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Tables of Dielectric Materials Volume IV

Technical Report No. 57
Laboratory for Insulation Research
Massachusetts Institute of Technology

January, 1953

TABLES OF DIELECTRIC MATERIALS
VOLUME IV

Laboratory for Insulation Research
Massachusetts Institute of Technology
Cambridge, Massachusetts

O. N. R. Contracts N5ori-07801
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January, 1953

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Tables of Dielectric Materials

Volume IV

Laboratory for Insulation Research
Massachusetts Institute of Technology
Cambridge, Massachusetts

About five years have passed since Volume III of the "Tables of Dielectric Materials" was issued. The world situation appeared to quiet down at that time, and we hoped to concentrate the whole activity of this laboratory on fundamental research in the field of dielectrics (polarization, magnetization and conduction). The outbreak of the Korean War found our country again unprepared and demonstrated with expensive clarity that we have to live on the alert for the rest of our lives. In consequence, the laboratory felt bound to retain the practical task assumed in World War II of acting as a clearing house for dielectric materials and their uses. One aspect of this activity is our long-range applied research program of tailoring dielectrics to order for specific applications. This work is concentrated at the present time on the problem of shaping the hysteresis loops of ferroelectrics and of ferromagnetic semiconductors to the requirements of the electrical engineer concerned with the development of memory systems, dielectric and magnetic amplifiers and other nonlinear devices. A second aspect is the "Tables of Dielectric Materials."

The "Tables" in their present form summarize the measurements of this laboratory on the complex permittivity (dielectric constant and loss tangent) and the complex permeability of important dielectrics made in this country. They are intended to aid government agencies, engineers and manufacturers in the proper application of dielectrics and in the development of better products. Volume IV reports on about 250 new materials; simultaneously, it has taken over and amplified the measurements given in the previous volumes as far as they still are of special interest. A number of materials now not in produc-

tion have been retained for this reason but are indicated as "discontinued." The total number of materials included amounts to over 600.

The selection of these materials was undertaken with the full co-operation of the manufacturers concerned. The laboratory measures any important new material free of charge for inclusion in the "Tables" if the manufacturer supplies all additional essential information. If some of this information is "confidential," it is locked away in our files and will be made available only after release by the manufacturer.

We are fully aware that these data should be expanded, especially towards higher temperatures and frequencies. Furthermore, additional measurements on d.c. conductivity, breakdown strength and other electric parameters would be of great value, and a presentation of the materials as in Volume III, where the dielectric characteristics of each individual dielectric have been plotted and essential information given on composition, properties, methods of handling and recommended uses. Finally, a real "dielectric analysis" of the materials should be undertaken, linking their dielectric response to composition and molecular structure. We have to ask for the indulgence of the users of these "Tables" on these scores; *ultra posse nemo obligatur*, or, in free translation, our budget is already stretched to the breaking point by our present obligations.

Volume IV does not contain our more extensive measurements on ferroelectrics and ferromagnetics. These data on nonlinear dielectrics will be issued in a separate Volume V as soon as they are reasonably complete.

The measurements were made by W. B. Westphal, group leader of our dielectric measurements group, who was ably supported by three staff operators: Helen M. Dunn, Patricia A. Fergus and Elizabeth McCarty. Invaluable help in the editing and correcting of the manuscript was given by Harriet B. Armstrong.

This work was sponsored under our O.N.R. contracts jointly by the Navy Department (Office of Naval Research), the Army Signal Corps and the Air Force

(Air Materiel Command); we thank all three Services for their understanding and co-operation.

von Hippel, Director
Laboratory for Insulation Research

Dielectric Parameters

1. ϵ' , the dielectric constant or permittivity relative to vacuum, also designated in the literature as K , κ , ϵ , D.C., etc.
2. $\tan \delta$ or $\tan \delta_d$, the dielectric loss tangent or dissipation factor, also designated in the literature as D.F., $1/Q$, and when losses are low, as power factor or $\cos \theta$.
3. μ' , the magnetic permeability relative to vacuum, also given in the literature as μ' or μ_0 .
4. $\tan \delta_m$, the magnetic loss tangent.
5. ρ , the a.c. volume resistivity in ohm cm. This parameter is used in these tables only for very high-loss materials.

Transformation to other parameters. The dielectric loss factor relative to vacuum, ϵ''/ϵ_0 , is the product of the dielectric loss tangent and ϵ'/ϵ_0 . A.c. volume conductivity, σ , is given by

$$\sigma = \frac{1}{\rho} = \frac{f(\epsilon'/\epsilon_0)\tan \delta}{1.8 \times 10^{12}} \quad [\text{mho cm.}] (f \text{ in c/s})$$

A chart is given (page x) for approximate calculations of σ or ρ from the data given in the tables.

The magnetic loss factor relative to vacuum, μ''/μ_0 , is the product of the magnetic loss tangent and μ'/μ_0 (in analogy to the dielectric loss factor). In the literature, the loss factor is sometimes given as $\frac{1}{\mu_0 Q}$ or in our notation, $\tan \delta_m/(\mu'/\mu_0)$.

The attenuation constant, α , for propagation in free space is

$$\frac{2\pi}{\lambda_0} \left[\frac{\mu'\epsilon'}{\mu_0\epsilon_0} \frac{1 - \tan \delta_d \cdot \tan \delta_m}{2} \left([1 + \tan^2(\delta_d + \delta_m)]^{1/2} - 1 \right) \right]^{1/2},$$

which for nonmagnetic dielectrics reduces to

$$\frac{2\pi}{\lambda_0} \left(\frac{\epsilon'}{\epsilon_0} \right)^{1/2} \left[\frac{(1 + \tan^2 \delta_d)^{1/2} - 1}{2} \right]^{1/2}$$

Charts for finding α in terms of ϵ'/ϵ_0 and $\tan \delta_d$ are included in this report (pages xi-xiii). They apply also to magnetic dielectrics when the product $(\mu'/\mu)(\epsilon'/\epsilon_0)$ is substituted for ϵ'/ϵ_0 and an equivalent combined loss tangent $\tan \delta_e$ is used instead of $\tan \delta_d$. A graph is given (page xiv) showing $\tan \delta_e$ for values of $\tan \delta_d$ and $\tan \delta_m$ in the range 0.1 to 10. For smaller values, $\tan \delta_e = \tan \delta_d + \tan \delta_m$.

