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RADIATION DAMAGE OF MATERIALS: PART I - A GUIDE
TO THE USE OF PLASTICS. ENGINEERING HANDBOOK

M.H. Van de Voorde, et al.

11 November 1966

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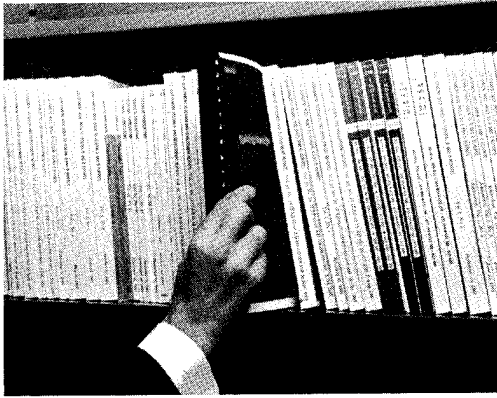
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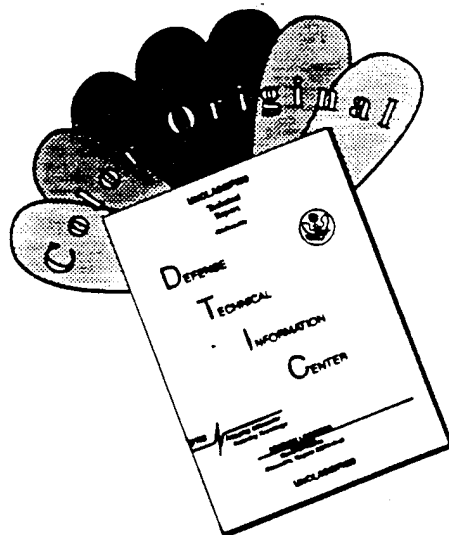
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RADIATION DAMAGE OF MATERIALS

ENGINEERING HANDBOOK

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M.H. Van de Voorde

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G. Pluym

PART I: A Guide to the Use of Plastics

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INTRODUCTION

The aim of design engineering is to select a material which will perform reliably under the most adverse conditions. A specific example of this is the growing need for materials which perform satisfactorily in radiation fields.

Plastics occupy a role of major significance in nuclear technology. They rank with metals and ceramics as the principal category of materials used in the construction of components in this field. Of all materials, organic materials are amongst those most sensitive to the effects of radiation.

The aim of this report is, therefore, twofold:

1. to give the general (mechanical, electrical, physical) properties of commercial plastics, and
2. to report the degeneration of these properties under nuclear radiation.

Thus, by cross reference, a guide is provided for the selection of plastics which has to fulfill specific requirements, even when subjected to high doses of absorbed radiation.

This engineering guide has shown itself to be all the more needed as data on radiation damage is scattered throughout - often not generally available - literature, measured under different conditions of irradiations, and thus often controversial in result. In reporting the data compiled in this report, exposures received by the various materials have, therefore, been expressed in a single unit of absorbed dose, the rad (= 100 ergs/gram). None of the data was taken during irradiation, only permanent effects have been reported.

RADIATION FIELDS AND CONVERSION FACTORS

Much of the published work on radiation effects on polymers is based on experiments carried out in the Oak Ridge reactor at

Tennessee and the BEPO reactor at Harwell. The pile unit employed at Oak Ridge corresponds to a neutron flux of 10^{18} thermal neutrons per cm^2 , whereas at Harwell one pile unit is 10^{17} slow n/cm^2 . The conversion factor from pile units to rads depends primarily on the elements present in the test specimen:

$$\begin{aligned} 10^{18} \text{ nvt} &= 10^9 \text{ rad for polyethylene} \\ 10^{18} \text{ nvt} &= 2.5 \times 10^9 \text{ rad for polyvinylchloride} \\ 10^{18} \text{ nvt} &= 7 \times 10^8 \text{ rad for polymethyl-methacrylate (1)} \end{aligned}$$

Electron irradiations are mostly done with a Van de Graaff generator. The total energy being delivered by the beam can be measured directly with a Faraday cup.

EXPLANATION OF TABLES AND FIGURES

A. Without Irradiation Effects

Tables 1 through 5 represent the physical, mechanical, electrical and thermal properties of:

- thermoplastic moulding materials
- thermoplastic sheet materials
- thermoplastic films
- thermosetting moulding materials, and
- thermoset laminated sheets respectively.

Although the diversity of plastics is enormous, the choice for a given application will lie within a narrow band of the plastics spectrum. Within this band, however, there may be several plastics which approximate the needed requirements. Selecting the best one requires comparing the properties of each plastic. Tables 6 through 8 are a selection guide based on types of applications.

B. Irradiation Effects

Figures 1 and 2 show the relative radiation resistances of the most used thermoplastic and thermosetting resins.

The most evident and, from an engineering viewpoint, most important changes which occur in polymers under irradiation affect their mechanical properties. These changes for commercial plastics are shown in figs. 3 through 30 and table 2 for thermoplastics, and in figs 31 through 43 and table 10 for thermosettings.

The effect of nuclear radiation on volume resistivity, dielectric strength and arc resistance is given in table 11 for thermoplastics and in table 12 for thermosetting resins. The materials used are grouped in a logical order, firstly chemical composition, then by trade names. The exact composition of commercial products is often not known precisely, or even the composition may have changed, whereas the trade name remains.

Table 13 groups data on dielectric constant and dissipation factor of commercial plastics resistant to an absorbed dose of 10^9 rads.

(All tests were carried out according to ASTM norms.)

Values for the total gas evolved from irradiated samples of 0.2 to 0.5 gramme weight are listed in tables 14 and 15 for thermoplastics and thermosettings respectively. In general, the quantity of gas is proportional to the dosage, so extrapolation of the table to other doses is possible. The effects of oxygen and temperature are very important. The yields presented in the tables are for room temperature and in vacuum. Plastics containing only carbon and hydrogen atoms will primarily give off hydrogen during irradiation. Those containing oxygen, chlorine or fluorine will also give oxygen, chlorine and fluorine components.

The influence of fillers on the radiation resistance of some commercial plastics is shown in tables 16, 17 and 18 and figure 44. It can be concluded that the stability of the filled plastic is proportional to the radiation quality of the filler used.

Radiation stability of plastics at temperatures above the usual service temperature (-75° C.) are listed in tables 19 and 20 for thermoplastics and thermosettings. It can be seen that for high temperature applications only mineral filled plastics can be considered. Recommendable resins are phenolics, melamine formaldehyde and epoxies.

At cryogenic temperatures, epoxies have the highest mechanical properties, with phenolics and polyesters following in that order.

Most plastics are known by their trade names, two lists of which are added to this guide; one with the trade-names and one with the chemical composition in alphabetical order.

Table 1. Thermoplastic moulding materials (General bibliography 2 1951)

PROPERTY	Cellulosics						Polyamides						Poly- sulfones
	Cellulose Acetate	Cellulose Acetate Butyrate	Cellulose Acetate Propionate	Cellulose Nitrate	Ethyl Cellulose	Nylon 6'6	Nylon 6'10	Nylon 6	Nylon 11	Poly- alomers			
Specific gravity g/cm ³	1,2 - 1,4	1,15 - 1,25	1,18 - 1,24	1,35 - 1,7	1,12 - 1,2	1,09 - 1,16	1,09	1,13 - 1,14	1,04 - 1,05	0,902	1,1		
Water absorption %	0,65 - 6,0	0,5 - 2,5	1,2 - 2,8	0,6 - 2,0	0,5 - 1,5	0,8 - 1,5	0,3 - 0,4	1,9 - 6,2	0,2	< 0,01	-		
Tensile strength lb/sq. in.	500 - 13.400	2.500-7.500	1.900-7.900	5.000-10.000	6.000-9.000	7.000-11.500	8.100-8.500	5.200-37.000	5.000-8.500	2.900 - 4.200	10.200		
Impact strength ft lb (zod per inch of notch)	0,2 - 9,9	0,5 - 6,5	0,5 - 11,0	4,0 - 8,0	2,0 - 8,5	1,0 - 4,0	1,3 - 4,0	0,62 - 6,0	7,5	1,5 - 12	1,5		
Modulus of elasticity 10 ⁵ lb/sq. in.	0,4 - 3,0	0,5 - 2,5	0,6 - 2,15	1,5 - 4,0	1,0 - 5,0	1,8 - 4,3	3,0	0,54 - 4,7	1,8	1 - 1,7	3,6		
Elongation %	10 - 78	8 - 88	30 - 100	10 - 82	5 - 40	80 - 150	100 - 250	10 - 470	30 - 300	400 - 500	50 - 100		
Flexural strength lb/sq. in	1.500-16.000	2.000-9.250	3.000-10.550	2.800-13.000	4.000-12.000	8.000-14.800	9.900	5.000-21.000	-	6.000 - 8.000	-		
Volume resistivity ohms - cm	10 ¹⁰ - 10 ¹³	10 ¹⁰ - 10 ¹³	10 ¹² - 10 ¹⁶	10 ¹⁰ - 10 ¹³	10 ¹² - 10 ¹⁵	10 ¹⁰ - 10 ¹⁴	10 ¹⁴	10 ¹¹ - 10 ¹⁵	10 ¹¹ 9 x 10 ¹³	> 10 ¹⁵	5.10 ¹⁶		
Surface resistivity ohms	4 x 10 ¹¹	10 ¹³	-	-	-	9 x 10 ¹¹	9 x 10 ¹¹	2 x 10 ¹¹ - 10 ¹⁴	10 ¹² 2 x 10 ¹⁴	> 10 ¹⁵	3.10 ¹⁶		
Electric strength volts / mil	150-1.250	250 - 540	300 - 1.500	150 - 1.200	800 - 1.500	270 - 470	270 - 470	300 - 510	225- 420	850	-		
Power factor 60 cycles/sec	0,01 - 0,2	0,01 - 0,04	0,01 - 0,04	0,03 - 0,15	0,007	0,01 - 0,09	0,02	0,011	-	10 ² e/s	0,0008-0,009		
10 ⁶ cycles/sec	0,01 - 0,1	0,01 - 0,05	0,01 - 0,04	0,07 - 0,1	0,007-0,05	0,02 - 0,08	0,05	0,04 - 0,13	0,02 - 0,05	0,000.4	0,005 - 0,0096		
60 cycles/sec	3,5 - 7,5	3,5 - 6,4	10 ² e/s 3,7 - 4,0	6,0 - 8,0	2,7	3,9 - 7,6	3,6 - 3,9	3,4	-	10 ² e/s 2,5	2,8 - 3,4		
Dielectric constant 10 ⁶ cycles/sec	3,2 - 7,2	3,2 - 6,2	3,0 - 3,7	6,0	2,0 - 3,0	3,4 - 3,6	3,5	4,0 - 6,5	3,2 - 3,3	-	2,7 - 3,3		
Softening point °C	51 - 115	58 - 94	50 - 120	49 - 71	49 - 66	250 - 264	220	210 - 220	180 - 300	150 - 240	160		

Table 1. Thermoplastic moulding materials

PROPERTY	Polythene		Polypropylene	P. T. F. E.	P. C. T. F. E.	Styrene polymers			Styrene/ Acrylonitrile	Polycarbonate	Polyphenylene oxides
	Low density	High density				Gen purposes	Toughened	ABS Co-polymers			
Specific gravity g/cm ³	0,91 - 0,93	0,936 - 0,96	0,90 - 0,91	2,1 - 2,3	2,1 - 2,3	1,04 - 1,07	1,04 - 1,07	1,01 - 1,07	1,07 - 1,1	1,2	1,06
Water absorption %	< 0,01	< 0,01	< 0,03	0,005	0,00	0,03 - 0,04	0,03 - 0,3	0,57	0,15 - 0,3	0,2 - 0,4	0,10 27 days
Tensile strength lb/sq in.	900 - 2.300	1.700-5.500	4.000-6.000	1.500-3.000	5.700-7.500	5.000-7.500	3.000-6.500	4.300-8.000	8.000-12.000	9.000-9.500	9.500-10.500
Impact strength ft lb (Izod per inch of notch)	> 16	1,0 - 20,0	0,5 - 4,0	> 3,0	1,2 - 3,6	0,18 - 0,6	0,4 - 3,0	1,5 - 10,0	0,25 - 0,7	2 - 2,5	1,5 - 1,9
Modulus of elasticity 10 ⁵ lb/sq. in.	0,13 - 0,33	0,5 - 10,3	1,3 - 1,7	0,58	1,05	1,5 - 5,0	2,5 - 5,5	2,5 - 3,5	4,0 - 6,0	3,1 - 3,5	3,7
Elongation %	125 - 800	20 - 600	220 - 900	100	35 - 190	1,0 - 3,6	10 - 40	15 - 30	2,0 - 4,0	60 - 100	80
Flexural strength lb/sq. in.	no fracture	2.000-3.000	6.500-7.500	no fracture	7.110-8.250	9.000-13.000	7.000-17.000	8.000-13.500	11.500-19.000	11.000-13.000	14.500
Volume resistivity ohms - cm	3 x 10 ¹⁶ -10 ²⁰	> 3 x 10 ¹⁶	3 x 10 ¹⁵ - 5 x 10 ¹⁶	10 ¹⁷ -10 ²⁰	10 ¹⁸	10 ¹⁷ -10 ²¹	10 ¹² -10 ¹⁷	> 10 ¹⁵	7 x 10 ¹⁵	10 ¹⁵ - 2,1 x 10 ¹⁶	10 ¹⁷
Surface resistivity ohms	> 4 x 10 ¹⁴	10 ¹² -10 ¹⁷	> 10 ¹⁵	3,6 x 10 ¹²	10 ¹² - 10 ¹³	7 x 10 ¹⁷	7 x 10 ¹⁷	> 10 ¹⁴	7 x 10 ¹⁷	6 x 10 ¹² - 8 x 10 ¹²	--
Electric strength volts / mil	440 - 1000	400 - 1.200	600 - 800	500	625	500 - 700	300 - 650	312 - 396	400 - 550	370 - 600	400 - 500
Power factor 60 cycles/sec	< 0,005	0,0001	0,0005	0,0002	0,002 -0,0025	0,0002	0,0009	0,004-0,016	0,004-0,006	0,0007 - 0,0009	0,00035 - 0,0009
Dielectric constant 10 ⁶ cycles/sec	0,0002-0,002	> 0,0001	0,0002-0,0003	0,0002	0,005-0,0085	0,0005	0,00012 - 0,002	0,007-0,03	0,001-0,01	0,01	
60 cycles/sec	2,2 - 2,3	2,3	2,2	2,0	2,3 - 2,4	2,5 - 2,65	2,45 - 4,75	2,76 - 4,76	2,9 - 3,4	2,95 - 3,3	2,58
10 ⁶ cycles/sec	2,3 - 2,35	2,3 - 2,35	2,0 - 2,15	2,0	2,1 - 2,5	2,5 - 2,65	2,4 - 4,0	2,44 - 3,78	2,8 - 3,1	2,9 - 3,0	2,58
Softening point °C	83 - 111	111 - 131	130 - 170	300 - 330	250 - 300	86 - 95	78 - 103	93 - 95	85 - 103	220 - 250	~ 250

Table 1. Thermoplastic moulding materials

PROPERTY	Polymethyl Methacrylate		Polyvinyl Chloride		Acetals	Phenoxics	Polyvinyl butyral	Polyvinyl formal
	Cast	Moulded	Rigid	Flexible				
Specific gravity g/cm ³	1,19	1,19	1,35 - 1,60	1,14 - 1,45	1,14 - 1,42	1,182	1,08 - 1,12	1,20 - 1,25
Water absorption %	0,18 - 0,4	0,3 - 0,4	0,07 - 0,4	0,1 - 0,75	0,12 - 0,4	0,13	0,3 - 0,6	1,0 - 1,5
Tensile strength lb/sq. in.	8,000-10,000	8,000-11,500	4,000-9,000	1,000-3,500	8,000-10,000	9,500	4,000 - 8,500	9,000 - 11,000
Impact strength ft lb (Izod per inch of notch)	0,25 - 0,35	0,25 - 0,4	0,5 - 15	not applicable	1,2 - 2,3	2 - 5	1,2	0,4 - 2,0
Modulus of elasticity 10 ⁵ lb/sq. in.	3,9 - 4,4	3,8 - 4,5	4,1 - 5,0	0,002-0,02	1,76	3,8	3,5 - 4	5 - 7
Elongation %	2 - 7	3 - 10	1 - 40	50 - 500	15 - 17	90	5 - 60	5 - 60
Flexural strength lb/sq. in.	12,000-17,000	13,000-17,000	10,000-16,000	not applicable	13,000-14,100	14,000	10,000	15,000 - 18,000
Volume resistivity ohms - cm	>10 ¹⁵	>10 ¹⁵	5 x 10 ¹⁴ - 1 x 10 ¹⁵	5 x 10 ¹⁴ - 5 x 10 ¹⁴	1 x 10 ¹⁴ - 6 x 10 ¹⁴	5.10 ¹³	>10 ¹⁴	-
Surface resistivity ohms	>10 ¹⁴	>10 ¹⁴	10 ¹² - 10 ¹³	>10 ¹⁴	>2 x 10 ¹³	-	-	-
Electric strength volts / mil	300 - 390	240 - 310	500	250 - 750	500 - 1200	490	-	860 - 1,000
Power factor 60 cycles/sec	0,05 - 0,08	0,04 - 0,06	0,007 - 0,02	0,07 - 0,35	---	0,0012	0,007	0,007
10 ⁶ cycles/sec	0,02	0,02 - 0,03	0,006 - 0,05	10 ² C/S	10 ² - 10 ⁵ C/S	0,03	0,0065	-
Dielectric constant 60 cycles/sec	2,7 - 2,9	3,5 - 4,5	3,2 - 3,6	0,1 - 0,12 ^H	---	4,1	3,61	3,7
10 ⁶ cycles/sec	3,25 - 4,25	2,7 - 3,2	2,1 - 3,5	3,5 - 0,0	10 ² - 10 ⁵ C/S	3,8	3,33	3,0
Softening point °C	90 - 115	45 - 115	75 - 165	not applicable	163 - 170	150 - 175	115	150 - 165

Table 2. Thermoplastic sheet materials

PROPERTY	Cellulose Nitrate	Cellulose Acetate	Vinyl Chloride Polymers		Styrene Polymers		Polymethyl Methacrylate	Polythene		Polypropylene	Casein
			Rigid	Flexible	Toughened	ABS Copolymers		Low density	High density		
Specific gravity g/cm ³	1.35 - 1.8	1.2 - 1.6	1.3 - 1.6	1.2 - 1.6	1.04 - 1.11	1.01 - 1.10	1.19	0.91 - 0.93	0.936 - 0.96	0.90 - 0.91	1.32 - 1.39
Thermal conductivity 10 ⁻⁴ cal/sec cm ² °C cm	3 - 5	5 - 8.5	3.5 - 4	3 - 4	1.9 - 2	4.64 - 6.3	3.5 - 5	7	10	3.3	-
Water absorption % 24 hr. immersion	1 - 3	0.7 - 3.5	0.015 - 0.15	0.5 - 0.75	0.03 - 0.5	0.1 - 0.57	0.3 - 0.4	< 0.01	< 0.01	< 0.03	3 - 7
Refractive index	1.5	1.5	1.52 - 1.54	-	not applicable	not applicable	1.49 - 1.495	1.52	1.54	-	not applicable
Tensile strength lb/sq. in.	3,000-8,000	2,800-7,050	6,000-10,000	2,800-9,000	3,200-4,000	4,800-7,500	6,900-10,800	1,500	3,000	4,000-4,200	4,500-10,000
Elongation %	20 - 40	25 - 44	4	230 - 500	10 - 40	100	2 - 7	450	625	350 - 600	-
Impact strength ft lb (ized per inch of notch)	4 - 8	2 - 7	0.2 - 0.7	not applicable	0.4 - 2	3.5 - 10.0	0.23 - 0.25	> 3	1.0 - 20.0	0.5 - 4.0	1.0 - 1.5
Brinell hardness	8 - 20	6 - 13	12 - 20	not applicable	-	R 90 - 105	18 - 29	175 D 47 - 55 Shore	D 60 - 70 Shore	R 77 - 88	23
Flexural strength lb/sq. in.	9,000-11,000	1,000-7,000	10,000-14,000	not applicable	7,000-17,000	6,400-11,500	12,000-17,000	no fracture	2,000-3,000	6,000-9,000	-
Modulus of elasticity 10 ⁹ lb/sq. in.	1.9 - 2	1.5 - 2.5	3.5 - 6	0,008 - 0.02	3.3 - 3.8	2.1	(3.9 - 4.82) x 10 ⁵	(0.13-0.33) x 10 ⁵	(0.5 - 10.3) x 10 ⁵	(1.3-1.7) x 10 ⁵	5.5 x 10 ⁵
Compressive strength lb/sq. in.	22,000-35,000	4,000-25,000	9,900-11,300	-	12,000-16,000	7,000-11,000	12,000-18,000	-	-	3,460	-
Shear strength lb/sq. in.	-	-	6,500-17,000	-	-	-	8,500-10,000	1,400-1,800	-	-	-
Volume resistivity ohms-cm	10 ¹⁰ -10 ¹²	1.3 x 10 ¹⁰ -5.5 x 10 ¹²	10 ¹⁴ - 10 ¹⁶	10 ¹² - 10 ¹⁴	10 ¹² - 10 ¹⁷	> 10 ¹⁵	> 10 ¹⁵	3 x 10 ¹⁶ -10 ²⁰	3 x 10 ¹⁶ -10 ¹⁸	3 x 10 ¹⁵ - 5 x 10 ¹⁶	5.8 x 10 ⁹ - 11 x 10 ⁹
Surface resistivity ohms	3 x 10 ¹⁰ - 3 x 10 ¹²	4 x 10 ¹¹ - 6.5 x 10 ¹²	10 ¹³ - 10 ¹⁵	> 10 ¹⁴	> 10 ¹⁵	> 10 ¹⁴	> 10 ¹⁴	> 4 x 10 ¹⁴	10 ¹² - 10 ¹⁷	> 10 ¹⁵	3.2 x 10 ¹⁰ - 8 x 10 ¹⁰
Electric strength	150 - 600	325 - 800	350 - 650	550	300 - 650	312	250 - 390	440 - 1,000	510 - 1,200	750 - 1,000	216 - 700
Power factor	50 - 10 ⁶ c/s	50 - 10 ⁶ c/s	50 - 10 ⁶ c/s	50 - 10 ⁶ c/s	10 ⁶ c/s	10 ⁶ c/s	10 ⁶ c/s	10 ⁶ c/s	10 ⁶ c/s	10 ⁶ c/s	10 ⁶ c/s
Dielectric constant	0.03 - 0.06	0.02 - 0.06	0.001-0.05	0.05 - 1.5	6,009-0,0012	0,007-0,012	0,02 - 0,05	0,00025	0,0001-0,001	0,0002-0,0003	0,052-0,06
	50-10 ⁶ c/s	60 c/s	50 - 10 ⁶ c/s	10 ⁶ c/s	60-10 ⁶ c/s	10 ⁶ c/s	10 ³ - 10 ⁶ c/s	10 ⁶ c/s	10 ⁶ c/s	10 ⁶ c/s	10 ⁶ c/s
	6 - 8	4 - 1.4	3 - 4	3.5 - 8.6	2.4 - 4.75	2.59 - 3.78	2.8 - 3.5	2.2 - 2.3	2.3 - 2.35	2.0 - 2.2	6.1 - 6.8

Table 3. Thermoplastic films

PROPERTY	Cellulose Acetate	Cellulose Acetate Butyrate	Cellulose Triacetate	Ethyl Cellulose	Polycarbonate	Polythene		Polypropylene	Nylon	Polyethylene Terephthalate	Polyimides
						Low density	High density				
Specific gravity g/cm ³	1,25 - 1,43	1,16 - 1,25	1,27 - 1,31	1,095 - 1,16	1,2	0,91 - 0,93	0,936 - 0,96	0,90 - 0,91	1,04 - 1,14	1,38 - 1,39	1,42
Water absorption % 24 hr. immersion	3,6 - 6,8	0,1 - 3,4	3,5 - 4,5	2,5 - 7,5	0,2 - 0,6	negligible	negligible	negligible	< 3,3	> 0,5	1,3
Moisture vapour permeability g/m ² / 24 hr / mil thickness	55 - 634	177 - 935	155 - 237	155 - 780	—	18 - 21	3,8	9,5	0,5 - 800	1,9 - 28	0,2 - 2
Tensile strength lb/sq. in.	5.400-14.000	4.100-9.700	9.000-16.000	6.000-10.600	6.400-20.000	1.500-4.000	3.400-4.500	3.000-6.500	9.000	17.000-25.800	37.000
Tear strength Elmendorf g/mil	2 - 25	3 - 16	4 - 6	2 - 36	10 - 16	120 - 300	16 - 60	40 - 80	50 - 70	2 - 40	8 - 40
Elongation %	15 - 45	20 - 100	10 - 40	20 - 80	50 - 120	100 - 800	70 - 400	100 - 1.000	250 - 450	35 - 130	70 - 100
Volume resistivity ohms-cm	10 ¹⁰ - 10 ¹²	10 ¹⁴	6 x 10 ¹³ - 5 x 10 ¹⁴	10 ¹² - 10 ¹⁵	8 x 10 ¹⁵ - 3 x 10 ¹⁶	3 x 10 ¹⁶ - 10 ²⁰	3 x 10 ¹⁶ - 10 ¹⁸	3 x 10 ¹⁵ - 5 x 10 ¹⁶	10 ¹⁰ - 10 ¹³	10 ¹⁷ - 10 ¹⁹	10 ¹⁸
Surface resistivity ohms	4 x 10 ¹¹	> 10 ¹⁴	—	—	6 x 10 ¹² - 8 x 10 ¹²	> 4 x 10 ¹⁴	10 ¹² - 10 ¹⁷	> 10 ¹⁵	> 10 ¹¹	—	10 ¹⁶ at 1 kv, 50% RH
Electric strength volts / mil	1.700-2.800	2.250-2.300	2.250-2.800	800-1.500	3.000-3.950	440-1.000	510-1.200	750-1.000	210 - 290	4.000	7.000
Power factor	50 c/s 0,013-0,02	8 x 10 ² c/s 0,012-0,024	8 x 10 ² c/s 0,019	60 c/s 0,007 10 ⁶ c/s 0,007-0,03	50 c/s 0,0009-0,0025 10 ⁶ c/s 0,0017-0,0095	10 ⁶ c/s 0,00025	10 ⁶ c/s 0,0001-0,002	10 ⁶ c/s 0,0002-0,0025	50 c/s 0,06-0,1 10 ⁶ c/s 0,004-0,13	32 - 32 x 10 ³ c/s 0,005	10 ³ c/s 0,003
Dielectric constant	50 c/s 4,9	8 x 10 ² c/s 3,5 - 4,1	8 x 10 ² c/s 3,9	60 c/s 2,7 10 ⁶ c/s 2,0 - 3,0	50 c/s 3,0 - 3,1 10 ⁶ c/s 2,0 - 2,98	10 ⁶ c/s 2,2 - 2,3	10 ⁶ c/s 2,3 - 2,35	10 ⁶ c/s 2,0 - 2,2	50 c/s 6,7 - 14 10 ⁶ c/s 4 - 6,7	32 - 32 x 10 ³ c/s 2,9 - 3,2	10 ³ c/s 3,5
Softening heat sealing temperature °C	140 - 260	60 - 121	—	99 - 132	220 - 250	115 - 120	135 - 191	169 - 170	190	230 - 250	280

Table 3. Thermoplastic films

PROPERTY	Vinyl Chloride Copolymers		Polyvinylidene Chloride	Rubber Hydrochloride	Polyvinyl Alcohol	Polystyrene	Parylenes	Fluorocarbon	
	Rigid	Flexible						CTFE	PVF
Specific gravity g/cm ³	1,3 - 1,5	1,15 - 1,5	1,60	1,11 - 1,15	1,21 - 1,32	1,05 - 1,07	1,1 - 1,3	2,1	1,5
Water absorption % 24 hr immersion	negligible	negligible	negligible	5 - 7	30 - 90	< 0,06	-	< 0,05	0,05
Moisture vapour permeability g/m ² / 24 hr / mil thickness	3,9 - 79	9,0 - 125	1 - 4	0,25 - 242	> 155	20 - 97	-	-	-
Tensile strength lb/sq. in.	5,500-10.000	1.000-5.600	7.000-15.000	3.500-6.000	3.000-10.000	7.000-12.100	9.000-13.000	5.000-8.000	7.000-18.000
Tear strength Elmendorf g/mil	10 - 700	13 - 1.400	30	60 - 1.600	55 - 800	2 - 8	-	10 - 26	12 - 100
Elongation %	2 - 25	50 - 500	20 - 40	200 - 800	200 - 800	3 - 10	200	30 - 150	135 - 250
Volume resistivity ohms-cm	5×10^{14} - 1×10^{15}	5×10^8 - 5×10^{14}	10^{12} - 10^{16}	$1,5 \times 10^{13}$	-	10^{17} - 10^{19}	$9,10^{16}$ - $2,10^{17}$	> 10^{18}	> 10^{18}
Surface resistivity ohms	10^{12} - 10^{13}	> 10^{14}	-	-	2×10^6	10^{14}	-	-	-
Electric strength volts / mil	3.500	1.400-2.900	3.000-5.000	-	-	3.000-4.000	3.700 - 6.500	-	-
Power factor	0×10^2 c/s 0,05	8×10^2 c/s 0,07 - 0,55	50 c/s 0,03 - 0,45	50 c/s 0,005	-	$60 - 10^9$ c/s 0,0003- 0,0005	$60 - 10^6$ c/s 0,000,2 - 0,000,6	-	-
Dielectric constant	10^3 c/s 3,0 - 3,5	10^3 c/s 4,5 - 6	50 c/s 4,5 - 6 10^6 c/s 3,0 - 5	10^7 c/s 3,51	10^3 c/s > 3	$60 - 10^9$ c/s 2,6 - 2,7	$60 - 10^6$ c/s 2,65	$60 - 10^6$ c/s 2,1	$160 - 10^6$ c/s 2,1
Softening heat sealing temperature °C	127 - 204	93 - 204	140	107 - 177	149 - 204	104 - 149	570 - 790 Melting point	300 - 350	225

