(T 5029)	Huber & Suhner	0	14.3	232		
			5×10^5	13.4	107		
			1×10^6	12.1	120		
			5×10^6				
210	Insulator	Felten & G.	0	7.2	348	29 C	19.3
			5×10^5	6.2	158	37 C	
			1×10^6	6.2	71	45 C	
			5×10^6	7.0	41	65 C	
222	(RM 106)	BICC	0	6.7	406	30.5 C	20.5
			5×10^5	4.9	249	29.6 C	
			1×10^6	4.6	168	31.3 C	
			5×10^6	3.7	24	53.4 C	
314		Pirelli	0	7.5	293	57 A	20.0
			5×10^5	6.1	132	68 A	
			1×10^6	6.1	86	76 A	
			5×10^6	5.4	18	85 A	
318	(75/4001)	Liljeholmens	0	7.4	252	60 A	19.5
			5×10^5	7.5	154	60 A	
			1×10^6	7.0	82	60 A	
			5×10^6	5.1	26	84 A	
343	Insulator	SILEC	0	9.3	634	17 D	19.5
			5×10^5	5.7	395	18.5 D	
			1×10^6	6.0	327	19 D	
			5×10^6	4.2	23	25 D	

No.	Type	Supplier	Dose (Gy)	Traction R (N/mm²)	Traction E (%)	Hardness H	Oxygen index (%)
362	Insulator	Pirelli	0	3.9	355	16 D	
			5×10^5	4.1	147	18 D	
			1×10^6	3.3	40	19.5 D	
			5×10^6	7.2	13	39 D	
363	Insulator	Pirelli	0	10.7	252	21.2 D	
			5×10^5	8.7	93	19 D	
			1×10^6	9.5	65	20.5 D	
			5×10^6	5.8	16	28 D	
			1×10^7	12.1	10	59 D	
371	Insulator	Kabel-Metall	0	9.2	616	19 D	23
			5×10^5	6.2	243	20.5 D	
			1×10^6	5.8	128	20.5 D	
			5×10^6	7.2	28	34 D	
373	Jacket, special material	Kabel-Metall	0	10.6	353	29.5 D	32
			5×10^5	8.9	143	31.5 D	
			1×10^6	7.9	93	34.1 D	
			5×10^6	8.3	31	56 D	
378	Insulator, compound A	Alfacavi	0	7.7	390	18.5 D	25
			5×10^5				
			1×10^6	8.0	102	19.5 D	
			5×10^6				
379	Insulator, compound B	Alfacavi	0	5.9	330	16 D	25
			5×10^5				
			1×10^6	6.9	134	15 D	
			5×10^6				
380	Insulator, compound C	Alfacavi	0	10.1	288	29 D	26
			5×10^5				
			1×10^6	11.6	119	29 D	
			5×10^6				

No.	Type	Supplier	Dose (Gy)	Traction R (N/mm²)	Traction E (%)	Hardness H	Oxygen index (%)
381	Jacket, compound D	Alfacavi	0	10.8	193	28 D	34
			5×10^5				
			1×10^6	11.0	84	27.5 D	
			5×10^6				
382	Jacket, compound E	Alfacavi	0	7.5	303	26.5 D	34
			5×10^5				
			1×10^6	8.0	114	27.2 D	
			5×10^6				



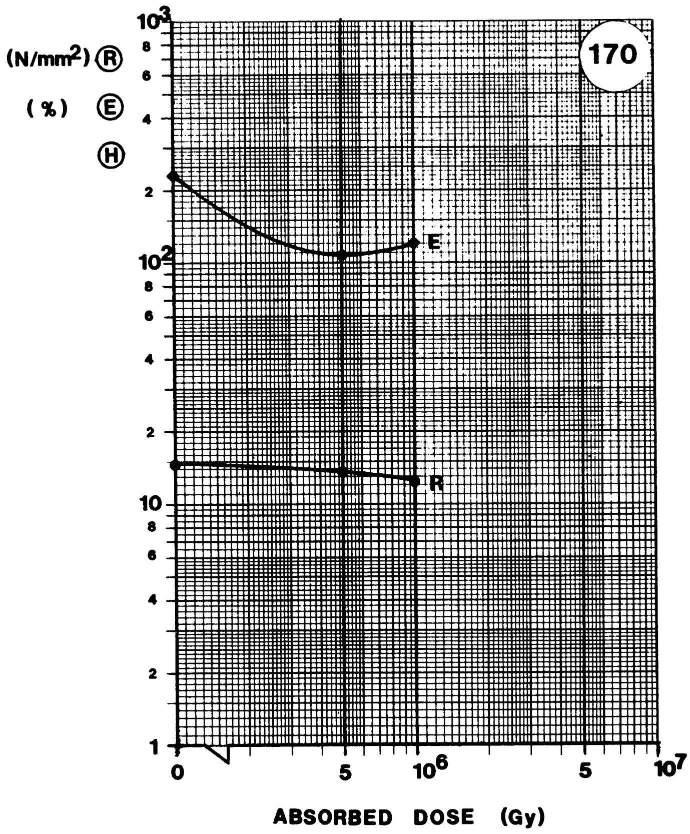
MATERIAL: EPR

TYPE:

SUPPLIER: KABEL-METALL

Remarks:

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	7.4	N/mm2
E	Elong. at break	162	%
H	Hardness	-	Shore C,D
	Oxygen index	-	



MATERIAL: EPR

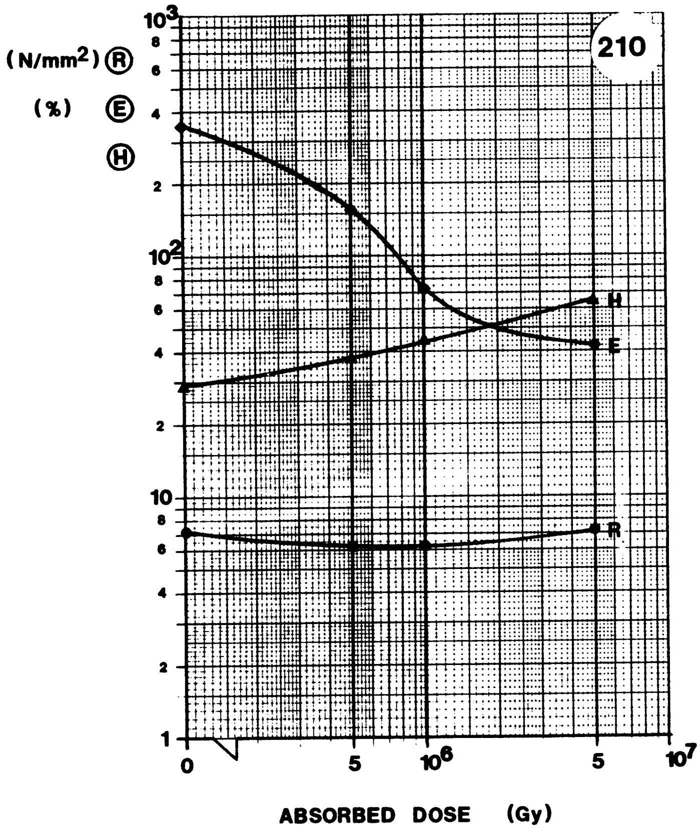
TYPE:

SUPPLIER: HUBER & SUHNER

Remarks:

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	14.3	N/mm2
E	Elong. at break	232	%
H	Hardness	-	Shore C,D
	Oxygen index	-	

EPR



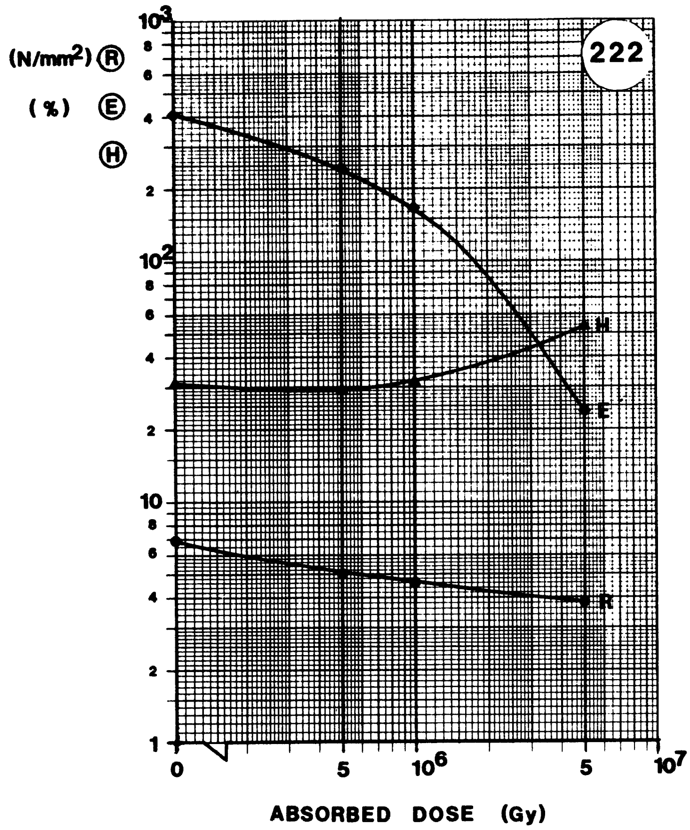
MATERIAL: EPR

TYPE: INSULATOR

SUPPLIER: FELTEN & G.

Remarks:

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	7.2	N/mm^2
E	Elong. at break	348	%
H	Hardness	29	Shore C
	Oxygen index	19.3	



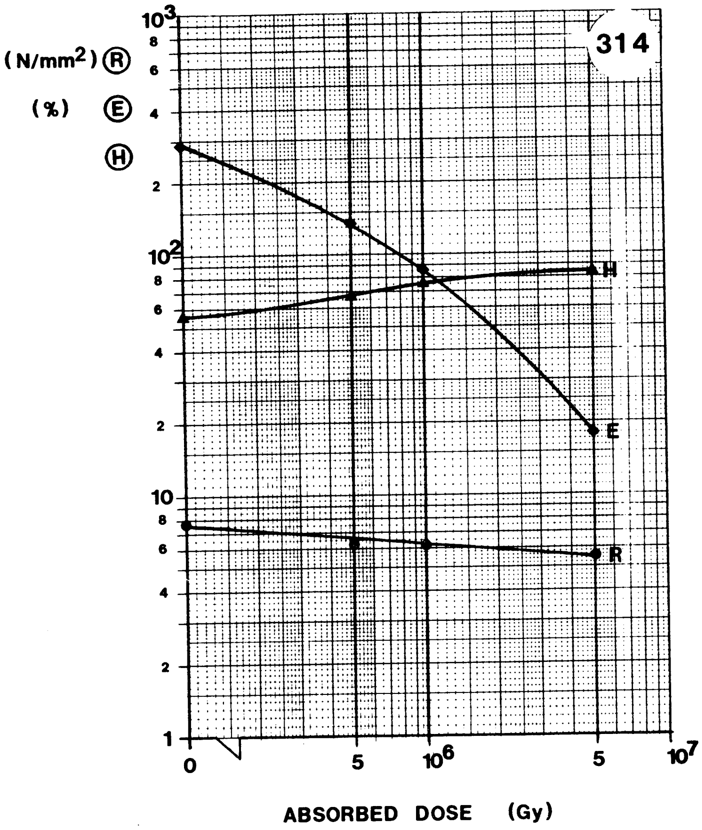
MATERIAL: EPR

TYPE:

SUPPLIER: BICC

Remarks:

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	6.7	N/mm^2
E	Elong. at break	406	%
H	Hardness	30.5	Shore C
	Oxygen index	20.5	



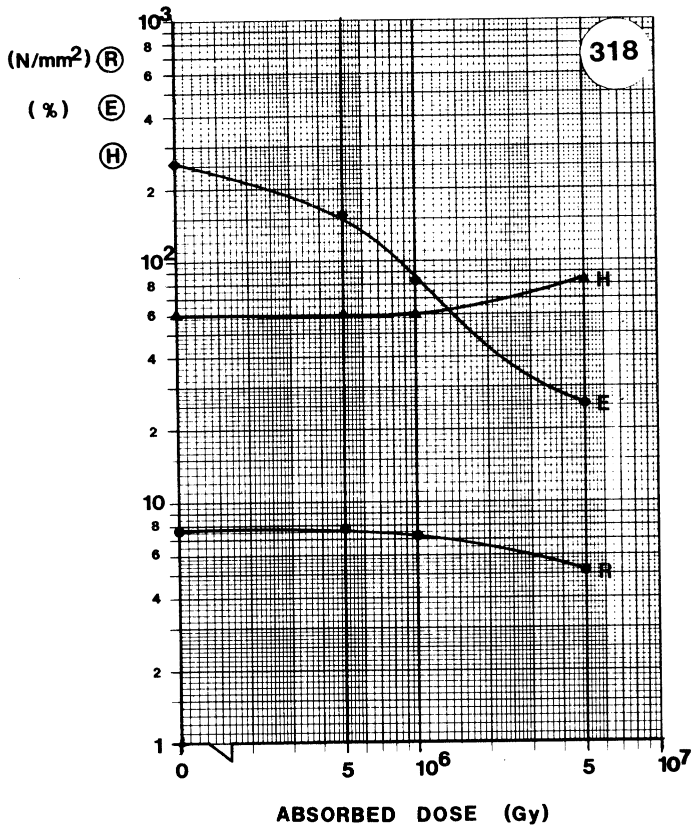
MATERIAL: EPR

TYPE:

SUPPLIER: PIRELLI

Remarks:

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	7.5	N/mm2
E	Elong. at break	293	%
H	Hardness	57	Shore A
	Oxygen index	20	



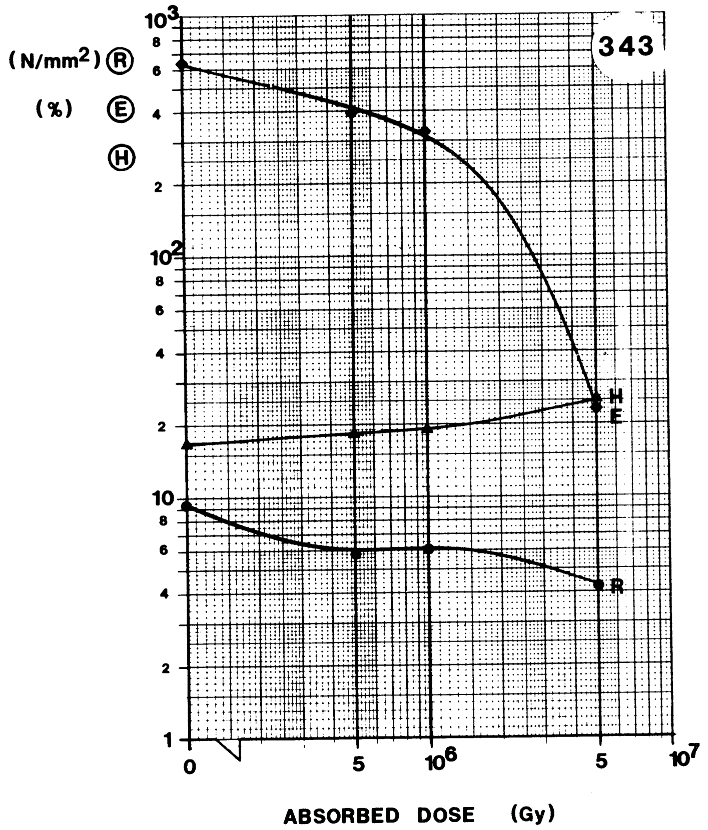
MATERIAL: EPR

TYPE:

SUPPLIER: LILJEHOLMENS

Remarks:

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	7.4	N/mm2
E	Elong. at break	252	%
H	Hardness	60	Shore A
	Oxygen index	19.5	



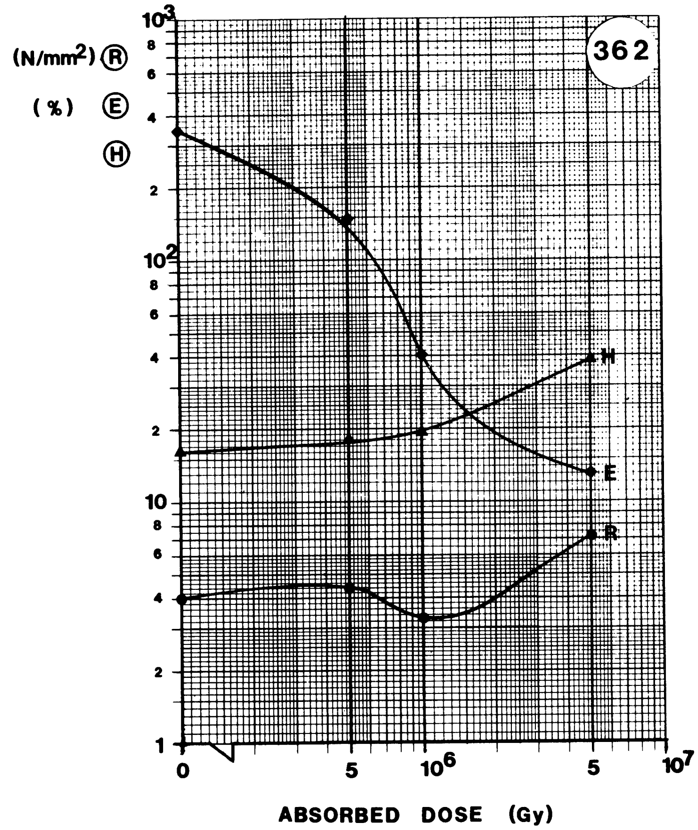
MATERIAL: EPR

TYPE: INSULATOR

SUPPLIER: SILEC

Remarks:

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	9.3	N/mm^2
E	Elong. at break	634	%
H	Hardness	17	Shore D
	Oxygen index	19.5	



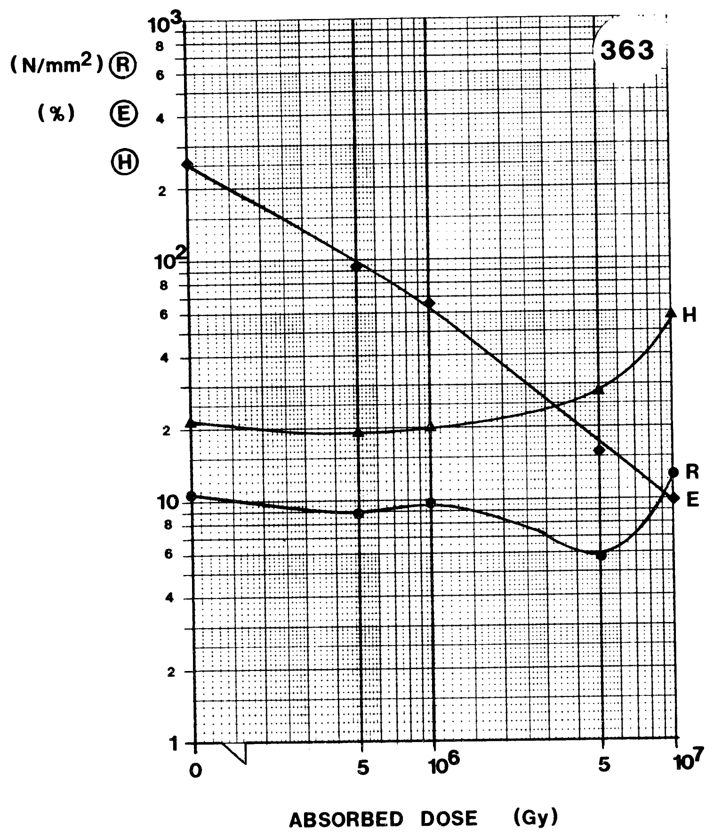
MATERIAL: EPR

TYPE: INSULATOR

SUPPLIER: PIRELLI

Remarks:

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	3.9	N/mm^2
E	Elong. at break	355	%
H	Hardness	16	Shore D
	Oxygen index	-	



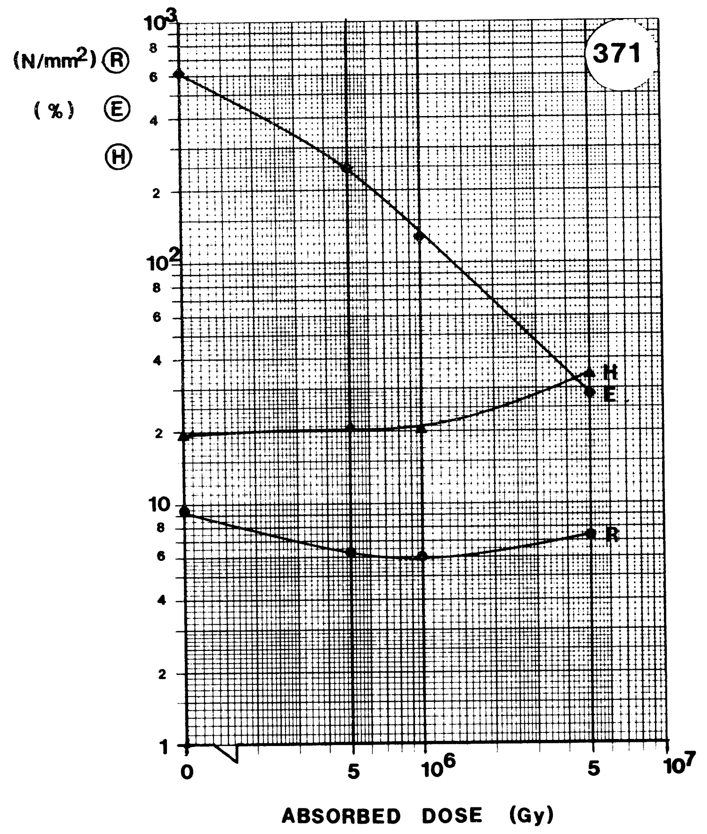
MATERIAL: EPR

TYPE: Insulator

SUPPLIER: Pirelli

Remarks:

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	10.7	N/mm^2
E	Elong. at break	252	%
H	Hardness	21.2	Shore D
	Oxygen index	-	



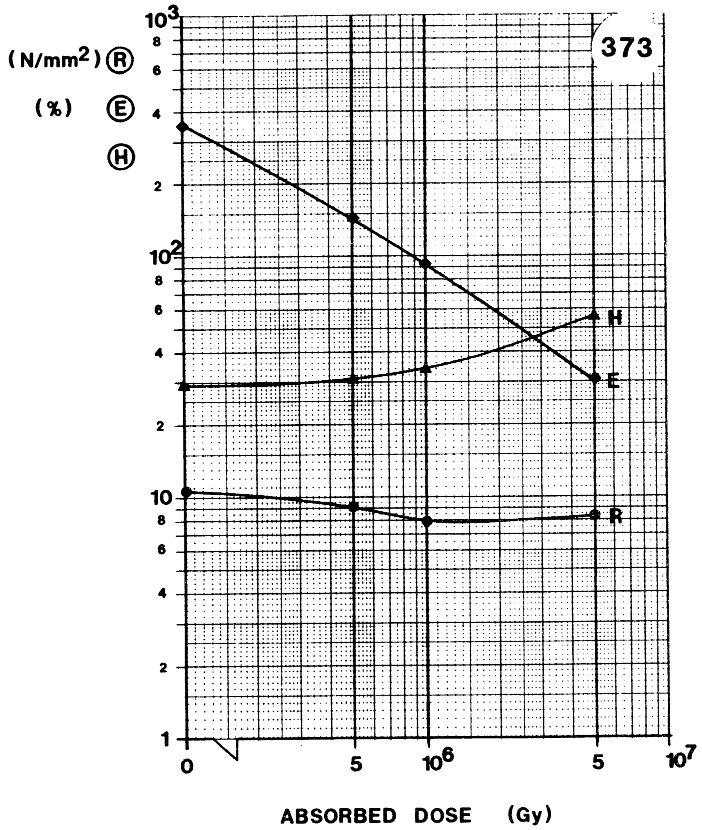
MATERIAL: EPR

TYPE: Insulator

SUPPLIER: Kabel-Metall

Remarks:

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	9.2	N/mm^2
E	Elong. at break	616	%
H	Hardness	19	Shore D
	Oxygen index	23	



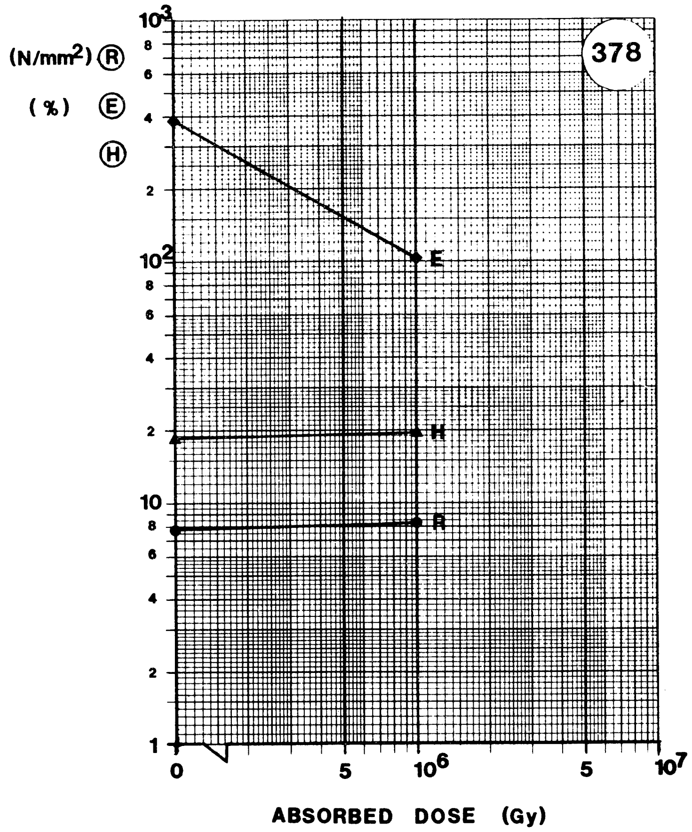
MATERIAL: EPR

TYPE: Jacket, special material

SUPPLIER: Kabel-Metall

Remarks:

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	10.6	N/mm^2
E	Elong. at break	353	%
H	Hardness	29.5	Shore D
	Oxygen index	32	



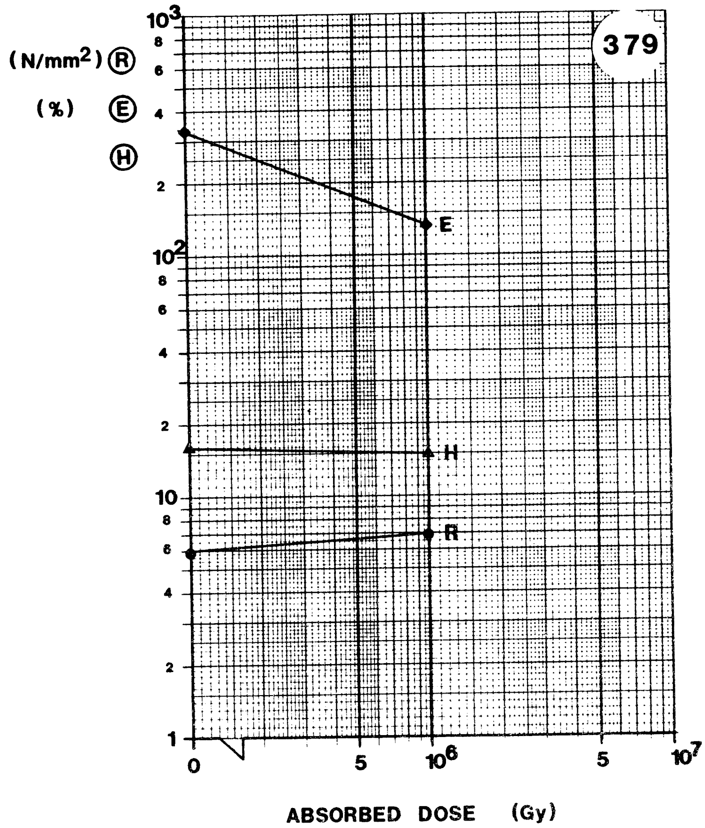
MATERIAL: EPR

TYPE: Insulator

SUPPLIER: Alfacavi

Remarks:

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	7.7	N/mm^2
E	Elong. at break	390	%
H	Hardness	18.5	Shore D
	Oxygen index	25	



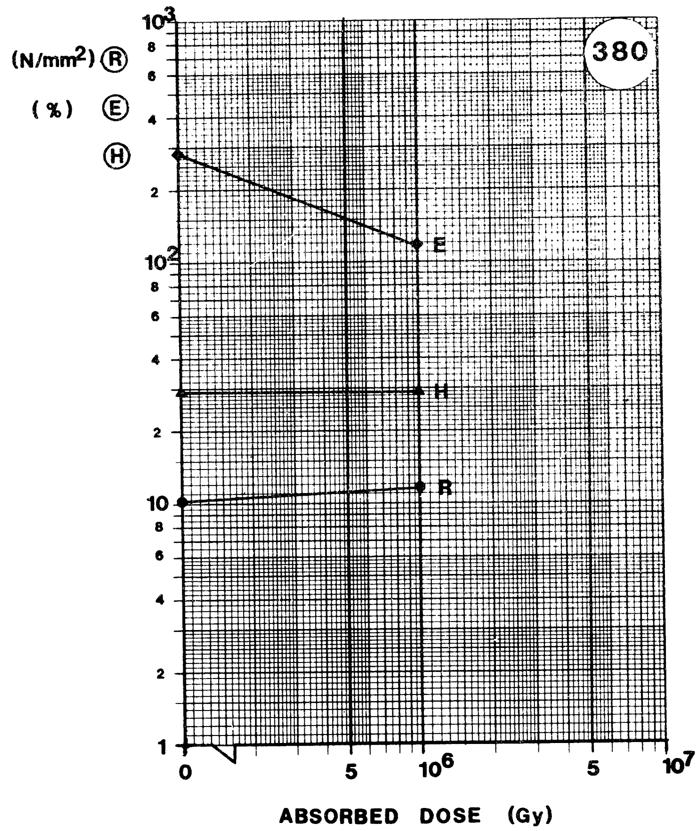
MATERIAL: EPR

TYPE: INSULATOR

SUPPLIER: ALFACAVI

Remarks:

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	5.9	N/mm^2
E	Elong. at break	330	%
H	Hardness	16	Shore D
	Oxygen index	25	



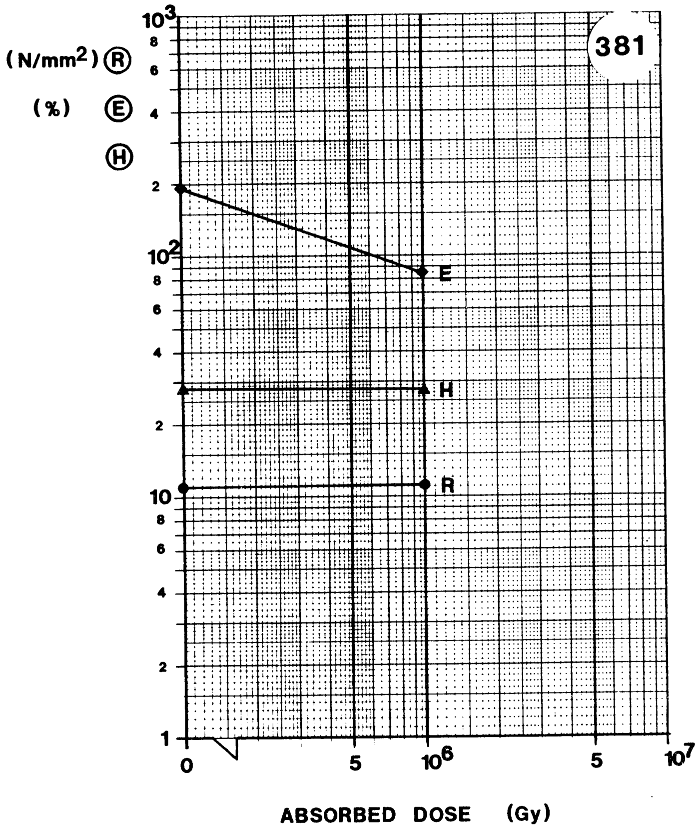
MATERIAL: EPR

TYPE: INSULATOR

SUPPLIER: ALFACAVI

Remarks:

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	10.1	N/mm^2
E	Elong. at break	288	%
H	Hardness	29	Shore D
	Oxygen index	26	



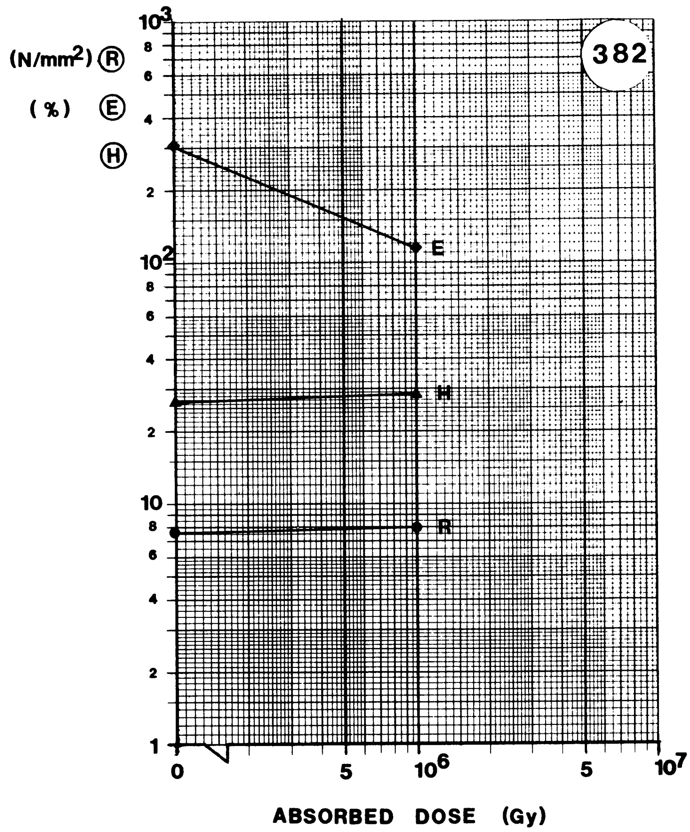
MATERIAL: EPR

TYPE: Jacket

SUPPLIER: Alfacavi

Remarks:

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	10.8	N/mm2
E	Elong. at break	193	%
H	Hardness	28	Shore D
	Oxygen index	34	



MATERIAL: EPR

TYPE: Jacket

SUPPLIER: Alfacavi

Remarks: Used for 1 kV, 400 mm² Al cables, SPS

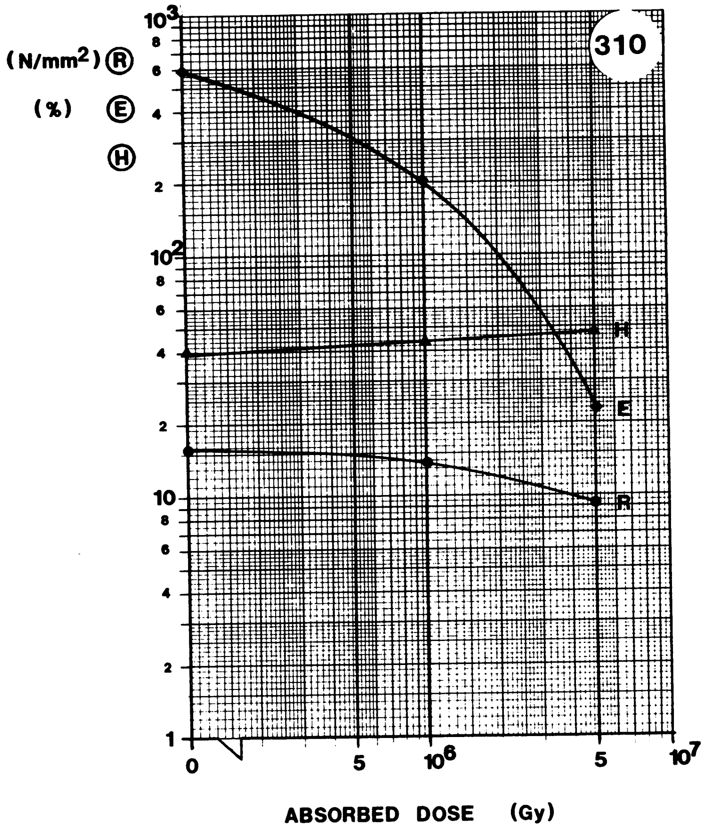
CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	7.5	N/mm2
E	Elong. at break	303	%
H	Hardness	26.5	Shore D
	Oxygen index	34	

ETHYLENE VINYL-ACETATE

Copolymer of ethylene ($CH_2 = CH_2$) and vinylacetate ($CH_3 - COOCH = CH_2$)

For general characteristics, see Table 1 in Section 2.

No.	Type	Supplier	Dose	Traction		Hardness H	Oxygen index
				R	E		
			(Gy)	(N/mm²)	(%)		(%)
310	4GJ-1	AEG-Telefunken	0	15.4	598	40 D	18
			5×10^5	-	-	-	
			1×10^6	12.9	204	44 D	
			5×10^6	9.4	23	48 D	
370	Insulator	Kabel-Metall	0	10.5	326	32 D	22
			5×10^5	9.5	174	31.5 D	
			1×10^6	9.3	104	34.5 D	
			5×10^6	11.8	22	49 D	



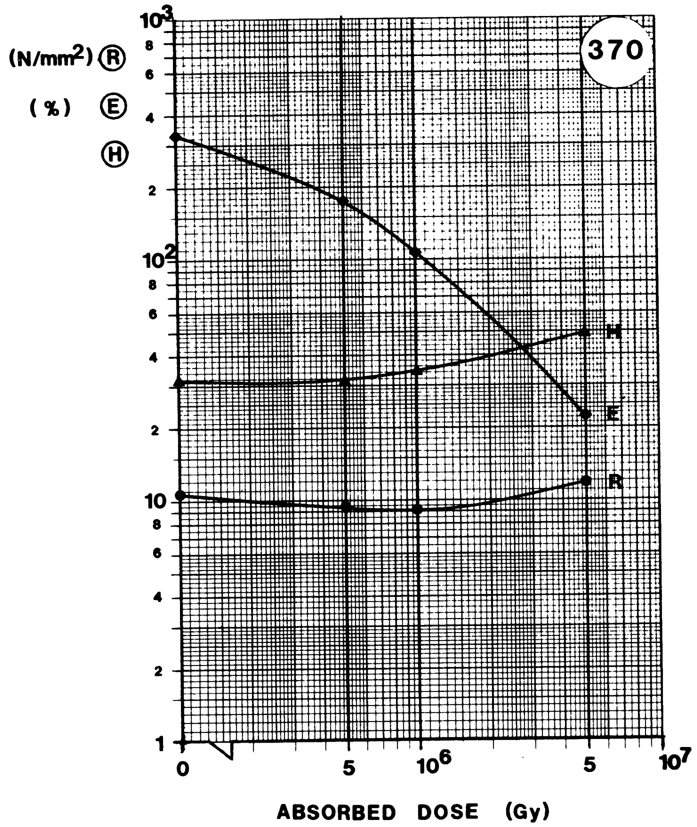
MATERIAL: EVA

TYPE: 4GJ-1

SUPPLIER: AEG-TELEFUNKEN

Remarks:

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	15.4	N/mm²
E	Elong. at break	598	%
H	Hardness	40	Shore D
	Oxygen index	18	



MATERIAL: EVA

TYPE: INSULATOR

SUPPLIER: KABEL-METALL

Remarks:

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	10.5	N/mm²
E	Elong. at break	326	%
H	Hardness	32	Shore D
	Oxygen index	22	

FLAMTROL
Polyolefin

FLUOROPOLYMERS
see HALAR
see TEFLON
see TEFZEL
see VITON

Trade name of Raychem.

Radiation cross-linked polyolefin.

Ultimate tensile strength 12.4 N/mm^2,
elongation at break 250 %,
oxygen index 28.

Radiation resistant up to 1×10^6 Gy according to information given by supplier.

HALAR
fluoropolymer

HYPALON
chlorosulfonated polyethylene (CSP)

HYTREL
polyester elastomer

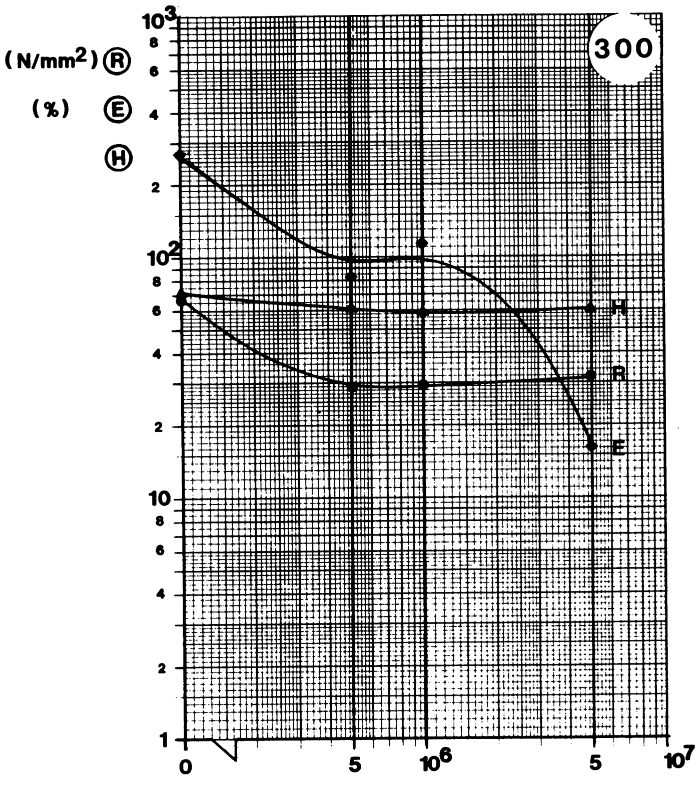
Trade name of Allied Chemical.

Copolymer of ethylene ($CH_2{=}CH_2$) and chlorotrifluoroethylene ($ClFC{=}CF_2$)

$$\left[-CH_2-CH_2-\underset{F}{\overset{Cl}{\underset{|}{\overset{|}{C}}}}-CF_2-\right]_n$$

For general characteristics, see Table 1 in Section 2.

No.	Type	Supplier	Dose (Gy)	Traction R (N/mm²)	Traction E (%)	Hardness H	Oxygen index (%)
300	E-CTFE	Allied Chemical	0	66.1	273	72.5 D	53
			5×10^5	28.3	82	63 D	
			1×10^6	29.4	114	59 D	
			5×10^6	31.5	16	61 D	



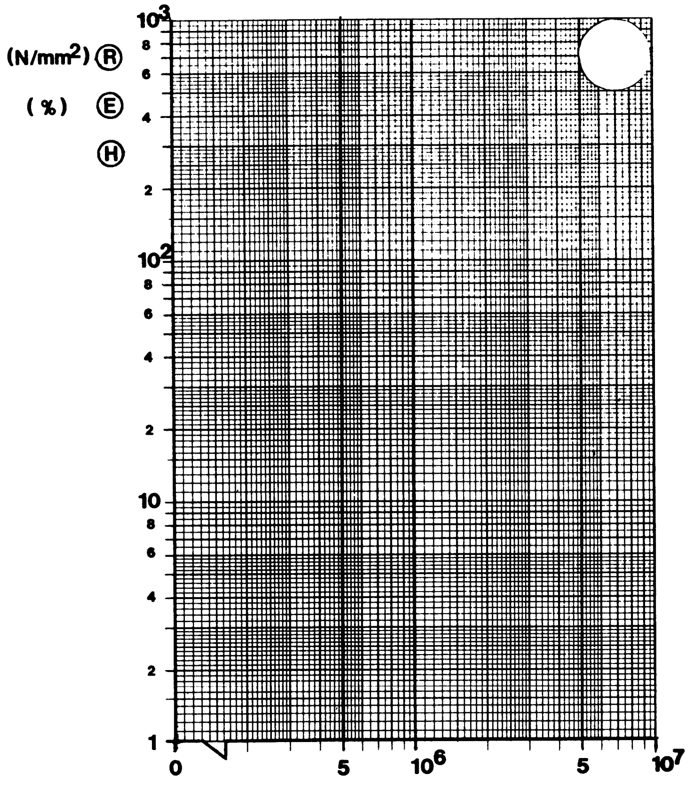
MATERIAL: HALAR

TYPE: E-CTFE

SUPPLIER: ALLIED CHEMICAL

Remarks:

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	66.1	N/mm^2
E	Elong. at break	273	%
H	Hardness	72.5	Shore D
	Oxygen index	53	



MATERIAL:

TYPE:

SUPPLIER:

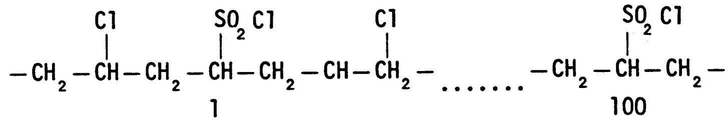
Remarks:

CURVE	PROPERTY	INITIAL VALUE
R	Tensile strength	N/mm^2
E	Elong. at break	%
H	Hardness	Shore C,D
	Oxygen index	

Trade name of Du Pont for

CHLOROSULFONATED POLYETHYLENE (CSP),

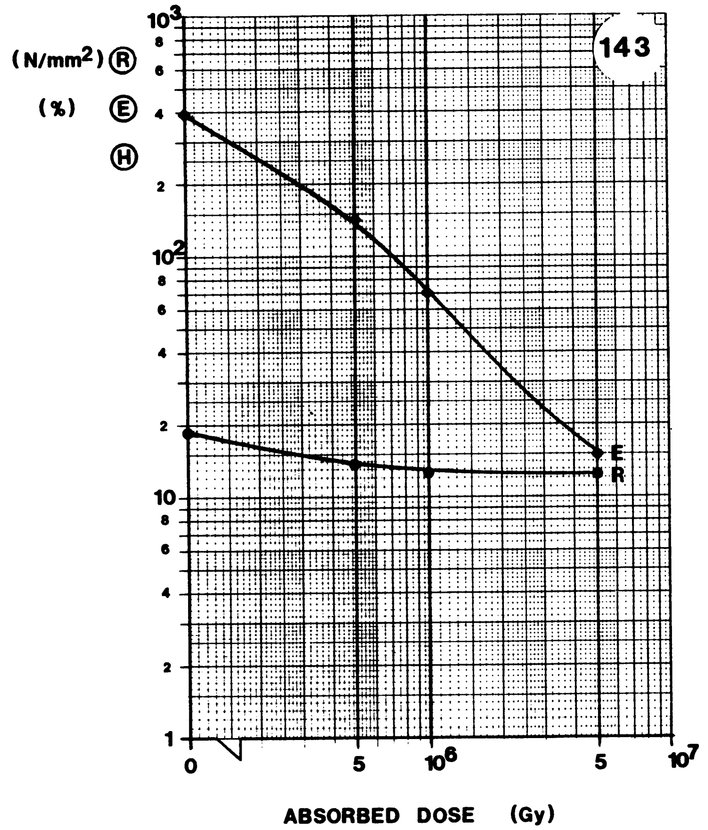
containing approximately one chlorine atom for every six or seven carbon atoms, and one sulfonylchloride group (SO_2Cl) for every hundred carbon atoms. Substitution is believed to be random*).