The phase constant β for propagation in free space is

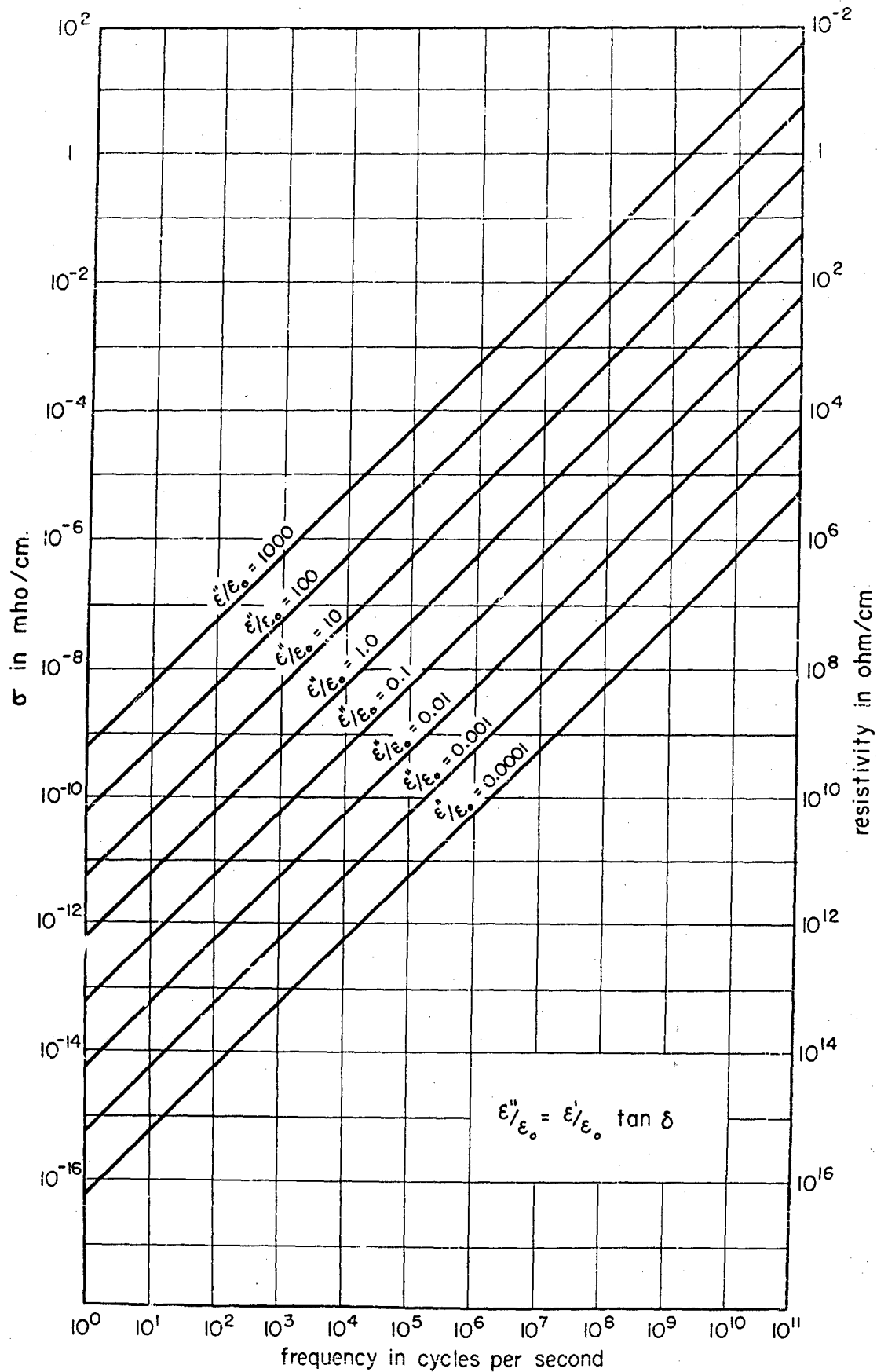
$$\frac{2\pi}{\lambda_0} \left[\frac{\mu' \epsilon'}{\mu_0 \epsilon_0} \frac{1 - \tan \delta_d \cdot \tan \delta_m}{2} \left(\left[1 + \tan^2(\delta_d + \delta_m) \right]^{1/2} + 1 \right) \right]^{1/2},$$

which reduces for nonmagnetic materials to

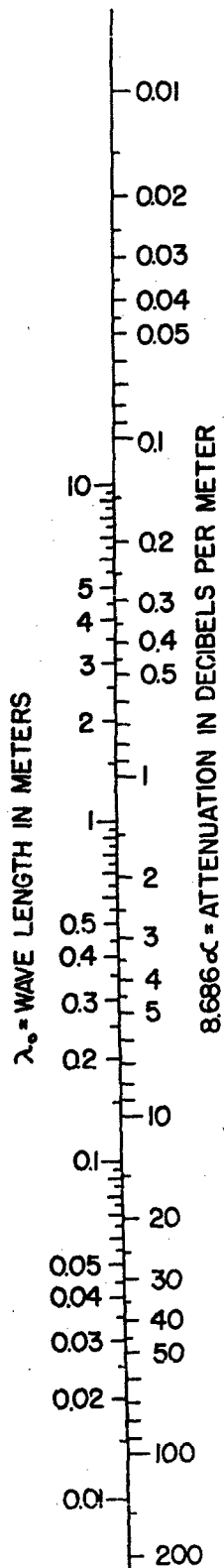
$$\frac{2\pi}{\lambda_0} \left(\frac{\epsilon'}{\epsilon_0} \right)^{1/2} \left[\frac{(1 + \tan^2 \delta_d)^{1/2} + 1}{2} \right]^{1/2}$$

The intrinsic impedance Z of the material is

$$377 \left(\frac{\mu^* \epsilon_0}{\mu_0 \epsilon^*} \right)^{1/2}$$



Conductivity-resistivity as function of ϵ''/ϵ_0 and frequency.

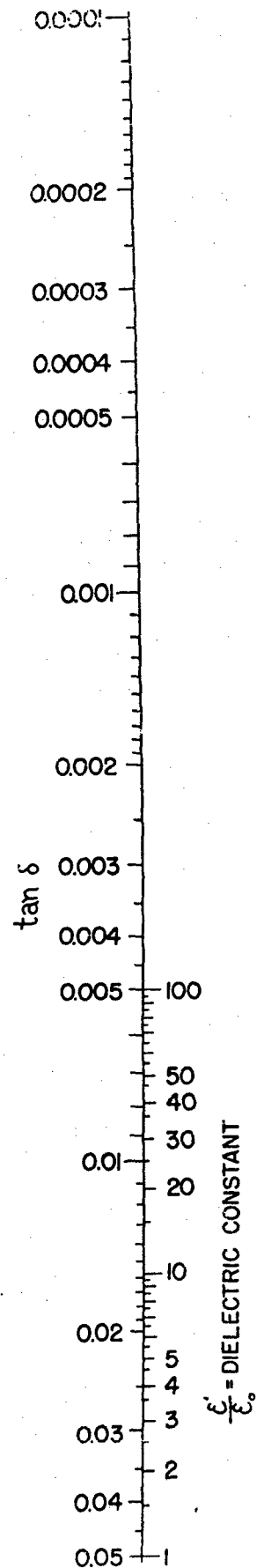
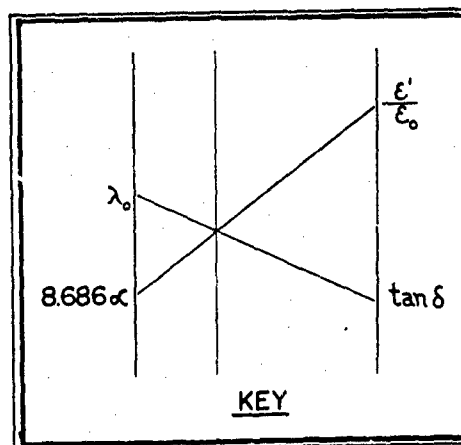


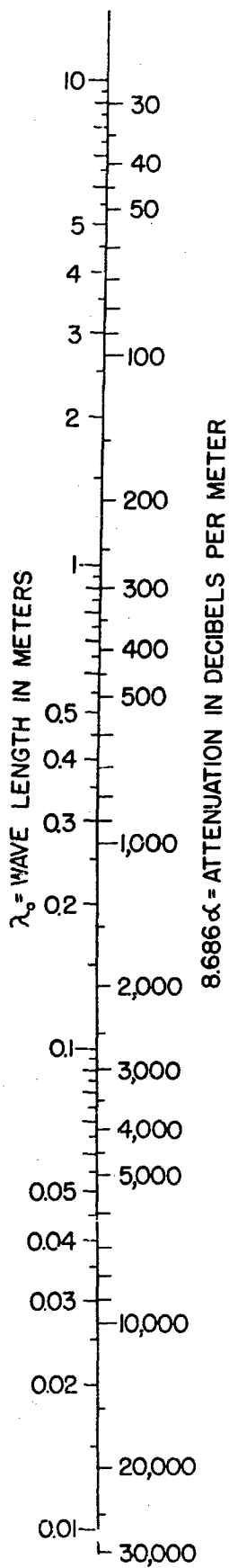
EQUATION

$$8.686\alpha = \frac{8.636 \cdot \pi \cdot \tan \delta}{\lambda_o} \sqrt{\frac{\epsilon' \mu}{\epsilon_o \mu_o}}$$

$$\frac{\mu}{\mu_o} = 1$$

$$\tan \delta = 0.0001 \text{ to } 0.05$$



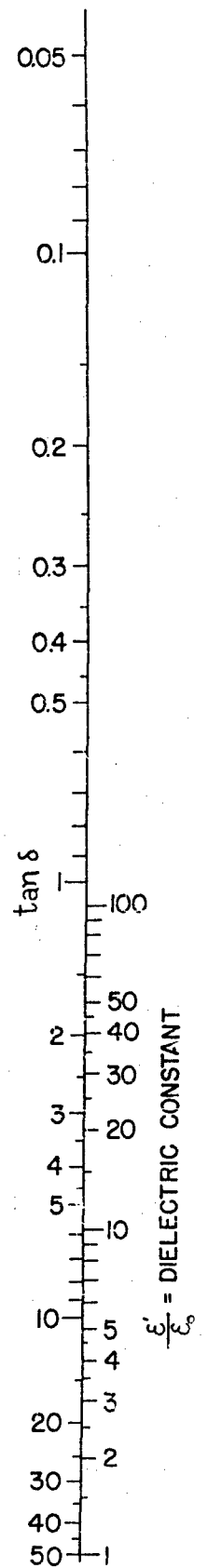
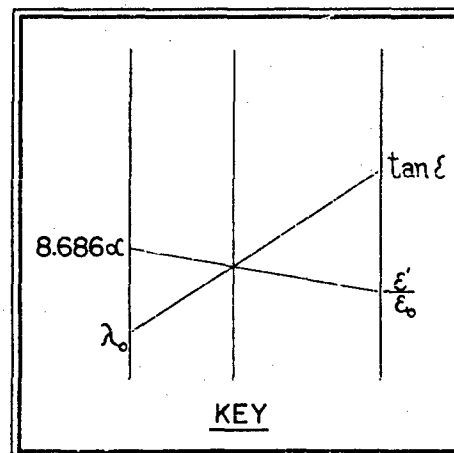