Table 4. Thermosetting moulding materials

PROPERTY	Phenolics							Epoxy			% urethane
	Wood flour	Asbestos	Fibre and fabric	Mineral	Nylon	No filler cast resin	Glass	No filler cast resin			
Specific gravity g/cm ³	1,32 - 1,39	1,29 - 1,51	1,32 - 1,44	1,46 - 1,90	1,16 - 1,54	1,30 - 1,32	2,00 - 2,10	1,19 - 1,23	1,21		
Water absorption %	3,0 - 8,0	0,7 - 1,2	0,5 - 1,6	0,04 - 0,25	0,25 - 0,4	0,3 - 0,4	0,02 - 0,08	0,07 - 0,14	0,3 - 0,9		
Tensile strength lb/sq. in.	4.500-12.000	5.500-9.000	4.500-9.000	2.000-8.500	4.500-9.000	2.000-9.000	6.000-10.000	8.000-12.000	6.400-8.600		
Impact strength ft lb (load per inch of notch)	1,0 - 1,8	0,20 - 0,52	0,38 - 6,60	0,18 - 0,72	0,26 - 0,52	0,50 - 0,80	5,0 - 8,0	0,72 - 1,38	> 1,0		
Modulus of elasticity 10 ⁶ lb/sq. in.	0,55-0,60	0,7 - 2,0	0,8 - 1,4	1,35 - 3,0	0,4 - 2,0	0,2 - 0,45	2,0 - 2,5	0,14 - 0,66	0,47 - 1,2		
Crushing strength lb/sq. in	27.000-58.000	20.000-40.000	20.000-42.000	14.000-25.000	15.000-40.000	6.700-15.000	20.000-25.000	13.000-18.500	-		
Flexural strength lb/sq. in	10.000 - 18.000	8.500-13.500	7.000-16.000	8.000-12.000	6.000-13.000	12.000 - 15.000	13.000 - 19.000	10.000 - 18.500	-		
Volume resistivity ohms - cm	5,8 x 10 ⁹ - 11,0 x 10 ⁹	10 ⁹ - 10 ¹³	10 ⁸ - 10 ¹³	10 ¹⁰ - 10 ¹⁴	10 ¹¹ - 10 ¹⁴	2,5 x 10 ¹⁰ - 10 ¹²	> 10 ¹⁴	5,9 x 10 ¹⁴ - 9,7 x 10 ¹⁴	6 x 10 ¹² - 10 ¹⁴		
Surface resistivity ohms	3,2 x 10 ¹⁰ - 8,0 x 10 ¹⁰	10 ⁸ - 5 x 10 ¹³	5 x 10 ⁷ - 10 ¹²	10 ¹⁰ - 10 ¹⁴	10 ¹¹ - 10 ¹⁴	10 ¹⁰ - 5 x 10 ¹⁰	> 10 ¹⁴	3,8 x 10 ⁷ - > 10 ¹⁴	6 x 10 ¹³ - 3 x 10 ¹³		
Electric strength volts / mil	216 - 700	15 - 250	10 - 180	75 - 400	30 - 275	250 - 400	250 - 350	36 - 300	500		
Power factor at 10 ⁶ cycles/sec	0,052-0,06	0,015-0,06	0,03 - 0,25	0,007-0,08	0,15 - 0,2	0,04 - 0,05	0,010-0,020	0,015-0,048	0,03 - 0,038		
Dielectric constant at 10 ⁶ cycles / sec	6,1 - 6,8	3,9 - 6,5	4,0 - 7,0	4,0 - 6,0	3,7 - 4,5	10 ³ C/S	4,0 - 5,5	3,3 - 6,2	3,3 - 3,8		
Softening point °C		149 - 200	149 - 170	121 - 149	140 - 160	116 - 127	140 - 200	122 - 208	150 - 165		

Table 4. Thermosetting moulding materials

PROPERTY	Silicones				Amines				Polyesters or alkyds					
	Glass	Ureas		Melamines		Mineral	α -cellulose	Mineral	Mineral	Glass filled	No filler coat resin			
		Wood flour	α -cellulose	Cellulose	Cellulose							α -cellulose	Mineral	Mineral
Specific gravity g/cm ³	1.80 - 1.90	1.50 - 1.60	1.50 - 1.60	1.50 - 1.60	1.80	1.35 - 1.40	1.70 - 2.23	1.2 - 2.0	1.20 - 1.40					
Water absorption %	0.16	0.7	0.4 - 0.8	0.3 - 0.5	0.10 - 0.20	0.01 - 1.0	-	0.1 - 2	0.03 - 0.4					
Tensile strength lb/sq. in.	2.400-3.000	7.500-14.000	7.500-11.500	8.000-12.000	4.000-6.000	6.000-7.500	3.000-6.500	6.000-10.000	5.000-13.000					
Impact strength ft lb (zod per inch of notch)	0.6 - 4.5	0.16 - 0.33	0.18 - 0.34	0.15 - 0.25	0.12 - 0.22	0.34 - 0.44	0.12 - 0.70	7 - 10	0.38 - 2.0					
Modulus of elasticity 10 ⁶ lb/sq. in.		0.90 - 1.0	0.95 - 1.0	1.3	1.6	-	1.4 - 2.7	0.6 - 1.7	0.4 - 0.65					
Crushing strength lb/sq. in.	9,000-15,000	29,000-36,000	28,000-35,000	25,000-43,000	30,000	-	18,000-28,000	15,000-28,000	18,000-28,000					
Flexural strength, lb/sq. in.	12,000 - 16,000	11,800 - 19,000	11,800 - 17,000	10,000 - 21,000	6,000-11,000	10,000 - 12,000	2,500-9,000	12,000 - 21,000	6,500-13,000					
Volume resistivity ohms - cm	> 10 ¹²	5 x 10 ¹¹ - 10 ¹⁴	5 x 10 ¹¹ - 10 ¹⁴	> 10 ¹³	10 ¹³ - 10 ¹⁴	> 10 ¹⁴	> 10 ¹⁴	10 ¹² - 10 ¹⁵	2.7 x 10 ¹⁴ - 2 x 10 ¹⁵					
Surface resistivity ohms	-	10 ¹¹ - 10 ¹⁴	10 ¹¹ - 10 ¹⁴	10 ¹² - 10 ¹⁴	10 ¹² - 10 ¹⁴	10 ⁹ - > 10 ¹⁴	> 10 ¹¹	10 ¹⁰ - 10 ¹⁴	10 ¹³ - 9,14 ¹³					
Electric strength volts / mil	> 100	20 - 180	20 - 240	70 - 240	130 - 250	250 - 350	250 - 430	150 - 350	245 - 420					
Power factor at 10 ⁶ cycles/sec	0.004-0.0065	8 x 10 ² c/s 0.05-0.1	8 x 10 ² c/s 0.04 - 0.8	0.027-0.045	0.035-0.055	8 x 10 ² c/s 0.02 - 0.05	0.015-0.04	1.1 - 0.04	0.01 - 0.03					
Dielectric constant at 10 ⁶ cycles/sec	up to 5	8 x 10 ² c/s 8 - 10	8 x 10 ² c/s 7 - 9	7.2 - 8.2	4.7 - 7.0	3.5 - 5.5	4.5 - 7.0	4.5 - 6.0	3.0 - 4.01					
Softening point °C		70 - 60	70 - 60	100 - 100	140 - 150	-	149 - 177	149 - 177	121					

Table 5. Thermoset laminated sheets

PROPERTY	Phenolics						Aminos Metamine Glass Fabric	Polyesters		Silicones Glass Fabric	Epoxides Glass Fabric
	Paper	Fabric	Asbestos Fabric	Glass Mat	Glass Fabric	Glass Mat		Glass Fabric			
Specific gravity g/cm ³	1,3 - 1,4	1,3 - 1,4	1,63	1,4 - 1,7	1,7 - 1,8	1,5 - 1,6	1,7 - 1,8	1,5 - 1,6	1,7 - 2,1	1,7 - 1,9	1,7 - 1,8
Tensile strength lb/sq in	8.000-23.000	8.000-19.000	6.000-12.000	15.000-25.000	18.000-35.000	10.000-30.000	23.000-40.000	10.000-30.000	15.000-52.000	8.000-25.000	30.000-95.000
Flexural strength lb/sq in	14.000-30.000	16.000-30.000	12.000	25.000-40.000	18.000-45.000	17.000-21.000	15.000-32.000	27.000-60.000	11.000-35.000	42.000-100.000	
Shear strength lb/sq in	9.500-16.500	9.000-16.000	10.000	-	-	21.000	12.000	10.000-20.000	13.000-15.000	-	
Impact strength edgewise ft lb	0,14 - 1,6	0,65 - 4,0	15 - 24	12 - 20	7 - 12	5 - 10	10 - 20	6 - 20	5 - 12	5 - 10	12 - 18
Water absorption mgms (on specimen $\frac{1}{2} \times \frac{1}{2} \times \frac{1}{8}$ in)	5 - 260	15 - 135	25 - 190	40 - 100	55 - 165	15 - 120	< 85	< 100	11 - 45	5 - 10	
Insulation resistance 24 hr. in water ohms	$6 \times 10^6 - 9 \times 10^{11}$	$3 \times 10^6 - 6 \times 10^9$	$0,5 \times 10^6$	> 10	$5 \times 10^6 - > 10$	$2 \times 10^3 - 10^9$	$5 \times 10^5 - 10^6$	$5 \times 10^6 - 10^9$	$4,5 \times 10^9 - 2 \times 10^{10}$	$0,5 \times 10^6 - 3 \times 10^{10}$	
Insulation resistance 48 hr. at 75% R.H. ohms	$6 \times 10^9 - 2 \times 10^{12}$	-	-	> 4×10^{12}	$1,5 \times 10^{12} - 2 \times 10^{12}$	$1 \times 10^{12} - 2 \times 10^{12}$	$2 \times 10^{12} - 5 \times 10^{12}$	$2 \times 10^{12} - 5 \times 10^{12}$	10^{12}	-	
Electrical strength flatwise at 90°C volts/mil	70 - 1.000	25 - 200	10 - 15	-	100 - 450	120 - 500	200 - 250	135 - 350	130 - 450	300 - 500	
Electrical strength edgewise at 90°C volts/mil	15 - 50	4 - 14	1	-	-	32	37,3	-	35 - 40	40 - 45	
Power factor at 10 ⁶ cycles/sec	0,03 - 0,056	0,05 - 0,1	0,06 - 0,1	0,02 - 0,025	0,01-0,085	0,01 - 0,02	0,023	0,003 - 0,05	0,003 - 0,022	0,01 - 0,035	
Dielectric constant at 10 ⁶ cycles/sec	4 - 6	5,0 - 6,5	5,5 - 10,0	3,9 - 4,4	4,0 - 5,6	4,2 - 6,5	2,6	3,5 - 5,6	3,5 - 4,5	4,2 - 5,3	
Percentage yield under compression	1,2 - 4,0	1,6 - 2,5	2,4	-	-	-	1,35 - 2,0	0,73 - 1,7	-	-	
Recommended max working temperature °C	93 - 121	107 - 121	135	-	135 - 140	140 - 170	-	-	100 - 250	100 - 260	

PLASTICS SELECTION TABLES (GENERAL BIBLIOGRAPHY P 119)TABLE 6 : PLASTICS FOR MECHANICAL APPLICATIONSA. Heavily stressed mechanical components - Cams, Gears, Couplings, Racks, Rollers etc.Properties required

- High impact strength
- High tensile strength
- Good fatigue resistance
- Excellent machinability or mouldable to close tolerance
- Stability at elevated temperatures.

Types of plastics with particular application

Acetals are recommended for:

- maximum fatigue life
- highly accurate parts
- exposure to extremely humid and corrosive conditions.

Epoxies for ultimate high tensile applications.

Fluorocarbons (P.T.F.E. filled acetals) for duty applications.

Nylons for general purpose gears and other mechanical components.

Phenolics (fabric filled) for thin stamped gears or parts.

B. Materials for low friction applications - Bearings, Bushings, Guides, Impellers, Slides, Valve, Valve liners, Wearing surfaces etc.

Properties required

- High resistance to abrasion
- Low friction co-efficient
- Heat resistance
- Corrosion resistance
- Good form stability.

Types of plastics with particular application

- Acetals for:- submerged (water or organic solvents) or humid service when resistance to creep is important.
 - for valve liners or slides to eliminate jerky starts.
- Fluorocarbons (especially P.T.F.E.) for:
 - sliding or low speed rotating dry bearings
 - highly corrosive service
 - service in extreme temperatures (-200 to + 260°C)
 - non-stick surfaces.
- Fluorocarbons (filled) for:
 - heavy loadings and
 - high creep resistance
- Nylon for general purpose bearings and wear surfaces.
- Polyethylene (high density) at very low speeds and loads.

TABLE 7 : PLASTICS FOR ELECTROSTRUCTURAL PARTSProperties required

- Excellent electrical resistance in low to medium frequencies.
- High tensile - and impact strength
- Good fatigue resistance
- Good dimensional stability and excellent moulding characteristics

Types of plastics with particular application

- Alkyds, Aminos and Polyesters are recommended for general electrical components.
- Epoxies: Potting and encapsulation of electronic components for maximum environmental resistance.
 - excellent dimensional stability over wide temperature ranges.
- Melamines for:
 - hardness
 - high shock resistance and
 - high resistance to burning
- Phenolics for punched and stamped parts
- Polycarbonates for transparent parts requiring high impact strength.
- Silicones for very high heat resistance.

NOTE:-

Polystyrene and teflon have excellent electrical properties in high frequency applications.

Iono ers, polyvinylchloride and polyethylene are recommended in high voltage applications.

TABLE 8 : PLASTICS FOR GENERAL APPLICATIONSA. For thermal and chemical equipment, plating components etc.Properties required

- Resistance to very high temperatures
- Resistance to a wide range of chemicals
- Minimum moisture absorption
- Good mechanical properties

Types of plastics with particular application

- Epoxy for greatest mechanical strength
- Fluorocarbons
 - a) P.T.F.E. for:
 - general chemical purposes
 - extreme temperature applications
 - b) P.C.T.F.E. for transparency
 - c) P.V.F. and P.C.T.F.E. for extreme chemical resistance combined with mechanical strength and stiffness.
- Polypropylene - Polyethylene (high density)
for plating and less severe chemical exposures.

NOTE:-

Polyvinylchloride has good chemical resistance but is not temperature resistant.

B. Materials for Containers, Ducts etc.Properties required

- Good impact strength and stiffness
- Good formability and mouldability characteristics
- Good environmental resistance
- Good mechanical properties and dimensional stability.

Types of plastics with particular application

- ABS recommended for general applications
- Polyesters (glass-filled) and epoxies (glass-filled) for:
 - maximum strength to weight ratios
 - stiffness
 - heat resistance
- Polypropylene, polyethylene (high density) and epoxy (glass-filled) for applications in corrosive environments.
Polypropylene has also a high flexing strength.

C. Plastics for Light - transmission Components, Models, etc.

Properties required

- good light transmission
- excellent formability and mouldability
- shatter resistance
- fair to good mechanical properties

Types of plastics with particular application

- Acrylics and Polystyrenes recommended for general purpose applications, especially for optical use.
- Acrylics have also excellent low temperature properties.
- Cellulose acetates and Vinyls for - flexible glazing
 - guards
- Cellulose butyrates for - excellent impact resistance
 - deep formability
- Ionomers for - excellent clarity
- Polycarbonates for - maximum strength
- Vinyls for - maximum formability
 - printability

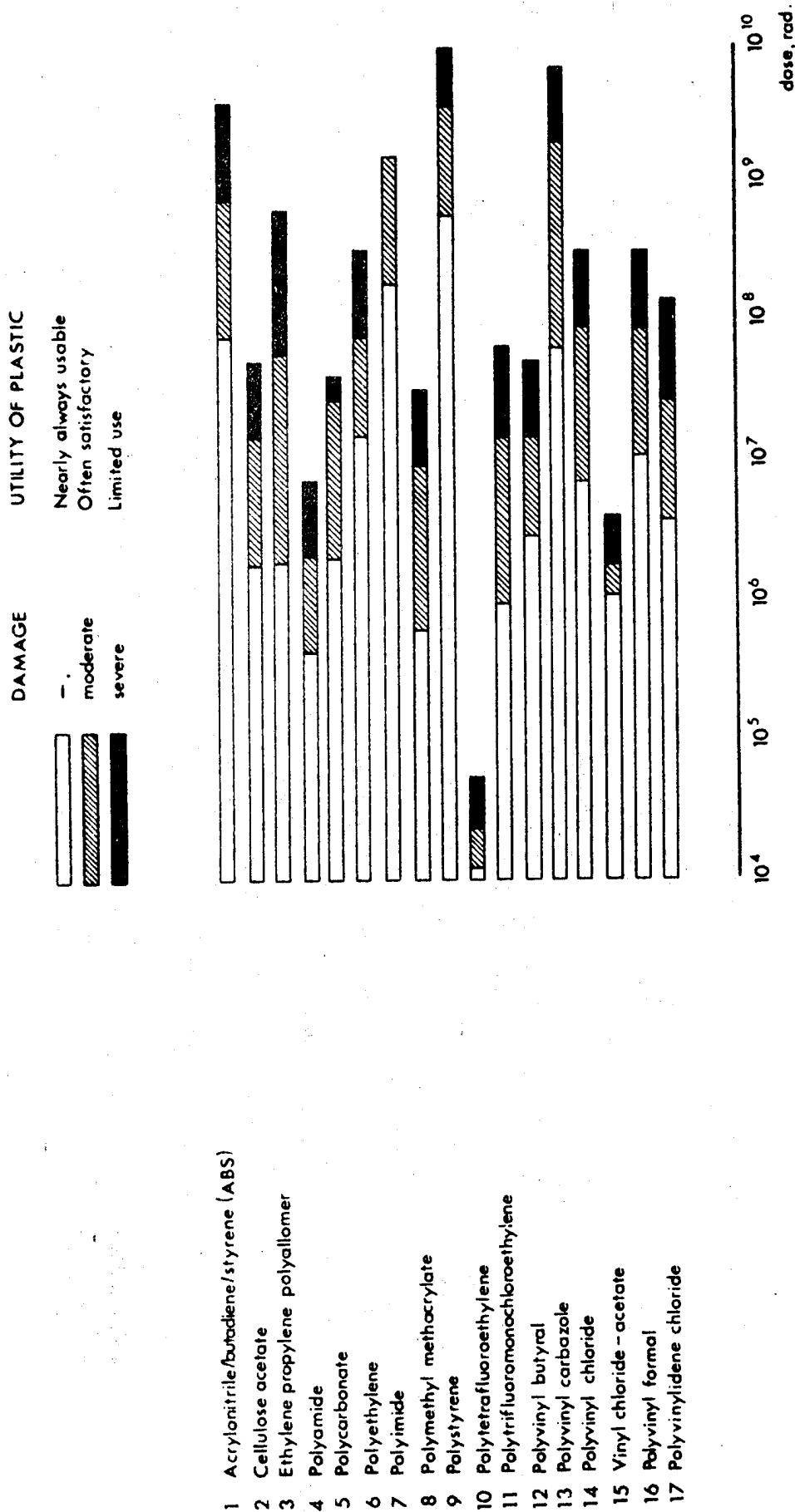


Fig. 1 RELATIVE RADIATION RESISTANCE OF THERMOPLASTIC RESINS (2,3,4,5)

DAMAGE

—
 moderate
 severe

UTILITY OF PLASTIC

Nearly always usable
 Often satisfactory
 Limited use



- 1 Aniline - formaldehyde
- 2 Epoxy, aromatic - type
- 3 Furane, resin
- 4 Melamine - formaldehyde
- 5 Phenolic, unfilled
- 6 Mylar
- 7 Polyester, unfilled
- 8 Silicone, unfilled
- 9 Urea - formaldehyde

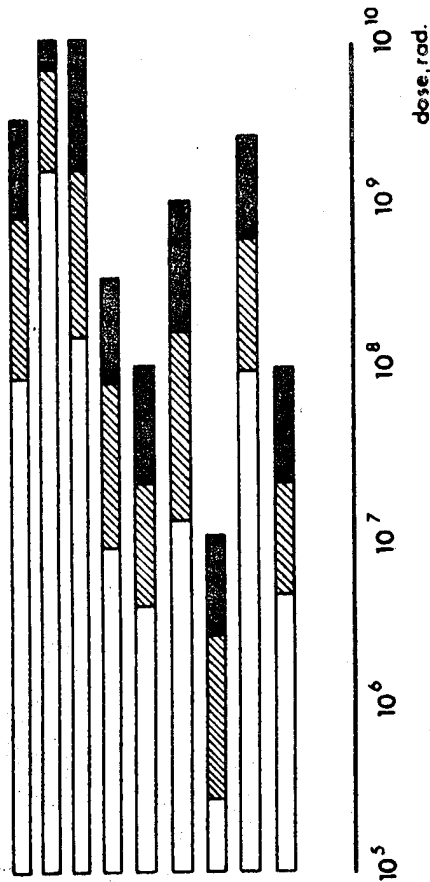
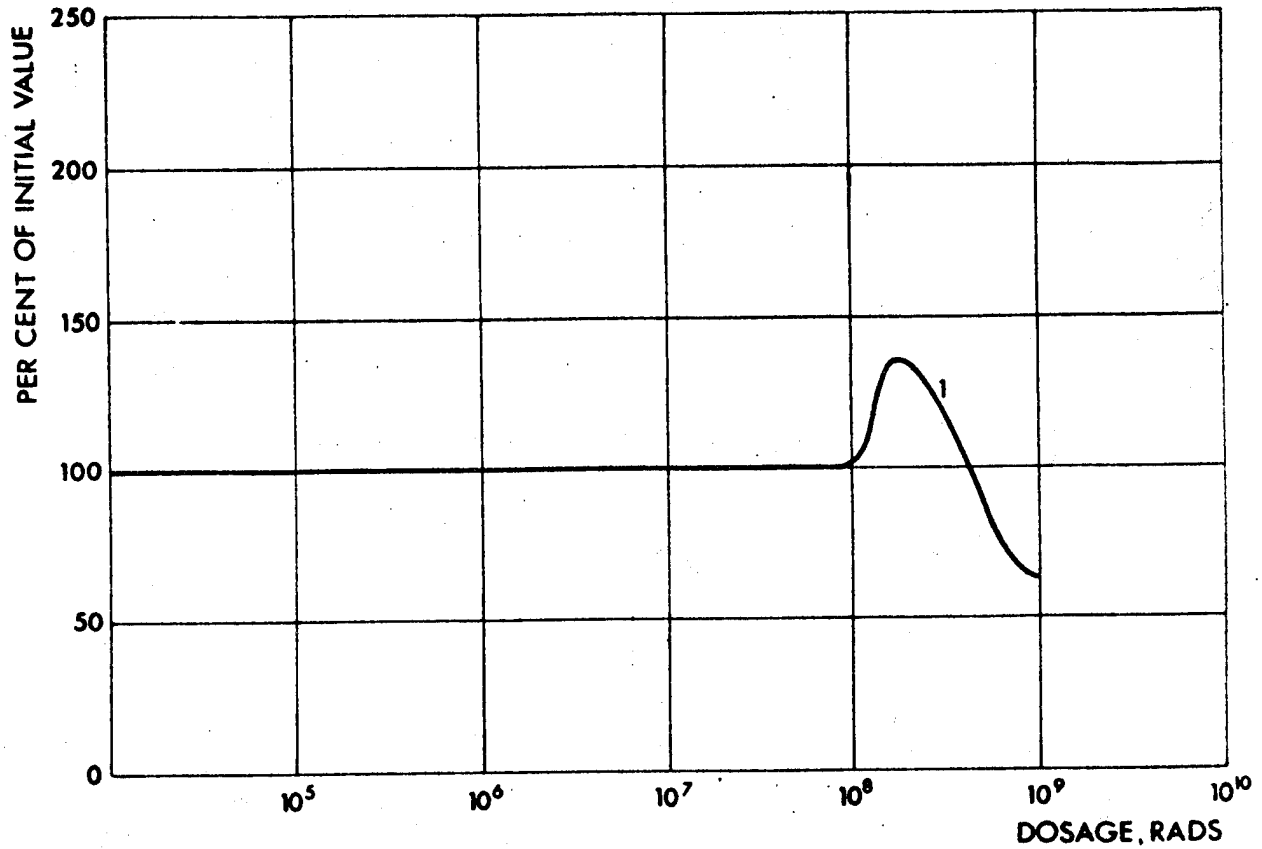


Fig. 2 RELATIVE RADIATION STABILITY OF THERMOSETTING RESINS (2,3,4,5)

Effect of radiation on mechanical properties

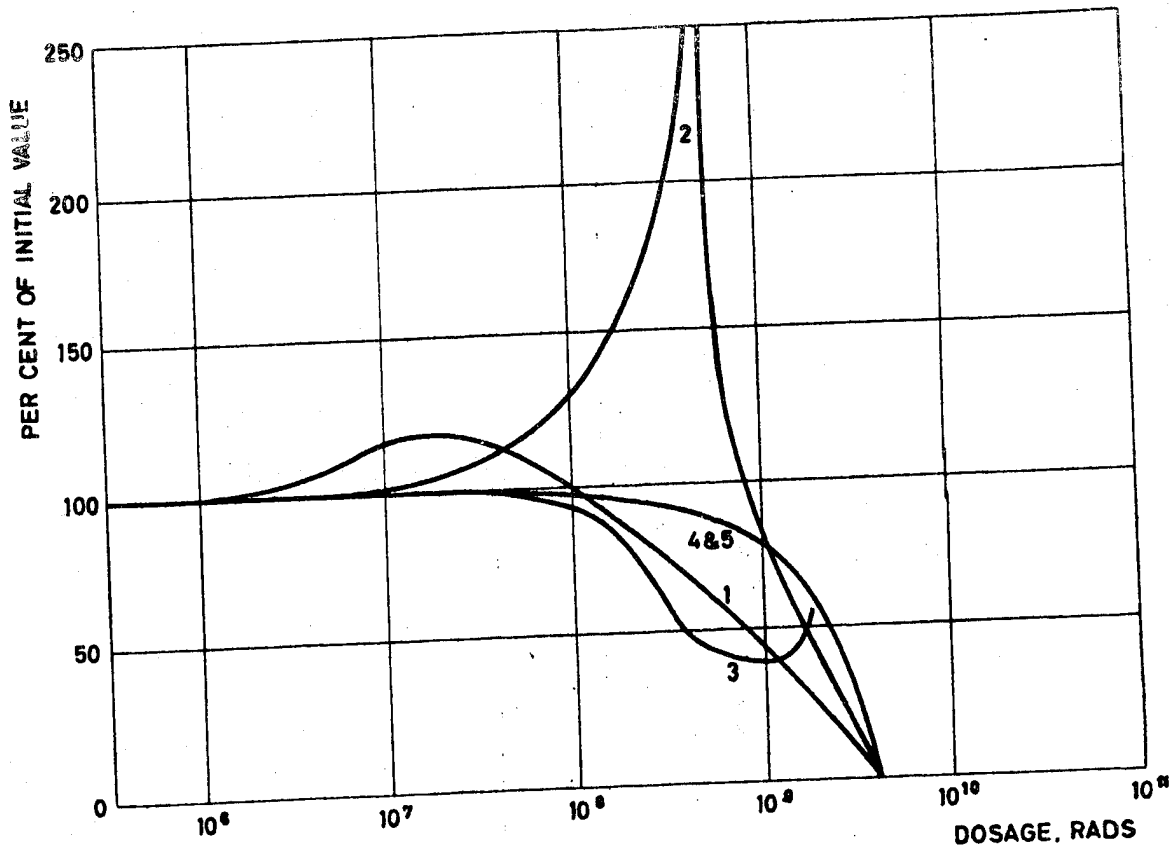


CURVE NO	PROPERTY	INITIAL VALUE
1	TENSILE STRENGTH	3.730 PSI
2	ELONGATION	—
3	ELASTIC MODULUS	—
4	SHEAR STRENGTH	—
5	IMPACT STRENGTH	—

Fig. 3 ABS (ACRYLONITRILE - BUTADIENE - STYRENE TERPOLYMER)

"KRALASTIC MV" (6)

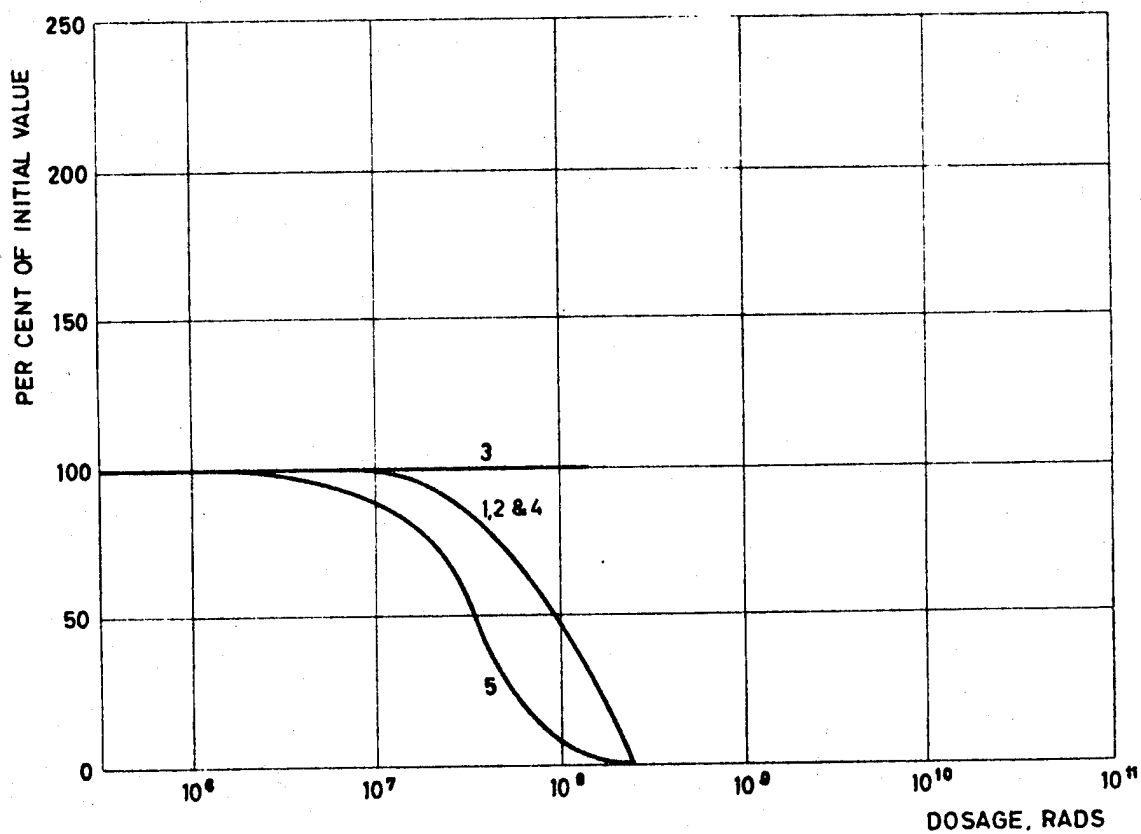
Effect of radiation on mechanical properties