For general characteristics, see Table 1 in Section 2.

*) R.A.V. Ruff and J.B. Allison, High polymers, Vol. XI: Polyethylene (Interscience Publ., New York, 1956).

No.	Type	Supplier	Dose (Gy)	Traction R (N/mm²)	Traction E (%)	Hardness H	Oxygen index (%)
143	Compound No. 41	DRAKA	0	18.5	394		
			5×10^5	13.5	141		
			1×10^6	12.6	70		
			5×10^6	12.3	15		
144	(5262-1)	DRAKA	0	18.4	560		28
			5×10^5	17.1	250		
			1×10^6	12.3	140	42 C	
			5×10^6	5.6	19	73 C	
201	Insulator	Pirelli	0	17.4	330	25 D	
			5×10^5	18.9	207	31 D	
			1×10^6	21.4	108	38 D	
			5×10^6	30.0	< 1	77 D	
208	Jacket	Felten & G.	0	13.3	510	28 D	24.8
			5×10^5	13.4	213	28 D	
			1×10^6	9.6	157	33 D	
			5×10^6	12.5	40	52 D	
223	CSP (RM 174)	BICC	0	15.8	421	34.6 C	32.7
			5×10^5	14.9	231	46.8 C	
			1×10^6	14.8	103	57.5 C	
			5×10^6	14.7	21	82.5 C	
302	Jacket, flame retardant	Dolder	0	14.7	435	15 D	27.5
			5×10^5	16.9	337	20 D	
			1×10^6	16.0	178	22 D	
			5×10^6	10.8	20.5	42 D	



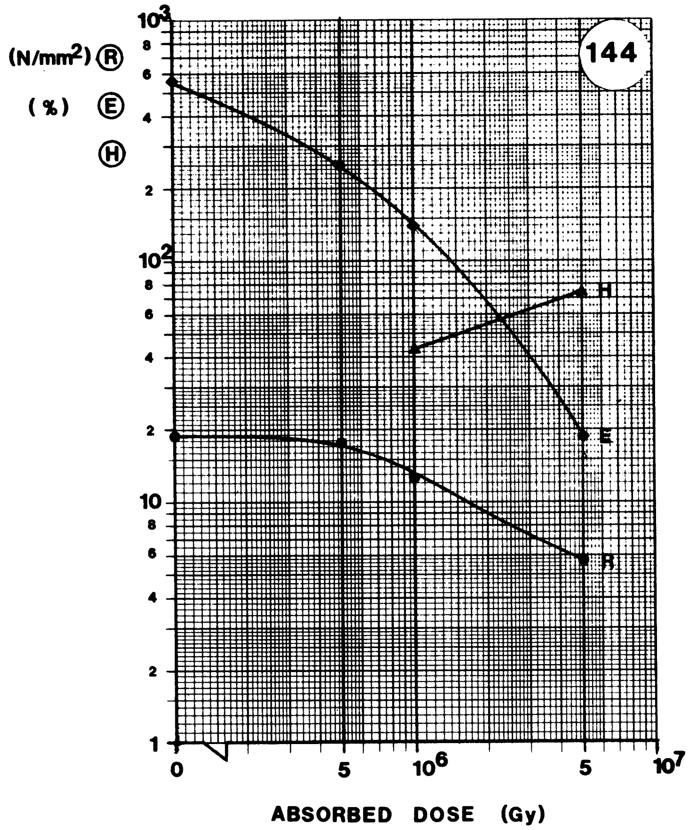
MATERIAL: HYPALON

TYPE:

SUPPLIER: DRAKA

Remarks:

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	18.5	N/mm2
E	Elong. at break	394	%
H	Hardness	-	Shore C,D
	Oxygen index	-	



MATERIAL: HYPALON

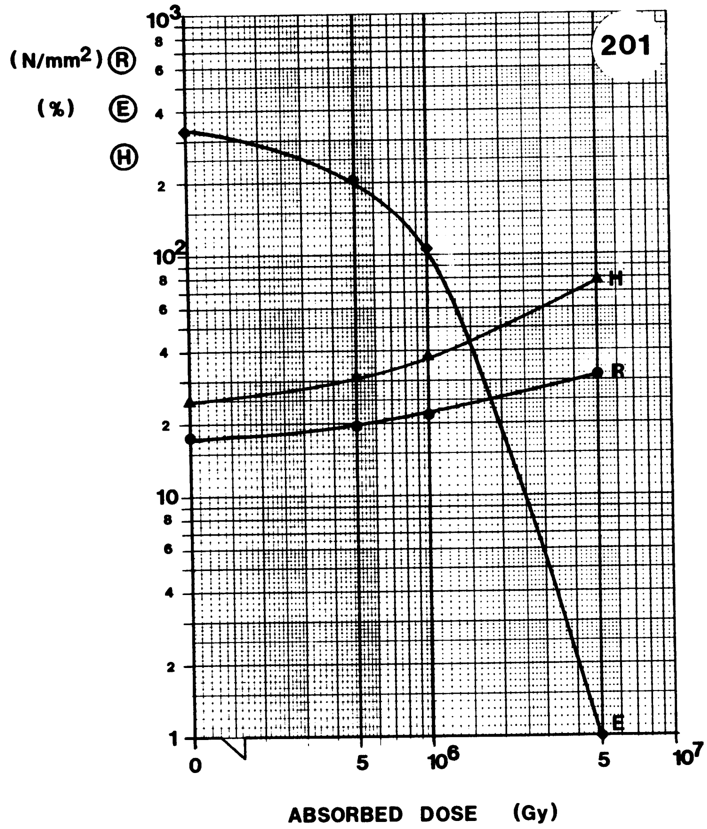
TYPE:

SUPPLIER: DRAKA

Remarks:

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	18.4	N/mm2
E	Elong. at break	560	%
H	Hardness	-	Shore C
	Oxygen index	28	

HYPALON



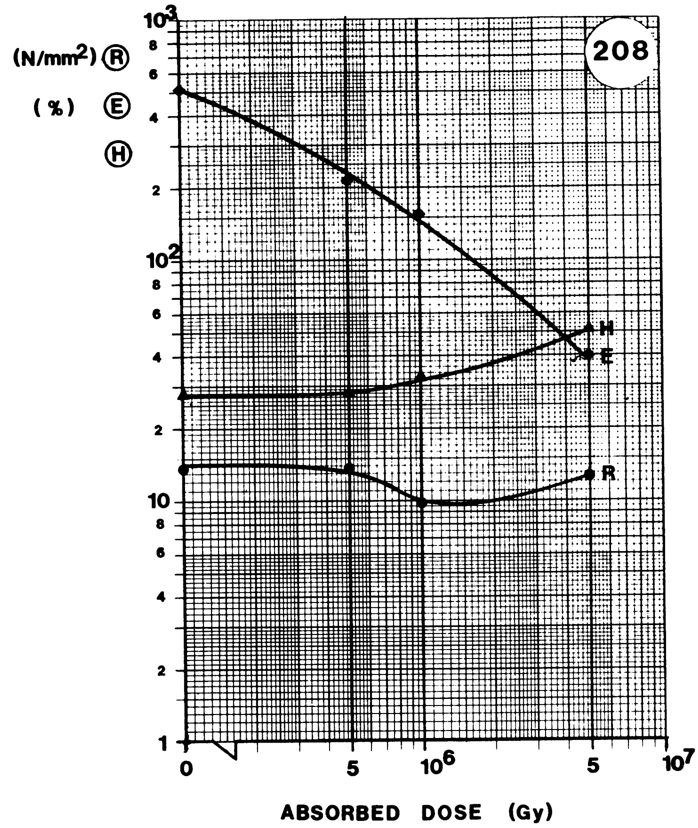
MATERIAL: HYPALON

TYPE: INSULATOR

SUPPLIER: PIRELLI

Remarks:

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	17.4	N/mm^2
E	Elong. at break	330	%
H	Hardness	25	Shore D
	Oxygen index	-	



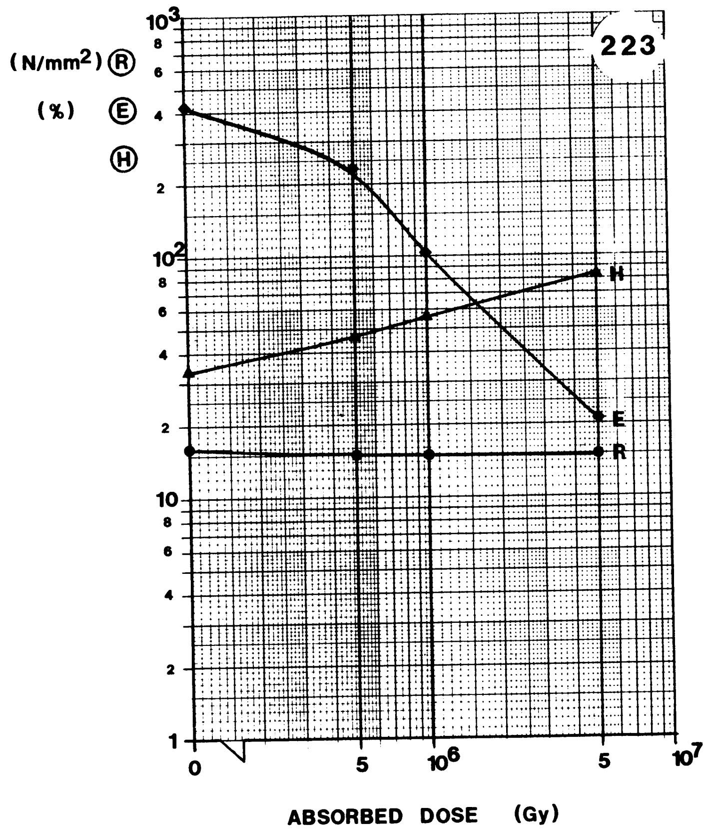
MATERIAL: HYPALON

TYPE: JACKET

SUPPLIER: FELTEN & G.

Remarks:

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	13.3	N/mm^2
E	Elong. at break	510	%
H	Hardness	28	Shore D
	Oxygen index	24.8	



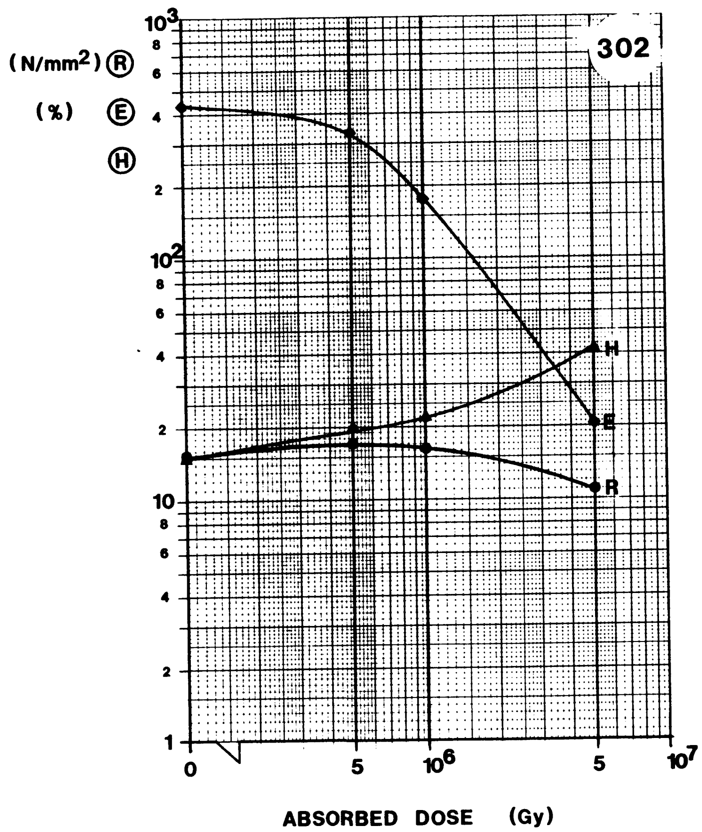
MATERIAL: HYPALON

TYPE:

SUPPLIER: BICC

Remarks:

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	15.8	N/mm²
E	Elong. at break	421	%
H	Hardness	34.6	Shore C
	Oxygen index	32.7	



MATERIAL: HYPALON

TYPE: Jacket, flame retardant

SUPPLIER: Dolder

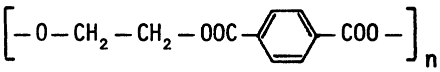
Remarks:

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	14.7	N/mm²
E	Elong. at break	435	%
H	Hardness	15	Shore D
	Oxygen index	27.5	

HYTREL

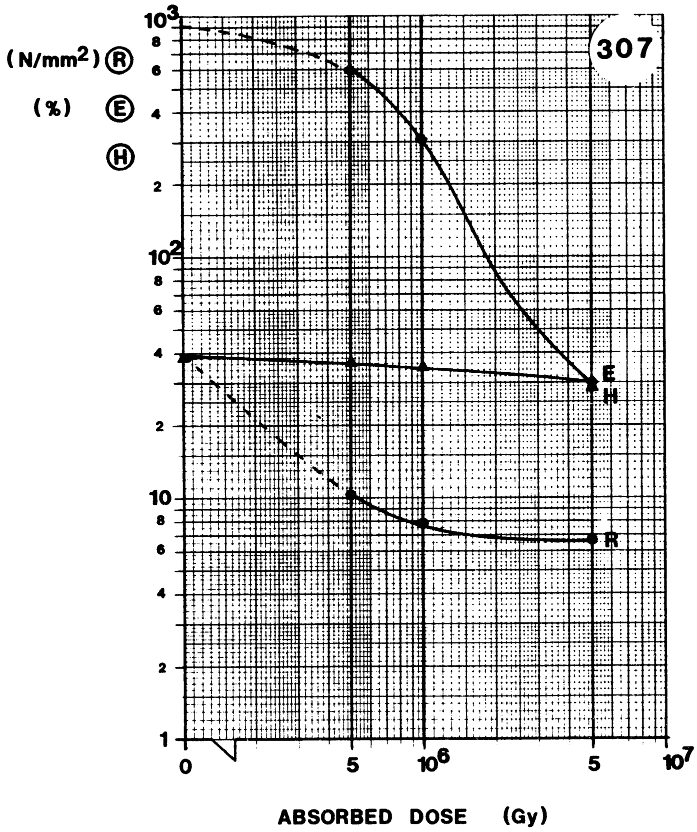
Trade name of Du Pont

Polyester elastomer

Copolymer of polyethylene terephthalate 

and polyalkenglykolen with molecular weight up to 25000.

No.	Type	Supplier	Dose (Gy)	Traction R (N/mm²)	E (%)	Hardness H	Oxygen index (%)
307	Flame retardant	Dolder	0	> 38.3	> 875	39 D	26
			5×10^5	10.0	600	37 D	
			1×10^6	7.7	305	35 D	
			5×10^6	6.6	30	30 D	



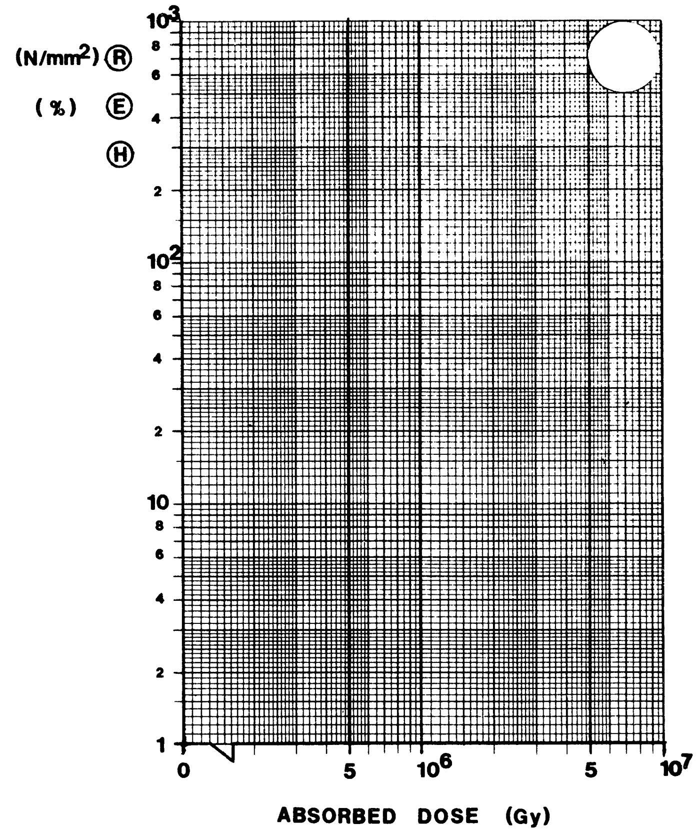
MATERIAL: HYTREL

TYPE: Flame retardant

SUPPLIER: Dolder

Remarks:

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	> 38.3	N/mm²
E	Elong. at break	> 875	%
H	Hardness	39	Shore D
	Oxygen index	26	



MATERIAL:

TYPE:

SUPPLIER:

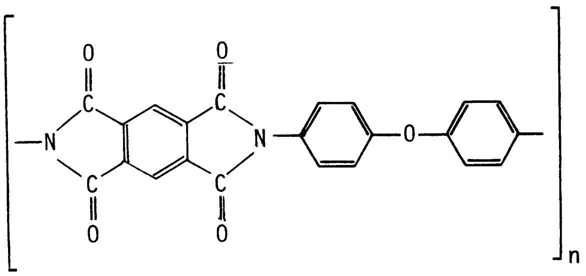
Remarks:

CURVE	PROPERTY	INITIAL VALUE
R	Tensile strength	N/mm²
E	Elong. at break	%
H	Hardness	Shore C,D
	Oxygen index	

KAPTON

Trade name of Du Pont

polyimide film (polyoxydiphenylene-pyromellitimide)



For the general characteristics, see Table 1 in Section 2.

According to the documentation given by the supplier, this material maintains 50% of the initial elongation at 6×10^7 Gy. At 1×10^8 Gy it darkens but remains tough.

LUPOLEN

trade name of BASF

see POLYETHYLENE

NEOPRENE

chloroprene rubber

NORDEL

trade name of Du Pont

see EPDM

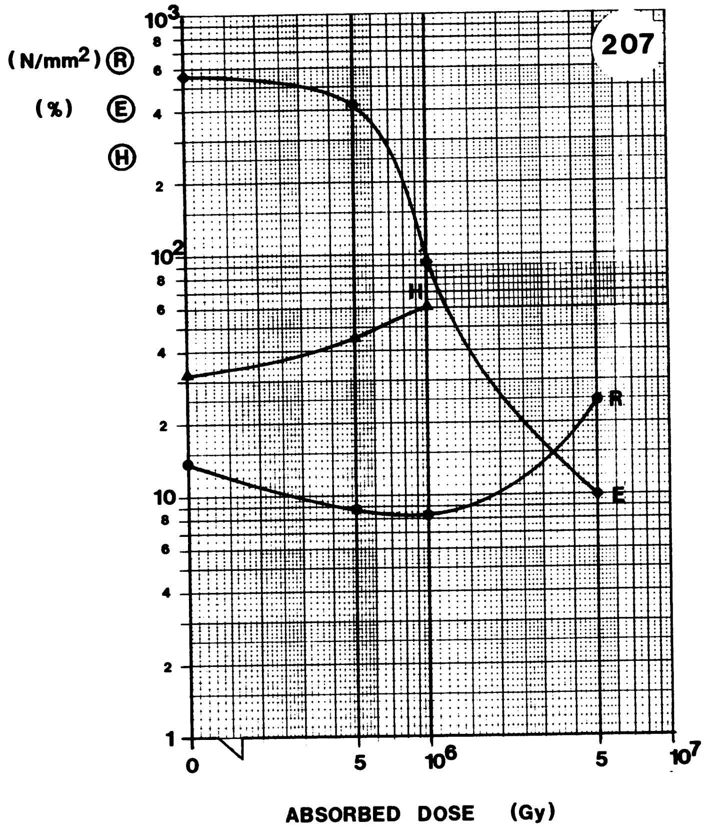
Trade name of Du Pont for

POLYCHLOROPRENE RUBBER

$$[-CH_2-CH=CCl-CH_2-]_n$$

For general characteristics, see Table 1 in Section 2.

No.	Type	Supplier	Dose (Gy)	Traction R (N/mm²)	Traction E (%)	Hardness H	Oxygen index (%)
207	Jacket	Felten & G.	0	13.5	554	33 C	30.8
			5×10^5	8.7	427	45 C	
			1×10^6	7.9	94	63 C	
			5×10^6	24.0	10	83 D	
315		Pirelli	0	11.8	416	18 D	27
			5×10^5	8.7	168	25 D	
			1×10^6	11.1	68	35 D	
			5×10^6	22.1	9	76 D	
344	Jacket	SILEC	0	21.8	360	17 D	33
			5×10^5	15.2	140	24 D	
			1×10^6	13.2	88	23.5 D	
			5×10^6	32.0	10	71 D	
364	Insulator	Pirelli	0	12.1	533	17 D	
			5×10^5	12.9	144	21 D	
			1×10^6	15.0	55	33 D	
			5×10^6	21.3	2	69 D	



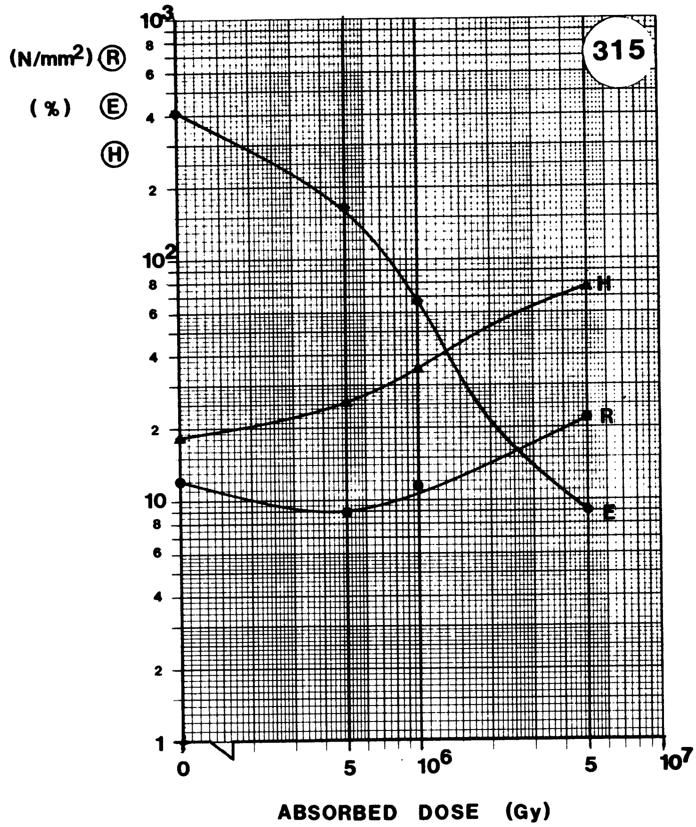
MATERIAL: NEOPRENE

TYPE: JACKET

SUPPLIER: FELTEN & G.

Remarks:

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	13.5	N/mm^2
E	Elong. at break	554	%
H	Hardness	33	Shore C
	Oxygen index	30.8	



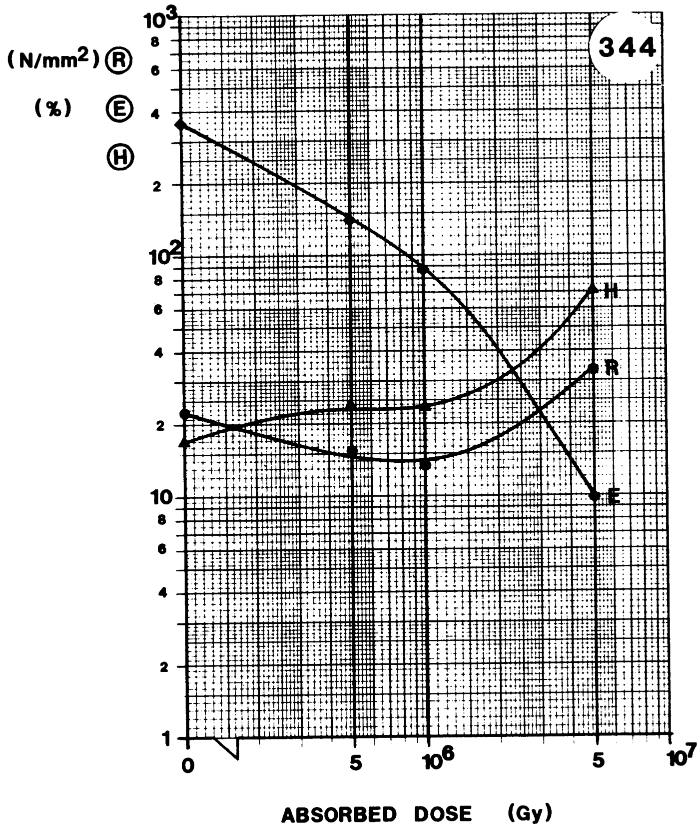
MATERIAL: NEOPRENE

TYPE:

SUPPLIER: PIRELLI

Remarks:

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	11.8	N/mm^2
E	Elong. at break	416	%
H	Hardness	18	Shore D
	Oxygen index	27	



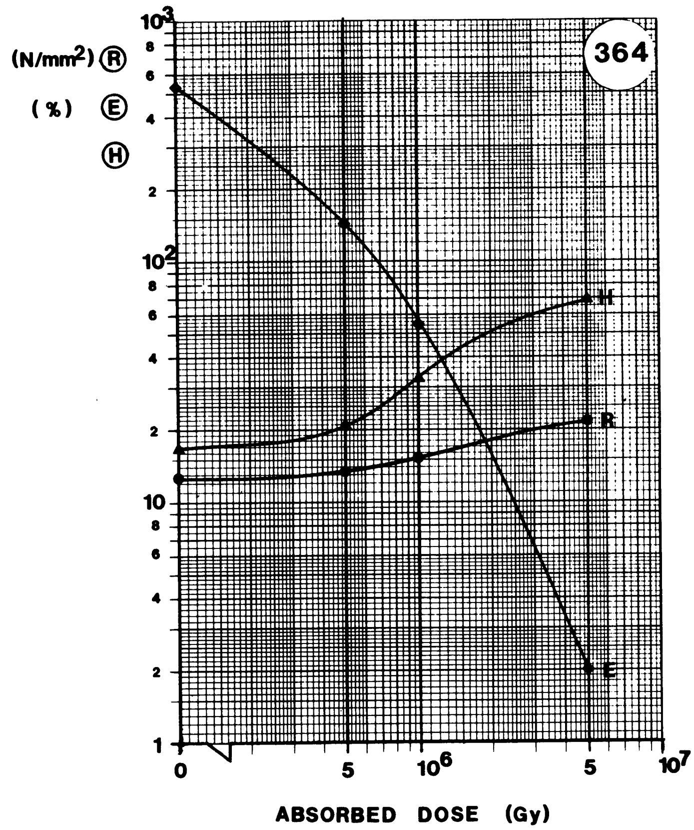
MATERIAL: NEOPRENE

TYPE: JACKET

SUPPLIER: SILEC

Remarks:

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	21.8	N/mm^2
E	Elong. at break	360	%
H	Hardness	17	Shore D
	Oxygen index	33	



MATERIAL: NEOPRENE

TYPE: INSULATOR

SUPPLIER: PIRELLI

Remarks:

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	12.1	N/mm^2
E	Elong. at break	533	%
H	Hardness	17	Shore D
	Oxygen index	-	

POLYCHLOROPRENE
see NEOPRENE

PE
polyethylene

POLYIMIDE
see KAPTON

PUR
polyurethane

PVC
polyvinylchloride
PVC standard
PVC flame retardant

PYROFIL
Trade name of Dätwyler for material basis of EPDM;
see EPDM No. 339 and No. 340

POLYETHYLENE*)

$$[-CH_2-CH_2-]_n$$

For general characteristics, see Table 1 in Section 2.

*) R.A.V. Ruff and J.B. Allison, High polymers, Vol. XI: Polyethylene (Interscience Publ., New-York, 1956).

No.	Type	Supplier	Dose (Gy)	Traction R (N/mm²)	Traction E (%)	Hardness H	Oxygen index (%)
156	(7217 B) (Lupolen 2012 DX)	Kabel-Metall	0	16.2	607		
			5×10^5	20.7	328		
			1×10^6	14.4	125		
			5×10^6	11.3	10		
157	(7217 D) stabilized	Kabel-Metall	0	17.2	608		
			5×10^5	14.5	401		
			1×10^6	9.8	188		
			5×10^6	10.5	11		
166	Lupolen 1812 D-SK	Kabel-Metall	0	12.8	630	51.3 D	
			5×10^5				
			1×10^6	11.8	90	58.5 D	
			5×10^6				
168	Lupolen 2012 DX	Kabel-Metall	0	15.7	675	52.1 D	
			5×10^5				
			1×10^6	14.7	170	52.8 D	
			5×10^6				
169	Lupolen flame retardant jacket (1817 HX)	Kabel-Metall	0	11.4	630	50.8 D	
			5×10^5				
			1×10^6	11.1	100	53 D	
			5×10^6				
173	PE/313/PVC standard	BICC	0	10.8	280		
			5×10^5	12.7	91		
			1×10^6	6.9	50		
			5×10^6				
174	PE/314/PVC standard	BICC	0	11.8	260		
			5×10^5	20.2	140		
			1×10^6	11.8	97		
			5×10^6				

No.	Type	Supplier	Dose (Gy)	Traction R (N/mm²)	Traction E (%)	Hardness H	Oxygen index (%)
175	PE/315/PVC standard	BICC	0	11.4	630		
			5×10^5	10.4	162		
			1×10^6	10.8	125		
			5×10^6				
178	PE/15074/01	Huber & Suhner	0	13.7	530		
			5×10^5	13.1	125		
			1×10^6	14.7	105		
			5×10^6				
179	PE/K 15017	Huber & Suhner	0	7.9	270		
			5×10^5	10.8	233		
			1×10^6	10.8	95		
			5×10^6				
181	E 1110 (XDK 74)	IKO	0	12.8	480		
			5×10^5	14.6	95		
			1×10^6	14.7	85		
			5×10^6				
182	450-1	IKO	0	16.4	325		
			5×10^5	16.2	185		
			1×10^6	14.7	130		
			5×10^6				
184	Insulator 1817 HX	Leonische	0	11.8	540		
			5×10^5	13.6	180		
			1×10^6	10.8	80		
			5×10^6				
185		NORSK KF	0	14.9	540		
			5×10^5	12.2	82		
			1×10^6	14.7	100		
			5×10^6				

No.	Type	Supplier	Dose (Gy)	Traction R (N/mm²)	Traction E (%)	Hardness H	Oxygen index (%)
186		NORSK KF	0	14.7	320		
			5×10^5	10.4	155		
			1×10^6	11.8	110		
			5×10^6				
188	Low-density PE with high loading of suitable anti-oxidants	Reliance Cords	0	13.7	525		
			5×10^5	10.7	202		
			1×10^6	10.8	100		
			5×10^6				
191		Thomson-Brandt	0	10.8	530		17.3
			5×10^5	12.6	204		
			1×10^6	9.8	120		
			5×10^6				
192		Thomson-Brandt	0	11.8	690		17.8
			5×10^5	13.5	176		
			1×10^6	9.4	112		
			5×10^6				
193		Siemens	0	18.6	692	51 D	18.7
			5×10^5	14.7	165	59.5 D	
			1×10^6	14.7	105	61 D	
			5×10^6	16.3	30	63.5 D	
197	High-voltage insulator	Pirelli	0	20.0	610		
			5×10^5	21.2	369		
			1×10^6	13.8	144		
			5×10^6	11.7	20		
206	Lupolen	Felten & G.	0	17.8	682	55 D	17.8
			5×10^5	13.8	277	58 D	
			1×10^6	13.2	101	61.5 D	
			5×10^6	13.1	31	58.5 D	

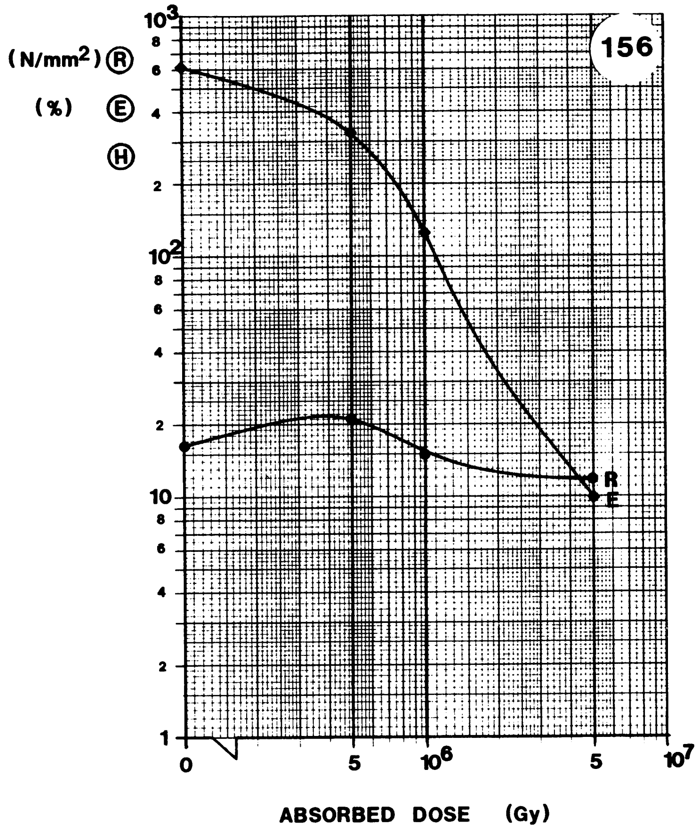
No.	Type	Supplier	Dose (Gy)	Traction R (N/mm²)	Traction E (%)	Hardness H	Oxygen index (%)
217	1812 D stabilized by means of Santonox R	Leonische	0	17.1	863	53 D	
			5×10^5	11.6	273	58 D	
			1×10^6	12.1	89	60 D	
			5×10^6	11.6	24	58 D	
218	1810 D with 0.1% stabilizer 4010 NA	Leonische	0	17.6	916	52.5 D	
			5×10^5	15.2	217	57 D	
			1×10^6	12.9	84	55.5 D	
			5×10^6	11.3	19	57.2 D	
219	1810 D with 0.5% stabilizer 4010 NA	Leonische	0	18.1	710	54.8 D	
			5×10^5	17.4	326	57 D	
			1×10^6	13.7	130	58.6 D	
			5×10^6	10.0	15	57.8 D	
220	1810 D with 0.1% stabilizer DPPD	Leonische	0	16.8	633	54.6 D	
			5×10^5	13.8	280	57 D	
			1×10^6	14.1	90	55 D	
			5×10^6	11.5	26	57 D	
221	1810 D with 0.5% stabilizer DPPD	Leonische	0	17.2	703	54.8 D	
			5×10^5	16.7	189	56.1 D	
			1×10^6	13.2	125	59.3 D	
			5×10^6	11.1	16	57.5 D	
224	Insulator	Huber & Suhner	0	13.6	492	53 D	
			5×10^5	11.0	248	57.4 D	
			1×10^6	11.9	121	59.5 D	
			5×10^6	11.2	17	58.6 D	
225	Insulator antirad	Huber & Suhner	0	16.3	653	54.8 D	
			5×10^5	14.4	403	56.6 D	
			1×10^6	11.8	148	58.1 D	
			5×10^6	11.6	26	56.7 D	

No.	Type	Supplier	Dose (Gy)	Traction R (N/mm²)	Traction E (%)	Hardness H	Oxygen index (%)
226	Insulator antirad	Huber & Suhner	0	15.5	610	53.8 D	
			5×10^5	15.8	415	54.4 D	
			1×10^6	11.2	211	55 D	
			5×10^6	11.6	25	56 D	
227	Insulator antirad	Huber & Suhner	0	13.5	590	48 D	
			5×10^5	11.9	313	45.5 D	
			1×10^6	10.6	193	45.8 D	
			5×10^6	9.5	25	45.4 D	
232	Silythene high-tension, insulator	SILEC	0	18.0	877	44 D	17.3
			5×10^5	16.2	312	47 D	
			1×10^6	12.2	117	48 D	
			5×10^6				
233	Silythene high-tension, conducting mixture extruded on insulator	SILEC	0	13.2	210	53 D	
			5×10^5	14.0	110	50 D	
			1×10^6	14.1	55	61 D	
			5×10^6				
234	Silythene high-tension, conducting mixture extruded on conductor	SILEC	0	8.7	535	42 D	
			5×10^5	10.3	272	46 D	
			1×10^6	12.2	182	47 D	
			5×10^6				
235	Isolant	Câbles de Lyon	0	18.4	732	47 D	
			5×10^5	12.8	252	49 D	
			1×10^6	12.8	81	50 D	
			5×10^6				
289 a	Semiconducting DHDA 7702	Huber & Suhner	0	11.2	295		
			5×10^5				
			1×10^6	21.5	85		
			5×10^6				

a - no graph

No.	Type	Supplier	Dose (Gy)	Traction R (N/mm^2)	Traction E (%)	Hardness H	Oxygen index (%)
290 a	Semiconducting E 8100	IKO	0	12.1	243		
			5×10^5				
			1×10^6	21.6	110		
			5×10^6				
308	1100	IKO	0	15.1	635	48 D	17.5
			5×10^5	12.3	250	50 D	
			1×10^6	13.4	102	51 D	
			5×10^6	15.1	21.5	53 D	
329	Lupolen	Kabel-Metall	0	16.7	580	44 D	18.7
			5×10^5	15.2	318	45 D	
			1×10^6	11.3	93	45 D	
			5×10^6	8.3	23	45 D	
330	Lupolen + 2% pigment	Kabel-Metall	0	15.7	600	48 D	28
			5×10^5	11.9	104	48 D	
			1×10^6	12.8	100	50 D	
			5×10^6	9.1	18	51 D	

a - no graph



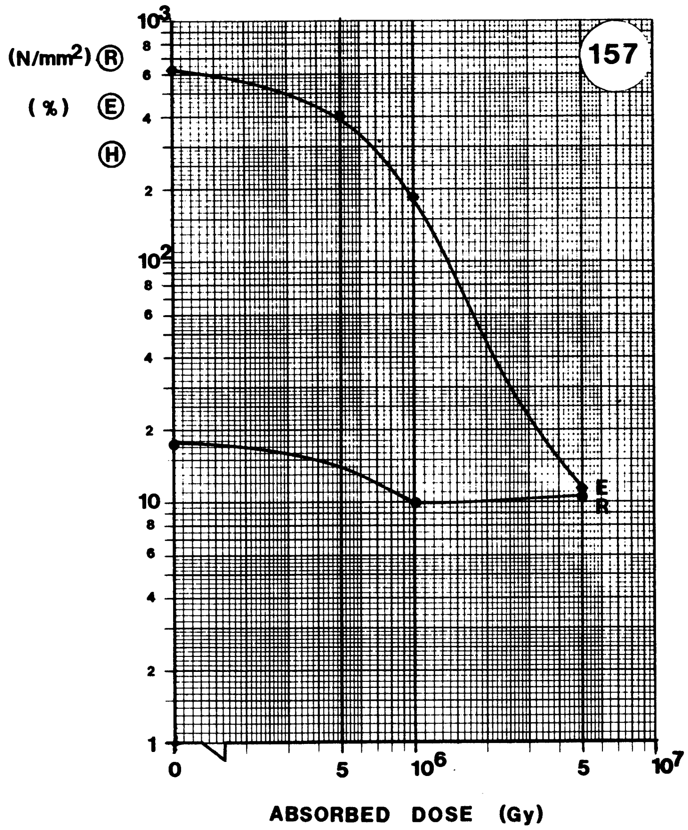
MATERIAL: PE

TYPE: Lupolen

SUPPLIER: Kabel-Metall

Remarks:

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	16.2	N/mm²
E	Elong. at break	607	%
H	Hardness	-	Shore C,D
	Oxygen index	-	



MATERIAL: PE

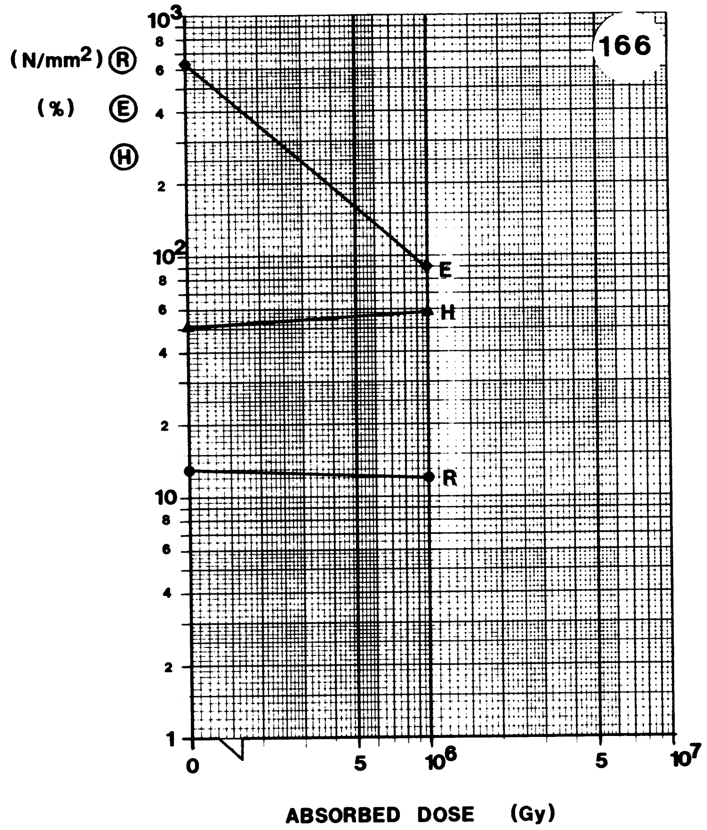
TYPE: Stabilized

SUPPLIER: Kabel-Metall

Remarks:

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	17.2	N/mm²
E	Elong. at break	608	%
H	Hardness	-	Shore C,D
	Oxygen index	-	

PE



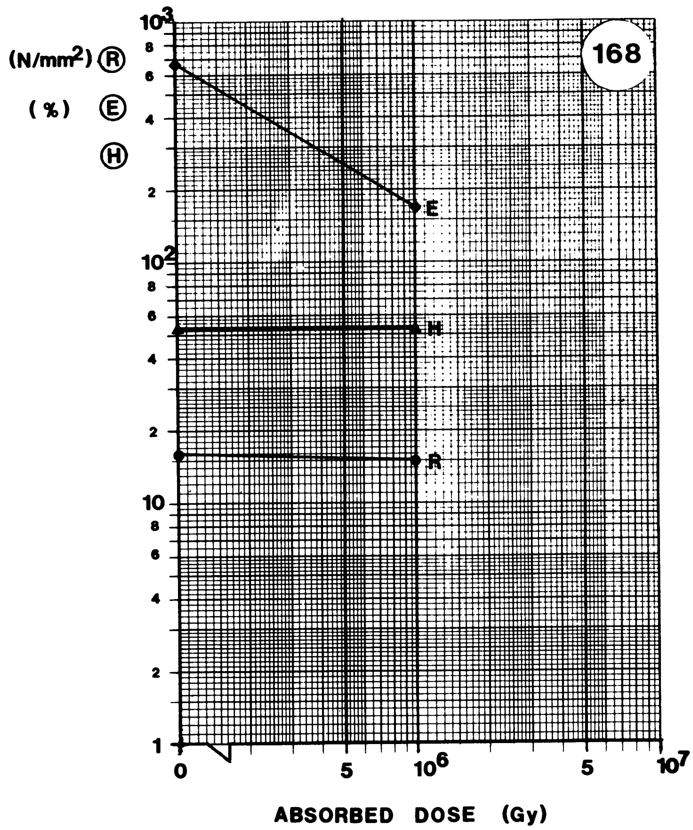
MATERIAL: PE

TYPE: LUPOLEN

SUPPLIER: KABEL-METALL

Remarks:

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	12.8	N/mm^2
E	Elong. at break	630	%
H	Hardness	51.3	Shore D
	Oxygen index	-	



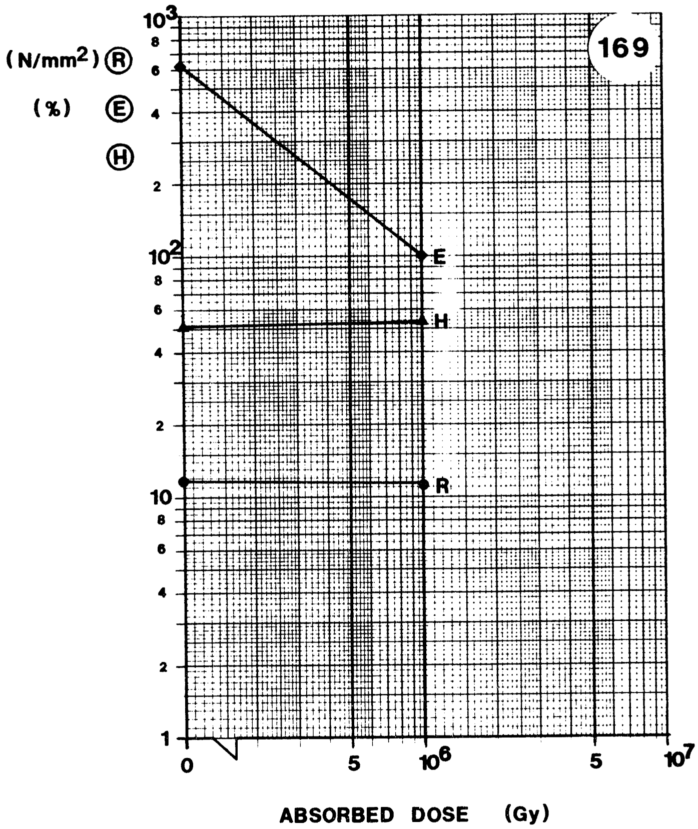
MATERIAL: PE

TYPE: LUPOLEN

SUPPLIER: KABEL-METALL

Remarks:

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	15.7	N/mm^2
E	Elong. at break	675	%
H	Hardness	52.1	Shore D
	Oxygen index	-	



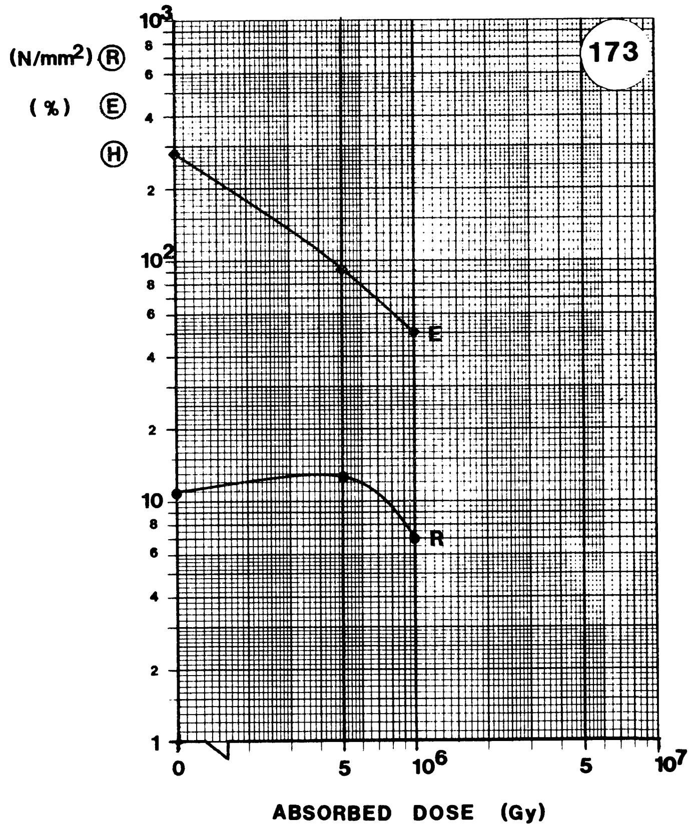
MATERIAL: PE

TYPE: LUPOLEN, JACKET

SUPPLIER: KABEL-METALL

Remarks: FLAME RETARDANT; USED FOR SPS WATER-COOLED POWER CABLES

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	11.4	N/mm^2
E	Elong. at break	630	%
H	Hardness	50.8	Shore D
	Oxygen index	-	



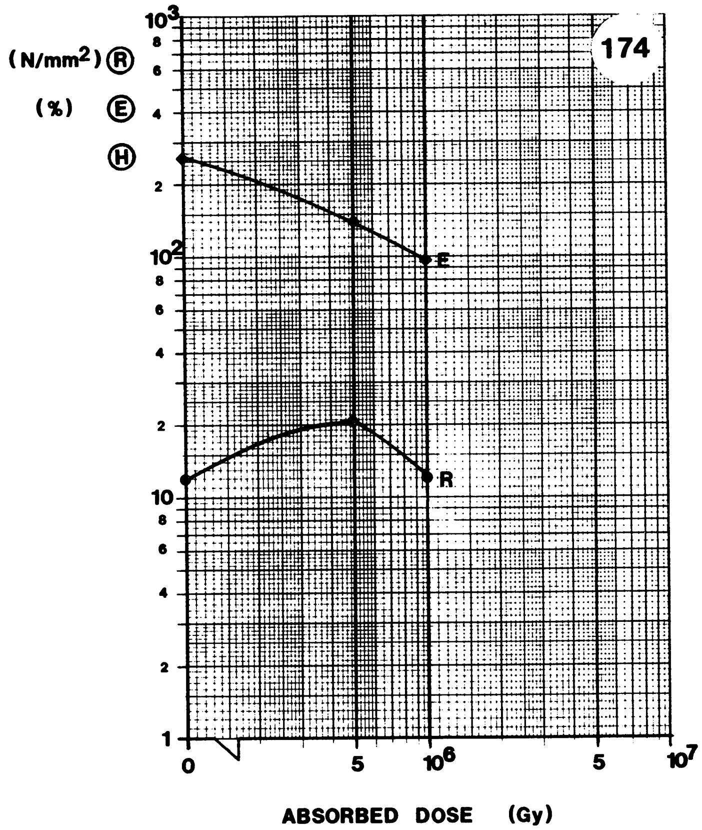
MATERIAL: PE

TYPE: PE/313/PVC

SUPPLIER: BICC

Remarks: SPS VIDEO CABLE VA 4 (INDOOR TYPE)

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	10.8	N/mm^2
E	Elong. at break	280	%
H	Hardness	-	Shore C,D
	Oxygen index	-	



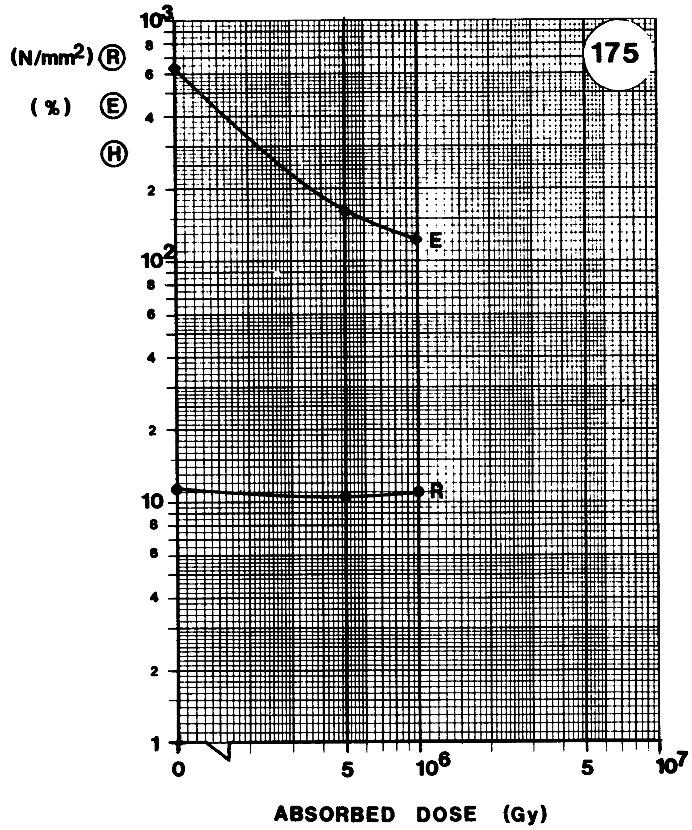
MATERIAL: PE

TYPE: PE/314/PVC

SUPPLIER: BICC

Remarks:

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	11.8	N/mm^2
E	Elong. at break	260	%
H	Hardness	-	Shore C,D
	Oxygen index	-	



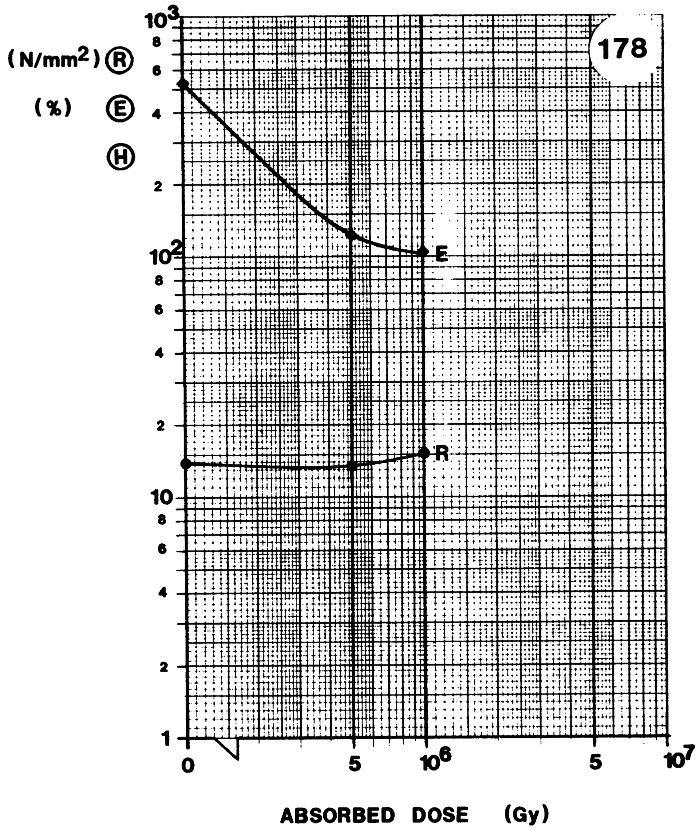
MATERIAL: PE

TYPE: PE/315/PVC

SUPPLIER: BICC

Remarks: VIDEO CABLE VAU 24 (UNDER-GROUND TYPE)

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	11.4	N/mm^2
E	Elong. at break	630	%
H	Hardness	-	Shore C,D
	Oxygen index	-	



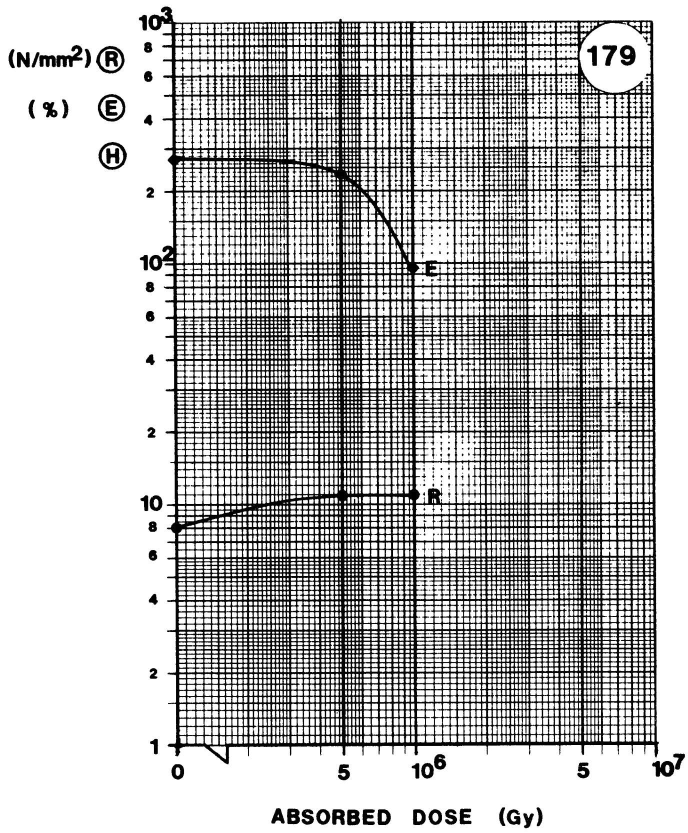
MATERIAL: PE

TYPE:

SUPPLIER: HUBER & SUHNER

Remarks:

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	13.7	N/mm2
E	Elong. at break	530	%
H	Hardness	-	Shore C,D
	Oxygen index	-	



MATERIAL: PE

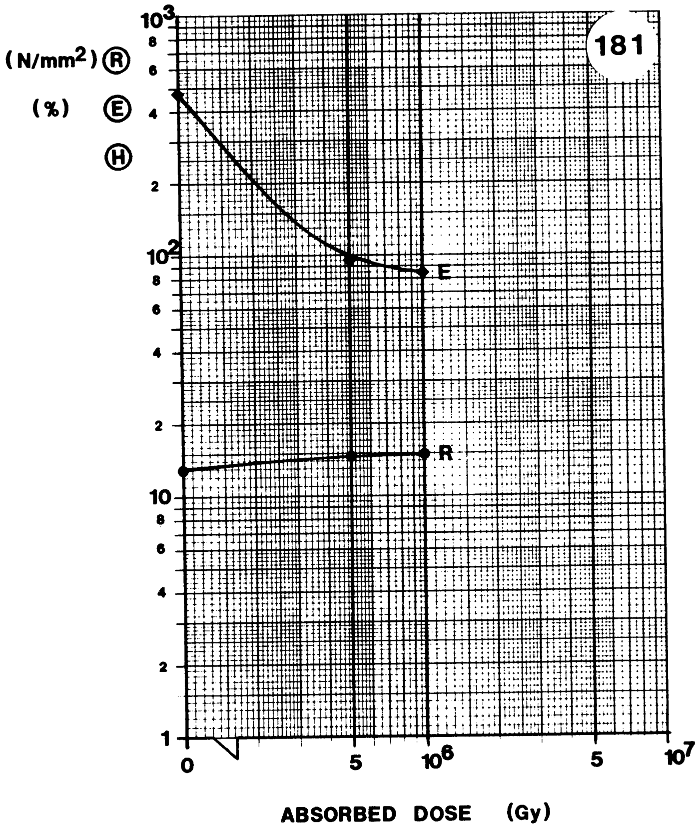
TYPE:

SUPPLIER: HUBER & SUHNER

Remarks: TWIN AXIAL CABLE RG22/U-TWB95

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	7.9	N/mm2
E	Elong. at break	270	%
H	Hardness	-	Shore C,D
	Oxygen index	-	

PE



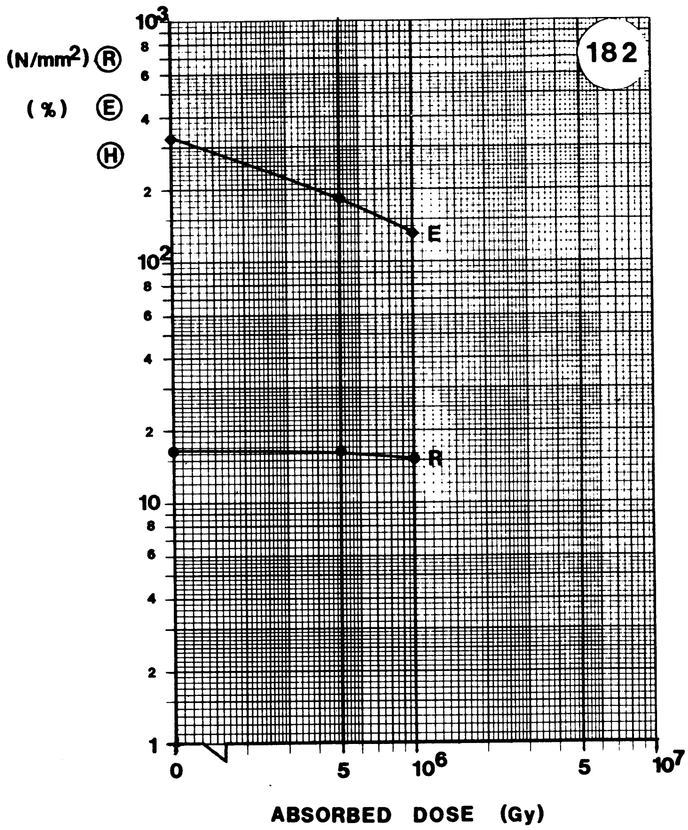
MATERIAL: PE

TYPE:

SUPPLIER: IKO

Remarks: VIDEO CABLES VA16 AND VA24 (INDOOR TYPE)

CURVE	PROPERTY	INITIAL	VALUE
R	Tensile strength	12.8	N/mm^2
E	Elong. at break	480	%
H	Hardness	-	Shore C,D
	Oxygen index	-	



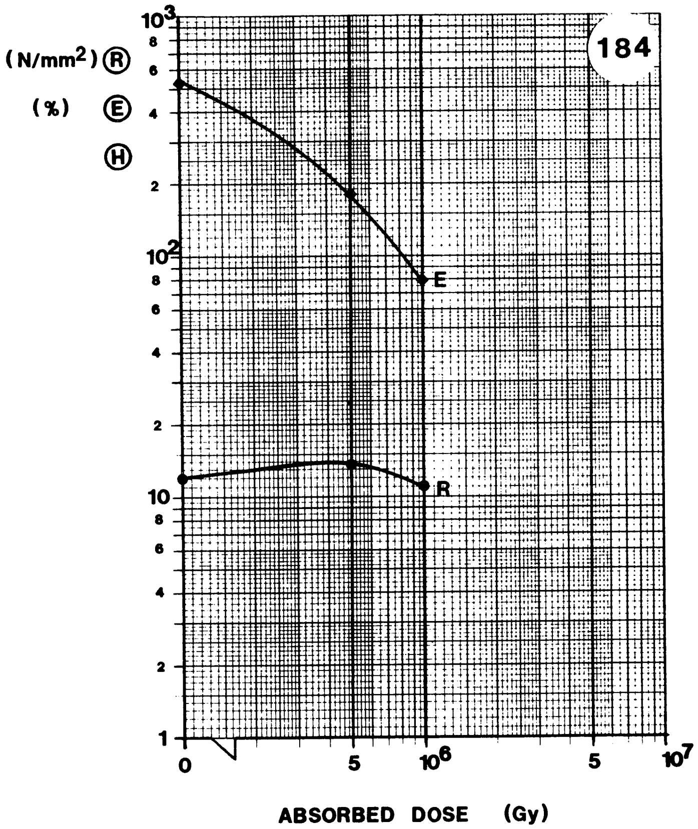
MATERIAL: PE

TYPE:

SUPPLIER: IKO

Remarks:

CURVE	PROPERTY	INITIAL	VALUE
R	Tensile strength	16.4	N/mm^2
E	Elong. at break	325	%
H	Hardness	-	Shore C,D
	Oxygen index	-	



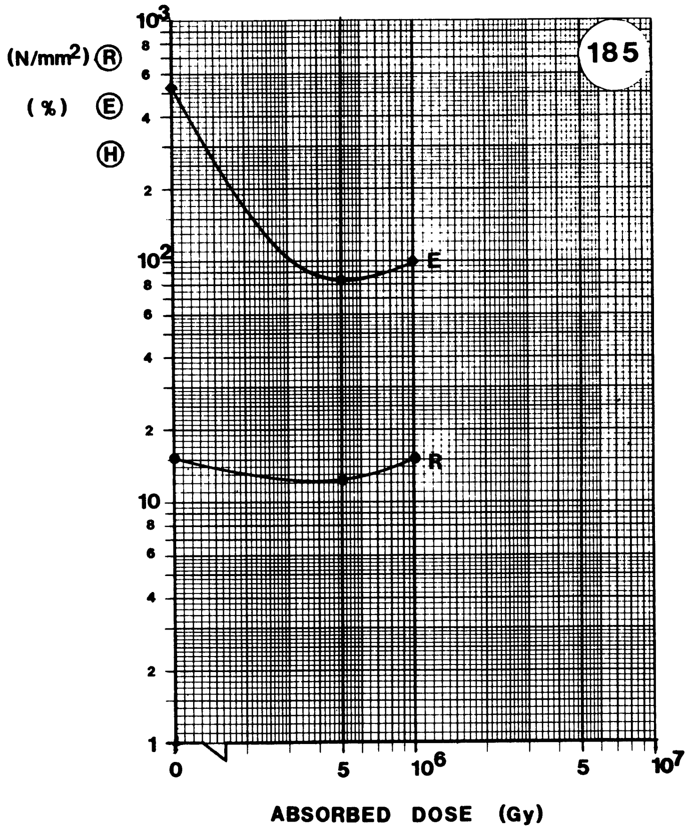
MATERIAL: PE

TYPE: Insulator

SUPPLIER: Leonische

Remarks:

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	11.8	N/mm^2
E	Elong. at break	540	%
H	Hardness	-	Shore C,D
	Oxygen index	-	



MATERIAL: PE

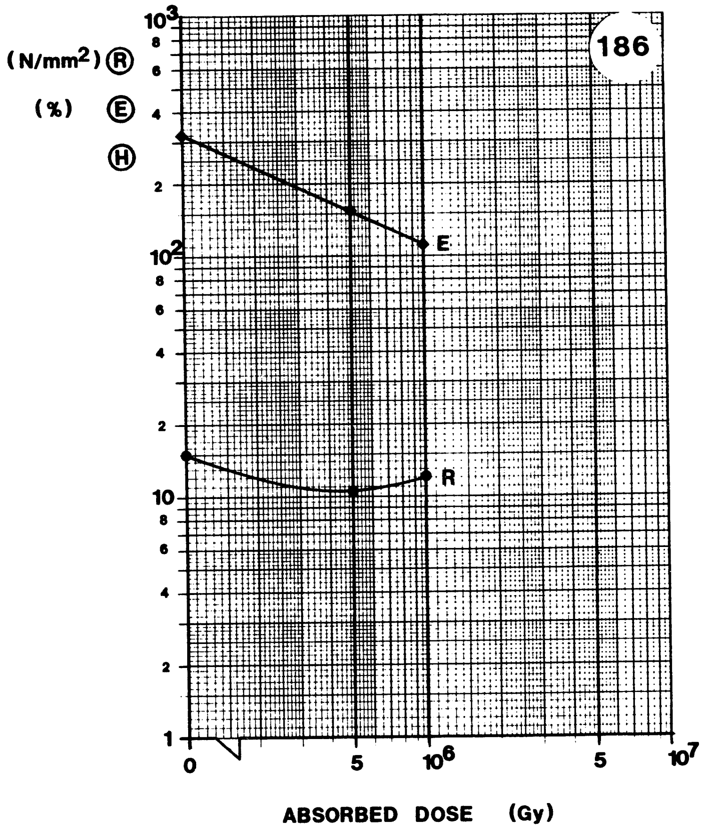
TYPE: Transparent

SUPPLIER: NORSK KF

Remarks: Vacuum pump supply cable SVH2

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	14.9	N/mm^2
E	Elong. at break	540	%
H	Hardness	-	Shore C,D
	Oxygen index	-	

PE



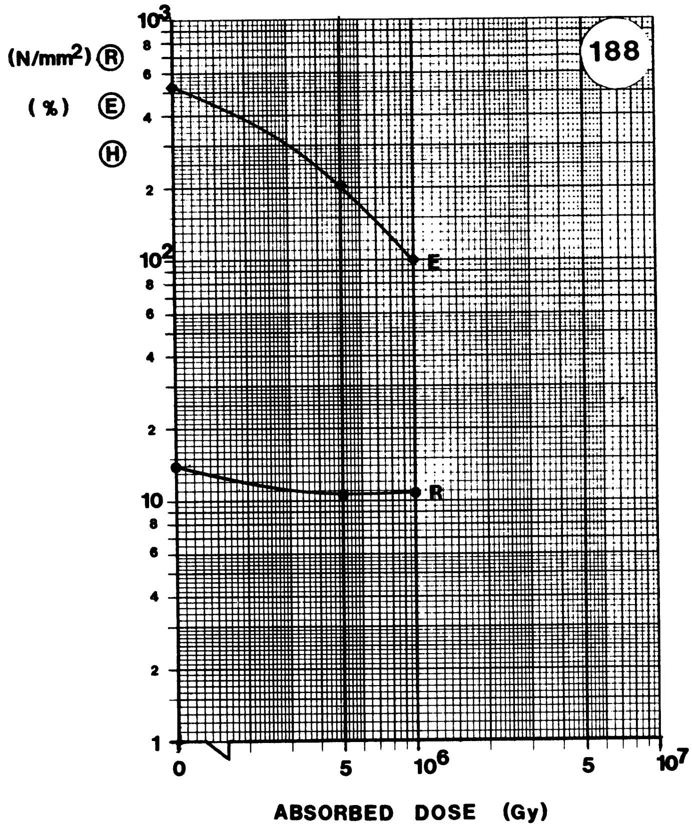
MATERIAL: PE

TYPE:

SUPPLIER: NORSK KF

Remarks:

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	14.7	N/mm²
E	Elong. at break	320	%
H	Hardness		Shore C,D
	Oxygen index		



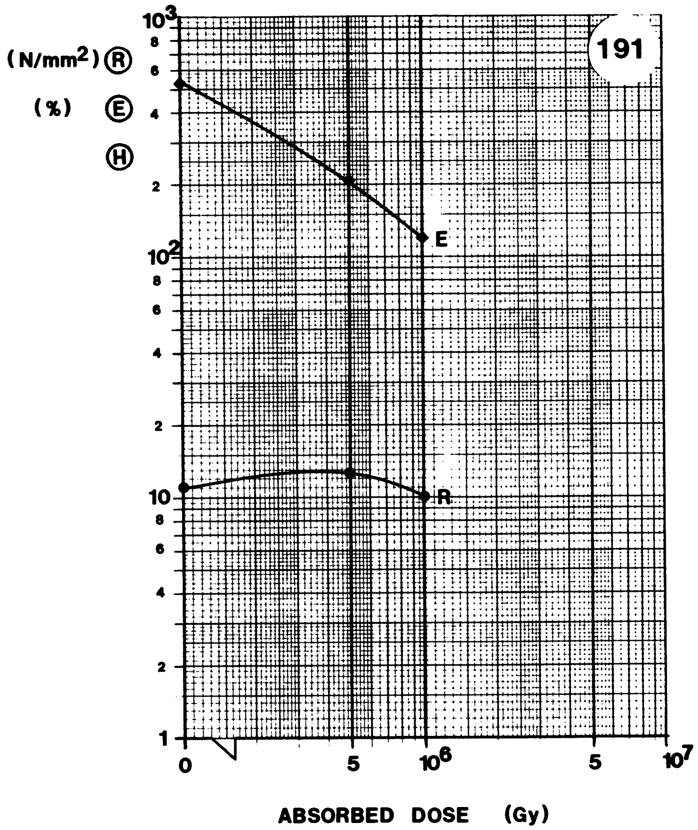
MATERIAL: PE

TYPE: Low-density with high loading of suitable antioxidants

SUPPLIER: Reliance Cords

Remarks:

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	13.7	N/mm²
E	Elong. at break	525	%
H	Hardness	-	Shore C,D
	Oxygen index	-	



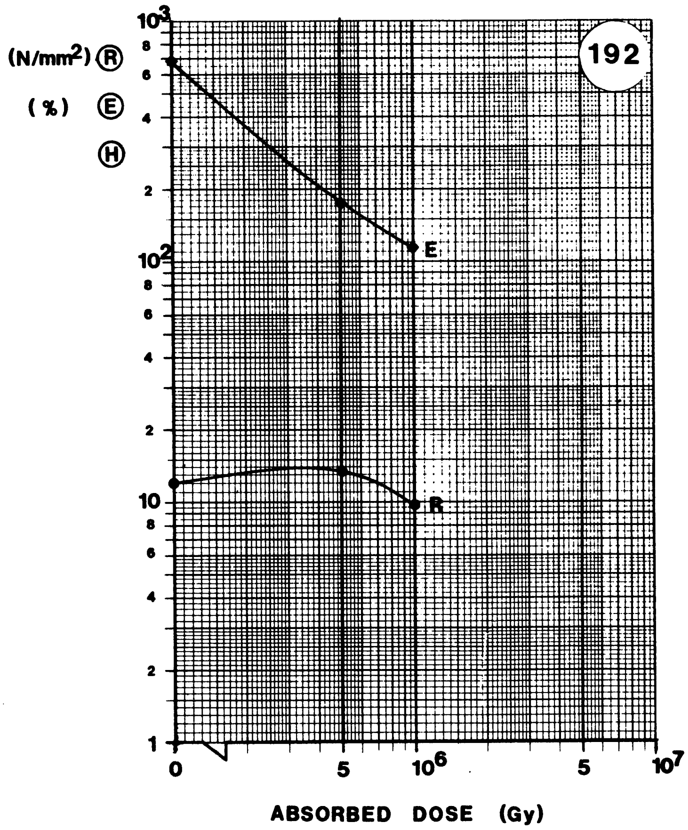
MATERIAL: PE

TYPE:

SUPPLIER: THOMSON-BRANDT

Remarks: MULTICOR CABLES FOR CLOSED-ORBIT CORRECTION SBA12, SBB12.

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	10.8	N/mm^2
E	Elong. at break	530	%
H	Hardness	-	Shore C,D
	Oxygen index	17.3	



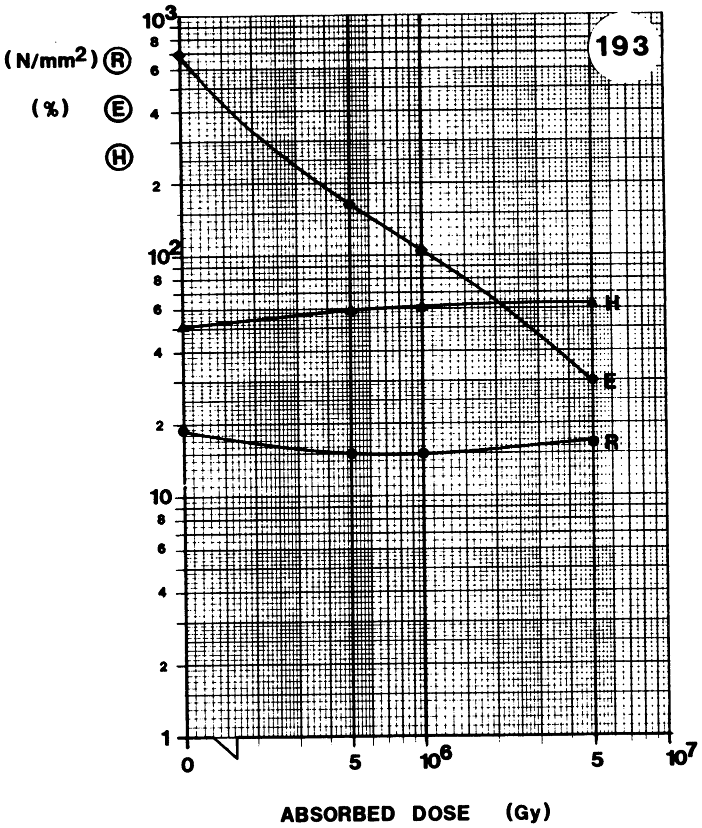
MATERIAL: PE

TYPE:

SUPPLIER: THOMSON-BRANDT

Remarks:

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	11.8	N/mm^2
E	Elong. at break	690	%
H	Hardness	-	Shore C,D
	Oxygen index	17.8	



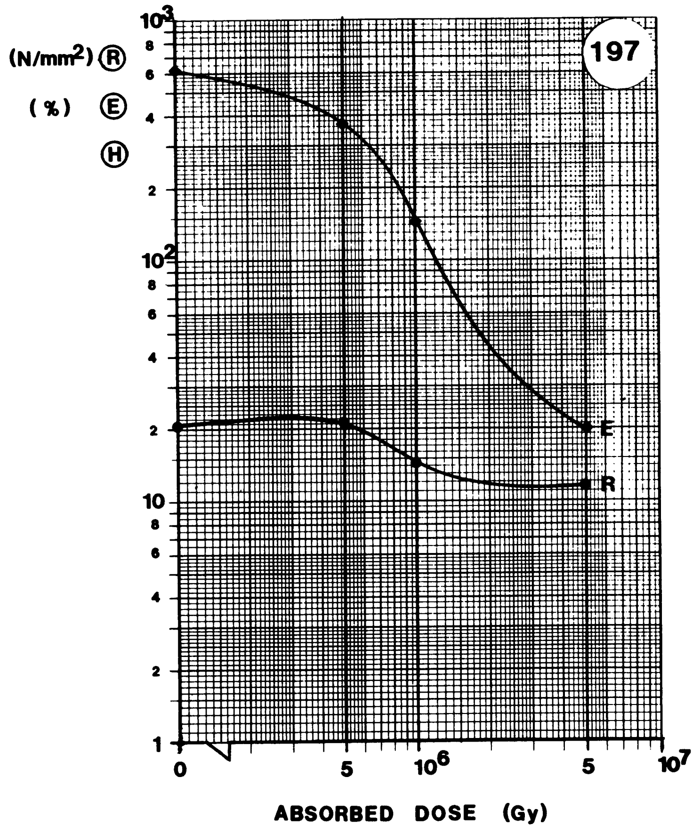
MATERIAL: PE

TYPE:

SUPPLIER: Siemens

Remarks:

CURVE	PROPERTY	INITIAL	VALUE
R	Tensile strength	18.6	N/mm²
E	Elong. at break	692	%
H	Hardness	51	Shore D
	Oxygen index	18.7	



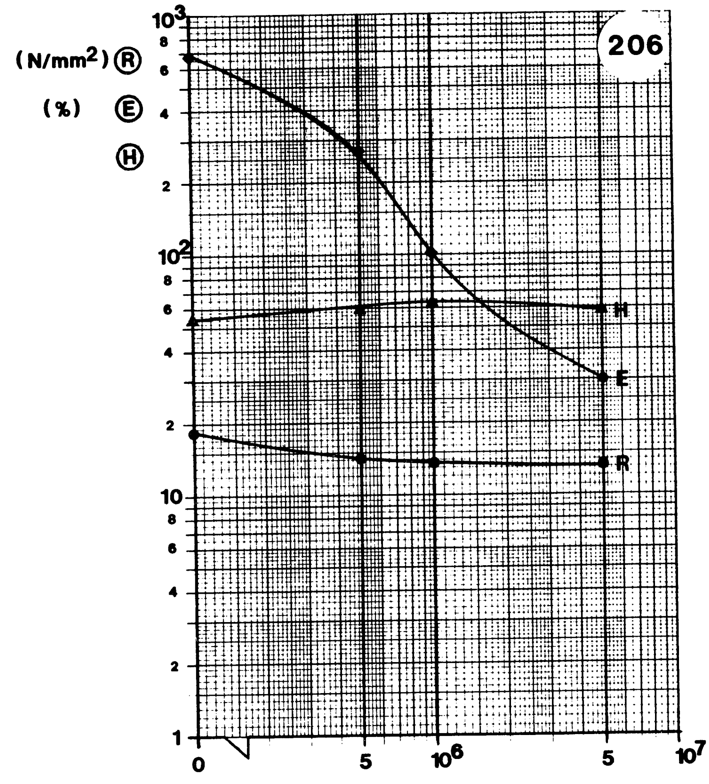
MATERIAL: PE

TYPE: High-voltage insulator

SUPPLIER: Pirelli

Remarks:

CURVE	PROPERTY	INITIAL	VALUE
R	Tensile strength	20.0	N/mm²
E	Elong. at break	610	%
H	Hardness	-	Shore C,D
	Oxygen index	-	



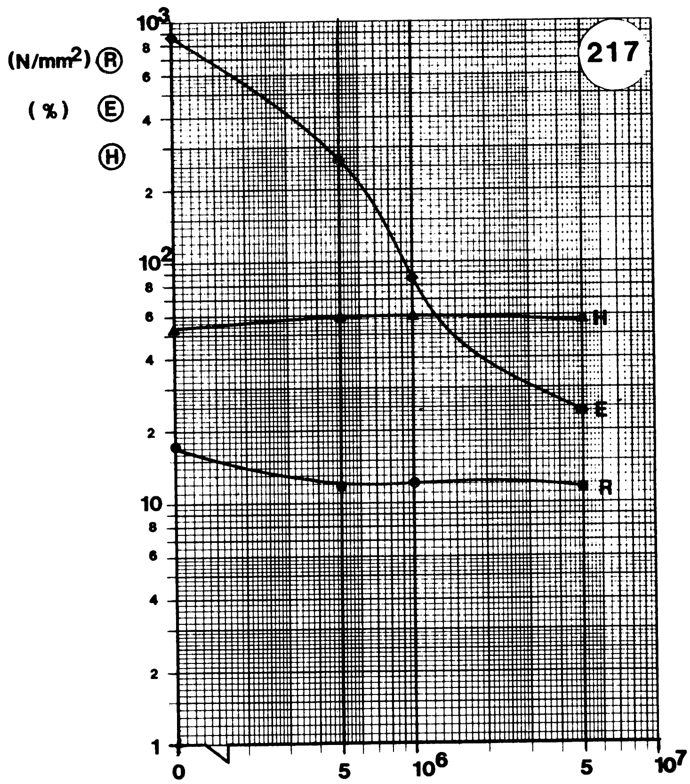
MATERIAL: PE

TYPE: Lupolen

SUPPLIER: Felten & G.

Remarks:

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	17.8	N/mm2
E	Elong. at break	682	%
H	Hardness	55	Shore D
	Oxygen index	17.8	



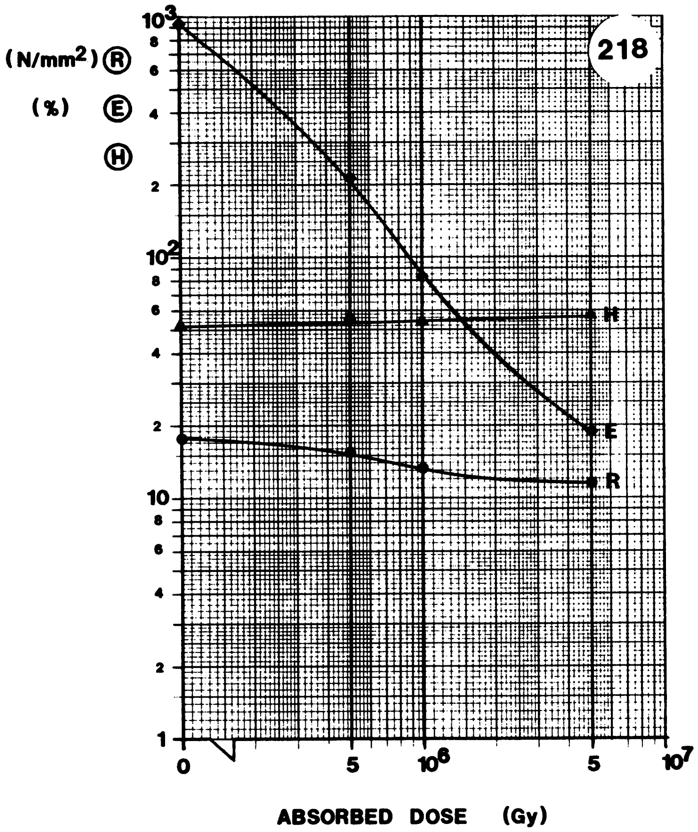
MATERIAL: PE

TYPE: Stabilized by means of Santonox R

SUPPLIER: Leonische

Remarks:

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	17.1	N/mm2
E	Elong. at break	863	%
H	Hardness	53	Shore D
	Oxygen index	-	



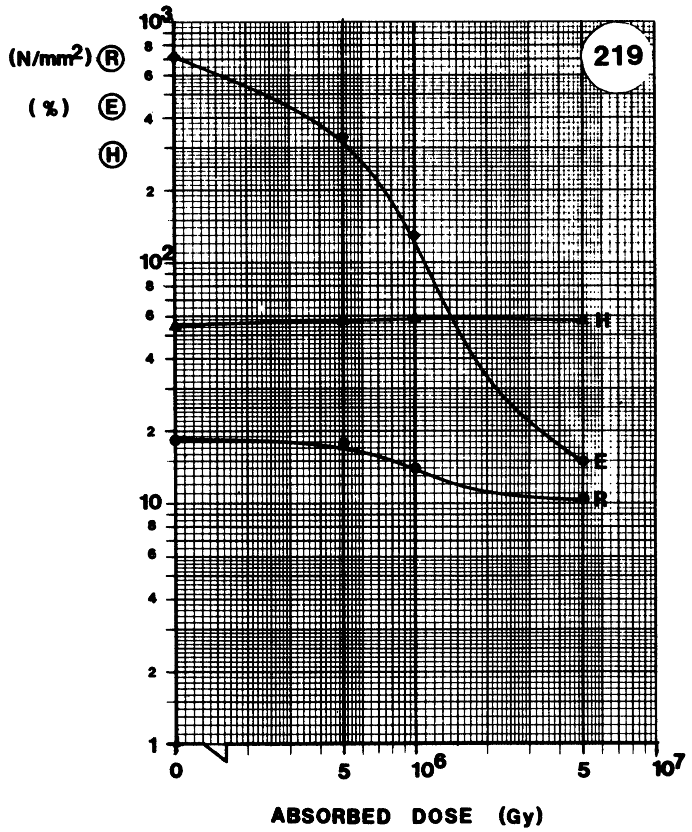
MATERIAL: PE

TYPE: 1810 D WITH 0.1% STABILIZER 4010 NA

SUPPLIER: LEONISCHE

Remarks:

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	17.6	N/mm^2
E	Elong. at break	916	%
H	Hardness	52.5	Shore D
	Oxygen index	-	



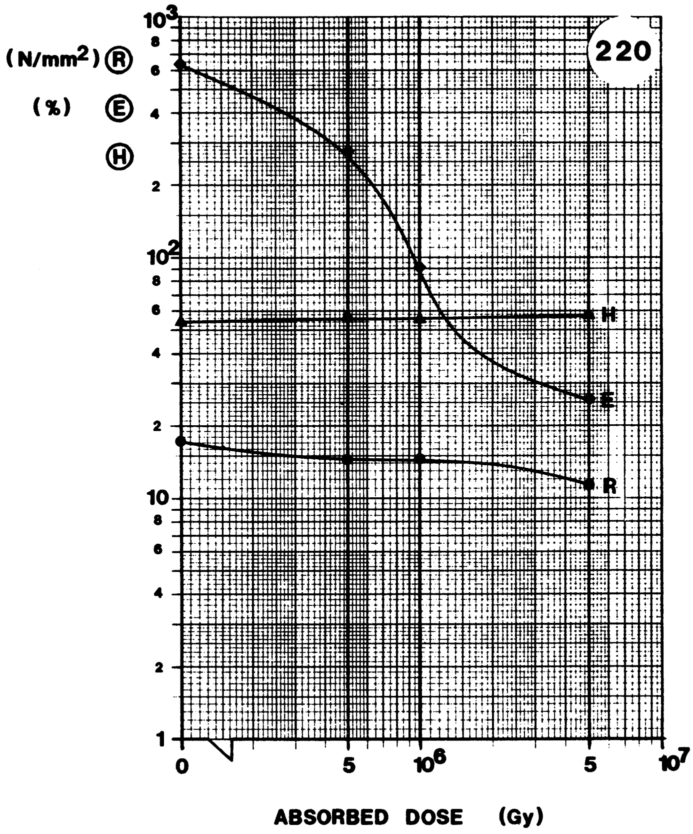
MATERIAL: PE

TYPE: 1810 D WITH 0.5% STABILIZER 4010 NA

SUPPLIER: LEONISCHE

Remarks:

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	18.1	N/mm^2
E	Elong. at break	710	%
H	Hardness	54.8	Shore D
	Oxygen index	-	



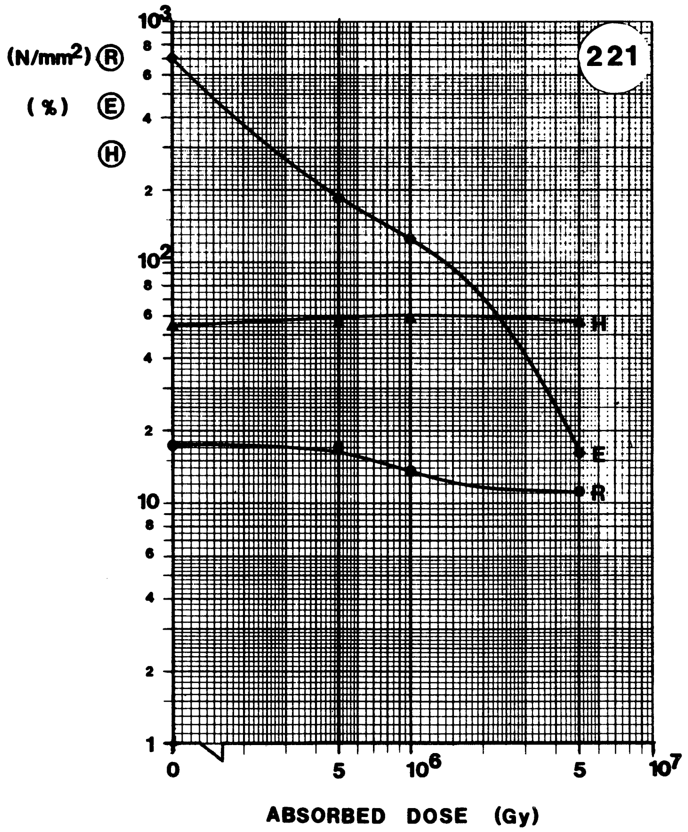
MATERIAL: PE

TYPE: 1810 D WITH 0.1% STABILIZER DPPD

SUPPLIER: LEONISCHE

Remarks:

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	16.8	N/mm^2
E	Elong. at break	633	%
H	Hardness	54.6	Shore D
	Oxygen index	-	



MATERIAL: PE

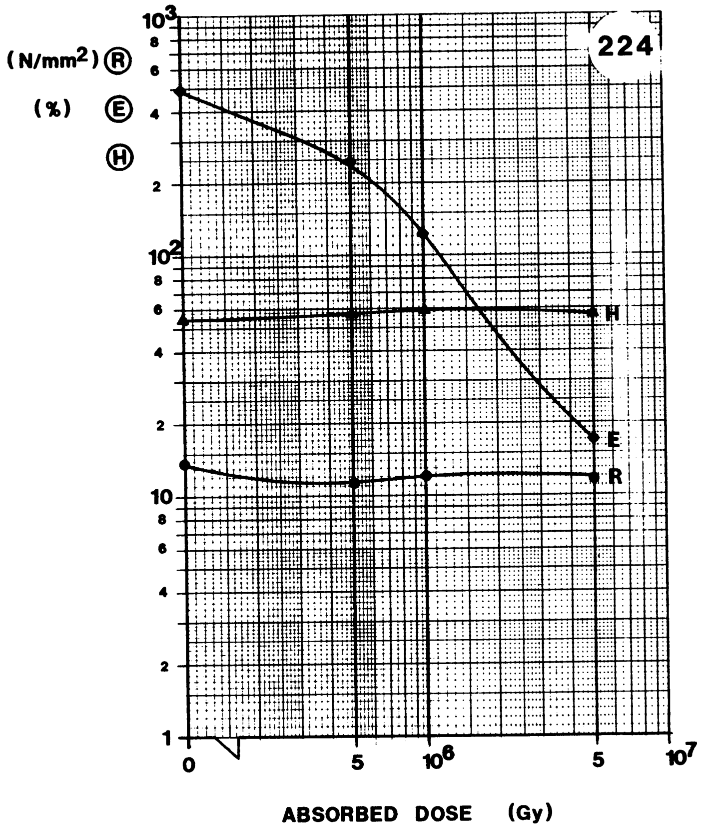
TYPE: 1810 D WITH 0.5% STABILIZER DPPD

SUPPLIER: LEONISCHE

Remarks:

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	17.2	N/mm^2
E	Elong. at break	703	%
H	Hardness	54.8	Shore D
	Oxygen index	-	