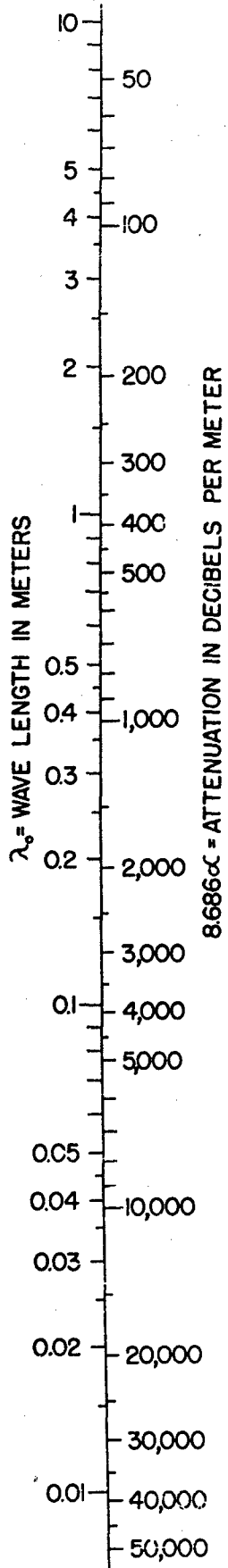
EQUATION

$$8.686\alpha = \frac{17.37\pi}{\lambda_0} \sqrt{\frac{\epsilon'\mu}{\epsilon_0\mu_0} \frac{\sqrt{1+\tan^2\delta}-1}{2}}$$

$$\frac{\mu}{\mu_0} = 1$$

$\tan \delta = 0.05 \text{ to } 50$



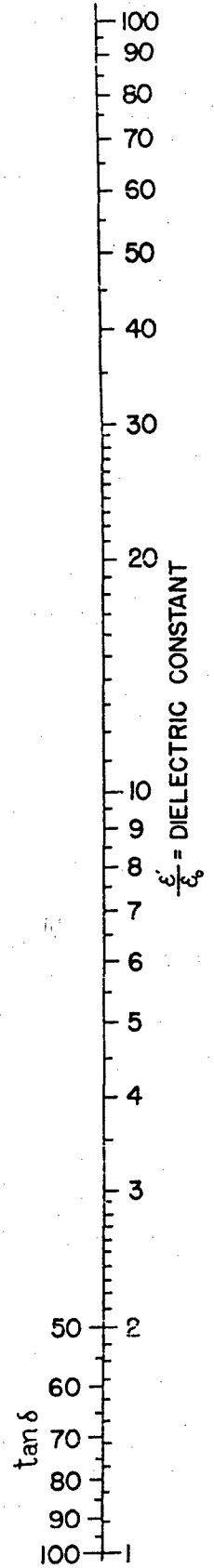
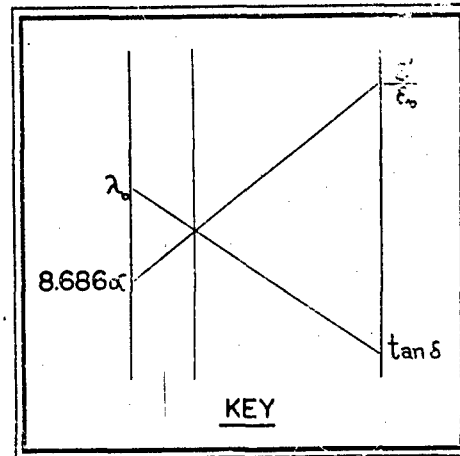


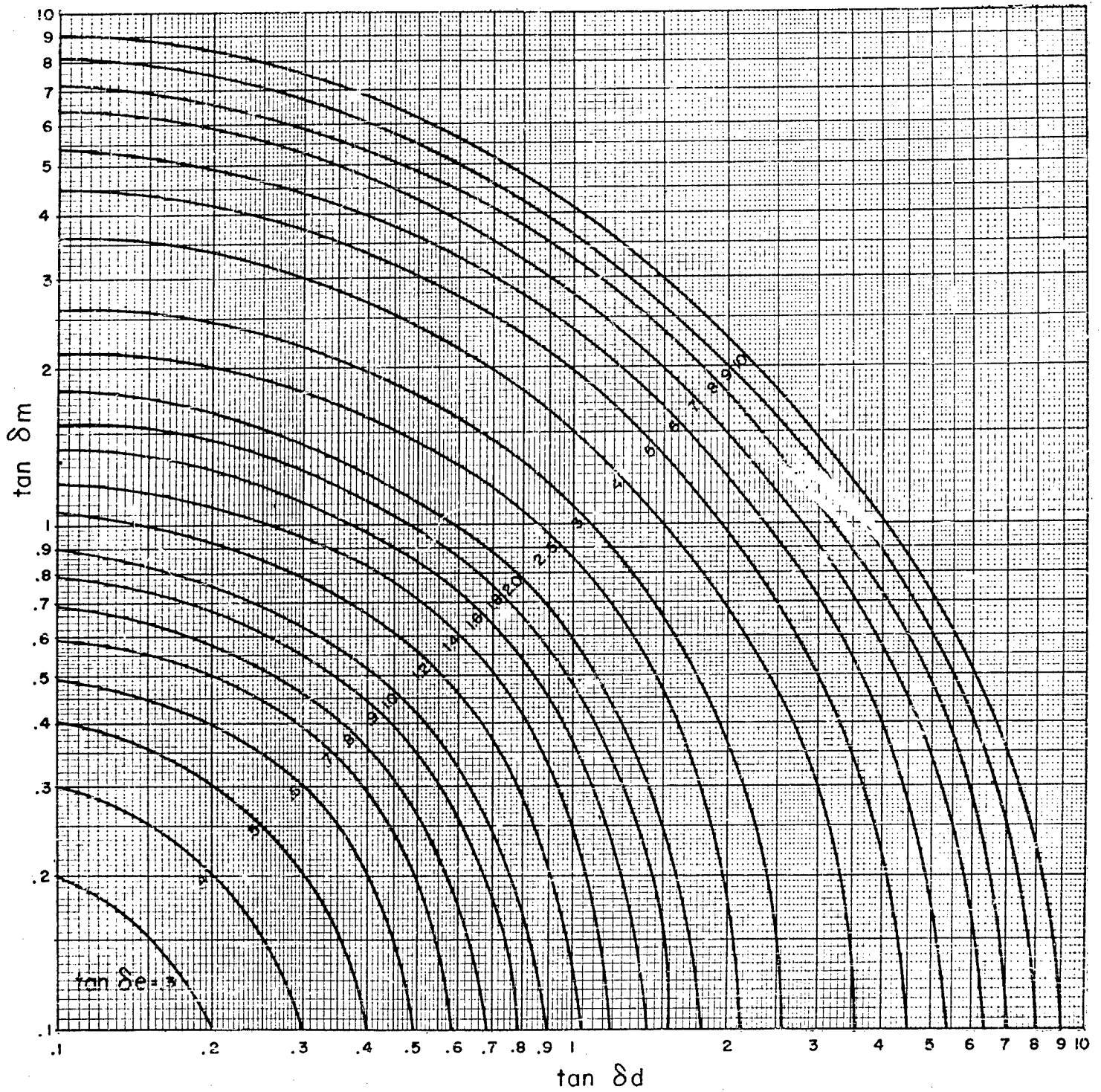
EQUATION

$$8.686\alpha = \frac{17.37\pi}{\lambda_0} \sqrt{\frac{\epsilon'\mu}{\epsilon_0\mu_0}} \frac{\tan\delta}{2}$$

$$\frac{\mu}{\mu_0} = 1$$

$\tan\delta = 50 \text{ to } 100$





Equivalent loss tangent of magnetic materials.