CURVE NO.	PROPERTY	INITIAL VALUE
1	TENSILE STRENGTH	6,700 PSI
2	ELONGATION	2.4 %
3	ELASTIC MODULUS	2.8×10^8 PSI
4	SHEAR STRENGTH	5,000 PSI
5	IMPACT STRENGTH	0.35 FT-LB/IN. OF NOTCH

Fig.4 Allyl diglycol carbonate - "CR-39" (7,8,9,10,11)

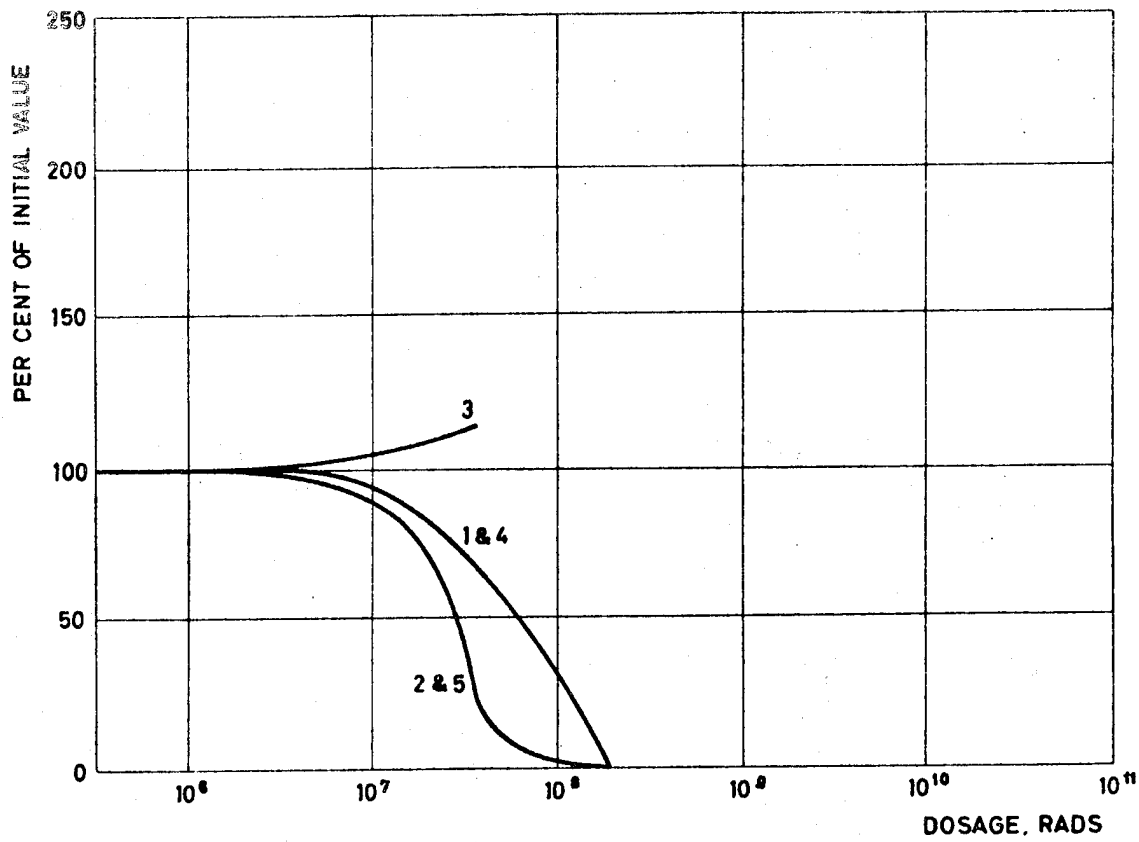
Effect of radiation on mechanical properties



CURVE NO.	PROPERTY	INITIAL VALUE
1	TENSILE STRENGTH	8,500 PSI
2	ELONGATION	2.0 %
3	ELASTIC MODULUS	5.7×10^5 PSI
4	SHEAR STRENGTH	9,800 PSI
5	IMPACT STRENGTH	0.50 FT-LB/IN. OF NOTCH

Fig. 5 Casein - "Ameroid" (7,8,11,12)

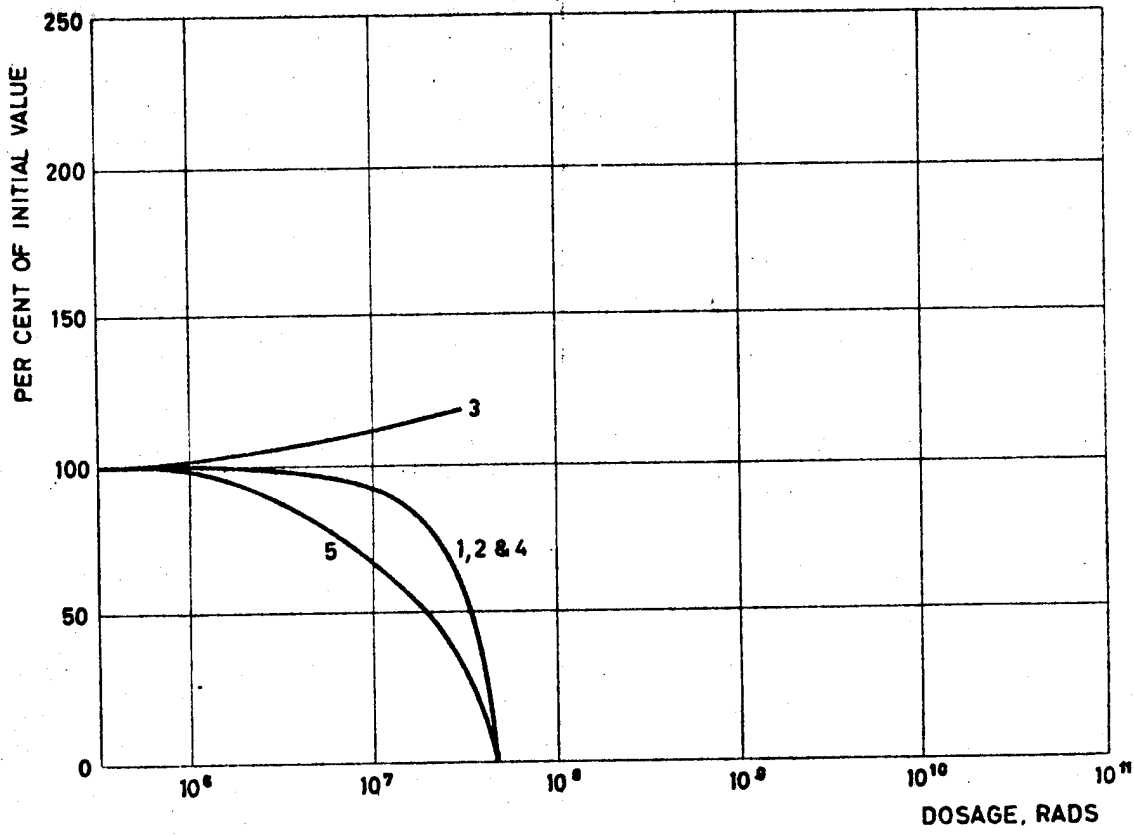
Effect of radiation on mechanical properties



CURVE NO.	PROPERTY	INITIAL VALUE
1	TENSILE STRENGTH	5,300 PSI
2	ELONGATION	20 %
3	ELASTIC MODULUS	2.6 x 10 ⁵ PSI
4	SHEAR STRENGTH	6,400 PSI
5	IMPACT STRENGTH	1.37 FT-LB/IN. OF NOTCH

Fig.6 Cellulose acetate - "Plastacele" (7,8,11,12,13)

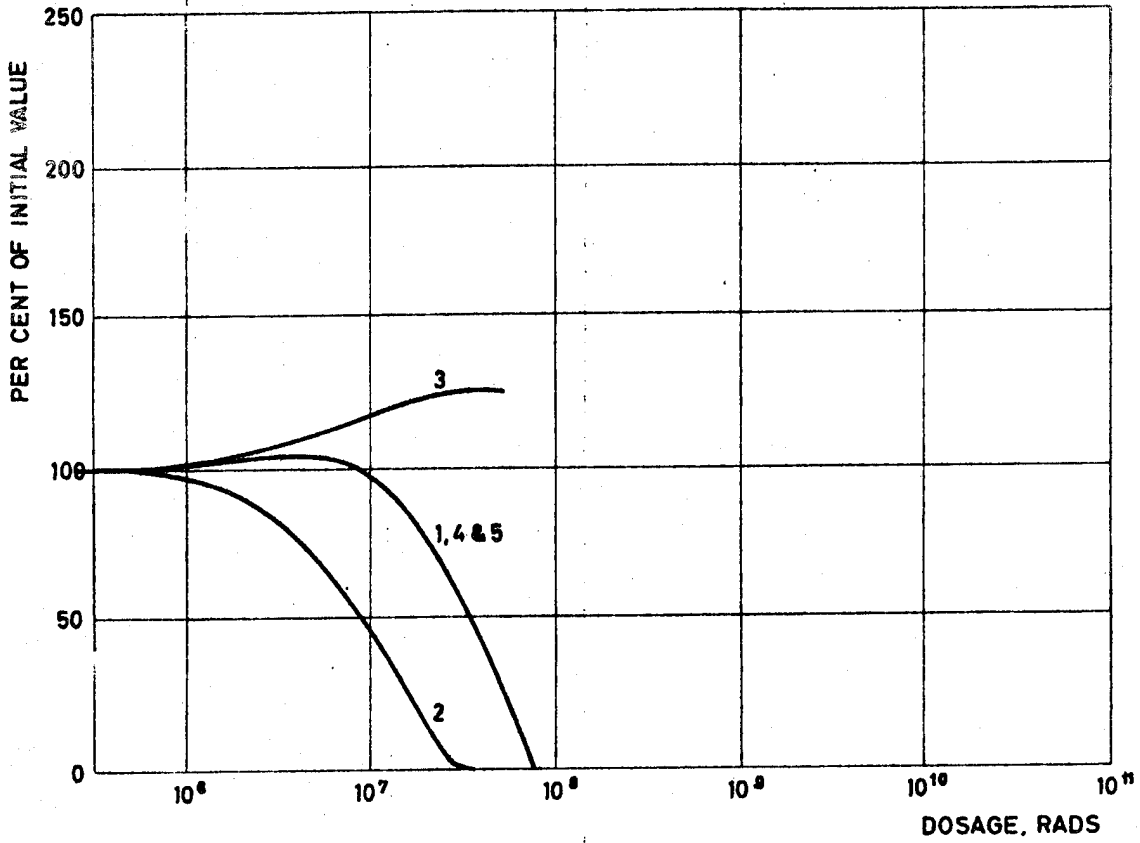
Effect of radiation on mechanical properties



CURVE NO.	PROPERTY	INITIAL VALUE
1	TENSILE STRENGTH	4,200 PSI
2	ELONGATION	60 %
3	ELASTIC MODULUS	1.6 x 10 ⁸ PSI
4	SHEAR STRENGTH	4,000 PSI
5	IMPACT STRENGTH	3.3 FT-LB/IN. OF NOTCH

Fig. 7 Cellulose acetate butyrate - "Tenite butyrate" (7,8,11,14)

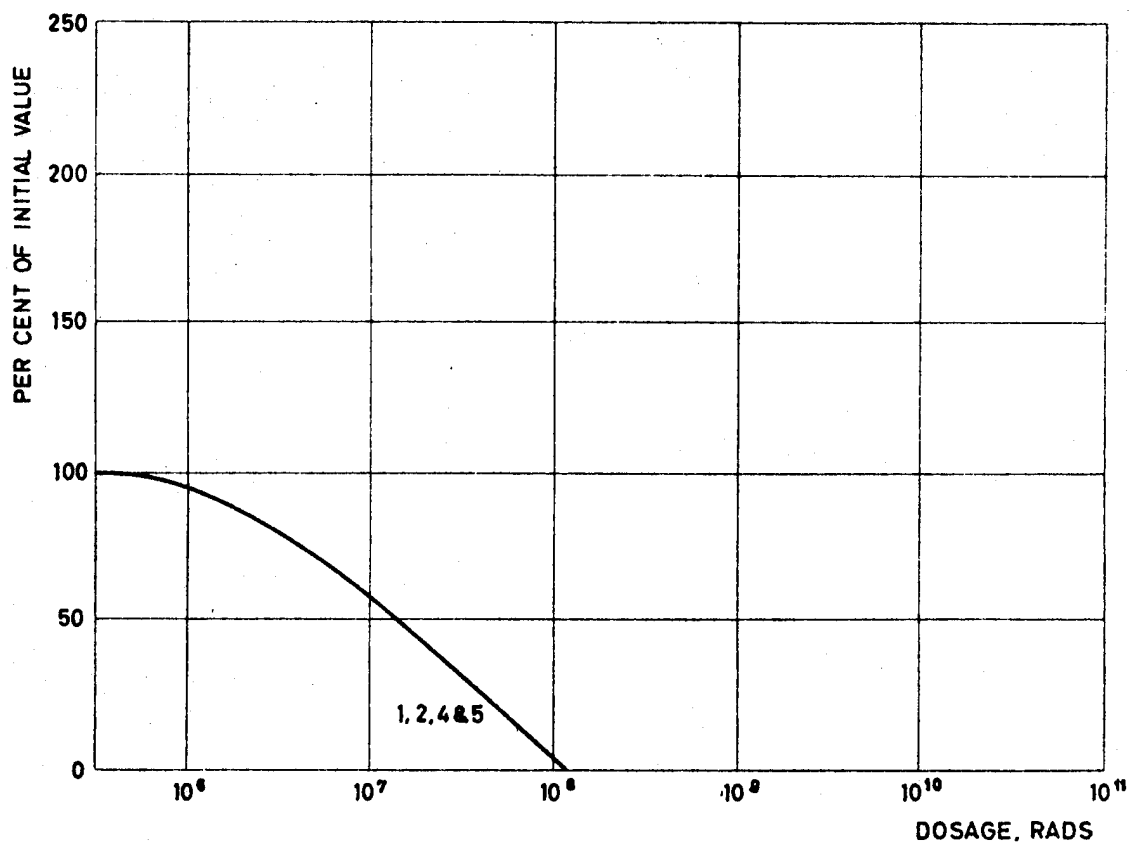
Effect of radiation on mechanical properties



CURVE NO.	PROPERTY	INITIAL VALUE
1	TENSILE STRENGTH	7,600 PSI
2	ELONGATION	30%
3	ELASTIC MODULUS	3.6×10^5 PSI
4	SHEAR STRENGTH	8,800 PSI
5	IMPACT STRENGTH	2.75 FT-LB/IN. OF NOTCH

Fig. 8 Cellulose nitrate - "Pyralin" (7,8,11,12)

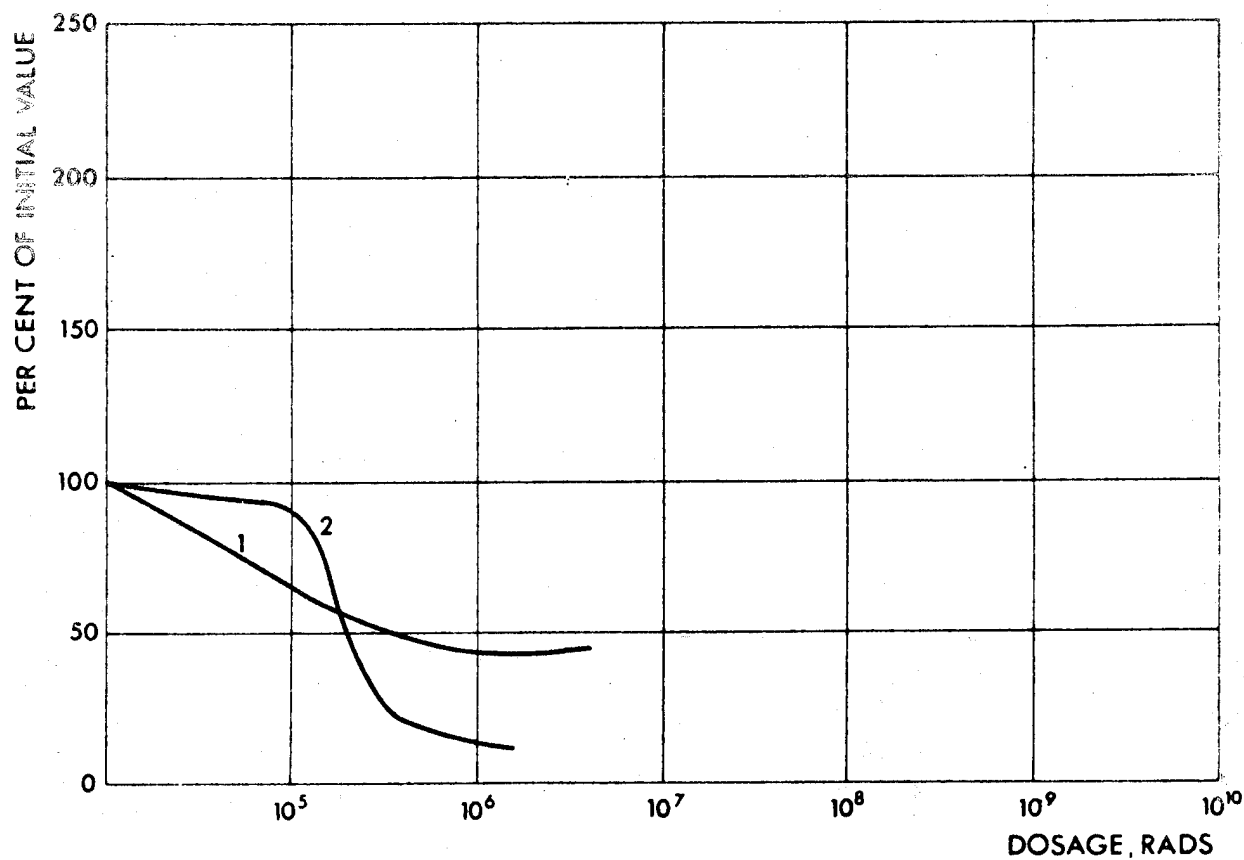
Effect of radiation on mechanical properties



CURVE NO.	PROPERTY	INITIAL VALUE
1	TENSILE STRENGTH	2,600 PSI
2	ELONGATION	1,6 %
3	ELASTIC MODULUS	—
4	SHEAR STRENGTH	2900 PSI
5	IMPACT STRENGTH	1,1 FT-LB/IN. OF NOTCH

Fig. 9 Cellulose propionate - "Tenite propionate" (7,8,11,12)

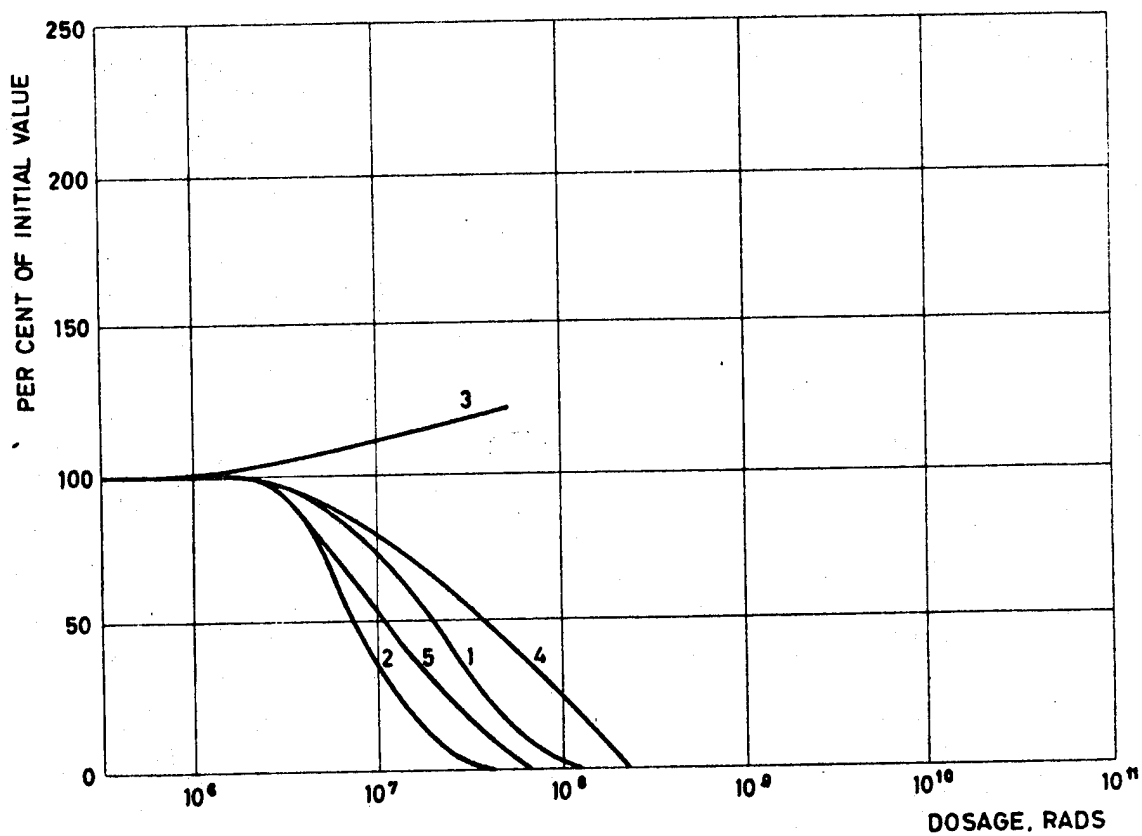
Effect of radiation on mechanical properties



CURVE NO	PROPERTY	INITIAL VALUE
1	TENSILE STRENGTH	3.000 PSI
2	ELONGATION	165%
3	ELASTIC MODULUS	—
4	SHEAR STRENGTH	—
5	IMPACT STRENGTH	—

Fig.10 COPOLYMER OF HEXAFLUOROPRENE AND
TETRAFLUROETHYLENE: TEFLON FEP 100 (15)

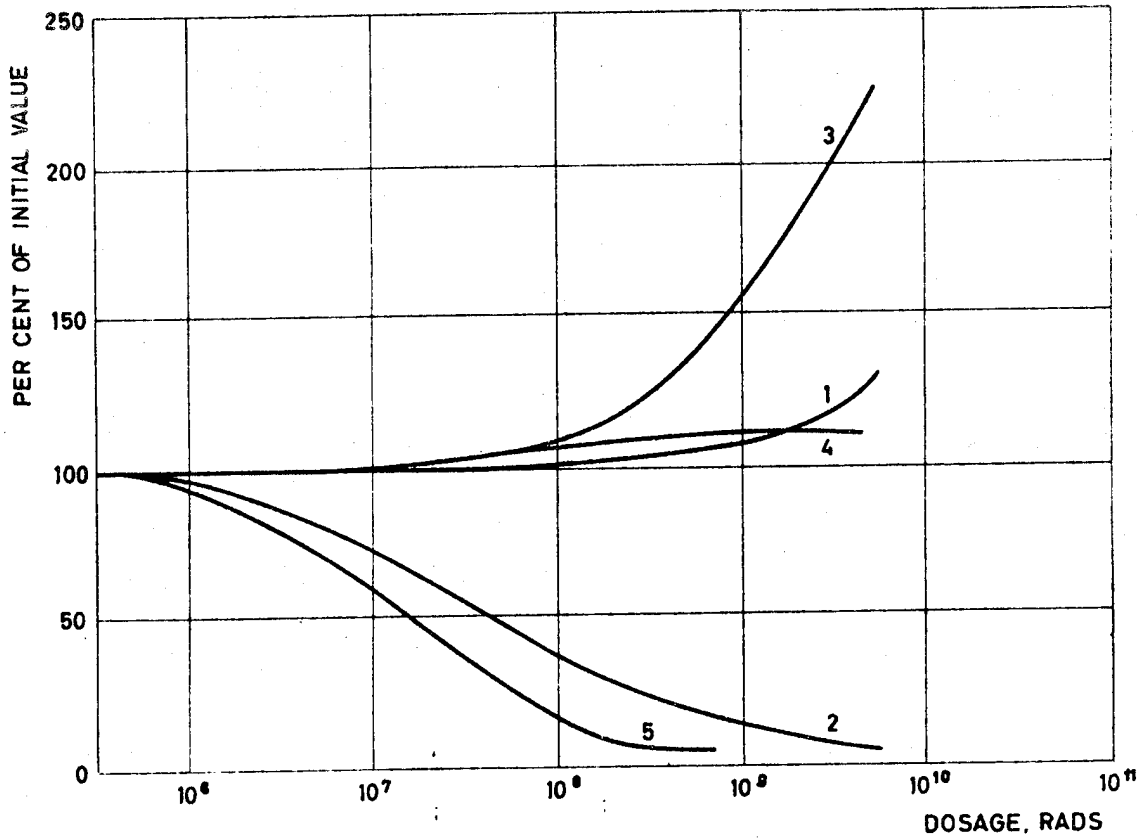
Effect of radiation on mechanical properties



CURVE NO.	PROPERTY	INITIAL VALUE
1	TENSILE STRENGTH	6,000 PSI
2	ELONGATION	40 %
3	ELASTIC MODULUS	2.1×10^5 PSI
4	SHEAR STRENGTH	6,700 PSI
5	IMPACT STRENGTH	2.0 FT-LB/IN. OF NOTCH

Fig. 11 Ethyl cellulose - "Ethocel" (7,8,11,12)

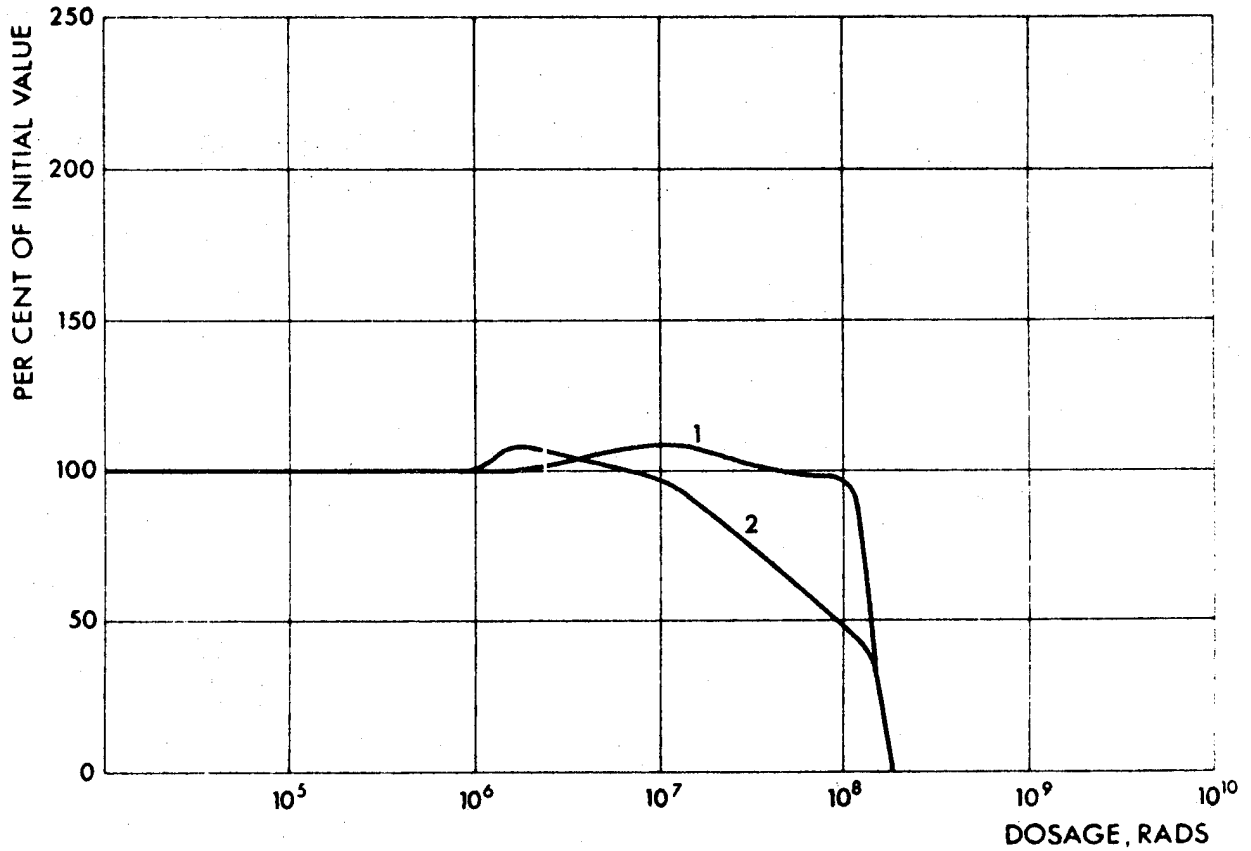
Effect of radiation on mechanical properties



CURVE NO.	PROPERTY	INITIAL VALUE
1	TENSILE STRENGTH	7,600 PSI
2	ELONGATION	62 %
3	ELASTIC MODULUS	2.0×10^5 PSI
4	SHEAR STRENGTH	7,300 PSI
5	IMPACT STRENGTH	2.8 FT-LB/IN. OF NOTCH

Fig. 12 Polyamide "Nylon" (7, 8, 11, 16, 17)