PE



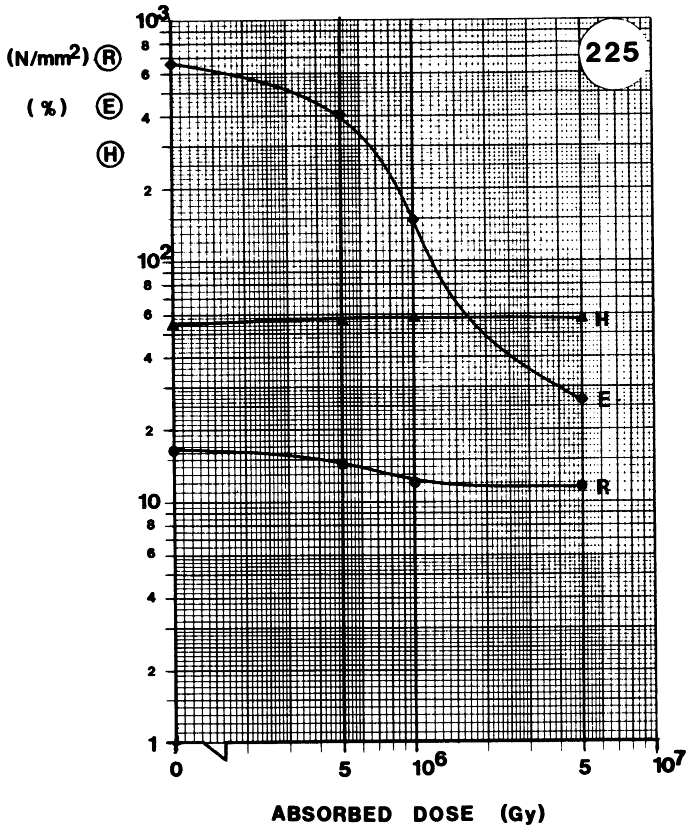
MATERIAL: PE

TYPE: INSULATOR

SUPPLIER: HUBER & SUHNER

Remarks:

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	13.6	N/mm^2
E	Elong. at break	492	%
H	Hardness	53	Shore D
	Oxygen index	-	



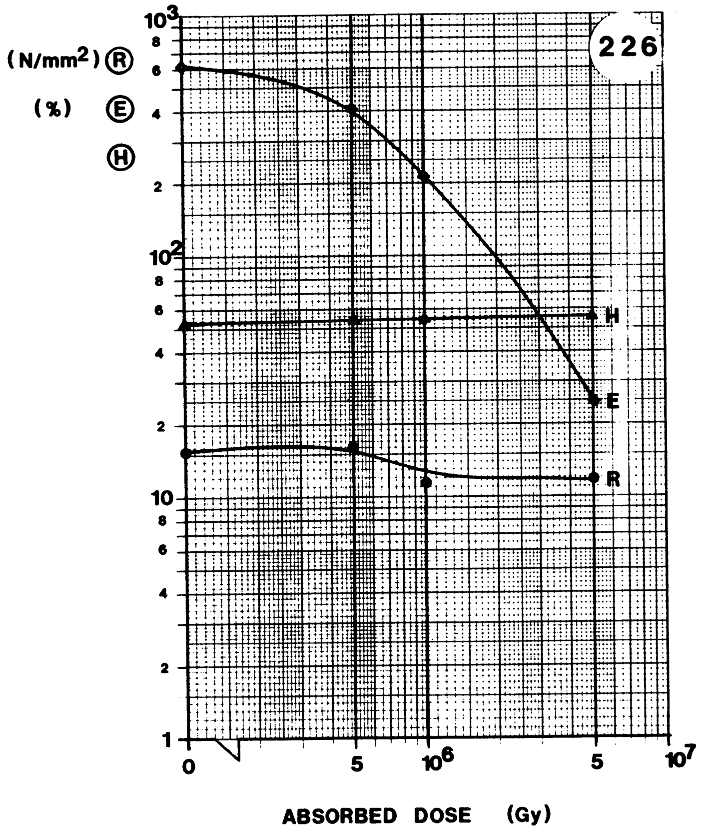
MATERIAL: PE

TYPE: INSULATOR, ANTIRAD

SUPPLIER: HUBER & SUHNER

Remarks:

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	16.3	N/mm^2
E	Elong. at break	653	%
H	Hardness	54.8	Shore D
	Oxygen index	-	



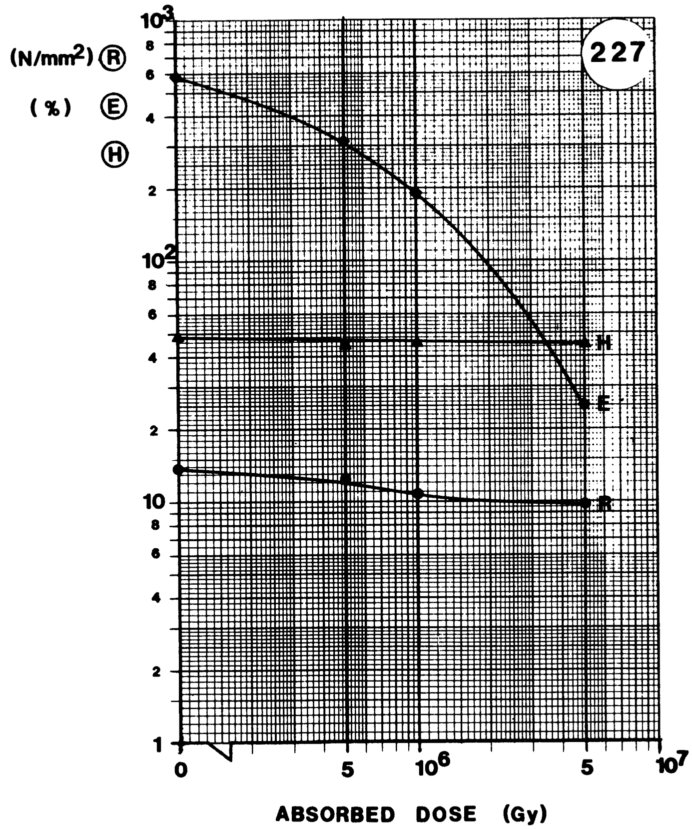
MATERIAL: PE

TYPE: INSULATOR, ANTIRAD

SUPPLIER: HUBER & SUHNER

Remarks:

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	15.5	N/mm^2
E	Elong. at break	610	%
H	Hardness	53.8	Shore D
	Oxygen index	-	



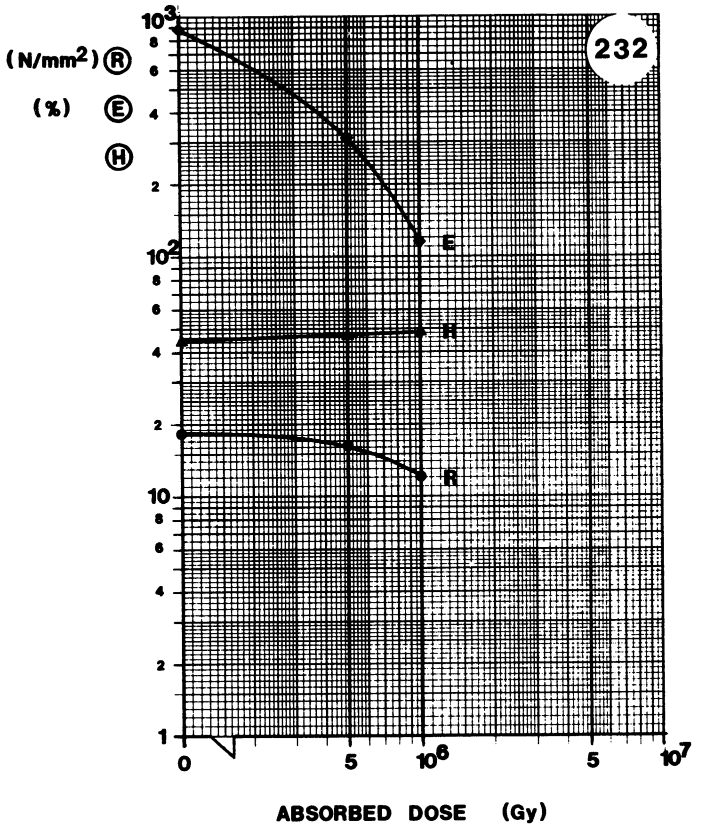
MATERIAL: PE

TYPE: INSULATOR, ANTIRAD

SUPPLIER: HUBER & SUHNER

Remarks:

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	13.5	N/mm^2
E	Elong. at break	590	%
H	Hardness	48	Shore D
	Oxygen index	-	



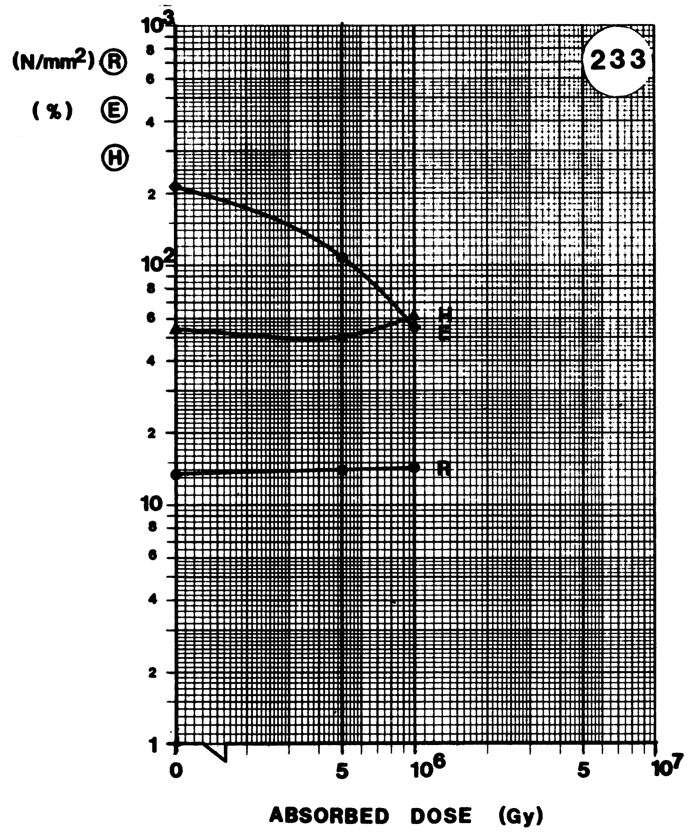
MATERIAL: PE

TYPE: SILYTHENE, HIGH-TENSION, INSULATOR

SUPPLIER: SILEC

Remarks: USED FOR SPS 300 kV D.C. CABLE

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	18.0	N/mm^2
E	Elong. at break	877	%
H	Hardness	44	Shore D
	Oxygen index	17.3	



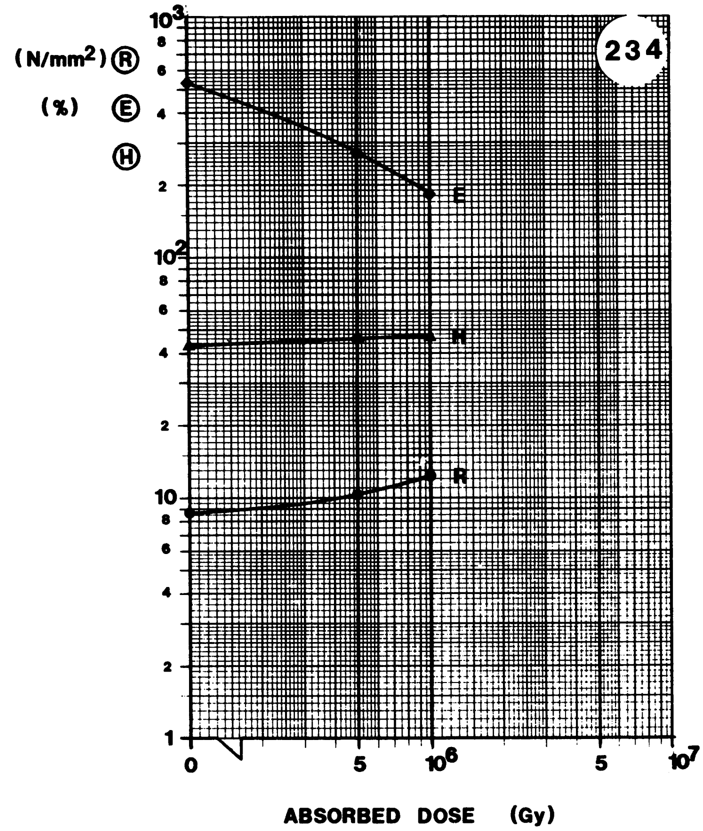
MATERIAL: PE

TYPE: SILYTHENE, HIGH-TENSION

SUPPLIER: SILEC

Remarks: CONDUCTING MIXTURE EXTRUDED ON INSULATOR
USED FOR SPS 300 kV D.C. CABLE

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	13.2	N/mm^2
E	Elong. at break	210	%
H	Hardness	53	Shore D
	Oxygen index	-	



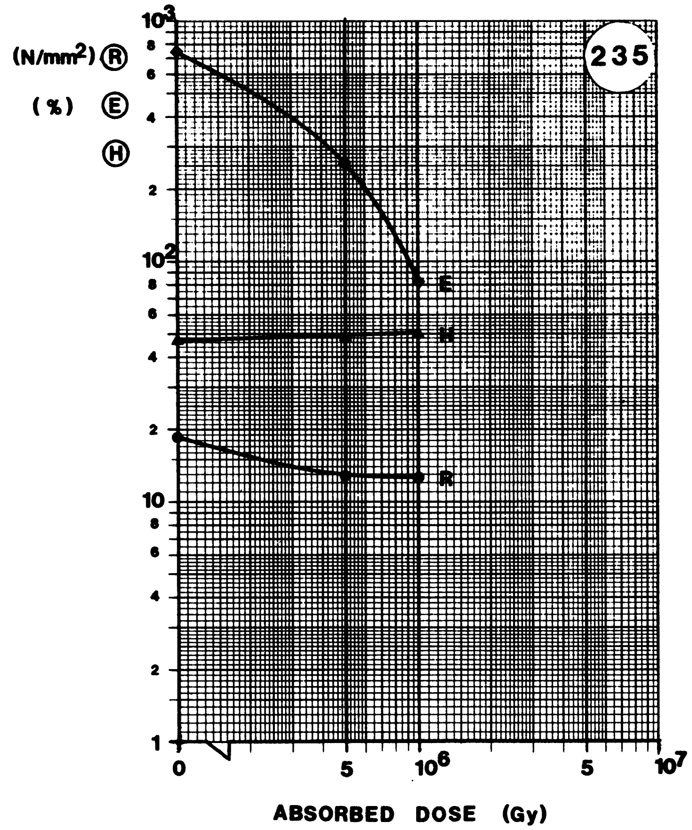
MATERIAL: PE

TYPE: SILYTHENE, HIGH-TENSION

SUPPLIER: SILEC

Remarks: CONDUCTING MIXTURE
USED FOR SPS 300 kV D.C. CABLE

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	8.7	N/mm²
E	Elong. at break	535	%
H	Hardness	42	Shore D
	Oxygen index	-	



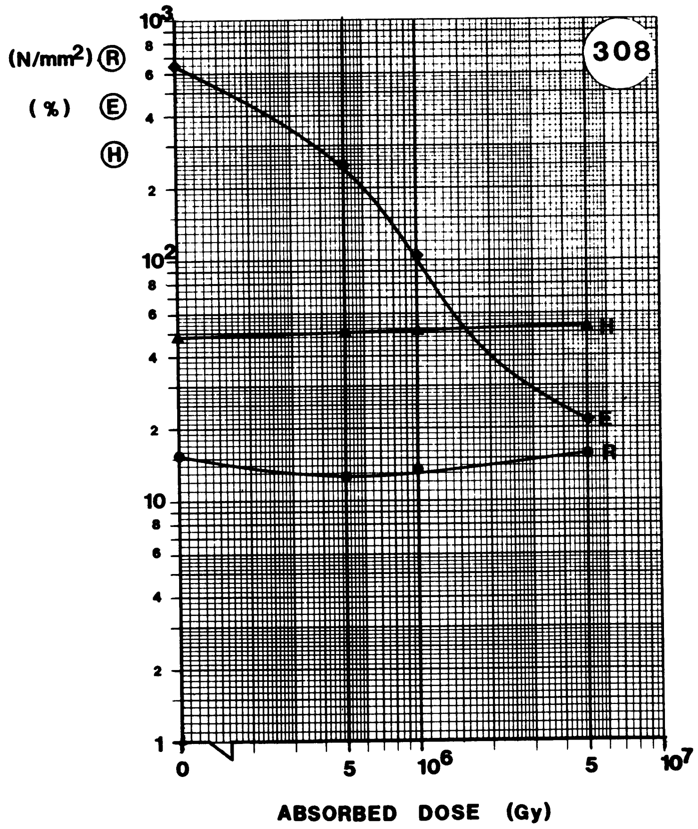
MATERIAL: PE

TYPE: INSULATOR

SUPPLIER: CABLES DE LYON

Remarks:

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	18.4	N/mm²
E	Elong. at break	732	%
H	Hardness	47	Shore D
	Oxygen index	-	



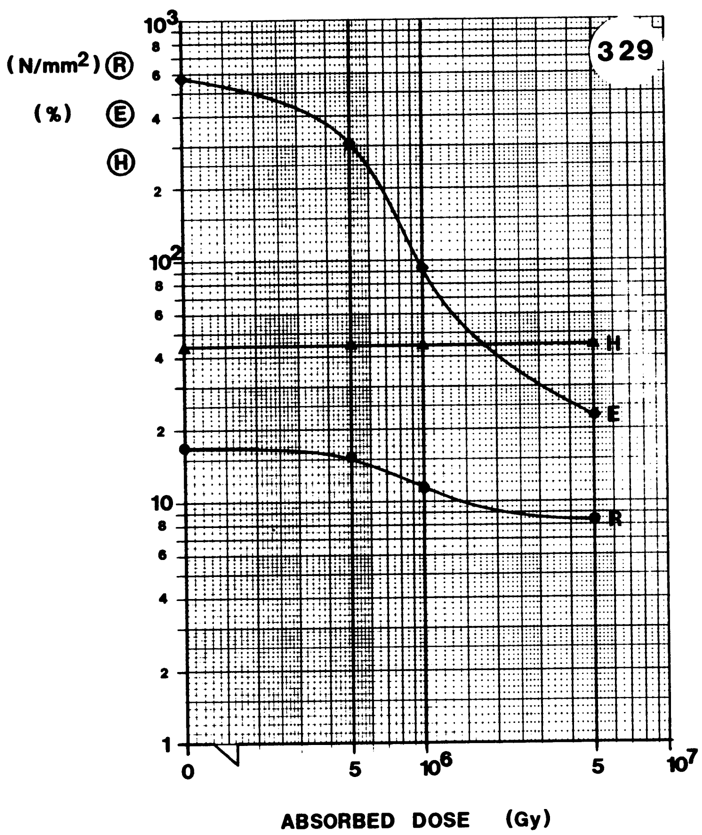
MATERIAL: PE

TYPE:

SUPPLIER: IKO

Remarks: POWER CABLE NL5

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	15.1	N/mm^2
E	Elong. at break	635	%
H	Hardness	48	Shore D
	Oxygen index	17.5	



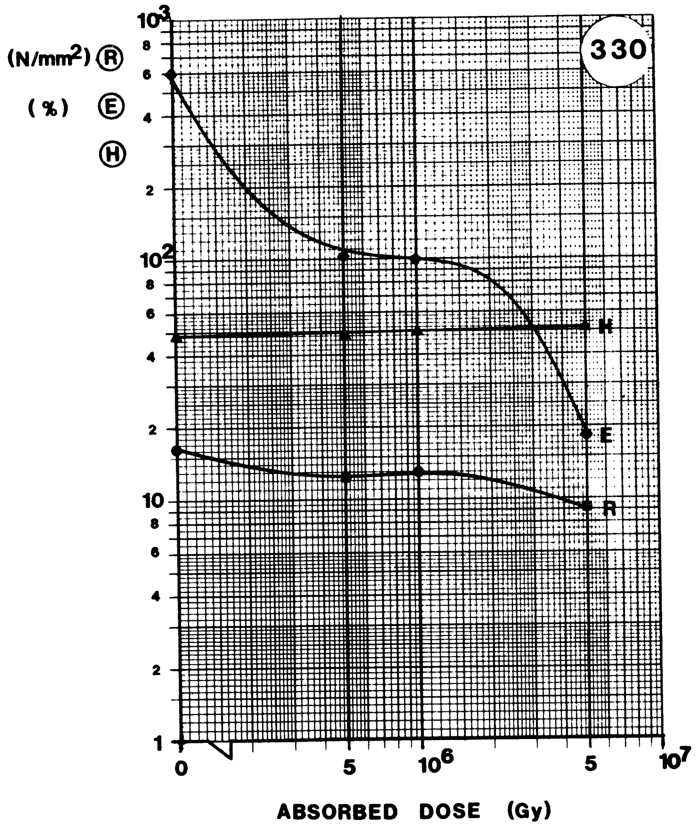
MATERIAL: PE

TYPE: LUPOLEN

SUPPLIER: KABEL-METALL

Remarks:

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	16.7	N/mm^2
E	Elong. at break	580	%
H	Hardness	44	Shore D
	Oxygen index	18.7	



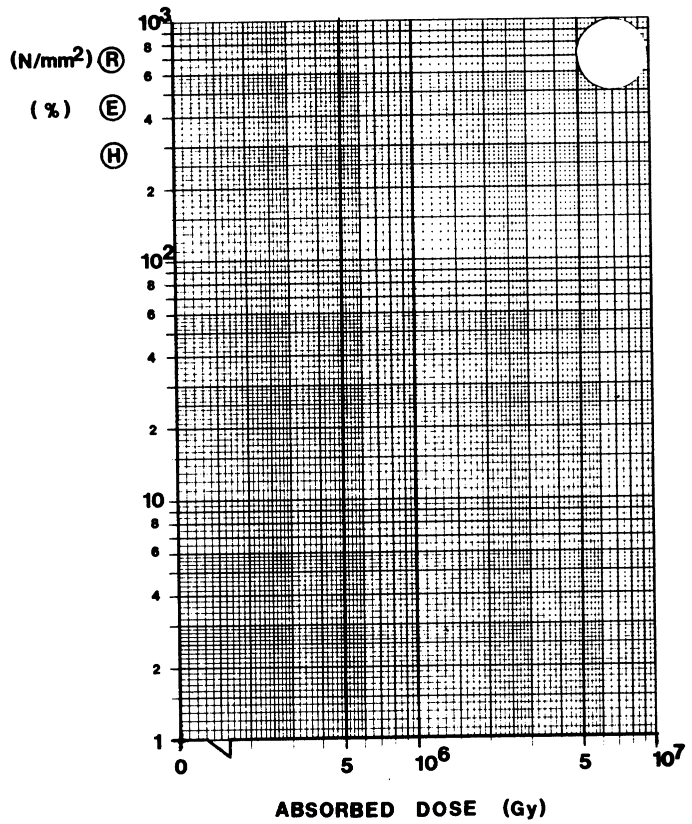
MATERIAL: PE

TYPE: LUPOLEN + 2% PIGMENT

SUPPLIER: KABEL-METALL

Remarks:

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	15.7	N/mm2
E	Elong. at break	600	%
H	Hardness	48	Shore D
	Oxygen index	28	



MATERIAL:

TYPE:

SUPPLIER:

Remarks:

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength		N/mm2
E	Elong. at break		%
H	Hardness		Shore C,D
	Oxygen index		

POLYURETHANE*)

Characteristic group

$$\left[-NH-\overset{O}{\overset{\|}{C}}-O-\right] \text{ urethane group}$$

Chemically, the commercial PUR elastomers are copolymers containing polyurethane and polyester or polyether units:

polyester $$\left[-\overset{O}{\overset{\|}{C}}-O-R'-O-\overset{O}{\overset{\|}{C}}-\right]_m$$

polyether $$O-\left[R''-O-\right]_m$$

They are linked together in the polymer formation to give the following urethane polymer linkage:

$$\left[-O-\overset{O}{\overset{\|}{C}}-NH-(R)_m-NH-\overset{O}{\overset{\|}{C}}-O-\right]_n$$

where n ranges from 50 to 100**).

For general characteristics, see Table 1 in Section 2.

---

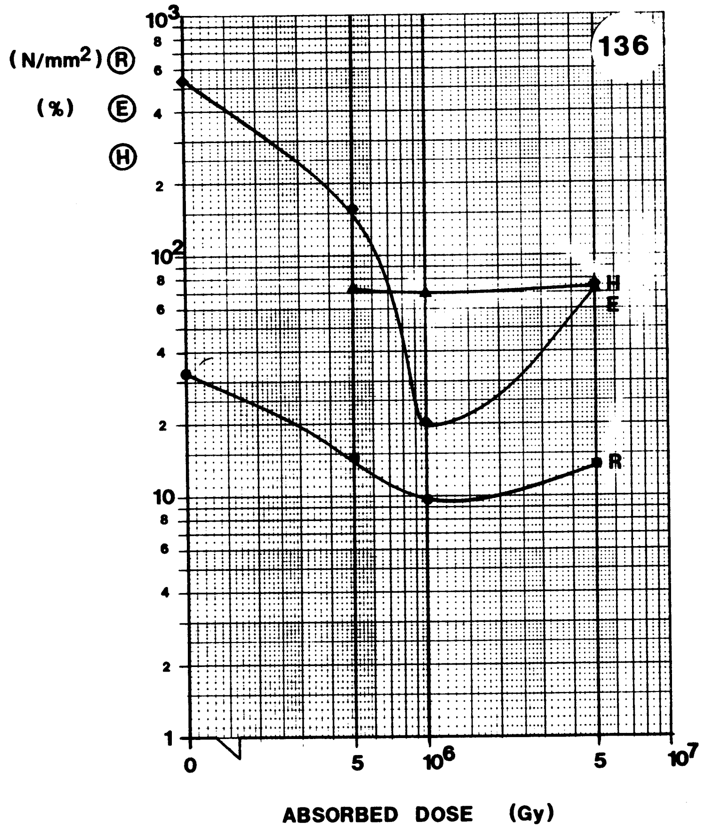
*) J.H. Saunders and K.C. Frisch, High polymers, Vol. XVI: Polyurethanes. Part 1 - Chemistry; Part 2 - Technology (Interscience Publ., New-York, 1964).

**) F.M. Clark, Insulating materials for design and engineering practice (John Wiley and Sons, Inc., New-York, 1962).

No.	Type	Supplier	Dose (Gy)	Traction R (N/mm²)	Traction E (%)	Hardness H	Oxygen index (%)
136	PUR 3 thermoplastic	DRAKA	0	32.4	530		24.5
			5×10^5	13.9	152	72.5 C	
			1×10^6	9.4	20	70 C	
			5×10^6	13.5	72	74 C	
283	786	FILECA	0	22.4	725		26.0
			5×10^5	20.6	641		
			1×10^6	12.7	450		
			5×10^6	9.1	138		
284	1680	FILECA	0	16.7	925		26.0
			5×10^5	6.6	319		
			1×10^6	4.3	141		
			5×10^6	1.7	10		
285	5830	FILECA	0	Do not break			21.5
			5×10^5	Do not break			
			1×10^6	Do not break			
			5×10^6	7.1	105		
286	58360	FILECA	0	Do not break			24.5
			5×10^5	15.4	480		
			1×10^6	13.7	255		
			5×10^6	14.6	72		
296	Royalar, jacket	Uniroyal*)	0	16.1	360		
			5×10^5	18.1	380		
			1×10^6	17.8	170		
			5×10^6				
352		Rheinkabel	0	60.8	561	28.5 D	22.5
			5×10^6	12.5	78	23 D	
			1×10^7	10.6	32	31 D	
			5×10^7	12.5	10	54 D	

*) Data from the supplier.

No.	Type	Supplier	Dose (Gy)	Traction R (N/mm²)	Traction E (%)	Hardness H	Oxygen index (%)
355	DESMOPAN	AEG-Telefunken	0	> 30.4	> 510	32 D	25.5
			5×10^6	10.6	125	27.5 D	
			1×10^7	12.1	76.5	36 D	
			2.5×10^7	15.4	7.5	44 D	
372	Insulator and jacket	Kabel-Metall	0	56.9	600	31 D	24.5
			5×10^5	26.1	575	29 D	
			1×10^6	25.8	505	25 D	
			5×10^6	8.3	116	24 D	



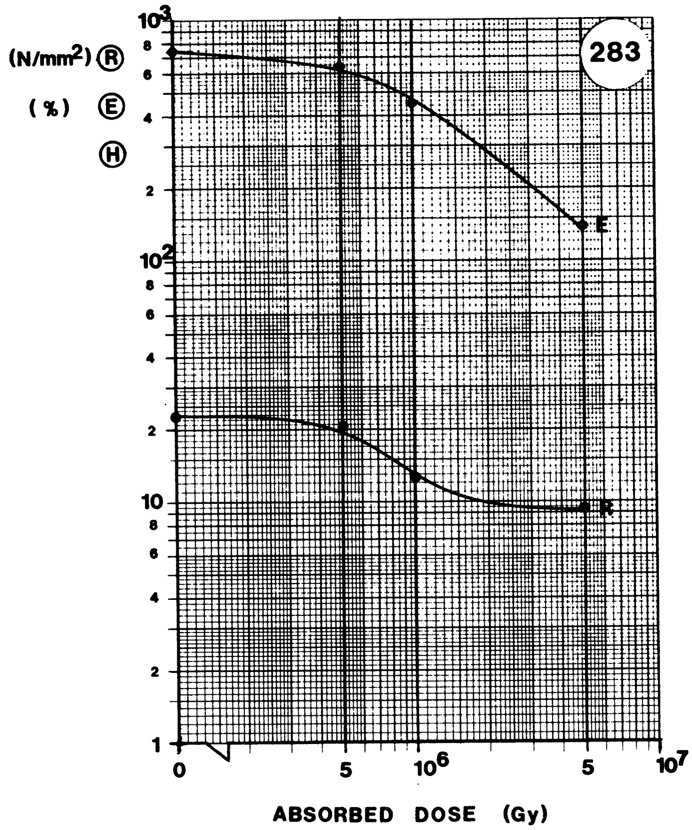
MATERIAL: PUR

TYPE: PUR 3, THERMOPLASTIC

SUPPLIER: DRAKA

Remarks:

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	32.4	N/mm^2
E	Elong. at break	530	%
H	Hardness	-	Shore C
	Oxygen index	24.5	



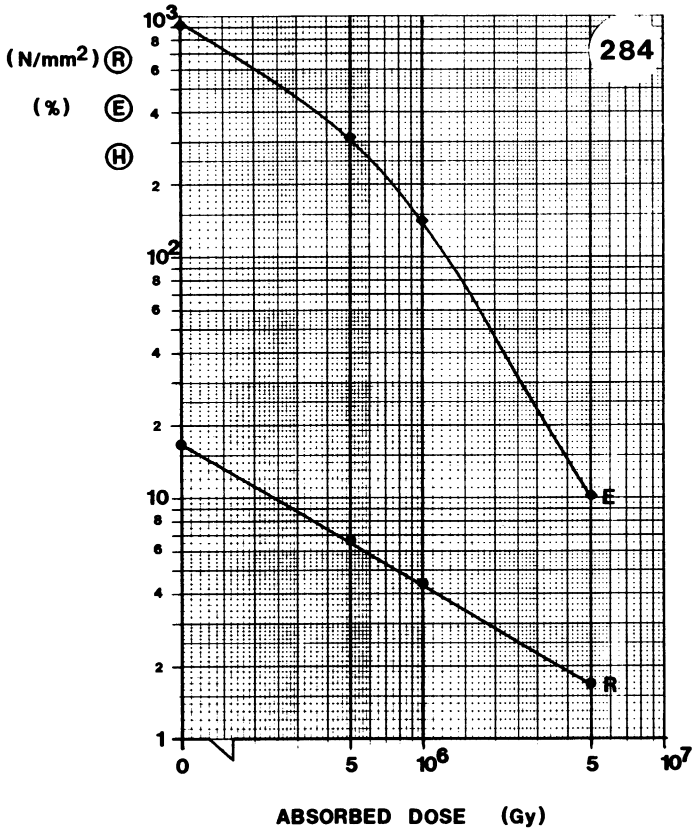
MATERIAL: PUR

TYPE: 786

SUPPLIER: FILECA

Remarks: NO LONGER COMMERCIALLY AVAILABLE

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	22.4	N/mm^2
E	Elong. at break	725	%
H	Hardness	-	Shore C,D
	Oxygen index	26	



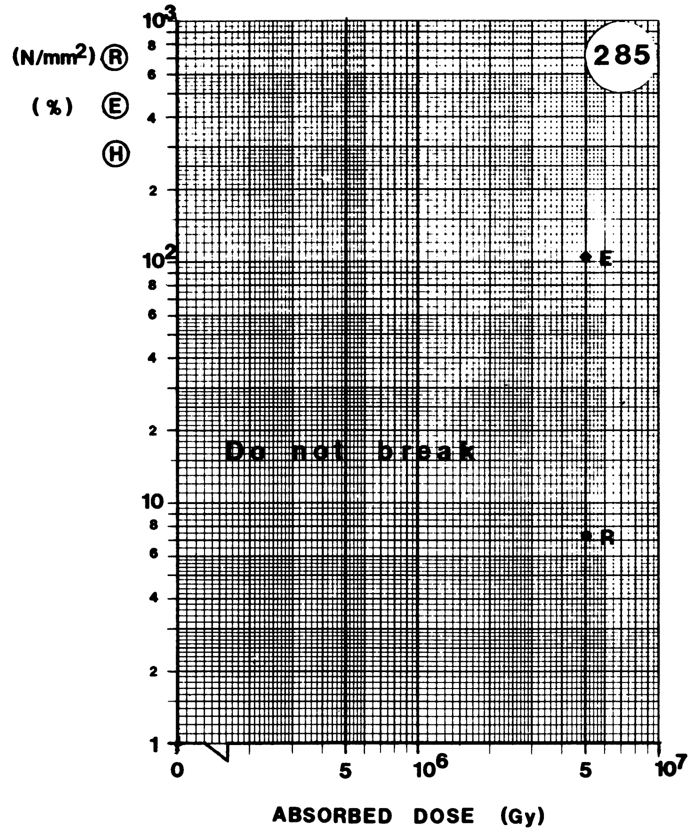
MATERIAL: PUR

TYPE: 1680

SUPPLIER: FILECA

Remarks: NO LONGER COMMERCIALLY AVAILABLE

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	16.7	N/mm^2
E	Elong. at break	925	%
H	Hardness	-	Shore C,D
	Oxygen index	26	



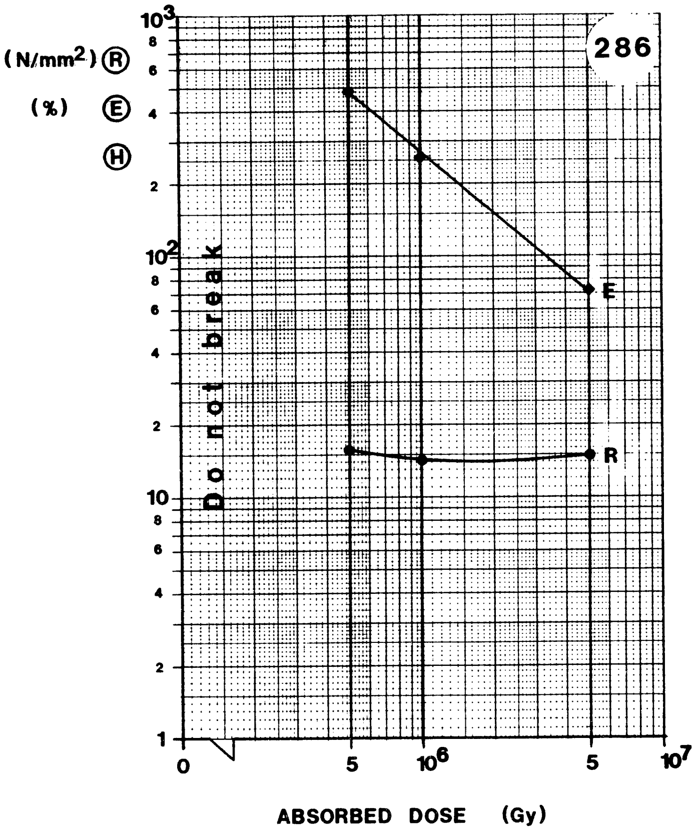
MATERIAL: PUR

TYPE: 5830

SUPPLIER: FILECA

Remarks: NO LONGER COMMERCIALLY AVAILABLE

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	-	N/mm^2
E	Elong. at break	-	%
H	Hardness	-	Shore C,D
	Oxygen index	21.5	



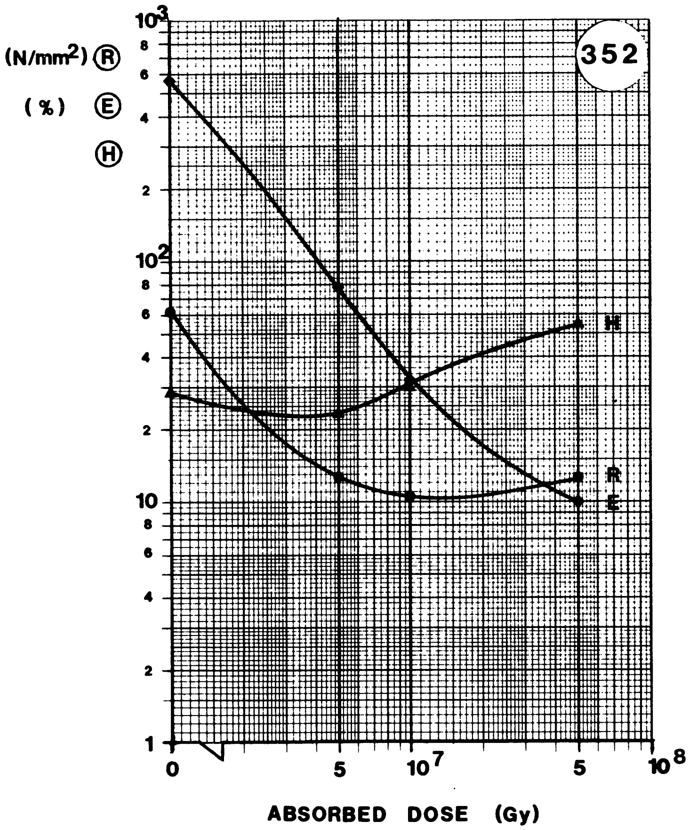
MATERIAL: PUR

TYPE: 5836

SUPPLIER: FILECA

Remarks: No LONGER COMMERCIALLY AVAILABLE

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	-	N/mm^2
E	Elong. at break	-	%
H	Hardness	-	Shore C,D
	Oxygen index	24.5	



* Attention! Scale changed *

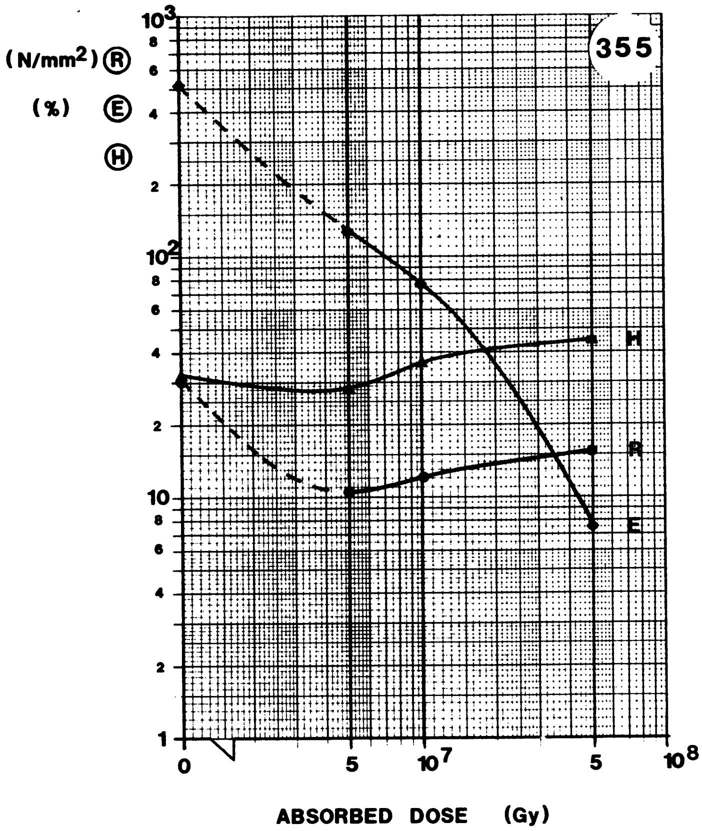
MATERIAL: PUR

TYPE:

SUPPLIER: RHEINKABEL

Remarks:

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	60.8	N/mm^2
E	Elong. at break	561	%
H	Hardness	28.5	Shore D
	Oxygen index	22.5	



* Attention! Scale changed *

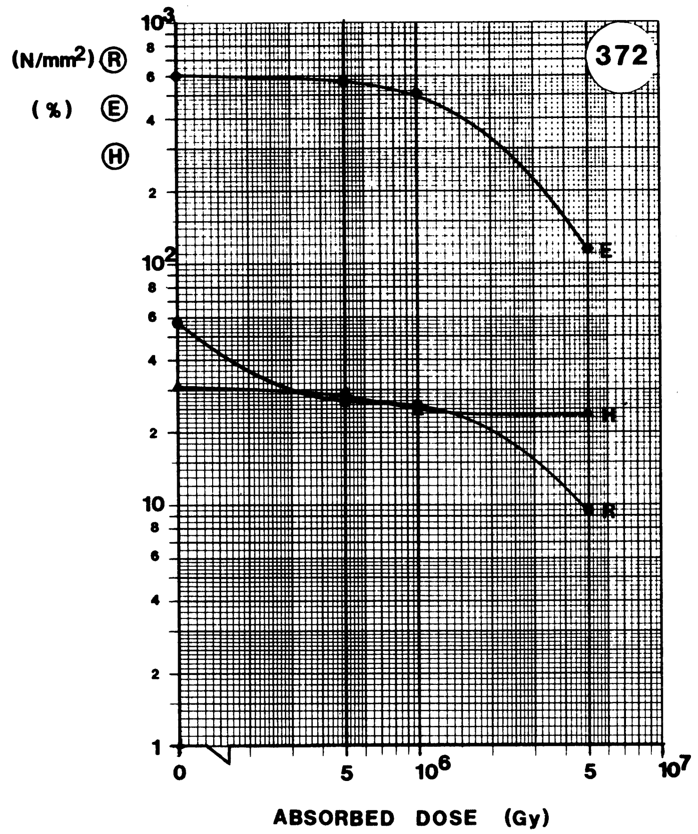
MATERIAL: PUR

TYPE: Desmopan

SUPPLIER: AEG-Telefunken

Remarks:

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	> 30.4	N/mm^2
E	Elong. at break	> 510	%
H	Hardness	32	Shore D
	Oxygen index	25.5	



MATERIAL: PUR

TYPE: Insulator and jacket

SUPPLIER: Kabel-Metall

Remarks:

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	56.9	N/mm^2
E	Elong. at break	600	%
H	Hardness	31	Shore D
	Oxygen index	24.5	

POLYVINYLCHLORIDE

$$\left[-CH_2-CHCl- \right]_n$$

Standard: oxygen index 21-26

For general characteristics, see Table 1 in Section 2.