Measurements and Accuracy

The measurements have been made, in general, on only one batch of the material and refer, unless otherwise specified, to samples dried over phosphorous pentoxide. Due to the wide variety of materials and improvements in techniques, no figures of general validity can be given concerning the accuracy of these measurements. For ϵ'/ϵ_0 , the nominal accuracy is $\pm 2\%$; the accuracy trends are toward $\pm 1\%$ for rigid, low-loss materials ($\tan \delta < 0.005$) and $\pm 5\%$ for high-loss materials ($\tan \delta > 1$). For $\tan \delta_d$, the nominal accuracy is $\pm 5\%$; for high-loss materials, the error may be $\pm 10\%$. For very low-loss materials ($\tan \delta < 0.002$), the accuracy is ± 0.0001 when the losses are given as multiples of 0.0001. When the loss is expressed in multiples of 0.00001, the error may be ± 0.00003 . For μ'/μ_0 , the nominal accuracy is $\pm 5\%$, for $\tan \delta_m$, $\pm 10\%$.

Field strengths. The linear dielectrics, those normally not field-strength sensitive, were measured at field strengths of approximately 50 volts per cm. in the frequency range 10^2 to 10^8 c/s and at lower field strengths at higher frequencies. At high temperatures (near 500°C) many of these materials show field-strength sensitivity, particularly at low frequencies. The effects may be wholly or partly due to space charge polarization.

The ferroelectric and ferromagnetic materials, unless otherwise noted, were measured at field strengths in their linear region. The values thus measured are the initial permittivity and permeability. Typical field strengths are 40 volts/cm. for titanate ceramics, 0.01 volts/cm. for KDP crystals, 0.01 oersteds for the ferrites.

I. SOLIDS

Values for $\tan \delta$ are multiplied by 10^4 ; frequency given in c/s.

A. Inorganic

1. Crystals	T°C										
		ϵ'/ϵ_0	$\tan \delta$	1×10^2	1×10^3	1×10^4	1×10^5	1×10^6	1×10^7	1×10^8	1×10^{10}
Ice ^a	-12	---	---	---	---	---	4.8	4.15	3.7	---	3.17
		$\tan \delta$	ϵ'/ϵ_0	$\tan \delta$	ϵ'/ϵ_0	$\tan \delta$	ϵ'/ϵ_0	$\tan \delta$	ϵ'/ϵ_0	$\tan \delta$	ϵ'/ϵ_0
Snow ^b	-20	---	---	---	---	---	8000	1200	180	---	7
		$\tan \delta$	ϵ'/ϵ_0	$\tan \delta$	ϵ'/ϵ_0	$\tan \delta$	ϵ'/ϵ_0	$\tan \delta$	ϵ'/ϵ_0	$\tan \delta$	ϵ'/ϵ_0
Snow ^c	-6	---	---	---	---	---	1.9	1.55	---	---	1.5
		$\tan \delta$	ϵ'/ϵ_0	$\tan \delta$	ϵ'/ϵ_0	$\tan \delta$	ϵ'/ϵ_0	$\tan \delta$	ϵ'/ϵ_0	$\tan \delta$	ϵ'/ϵ_0
Aluminum oxide, sapphire ^d	25	---	---	---	---	---	15300	2900	---	---	9
(field $\perp$ optical axis)		$\tan \delta$	ϵ'/ϵ_0	$\tan \delta$	ϵ'/ϵ_0	$\tan \delta$	ϵ'/ϵ_0	$\tan \delta$	ϵ'/ϵ_0	$\tan \delta$	ϵ'/ϵ_0
(field $\parallel$ optical axis)		$\tan \delta$	ϵ'/ϵ_0	$\tan \delta$	ϵ'/ϵ_0	$\tan \delta$	ϵ'/ϵ_0	$\tan \delta$	ϵ'/ϵ_0	$\tan \delta$	ϵ'/ϵ_0
Ammonium dihydrogen phosphate (field $\perp$ optical axis) ^e	25	---	---	---	---	---	55.9	55.9	55.9	55.9	55.9
(field $\parallel$ optical axis)		$\tan \delta$	ϵ'/ϵ_0	$\tan \delta$	ϵ'/ϵ_0	$\tan \delta$	ϵ'/ϵ_0	$\tan \delta$	ϵ'/ϵ_0	$\tan \delta$	ϵ'/ϵ_0
Lithium fluoride ^f	25	---	---	---	---	---	70	60	10	---	5
		$\tan \delta$	ϵ'/ϵ_0	$\tan \delta$	ϵ'/ϵ_0	$\tan \delta$	ϵ'/ϵ_0	$\tan \delta$	ϵ'/ϵ_0	$\tan \delta$	ϵ'/ϵ_0
Magnesium oxide ^g	25	---	---	---	---	---	9.65	9.65	9.65	9.65	9.65
Potassium bromide ^f	25	---	---	---	---	---	4.90	4.90	4.90	4.90	4.90
		$\tan \delta$	ϵ'/ϵ_0	$\tan \delta$	ϵ'/ϵ_0	$\tan \delta$	ϵ'/ϵ_0	$\tan \delta$	ϵ'/ϵ_0	$\tan \delta$	ϵ'/ϵ_0
Potassium dihydrogen phosphate (field $\perp$ optical axis) ^e	25	---	---	---	---	---	44.3	44.3	44.3	44.3	44.3
(field $\parallel$ optical axis)		$\tan \delta$	ϵ'/ϵ_0	$\tan \delta$	ϵ'/ϵ_0	$\tan \delta$	ϵ'/ϵ_0	$\tan \delta$	ϵ'/ϵ_0	$\tan \delta$	ϵ'/ϵ_0
Selenium, multi-crystal- ^h	25	---	---	---	---	---	11.0	10.4	---	---	7.5
line		$\tan \delta$	ϵ'/ϵ_0	$\tan \delta$	ϵ'/ϵ_0	$\tan \delta$	ϵ'/ϵ_0	$\tan \delta$	ϵ'/ϵ_0	$\tan \delta$	ϵ'/ϵ_0

a. From conductivity water. b. Freshly fallen snow. c. Hard-packed snow followed by light rain. d. Linde Air. e. Brush.

f. Fresh crystals (Harshaw). g. Norton. h. Lab. Ins. Res.

* -6°C.

I. Solids, A. Inorganic,

1. Crystals (cont.)

Values for $\tan \delta$ are multiplied by 10^4 ; frequency given in c/s.

T, °C	ϵ'/ϵ_0	1×10^2	1×10^3	1×10^4	1×10^5	1×10^6	1×10^7	1×10^8	3×10^8	3×10^9	1×10^{10}	2.5×10^{10}
25	$\tan \delta$	5.90	5.90	5.90	5.90	5.90	5.90					5.90
85	ϵ'/ϵ_0	6.35	6.11	6.00	5.98	5.98	5.98					< 5
25	$\tan \delta$	170	240	70	6	< 2	< 2					5.97
25	ϵ'/ϵ_0	3.75	3.75									< 3.9
25	$\tan \delta$	< 5	< 5									
25	ϵ'/ϵ_0	3.95	3.95									
25	$\tan \delta$	< 5	< 5									
25	ϵ'/ϵ_0	4.45	4.45									
25	$\tan \delta$	< 5	< 5									
25	ϵ'/ϵ_0	3.69	3.69	3.69	3.69	3.69	3.69					
25	$\tan \delta$	3	2	< 2	< 2	< 2	< 2			3.62	3.58	
25	ϵ'/ϵ_0	31.1	30.3	30.3	30.3	30.3	30.3			.4	1.5	
25	$\tan \delta$	1300	128	13.3	2	1	.4					
25	ϵ'/ϵ_0	22.3	21.8	21.8	21.8	21.8	21.8					
25	$\tan \delta$	950	120	12	1.2	.5	.5					
193	ϵ'/ϵ_0	-----	-----	-----	-----	-----	37.3					
	$\tan \delta$	-----	-----	-----	-----	-----	820					
25	ϵ'/ϵ_0	32.9	32.0	32.0	31.8							
	$\tan \delta$	4500	441	46	5.9							
25	ϵ'/ϵ_0	32.9	32.8	32.5	32.5	32.5	32.5					
	$\tan \delta$	29800	2800	277	37	4	.4					
25	ϵ'/ϵ_0	87.3	86.7	86.4	86	85.8	85.8					
	$\tan \delta$	110	32	9	4	2	2					
25	ϵ'/ϵ_0	-----	-----	200	170	170	160					
	$\tan \delta$	-----	-----	3500	600	80	16					

a. Fresh crystals (Harshaw). b. Measured with field $\perp$ to cuts indicated. Grown at Lab. Ins. Res. c. U.S.P. d. Grown at Eng. Res. and Dev. Lab., Fort Belvoir, Va. e. KRS-6, 60% ThBr, 40% ThCl. f. KRS-5, 42% ThBr, 58% ThI. g. Linde Air.