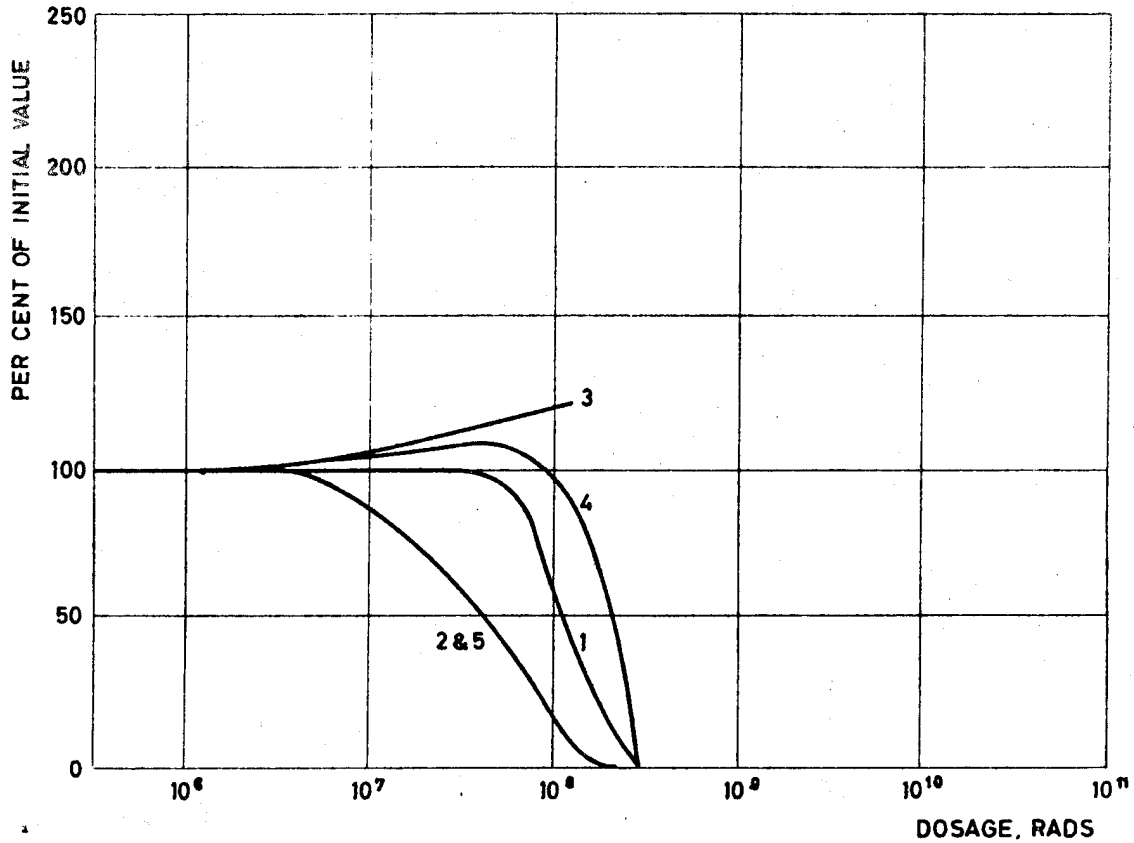
Effect of radiation on mechanical properties



CURVE NO	PROPERTY	INITIAL VALUE
1	TENSILE STRENGTH	6.200 PSI
2	ELONGATION	96%
3	ELASTIC MODULUS	—
4	SHEAR STRENGTH	—
5	IMPACT STRENGTH	—

Fig. 13 POLYCARBONATE "LEXAN FILM" (18,11,20)

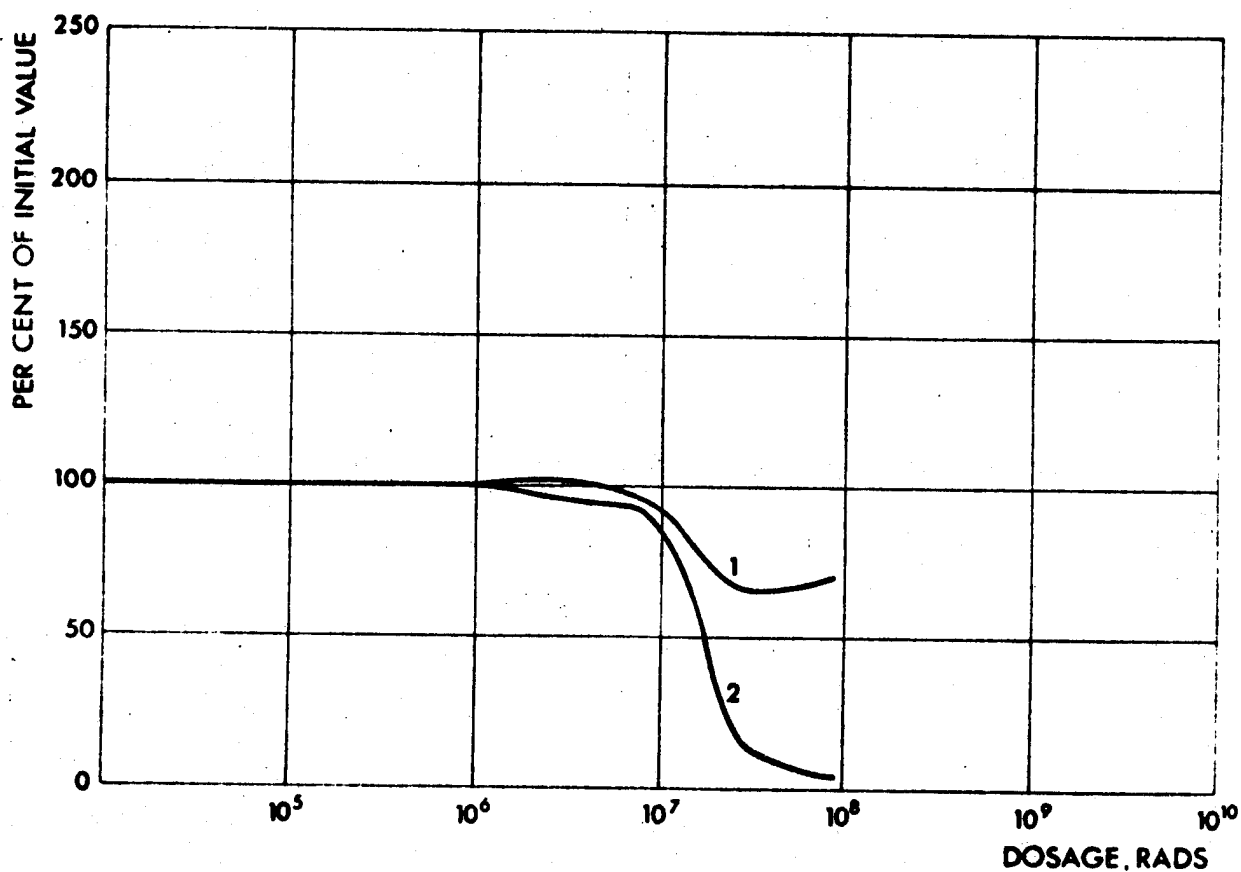
Effect of radiation on mechanical properties



CURVE NO.	PROPERTY	INITIAL VALUE
1	TENSILE STRENGTH	4,900 PSI
2	ELONGATION	50 %
3	ELASTIC MODULUS	1.8x10 ⁵ PSI
4	SHEAR STRENGTH	5,300 PSI
5	IMPACT STRENGTH	1.9 FT-LB/IN. OF NOTCH

Fig. 14 Polychlorotrifluoroethylene - "Fluoroethene" (7,8,11,21,22)

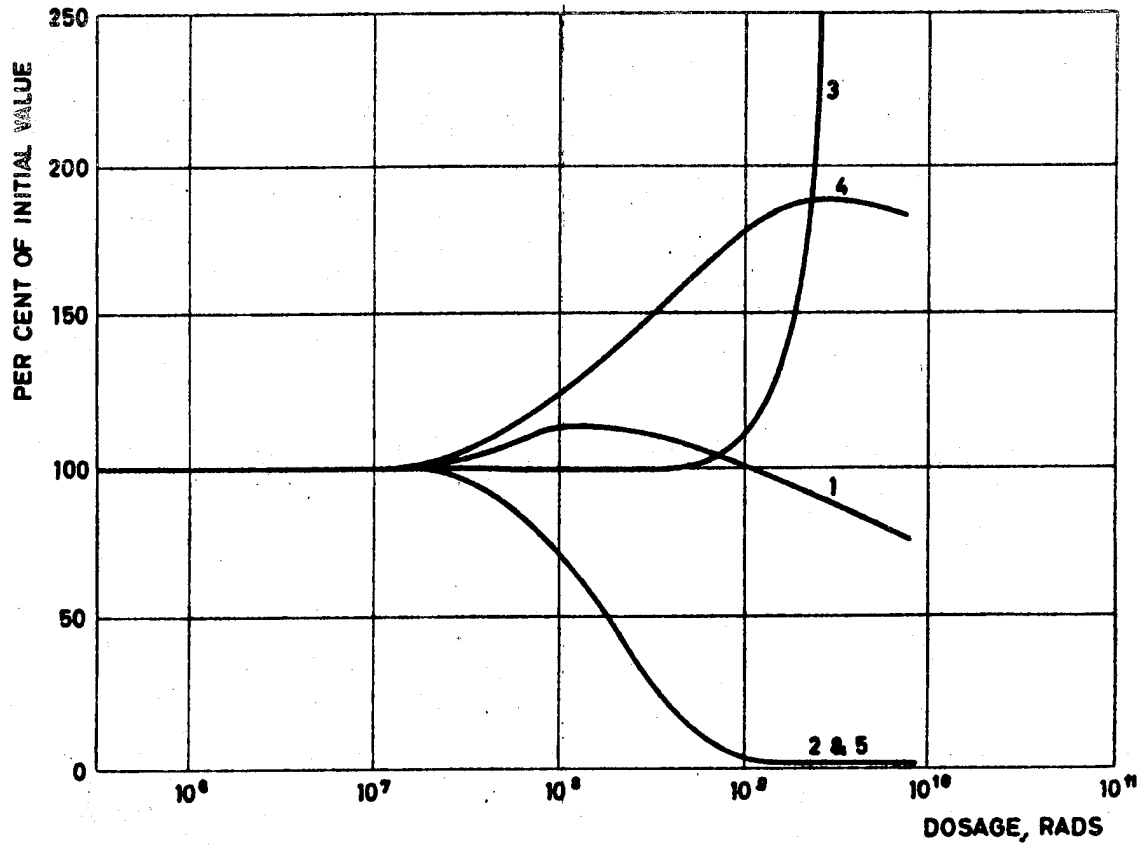
Effect of radiation on mechanical properties



CURVE NO	PROPERTY	INITIAL VALUE
1	TENSILE STRENGTH	1.915 PSI
2	ELONGATION	38%
3	ELASTIC MODULUS	—
4	SHEAR STRENGTH	—
5	IMPACT STRENGTH	—

Fig. 15 POLYETHYLENE "ALATHON 3, NC-10FILM" (20)

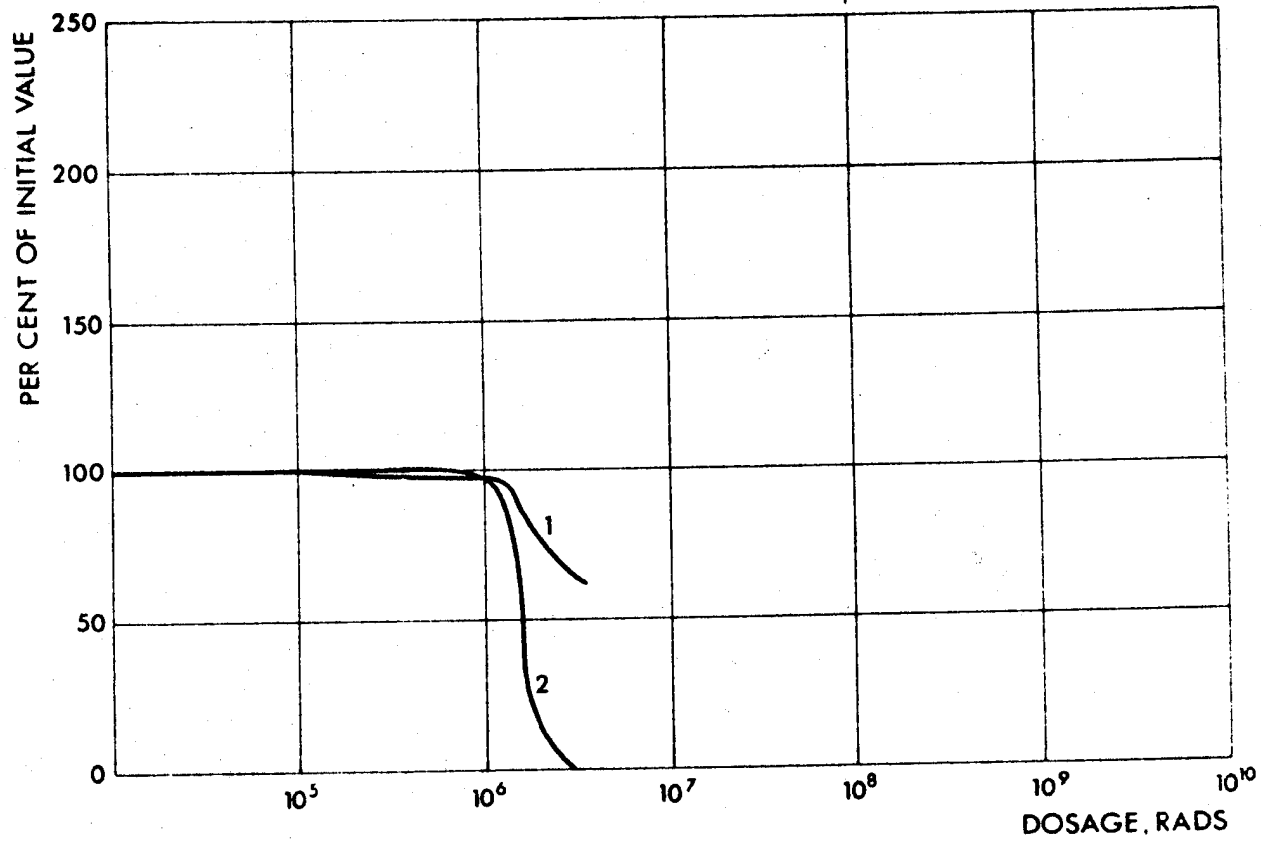
Effect of radiation on mechanical properties



CURVE NO.	PROPERTY	INITIAL VALUE
1	TENSILE STRENGTH	1400 PSI
2	ELONGATION	250%
3	ELASTIC MODULUS	0.30x10 ⁶ PSI
4	SHEAR STRENGTH	1400 PSI
5	IMPACT STRENGTH	11.2 FT-LB/IN. OF NOTCH

Fig. 16 Polyethylene "Polythene" (7,8,11,23,24, 25,26,27,28)

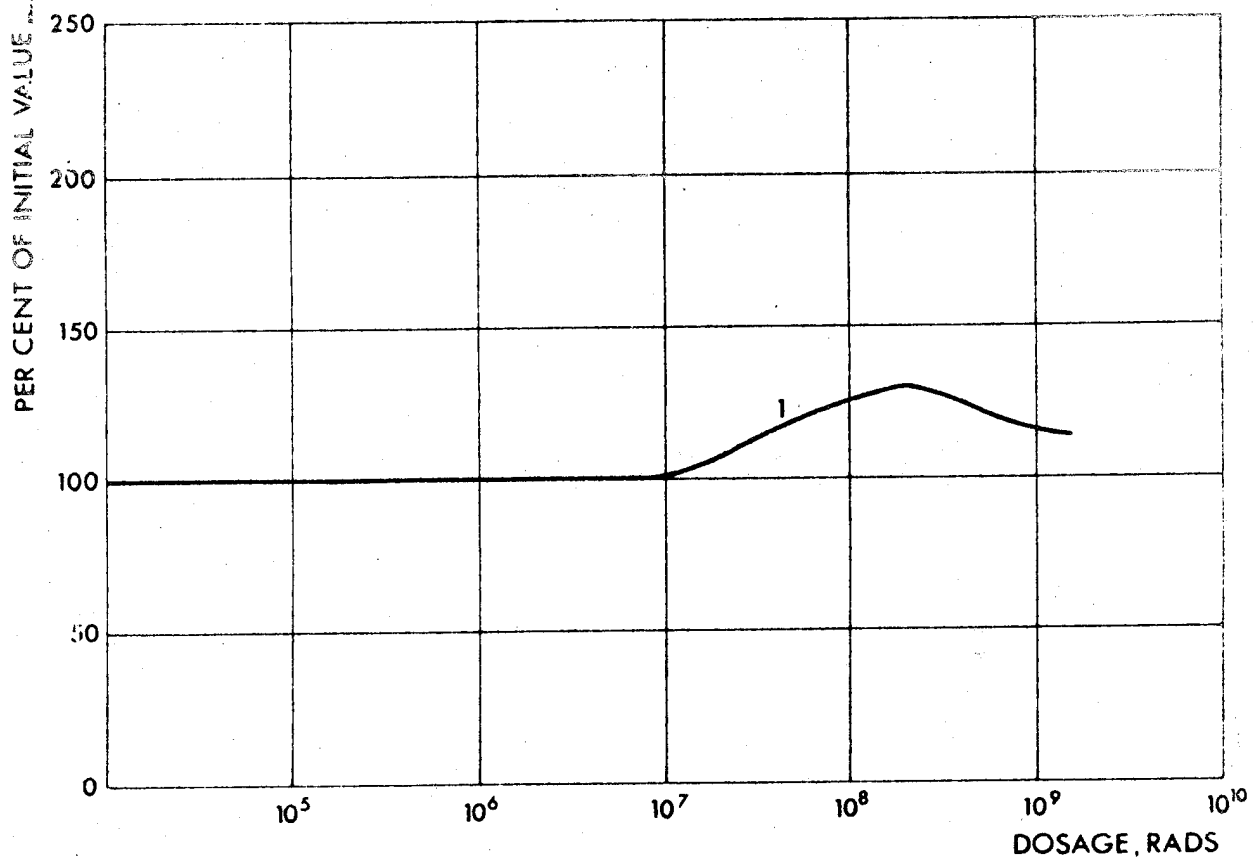
Effect of radiation on mechanical properties



CURVE NO	PROPERTY	INITIAL VALUE
1	TENSILE STRENGTH	10.450 PSI
2	ELONGATION	70%
3	ELASTIC MODULUS	—
4	SHEAR STRENGTH	—
5	IMPACT STRENGTH	—

Fig.17 POLYFORMALDEHYDE "DELFIN" (12,29)

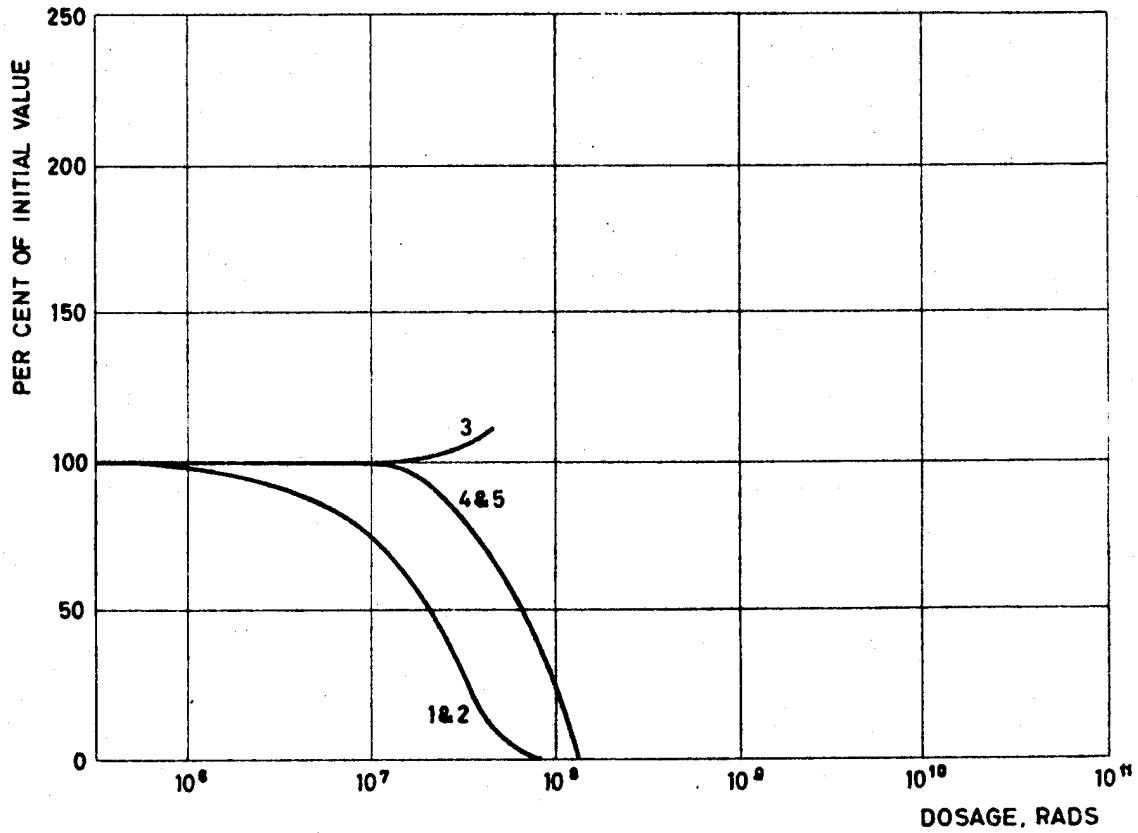
Effect of radiation on mechanical properties



CURVE NO	PROPERTY	INITIAL VALUE
1	TENSILE STRENGTH	23,000 PSI
2	ELONGATION	—
3	ELASTIC MODULUS	—
4	SHEAR STRENGTH	—
5	IMPACT STRENGTH	—

Fig. 18 POLYIMIDE "H-FILM" (30)

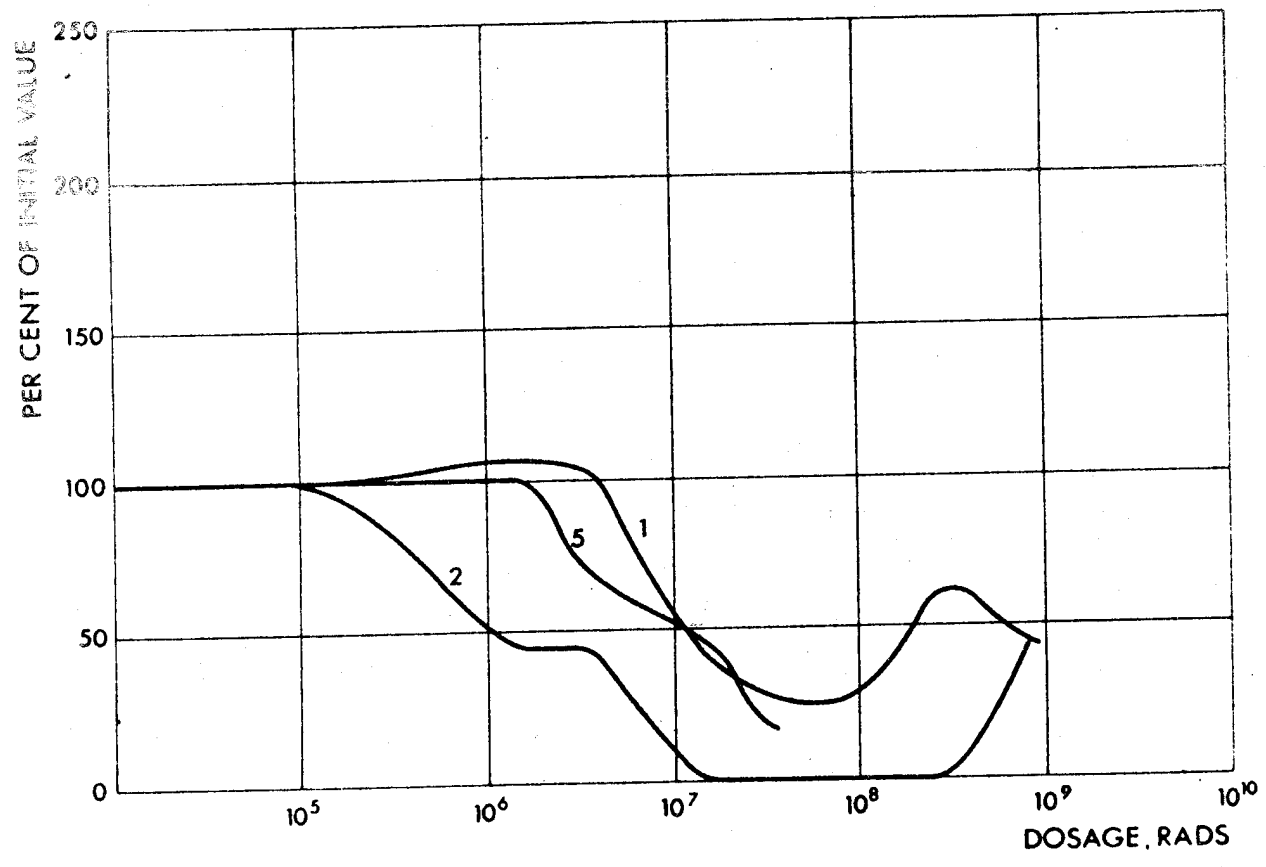
Effect of radiation on mechanical properties



CURVE NO.	PROPERTY	INITIAL VALUE
1	TENSILE STRENGTH	10,700 PSI
2	ELONGATION	4.5 %
3	ELASTIC MODULUS	4.8×10^5 PSI
4	SHEAR STRENGTH	6,700 PSI
5	IMPACT STRENGTH	0.37 FT-LB/IN. OF NOTCH

Fig. 19 Methyl methacrylate - "Perspex" (7,8,11,17,24,31,32,33)

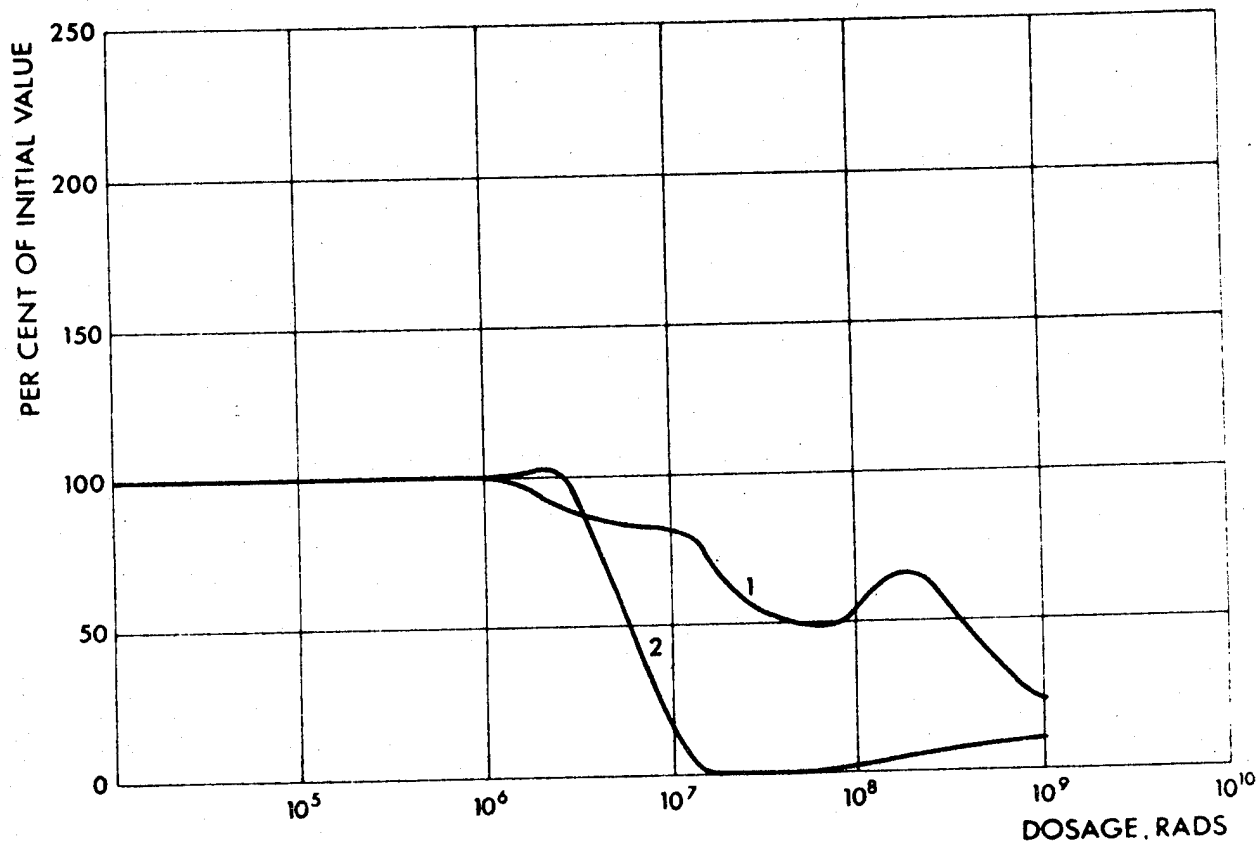
Effect of radiation on mechanical properties



CURVE NO	PROPERTY	INITIAL VALUE
1	TENSILE STRENGTH	4,660 PSI
2	ELONGATION	70%
3	ELASTIC MODULUS	—
4	SHEAR STRENGTH	—
5	IMPACT STRENGTH	0,79 FT-LB/IN of notch

Fig. 20 POLYPROPYLENE "PRO-FAX" (34,35,36,37)