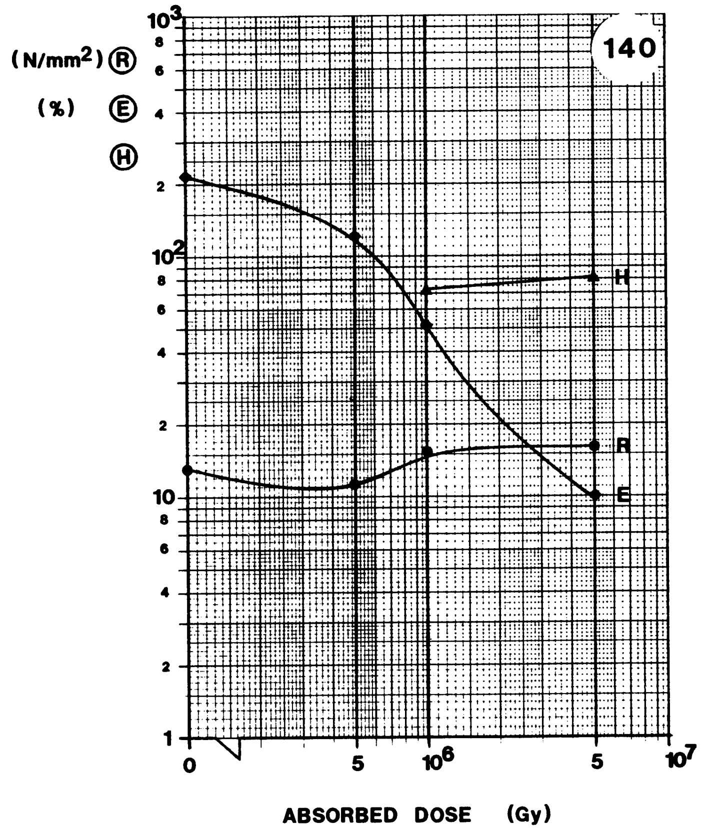
No.	Type	Supplier	Dose (Gy)	Traction R (N/mm²)	Traction E (%)	Hardness H	Oxygen index (%)
140		DRAKA	0	13.1	218		
			5×10^5	11.1	120		
			1×10^6	15.3	52	73 C	
			5×10^6	15.7	9.5	83 C	
141		DRAKA	0	20.7	262		
			5×10^5	22.1	212		
			1×10^6	22.9	104		
			5×10^6	32.4	9.7		
151		Aumann & Co.	0	9.0	330		
			5×10^5	9.3	175		
			1×10^6	8.7	118		
			5×10^6	6.5	20		
152	Jacket	Aumann & Co.	0	13.8	246		
			5×10^5	14.0	230		
			1×10^6	15.1	134		
			5×10^6	8.9	44		
155	Chlorostop jacket 72-17-A	Kabel-Metall	0	10.0	155		
			5×10^5	10.4	93		
			1×10^6	13.0	64		
			5×10^6	broken			
163	Jacket 72-17-K	Kabel-Metall	0	14.0	240		
			5×10^5	12.6	135		
			1×10^6	12.9	79		
			5×10^6	7.6	< 1		
164	Insulator 72-17-I	Kabel-Metall	0	27.3	258		
			5×10^5	23.6	170		
			1×10^6	21.8	90		
			5×10^6	21.6	< 1		

No.	Type	Supplier	Dose (Gy)	Traction R (N/mm²)	Traction E (%)	Hardness H	Oxygen index (%)
167	66 VYM 26	Kabel-Metall	0	9.2	230	36 D	
			5×10^5				
			1×10^6	9.9	120	31.8 D	
			5×10^6				
183	Jacket No. 140673	Leonische	0	19.6	300		24.7
			5×10^5	16.5	125		
			1×10^6	14.7	95		
			5×10^6				
199	Low-voltage insulator	Pirelli	0	23.8	208	64 D	
			5×10^5	20.5	172	64 D	
			1×10^6	20.6	95	66 D	
			5×10^6	22.9	29	72 D	
200	Jacket	Pirelli	0	18.9	240		
			5×10^5	16.2	162		
			1×10^6	16.2	117		
			5×10^6	17.5	24		
204	Without filler, S34	Felten & G.	0	14.8	256	45 D	
			5×10^5	12.6	143	47 D	
			1×10^6	12.5	120	48 D	
			5×10^6	17.2	22.5	76 D	
205	Insulator and jacket S2b	Felten & G.	0	26.6	234	71 D	
			5×10^5	23.5	192	72 D	
			1×10^6	23.6	127	72 D	
			5×10^6	25.3	20	77 D	
211	52058	NORSK KF	0	22.8	328	46.1 D	
			5×10^5	17.3	170	51 D	
			1×10^6	22.3	74	59.6 D	
			5×10^6	19.9	10	75 D	

No.	Type	Supplier	Dose (Gy)	Traction R (N/mm^2)	Traction E (%)	Hardness H	Oxygen index (%)
228	Standard jacket L 7932	Huber & Suhner	0	15.7	350	48 C	
			5×10^5	13.9	270	48 C	
			1×10^6	11.4	177	48.5 C	
			5×10^6	6.3	36	58.5 C	
229	L 7932/19	Huber & Suhner	0	16.7	276	54 C	
			5×10^5	15.7	243	54.3 C	
			1×10^6	14.6	177	52.5 C	
			5×10^6	5.9	36	62 C	
238	Jacket 160	Sieverts	0	16.1	277	32 D	24.5
			5×10^5	15.4	160	27 D	
			1×10^6	14.5	62	36 D	
			5×10^6	7.1	37	40 D	
239	Insulator 165	Sieverts	0	17.6	265	66 C	25.3
			5×10^5	18.7	128	65 C	
			1×10^6	20.3	78	73 C	
			5×10^6	14.3	35	84 C	
255	Jacket	IKO	0	15.7	246	66 C	23
			5×10^5	14.3	202	64 C	
			1×10^6	13.8	150	64 C	
			5×10^6	11.6	32	80 C	

No.	Type	Supplier	Dose (Gy)	Traction R (N/mm²)	Traction E (%)	Hardness H	Oxygen index (%)
264	Compound No. M1	Leonische	0	13.5	315	47 C	21.7
			5×10^5	10.1	155	51 C	
			1×10^6	10.3	120	51 C	
			5×10^6	6.8	7.5	72 C	
265	Compound No. 0	Leonische	0	19.8	325	65 C	24.3
			5×10^5	15.0	117	62 C	
			1×10^6	15.4	107	66 C	
			5×10^6				
266	Compound No. 4	Leonische	0	15.3	302	56 C	22.8
			5×10^5	12.1	142	58 C	
			1×10^6	13.9	100	58 C	
			5×10^6				
267	Compound No. 5	Leonische	0	18.2	340	58 C	23
			5×10^5	12.9	150	57 C	
			1×10^6	13.2	120	61 C	
			5×10^6	10.4	26	66 C	
268	Compound No. 6	Leonische	0	16.9	305	56 C	23
			5×10^5	12.9	145	58 C	
			1×10^6	13.1	112	58 C	
			5×10^6				
269	Compound No. 7	Leonische	0	16.8	310	58 C	22.8
			5×10^5	11.0	115	57 C	
			1×10^6	13.3	112	60 C	
			5×10^6	5.7	5	67 C	

No.	Type	Supplier	Dose (Gy)	Traction R (N/mm²)	Traction E (%)	Hardness H	Oxygen index (%)
270	Compound No. 8	Leonische	0	16.2	302	56 C	23.3
			5×10^5	11.0	124	59 C	
			1×10^6	11.7	125	56 C	
			5×10^6	12.9	10	61 C	
271	Compound No. 9	Leonische	0	19.9	335	59 C	23
			5×10^5	13.1	137	61 C	
			1×10^6	12.9	107	62 C	
			5×10^6				
272	Compound No. 10	Leonische	0	18.2	317	58 C	23.2
			5×10^5	12.1	132	60 C	
			1×10^6	12.4	107	60 C	
			5×10^6				
309	Jacket 47.4E	IKO	0	18.6	280	36 D	25.5
			5×10^5	14.7	181	35.5 D	
			1×10^6	14.7	132	40 D	
			5×10^6	12.8	40	45 D	



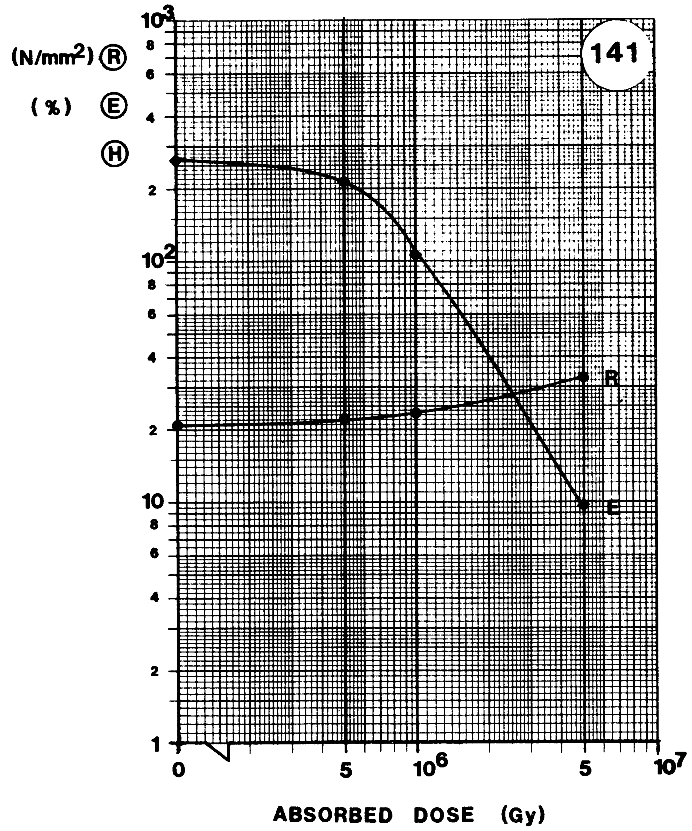
MATERIAL: PVC

TYPE:

SUPPLIER: DRAKA

Remarks:

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	13.1	N/mm^2
E	Elong. at break	218	%
H	Hardness	-	Shore C
	Oxygen index	-	



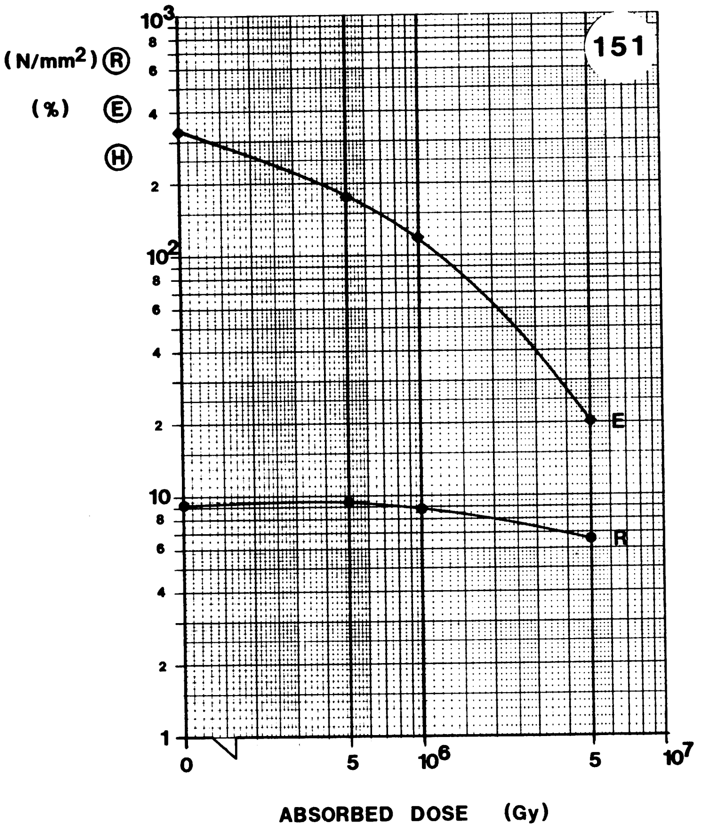
MATERIAL: PVC

TYPE:

SUPPLIER: DRAKA

Remarks:

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	20.7	N/mm^2
E	Elong. at break	262	%
H	Hardness	-	Shore C,D
	Oxygen index	-	



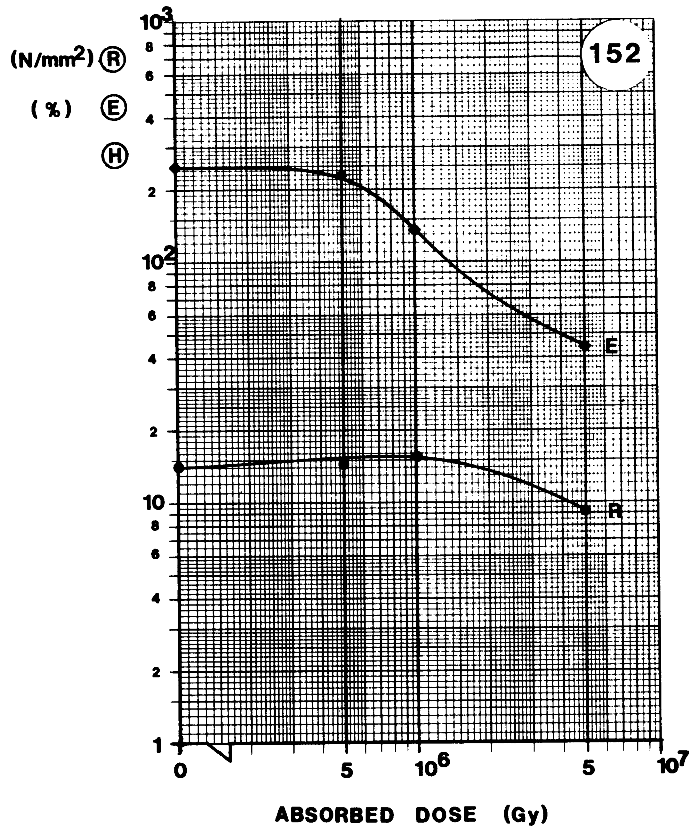
MATERIAL: PVC

TYPE:

SUPPLIER: Aumann & Co.

Remarks:

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	9.0	N/mm²
E	Elong. at break	330	%
H	Hardness	-	Shore C,D
	Oxygen index	-	



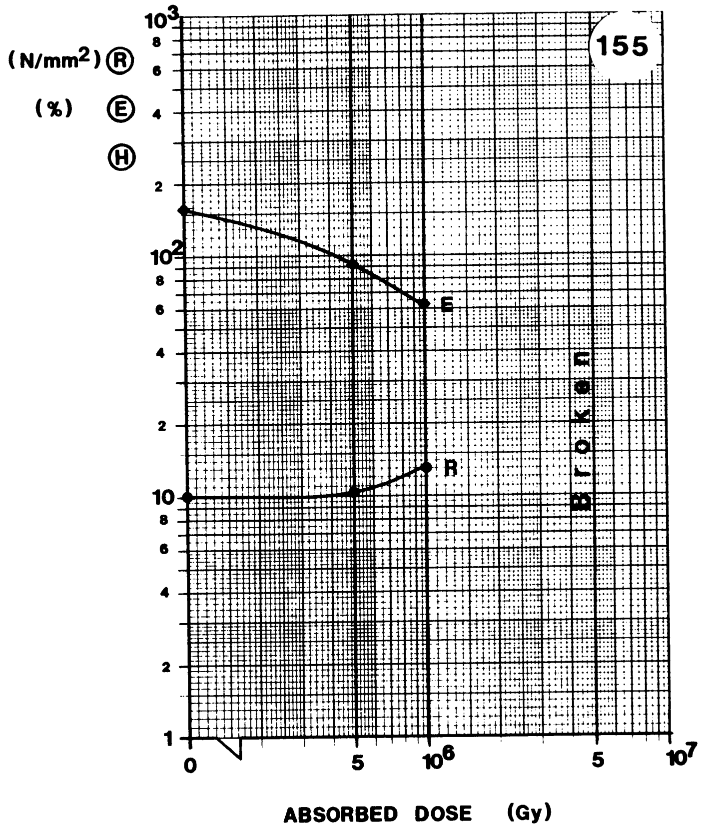
MATERIAL: PVC

TYPE: Jacket

SUPPLIER: Aumann & Co.

Remarks:

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	13.8	N/mm²
E	Elong. at break	246	%
H	Hardness	-	Shore C,D
	Oxygen index	-	



MATERIAL: PVC

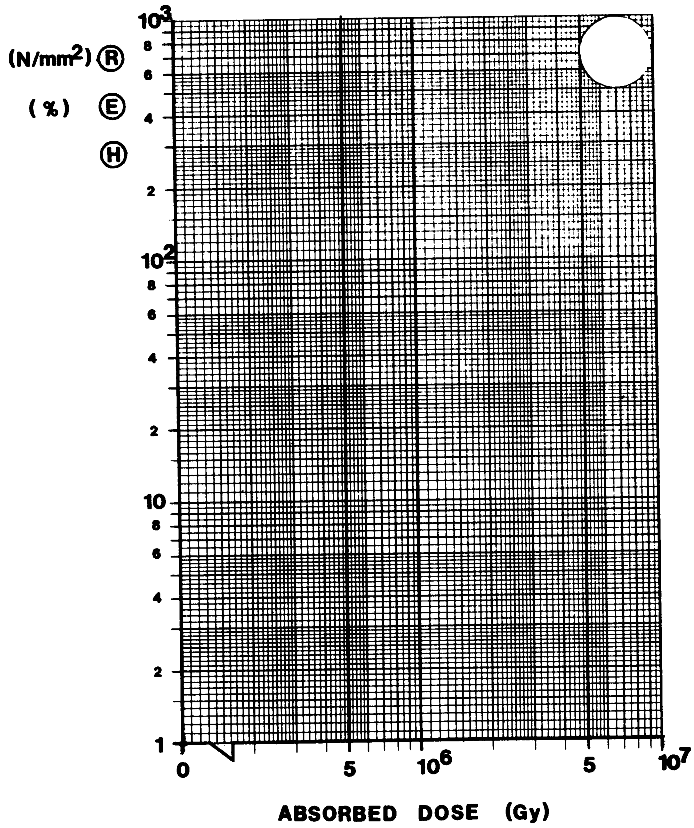
TYPE: Chlorostop

SUPPLIER: Kabel-Metall

Remarks:

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	10.5	N/mm²
E	Elong. at break	155	%
H	Hardness	-	Shore C,D
	Oxygen index	-	

CONTINUED NEXT PAGE



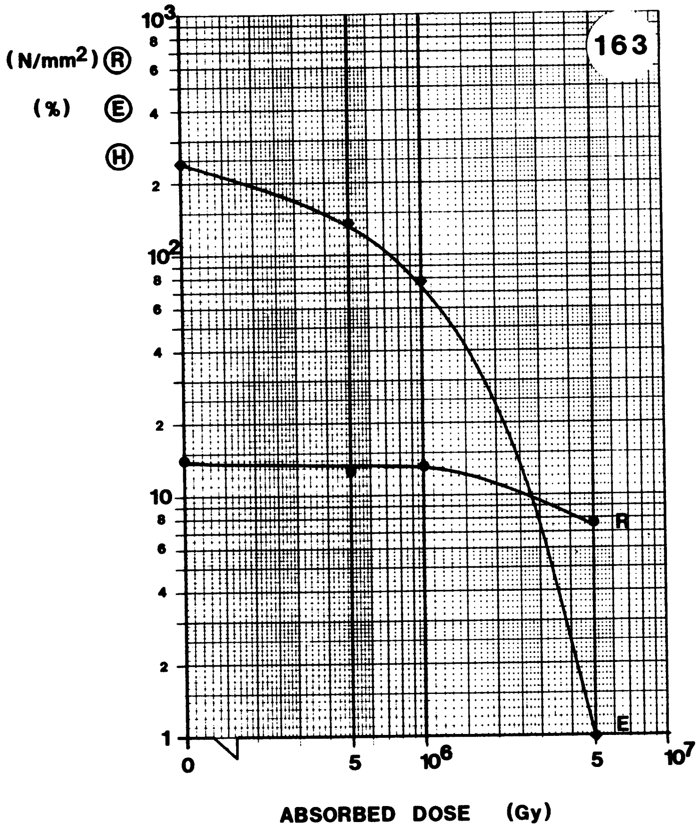
MATERIAL:

TYPE:

SUPPLIER:

Remarks:

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength		N/mm2
E	Elong. at break		%
H	Hardness		Shore C,D
	Oxygen index		



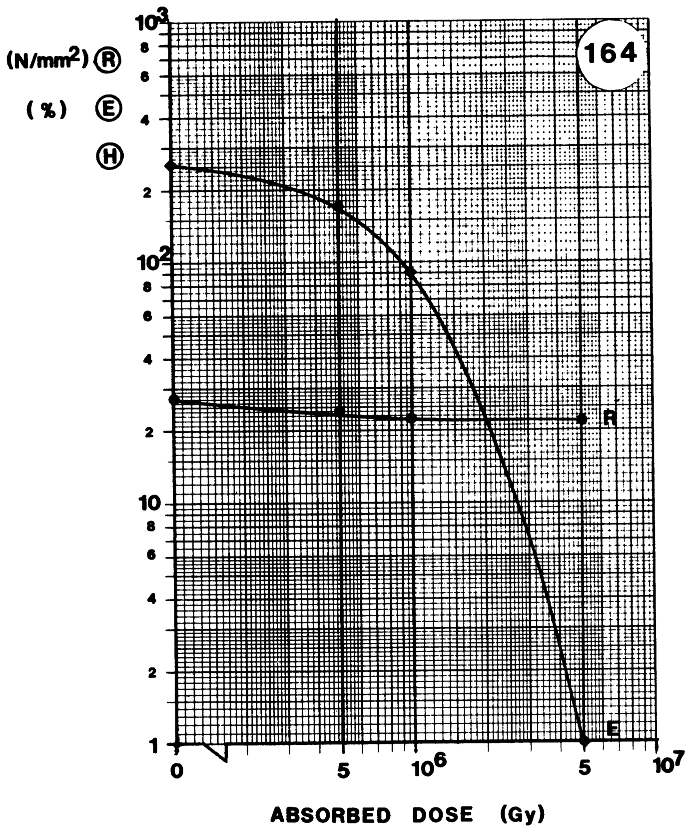
MATERIAL: PVC

TYPE: JACKET

SUPPLIER: KABEL-METALL

Remarks:

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	14.0	N/mm2
E	Elong. at break	240	%
H	Hardness	-	Shore C,D
	Oxygen index	-	



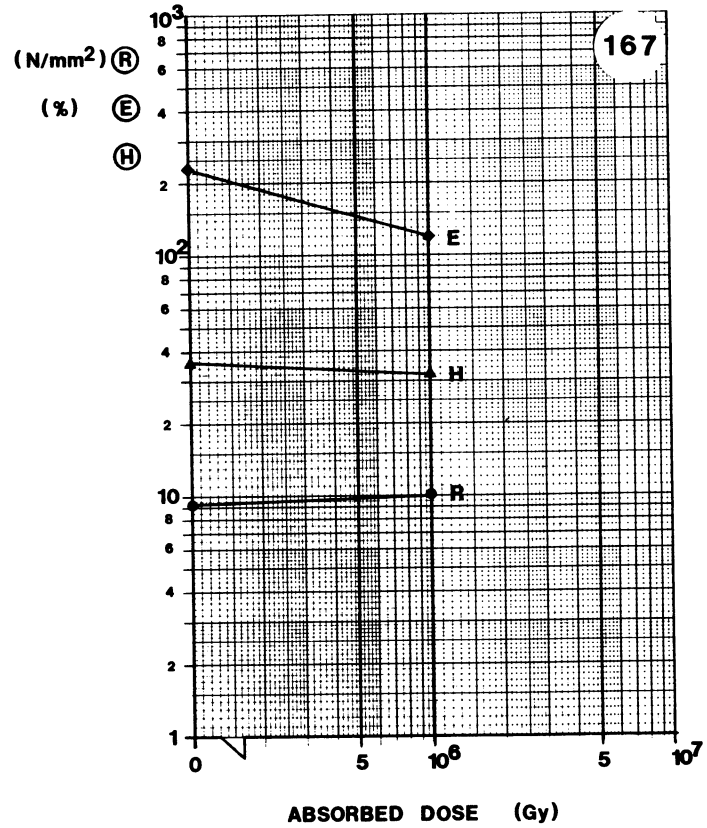
MATERIAL: PVC

TYPE: INSULATOR

SUPPLIER: KABEL-METALL

Remarks:

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	27.3	N/mm2
E	Elong. at break	258	%
H	Hardness	-	Shore C,D
	Oxygen index	-	



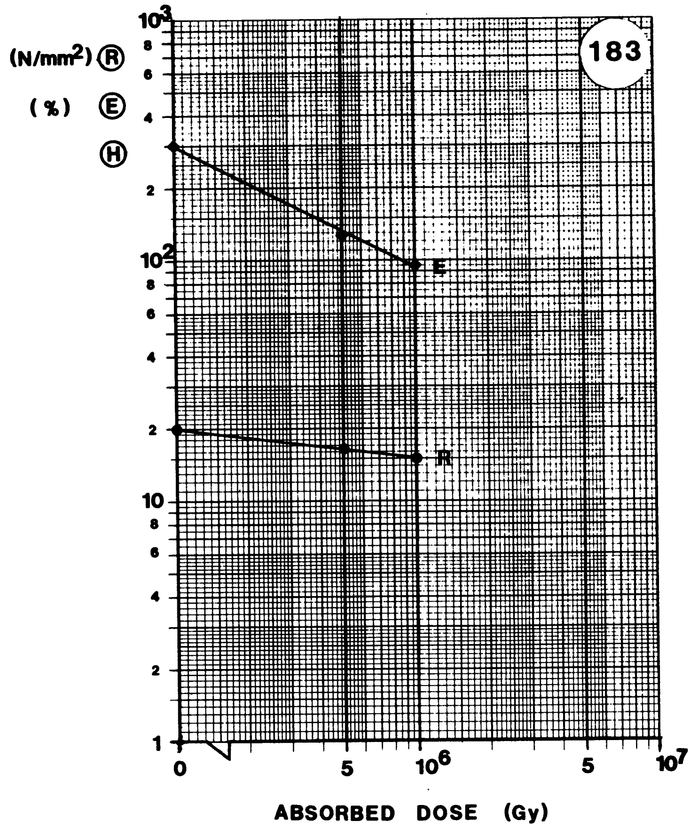
MATERIAL: PVC

TYPE:

SUPPLIER: Kabel-Metall

Remarks: Used for SPS water-cooled power cables

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	9.2	N/mm2
E	Elong. at break	230	%
H	Hardness	36	Shore D
	Oxygen index	-	



MATERIAL: PVC

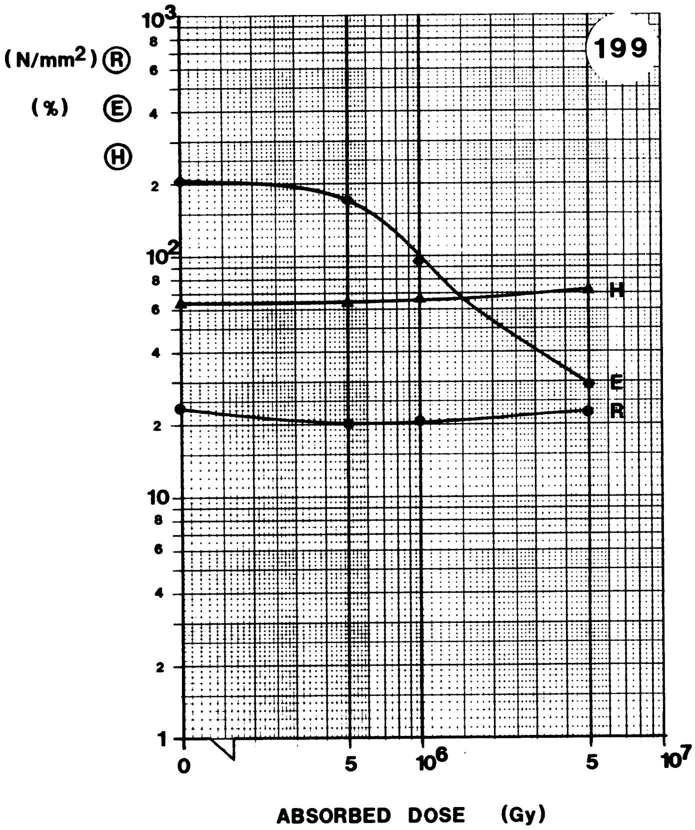
TYPE: Jacket

SUPPLIER: Leonische

Remarks:

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	19.6	N/mm2
E	Elong. at break	300	%
H	Hardness	-	Shore C,D
	Oxygen index	24.7	

PVC



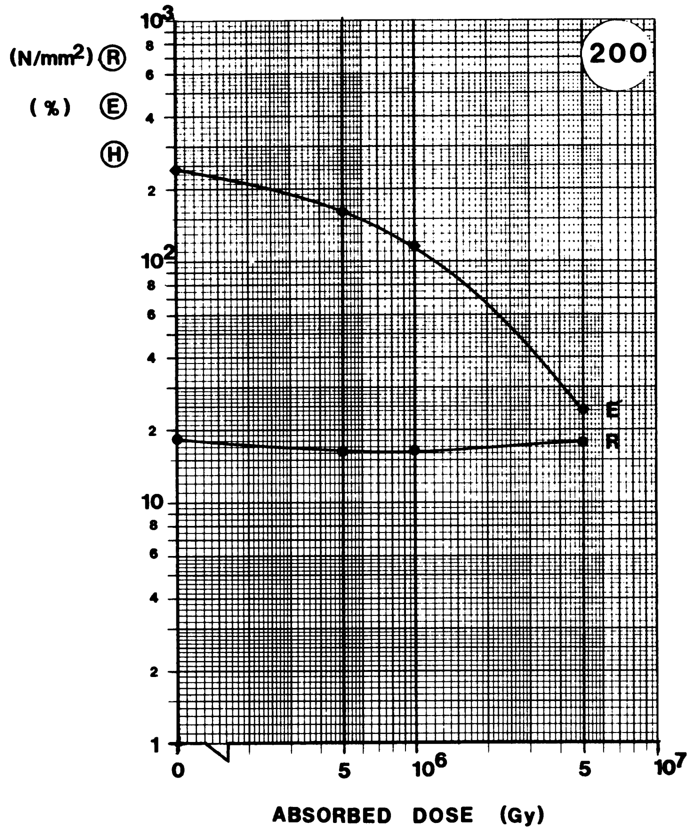
MATERIAL: PVC

TYPE: Low-voltage insulator

SUPPLIER: Pirelli

Remarks:

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	23.8	N/mm^2
E	Elong. at break	208	%
H	Hardness	64	Shore D
	Oxygen index		



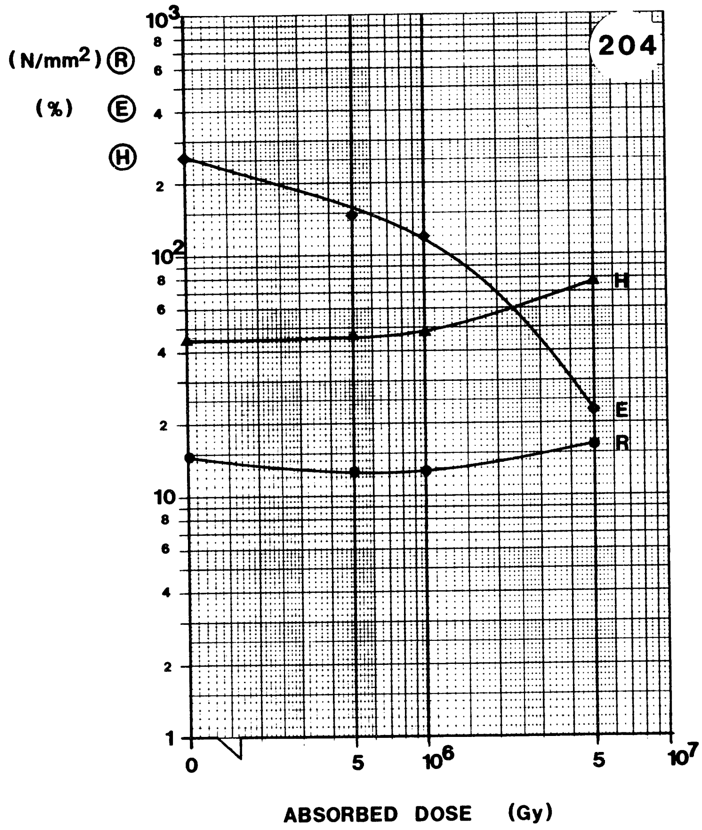
MATERIAL: PVC

TYPE: Jacket

SUPPLIER: Pirelli

Remarks:

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	18.9	N/mm^2
E	Elong. at break	240	%
H	Hardness	-	Shore C,D
	Oxygen index	-	



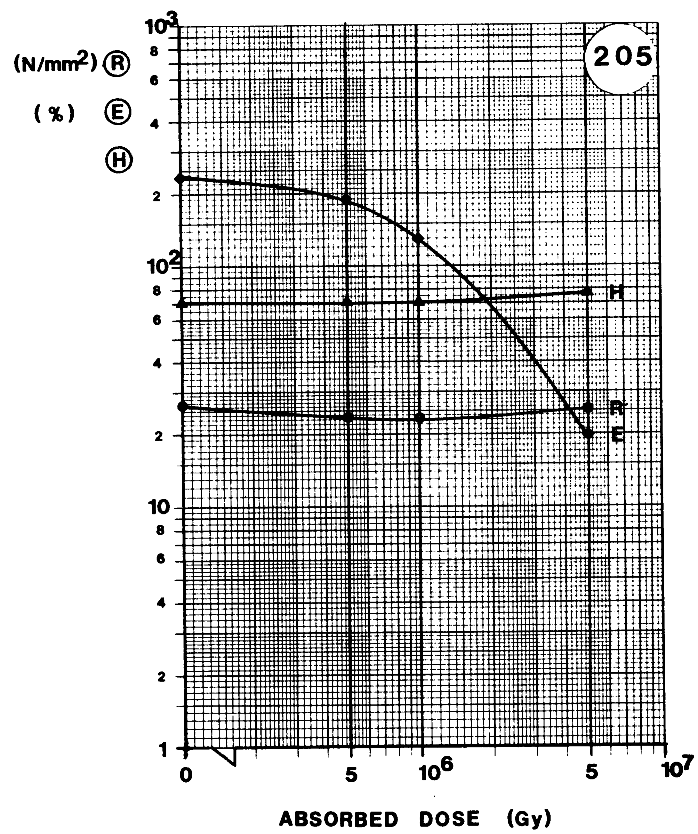
MATERIAL: PVC

TYPE: Without filler

SUPPLIER: Felten & G.

Remarks:

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	14.8	N/mm^2
E	Elong. at break	256	%
H	Hardness	45	Shore D
	Oxygen index	-	



MATERIAL: PVC

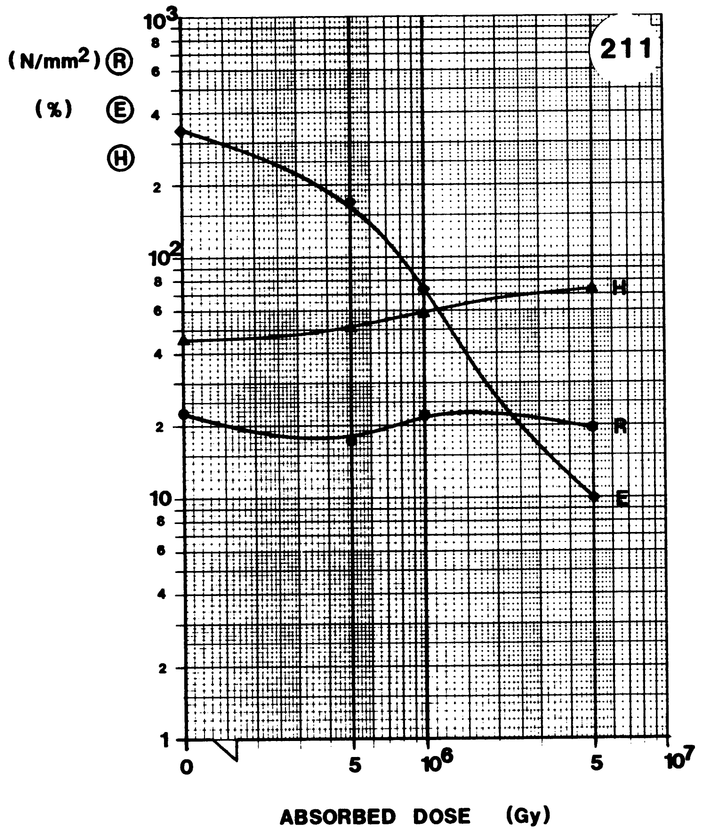
TYPE: Insulator and jacket

SUPPLIER: Felten & G.

Remarks:

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	26.6	N/mm^2
E	Elong. at break	234	%
H	Hardness	71	Shore D
	Oxygen index		

PVC



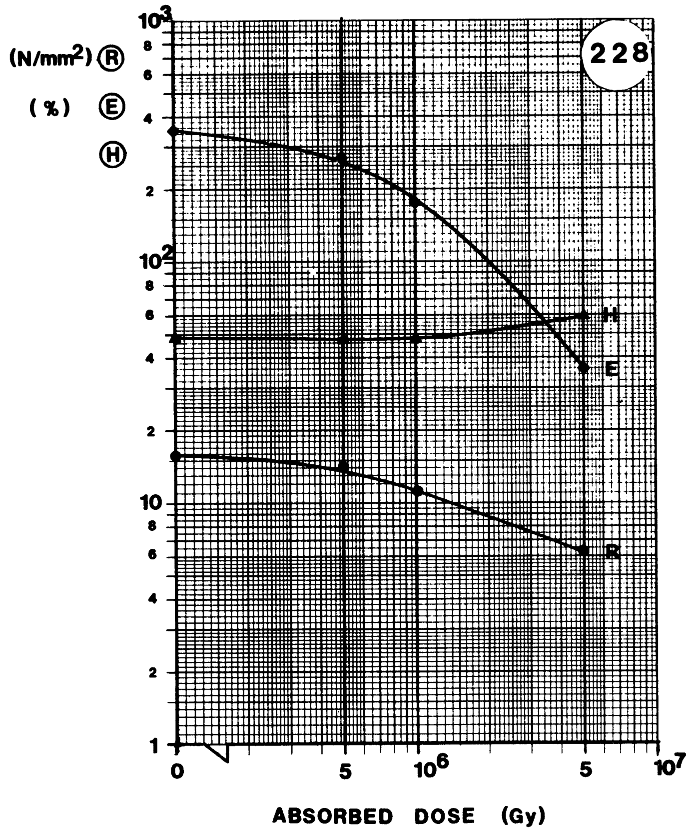
MATERIAL: PVC

TYPE:

SUPPLIER: NORSK KF

Remarks:

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	22.8	N/mm^2
E	Elong. at break	328	%
H	Hardness	46.1	Shore D
	Oxygen index		



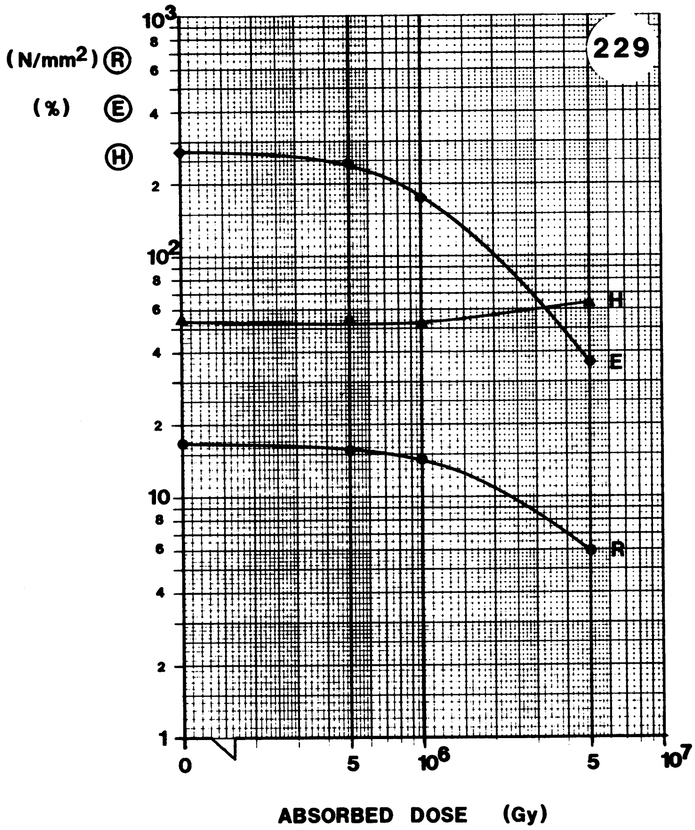
MATERIAL: PVC

TYPE: STANDARD JACKET

SUPPLIER: HUBER & SUHNER

Remarks:

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	15.7	N/mm^2
E	Elong. at break	350	%
H	Hardness	48	Shore C
	Oxygen index		



MATERIAL: PVC

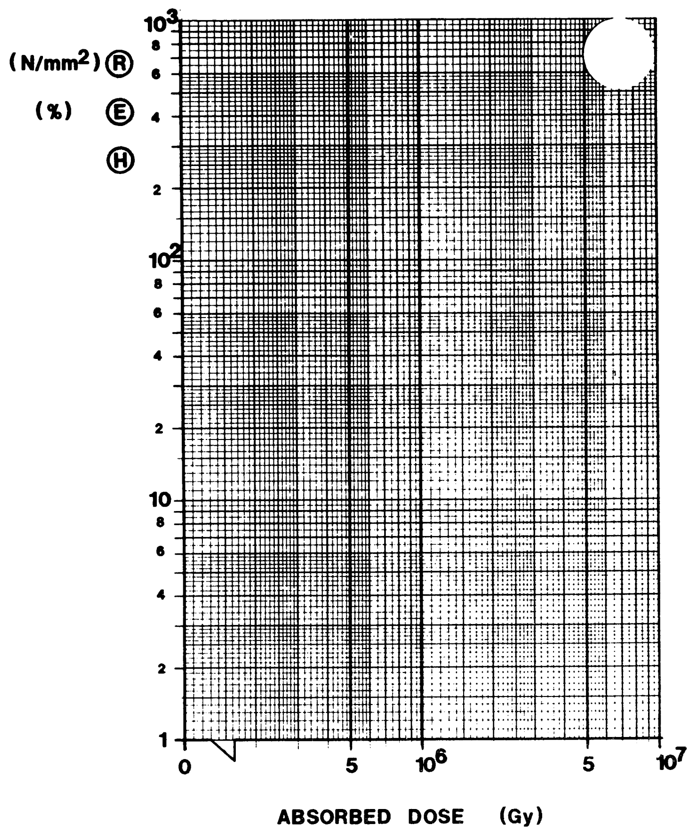
TYPE:

SUPPLIER: Huber & Suhner

Remarks:

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	16.7	N/mm^2
E	Elong. at break	276	%
H	Hardness	54	Shore C
	Oxygen index	-	

Effect of radiation on cable insulating materials



MATERIAL:

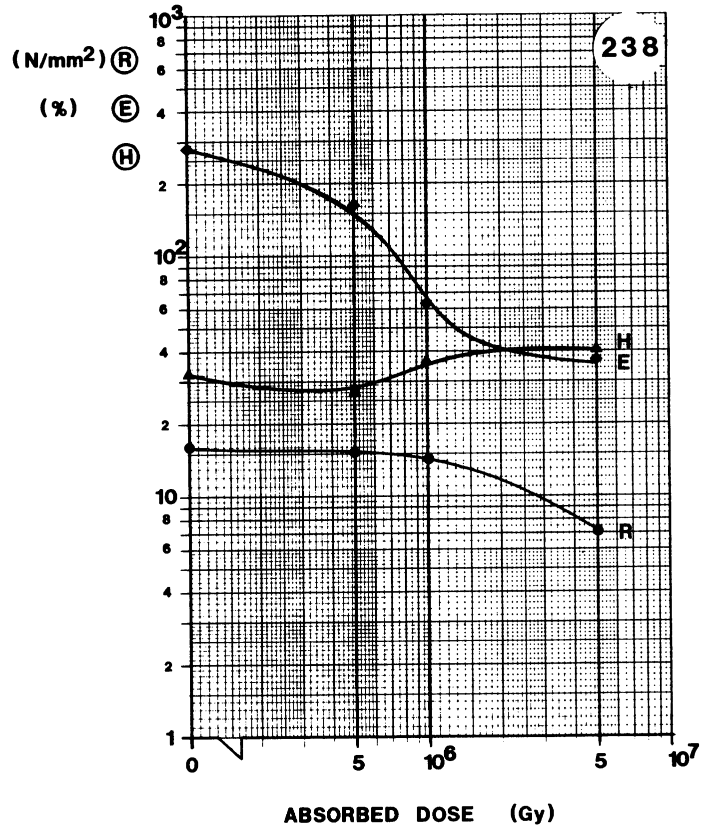
TYPE:

SUPPLIER:

Remarks:

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength		N/mm^2
E	Elong. at break		%
H	Hardness		Shore C,D
	Oxygen index		

PVC



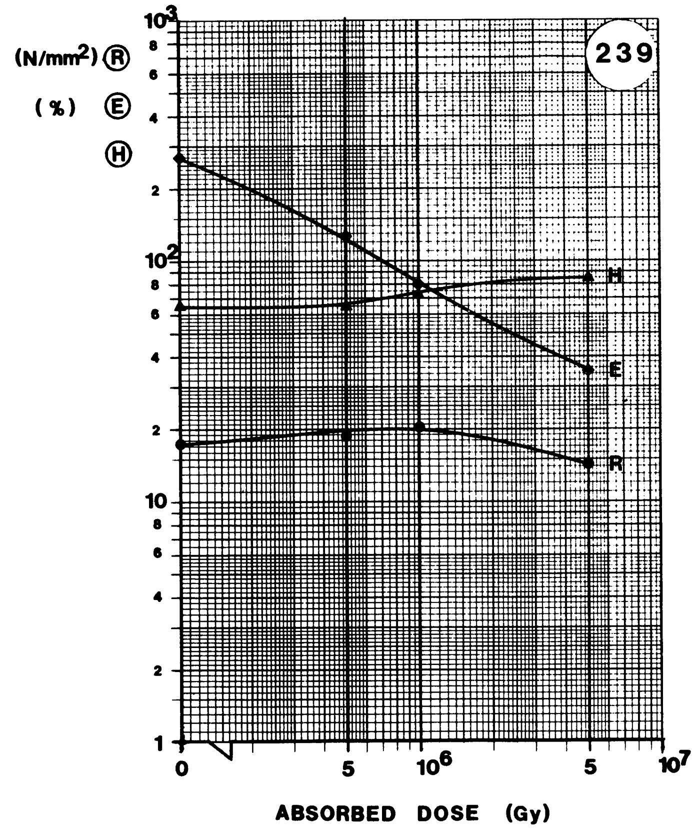
MATERIAL: PVC

TYPE: JACKET

SUPPLIER: SIEVERTS

Remarks:

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	16.1	N/mm^2
E	Elong. at break	277	%
H	Hardness	32	Shore D
	Oxygen index	24.5	



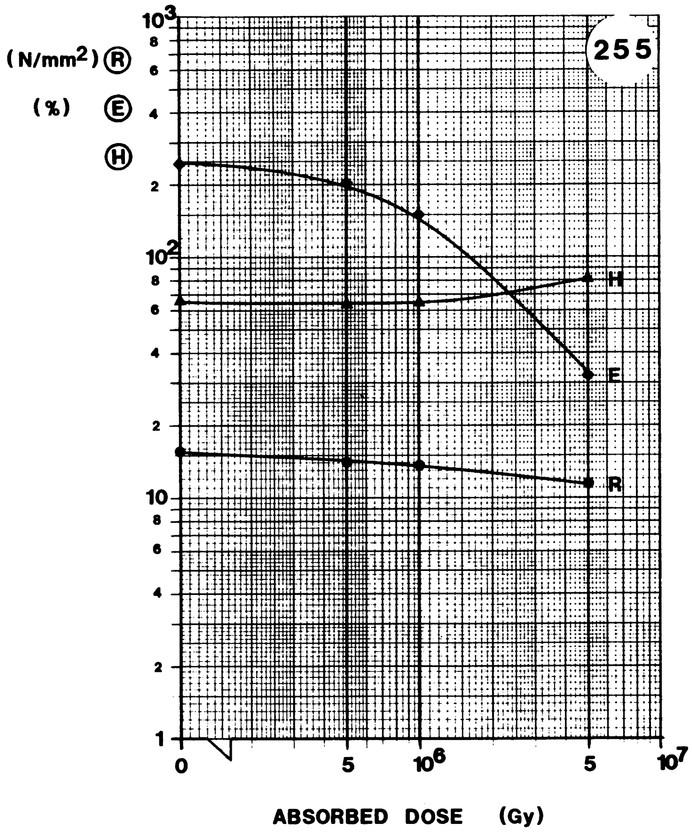
MATERIAL: PVC

TYPE: INSULATOR

SUPPLIER: SIEVERTS

Remarks:

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	17.6	N/mm^2
E	Elong. at break	265	%
H	Hardness	66	Shore C
	Oxygen index	25.3	