1. Solids, A. Inorganic

2. Ceramics

a. Steatite Bodies

ALSiMag A-35^a

ALSiMag A-196^a

ALSiMag 211^a

ALSiMag 228^a

ALSiMag 243^a

ALSiMag 393^b

Ceramic F-66^c

Steatite Type 302^d

Steatite Type 400^d

Steatite Type 410^d

Steatite Type 452^d

Values for tan δ are multiplied by 10^4 ; frequency given in c/s.

T°C	1×10^2	1×10^3	1×10^4	1×10^5	1×10^6	1×10^7	3×10^8	3×10^9	1×10^{10}	2.5×10^{10}
23	ϵ'/ϵ_0	6.10	5.96	5.89	5.86	5.84	5.80	5.75	-----	5.36
	tan δ	150	100	70	50	38	35	37	-----	58
85	ϵ'/ϵ_0	6.84	6.37	6.11	5.96	5.86	5.80	5.75	-----	5.50
	tan δ	890	370	175	103	77	50	50	-----	47
25	ϵ'/ϵ_0	5.90	5.88	5.84	5.80	5.70	5.65	5.60	5.24	5.18
	tan δ	30	59	79.5	55	30.5	19	16	26	38
81	ϵ'/ϵ_0	5.90	5.88	5.84	5.80	5.70	5.65	5.60	-----	5.42
	tan δ	58	40	46.5	70.5	66	40.5	24	-----	18
25	ϵ'/ϵ_0	6.00	5.98	5.98	5.97	5.97	5.96	5.96	5.90	-----
	tan δ	92	34	12	6	5	4	4	14	-----
25	ϵ'/ϵ_0	6.40	6.40	6.40	6.40	6.36	6.30	6.20	5.97	5.83
	tan δ	15.6	20	20	15.6	12.4	11.2	10	13	42
81	ϵ'/ϵ_0	6.52	6.46	6.40	6.40	6.36	6.30	-----	5.95	-----
	tan δ	35.6	22	18	21.5	18.4	11.8	-----	11	-----
22	ϵ'/ϵ_0	6.30	6.30	6.28	6.25	6.22	6.17	6.10	5.76	5.75
	tan δ	12.5	4.5	4.0	< 9	3.7	3.5	3	8.5	12
85	ϵ'/ϵ_0	6.37	6.37	6.37	6.36	6.32	6.28	-----	5.88	-----
	tan δ	21	13.7	8.0	< 9	3.7	3.5	-----	6	-----
24	ϵ'/ϵ_0	4.95	4.95	4.95	4.95	4.95	4.95	4.95	4.95	4.91
	tan δ	38	23	16	12	10	10	10	9.7	14
25	ϵ'/ϵ_0	6.22	6.22	6.22	6.22	6.22	6.22	6.22	-----	6.2
	tan δ	14.5	9	5	2	1	1.5	3	-----	11
25	ϵ'/ϵ_0	5.80	5.80	5.80	5.80	5.80	5.80	5.80	5.8	5.8
	tan δ	32	20	16	13	12	12	12	36	36
25	ϵ'/ϵ_0	5.54	5.54	5.54	5.54	5.54	5.54	5.54	5.5	5.5
	tan δ	160	100	72	60	50	45	39	53	53
25	5.77	5.77	5.77	5.77	5.77	5.77	5.77	5.77	5.7	5.7
	tan δ	55	30	16	9	7	6	6	22	22
25	ϵ'/ϵ_0	8.15	8.15	8.15	8.15	8.15	8.15	8.15	8.15	8.15
	tan δ	65	28	17	12	10	10	10	31	31

a. Magnesium silicate (Am. Lava). b. 93% Al₂O₃. 6% SiO₂. 1% MgO (Am. Lava). c. 60% talc, 15% kaolin, 17.5% BaCO₃, 7.5% MgCO₃ (Bell). d. Centralab.

I. Solids, A. Inorganic (cont.)

2. Ceramics (cont)

a. Steatite Bodies(cont.)		T°C												
Steatite Body 7292 ^a	25	ϵ'/ϵ_0	$\frac{1 \times 10^2}{6.55}$	$\frac{1 \times 10^3}{6.55}$	$\frac{1 \times 10^4}{6.54}$	$\frac{1 \times 10^5}{6.53}$	$\frac{1 \times 10^6}{6.53}$	$\frac{1 \times 10^7}{6.53}$	$\frac{1 \times 10^8}{6.53}$	$\frac{3 \times 10^8}{6.53}$	$\frac{3 \times 10^9}{6.52}$	$\frac{1 \times 10^{10}}{6.51}$	$\frac{2.5 \times 10^{10}}{6.51}$	
		$\tan \delta$	14	7	4.8	3.9	4.9	5.2	6.2	6.8	9	10.9		
Crolite #29 ^b	24	ϵ'/ϵ_0	6.04	6.04	6.04	6.04	6.04	6.04	-----	-----	5.90	5.71		
		$\tan \delta$	25	19	15	13	11	10	-----	-----	24	30		

b. Titania and Titanate

Bodies

Ceramic NPOT96 ^c	25	ϵ'/ϵ_0	29.5	29.5	29.5	29.5	29.5	29.5	29.5	-----	-----	28.9	
		$\tan \delta$	12	4.9	3.3	2.5	1.6	1.7	2	-----	-----	20	
Ceramic N75OT96 ^c	25	ϵ'/ϵ_0	83.4	83.4	83.4	83.4	83.4	83.4	83.4	-----	-----	83.4	
		$\tan \delta$	5.7	4.5	3.5	2.5	2.2	2.3	4.6	-----	-----	14.6	
Ceramic N14OOT110 ^c	25	ϵ'/ϵ_0	131	130.8	130.7	130.5	130.2	130.2	130.0	-----	-----		
		$\tan \delta$	6.7	5.5	3.3	1.4	3.0	5.5	7.0	-----	-----		
Body T106 ^c	25*	ϵ'/ϵ_0	1518	1508	1480								
		$\tan \delta$	31	87	99								

TI Pure R-200^d

	25**	ϵ'/ϵ_0	1308	1280	1260	1245	1232	1220	1210				
		$\tan \delta$	98	120	140	100	85	150	420				
	26	ϵ'/ϵ_0	100	100	100	100	100	100	100	-----	-----	90	
		$\tan \delta$	23	15	6.2	4	3	2.5	2.5	-----	-----	20	

Tam Ticon T-J, T-L and T-M^e

	78	ϵ'/ϵ_0	97.5	97	97	97	97	97	97				
		$\tan \delta$	130	60	33	13	4.5	2.3					

Tam Ticon MC^f

	24	ϵ'/ϵ_0	96	96	96	96	96	96	96	-----	96	-----	91
		$\tan \delta$	8	4.5	2	1	2	3	-----	-----	3.4	-----	33
	78	ϵ'/ϵ_0	90	89	88.5	88	87.5	87					
		$\tan \delta$	55	16	4	4	4	4					
	25	ϵ'/ϵ_0	13.9	13.9	13.9	13.9	13.9	13.9	13.9	13.9	13.8	13.8	13.7
		$\tan \delta$	15	11	9	7	4	4	5	9	17	28	65

a. Gen. Ceramics and Steatite. b. Al₂O₃, SiO₂, MgO, CaO, BaO (Crowley). c. Amer. Lava. d. Rutile (Dupont, fired at Lab. Ins. Res.). e. Rutile (Titanium Alloy, fired at Lab. Ins. Res.). f. Magnesium titanate (Titanium Alloy, fired at Lab. Ins. Res.).

* - 3/4" Disk. ** 0.2" disk cut from 3/4" disk.