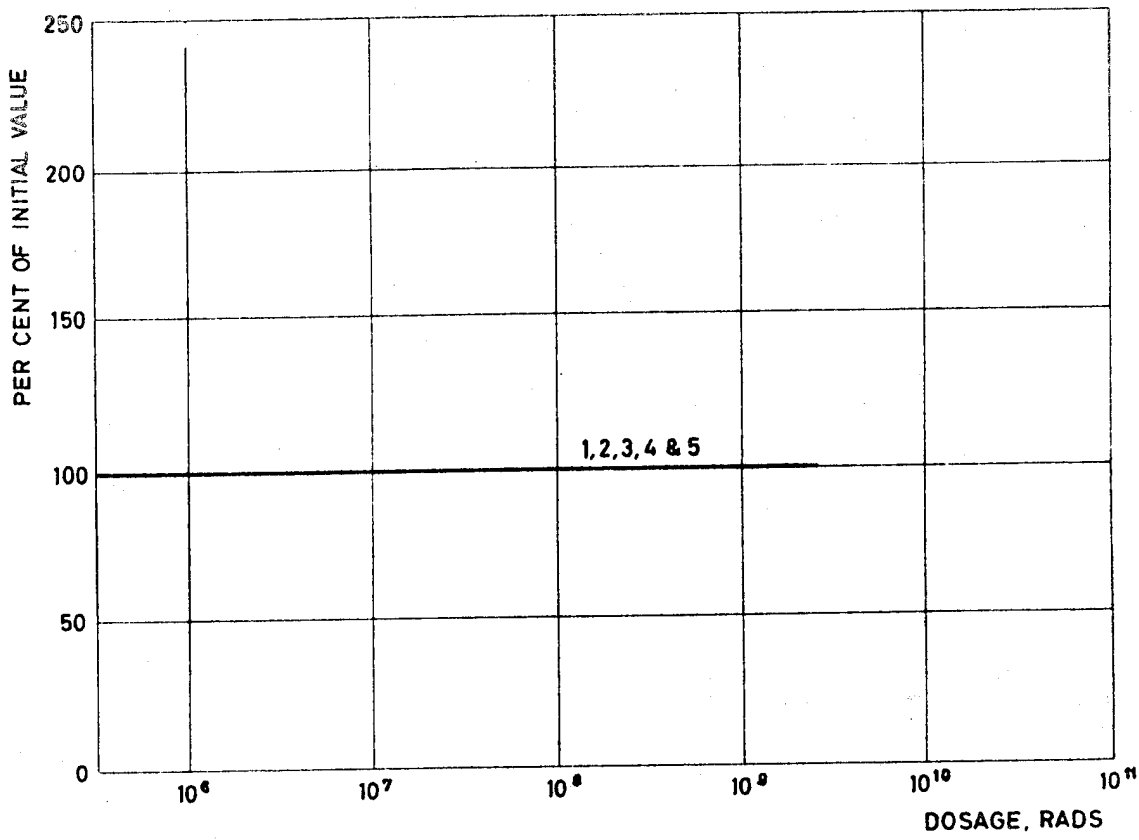
Effect of radiation on mechanical properties



CURVE NO	PROPERTY	INITIAL VALUE
1	TENSILE STRENGTH	4.380 PSI
2	ELONGATION	770%
3	ELASTIC MODULUS	—
4	SHEAR STRENGTH	—
5	IMPACT STRENGTH	—

Fig. 21 POLYPROPYLENE-ETHYLENE POLYALLOMER (6)

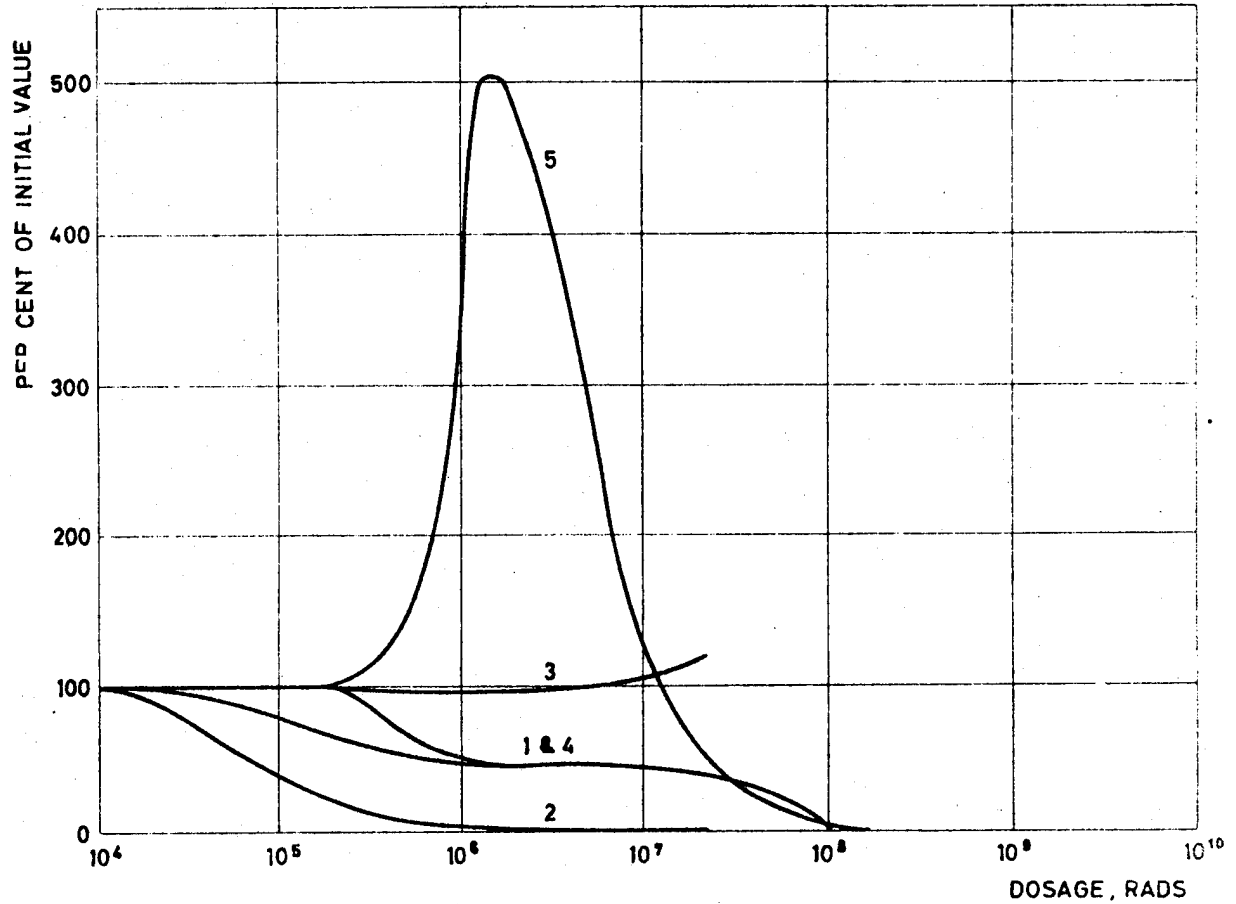
Effect of radiation on mechanical properties



CURVE NO.	PROPERTY	INITIAL VALUE
1	TENSILE STRENGTH	4,400 PSI
2	ELONGATION	1.0 %
3	ELASTIC MODULUS	4.8×10^5 PSI
4	SHEAR STRENGTH	5,500 PSI
5	IMPACT STRENGTH	0.20 FT-LB / IN. OF NOTCH

Fig. 22 Polystyrene - "Styron" (7,8,11,38,39)

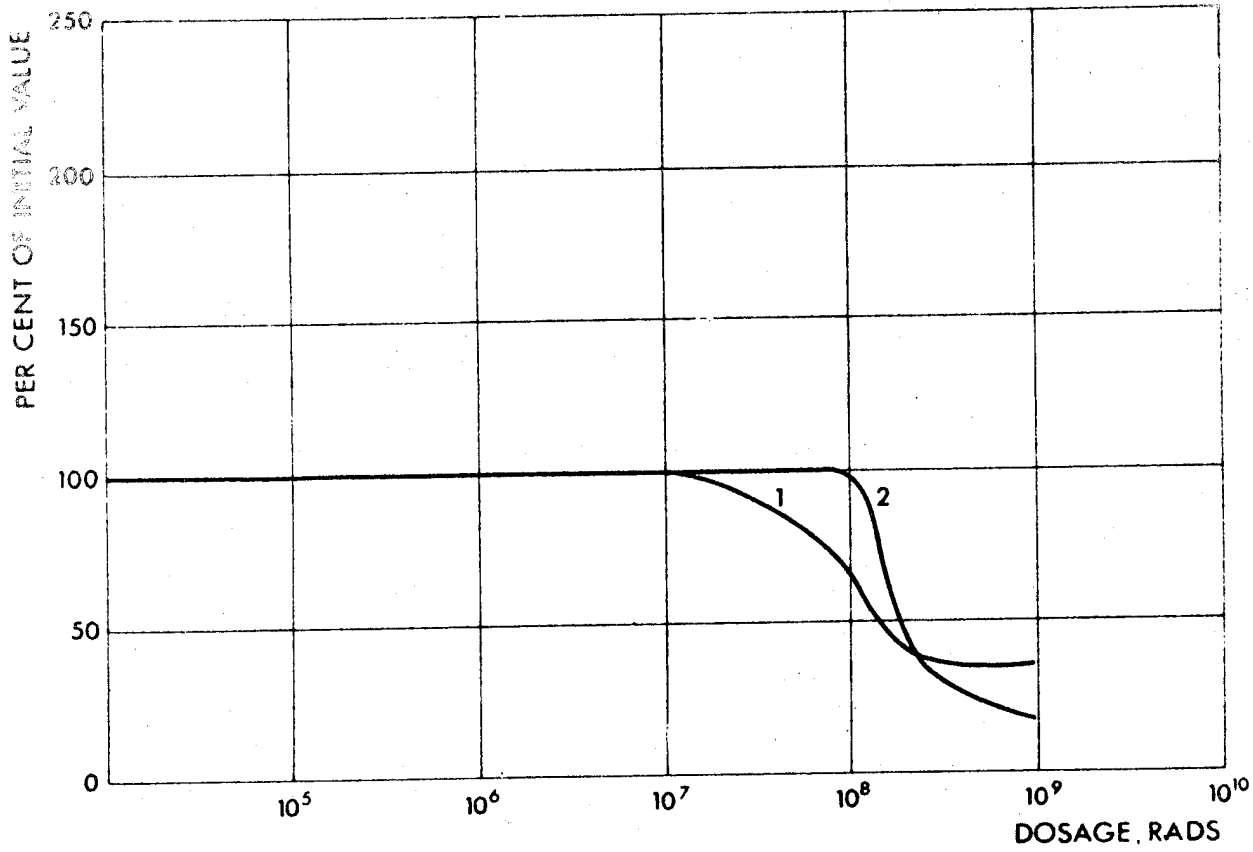
Effect of radiation on mechanical properties



CURVE NO.	PROPERTY	INITIAL VALUE
1	TENSILE STRENGTH	3,400 PSI
2	ELONGATION	250 %
3	ELASTIC MODULUS	1.0×10^5 PSI
4	SHEAR STRENGTH	2,830 PSI
5	IMPACT STRENGTH	3.3 FT-LB/IN. OF NOTCH

Fig. 23 Polytetrafluoroethylene (P.T.F.E.) "Teflon" (7, 8, 11, 20)

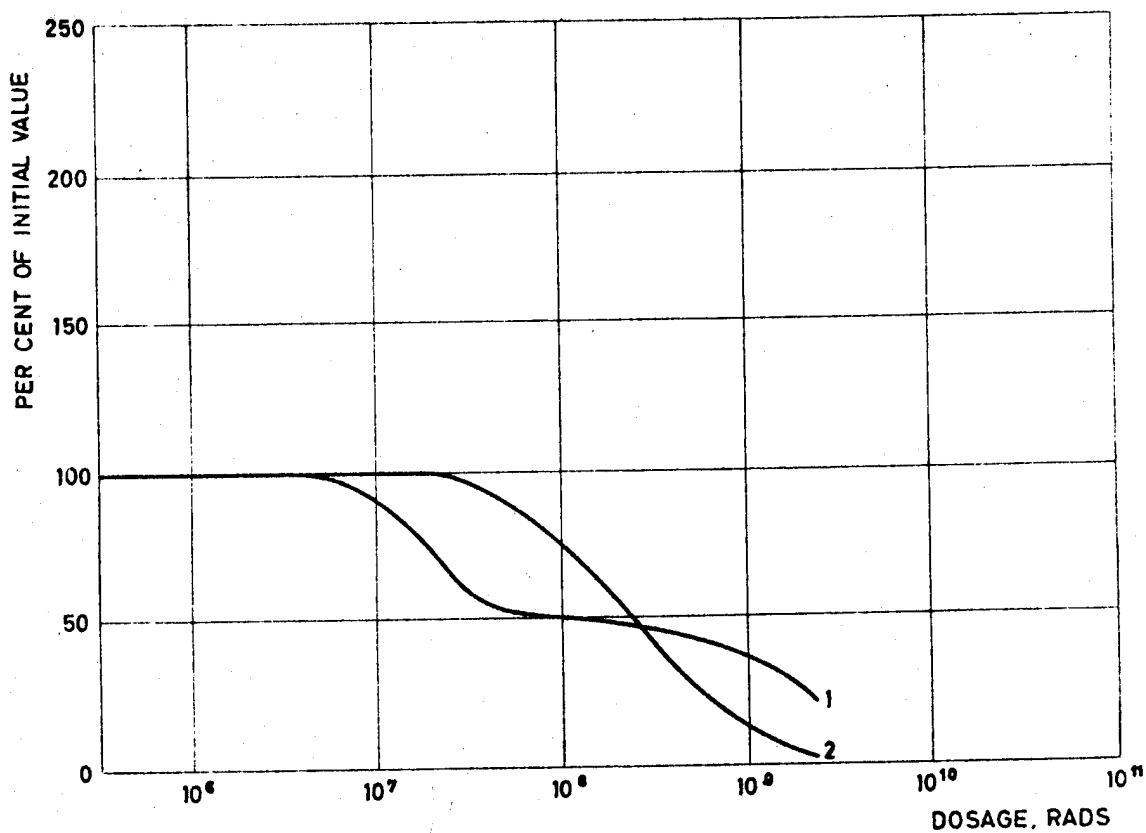
Effect of radiation on mechanical properties



CURVE NO	PROPERTY	INITIAL VALUE
1	TENSILE STRENGTH	6.390 PSI
2	ELONGATION	500%
3	ELASTIC MODULUS	—
4	SHEAR STRENGTH	—
5	IMPACT STRENGTH	—

Fig. 24 POLYURETHANE "ESTANE VC" (1,12,40,41)

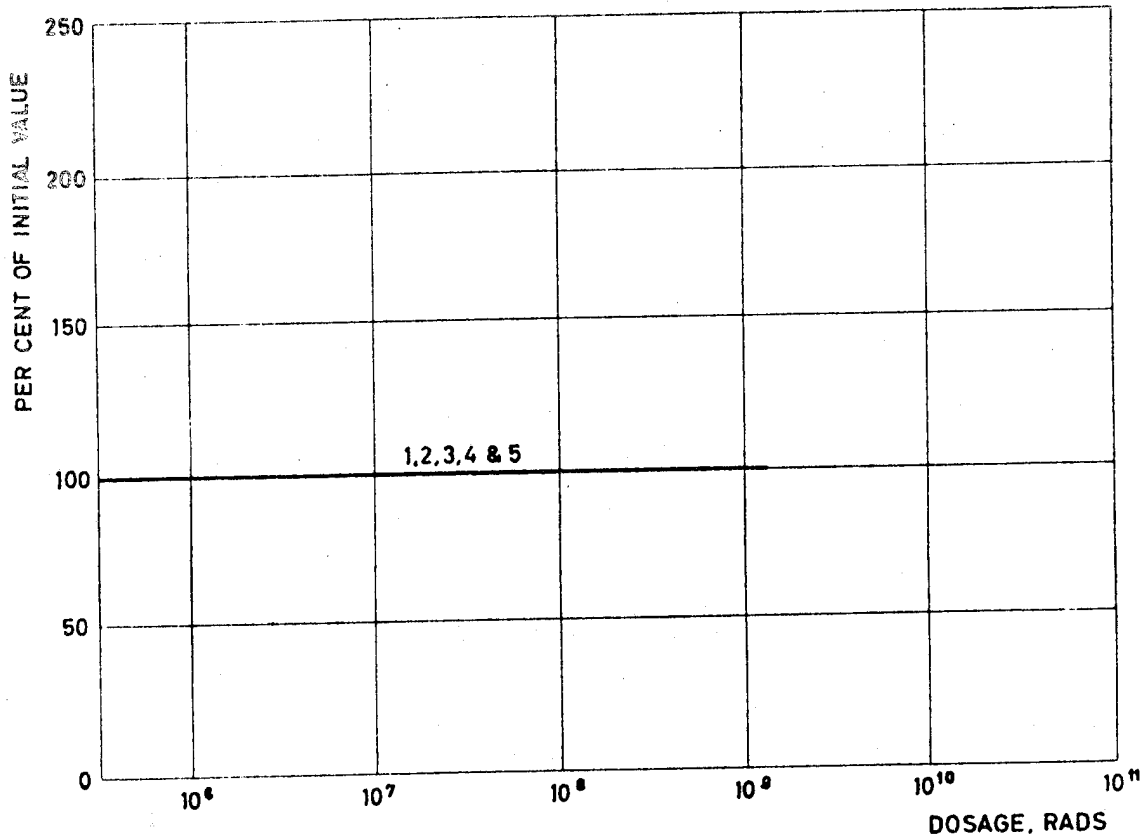
Effect of radiation on mechanical properties



CURVE NO.	PROPERTY	INITIAL VALUE
1	TENSILE STRENGTH	2200 PSI
2	ELONGATION	225 %
3	ELASTIC MODULUS	—
4	SHEAR STRENGTH	—
5	IMPACT STRENGTH	—

Fig. 25 Polyvinyl butyral - "Butacite Film" (7, 8, 11)

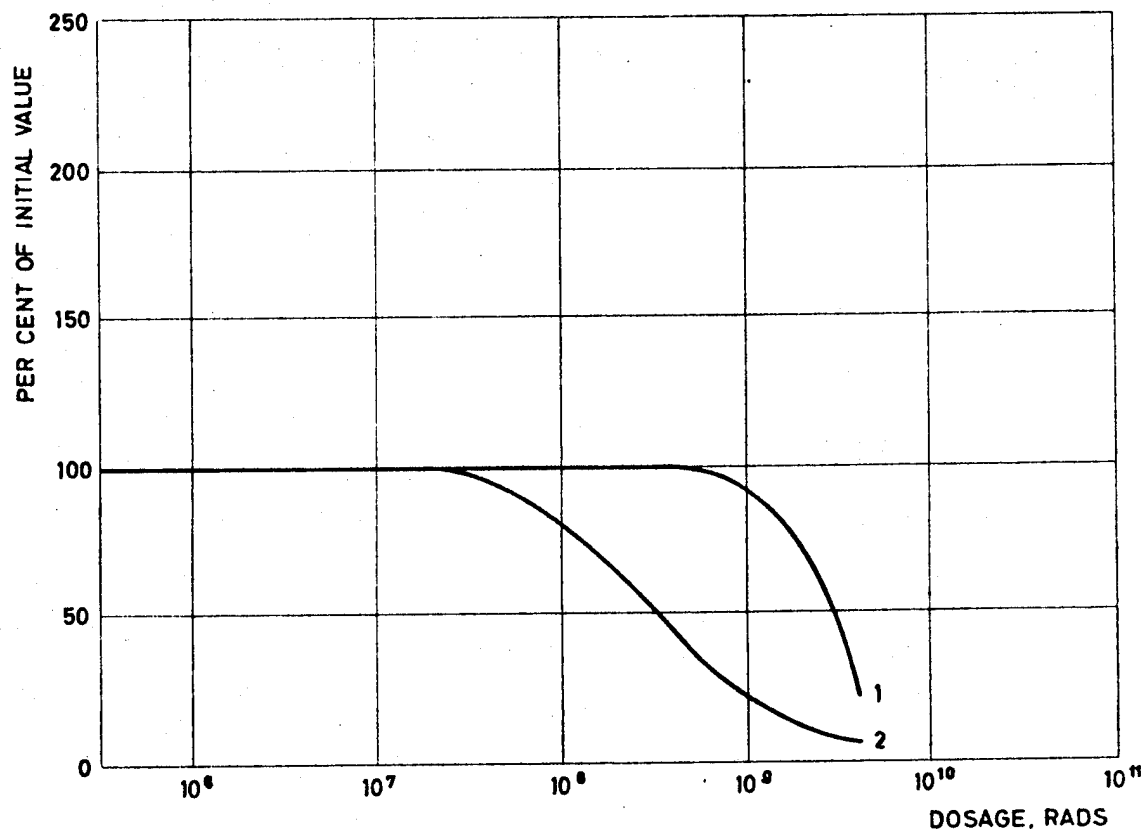
Effect of radiation on mechanical properties



CURVE NO.	PROPERTY	INITIAL VALUE
1	TENSILE STRENGTH	1,800 PSI
2	ELONGATION	0.32 %
3	ELASTIC MODULUS	5.8×10^5 PSI
4	SHEAR STRENGTH	3,500 PSI
5	IMPACT STRENGTH	0.19 FT-LB/IN. OF NOTCH

Fig. 26 Polyvinyl carbazole - "Polectron" (7, 8, 11)

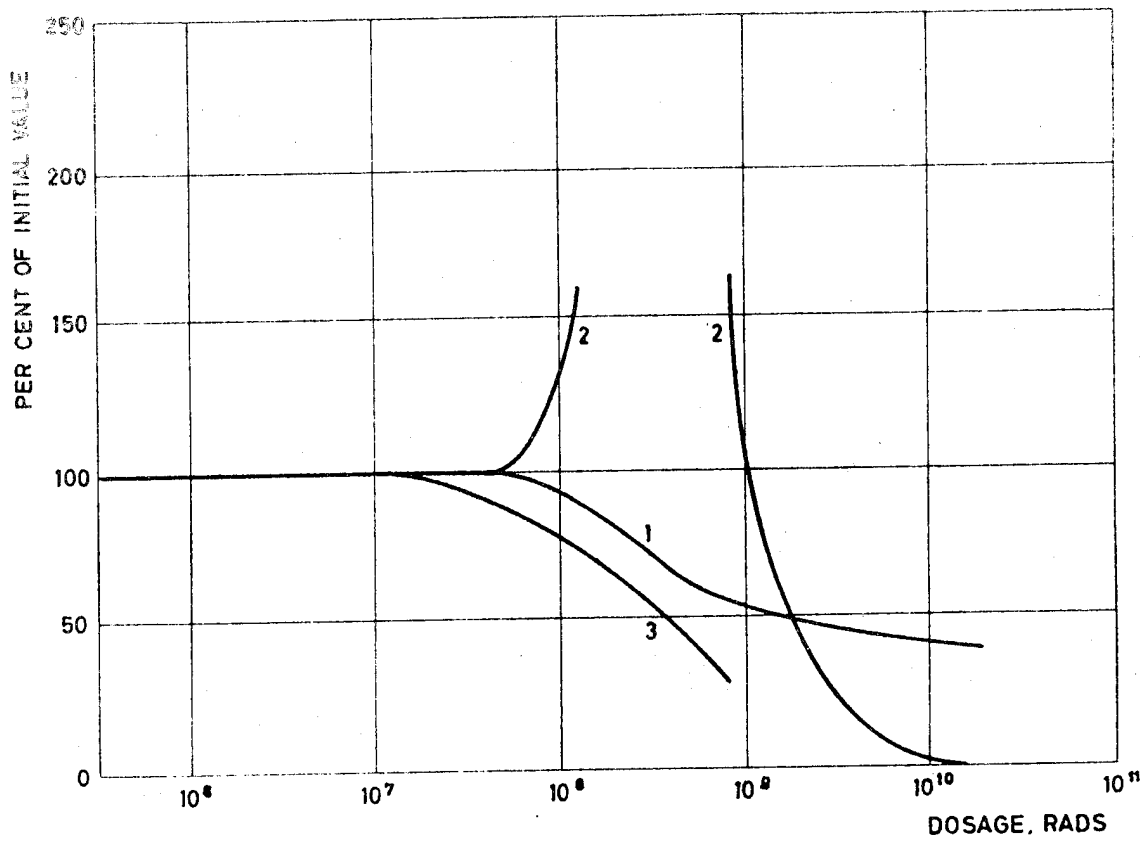
Effect of radiation on mechanical properties



CURVE NO.	PROPERTY	INITIAL VALUE
1	TENSILE STRENGTH	2,800 PSI
2	ELONGATION	310 %
3	ELASTIC MODULUS	—
4	SHEAR STRENGTH	—
5	IMPACT STRENGTH	—

Fig. 27 Polyvinyl chloride - "Geon" (7,8,11,42)

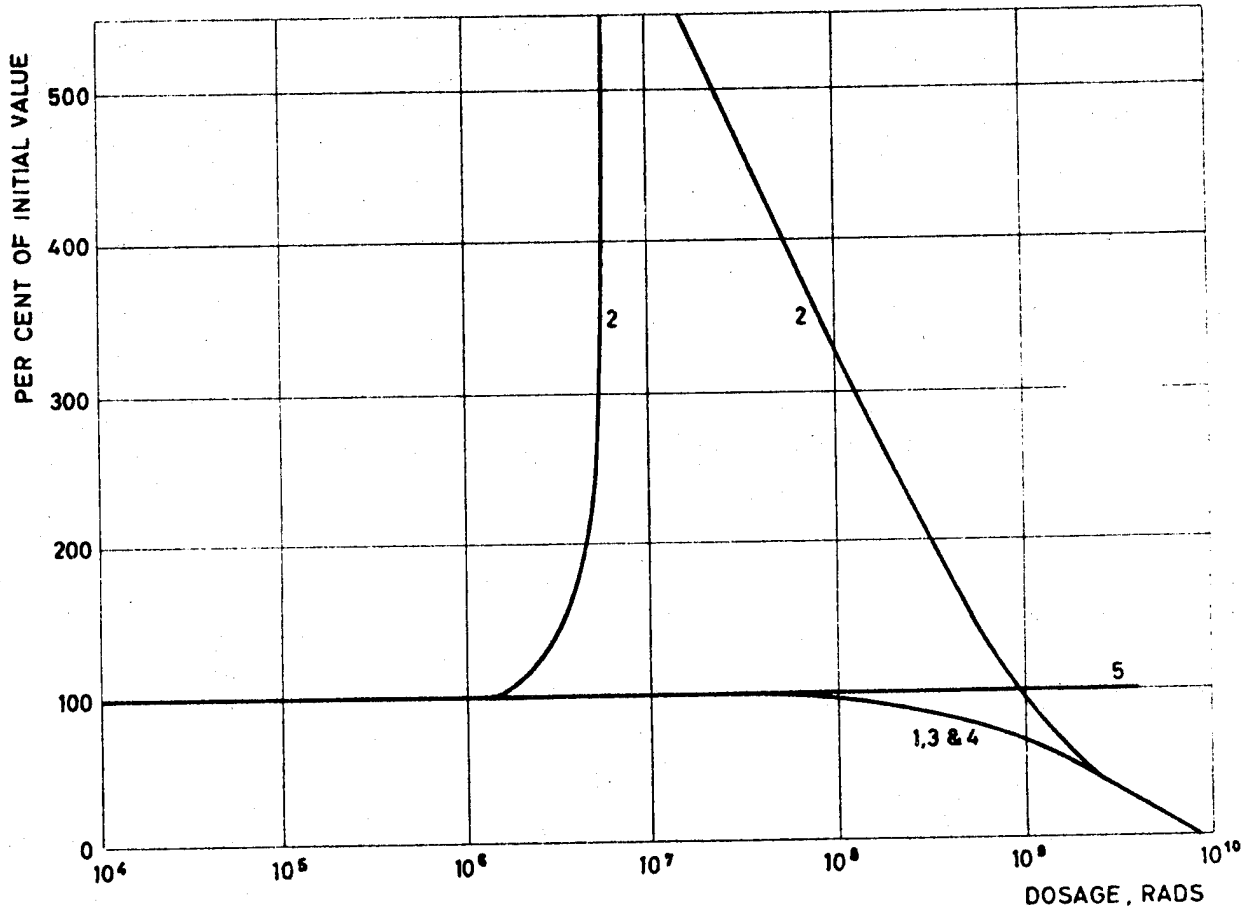
Effect of radiation on mechanical properties



CURVE NO.	PROPERTY	INITIAL VALUE
1	TENSILE STRENGTH	7400 PSI
2	ELONGATION	2 %
3	ELASTIC MODULUS	5×10^5 PSI
4	SHEAR STRENGTH	—
5	IMPACT STRENGTH	—

Fig. 28 Polyvinyl formal - "Formvar" (7,11)

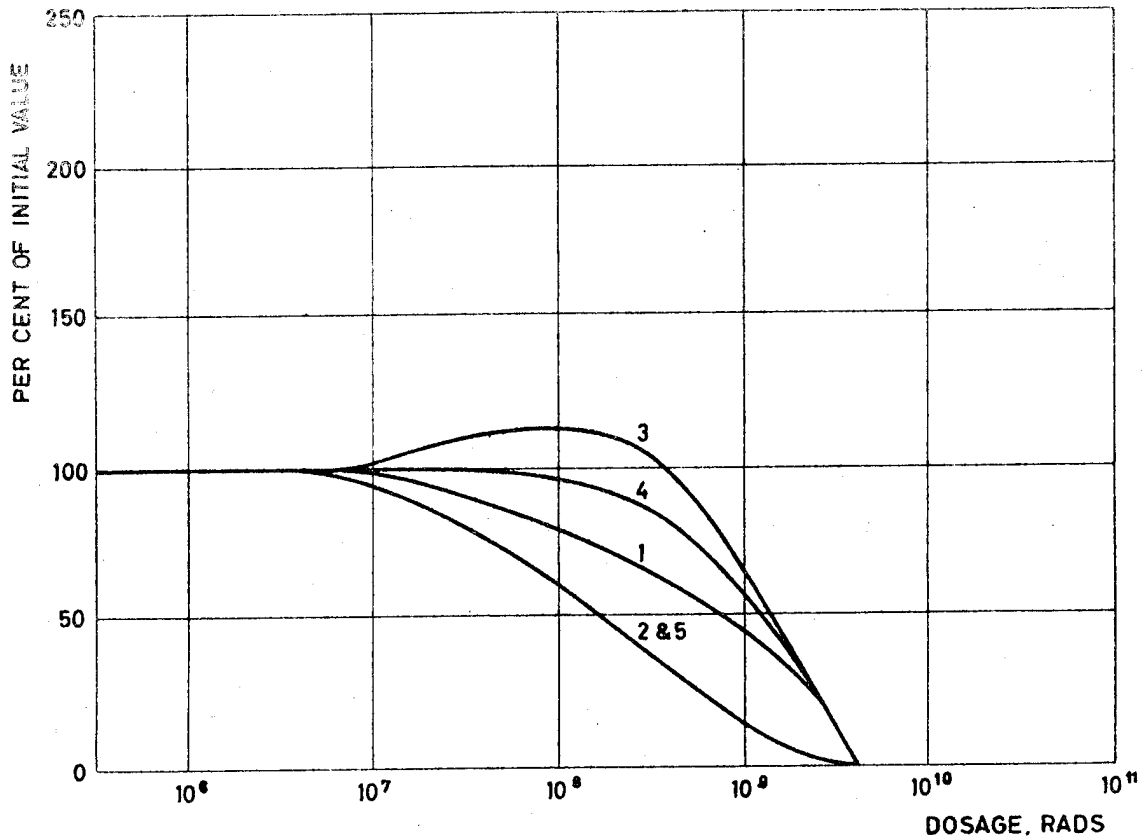
Effect of radiation on mechanical properties