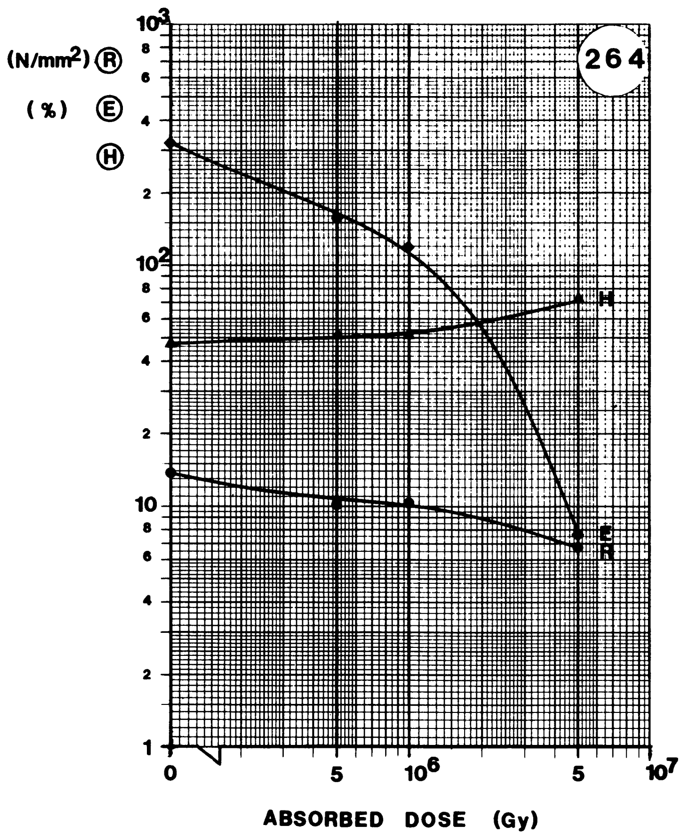
MATERIAL: PVC

TYPE: JACKET

SUPPLIER: IKO

Remarks:

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	15.7	N/mm^2
E	Elong. at break	246	%
H	Hardness	66	Shore C
	Oxygen index	23	



MATERIAL: PVC

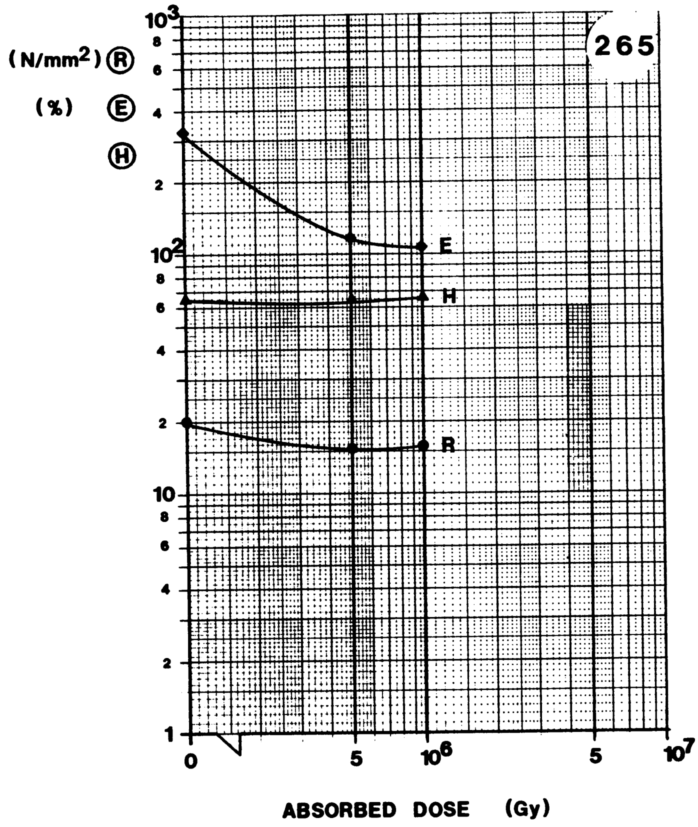
TYPE: COMPOUND No. M1

SUPPLIER: LEONISCHE

Remarks:

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	13.5	N/mm^2
E	Elong. at break	315	%
H	Hardness	47	Shore C
	Oxygen index	21.7	

PVC



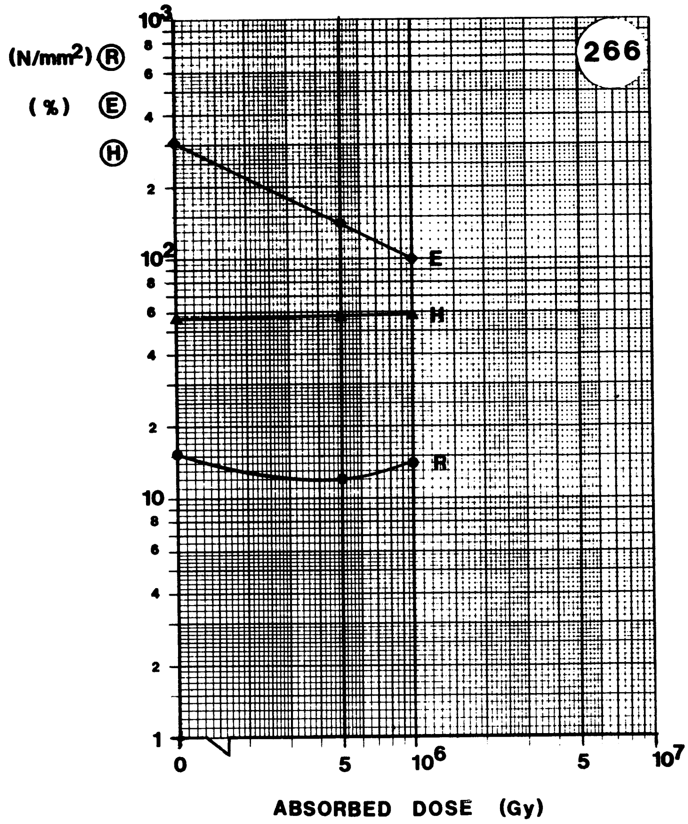
MATERIAL: PVC

TYPE: Compound No. 0

SUPPLIER: Leonische

Remarks:

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	19.8	N/mm^2
E	Elong. at break	325	%
H	Hardness	65	Shore C
	Oxygen index	24.3	



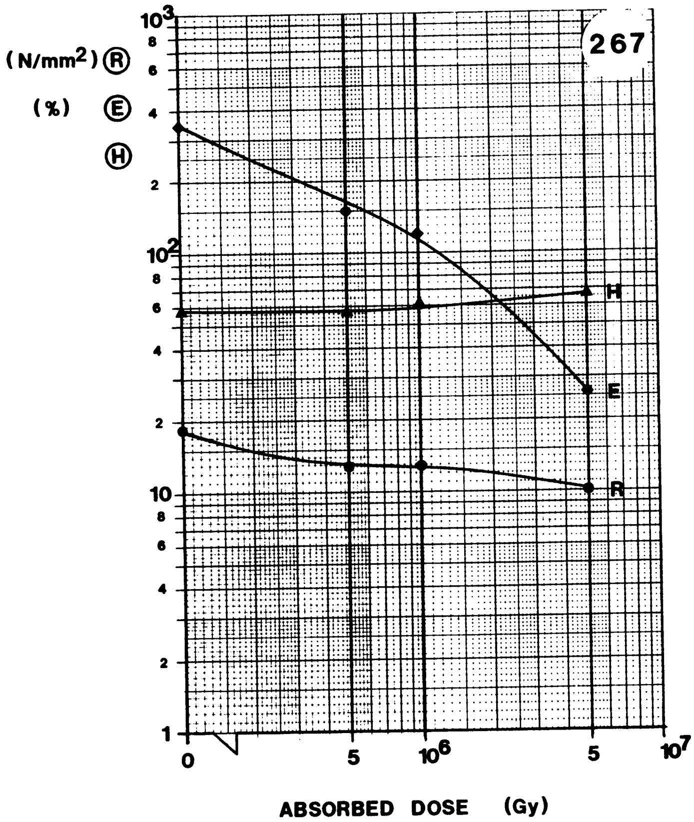
MATERIAL: PVC

TYPE: Compound No. 4

SUPPLIER: Leonische

Remarks:

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	15.3	N/mm^2
E	Elong. at break	302	%
H	Hardness	56	Shore C
	Oxygen index	22.8	



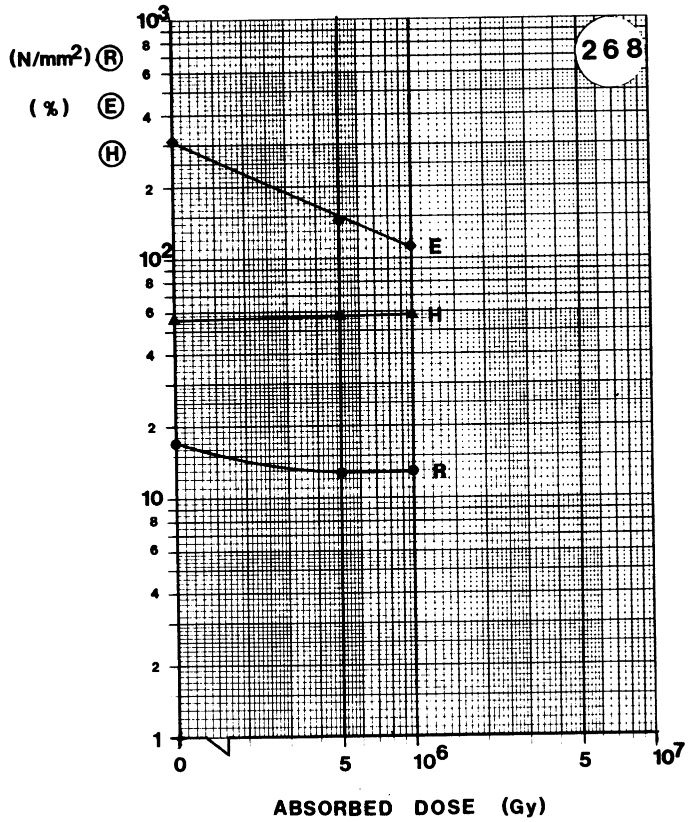
MATERIAL: PVC

TYPE: Compound No. 5

SUPPLIER: Leonische

Remarks:

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	18.2	N/mm^2
E	Elong. at break	340	%
H	Hardness	58	Shore C
	Oxygen index	23	



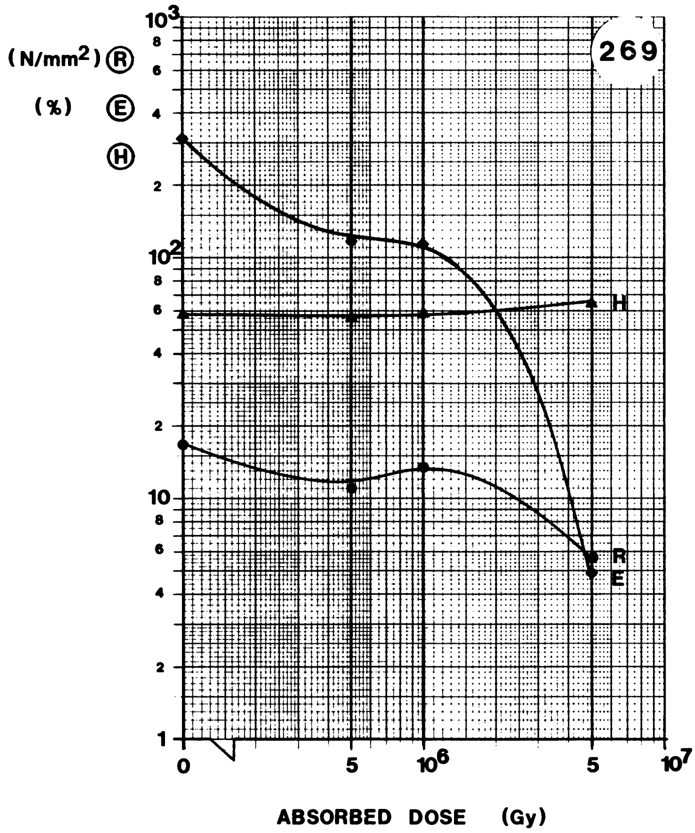
MATERIAL: PVC

TYPE: Compound No. 6

SUPPLIER: Leonische

Remarks:

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	16.9	N/mm^2
E	Elong. at break	305	%
H	Hardness	56	Shore C
	Oxygen index	23	



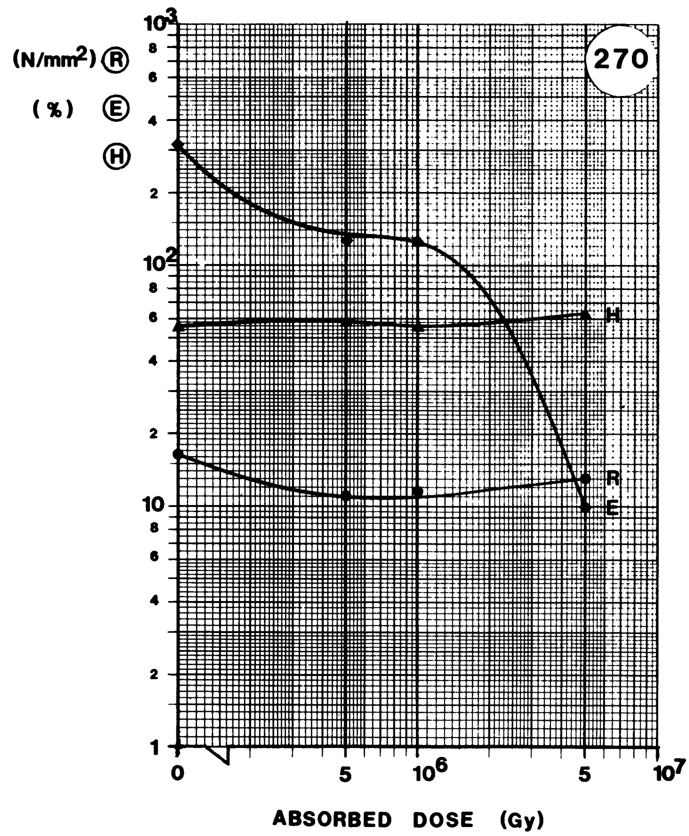
MATERIAL: PVC

TYPE: Compound No. 7

SUPPLIER: Leonische

Remarks:

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	16.8	N/mm²
E	Elong. at break	310	%
H	Hardness	58	Shore C
	Oxygen index	22.8	



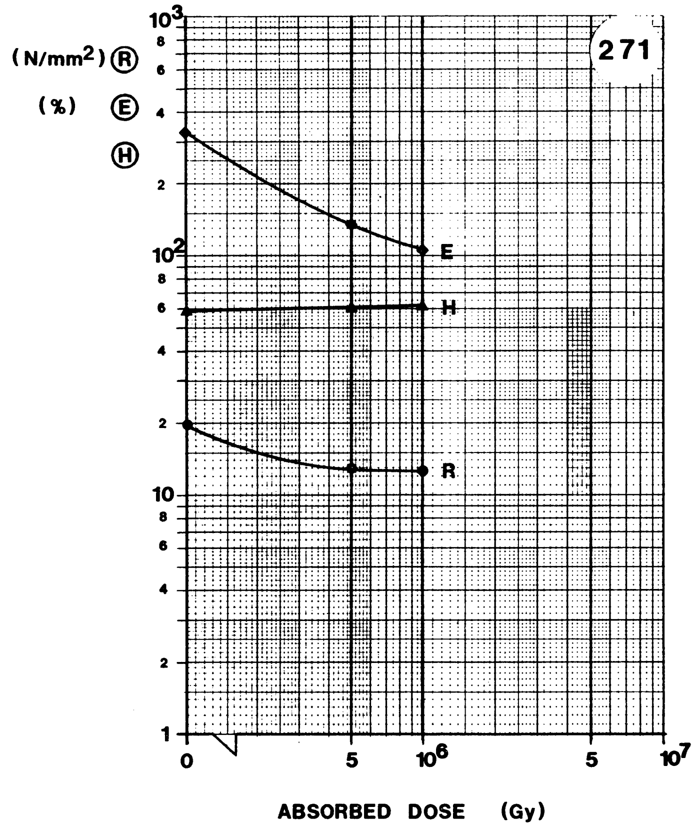
MATERIAL: PVC

TYPE: Compound No. 8

SUPPLIER: Leonische

Remarks:

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	16.2	N/mm²
E	Elong. at break	302	%
H	Hardness	56	Shore C
	Oxygen index	23.3	



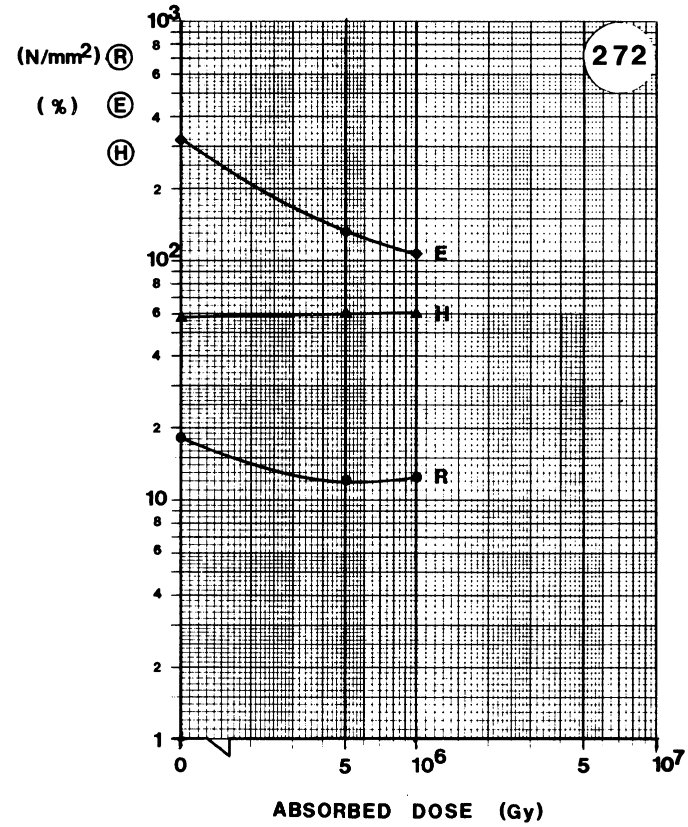
MATERIAL: PVC

TYPE: Compound No. 9

SUPPLIER: Leonische

Remarks:

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	19.9	N/mm^2
E	Elong. at break	335	%
H	Hardness	59	Shore C,D
	Oxygen index	23	



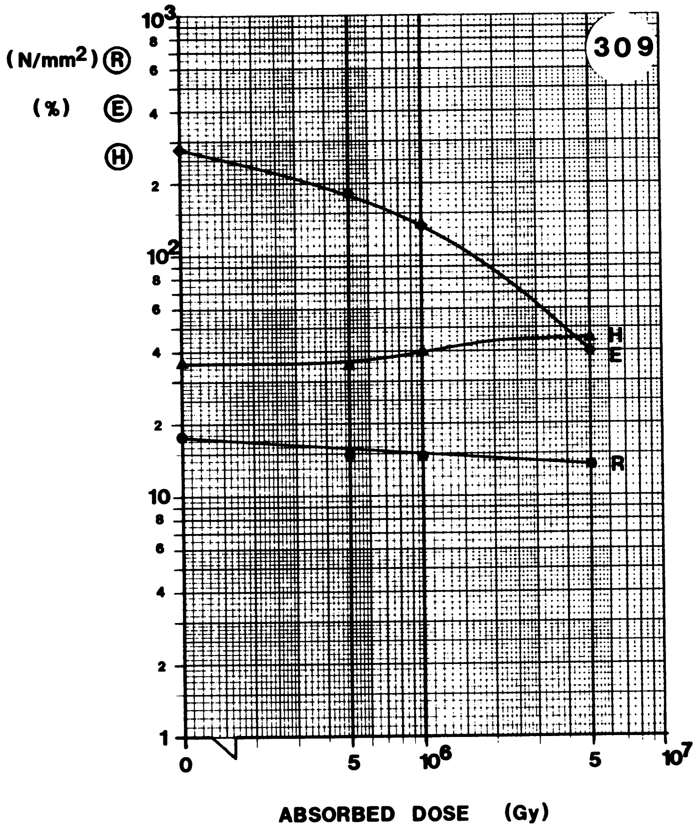
MATERIAL: PVC

TYPE: Compound No. 10

SUPPLIER: Leonische

Remarks:

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	18.2	N/mm^2
E	Elong. at break	317	%
H	Hardness	58	Shore C,D
	Oxygen index	23.2	



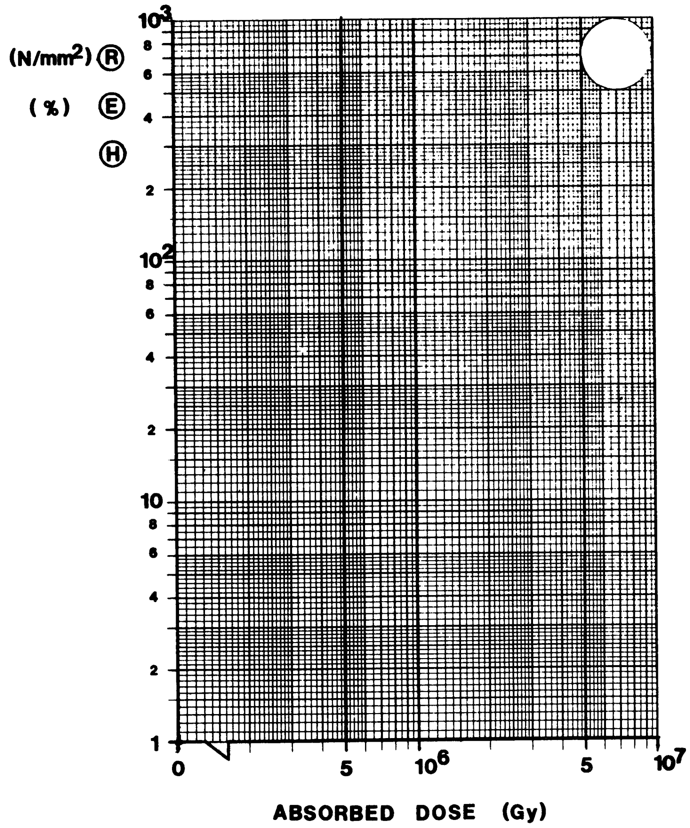
MATERIAL: PVC

TYPE: JACKET

SUPPLIER: IKO

Remarks: POWER CABLE NL5

CURVE	PROPERTY	INITIAL VALUE
R	Tensile strength	18.6 N/mm^2
E	Elong. at break	280 %
H	Hardness	36 Shore D
	Oxygen index	25.5



MATERIAL:

TYPE:

SUPPLIER:

Remarks:

CURVE	PROPERTY	INITIAL VALUE
R	Tensile strength	N/mm^2
E	Elong. at break	%
H	Hardness	Shore C,D
	Oxygen index	

POLYVINYLCHLORIDE

$$\left[-CH_2-CHCl- \right]_n$$

Flame retardant: oxygen index > 26.

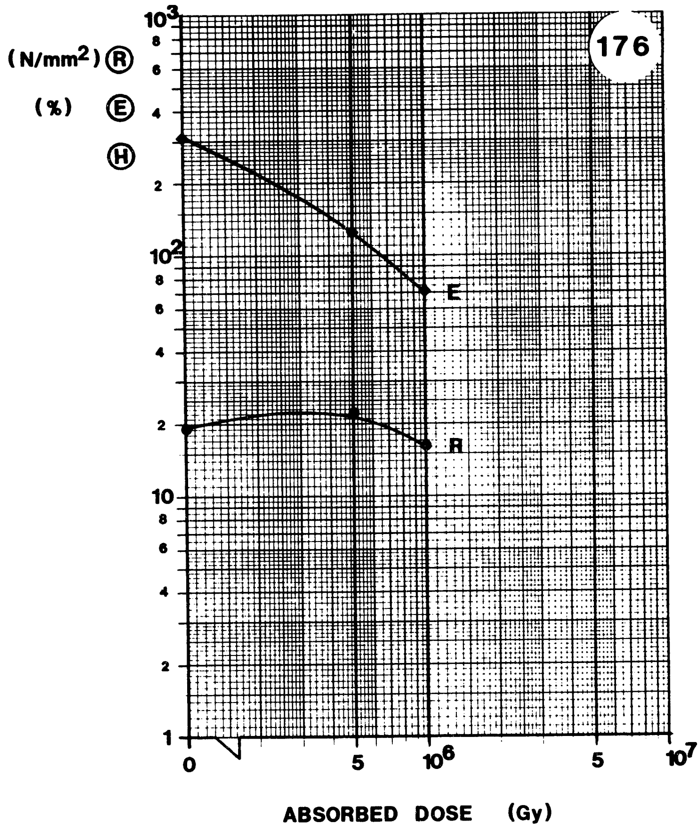
For general characteristics, see Table 1 in Section 2.

No.	Type	Supplier	Dose (Gy)	Traction R (N/mm^2)	Traction E (%)	Hardness H	Oxygen index (%)
176		Filotex	0	19.1	310		30
			5×10^5	21.7	126		
			1×10^6	16.0	70		
			5×10^6				
190		Thomson-Brandt	0	21.6	290		31
			5×10^5	27.5	180		
			1×10^6	23.2	175		
			5×10^6				
213	Antirad	Thomson-Brandt	0	22.7	212	49.4 D	33.5
			5×10^5	23.0	172	64 D	
			1×10^6	26.4	110	66.1 D	
			5×10^6	14.0	8	82 D	
237	Jacket	Câbles de Lyon	0	18.3	275	40 D	31.8
			5×10^5	13.6	185	42 D	
			1×10^6	13.3	105	43 D	
			5×10^6				
242	Jacket	Thomson-Brandt	0	17.6	313	47 D	31.5
			5×10^5	16.7	127	49.3 D	
			1×10^6	16.8	78	55 D	
			5×10^6	18.8	6.3	65 D	
244		Sieverts	0	16.9	315	60 C	27.5
			5×10^5	14.0	228	57 C	
			1×10^6	14.5	148	62 C	
			5×10^6	15.5	37.5	71 C	
246	FGP 162	FILECA	0	16.1	166	78 C	29
			5×10^5	14.0	60	89 C	
			1×10^6	15.2	30	90 C	
			5×10^6	broken			

No.	Type	Supplier	Dose (Gy)	Traction R (N/mm²)	Traction E (%)	Hardness H	Oxygen index (%)
247	EX KI 50/002	FILECA	0	20.6	240	75 C	30
			5×10^5	18.2	156	84 C	
			1×10^6	22.0	96	87 C	
			5×10^6	16.2	10	88 C	
248	EX KI 50/0002	FILECA	0	21.6	265	76 C	29.9
			5×10^5	19.2	165	83 C	
			1×10^6	22.3	90	88 C	
			5×10^6	15.4	11	92 C	
250		Câbles de Lyon	0	14.6	330	68 C	27.5
			5×10^5	14.9	141	69 C	
			1×10^6	14.5	115	69 C	
			5×10^6	11.2	2.5	76 C	
251	TG 1774/4	Sieverts	0	18.5	345	69 C	30.5
			5×10^5	16.8	155	72 C	
			1×10^6	16.3	97	72 C	
			5×10^6	20.5	< 1	97 C	
277	Jacket	SILEC	0	10.8	280		30.5
			5×10^5	11.2	187		
			1×10^6	11.9	90		
			5×10^6	12.5	10		
278	Jacket	SILEC	0	11.4	288		32
			5×10^5	11.4	185		
			1×10^6	10.1	80		
			5×10^6	7.8	25		
313		Pirelli	0	17.7	254	37.5 D	32
			5×10^5	14.8	162	40 D	
			1×10^6	17.6	98	41 D	
			5×10^6	13.8	12.5	68 D	

No.	Type	Supplier	Dose (Gy)	Traction R (N/mm²)	Traction E (%)	Hardness H	Oxygen index (%)
317	RGH 334	Thomson-Brandt	0	21.6	275	40 D	32
			5×10^5	19.6	142	44 D	
			1×10^6	22.6	80	50 D	
			5×10^6	14.6	3.5	75 D	
319	HT 1129	Liljeholmens	0	13.6	261	34 D	30.5
			5×10^5	10.3	153	37 D	
			1×10^6	14.9	89	48.5 D	
			5×10^6	17.2	5.2	75 D	
321	Jacket	BICC	0	15.9	198	45 D	38.5
			5×10^5	13.6	89	49 D	
			1×10^6	19.0	38	57 D	
			5×10^6	20.2	2.4	75 D	
322		Sieverts	0	16.7	235	34 D	30
			5×10^5	13.0	145	36 D	
			1×10^6	18.6	64	40 D	
			5×10^6	16.9	4.4	69 D	
323		Sieverts	0	15.7	220	46.5 D	39
			5×10^5	15.2	100	46 D	
			1×10^6	21.6	30	50 D	
			5×10^6	17.8	2.4	76 D	
331	V1HYM-52-11	Kabel-Metall	0	13.7	250	33 D	32.6
			5×10^5	13.1	142	37 D	
			1×10^6	15.1	120	38 D	
			5×10^6	17.0	4	70 D	
332	V1HYM-91-11	Kabel-Metall	0	14.0	212	38 D	38.8
			5×10^5	11.8	99	43 D	
			1×10^6	13.4	114	48 D	
			5×10^6	13.4	3	71 D	

No.	Type	Supplier	Dose (Gy)	Traction R (N/mm²)	Traction E (%)	Hardness H	Oxygen index (%)
336	Jacket L 7016/82	Huber & Suhner	0	11.8	144	43 D	31
			5×10^5	11.5	110	45.5 D	
			1×10^6	12.8	88	49.5 D	
			5×10^6	16.5	15	67.5 D	
342	Insulator	Dätwyler	0	15.2	200	52 D	32.5
			5×10^5	13.7	100	50.5 D	
			1×10^6	17.2	60	58 D	
			5×10^6	22.1	1	75 D	
360		Huber & Suhner	0	14.6	243	41.5 D	
			5×10^5	13.7	135	37 D	
			1×10^6	13.8	77	39.5 D	
			5×10^6	13.6	4	69 D	



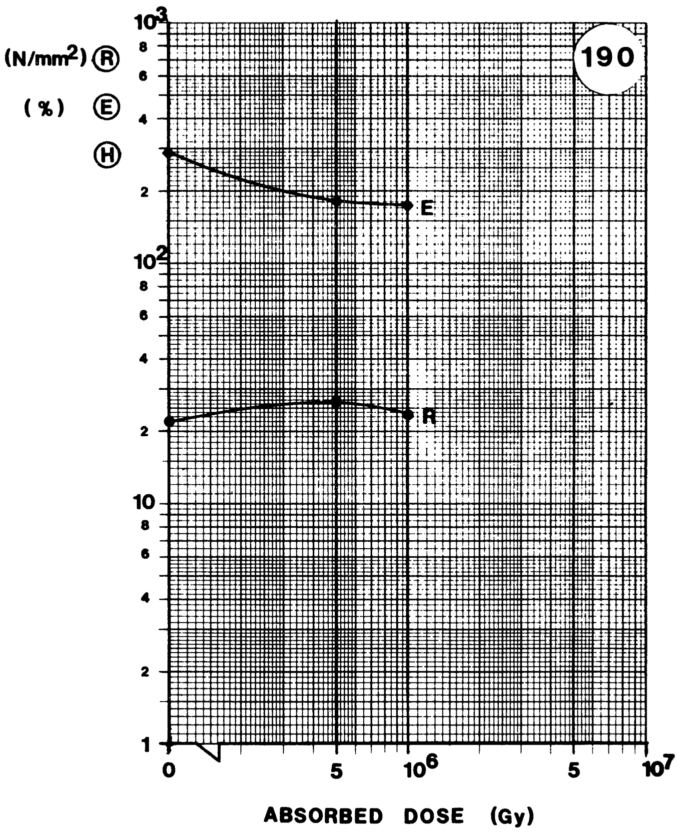
MATERIAL: PVC$_F$

TYPE:

SUPPLIER: Filotex

Remarks:

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	19.1	N/mm^2
E	Elong. at break	310	%
H	Hardness	-	Shore C,D
	Oxygen index	30	



MATERIAL: PVC$_F$

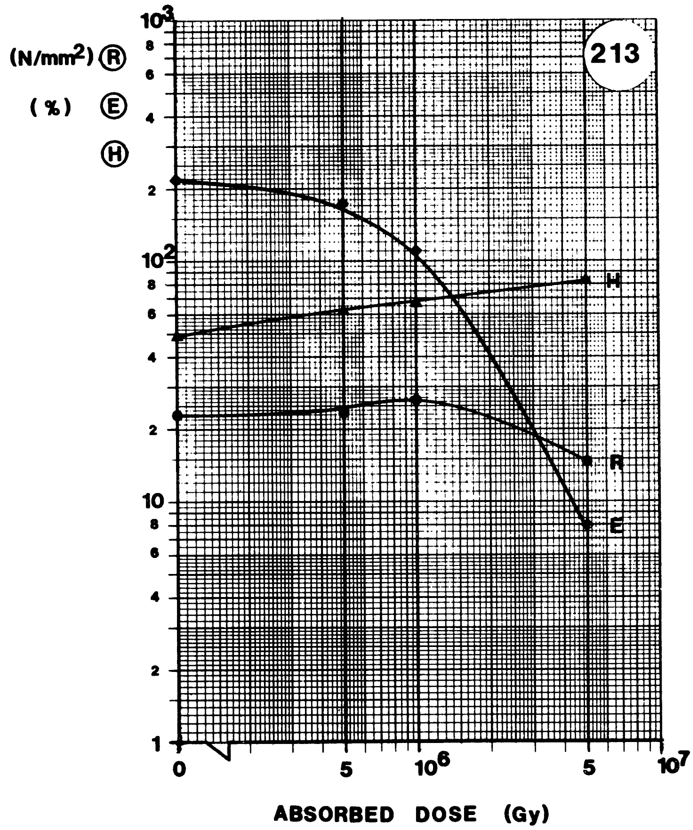
TYPE: Antirad

SUPPLIER: Thomson-Brandt

Remarks: Multicor cables ND26, ND48, NE10, NE18, NE26, NE48, NF12.

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	21.6	N/mm^2
E	Elong. at break	290	%
H	Hardness	-	Shore C,D
	Oxygen index	31	

PVC_F



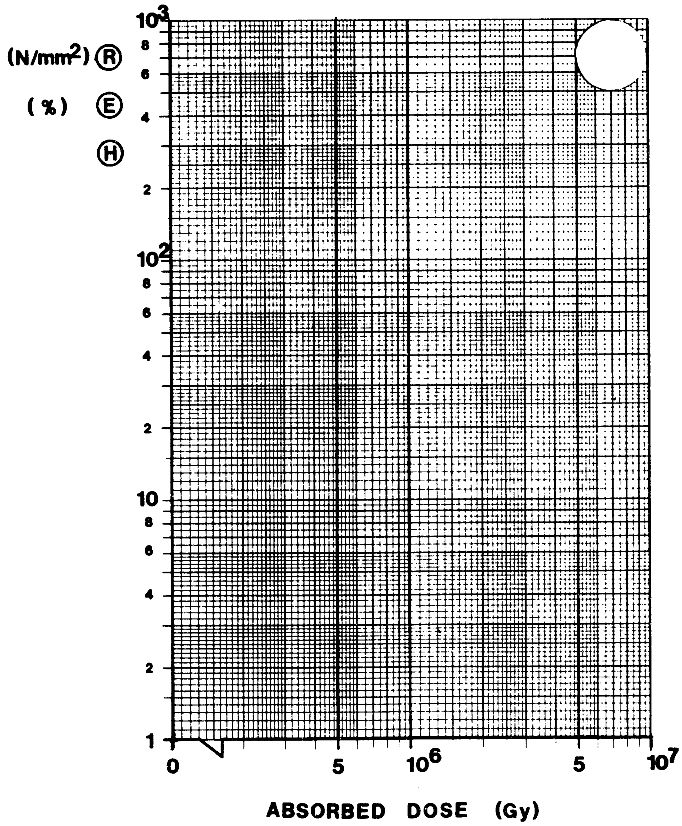
MATERIAL: PVC_F

TYPE: Antirad

SUPPLIER: Thomson-Brandt

Remarks: Used for SPS 1 kV cables

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	22.7	N/mm²
E	Elong. at break	212	%
H	Hardness	49.4	Shore D
	Oxygen index	33.5	



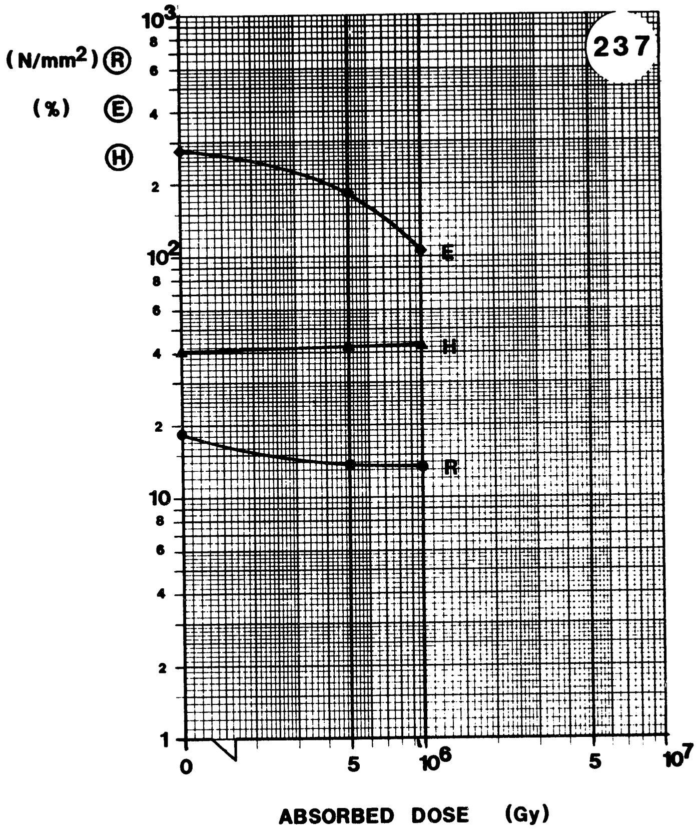
MATERIAL:

TYPE:

SUPPLIER:

Remarks:

CURVE	PROPERTY	INITIAL VALUE
R	Tensile strength	N/mm²
E	Elong. at break	%
H	Hardness	Shore C,D
	Oxygen index	



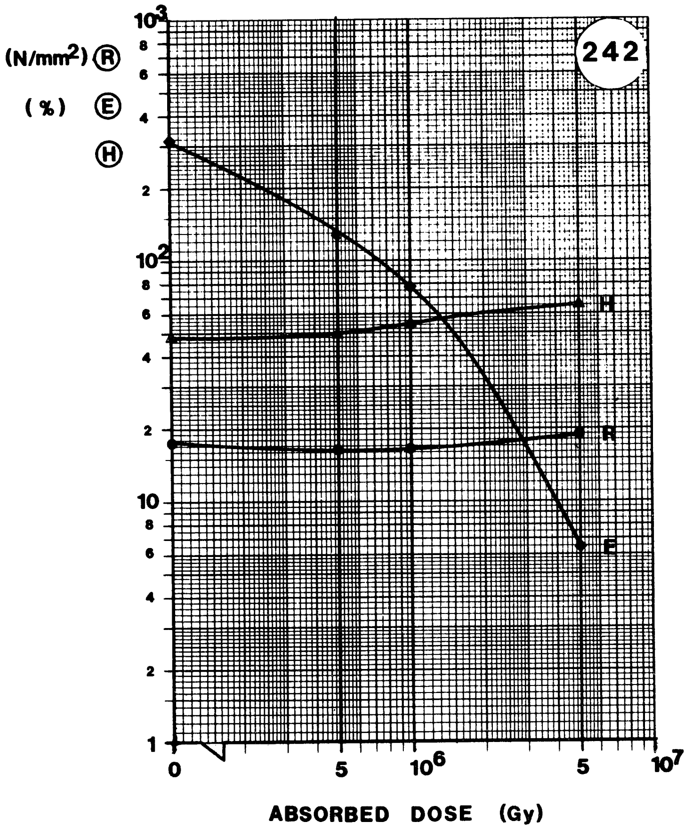
MATERIAL: PVC_F

TYPE: JACKET

SUPPLIER: CABLES DE LYON

Remarks:

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	18.3	N/mm^2
E	Elong. at break	275	%
H	Hardness	40	Shore D
	Oxygen index	31.8	



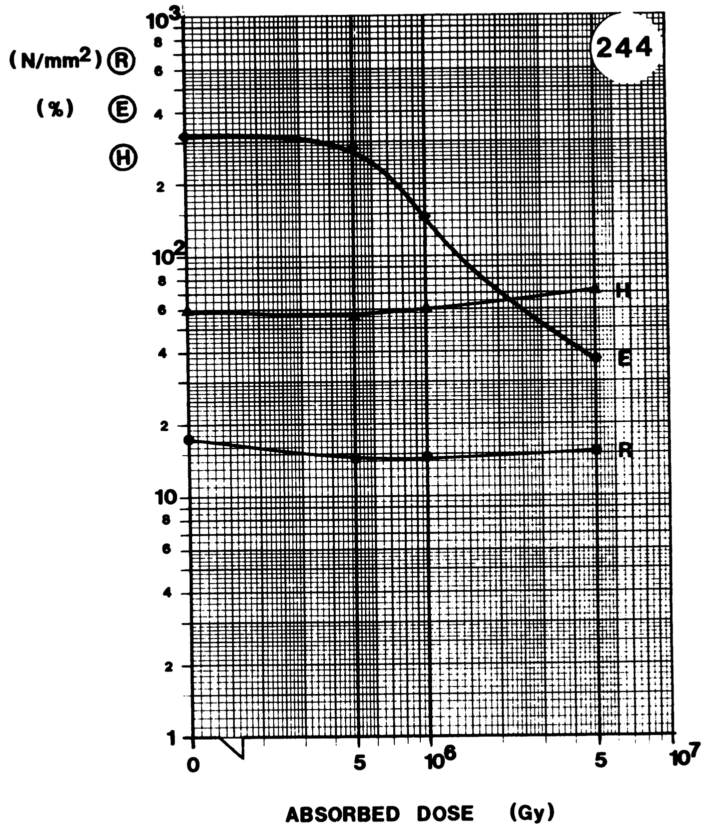
MATERIAL: PVC_F

TYPE: JACKET

SUPPLIER: THOMSON-BRANDT

Remarks: USED FOR SPS 1 kV POWER CABLES

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	17.5	N/mm^2
E	Elong. at break	313	%
H	Hardness	47	Shore D
	Oxygen index	31.5	



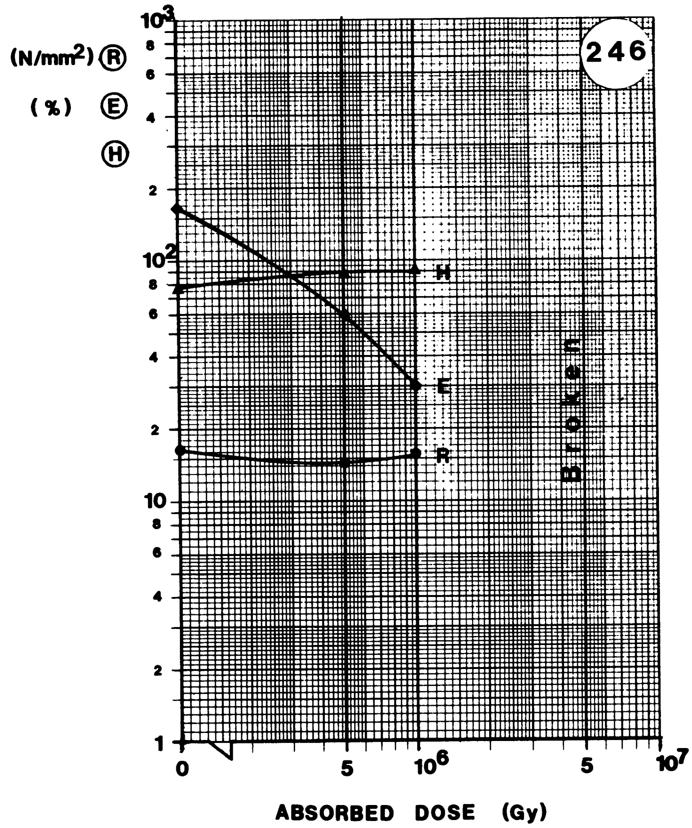
MATERIAL: PVC$_F$

TYPE:

SUPPLIER: SIEVERTS

Remarks: USED FOR SPS 1 KV AL CABLE

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	16.9	N/mm^2
E	Elong. at break	315	%
H	Hardness	60	Shore C
	Oxygen index	27.5	



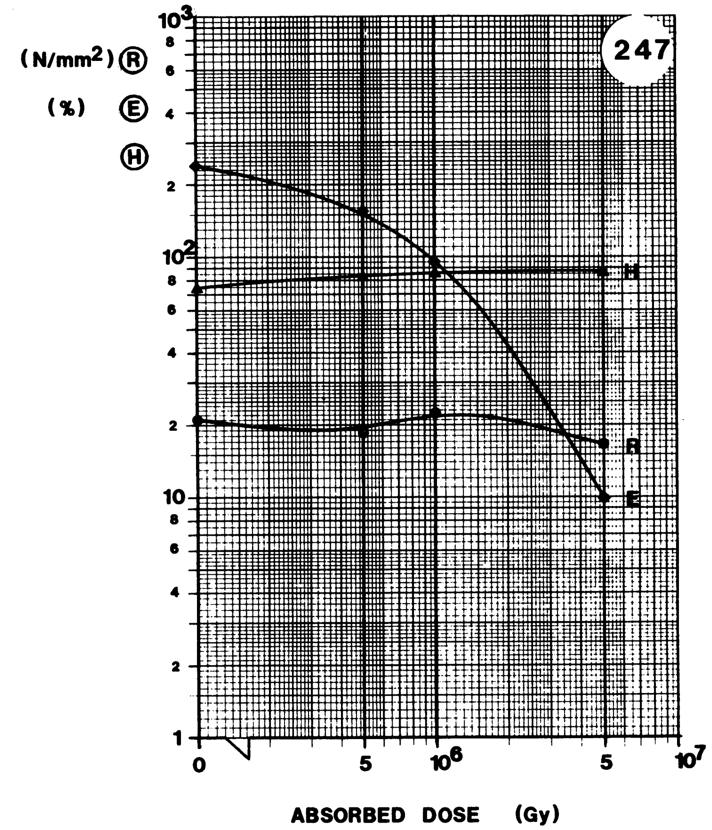
MATERIAL: PVC$_F$

TYPE: FGP 162

SUPPLIER: FILECA

Remarks: NO LONGER COMMERCIALLY AVAILABLE

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	16.1	N/mm^2
E	Elong. at break	166	%
H	Hardness	78	Shore C
	Oxygen index	29	