I. Solids, A. Inorganic (cont.)

2. Ceramics (cont.)

b. Titanite and titanate

bodies (cont.)

bodies (cont.)	T°C	$\frac{1 \times 10^2}{\epsilon'/\epsilon_0}$	$\frac{1 \times 10^3}{\tan \delta}$	$\frac{1 \times 10^4}{\epsilon'/\epsilon_0}$	$\frac{1 \times 10^5}{\tan \delta}$	$\frac{1 \times 10^6}{\epsilon'/\epsilon_0}$	$\frac{1 \times 10^7}{\tan \delta}$	$\frac{1 \times 10^8}{\epsilon'/\epsilon_0}$	$\frac{3 \times 10^8}{\tan \delta}$	$\frac{1 \times 10^{10}}{\epsilon'/\epsilon_0}$	$\frac{2.5 \times 10^{10}}{\tan \delta}$
Titanite Ceramic ^a	25	---	---	---	---	33	---	---	---	---	---
	25	---	---	---	---	5.2	60.5	60	---	---	---
	25	---	---	---	---	---	8.3	11	---	---	---
Titanite Ceramic ^b	25	167.8	167.7	167.7	167.7	167.7	167.7	166.8	165	165	165
Tam Ticon C ^c	82	13.6	4.4	2.5	2	2	2	5	23	85	---
	82	157	156	156	156	156	156	---	---	---	---
	82	400	49	11	6	6	6	---	---	---	---
Tam Ticon S ^d	25	234	233	232	232	232	232	232	---	230	---
	25	21	11	8	5	2	1	1	---	28	---
Tam Ticon B ^e	25	1240	1200	1170	1153	1143	1140	---	1100	150	100
	25	360	130	150	120	105	75	---	500	5000	6000
Tam Ticon BS ^f	25	8700	8500	8200	8100	8000	8000	8000	7000	2000	---
(discontinued)	25	230	200	230	90	48	98	400	5000	4000	---
Mix 71 BaTiO ₃ ^g	25	1740	1720	1680	1650	---	---	---	---	---	---
	25	63	107	170	150	---	---	---	---	---	---
Mix 72 BaTiO ₃ 90% ^g	25	1310	13.7	1300	1280	1275	---	---	---	---	---
SrTiO ₃ 10% ^g	25	31	43	70	77	46	---	---	---	---	---
Mix 73 BaTiO ₃ 80% ^g	25	2163	2160	2120	2020	1960	---	---	---	---	---
SrTiO ₃ 20% ^g	25	94	155	280	200	75	---	---	---	---	---
Mix 74 BaTiO ₃ 70.9% ^g	25	2990	2970	2910	2840	2820	---	---	---	---	---
SrTiO ₃ 29.1% ^g	25	47	61	88	67	40	---	---	---	---	---
Mix 75 BaTiO ₃ 60% ^g	25	1125	1122	1120	1110	1090	---	---	---	---	---
SrTiO ₃ 40% ^g	25	110	72	45	30	19	---	---	---	---	---

a. 84.3% TiO_2 , 11.1% MgCO_3 , 4.6% MgSiO_3 (Lab. Ins. Res.). b. 84.6% TiO_2 , 15.4% BaO (Lab. Ins. Res.). c. Calcium titanate (Titanium Alloy; fired at Lab. Ins. Res.). d. Strontium titanate (Titanium Alloy; fired at Lab. Ins. Res.). e. Barium titanate (Titanium Alloy; fired at Lab. Ins. Res.). f. 79% barium, 21% strontium titanate (Titanium Alloy; fired at Lab. Ins. Res.). g. Thin sheet (Glenco).

I. Solids, A. Inorganic (cont.)

2. Ceramics (cont.)

b. Titanate and titanate bodies (cont.)

	T ^o C	ϵ'/ϵ_0	$\frac{1 \times 10^2}{740}$	$\frac{1 \times 10^3}{738}$	$\frac{1 \times 10^4}{735}$	$\frac{1 \times 10^5}{732}$	$\frac{1 \times 10^6}{730}$	$\frac{1 \times 10^7}{---}$	$\frac{3 \times 10^8}{---}$	$\frac{3 \times 10^9}{---}$	$\frac{1 \times 10^{10}}{---}$
Mix 76 BaTiO ₃ 50% ^a	25	ϵ'/ϵ_0	740	738	735	732	730	---	---	---	---
SrTiO ₃ 50%		tan δ	10.7	6	7	21	28	---	---	---	---
Mix 77 BaTiO ₃ 68.1% ^a	25	ϵ'/ϵ_0	892	890	890	890	890	---	---	---	---
SrTiO ₃ 28.1%		tan δ	16	10	12	25	8	---	---	---	---
MgZrO ₃ 2.8%											

c. Porcelains

Zirconium Porcelain Zi-4 ^b	25	ϵ'/ϵ_0	6.44	6.40	6.35	6.32	6.32	6.30	6.30	6.23	6.18
		tan δ	59	40	31	27	23	21	25	45	57
Porcelain, wet process ^c	25	ϵ'/ϵ_0	6.47	6.24	6.08	5.98	5.87	5.82	5.80	5.75	5.51
		tan δ	280	180	130	105	90	115	135	140	155
Porcelain, dry process ^c	25	ϵ'/ϵ_0	5.50	5.36	5.23	5.14	5.08	5.04	5.04	5.02	4.74
		tan δ	220	140	105	85	75	70	78	98	156
Coors AI-200 ^d	25	ϵ'/ϵ_0	8.83	8.83	8.82	8.80	8.80	8.80	8.80	---	8.79
		tan δ	14	5.7	4.8	3.8	3.3	3.2	3.0	10	18
Porcelain #4462 ^e	25	ϵ'/ϵ_0	8.99	8.95	8.95	8.95	8.95	8.95	8.95	8.93*	8.90
		tan δ	22	9.1	6.0	3.0	2.0	2.0	4.0	9*	14
Coors AB-2 ^d	25	ϵ'/ϵ_0	8.22	8.18	8.17	8.17	8.16	8.16	8.16	---	8.08
		tan δ	20	13.4	11.4	10.5	9.0	7.5	9.0	16	27
ALSiMag 491 ^f	25	ϵ'/ϵ_0	---	---	---	---	8.74	---	---	8.60	8.50
		tan δ	---	---	---	---	22	---	---	17	23
d. Miscellaneous Ceramics											
Beryllium oxide ^g	25	ϵ'/ϵ_0	4.61	4.47	4.41	4.34	4.28	4.24	4.23	---	4.20
		tan δ	170	84	74	72	38	19	12.5	---	5
Porous Ceramic AF-497 ^h	25	ϵ'/ϵ_0	---	---	---	---	---	---	---	---	1.472
		tan δ	---	---	---	---	---	---	---	---	17

a. Thin sheet (Glenco). b. Coors. c. Knox. d. Aluminum oxide (Coors). e. Aluminum oxide (Frenchtown Porcelain). f. Aluminum oxide (Amer. Lava). g. Norton. h. 53% diatomaceous-earth, 32% anthracite coal, 5.5% whiting (Stupakoff). *Frequency = 1×10^9 .

I. Solids, A. Inorganic, 2. Ceramics (cont.)

e. Ferrites

Frequency given in c/s; temperature = 25°C.