CURVE NO.	PROPERTY	INITIAL VALUE
1	TENSILE STRENGTH	9,000 PSI
2	ELONGATION	3.1 %
3	ELASTIC MODULUS	4.8×10^5 PSI
4	SHEAR STRENGTH	6,800 PSI
5	IMPACT STRENGTH	0.5 FT-LB/IN. OF NOTCH

Fig. 29 Vinyl chloride acetate - "Vinylite" (7,8,11,43,44)

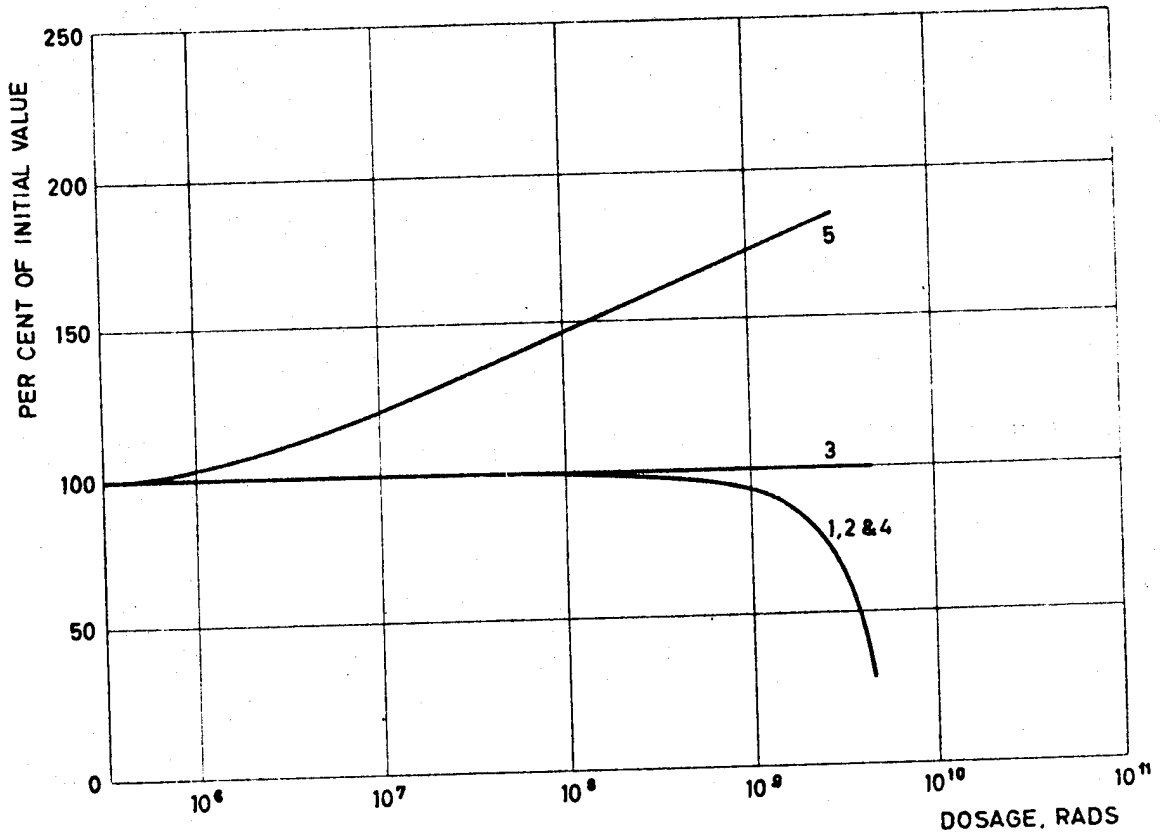
Effect of radiation on mechanical properties



CURVE NO.	PROPERTY	INITIAL VALUE
1	TENSILE STRENGTH	3,700 PSI
2	ELONGATION	200 %
3	ELASTIC MODULUS	0.65×10^5 PSI
4	SHEAR STRENGTH	2,900 PSI
5	IMPACT STRENGTH	1,6 FT-LB/IN. OF NOTCH

Fig. 30 Vinylidene chloride - "Saran" (7,8,11,43,45)

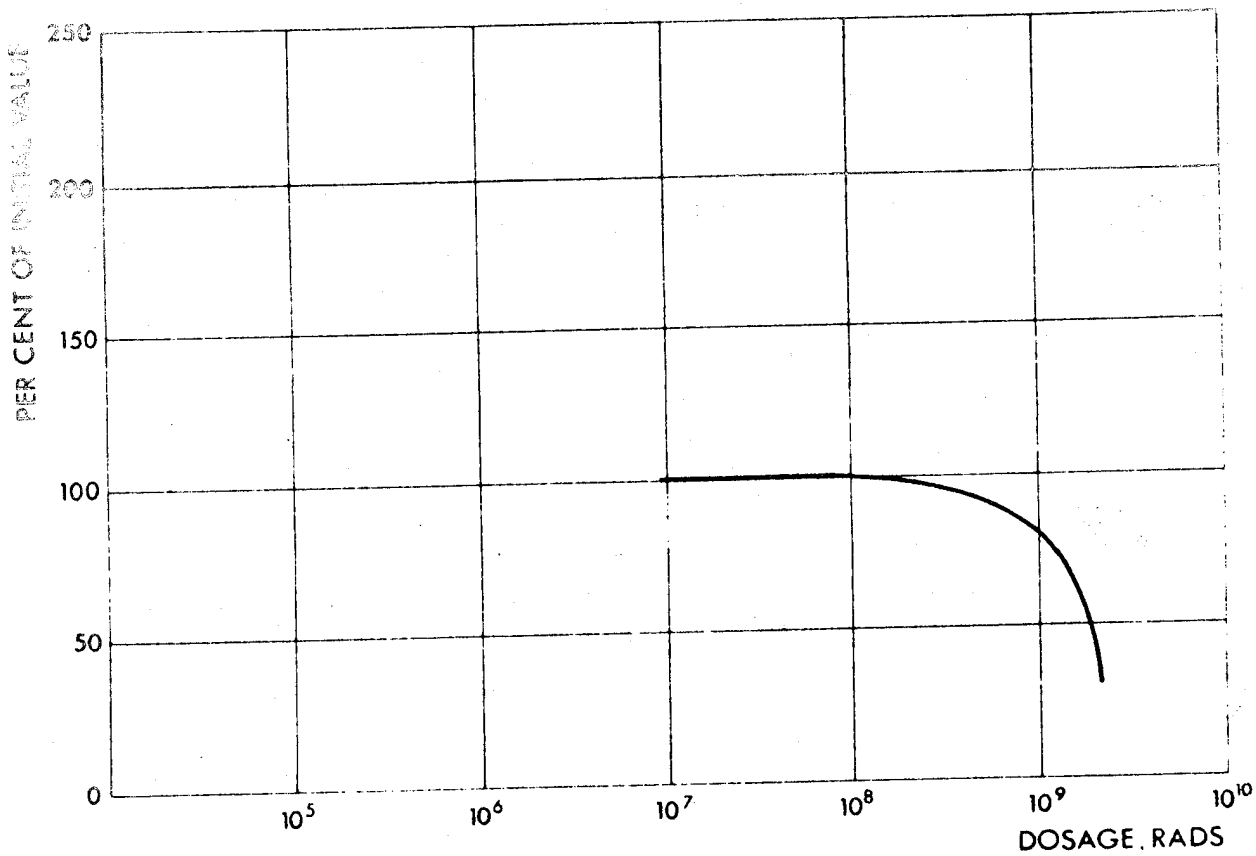
Effect of radiation on mechanical properties



CURVE NO.	PROPERTY	INITIAL VALUE
1	TENSILE STRENGTH	9,200 PSI
2	ELONGATION	1.8 %
3	ELASTIC MODULUS	6.0×10^5 PSI
4	SHEAR STRENGTH	9,700 PSI
5	IMPACT STRENGTH	0.20 FT-LB/IN. OF NOTCH

Fig. 31 Aniline formaldehyde - unfilled - "Cibanite" (7,8,11)

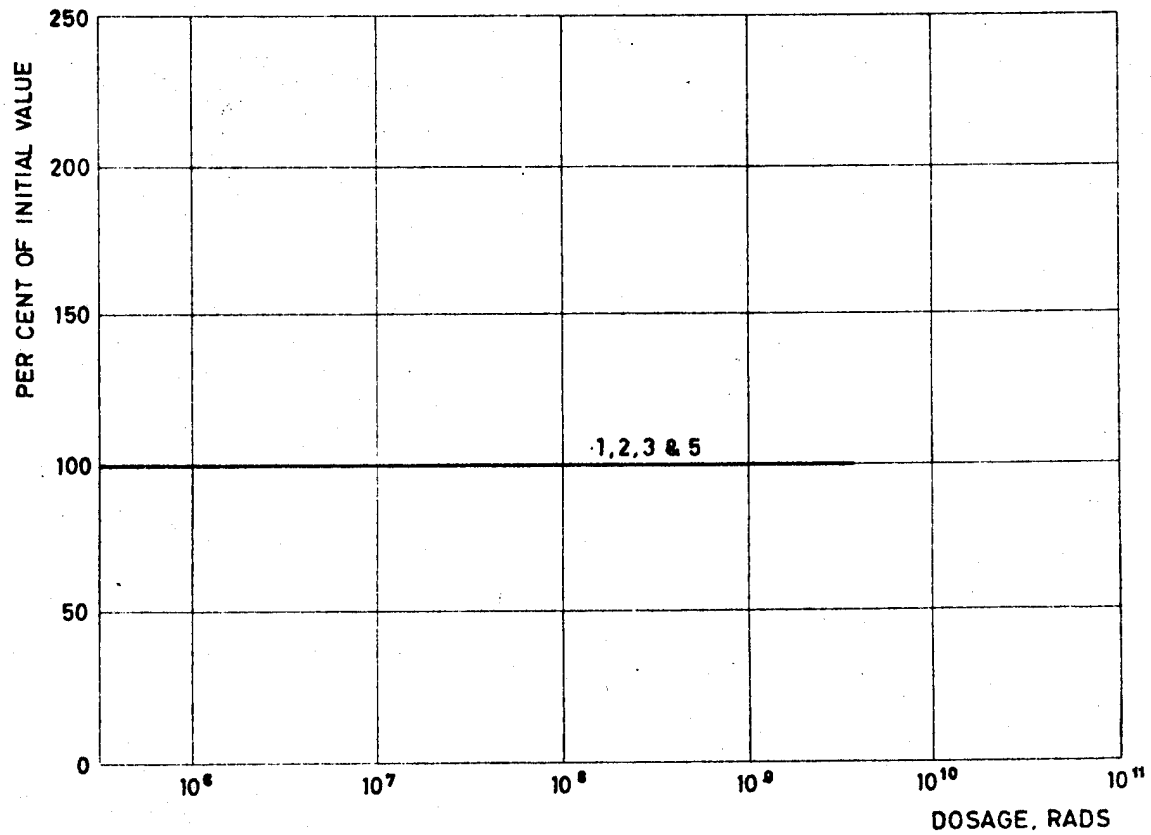
Effect of radiation on mechanical properties



CURVE NO	PROPERTY	INITIAL VALUE
1	FLEXURAL STRENGTH	238 PSI
2	—	—
3	—	—
4	—	—
5	—	—

Fig. 32 EPOXY - "ARALDITE" (46)

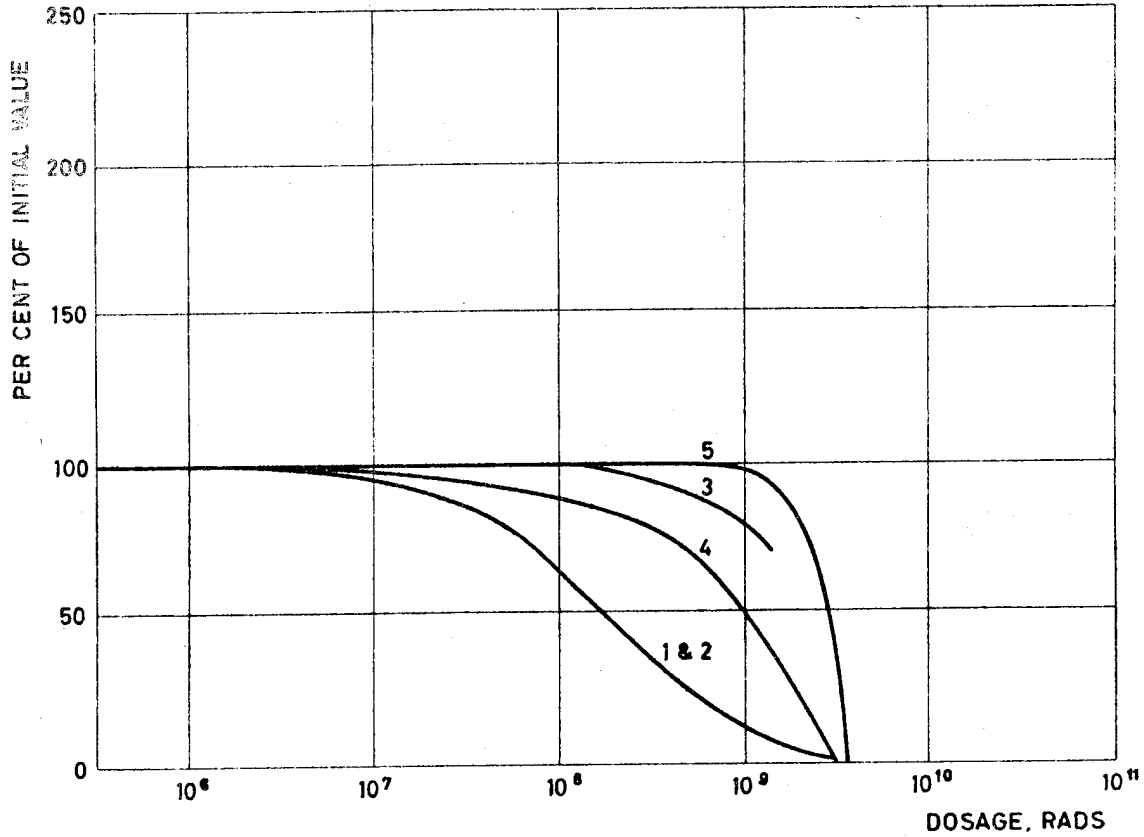
Effect of radiation on mechanical properties



CURVE NO.	PROPERTY	INITIAL VALUE
1	TENSILE STRENGTH	2,200 PSI
2	ELONGATION	0.39 %
3	ELASTIC MODULUS	8×10^5 PSI
4	SHEAR STRENGTH	—
5	IMPACT STRENGTH	0.31 FT-LB/IN. OF NOTCH

Fig. 33 Furan-asbestos and carbon black filler - "Duralon" (7,8,11,12)

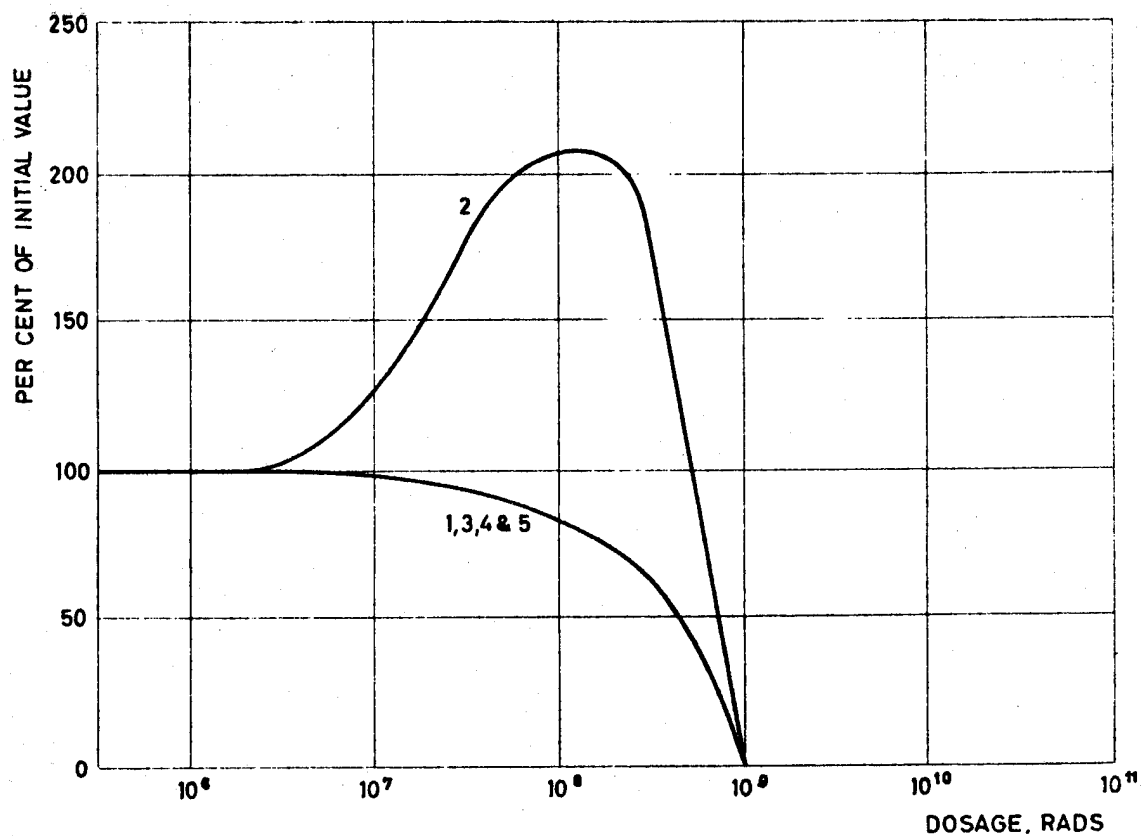
Effect of radiation on mechanical properties



CURVE NO.	PROPERTY	INITIAL VALUE
1	TENSILE STRENGTH	9,100 PSI
2	ELONGATION	0.65%
3	ELASTIC MODULUS	14x10 ⁵ PSI
4	SHEAR STRENGTH	11,000 PSI
5	IMPACT STRENGTH	0.29 FT-LB/IN. OF NOTCH

Fig. 34 Melamine formaldehyde-cellulose filler - "Melmac"(7,8,11,12)

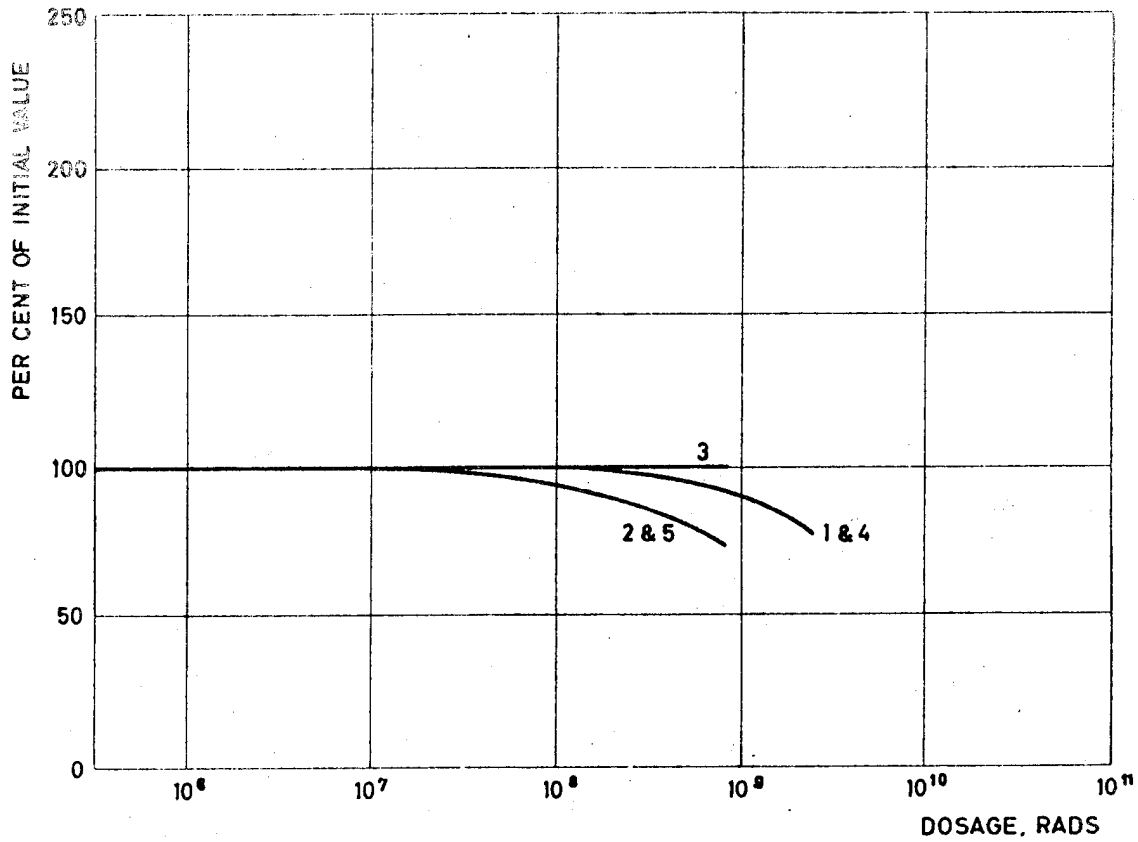
Effect of radiation on mechanical properties



CURVE NO.	PROPERTY	INITIAL VALUE
1	TENSILE STRENGTH	10,000 PSI
2	ELONGATION	2%
3	ELASTIC MODULUS	6×10^5 PSI
4	SHEAR STRENGTH	8,600 PSI
5	IMPACT STRENGTH	0.53 FT-LB/IN. OF NOTCH

Fig. 35 Phenol formaldehyde - "Catalin" (7,8,9,10,11,45)

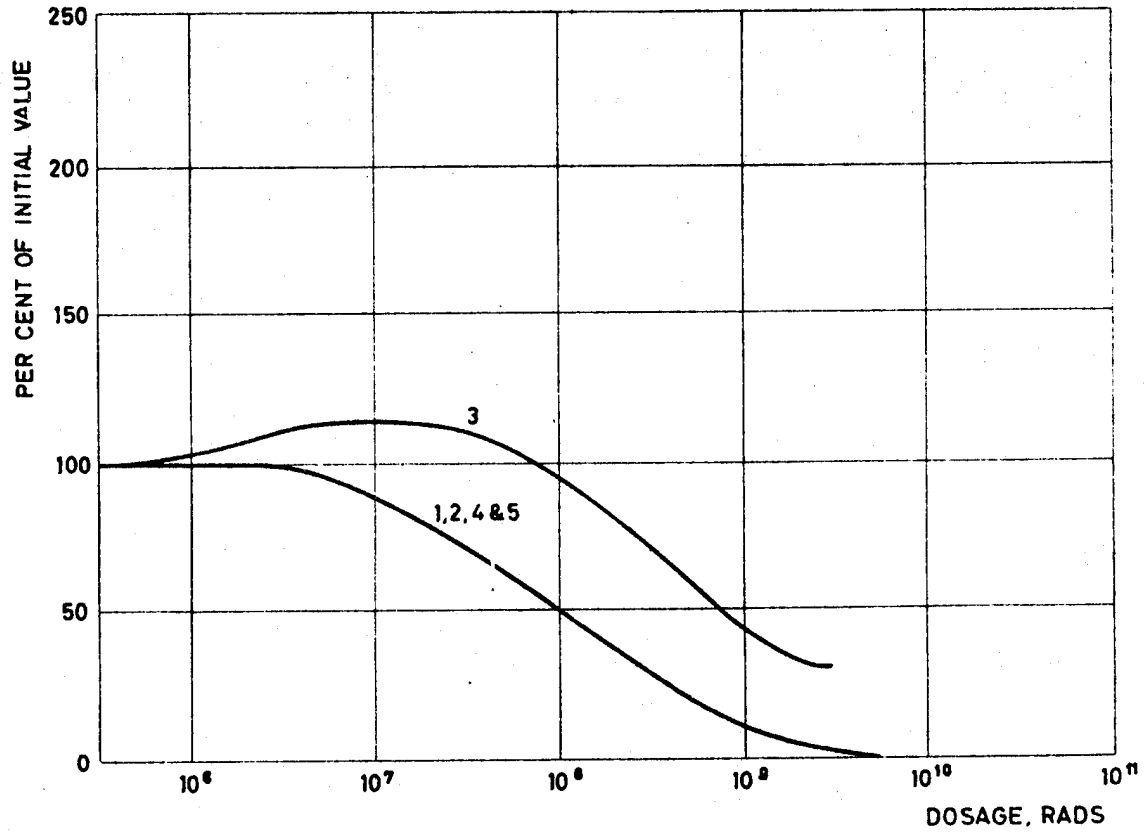
Effect of radiation on mechanical properties



CURVE NO.	PROPERTY	INITIAL VALUE
1	TENSILE STRENGTH	11,000 PSI
2	ELONGATION	1.3 %
3	ELASTIC MODULUS	18 x 10 ⁵ PSI
4	SHEAR STRENGTH	15,000 PSI
5	IMPACT STRENGTH	5.2 FT-LB / IN. OF NOTCH

Fig. 36 Phenol formaldehyde - asbestos laminate filler - "Bakelite" (7, 8, 9, 11)

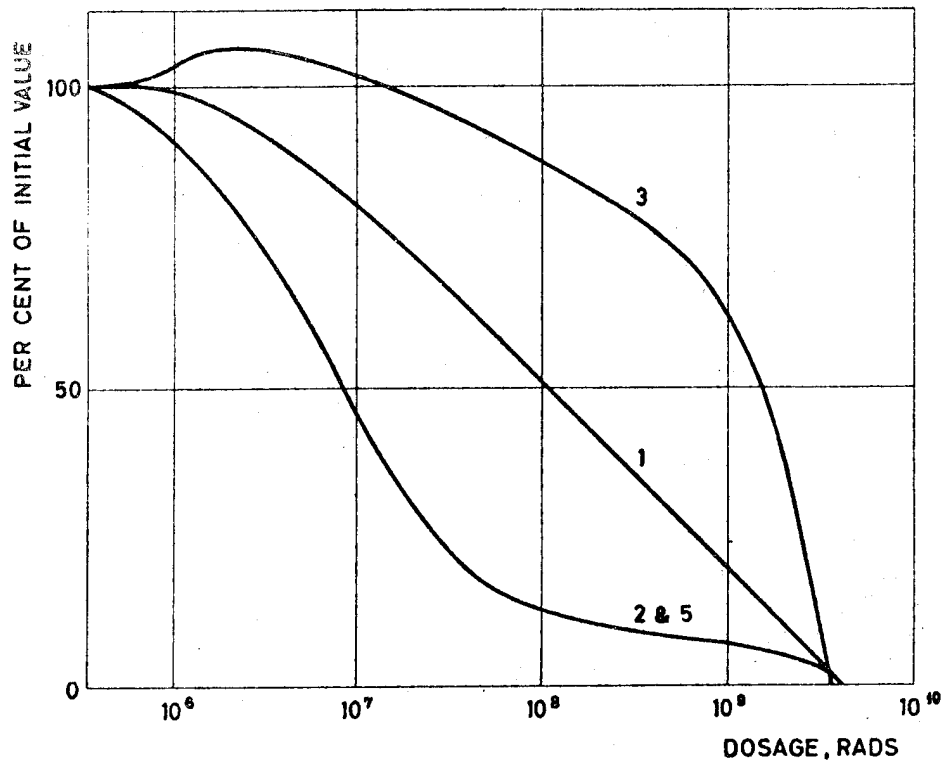
Effect of radiation on mechanical properties



CURVE NO.	PROPERTY	INITIAL VALUE
1	TENSILE STRENGTH	12,100 PSI
2	ELONGATION	1.8 %
3	ELASTIC MODULUS	16 x 10 ⁵ PSI
4	SHEAR STRENGTH	14,400 PSI
5	IMPACT STRENGTH	0.58 FT-LB/IN. OF NOTCH

Fig. 37 Phenol formaldehyde - paper filler - "Bakelite" (7, 8, 9, 11)