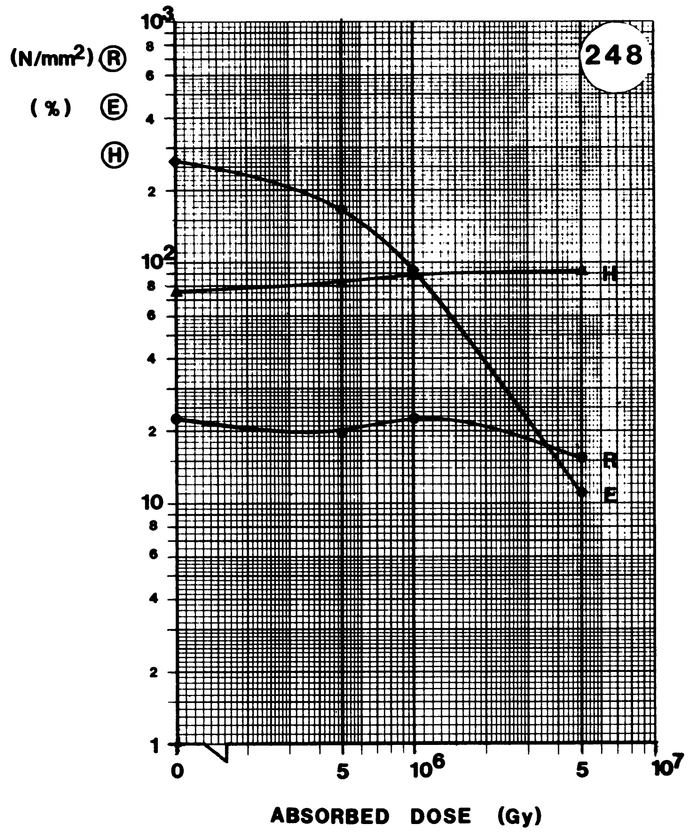
MATERIAL: PVC$_F$

TYPE: EX KI 50/002

SUPPLIER: FILECA

Remarks: No LONGER COMMERCIALLY AVAILABLE

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	20.6	N/mm^2
E	Elong. at break	240	%
H	Hardness	75	Shore C
	Oxygen index	30	



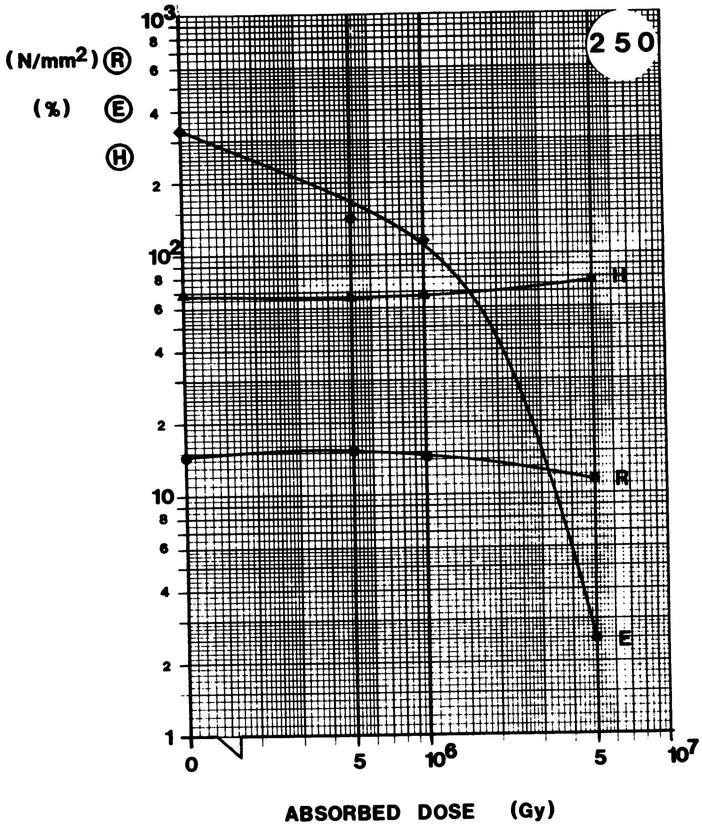
MATERIAL: PVC$_F$

TYPE: EX KI 50/0002

SUPPLIER: FILECA

Remarks: No LONGER COMMERCIALLY AVAILABLE

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	21.6	N/mm^2
E	Elong. at break	265	%
H	Hardness	76	Shore C
	Oxygen index	29.9	



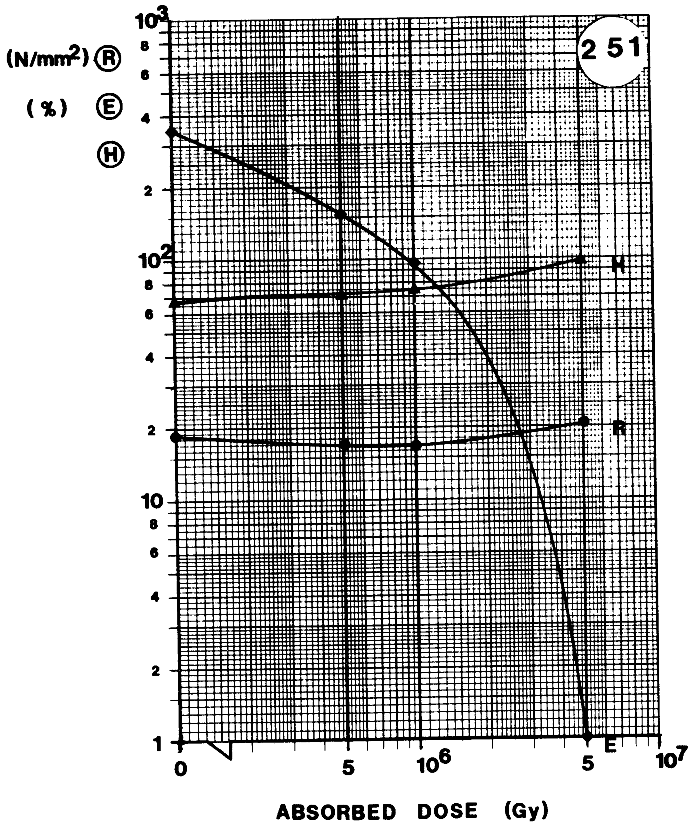
MATERIAL: PVC_F

TYPE:

SUPPLIER: CABLES DE LYON

Remarks:

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	14.6	N/mm^2
E	Elong. at break	330	%
H	Hardness	68	Shore C
	Oxygen index	27.5	



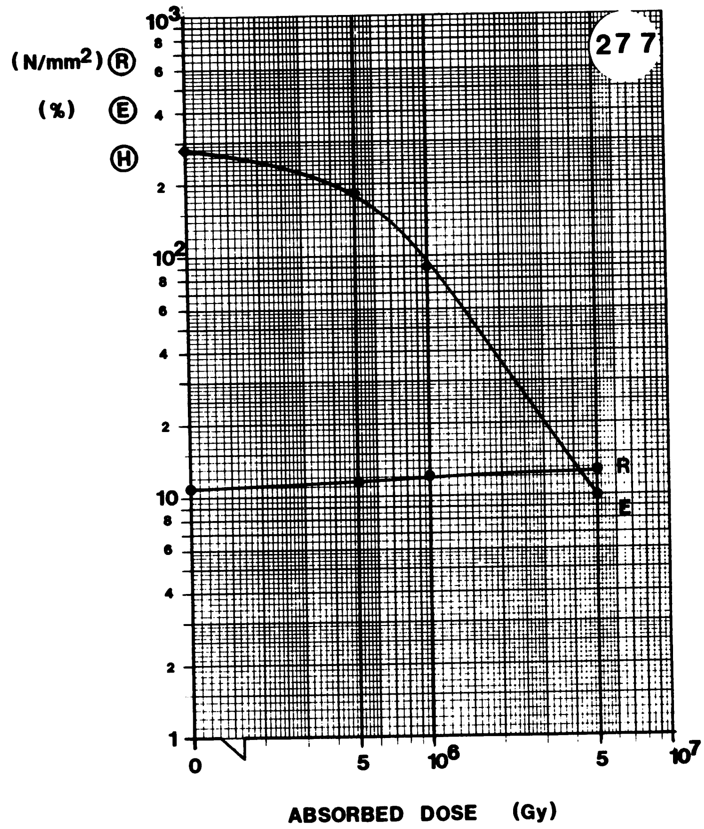
MATERIAL: PVC_F

TYPE:

SUPPLIER: SIEVERTS

Remarks:

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	18.5	N/mm^2
E	Elong. at break	345	%
H	Hardness	69	Shore C
	Oxygen index	30.5	



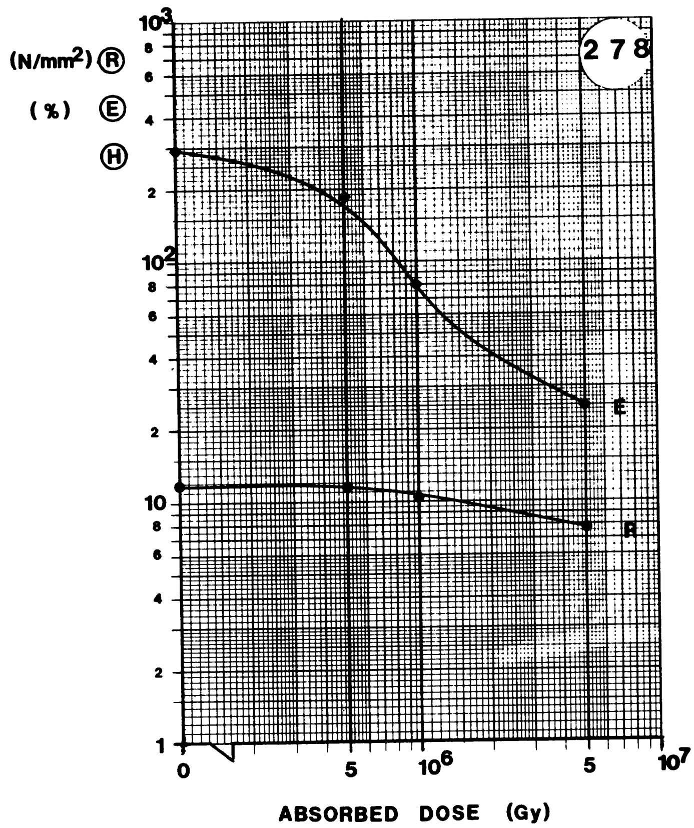
MATERIAL: PVC$_F$

TYPE: JACKET

SUPPLIER: SILEC

Remarks:

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	10.8	N/mm^2 *)
E	Elong. at break	280	%
H	Hardness	-	Shore C,D
	Oxygen index	30.5	



MATERIAL: PVC$_F$

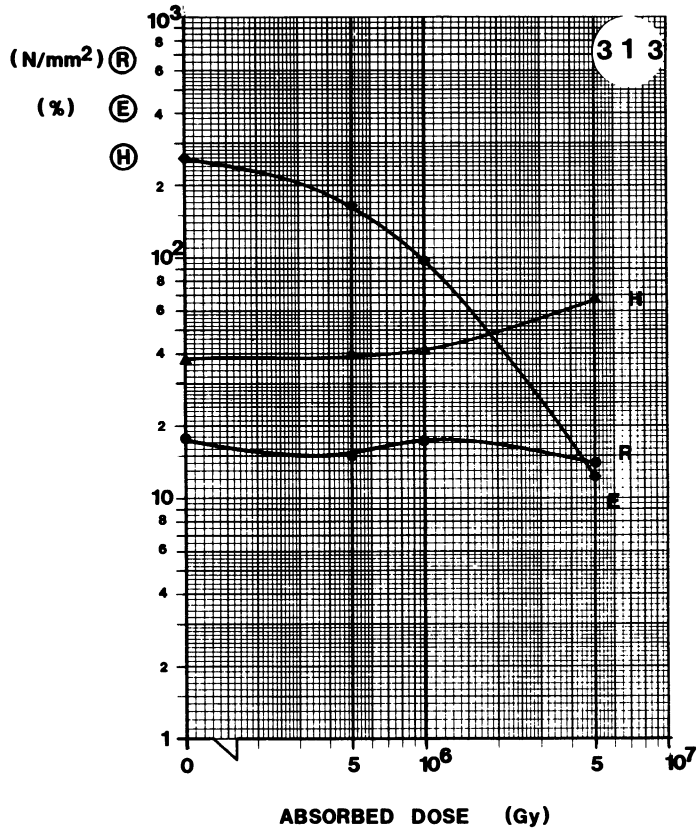
TYPE: JACKET

SUPPLIER: SILEC

Remarks:

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	11.4	N/mm^2 *)
E	Elong. at break	288	%
H	Hardness		Shore C,D
	Oxygen index	32	

*) if sample taken from cable a higher value is obtained



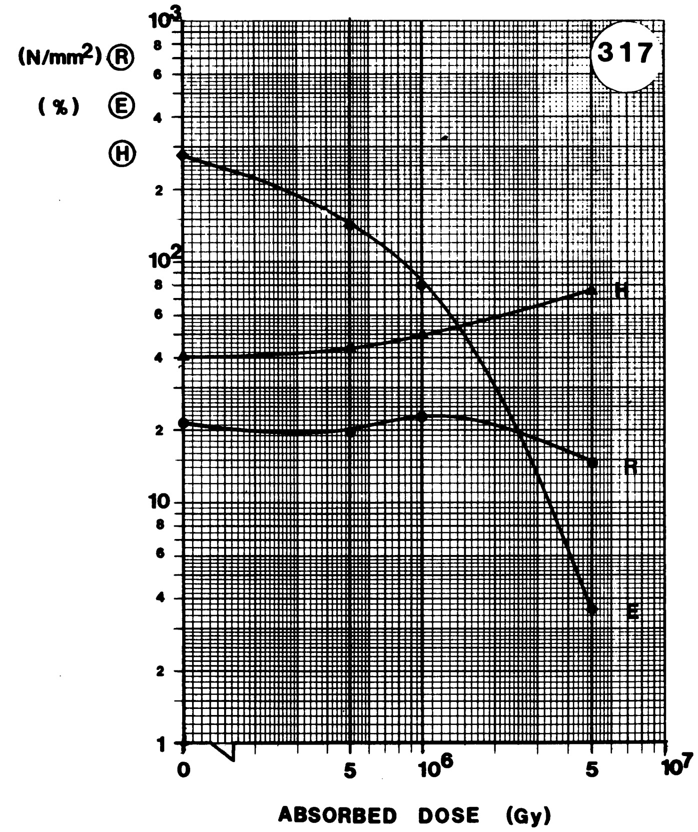
MATERIAL: PVC_F

TYPE:

SUPPLIER: Pirelli

Remarks:

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	17.7	N/mm²
E	Elong. at break	254	%
H	Hardness	37.5	Shore D
	Oxygen index	32	



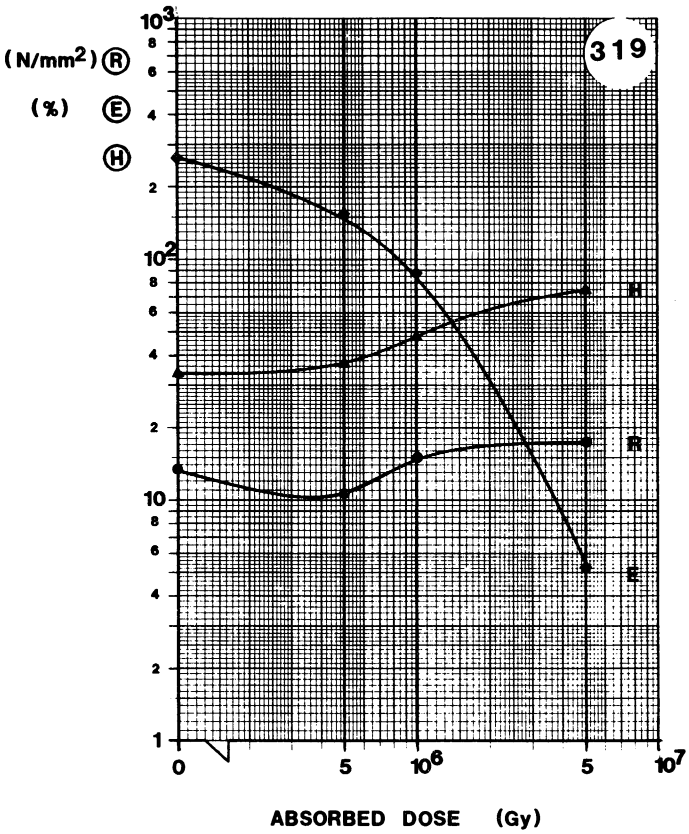
MATERIAL: PVC_F

TYPE: Jacket

SUPPLIER: Thomson-Brandt

Remarks: Used for SPS 1 kV and 3.3 kV Al 240 and 400 mm² cables

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	21.6	N/mm²
E	Elong. at break	275	%
H	Hardness	40	Shore D
	Oxygen index	32	



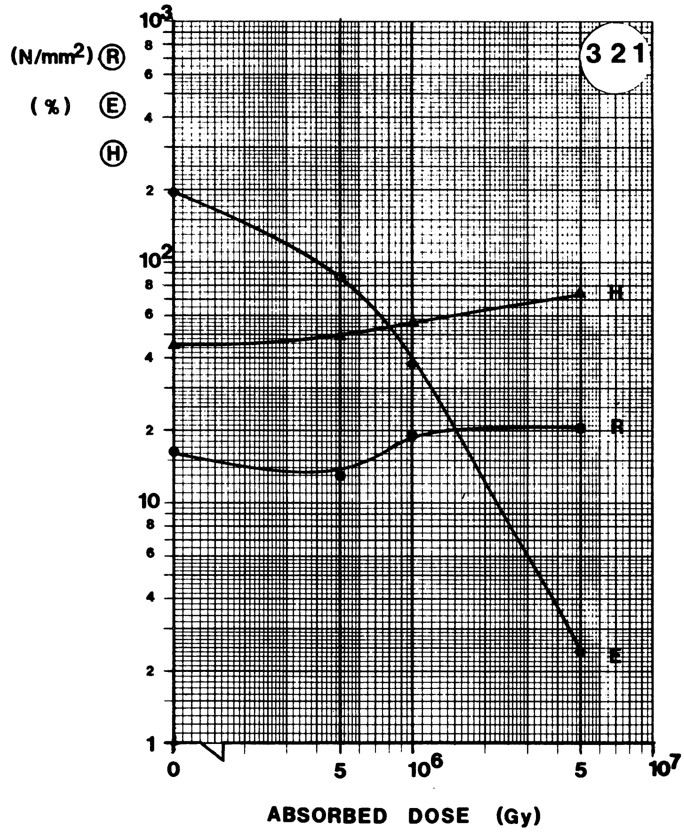
MATERIAL: PVC_F

TYPE:

SUPPLIER: LILJEHOLMENS

Remarks:

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	13.6	N/mm^2
E	Elong. at break	261	%
H	Hardness	34	Shore D
	Oxygen index	30.5	



MATERIAL: PVC_F

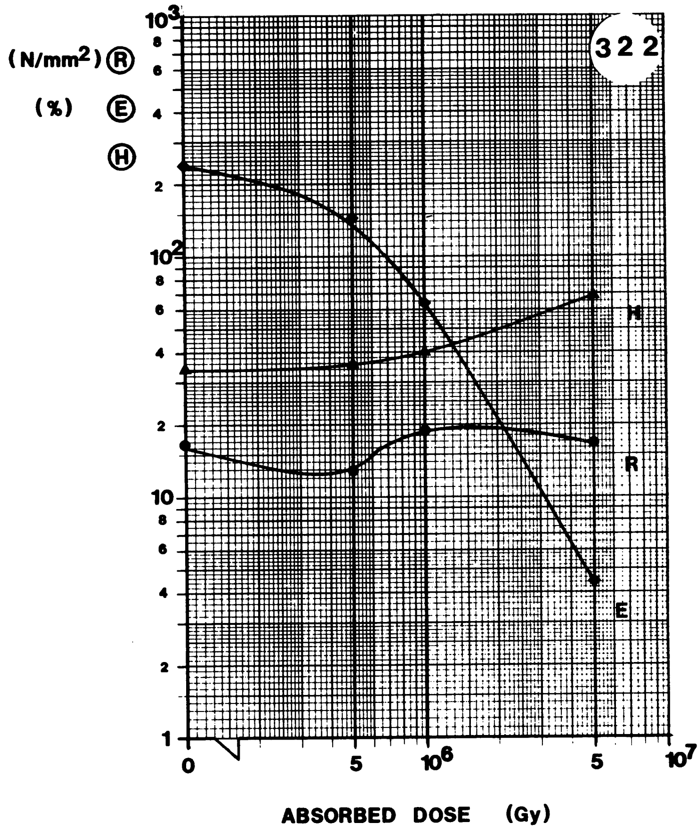
TYPE: JACKET

SUPPLIER: BICC

Remarks:

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	15.9	N/mm^2
E	Elong. at break	198	%
H	Hardness	45	Shore D
	Oxygen index	38.5	

PVC_F



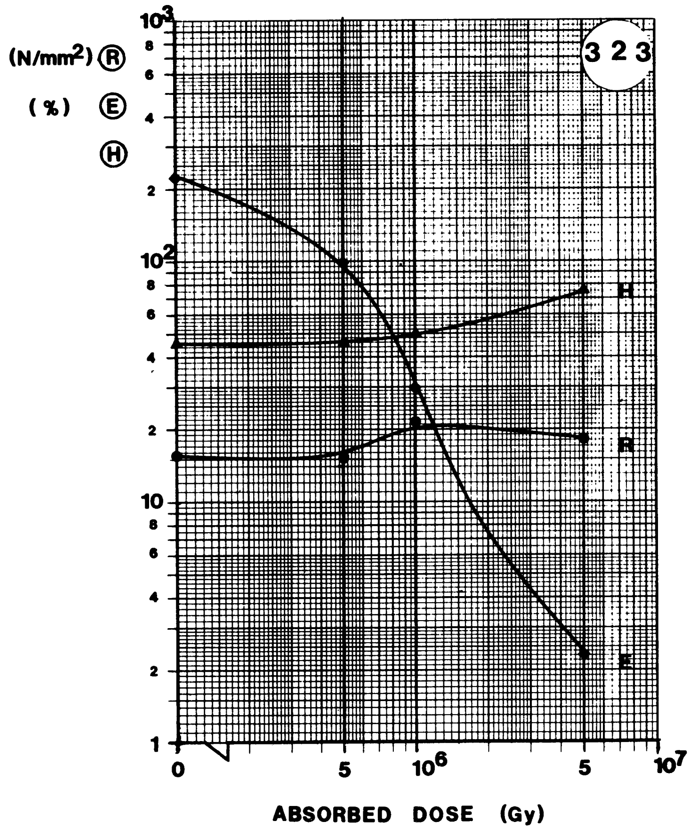
MATERIAL: PVC_F

TYPE:

SUPPLIER: Sieverts

Remarks:

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	16.7	N/mm²
E	Elong. at break	235	%
H	Hardness	34	Shore D
	Oxygen index	30	



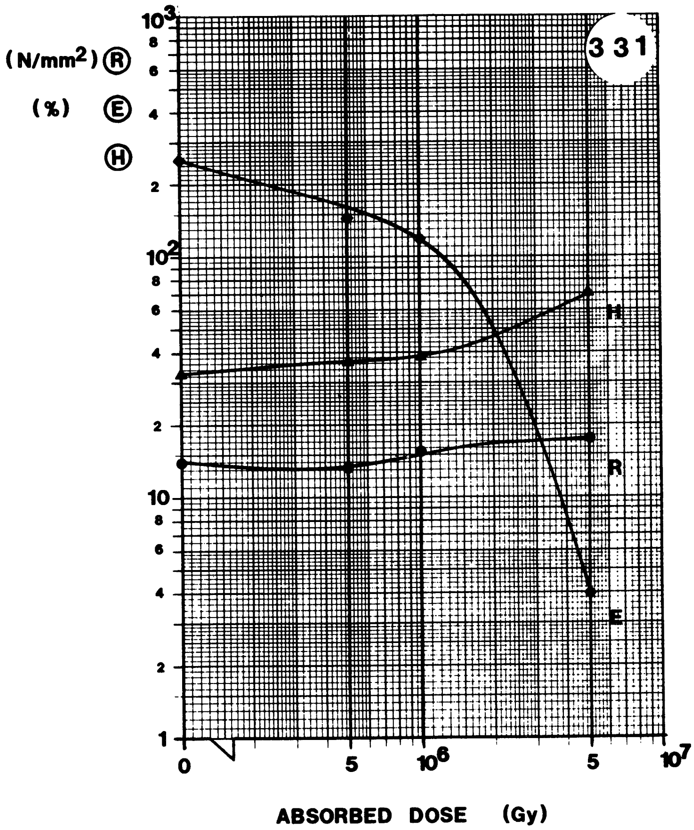
MATERIAL: PVC_F

TYPE:

SUPPLIER: Sieverts

Remarks:

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	15.7	N/mm²
E	Elong. at break	220	%
H	Hardness	46.5	Shore D
	Oxygen index	39	



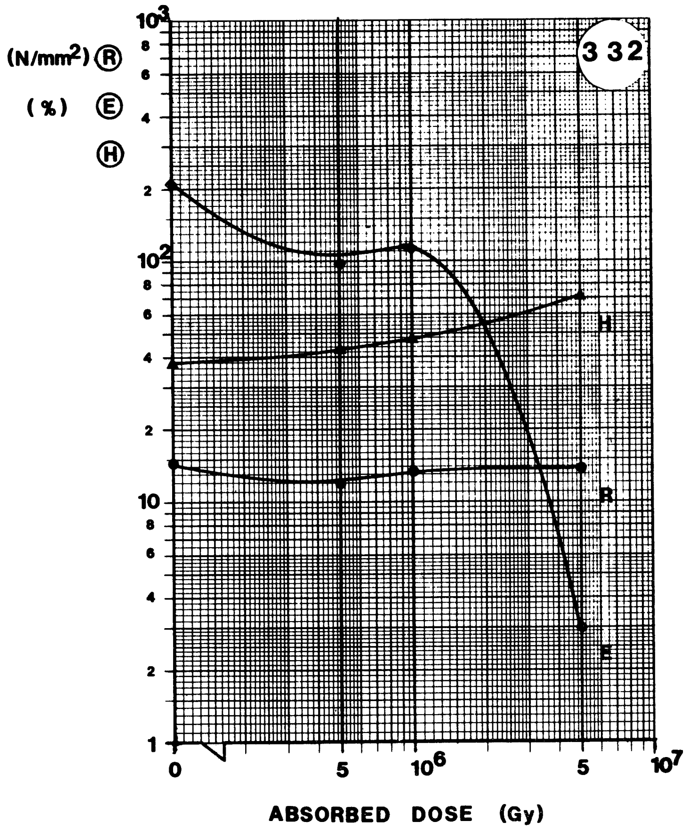
MATERIAL: PVC$_F$

TYPE:

SUPPLIER: KABEL-METALL

Remarks:

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	13.7	N/mm^2
E	Elong. at break	250	%
H	Hardness	33	Shore D
	Oxygen index	32.6	



MATERIAL: PVC$_F$

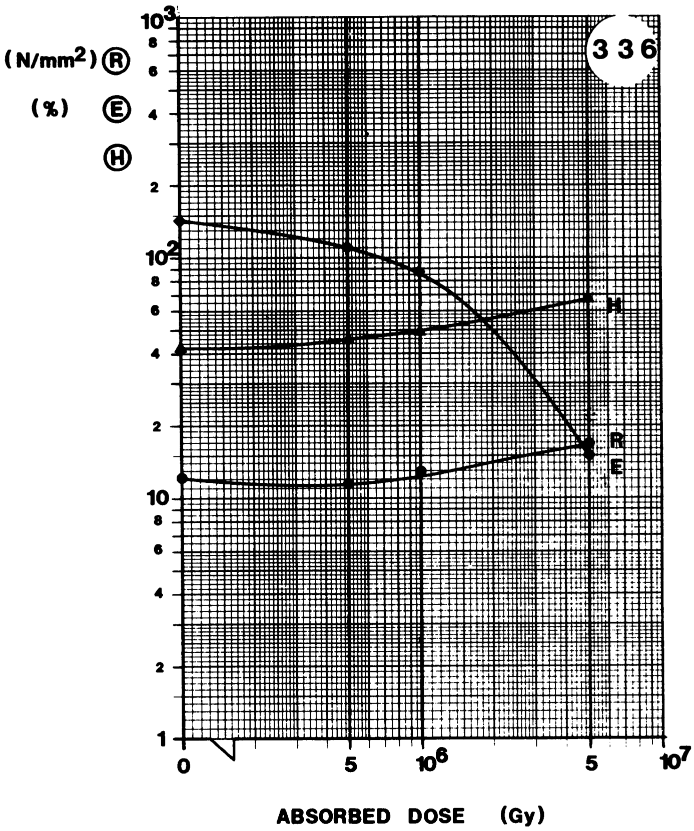
TYPE:

SUPPLIER: KABEL-METALL

Remarks:

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	14.0	N/mm^2
E	Elong. at break	212	%
H	Hardness	38	Shore D
	Oxygen index	38.8	

PVC$_F$



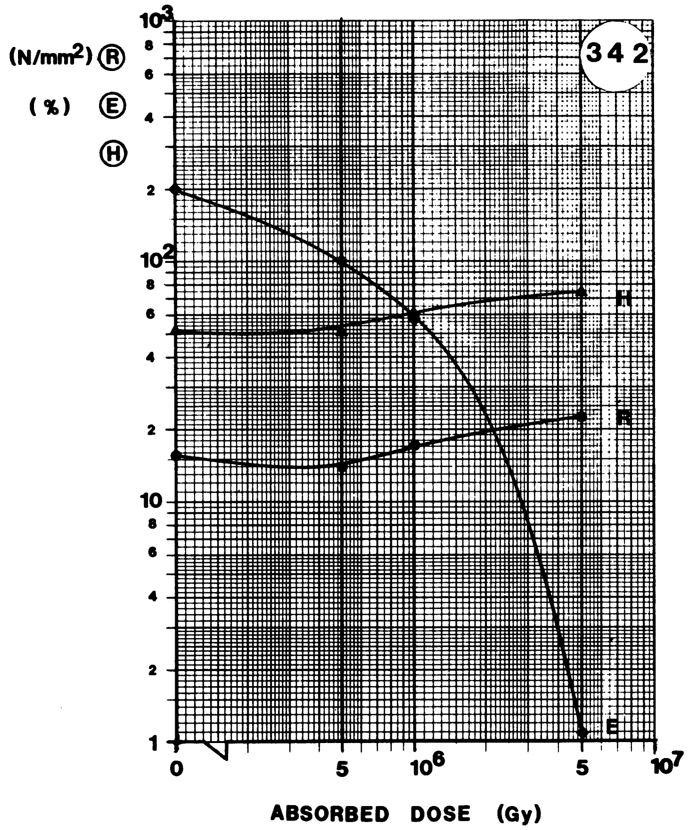
MATERIAL: PVC$_F$

TYPE: Jacket

SUPPLIER: Huber & Suhner

Remarks:

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	11.8	N/mm^2
E	Elong. at break	144	%
H	Hardness	43	Shore D
	Oxygen index	31	



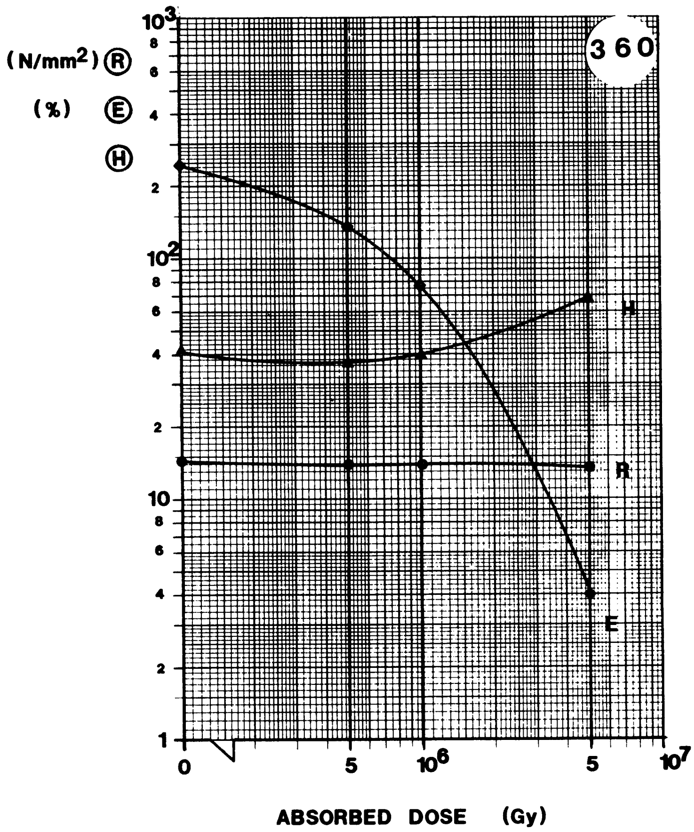
MATERIAL: PVC$_F$

TYPE: Insulator

SUPPLIER: Dätwyler

Remarks:

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	15.2	N/mm^2
E	Elong. at break	200	%
H	Hardness	52	Shore D
	Oxygen index	32.5	



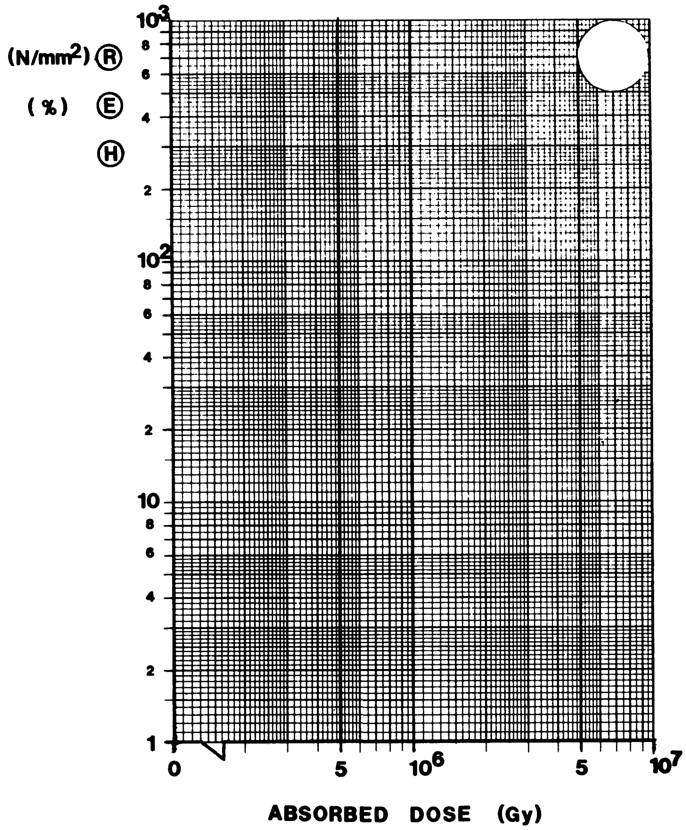
MATERIAL: PVC_F

TYPE:

SUPPLIER: HUBER & SUHNER

Remarks:

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	14.6	N/mm^2
E	Elong. at break	243	%
H	Hardness	41.5	Shore D
	Oxygen index	-	



MATERIAL:

TYPE:

SUPPLIER:

Remarks:

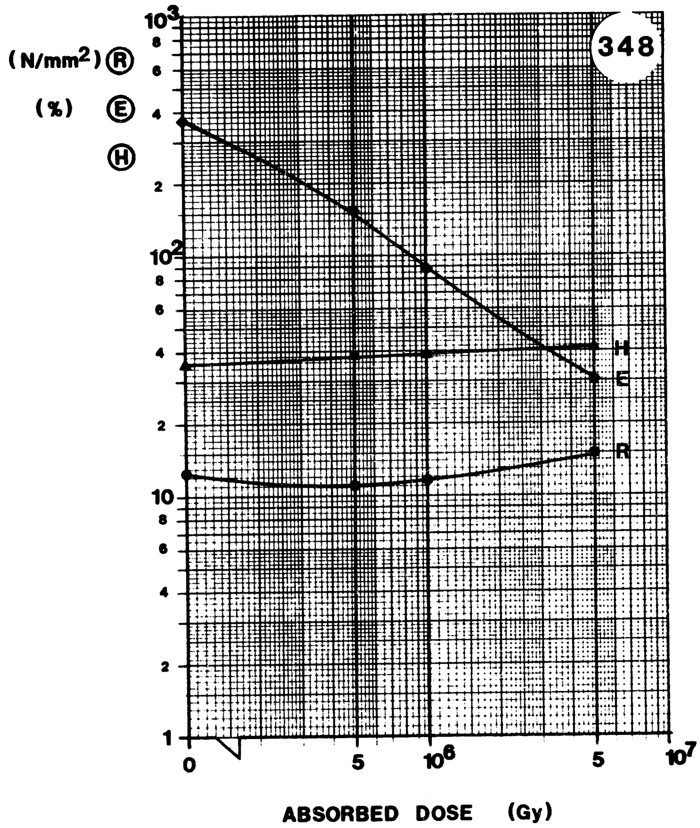
CURVE	PROPERTY	INITIAL VALUE
R	Tensile strength	N/mm^2
E	Elong. at break	%
H	Hardness	Shore C,D
	Oxygen index	

RADOX

Trade name of Huber & Suhner

Radiation cross-linked polyolefins copolymer

No.	Type	Supplier	Dose (Gy)	Traction R (N/mm²)	Traction E (%)	Hardness H	Oxygen index (%)
348	Radox 110	Huber & Suhner	0	12.2	371	35 D	27
			5×10^5	10.8	152	38.5 D	
			1×10^6	11.6	88	39.5 D	
			5×10^6	14.7	25	41.5 D	
349	Radox 130	Huber & Suhner	0	13.5	292	35 D	25
			5×10^5	12.0	84	41 D	
			1×10^6	9.8	41	40 D	
			5×10^6	11.1	17.5	50 D	
350	Radox 155	Huber & Suhner	0	13.6	240	43 D	25
			5×10^5	10.8	92	43.5 D	
			1×10^6	7.6	39	45 D	
			5×10^6	9.1	16	59.5 D	



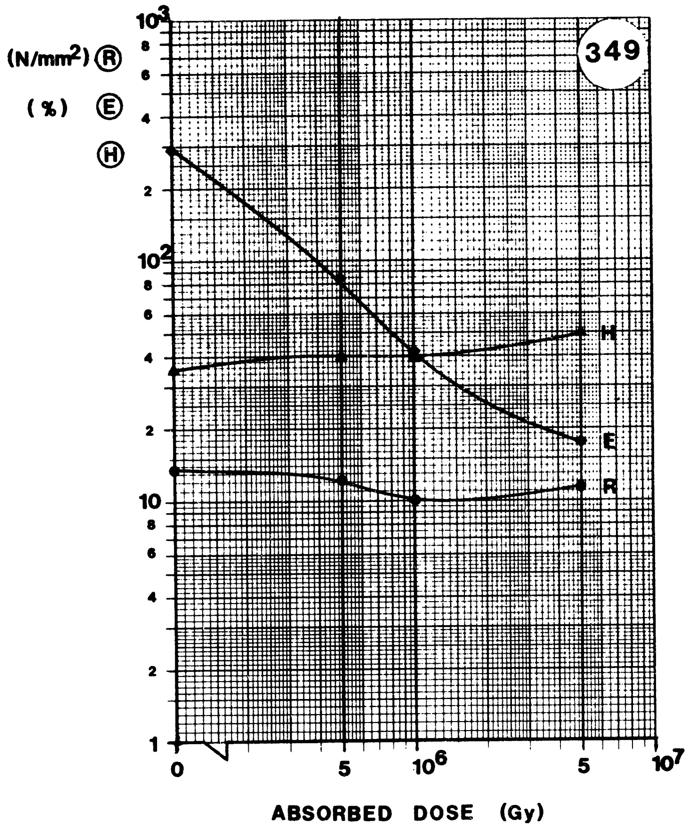
MATERIAL: RADOX

TYPE: Radox 110

SUPPLIER: Huber & Suhner

Remarks: For service temperatures up to 110°C

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	12.2	N/mm²
E	Elong. at break	371	%
H	Hardness	35	Shore D
	Oxygen index	27	



MATERIAL: RADOX

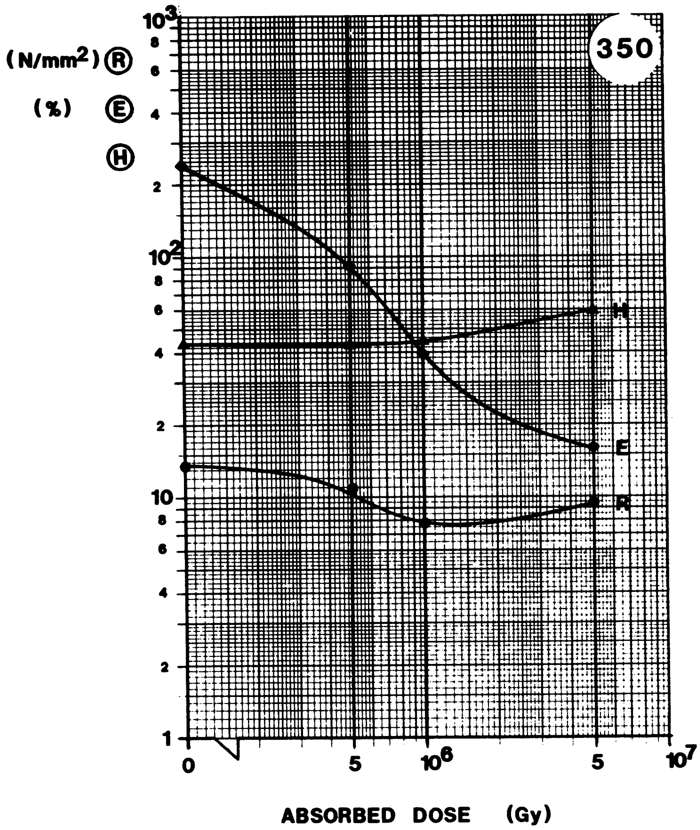
TYPE: Radox 130

SUPPLIER: Huber & Suhner

Remarks: For service temperatures up to 130°C

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	13.5	N/mm²
E	Elong. at break	292	%
H	Hardness	35	Shore D
	Oxygen index	25	

RADOX



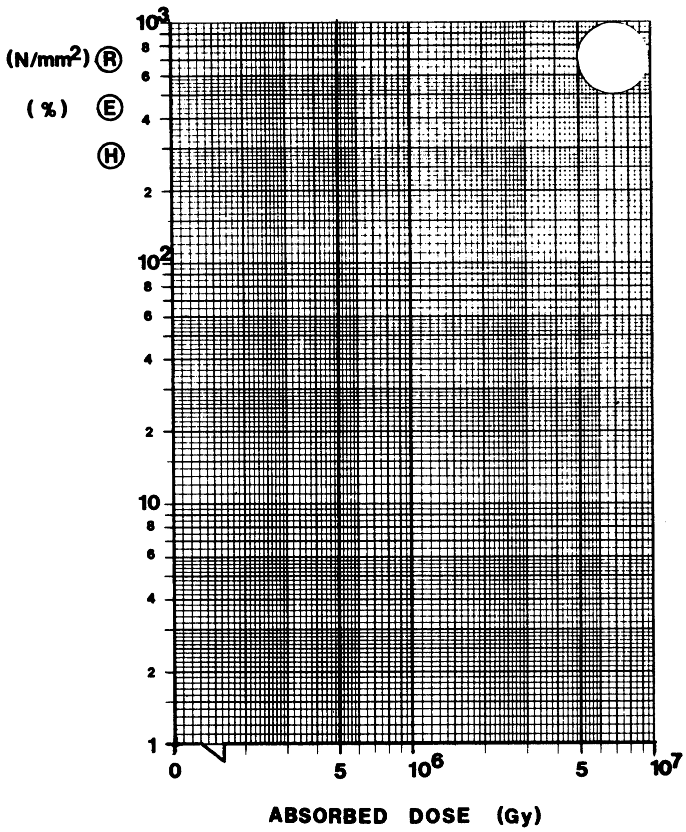
MATERIAL: RADOX

TYPE: Radox 155

SUPPLIER: Huber & Suhner

Remarks: For service temperatures up to 155°C

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	13.6	N/mm²
E	Elong. at break	240	%
H	Hardness	43	Shore D
	Oxygen index	25	



MATERIAL:

TYPE:

SUPPLIER:

Remarks:

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength		N/mm²
E	Elong. at break		%
H	Hardness		Shore C,D
	Oxygen index		

SEMICONDUCTING PE
see PE

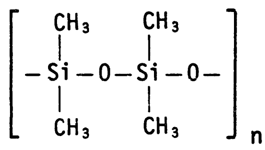
SIR
Silicone rubber

SILYTHENE
see PE

STILAN
Polyarylene

SILICONE RUBBER

The silicone rubbers are polysiloxanes. The most widely used type is polydimethylsiloxane*).

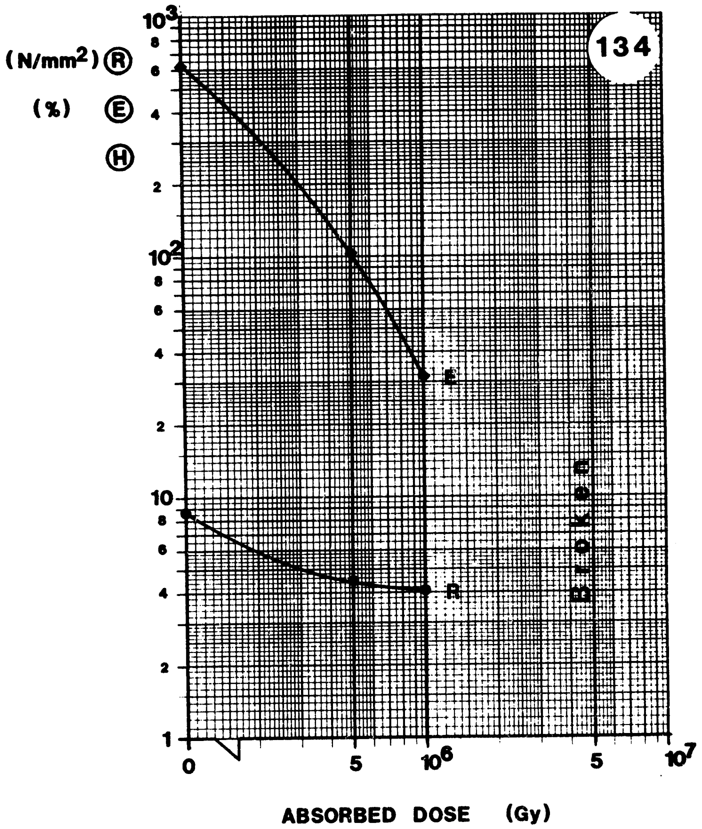


For general characteristics, see Table 1 in Section 2.