Freq.	Crowley 20 ^a				Crowley 70 ^a				Crowley BX113 ^{a*}				Crowley BX114 ^a			
	ϵ'/ϵ_0	$\tan \delta_d$	μ'/μ_0	$\tan \delta_m$	ϵ'/ϵ_0	$\tan \delta_d$	μ'/μ_0	$\tan \delta_m$	ϵ'/ϵ_0	$\tan \delta_d$	μ'/μ_0	$\tan \delta_m$	ϵ'/ϵ_0	$\tan \delta_d$	μ'/μ_0	$\tan \delta_m$
10 ²	35400	2.41	----	----	440000	26.7	400	----	19.4	.59	----	----	29	.58	21	----
4x10 ²	9900	3.94	----	----	----	----	----	----	----	----	----	----	19.2	----	----	----
10 ³	5430	2.65	120	----	350000	3.35	400	----	14.7	.20	14.5	----	19.2	.30	17.5	----
10 ⁴	1590	1.47	120	----	250000	.78	400	----	13.0	.066	14.5	----	14.9	.15	15.6	----
10 ⁵	480	1.6	120	----	123000	.64	400	----	12.8	.024	14.5	----	12.9	.06	14.5	----
10 ⁶	----	----	----	----	----	----	440	.28	12.6	.010	14	----	12.6	.024	----	----
3x10 ⁶	----	----	108	.08	----	----	147	1.53	----	----	13	<.1	----	----	16	<.1
10 ⁷	18	1.1	84	.48	16400	1.4	92	.24	12.5	.005	12,47	<.1, .02	12.4	.007	18.5	<.1
2x10 ⁷	----	----	----	----	----	----	----	----	----	----	12	<.2	----	----	----	----
3x10 ⁷	----	----	47	.92	----	----	----	----	----	----	12.8, 46	.05, .03	----	----	20.7	<.1
6.5x10 ⁷	----	----	35	1.16	----	----	41	1.92	----	----	51	.25	----	----	23	<.1
8x10 ⁷	----	----	24.6	1.58	----	----	29	2.36	----	----	49.4	.46	----	----	24	<.1
10 ⁸	----	----	17.9	2.15	----	----	18	3.35	12.5	.0026	37	.74	12.4	.0037	26	<.1
1.2x10 ⁸	----	----	15.9	1.98	----	----	21	2.58	----	----	34	.9	----	----	30	.13
1.4x10 ⁸	----	----	24.6	1.43	----	----	----	----	----	----	28.5	1.15	----	----	31	.32
3x10 ⁸	----	----	----	----	----	----	----	----	----	----	17.9	1.5	----	----	17.6	1.61
9x10 ⁸	12	.07	----	----	----	----	----	----	----	----	5.34	3.4	----	----	3.25	4.46
10 ⁹	12	.07	.98	5.8	----	----	----	----	----	----	----	----	----	----	----	----
3x10 ⁹	12	.04	.28	7.2	42	----	.19	10.6	12	<.012	1.74	1.9	12	<.01	1.34	2.48

a. H. L. Crowley.

*Two samples were measured; they differed as shown by the two sets of values at 10⁷ and 3x10⁷. Lower μ'/μ_0 values were obtained on sample cut from 2" disk, higher values on 3/4" disk. ϵ'/ϵ_0 values did not differ.

I. Solids, A. Inorganic, 2. Ceramics (cont.)

a. Ferrites (cont.)

Frequency given in c/s; temperature = 25°C.

Freq.	Ferramic A ^{a,b}				Ferramic B ^a				Ferramic C ^a				Ferramic D ^a			
	ϵ'/ϵ_0	$\tan \delta_d$	μ'/μ_0	$\tan \delta_m$	ϵ'/ϵ_0	$\tan \delta_d$	μ'/μ_0	$\tan \delta_m$	ϵ'/ϵ_0	$\tan \delta_d$	μ'/μ_0	$\tan \delta_m$	ϵ'/ϵ_0	$\tan \delta_d$	μ'/μ_0	$\tan \delta_m$
10^3	9.82	.112	19.6	----	20800	4.5	----	----	110000	2.4	240	----	35000	84	380	----
10^4	9.30	.026	19.6	----	19700	4.8	94	----	32000	1.44	240	----	35000	8.1	380	----
10^5	9.13	.0076	19.5	----	15500	.78	----	----	22000	1	----	----	----	----	----	----
10^6	8.99	.0032	19.4	----	8600	.65	----	----	13500	1.32	242	.015	17600	.77	510	<.05
2×10^6	----	----	20.0	----	----	----	108	.027	----	----	259	----	----	----	550	.18
3×10^6	----	----	22	----	----	----	----	----	----	----	267	.068	11000	.80	565	.47
4×10^6	----	----	----	----	----	----	----	----	----	----	----	----	----	----	411	.55
7×10^6	----	----	23	----	----	----	----	----	----	----	----	----	----	----	112	2.76
10^7	8.87	.0016	24.6	.08	1060	2.9	107	.36	2850	2.0	195	.85	6000	.90	52	4.0
2×10^7	----	----	25.4	.177	----	----	----	----	----	----	78	1.6	----	----	17.7	5.8
3×10^7	----	----	----	----	----	----	62	.67	----	----	33.5	2.7	----	----	12.9	6.2
5×10^7	8.5	<.1	12.5	1.00	----	----	----	----	----	----	----	----	485	2.9	----	----
10^8	----	----	7.2	1.29	----	----	14.4	1.12	64	.70	16.8	.61	106	3.1	1.09	18.4
3×10^8	----	----	2.8	1.6	51	1.56	----	----	----	----	----	----	----	----	----	----
5×10^8	----	----	2.0	1.2	----	----	----	----	----	----	----	----	----	----	----	----
10^9	8.5	<.1	3.0	.67	----	----	----	----	----	----	----	----	----	----	----	----
2×10^9	----	----	1.0	2.0	----	----	----	----	----	----	----	----	----	----	----	----
3×10^9	----	----	.6	2.0	20	.68	.29	10	24.6	1.14	.18	22	35	3.3	.15	20
10^{10}	8.5	<.1	1.0	----	15	.52	.42	.37	18.7	.58	.51	1.26	30	1.35	1.9	1.0

Freq.	Ferramic G ^a				Ferramic H ^a				Ferramic I ^a				Ferramic J ^a			
	ϵ'/ϵ_0	$\tan \delta_d$	μ'/μ_0	$\tan \delta_m$	ϵ'/ϵ_0	$\tan \delta_d$	μ'/μ_0	$\tan \delta_m$	ϵ'/ϵ_0	$\tan \delta_d$	μ'/μ_0	$\tan \delta_m$	ϵ'/ϵ_0	$\tan \delta_d$	μ'/μ_0	$\tan \delta_m$
10^3	----	----	450	----	670000	7.2	720	----	12000	2.9	890	----	----	----	256	----
10^4	23.5	.60	400	----	152500	4.5	720	----	7800	.81	890	----	17.5	1.95	256	----
10^5	15.5	.216	360	----	22400	4.2	720	----	930	3.1	890	<.1	13.8	.37	256	----
10^6	13.6	.069	340	.05	1600	8.2	690	.18	90	4.7	1050	.29	12.6	.062	256	.015
10^7	13.0	.026	245	.66	----	----	300	1.33	26	2.1	215	1.6	12.4	.015	196	.66
3×10^8	----	----	----	----	----	----	----	----	13.6	.114	10.7	1.03	----	----	----	----
3×10^9	----	----	----	----	----	----	----	----	12	.012	.90	.04	----	----	----	----

a. Gen. Ceramics and Steatite. b. Data partly from Rado, Wright and Emerson, Phys. Rev. 80, 273 (1950).

I. Solids, A. Inorganic (cont.)

Values for $\tan \delta$ are multiplied by 10^4 ; frequency given in c/s.