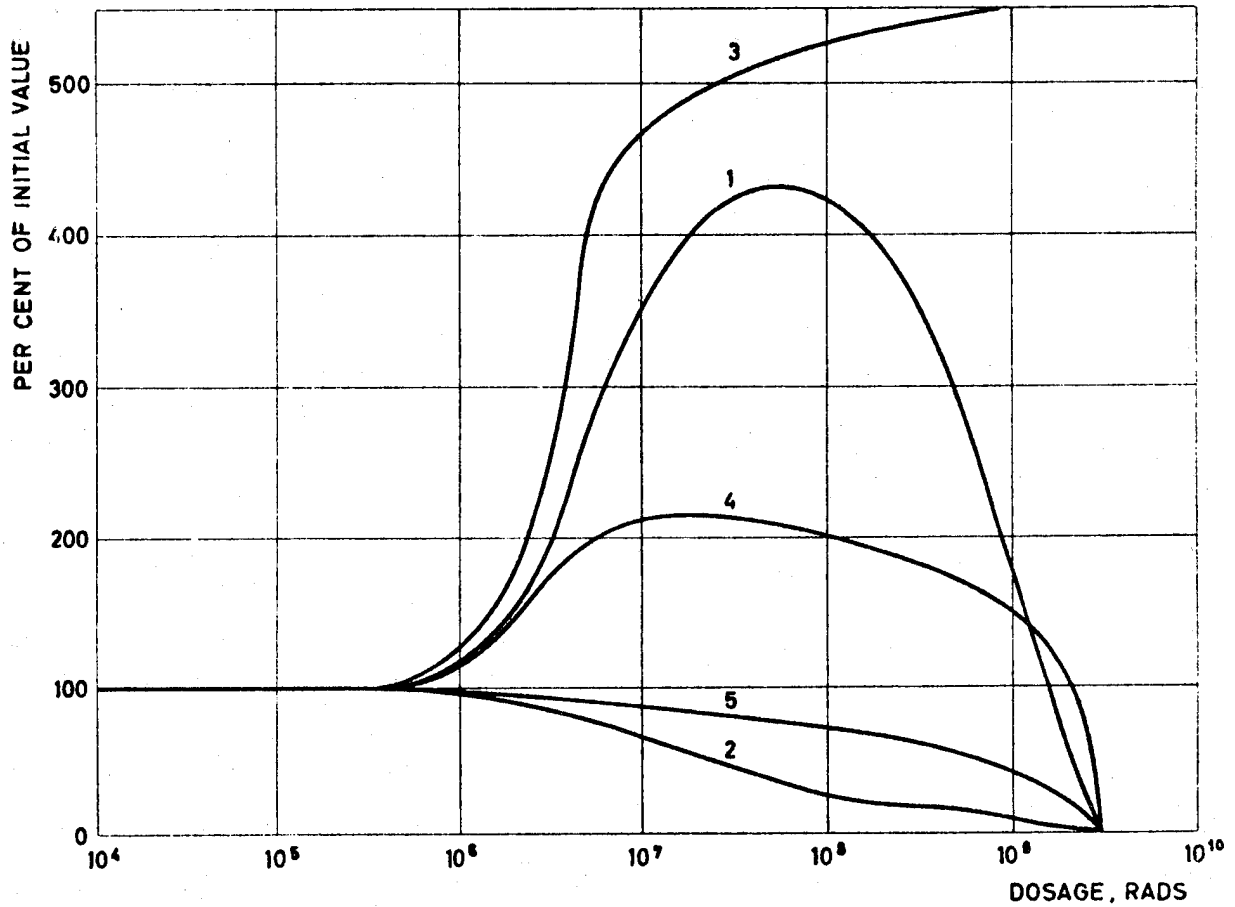
Effect of radiation on mechanical properties



CURVE NO.	PROPERTY	INITIAL VALUE
1	TENSILE STRENGTH	11,000 PSI
2	ELONGATION	4.0 %
3	ELASTIC MODULUS	11×10^5 PSI
4	SHEAR STRENGTH	—
5	IMPACT STRENGTH	2.75 FT-LB/IN. OF NOTCH

Fig. 38 Phenol formaldehyde-linen laminate filler - "Bakelite" (7,8)

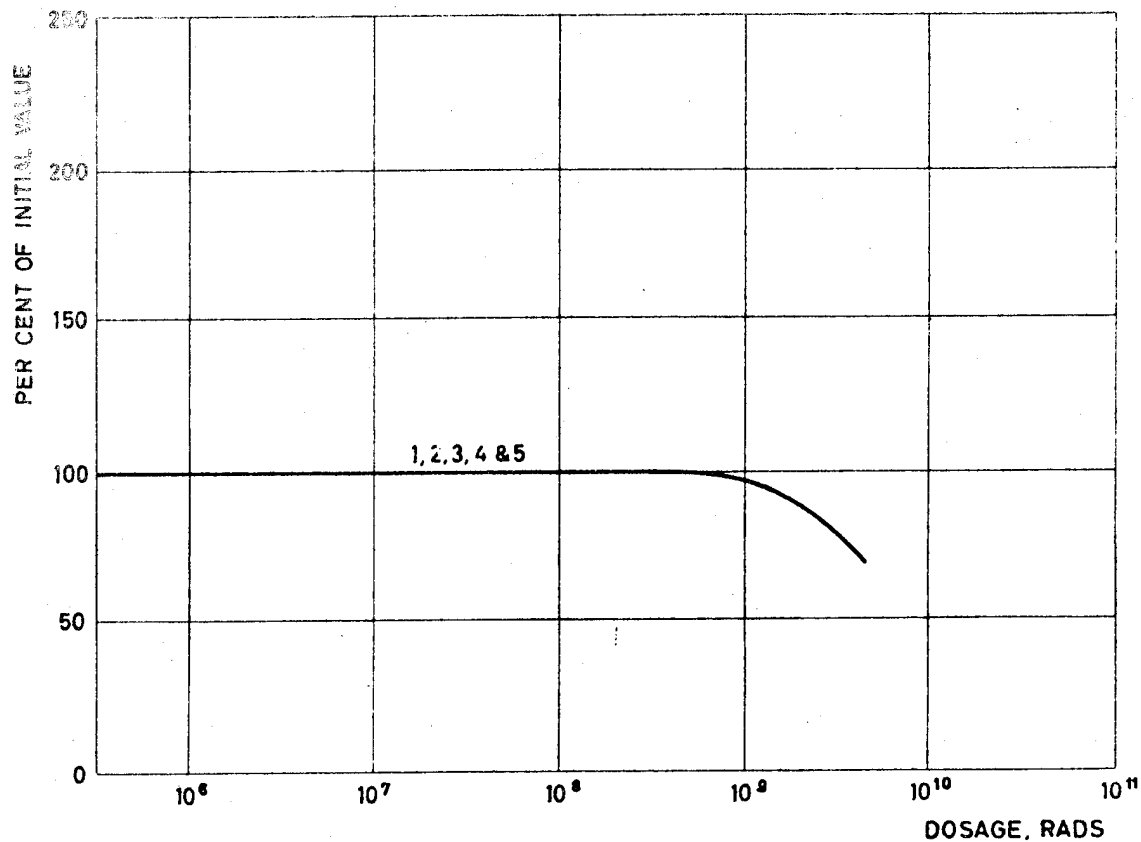
Effect of radiation on mechanical properties



CURVE NO.	PROPERTY	INITIAL VALUE
1	TENSILE STRENGTH	2,000 PSI
2	ELONGATION	20%
3	ELASTIC MODULUS	0.58×10^5 PSI
4	SHEAR STRENGTH	3,100 PSI
5	IMPACT STRENGTH	0.73 FT-LB/IN OF NOTCH

Fig. 39 Polyester - "Selectron" (7,8,9,11,47,48,49)

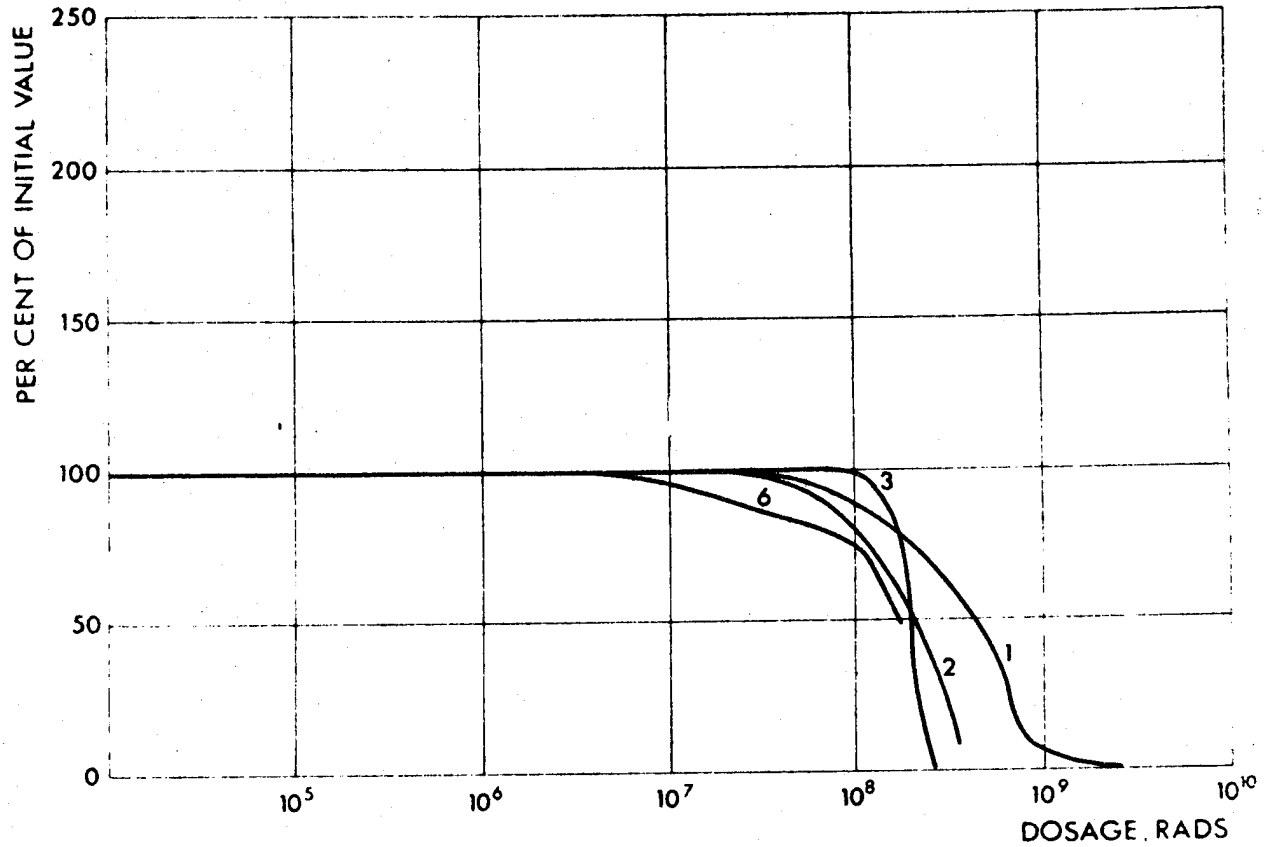
Effect of radiation on mechanical properties



CURVE NO.	PROPERTY	INITIAL VALUE
1	TENSILE STRENGTH	4,700 PSI
2	ELONGATION	0.17%
3	ELASTIC MODULUS	32 × 10 ⁵ PSI
4	SHEAR STRENGTH	7,000 PSI
5	IMPACT STRENGTH	0.36 FT-LB/IN. OF NOTCH

Fig. 40 Polyester-mineral filler - "Plaskon Alkyd" (7, 8, 9, 11)

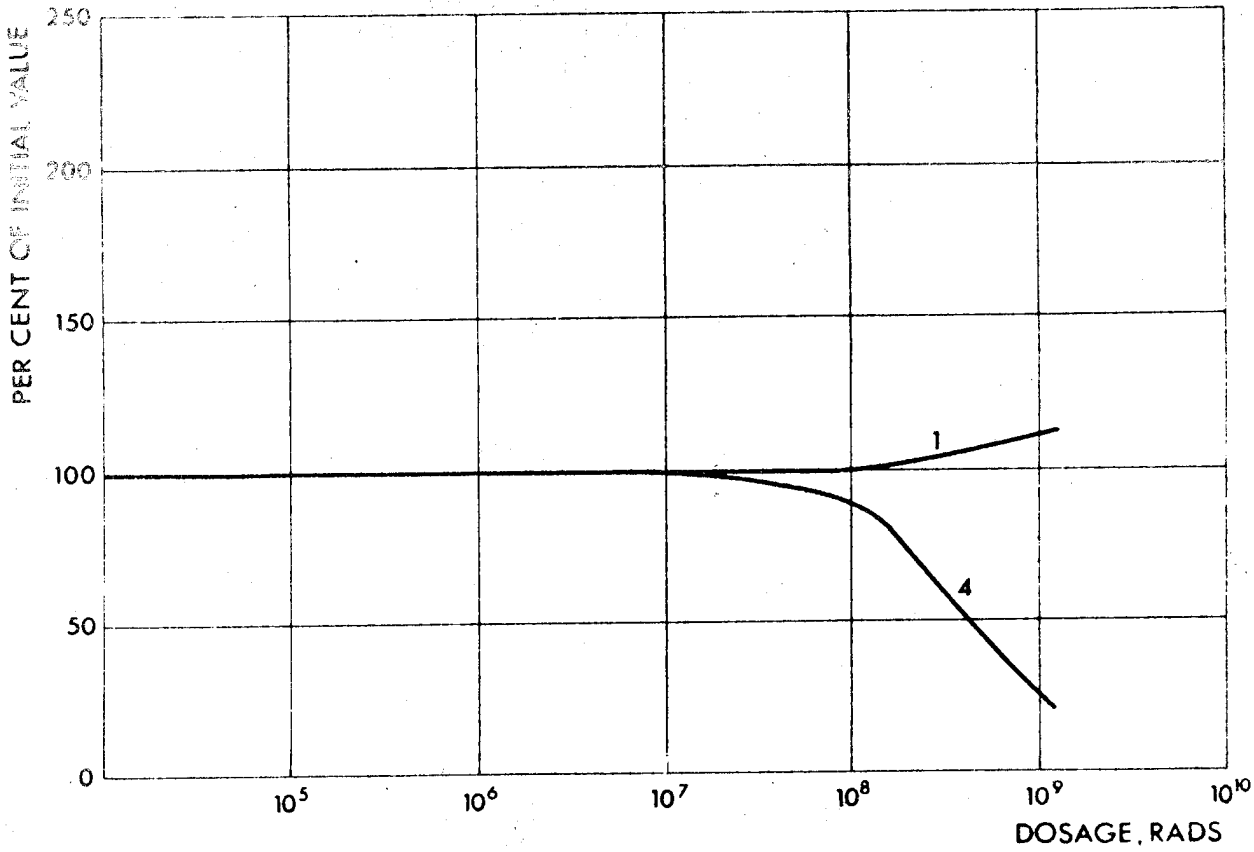
Effect of radiation on mechanical properties



CURVE N ^o	PROPERTY	INITIAL VALUE
1	TENSILE STRENGTH	25.000 PSI
2	ELONGATION	50%
3	ELASTIC MODULUS	2,95 10 ⁵ PSI
4	SHEAR STRENGTH	—
5	IMPACT STRENGTH	—
6	BURSTING PRESSURE	105 PSI

Fig.41 POLYETHYLENE TEREPHTHALATE "MYLAR FILM"(30,50,51,52)

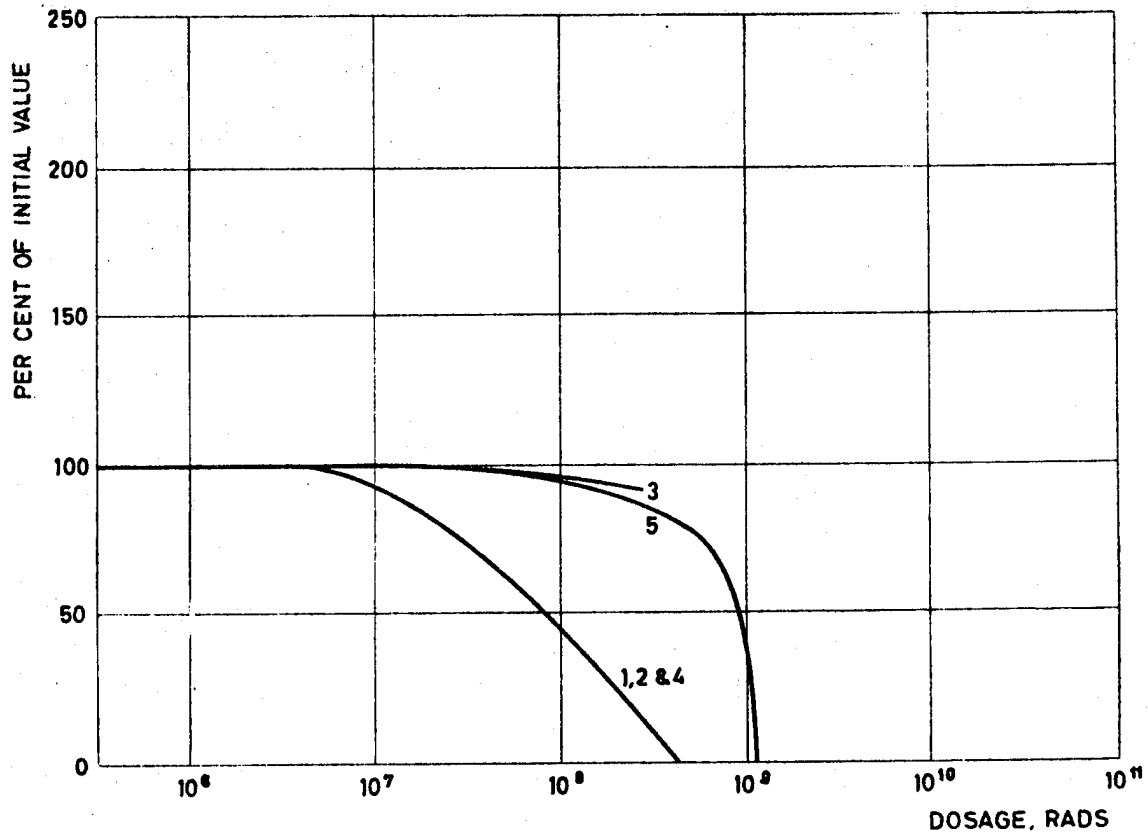
Effect of radiation on mechanical properties



CURVE NO	PROPERTY	INITIAL VALUE
1	TENSILE STRENGTH	16.000 PSI
2	ELONGATION	—
3	ELASTIC MODULUS	—
4	SHEAR STRENGTH	13.500 PSI
5	IMPACT STRENGTH	—

Fig.42 SILICONE, GLASS FILLED (7,8,9,11,53,54,55)

Effect of radiation on mechanical properties



CURVE NO.	PROPERTY	INITIAL VALUE
1	TENSILE STRENGTH	7,800 PSI
2	ELONGATION	0.5 %
3	ELASTIC MODULUS	14 x 10 ⁵ PSI
4	SHEAR STRENGTH	10,000 PSI
5	IMPACT STRENGTH	0.30 FT-LB/IN. OF NOTCH

Fig.43 Urea formaldehyde - "Beetle" (7,8,12)

Table 9 (7) (8) (11) (12)

Material (Trade names)	Absorbed dose, Rads x10 ⁺³	Rockwell hardness, R scale	Water absorption %	Specific gravity
Casein (Ameroid)	0	125	9,0	1,34
	0,045	125	9,5	1,34
	0,45	125	13,0	1,34
	4,5	-	-	-
	45	-	-	-
Cellulose Acetate (Plastacele)	0	102	3	1,31
	0,035	102	3	1,31
	0,35	104	4	1,31
	3,5	-	-	-
	35	-	-	-
Cellulose Propionate (Tenite Propionate)	0	83	1	1,19
	0,037	80	1	1,19
	0,37	-	1	1,19
	3,7	-	-	-
	37	-	-	-
Cellulose Acetate Butyrate (Tenite Butyrate)	0	88	1,1	1,19
	0,037	86	1,1	1,19
	0,37	80	1,2	1,19
	3,7	-	-	-
	37	-	-	-
Cellulose Nitrate (Pyralin)	0	111	1,2	1,41
	0,03	112	1,2	1,41
	0,3	116	1,2	1,41
	3	-	-	-
	30	-	-	-
Ethyl Cellulose (Ethocel)	0	113	1,2	1,13
	0,042	113	1,2	1,13
	0,42	112	1,2	1,13
	4,2	-	-	-
	42	-	-	-
Polyethylene (Polythene)	0	-20	0,02	0,91
	0,06	-20	0,02	0,91
	0,6	+10	0,02	0,91
	6	60	0,02	0,92
	60	120	0,03	0,96

Material (Trade names)	Absorbed- dose, Rads x 10 ⁺⁸	Rockwell hardness, R scale	Water absorption %	Specific gravity
Polychlorotrifluoro- ethylene (Fluorothene)	0	110	0,01	2,12
	0,06	110	0,01	2,12
	0,6	106	0,01	2,12
	6	-	-	-
	60	-	-	-
Polytetrafluoro- ethylene (Teflon)	0	35	0,04	2,17
	0,02	20	0,04	2,18
	0,2	35	0,04	2,20
	2	-	0,04	2,23
	20	-	-	-
Polyvinylchloride acetate (Vinylite)	0	120	0,05	1,36
	0,15	115	0,1	1,36
	1,5	112	0,4	1,36
	15	92	0,8	1,34
	150	-	-	-
Polyvinyl formal (Formvar)	0	-	-	1,21
	0,04	-	-	1,21
	0,4	-	-	1,20
	4	-	-	1,17
	40	-	-	1,14
Polymethylmetha- crylate (Perspex)	0	122	0,4	1,19
	0,04	122	0,4	1,19
	0,4	122	0,4	1,19
	4	-	-	-
	40	-	-	-
Polystyrene unpigmented (Amphenol)	0	122	0,05	1,05
	0,04	122	0,05	1,05
	0,4	122	0,05	1,05
	4	122	0,07	1,05
	40	122	0,10	1,06
Allyldiglycol- carbonate (CR 39)	0	118	0,4	1,31
	0,037	118	0,4	1,31
	0,37	115	0,5	1,31
	3,7	90	1,2	1,29
	37	-	2,8	1,23
Polyester (Plaskon Alkyd)	0	122	0,2	2,22
	0,035	122	0,2	2,22
	0,35	122	0,2	2,22
	3,5	122	0,3	2,21
	35	108	0,7	2,18

Material (Trade names)	Absorbed- dose, Rads $\times 10^{+8}$	Rockwell hardness, R scale	Water absorption %	Specific gravity
Polyester (Selectron)	0	50	0,6	1,25
	0,035	110	0,6	1,25
	0,35	120	0,6	1,25
	3,5	110	0,6	1,26
	35	-	0,8	1,21
Polyamide (Nylon)	0	105	1,5	1,142
	0,055	105	1,5	1,142
	0,55	108	1,5	1,142
	5,5	118	1,5	1,146
	55	123	13	1,156
Polyformaldehyde (Delrin)	0	75 D*	-	-
	0,02	81 D*	-	-
	0,05	84 D*	-	-
Polypropylene (Pro-Fax)	0	75 D*	-	-
	0,55	75 D*	-	-
	1	74 D*	-	-
	5	67 D*	-	-
	10	54 D*	-	-
Polyurethane (Estane VC)	0	87 D*	-	-
	1	88 D*	-	-
	5	90 D*	-	-
	10	92 D*	-	-

* Shore D hardness used

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Table 10

Material (Trade names)	Absorbed dose, Rads x 10 ⁺⁸	Rockwell hardness, R scale	Water absorption %	Specific gravity
Aniline formaldehyde, no filler (Cibanite)	0	128	0,1	1,21
	0,045	128	0,1	1,21
	0,45	128	0,1	1,21
	4,5	127	0,1	1,21
	45	126	0,1	1,21
Furan, asbestos filler (Duralon)	0	117	0,8	1,85
	0,035	117	0,8	1,85
	0,35	117	0,7	1,85
	3,5	117	0,7	1,85
	35	118	1	1,85
Malamine formaldehyde, cellulose filler (Melmac)	0	128	1	1,46
	0,075	128	1	1,46
	0,75	128	1	1,46
	7,5	126	2	1,46
	75	106	11	1,20
Phenol formaldehyde, unfilled (Catalin)	0	123	0,3	1,3
	0,035	121	0,4	1,3
	0,35	118	0,5	1,3
	3,5	113	0,8	1,3
	35	-	-	powder
Phenol formaldehyde, Linen fabric laminate (Bakelite)	0	122	1	1,34
	0,035	122	1	1,34
	0,35	122	1	1,34
	3,5	122	2	1,34
	35	-	30	0,8
Phenol formaldehyde, Paper laminate (Bakelite)	0	122	1	1,37
	0,035	122	1	1,37
	0,35	122	1	1,37
	3,5	118	3	1,36
	35	106	80	0,8
Phenol formaldehyde, asbestos filler (Haveg)	0	110	4,2	1,66
	0,035	110	4,2	1,66
	0,35	110	4,2	1,66
	3,5	110	4,2	1,66
	35	110	4,2	1,66

Material (Trade names)	Absorbed dose, Rads x 10 ⁺³	Rockwell hardness, R scale	Water absorption %	Specific gravity
Phenol formaldehyde, Graphite filler (Karbate)	0	84	4,5	1,70
	0,035	84	4,5	1,70
	0,35	85	4,5	1,69
	3,5	88	4,5	1,68
	35	100	4,5	1,68
Urea-formaldehyde, Cellulose filler (Beetle)	0	128	1,0	1,50
	0,06	128	1,0	1,50
	0,6	127	1,5	1,50
	6	120	20	1,47
	60	-	-	-

TABLE 11 (7) (1) (11) (4c) (55) (56) (57) (5)

Effect of nuclear radiation on volume resistivity, dielectric strength and Arc resistance of plastics.

A. THERMOPLASTIC

Material (Trade Names)	Specimen Thickness (Inches)	Radiation Type and Energy in Mev	Dose Rate* 10^7 xrad/hr	Dose 10^8 x rad	Volume Resistivity (ohm-cm)	Dielectric Strength Volts/mil	Arc Resistance seconds	Failure of Failure
Allyl diglycol carbonate polymer (CS-39)	0.30	Pile	-	0	-	50	-	-
				15	10^{14}	600	-	-
				0	10^{13}	-	120	Melted
				5	$2 \cdot 10^{12}$	-	-	-
	0.125	Pile	-	5	$2 \cdot 10^{12}$	-	-	-
				15	-	-	120	Melted
Casey (Asteroïd)	0.120	Pile	-	0	$1 \cdot 10^{11}$	600	70	Carbonized
				1	$1 \cdot 10^{11}$	-	60	Carbonized
				2	-	300	-	-
Cellulose acetate (Plastacel)	0.150	Pile	-	0	$5 \cdot 10^{12}$	-	190	Melted
				0.35	$2 \cdot 10^{11}$	-	-	-
				0.7	$2 \cdot 10^{11}$	-	-	-
				1.7	$2 \cdot 10^{11}$	-	-	-
	0.020	Pile	-	1	-	-	90	Melted
				1.5	-	1000	-	-
Cellulose acetate (Terite butyrate)	0.195	Pile	-	0	-	1000	-	-
				2	10^{14}	700	-	-
				0	10^{13}	-	140	Melted
	0.025	Pile	-	0.25	$5 \cdot 10^{13}$	-	115	Melted
				1	$2 \cdot 10^{12}$	-	55	Melted
Cellulose nitrate (Pyralin)	0.122	Pile	-	0	-	900	-	-
				1.5	$2 \cdot 10^{11}$	700	-	-
				0.9	$1 \cdot 10^{11}$	-	22	Melted
					$1 \cdot 10^{11}$	-	13	Melted

* The irradiation in the pile took place at an approximate equivalent rate of 10^5 to 10^7 rads/hr.