*) F.M. Clark, Insulating materials for design and engineering practice (John Wiley and Sons, Inc., New-York, 1962).

B.R. McGregor, Silicones and their use (McGraw-Hill Book Co., Inc., New-York, 1954).

No.	Type	Supplier	Dose (Gy)	Traction R (N/mm²)	Traction E (%)	Hardness H	Oxygen index (%)
134		DRAKA	0	8.5	637		
			5×10^5	4.4	104		
			1×10^6	4.0	32		
			5×10^6	broken			
138		DRAKA	0	8.8	432		
			5×10^5	4.8	28		
			1×10^6	4.6	14.5		
			5×10^6	broken			
150		Aumann & Co.	0	4.2	367		
			5×10^5	2.9	41		
			1×10^6	2.4	17.5		
			5×10^6	broken			



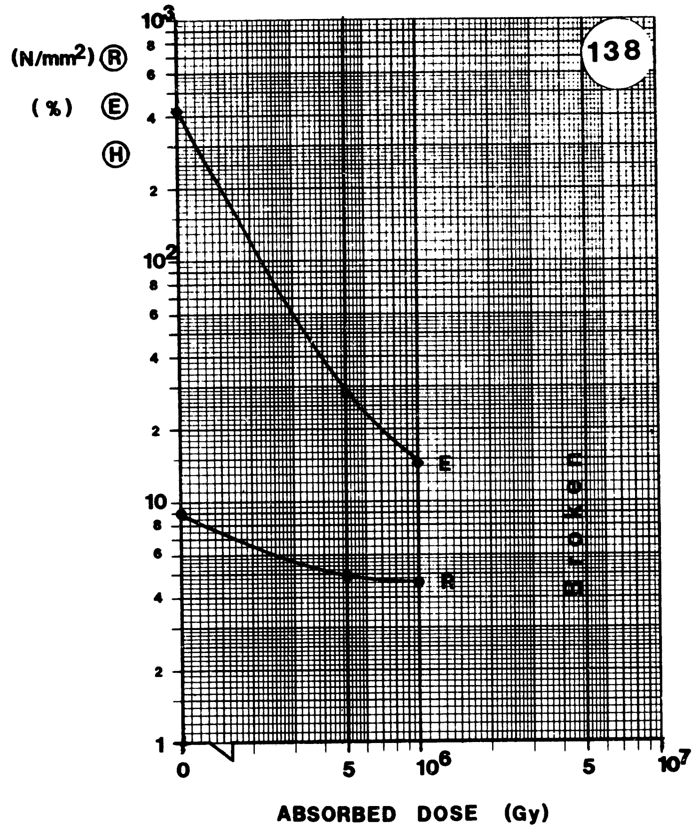
MATERIAL: SILICONE RUBBER

TYPE:

SUPPLIER: DRAKA

Remarks:

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	8.5	N/mm²
E	Elong. at break	637	%
H	Hardness	-	Shore C,D
	Oxygen index	-	



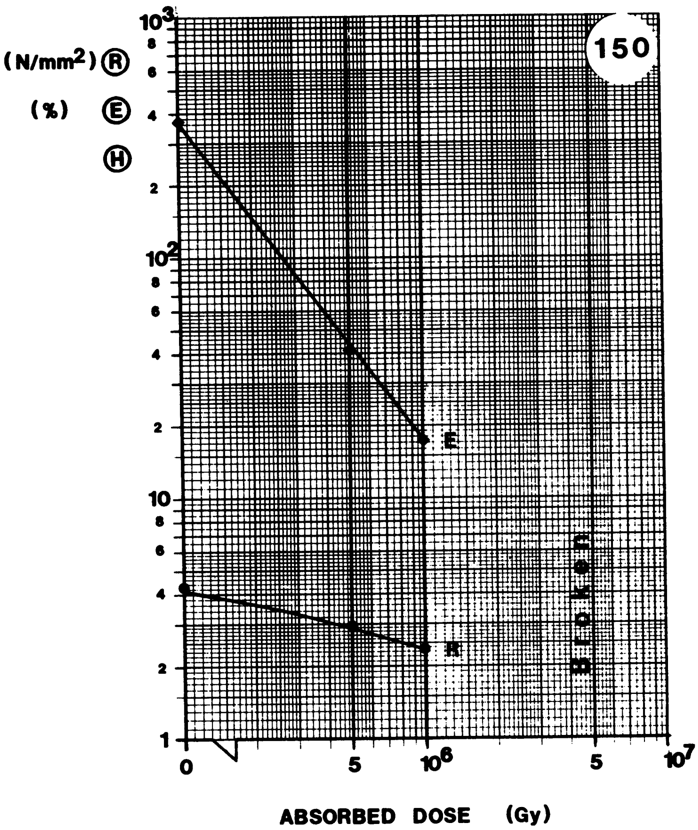
MATERIAL: SILICONE RUBBER

TYPE:

SUPPLIER: DRAKA

Remarks:

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	8.8	N/mm²
E	Elong. at break	432	%
H	Hardness	-	Shore C,D
	Oxygen index	-	



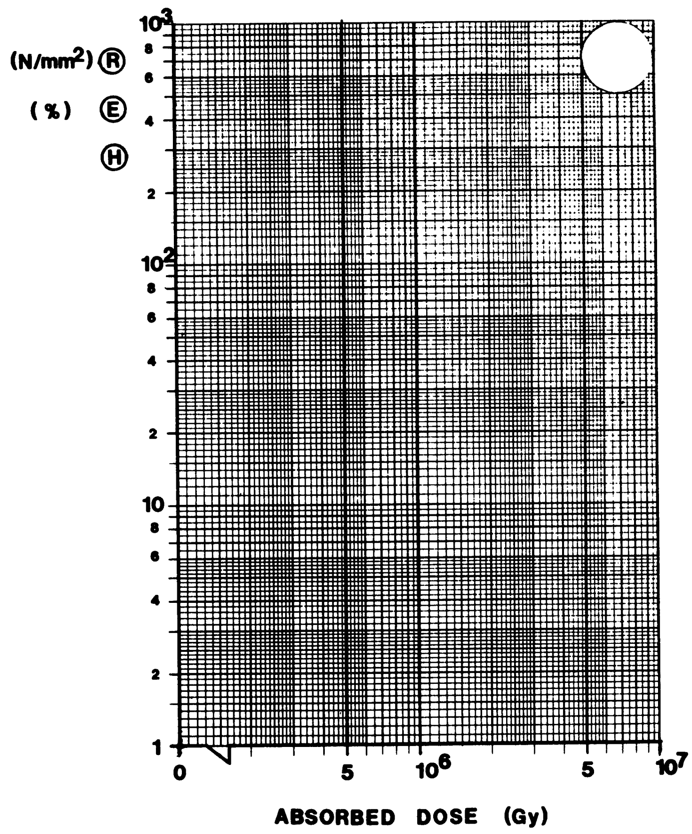
MATERIAL: SILICONE RUBBER

TYPE:

SUPPLIER: AUMANN & Co.

Remarks:

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	4.2	N/mm^2
E	Elong. at break	367	%
H	Hardness	-	Shore C,D
	Oxygen index	-	



MATERIAL:

TYPE:

SUPPLIER:

Remarks:

CURVE	PROPERTY	INITIAL VALUE
R	Tensile strength	N/mm^2
E	Elong. at break	%
H	Hardness	Shore C,D
	Oxygen index	

Trade name of Raychem

Polyarylene

The general characteristics may be summarized as follows:

Specific gravity (g/cm^3)	1.3
Dielectric constant at 1 kHz	3.4
Loss factor at 1 kHz	0.003
Resistivity (Ω cm)	$> 10^{16}$
Ultimate tensile strength (N/mm^2)	103
Ultimate elongation (%)	120
Oxygen index	36

According to the supplier's documentation, remains unchanged after exposure to 1×10^8 Gy.

TEFLON

fluoropolymer

TEFLON PTFE

TEFLON FEP

TEFZEL

fluoropolymer

Trade name of Du Pont

TEFLON PTFE - Polytetrafluoroethylene

$$[-CF_2-CF_2-]_n$$

Copolymer of tetrafluoroethylene ($CF_2=CF_2$) and hexafluoropropylene
TEFLON FEP - ($CF_2=CF-CF_3$)

$$\left[-CF_2-CF_2-CF_2-\underset{\displaystyle CF_3}{\overset{\displaystyle F}{\overset{|}{\underset{|}{C}}}}-\right]_n$$

For general characteristics, see Table 1 in Section 2.

Severe radiation damage occurs at doses above 10^3 Gy for TEFLON PTFE and 10^5 Gy for TEFLON FEP.

Use not recommended in radiation areas.

Trade name of Du Pont

Copolymer of ethylene ($CH_2=CH_2$) and tetrafluoroethylene ($CF_2=CF_2$)

$$[-CH_2-CH_2-CF_2-CF_2-]_n$$

For general characteristics, see Table 1 in Section 2.

Radiation resistant up to 2×10^6 Gy according to information from supplier.

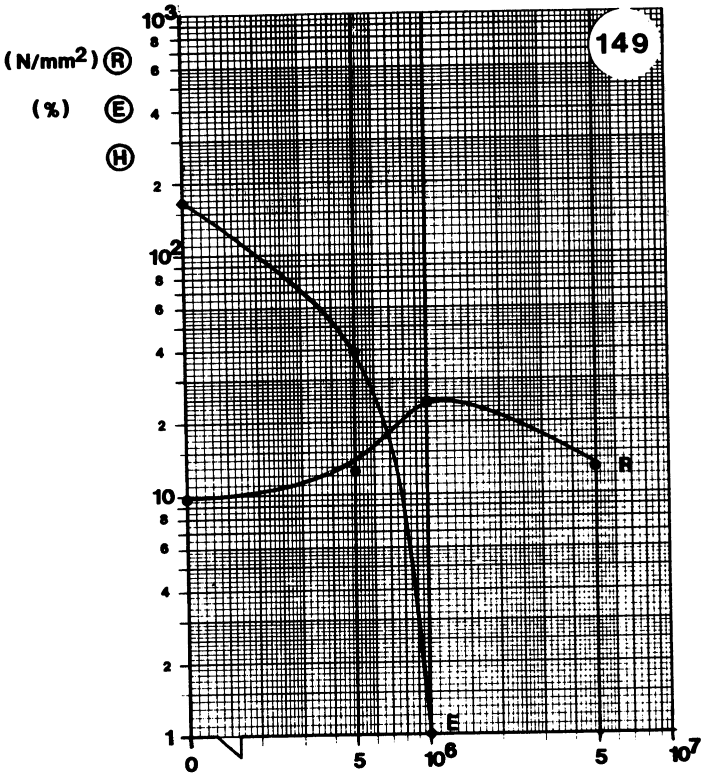
VITON

Trade name of Du Pont

Copolymer of vinylidene fluoride ($CF_2{=}CH_2$) and hexafluoropropylene ($CF_2{=}CF-CF_3$)

$$\left[-CF_2-CH_2-CF_2-\underset{\displaystyle CF_3}{\underset{|}{CF}}- \right]_n$$

No.	Type	Supplier	Dose (Gy)	Traction R (N/mm²)	Traction E (%)	Hardness H	Oxygen index (%)
149	E 60 C	Gummi Maag	0	9.5	168		67
			5×10^5	12.7	40		
			1×10^6	24.1	< 1		
			5×10^6	12.8	< 1		



ABSORBED DOSE (Gy)

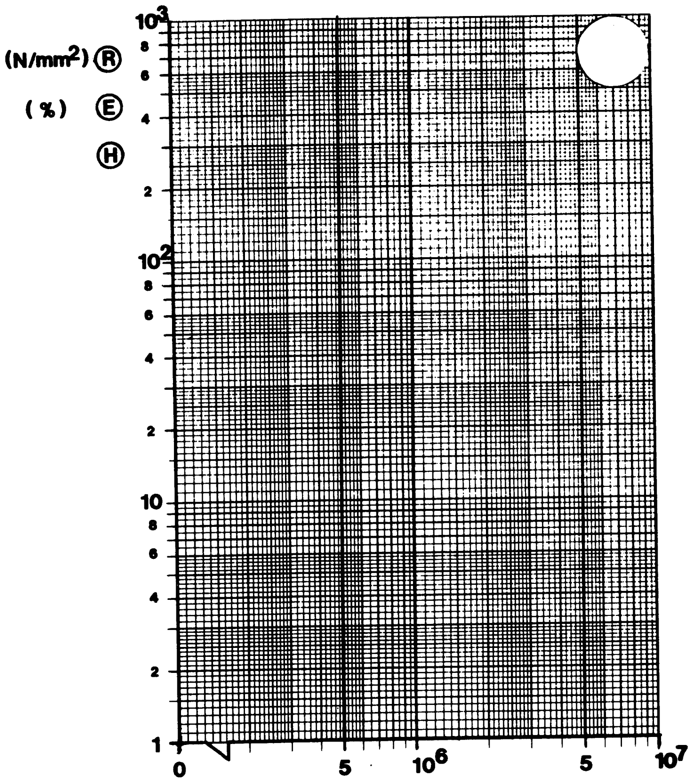
MATERIAL: VITON

TYPE:

SUPPLIER: GUMMI MAAG

Remarks:

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	9.5	N/mm^2
E	Elong. at break	168	%
H	Hardness	-	Shore C,D
	Oxygen index	67	



ABSORBED DOSE (Gy)

MATERIAL:

TYPE:

SUPPLIER:

Remarks:

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength		N/mm^2
E	Elong. at break		%
H	Hardness		Shore C,D
	Oxygen index		

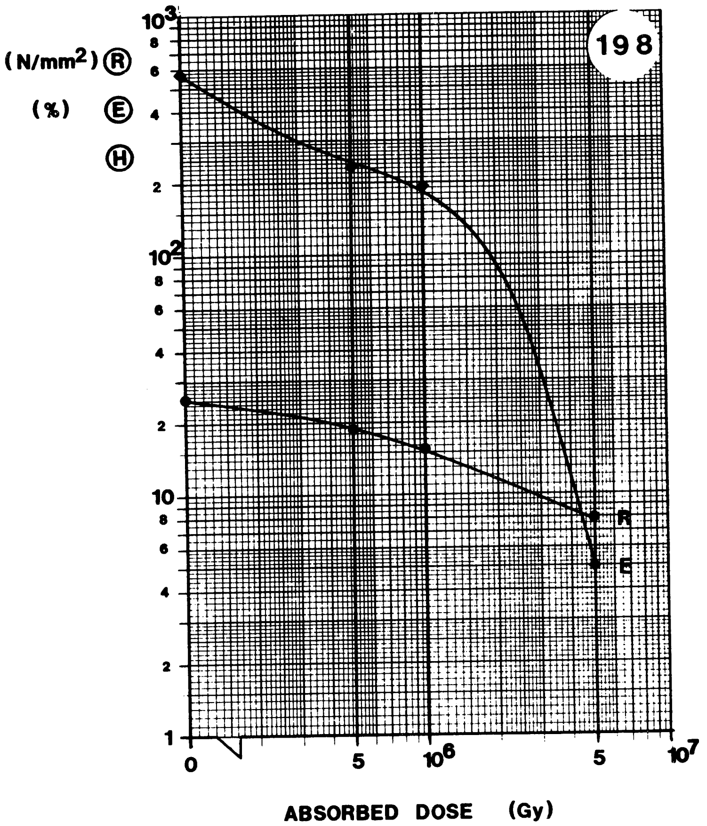
XLPE

chemically or radiation cross-linked polyethylene

For general characteristics, see Table 1 in Section 2.

No.	Type	Supplier	Dose (Gy)	Traction R (N/mm²)	Traction E (%)	Hardness H	Oxygen index (%)
198	High-voltage insulator	Pirelli	0	25.1	569		
			5×10^5	18.6	232		
			1×10^6	15.4	192		
			5×10^6	7.9	5	82 C	
203	Low-voltage insulator	Pirelli	0	20.5	503	48 D	
			5×10^5	18.6	342	48 D	
			1×10^6	17.1	238	51 D	
			5×10^6	8.1	5	51 D	
214	PRC, antirad	Thomson-Brandt	0	17.5	480	47.7 D	18.6
			5×10^5	17.6	270	50 D	
			1×10^6	12.7	108	47.1 D	
			5×10^6	11.1	11.5	55 D	
245		Sieverts	0	22.5	525	77 C	17.5
			5×10^5	15.0	320		
			1×10^6	11.0	75		
			5×10^6	10.2	18.8		
249	PRC	Câbles de Lyon	0	18.9	394	78 C	18.3
			5×10^5	16.2	197	81 C	
			1×10^6	15.3	141	81 C	
			5×10^6	9.6	15	84 C	
256	Insulator	IKO	0	15.1	470	84 C	18.7
			5×10^5	12.1	260	84 C	
			1×10^6	11.0	127	86 C	
			5×10^6	12.4	20	91 C	
274	Mixture A, PRC, insulator	SILEC	0	10.7	376		17.5
			5×10^5	11.1	310		
			1×10^6	10.9	215		
			5×10^6	9.4	25		

No.	Type	Supplier	Dose (Gy)	Traction R (N/mm²)	Traction E (%)	Hardness H	Oxygen index (%)
294	Insulator	Dätwyler	0	15.7	249	49 D	24.0
			5×10^5	16.4	161	51 D	
			1×10^6	16.8	145	52 D	
			5×10^6	16.9	33	53 D	
320	Insulator	BICC	0	20.8	450	39 D	19
			5×10^5	15.2	297	41 D	
			1×10^6	13.1	187	44 D	
			5×10^6	6.9	24.8	40 D	
324		Sieverts	0	19.6	420	45 D	19
			5×10^5	16.3	231	43 D	
			1×10^6	14.7	130	40 D	
			5×10^6	6.4	25	38 D	
325	Special grade	Sieverts	0	16.7	205	51 D	22.5
			5×10^5	15.4	143	49 D	
			1×10^6	15.7	95	51 D	
			5×10^6	16.2	29	55 D	
341	XLPE Insulator without halogen 4-4770	Dätwyler	0	19.6	230	49.5 D	25
			5×10^5	18.9	140	51 D	
			1×10^6	18.3	106	52 D	
			5×10^6	18.0	24	58 D	
365	Insulator	Sieverts	0	17.0	423	46 D	
			5×10^5	14.3	191	44.5 D	
			1×10^6	12.1	136	45.5 D	
			5×10^6	10.2	19.5	44.5 D	



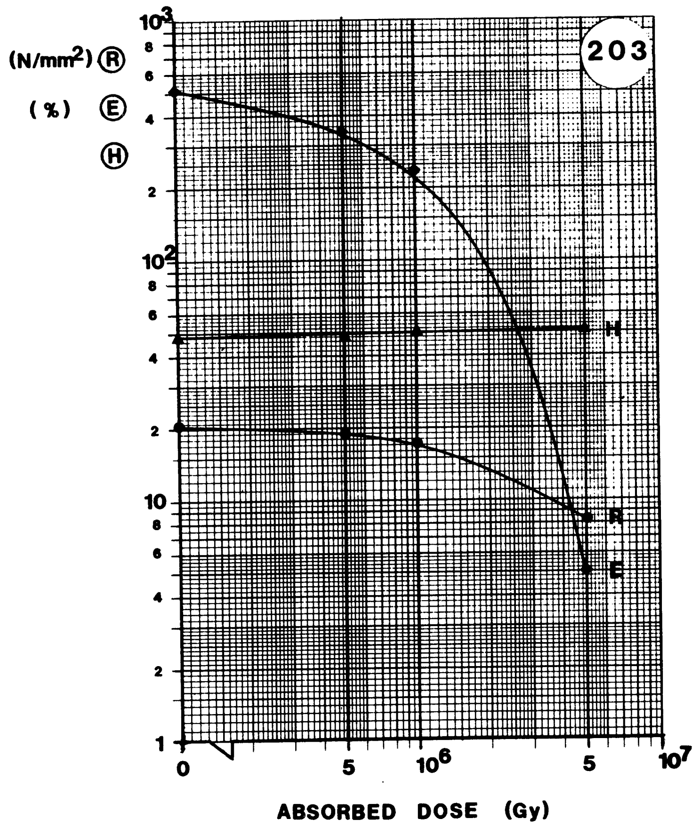
MATERIAL: XLPE

TYPE: HIGH-VOLTAGE INSULATOR

SUPPLIER: PIRELLI

Remarks:

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	25.1	N/mm^2
E	Elong. at break	569	%
H	Hardness	-	Shore C,D
	Oxygen index	-	



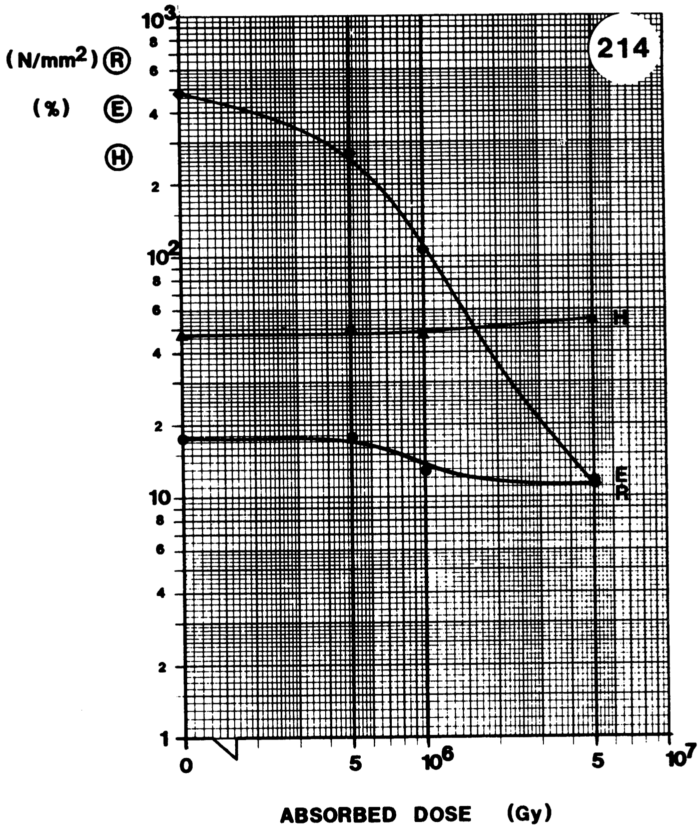
MATERIAL: XLPE

TYPE: LOW-VOLTAGE INSULATOR

SUPPLIER: PIRELLI

Remarks:

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	20.5	N/mm^2
E	Elong. at break	503	%
H	Hardness	48	Shore D
	Oxygen index	-	



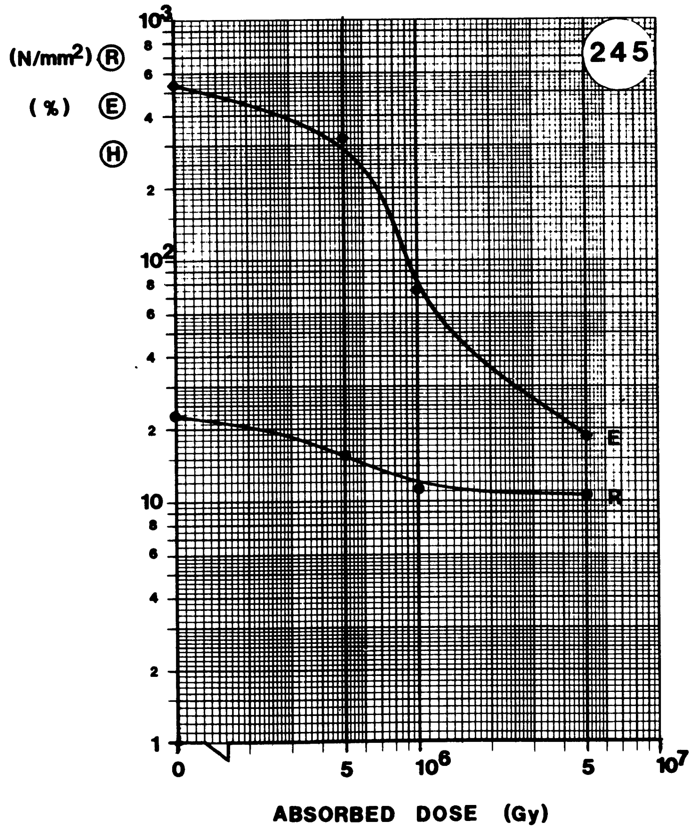
MATERIAL: XLPE

TYPE: ANTIRAD, PRC

SUPPLIER: THOMSON-BRANDT

Remarks: USED FOR SPS 1 kV CABLES

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	17.5	N/mm^2
E	Elong. at break	480	%
H	Hardness	47.7	Shore D
	Oxygen index	18.6	



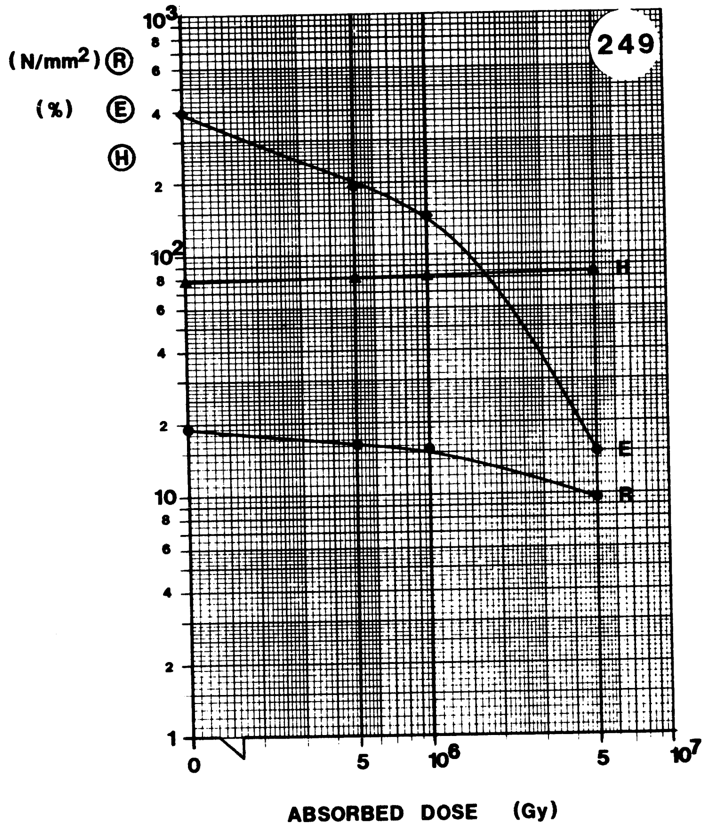
MATERIAL: XLPE

TYPE:

SUPPLIER: SIEVERTS

Remarks:

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	22.5	N/mm^2
E	Elong. at break	525	%
H	Hardness	77	Shore C
	Oxygen index	17.5	



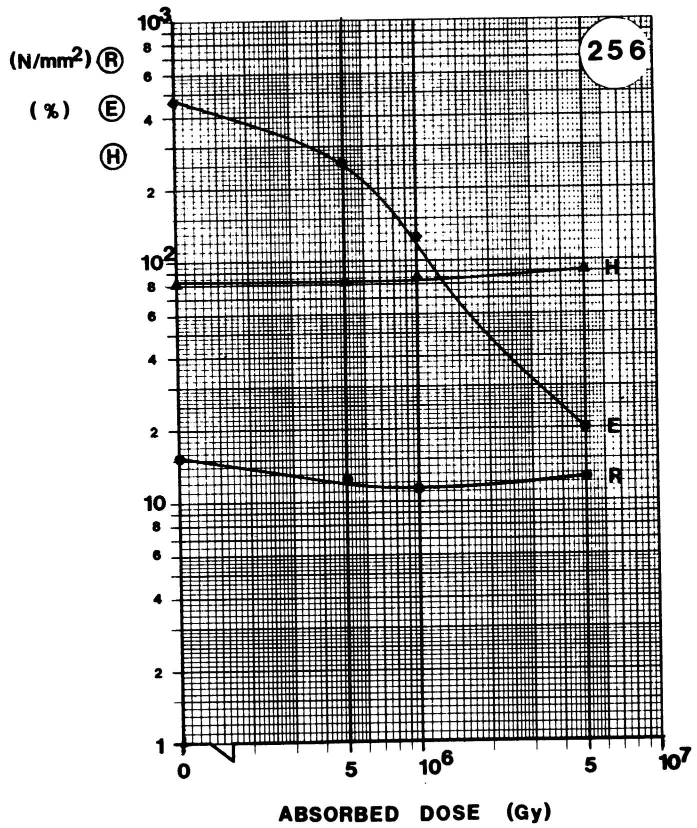
MATERIAL: XLPE

TYPE: PRC

SUPPLIER: CABLES DE LYON

Remarks:

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	18.9	N/mm²
E	Elong. at break	394	%
H	Hardness	78	Shore C
	Oxygen index	18.3	



MATERIAL: XLPE

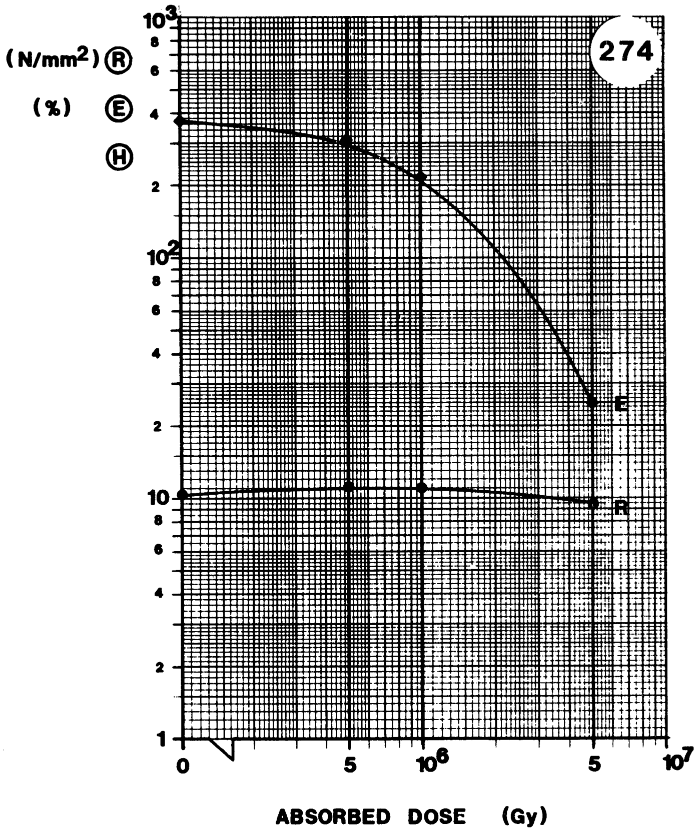
TYPE: INSULATOR

SUPPLIER: IKO

Remarks:

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	15.1	N/mm²
E	Elong. at break	470	%
H	Hardness	84	Shore C
	Oxygen index	18.7	

XLPE



MATERIAL: XLPE

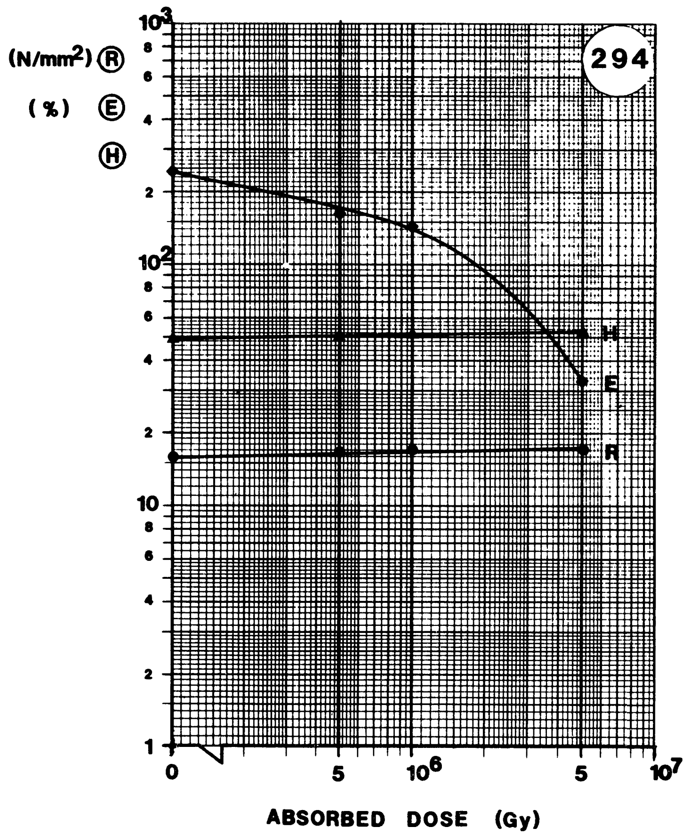
TYPE: Insulator, mixture A, PRC

SUPPLIER: SILEC

Remarks:

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	10.7	N/mm2 *)
E	Elong. at break	376	%
H	Hardness	-	Shore C,D
	Oxygen index	17.5	

*) if sample taken from cable a higher value is obtained



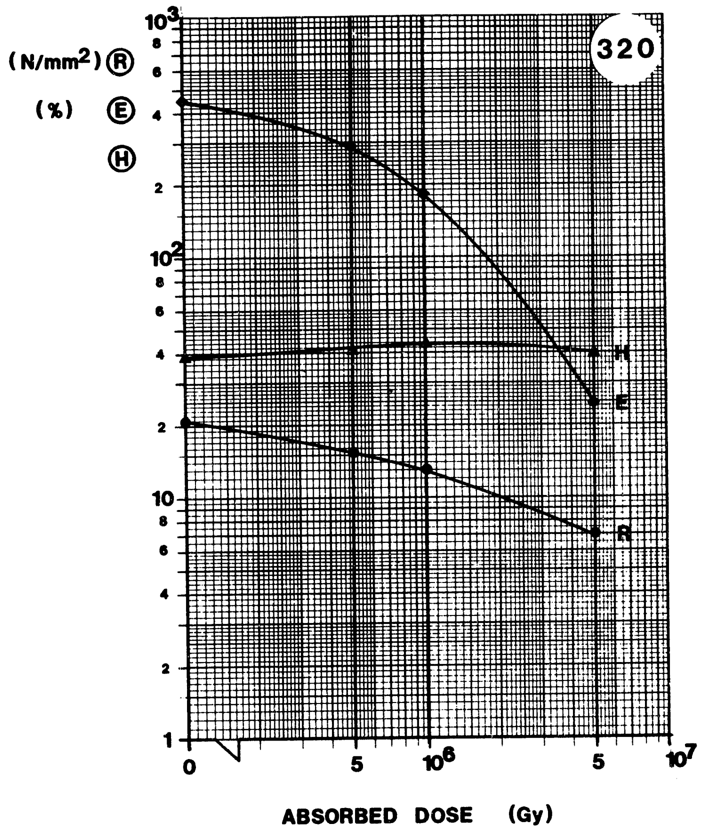
MATERIAL: XLPE

TYPE: Insulator

SUPPLIER: Dätwyler

Remarks:

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	15.7	N/mm2
E	Elong. at break	249	%
H	Hardness	49	Shore D
	Oxygen index	24	



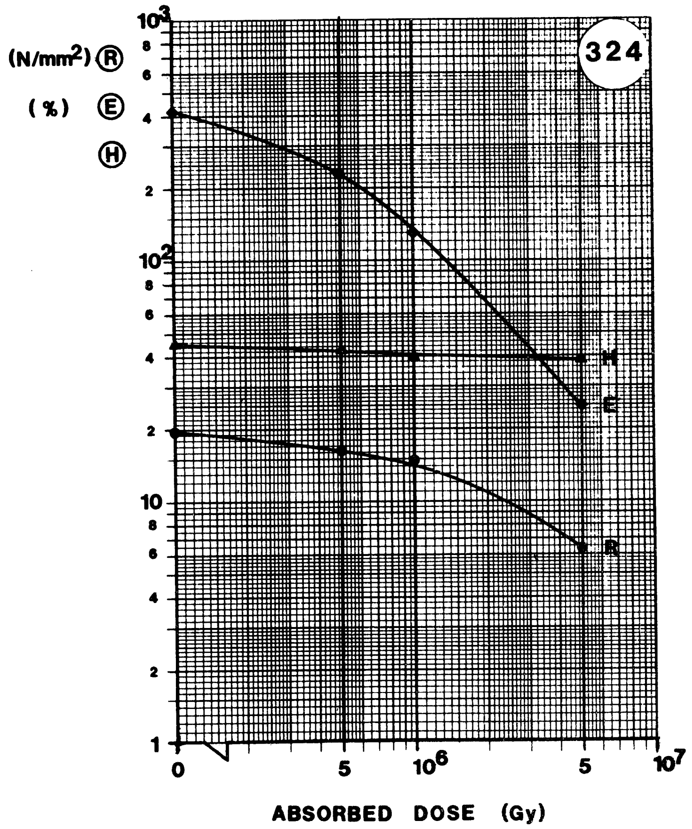
MATERIAL: XLPE

TYPE: Insulator

SUPPLIER: BICC

Remarks:

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	20.8	N/mm^2
E	Elong. at break	450	%
H	Hardness	39	Shore D
	Oxygen index	19.0	



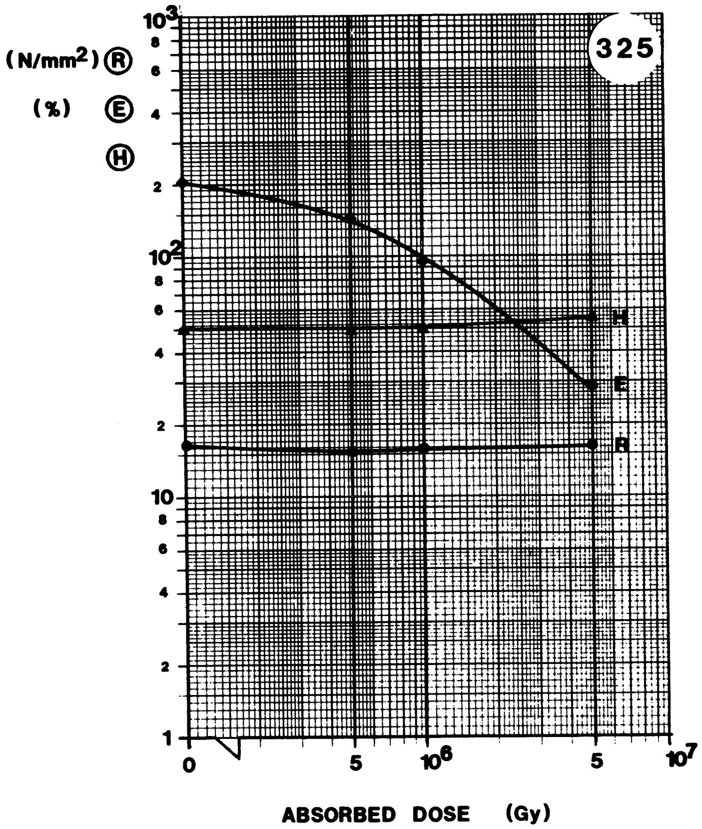
MATERIAL: XLPE

TYPE:

SUPPLIER: Sieverts

Remarks:

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	19.6	N/mm^2
E	Elong. at break	420	%
H	Hardness	45	Shore D
	Oxygen index	19	



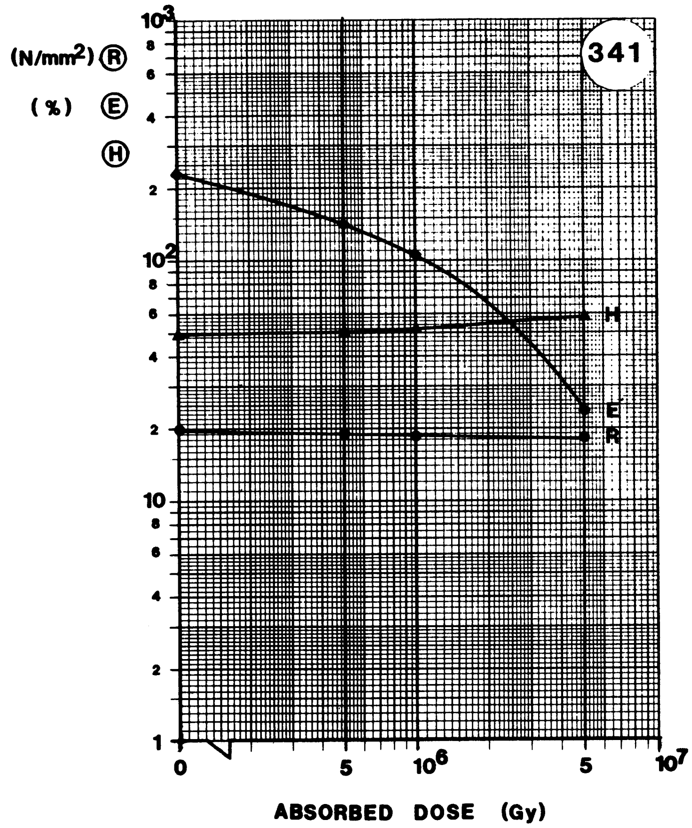
MATERIAL: XLPE

TYPE: SPECIAL GRADE

SUPPLIER: SIEVERTS

Remarks:

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	16.7	N/mm^2
E	Elong. at break	205	%
H	Hardness	51	Shore D
	Oxygen index	22.5	



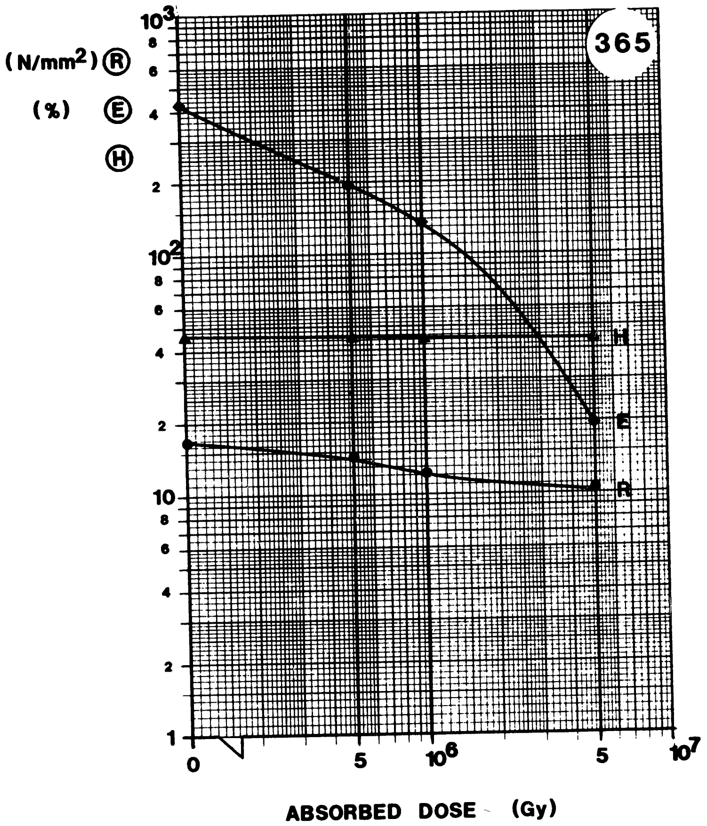
MATERIAL: XLPE

TYPE: XLPE/ INSULATOR WITHOUT HALOGEN

SUPPLIER: DÄTWYLER

Remarks:

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	19.6	N/mm^2
E	Elong. at break	230	%
H	Hardness	49.5	Shore D
	Oxygen index	25.0	



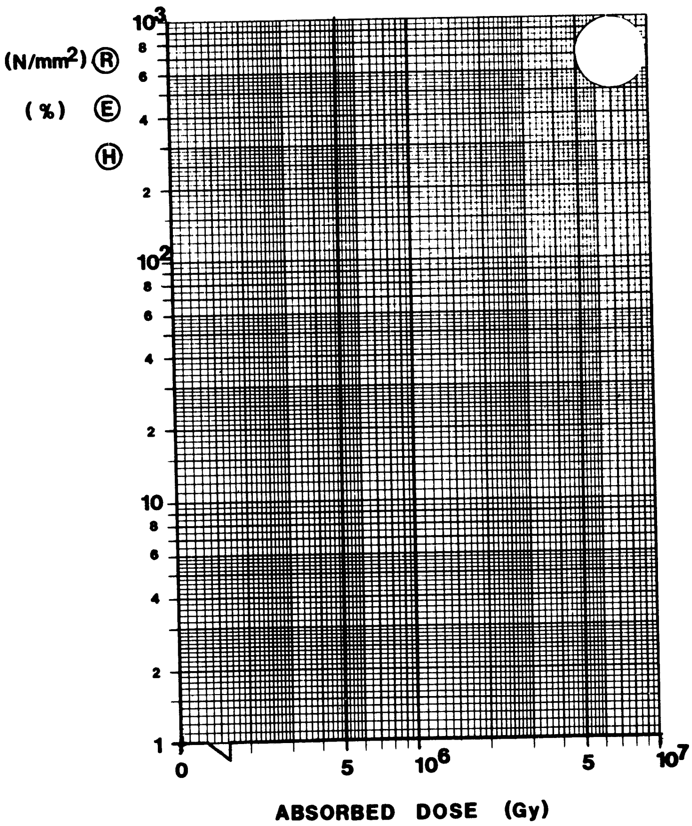
MATERIAL: XLPE

TYPE: Insulator

SUPPLIER: Sieverts

Remarks:

CURVE	PROPERTY	INITIAL VALUE	
R	Tensile strength	17.0	N/mm^2
E	Elong. at break	423	%
H	Hardness	46	Shore D
	Oxygen index	-	



MATERIAL:

TYPE:

SUPPLIER:

Remarks:

CURVE	PROPERTY	INITIAL VALUE
R	Tensile strength	N/mm^2
E	Elong. at break	%
H	Hardness	Shore C,D
	Oxygen index	