TABLE 11 (Continued) (2)

Cellulose Propionate (Fenite Propionate)	0,020 0,120	Pile Pile	- -	0 0,55 0 0,06 0,15 0,15 1,25	- -10 -10 -10 -	1,000 1,000 -	- 125 120 -	- Melted Melted -
Ethyl Cellulose (Ethocel)	0,021 0,150	Pile Pile	- -	0 1 0 0,2 1,2	- -14 1,10 -14 1,10	1,250 1,250 -	- 120 100 0	- Melted Melted Melted
Polyamid (Nylon)	0,032 0,140	Pile Pile	- -	0 2 0 1,5 9,5 40	- -13 1,10 - 4,10	260 550 -	- 120 100 50 70	- Carbonized Carbonized Carbonized Carbonized
Polychlortri- fluoroethylene (Fluorothene)	0,030 0,125	Pile Pile	- -	0 3 0 2	- -10 -10	900 900 -	- 300 200	- Melted Melted
Polyethylene (Polythene)	0,050 0,055 0,110 0,115	Pile Pile 2,0 (e") 2,5 (Z)	- - 5,3 1,2 0,54	0 30 0 30 30 0,7 0 0,2 0,4	- -10 -10 -10 -10 -10 -10 -10 -10	400 500 -	- 130 130	- Melted Melted
Polyethylene terephthalate (Kydex)	0,002	Pile	-	0 2,1 3,6	1,10 1,10 1,10	- -	- -	- -

7/5020/5

cm

TABLE 11 (Continued) (3)

Polyester, General filled (Pleasor Alfyd)	0,120	Pile	-	0	-10 ¹⁴ -10 ¹⁴ 3.10 ¹³	250 250 245	190 - 190	Carbonized - Carbonized
	0,021	Pile	-	0	-	500	-	-
	0,250	Pile	-	12 0 3 13	1.10 ¹¹ 6.10 ¹² -1.10 ¹⁴	300 - -	63 - 69	Melted - Melted
Polymethyl acrylate (Perapex)	0,021	Pile	-	0	-	1.000	-	-
	0,050	Pile	-	0,7 0 0,5 1	-10 ¹⁴ -10 ¹⁴ -10 ¹⁴	- - -	120 80 30	Melted Melted Melted
	0,115	2,5(X)	1,06	0 0,2 0	-10 ¹⁵ -10 ¹⁵ -10 ¹⁵	- - -	- - -	- - -
			0,54	0 0,4	-10 ¹⁵ -10 ¹⁵	- -	- -	- -
	0,019	Pile	-	0	-	1.500	-	-
Polystyrene, no pigment (Amphanc)	0,090	Pile	-	36 0 35 52	-10 ¹⁴ -10 ¹⁴ -10 ¹⁴	1.500 - -	3-10 - 26	Melted - Carbonized
	0,085	Pile	-	0	-	1.100	-	-
	0,100	Pile	-	54 0 54 66	-10 ¹⁴ -10 ¹⁴ -10 ¹⁴	1.100 - -	60 - 80	Carbonized - Carbonized
	0,023	Pile	-	0	-	1.100	-	-
Polytetrafluoro- ethylene (0,125	Pile	-	1,5 0	-10 ¹⁴	500 -	- 300	- Electrode holder burnen
	0,115	Pile	-	0,5 0	1.10 ¹⁴ -10 ¹⁵	- -	250 -	Melted -
	0,115	Pile (37)	7,25	0 0,1	-10 ¹⁴ -10 ¹⁴	- -	- -	- -

62/5020*5 ems

TABLE 1 - (Continued) (4)

Polytetrafluoro-ethylene (cont..) (Teflon)		2,5(X)	0,5 1,08	0 0,4 0 0,2	15 4,2-10 ¹⁴ 10 ¹⁵ 4,2-10 ¹⁴			
Polyvinylcarbazole (Polacaron)	0,150	Pile	-	0 20	10 ¹⁴ 10 ¹⁴	200 200	20 20	Carbonized Carbonized
Polyvinyl-oxalide (Glen)	0,02	Pile	-	0 5,3	1-10 ¹³ 1-10 ⁶			
Polyvinylchloride acetate (Vinylite)	0,20 0,130	Pile Pile	- -	0 7,5 0 0,3 1 4,5	- 14 10 ¹⁴ 10 ¹⁴ <10 ⁶	1,100 500	- 70 20 10 0	- Carbonized Carbonized Carbonized Carbonized
Polyvinylformal (Formvar)	0,005	Pile	-	0 3	1-10 ¹⁴ 1-10 ¹⁴			
Polyvinyl vinylidene chloride (Saran)	0,030 0,130	Pile Pile	- -	0 22 0 0,27 0,39 0,51 1,4 0 0,4 0 0,4 0,4 0,7 0,8 0,8 0,8 0,017 0,35	- 14 2-10 ¹³ 2-10 ¹² 7-10 ¹² 3-10 ⁷ 3-10 ¹⁵ 10 ¹⁵ 7,8-10 ¹² 10 ¹⁴ 1,4-10 ¹³ 1,2-10 ¹³ 4-10 ¹³ 10 ¹⁵ 1,2-10 ¹³ 10 ¹⁵ 2-10 ¹⁴ 10 ¹⁵ 2-10 ¹⁴	€20 230		
	0,118	2,0 (e ⁻)	5,2 11,7					
	0,118	2,5(X)	23,4 0,06 0,35					

TABLE 11 (Continued) (5)

Polyvinyl vinylidene chloride (Saran)			1,1	0	10,15	-	-	-
				0,2	1,4,10,14	-	-	-
				0,29	7,2,10,13	-	-	-

(continued)

66/5020/5
CMS

TABLE 12 (7) (6) (11) (46) (55) (56)
EFFECTS OF NUCLEAR RADIATION ON VOLUME RESISTIVITY, DIELECTRIC STRENGTH AND ARC RESISTANCE OF PLASTICS

B. THERMOSETTINGS

Material (Trade Names)	Specimen Thickness (inches)	Radiation Type and Energy in Mev	Dose rate * 10^7 rad/hr	Dose 10^8 rad	Volume resistivity (ohm-cm)	Dielectric Strength Volts/ml	Arc Resistance seconds	Ma per failure
Aniline formaldehyde (Cibanite)	0.140	Pile	-	0 30 40	10^{14} 10^{14} -	300 200 -	20 - 20	carbonized - carbonized
Furan resin, asbestos filled (Duralon)	0.175	Pile	-	0 36 42	$1 \cdot 10^9$ - $1 \cdot 10^9$	55 55 -	4 - -	carbonized - carbonized
Urethane formaldehyde (Velmac)	0.175	Pile	-	0 1.7 4 6 10 22	$1 \cdot 10^{11}$ - - - - $1 \cdot 10^{11}$	200 - - - 300 -	100 130 150 10 - 70	carbonized carbonized carbonized carbonized - carbonized
Phenol formaldehyde unfilled - (Gavalin)	0.100	Pile	-	0 2 7	$1 \cdot 10^{12}$ - $1 \cdot 10^{12}$	100 - 100	5 - -	carbonized - carbonized
Phenol formaldehyde paper laminate (Bacelite)	0.125	Pile	-	0 10 1 30	$1 \cdot 10^{13}$ $1 \cdot 10^{13}$ - $1 \cdot 10^{11}$	250 - 250 -	5 - - 2	carbonized - - carbonized

* The irradiation in the pile took place at an approximate equivalent rate of 10^6 to 10^7 rads/hr.
65/5004/5) /mm

TABLE 12 continued

Phenol formaldehyde asbestos fiber filler (Barellite)	0.130	Pile	-	0	2.10 ¹⁰		150	4	carbonized
					3:	3.10 ¹⁰			
Phenol formaldehyde graphite filler (Karoate)	0.124	Pile	-	0	-	-	70	-	-
				5%	-	-	70	-	-
Silicon oxide filler (G.E. 1-132 Super- filled 3-352)	0.016	Pile	-	0	10 ¹⁴	10 ¹¹	254	-	-
				20	-	-	196	-	-
Urea formaldehyde cellulose filler (Barellite)	0.123	Pile	-	0	2.10 ¹³	-	230	130	carbonized
				1.5	-	-	-	120	carbonized
				3	-	-	-	0	carbonized
				4.5	-	-	-	0	carbonized
				3	-	-	230	-	-
				1	1.10 ¹¹	-	-	20	carbonized

TABLE 13* (7) (5) (55) (57) (59) (60)

Material (Trade Name)	Thick- ness (mils)	Dielectric Constant		Dissipation Factor				
		Frequency=1kc Before irr. After irr.	Frequency=1mc Before irr. After irr.	Frequency=1kc Before irr. After irr.	Frequency=1mc Before irr. After irr.			
A. Thermo- Plastics								
acrylonitrile- butadiene- styrene (Koyalite)	50	2,93	2,85	2,89	0,0077	0,0074	0,013	0,013
Polyamide (Nylon 610)	70	3,94	3,21	3,11	0,059	0,013	0,036	0,021
Polyamide (Nylon 6)	65	4,1	3,70	3,55	0,11	0,023	0,064	0,033
Polyethylene- high density (Marlex)	55	2,35	2,32	2,35	0,000,11	0,000,70	0,000,04	0,000,70
Polyethylene- low density (Dylar)	60	2,24	2,20	2,27	0,000,00	0,001,4	0,000,12	0,000,34
Polyethylene- carbonfilled	60	2,78	2,61	2,56	0,000,55	0,001,1	0,001,4	0,002,1
Polypropylene	53	2,29	2,25	2,21	0,000,65	0,002,9	0,000,55	0,001,7
Polystyrene (Ampacel)	65	2,51	2,51	2,53	0,000,14	0,000,11	0,000,26	0,000,24
Polyvinyl- chloride semirigid (Vinylite)	16	3,19	3,54	3,24	0,000,1	0,014	0,013	0,0,1

Cont ... /...

50/5000/5 /year

CABLE 13* CONT.

Material (Trade Name)	Thick- ness (mils)	Dielectric Constant		Frequency=mc		Dissipation Factor		
		Before irr.	After irr.	Before irr.	After irr.	Before irr.	After irr.	
Polystyrene	5	3.69	3.46	3.40	0.0023	0.0019	0.029	0.031
Styrene with impact modifier	5	2.49	2.51	2.41	0.000.41	0.0015	0.000.45	0.000.65
Thermo- Safing	5	4.14	4.28	4.17	0.014	0.010	0.013	0.013
Polystyrene (Diacron)	5	4.70	9.50	7.77	0.016	0.001	0.056	0.041
Polystyrene with cellulose acetate (Mylar)	70	15.4	13.1	15.71	0.15	0.13	0.0016	0.004
Polyethylene terephthalate (Mylar)	5	3.05	3.07	2.91	0.0022	0.0032	0.012	0.011

* The irradiations were carried out in a Van der Graaff accelerator operated with a dose rate of 3.10 rad/hr. All the plastics were subjected to a radiation dose of about 1.10 rad.

TABLE 14

Gasevolution * (7) (8) (11) (61) (62) (63) (64)

<u>Material - Thermoplastic</u>	<u>Gas evolved - ml/g. at 10⁹ rads.</u>
Allyl diglycol carbonate	40-55
Casein	4-7
Cellulose Acetate	17-20
Cellulose Acetate Butyrate	28-30
Cellulose propionate	35
Cellulose Nitrate	105-120
Ethylcellulose	30-35
Polyamide	20-25
Polychlorotri fluoroethylene	3.5
Polyethylene	70
Polyethylene terephthalate	3-5
Poly α -methylstyrene	1,5-10
Polymethylmethacrylate	30-35
Polypropylene	70-90
Polystyrene	1-1,5
Polytetrafluroethylene	0,5-1,2
Polyvinylalcohol	25-40
Polyvinylchloride	6-9
Polyvinyl formal	~100
Styrene-butadiene plastic	~2
Triallyl cyanurate polymer	~2

TABLE 18

Gasevolution * * (7) (8) (11) (14) (12) (60) (14)

Material - Thermosettings	Gas evolved - ml/g. at 10^9 rads.
Aniline formaldehyde	~ 2
Furan resin	< 0,10
Melamine formaldehyde (cellulose filler)	6-10
Phenol formaldehyde	
No filler	5
Linen fabric filler	14
Paper filler	17
Asbestos filler	< 0,10
Graphite filler	< 0,05
Polyesters (general)	2-40
Urea formaldehyde (cellulose filler)	10-17

* The gasevolution was measured from samples of 0,2 to 0,4 gramme

ce/1010/t

SP.

TABLE 16 (7) (11)

Effect of filler material on the radiation stability of phenol formaldehyde.

Material	Additive — Filler	Relation Stability of filler	Threshold Damage (rads)	25 % Damage Dosage (rads)
Phenol formaldehyde	None		$2,7 \cdot 10^6$	$1,1 \cdot 10^7$
Phenol formaldehyde	Asbestos fiber	Better	$7,8 \cdot 10^7$	$8,9 \cdot 10^8$
Phenol formaldehyde	Asbestos	Better	$3,9 \cdot 10^8$	$3,9 \cdot 10^9$
Phenol formaldehyde	Graphite	Better	$8,9 - 10^5$	$7,7 \cdot 10^7$
Phenol formaldehyde	Linen fabric laminate	Less	$3,4 \cdot 10^5$	$8,2 \cdot 10^6$
Phenol formaldehyde	Paper	Less	$3,8 \cdot 10^5$	$2,6 \cdot 10^7$

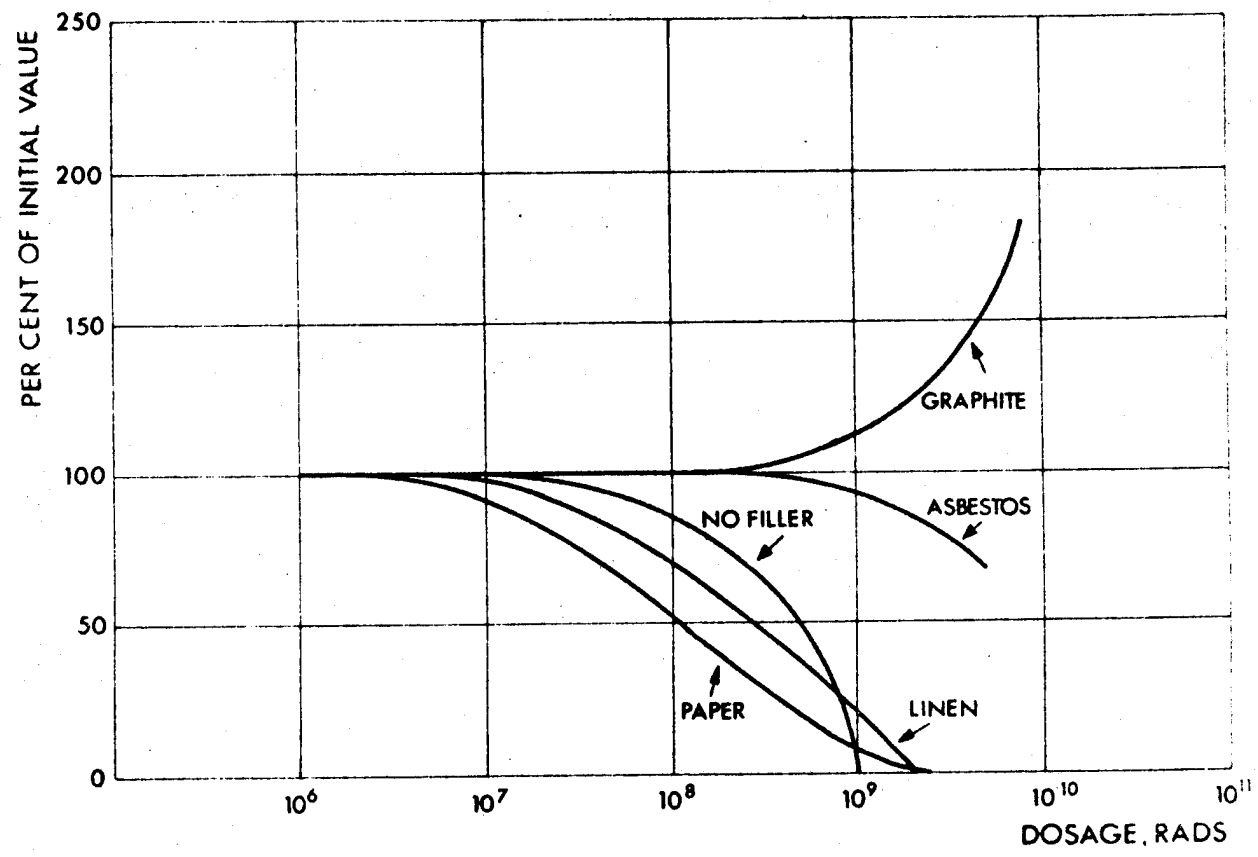


Fig. 44

EFFECT OF FILLERS ON THE TENSILE STRENGTH OF PHENOL FORMALDEHYDE RESINS AFTER IRRADIATION (7,9,11)

TABLE 17

Effects of fillers on the elongation
of polyvinylchloride (65)

	0	1×10^8	2×10^8
No filler	100	78	58
Carbon black	100	79	64
TiO ₂ , rutile	100	73	54
Whiting	100	73	42
China Clay	100	82	65

TABLE 13

Effect of fillers on the radiation stability of polyester - and silicone resins (66)

Material	EXPOSURE : rads.			
	Filler	Threshold	25% damage	50% damage
<u>Polyester</u>	unfilled	$6 \cdot 10^5$	10^6	$5 \cdot 10^7$
	glass fibre	$6 \cdot 10^3$	$5 \cdot 10^5$	10^{10}
	Mineral	$7 \cdot 10^7$	$1 \cdot 10^9$	$4 \cdot 10^9$
<u>Silicone</u>	unfilled	10^3	$4 \cdot 10^3$	$2 \cdot 10^4$
	glass fibre	$1 \cdot 10^3$	10^{10}	$6 \cdot 10^{10}$
	Mineral	$1 \cdot 10^3$	-	-

TABLE 19

Radiation stability of plastics at
temperatures above 75°C (11) (67) (68)

Material-Thermoplastic	Temp. °C	Max. dose (electrical) rad.	Max. dose (Mechanical) rad.
Cresolin	125-140	-	$2,5 \times 10^7$
Monochlorotrifluoro- ethylene	200	5×10^8	5×10^6
Polyamide	100	5×10^3	$2,5 \times 10^3$
Polyethylene	85	5×10^9	$2,5 \times 10^8$
Polystyrene	75	5×10^9	5×10^8
Polytetrafluoroethylene	250	$2,5 \times 10^9$	$2,5 \times 10^5$
Polyvinylacetate	130	5×10^8	$2,5 \times 10^8$
Polyvinylcarbazole	150	5×10^9	5×10^8
Polyvinylchloride	85	10^9	5×10^7
Polyvinylformal	130	10^9	5×10^3

T A B L E 20

Radiation stability of plastics at temperatures above
75°C. (11) (67) (68)

Material - Thermosettings	Temp. °C	Max . dose (Electrical) rads	Max . dose (Mechanical) rads
Epoxy	130	5×10^9	2×10^9
Furan	120 - 160	—	$3,3 \times 10^9$
Melamine formaldehyde			
Cellulose filler	110	—	1×10^8
Glass fibre filler	120	—	1×10^8
Phenol formaldehyde			
No filler	120	—	$1,1 \times 10^7$
Cellulose Filler	120	—	$2,8 \times 10^6$ - $2,6 \times 10^7$
Mineral filler	175 - 190	—	$7,7 \times 10^7$ - $3,9 \times 10^8$
Polyester			
No filler	100	—	$8,7 \times 10^5$
Mineral filler	110	—	$3,9 \times 10^9$
Silicones	150	5×10^9	$2,5 \times 10^8$

TABLE 21

TRADE NAMES OF PLASTICS

<u>Trade Name</u>	<u>Chemical Name</u>
Abcolite	Polystyrene
Abson	Acrylonitrile butadiene styrene
Acrolite	Urea Formaldehyde
Alathon	Polyethylene
Agilene	Polyethylene
*Algoflon	Polytetrafluoroethylene (F.T.F.E.)
Alkathene	Polyethylene
Alphalux 400	Polyphenylene oxide
Ameroid	Casein
Ampacet	Polystyrene
Araldite	Epoxy
Aropol	Polyester
Atlac	Polyester
*Agilide	Polyvinylchloride

B)

Trade NameChemical Name

Bakelite

Phenolic

Beetle

Urea Formaldehyde

Boxoid

Cellulose acetate

Butacite

Polyvinyl Butyral

<u>Trade Name</u>	<u>Chemical Name</u>
Caladone	Phenolic
Capran Film	Nylon 6
Cariflex	Butadiene styrene
Carina	Polyvinylchloride
Carlona	Polyethylene
Carlona P	Polypropylene
Catabond	Polyester
Catalin	Phenolic
Capron	Polyester
Cellidor	Cellulosics
Cellit	Cellulosics
Cellophane	Cellulosics
Cellofoam	Polystyrene
Cibanite	Aniline Formaldehyde
Covisil	Silicones
CR 39	Polycarbonate
Crystic	Polyester
Cycolac	ABS
Cymel	Melamine Formaldehyde

Trade NameChemical Name

Dacron	Polyester
Dapon	Polyester
Darvic	Polyvinylchloride
D.C. Resins	Silicones
Delrin	Acetal
Desmodur	Polyurethane
Devcon	Epoxy
Diakon	Polymethylmethacrylate
Diorit	Polyvinylidenechloride
Dow Corning	Silicones
Duralon	Furan
Durez	Phenolic
Durite	Phenolic
Duthane	Polyurethane
Dylan	Polyethylene

E)

Trade NameChemical Name

Epiall	Epoxy
Epikote	Epoxy
Epons	Epoxy
Epophen	Epoxy
Epoxylite	Epoxy
Erinoid	Casein
Estane	Polyurethane
Ethocel	Ethyl cellulose
Exon	Polyvinylchloride

F)

Trade NameChemical Name

Flexon

Polyvinylchloride

Fluon

P.T.F.E.

Fluorothene

Polytrifluoromonochloroethylene
(P.C.T.F.E.)

Formica

Melamine Formaldehyde

Formvar

Polyvinylformal

Forticel

Cellulosics

c)

Trade NameChemical Name

Gabraster

Polyester

Gabrite

Urea Formaldehyde

Gansolite

Casein

Gedex

Polystyrene

Gelva

Polyvinylacetate

Gelvatol

Polyvinylalcohol

Geon

Polyvinylchloride

Glidpol

Polyester

Grilen

Polyamide

H)

Trade NameChemical Name

H Film

Polyimide

Halon

P.T.F.E.

Havog

Phenolic

Hotron

Polyester

Hifax

Polyethylene

Hostaflon

Polytrifluoromonochloroethylene

Hostaflon TF

Polytetrafluoroethylene

HT Film

Polyimide

Hypalon

Chloro sulfonated polyethylene

K)

Trade Name

Kapton

Karbato

Kcl F

Kerosal

Kralastic

Kynar

Chemical Name

Polyimide

Phenolic

Polytrifluoromethochloroethylene

Modified Polyvinylchloride

ABS

Polyvinylidene Fluoride

L)

Trade NameChemical Name

Lactophane

Cellulosics

Laminac

Polyester

Leguval

Polyester

Lekutherm

Epoxy

Lexan

Polycarbonate

Lucite

Polymethylmethacrylate

Lustran

ABS (Acrylonitrile butadiene styrene)

Lustrex

Polystyrene

Luvican

Polyvinylcarbazol

E)

Trade NameChemical Name

Marblatte

Phenolic

Marco MR

Polyesters

Marfoam

Polyurethane

Marlex

Polyethylene

Marvincl

Polyvinylchloride

Melinex

Polyethylene Terephthalate

Melmac

Melamine Formaldehyde

Melox

Melamin Formaldehyde

Merlon

Polycarbonate

Micasite

Phenolic

Mondur

Isocyanates

Monsanto

Polyethylene

Mylar

Polyethylene terephthalate

3M

Epoxy

1)
2)

Trade NameChemical Name

Nailonplast

Polyamide

Nonaex Yarn

Polyimide

Nylon

Polyamide

Trade NameChemical Name

Opalen

Polyvinylchloride

Orizon

Polyethylene

P)

Trade NameChemical Name

PPO	Polyphenylene oxide
Paraplex	Polyester
Parylene N, C, D	Parylene
Penton	Chlorinated Polyether
Perlon	Polyamide
Perspex	Polymethylmethacrylate
Pet:othene	Polyethylene
Phenolite	Phenolic
Plaskon Alkyd	Polyester
Plastacel	Cellulose acetate
Pleogen	Polyester
Plexiglas	Polymethylmethacrylate
Pliolite	Styrene-butadiene
Pliovic	Polyvinylchloride
Plyophen	Phenolic
Polectron	Polyvinylcarbazole
Polydur	Polyethylene
Polyflon	Polytetrafluoroethylene
Polyox	Polyethyleneoxyde
Polystyrole	Polystyrene
Polythene	Polyethylene
Polytherm	Polyvinylchloride
Pro-Fax	Polypropylene
Pyraline	Cellulose nitrate

R)

<u>Trade Name</u>	<u>Chemical Name</u>
Resimene	Melamine
Resinol	Phenolic
Resinox	Phenolic
Résocel	Phenolic
Résofil	Phenolic
Rosite 2000	Phenolic
Rayolin	Polyolefin
Royalite	ABS

8)

Trade NameChemical Name

Saflex

Polyvinylbutyral

Saran

Polyvinylidene chloride

Saran F

Polyvinylchloride

Selectron

Polyester

Silastic 20

Silicones

Silmar

Polyester

Solithane

Polyurethane

Sonoplas

Polyvinylchloride

Soreflon

Polytetrafluoroethylene

Styrex

Polystyrene

Styron

Polystyrene

Styrofoam

Polystyrene

Sylgard

Silicones

Swilyn

Ionomer

Synvaron

Phenolics

Synvarite

Phenolics

Synvarol

Ureaformaldehyde

T)

Trade NameChemical Name

Tedlar

Polyvinylfluoride

Teflon

Polytetrafluoroethylene

Teflon FEP

Copolymer of hexafluoropropene
and tetrafluoroethylene

Tunitc Butyrate

Cellulose Acetate butyrate

Terylene

Polyethylene Terephthalate

Tetran

Polytetrafluoroethylene

Texin

Polyurethane

Thiokol

Polysulfide

Triacel

Cellulose acetate

Trulen

Polyvinylchloride

Tufnol

Phenolic

Tybrene

ABS

Tygon

Polyvinylchloride

b)

Trade NameChemical Name

Ultron

Polyvinylchloride

Union Carbide

Silicones

Urox

Urea Formaldehyde

v)
w)
x)
z)

Trade NameChemical Name

Varcum

Phenolic

Valon

Polyvinylidene chloride

Veston

Polyvinylidene chloride

Vibrathene

Polyester

Vibrin

Polyester

Viscose

Cellulosics

Vinidur

Polyvinylchloride

Vybak

Polyvinylchloride

Vinylite A

Polyvinyl acetate

Trade NameChemical Name

Wolvic

Polyvinylchloride

Trade NameChemical Name

Xylonite

Cellulosics

Trade NameChemical Name

Zytel

Polyamide

Chemical NameTrade Name

ABS (Acrylonitrile butadiene styrene)	Cycolac
ABS " " "	Kralastic
ABS	Lustran
ABS	Royalite
ABS	Tybrene
Acetal	Delrin
Acrylonitrile Butadiene Styrene	Abson
Aniline formaldehyde	Cibanite

B)

Chemical NameTrade Name

Butadiene Styrene

Cariflex

c)

<u>Chemical Name</u>	<u>Trade Name</u>
Carbonate	CR 39
Cascin	Aneroid
Cascin	Gansolite
Cellulose acetate	Bexoid
Cellulose acetate	Plastacule
Cellulose acetate	Triacel
Cellulose acetate butyrate	Tenite butyrate
Cellulose nitrate	Pyraline
Cellulosics	Cellidor
Cellulosics	Forticel
Cellulosics	Cellit
Cellulosics	Cellophane
Cellulosics	Lactophane
Cellulosics	Viscose
Cellulosics	Xylonite
Chlorinated polyether	Penton
Chlore sulfonated polyethylene	Hypalon
Copolymer of hexa fluoropropene and tetrafluoroethylene	Teflon F E P

E)

<u>Chemical Name</u>	<u>Trade Name</u>
Epoxy	Araldite
Epoxy	Devcon
Epoxy	Epiall
Epoxy	Epikote
Epoxy	Epon
Epoxy	Epophen
Epoxy	Epoxylite
Epoxy	Lekuthern
Epoxy	3 M
Ethyl Cellulose	Ethocel

Chemical NameTrade Name

Furan

Duralon

I)

Chemical NameTrade Name

Ionomer

Swilyn

Isocyanates

Mondur

H)

<u>Chemical Name</u>	<u>Trade Name</u>
Melamine formaldehyde	Cymel
Melamine formaldehyde	Formica
Melamine formaldehyde	Melmac
Melamine formaldehyde	Melox
Melamine	Resimene
Modified polyvinylchloride	Koroseal

N)

Chemical Name

Trade Name

Nylon 6

Capron film

P) -1-

<u>Chemical Name</u>	<u>Trade Name</u>
Parylene	Parylene
P.C.T.F.E. (Polytrifluoromonoethyleno)	Fluorothene
P.C.T.F.E. "	Hostaflon
P.C.T.F.E. "	Kel F.
Phenolic	Bakelite
Phenolic	Catalin
Phenolic	Durez
Phenolic	Haveg
Phenolic	Karbata
Phenolic	Micarta
Phenolic	Phenolite
Phenolic	Plyophen
Phenolic	Resinol
Phenolic	Resinox
Phenolic	Résocel
Phenolic	Résofil
* Phenolic	Synvaron
Phenolic	Synvarite
Phenolic	Tufnol
Polyamide	Grilon
Polyamide	Nailonplast
Polyamide	Nylon
Polyamide	Parlon
Polyamide	Zytel
Polycarbonate	CR 39
Polycarbonate	Lexan
Polycarbonate	Merlon
Polyester	Aropol
Polyester	Atlac
Polyester	Catabond
Polyester	Ceapren
Polyester	Crystic
* Phenolic	Varcum

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-2-

<u>Chemical Name</u>	<u>Trade Name</u>
Polyester	Dacron
Polyester	Dapon
Polyester	Gebraster
Polyester	Glupol
Polyester	Hotron
Polyester	Laminac
Polyester	Leguval
Polyesters	Marco MR
Polyester	Paraplex
Polyester	Plaskon Alkyd
Polyester	Pleogen
Polyester	Selectron
Polyester	Silmar
Polyester	Vibrothane
Polyester	Vitrin
Polyethylene	Alathon
Polyethylene	Agilene
Polyethylene	Alkathene
Polyethylene	Carlone
Polyethylene	Dylan
Polyethylene	Hifax
Polyethylene	Marlex
Polyethylene	Orizon
Polyethylene	Petrothane
Polyethylene	Polydur
Polyethylene	Polythene
Polyethyleneoxide	Polyox
Polyphenylene oxide	PPO
Polyethylene terephthalate	Melinex
Polyethylene terephthalate	Mylar
Polyethylene terephthalate	Terylene
Polyimide	H Film

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P) -3-

<u>Chemical Name</u>	<u>Trade Name</u>
Polyimide	H Film
Polyimide	Kapton
Polyimide	Nomex yarn
Polymethylmethacrylate	Diakon
Polymethylmethacrylate	Lucite
Polymethylmethacrylate	Perspex
Polymethylmethacrylate	Flexiglas
Polyolefin	Rayolin
Polyphenylene oxide	Alphalux 400
Polypropylene	Carlona P
Polypropylene	Pro - Fax
Polystyrene	Abcolite
Polystyrene	Ampacet
Polystyrene	Cellofoam
Polystyrene	Godex
Polystyrene	Lustrex
Polystyrene	Monsanto
Polystyrene	Styrex
Polystyrene	Styron
Polystyrene	Styrofoam
Polysulfide	Thiokol
Polytetrafluoroethylene (P.T.F.E.)	Algoilon
Polytetrafluoroethylene	Fluon
Polytetrafluoroethylene	Halon
Polytetrafluoroethylene	Hestaflon TF
Polytetrafluoroethylene	Polyflon
Polytetrafluoroethylene	Soreflon
Polytetrafluoroethylene	Teflon
Polytetrafluoroethylene	Tetran
Polyurethane	Desmodur
Polyurethane	Duthane

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P) -4-

<u>Chemical Name</u>	<u>Trade Name</u>
Polyurethane	Estane
Polyurethane	Marfoam
Polyurethane	Solithane
Polyurethane	Texin
Polyvinylacetate	Gelva
Polyvinylacetate	Vinylite A
Polyvinylalcohol	Gelvatol
Polyvinylbutyral	Butacite
Polyvinylbutyral	Saflex
Polyvinylcarbazol	Luvican
Polyvinylcarbazol	Polectron
Polyvinylchloride	Agilide
Polyvinylchloride	Carina
Polyvinylchloride	Darvic
Polyvinylchloride	Exon
Polyvinylchloride	Flexon
Polyvinylchloride	Geon
Polyvinylchloride	Marvinol
Polyvinylchloride	Opalon
Polyvinylchloride	Pliovic
Polyvinylchloride	Polytherm
Polyvinylchloride	Saran F
Polyvinylchloride	Somaplas
Polyvinylchloride	Trulon
Polyvinylchloride	Tygon
Polyvinylchloride	Vinidur
Polyvinylchloride	Vybak
Polyvinylchloride	Welvic
Polyvinylfluoride	Tedlar
Polyvinylformal	Formvar
Polyvinylidenechloride	Diorit

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P) -5-

<u>Chemical Name</u>	<u>Trade Name</u>
Polyvinylidene chloride	Saran
Polyvinylidene chloride	Velon
Polyvinylidene fluoride	Kynar
Polyvinylidene chloride	Vestan

s)

<u>Chemical Name</u>	<u>Trade Name</u>
Silicones	Covisil
Silicones	D.C. Resins
Silicones	Dow Corning
Silicones	Silastic 80
Silicones	Sylgard
Silicones	Union Carbide
Styrene Polymers	Sec Polystyrene
Styrene Butadiene	Pliolite

U)

<u>Chemical Name</u>	<u>Trade Name</u>
Urea Formaldehyde	Acrolite
Urea Formaldehyde	Beetle
Urea Formaldehyde	Gabrite
Urea Formaldehyde	Synvarol
Urea Formaldehyde	Urox

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