3. Glasses	T ^o C	ϵ'/ϵ_0	$\tan \delta$	1×10^2	1×10^3	1×10^4	1×10^5	1×10^6	1×10^7	1×10^8	3×10^8	1×10^9	1×10^{10}	2.5×10^{10}
Phosphate Glass #2043r ^a	25	ϵ'/ϵ_0	$\tan \delta$	5.25	5.25	5.25	5.25	5.25	5.25	5.24	5.23	5.17	5.00	4.93
Phosphate Glass #2279x ^b	25	ϵ'/ϵ_0	$\tan \delta$	4.92	4.92	4.92	4.92	4.92	4.92	4.92	---	4.9	4.9	4.9
Borosilicate Glass ^c	25	ϵ'/ϵ_0	$\tan \delta$	4.05	4.05	4.05	4.05	4.05	4.05	4.05	---	4.05	4.05	4.05
Corning 001c ¹	24	ϵ'/ϵ_0	$\tan \delta$	13.6	8.6	4.4	4.4	5.8	7.0	8.0	---	10.6	15.5	---
Corning 0014 ^a	25	ϵ'/ϵ_0	$\tan \delta$	6.68	6.63	6.57	6.50	6.43	6.39	6.33	---	6.1	5.96	5.87
Corning 0080 ^f	23	ϵ'/ϵ_0	$\tan \delta$	77.5	53.5	35	23	16.5	15	23	---	60	90	110
Corning 0090 ^g	20	ϵ'/ϵ_0	$\tan \delta$	6.78	6.77	6.76	6.75	6.73	6.72	6.70	6.69	---	6.64	---
Corning 0100 ^h	25	ϵ'/ϵ_0	$\tan \delta$	23.1	17.2	14.4	12.2	12.4	13.8	17.0	19.5	---	70	---
Corning 0120 ⁱ	23	ϵ'/ϵ_0	$\tan \delta$	8.30	7.70	7.35	7.08	6.90	6.82	6.75	---	6.71	6.71	6.62
Corning 0170 ^j	25	ϵ'/ϵ_0	$\tan \delta$	780	400	220	140	100	85	90	---	126	170	180
Corning 1770 ^j	25	ϵ'/ϵ_0	$\tan \delta$	9.15	9.15	9.15	9.14	9.12	9.10	9.02	---	8.67	8.45	8.25
Corning 1990 ^k	24	ϵ'/ϵ_0	$\tan \delta$	12	8	7	7	8	12	18	---	54	103	122
Corning 1991 ^m	24	ϵ'/ϵ_0	$\tan \delta$	7.18	7.17	7.16	7.14	7.10	7.10	7.07	---	7.00	6.95	6.87
Corning 3320 ⁿ	24	ϵ'/ϵ_0	$\tan \delta$	24	16	13.5	13	14	17	24	---	44	63	106
Corning 7040 ^o	25	ϵ'/ϵ_0	$\tan \delta$	6.75	6.70	6.66	6.65	6.65	6.65	6.65	---	6.64	6.60	6.51
Corning 7050 ^p	25	ϵ'/ϵ_0	$\tan \delta$	46	30	20	14	12	13	18	---	41	63	127
	24	ϵ'/ϵ_0	$\tan \delta$	6.25	6.16	6.10	6.03	6.00	6.00	6.00	---	5.95	5.83	5.44
	24	ϵ'/ϵ_0	$\tan \delta$	49.5	42	33	26	27	34	38	---	56	84	140
	24	ϵ'/ϵ_0	$\tan \delta$	8.40	8.38	8.35	8.32	8.30	8.25	8.20	---	7.99	7.94	7.84
	24	ϵ'/ϵ_0	$\tan \delta$	4	4	3	4	5	7	9	---	19.9	42	112
	24	ϵ'/ϵ_0	$\tan \delta$	8.10	8.10	8.08	8.08	8.08	8.06	8.00	---	7.92	7.83	---
	24	ϵ'/ϵ_0	$\tan \delta$	12	9	6	5	5	7	12	---	38	51	---
	24	ϵ'/ϵ_0	$\tan \delta$	5.00	4.93	4.88	4.82	4.79	4.78	4.77	---	4.74	4.72	4.7
	25	ϵ'/ϵ_0	$\tan \delta$	80	58	43	34	30	30	32	---	55	73	120
	25	ϵ'/ϵ_0	$\tan \delta$	4.84	4.82	4.79	4.77	4.73	4.70	4.68	---	4.67	4.64	4.52
	25	ϵ'/ϵ_0	$\tan \delta$	50	34	25.5	20.5	19	22	27	---	44	57	73
	25	ϵ'/ϵ_0	$\tan \delta$	4.88	4.84	4.82	4.80	4.78	4.76	4.75	---	4.74	4.71	4.64
	25	ϵ'/ϵ_0	$\tan \delta$	81	56	43	33	27	28	35	---	52	61	83

a. Contains 2% iron oxide (Am. Optical). b. Aluminum-zinc phosphate. (ca. 70% P₂O₅) (Am. Optical). c. 73.2% SiO₂, 24.8% B₂O₃ (Components and Systems Lab., Air Materiel Command). d. Soda-potash-lead silicate ca. 20% PbO. e. Lead-barium glass. f. Soda-lime-silicate. g. Potash-lead-silicate. h. Potash-soda-barium silicate. i. Soda-potash-lead-silicate. j. Lime-alumina-silicate. k. Iron-sealing glass. m. 45% SiO₂, 14% K₂O, 6% Na₂O, 3% PbO, 5% CaO (iron-sealing glass). n. Soda-potash-borosilicate. o. Soda-potash-borosilicate. p. Soda-borosilicate (ca. 70% SiO₂).

I. Solids, A. Inorganic (cont.)

Values for $\tan \delta$ are multiplied by 10^4 ; frequency given in c/s.

3. Glasses (cont.)	T ^o C	ϵ'/ϵ_0	$\tan \delta$	1×10^2	1×10^3	1×10^4	1×10^5	1×10^6	1×10^7	1×10^8	3×10^8	3×10^9	1×10^{10}	2.5×10^{10}
Corning 7052 ^a	23	ϵ'/ϵ_0		5.20	5.18	5.14	5.12	5.10	5.10	5.09	-----	5.04	4.93	4.85
		$\tan \delta$		68	49	34	26	24	28	34	-----	58	81	114
Corning 7055	25	ϵ'/ϵ_0		5.45	5.41	5.38	5.33	5.31	5.30	5.27	5.25	-----	5.08	-----
		$\tan \delta$		45	36	30	28	28	29	38	49	-----	130	-----
Corning 7060 ^b	25	ϵ'/ϵ_0		5.02	4.97	4.92	4.86	4.84	4.84	4.84	-----	4.82	4.80	4.65
		$\tan \delta$		89	55	42	40	36	30	30	-----	54	98	90
Corning 7070 ^c	23	ϵ'/ϵ_0		4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	3.9
		$\tan \delta$		6	5	5	6	8	11	12	12	12	21	31
	100	ϵ'/ϵ_0		4.17	4.16	4.15	4.14	4.13	4.10	-----	-----	4.00	4.00	-----
		$\tan \delta$		50	22	13	10	9	11	-----	-----	19	21	-----
Corning 7230 ^d	25	ϵ'/ϵ_0		3.88	3.86	3.85	3.85	3.85	3.85	-----	-----	3.75	-----	-----
		$\tan \delta$		33	23	16	13	11	12	-----	-----	22	-----	-----
Corning 7570	25	ϵ'/ϵ_0		14.58	14.56	14.54	14.53	14.52	14.50	14.42	14.4	-----	14.2	-----
		$\tan \delta$		11.5	13.5	15.9	16.5	19.0	23.5	.33	44	-----	98	-----
Corning 7720 ^e	24	ϵ'/ϵ_0		4.74	4.70	4.67	4.64	4.62	4.61	-----	-----	-----	4.59	-----
		$\tan \delta$		78	42	29	22	20	23	-----	-----	-----	43	-----
Corning 7740 ^f	25	ϵ'/ϵ_0		4.80	4.73	4.70	4.60	4.55	4.52	4.52	-----	-----	4.52	4.50
		$\tan \delta$		128	86	65	54	49	45	45	-----	-----	85	96
Corning 7750 ^f	25	ϵ'/ϵ_0		4.45	4.42	4.39	4.38	4.38	4.38	-----	-----	4.38	4.38	-----
		$\tan \delta$		45	33	24	20	18	19	-----	-----	43	54	-----
Corning 7900 ^g	20	ϵ'/ϵ_0		3.85	3.85	3.85	3.85	3.85	3.85	-----	3.85	3.84	3.82	3.82
		$\tan \delta$		6	6	6	6	6	6	-----	6	6.8	9.4	13
	100	ϵ'/ϵ_0		3.85	3.85	3.85	3.85	3.85	3.85	-----	3.85	3.84	3.82	-----
		$\tan \delta$		37	17	12	10	8.5	7.5	-----	7.5	10	13	-----
Corning 7911	25	ϵ'/ϵ_0		-----	-----	-----	-----	-----	-----	-----	-----	-----	3.82	-----
		$\tan \delta$		-----	-----	-----	-----	-----	-----	-----	-----	-----	6.5	-----
Corning 8460 ^h	25	ϵ'/ϵ_0		8.35	8.30	8.30	8.30	8.30	8.30	8.30	-----	8.10	8.06	8.05
		$\tan \delta$		11	9	7.5	7	8	10	16	-----	40	57	60
Corning 8830	25	ϵ'/ϵ_0		5.38	5.28	5.20	5.11	5.05	5.01	5.00	4.97	-----	4.83	-----
		$\tan \delta$		204	130	91	73	60	54	57	63	-----	99	-----

a. Soda-potash-lithia-borosilicate. b. Soda-borosilicate (Pyrex). c. Low alkali potash-lithia-borosilicate. d. Aluminum borosilicate.

e. Soda-lead borosilicate. f. Soda-borosilicate (ca. 80% SiO₂). g. 96% SiO₂. h. Barium borosilicate.

I. Solids, A. Inorganic (cont.)

Values for $\tan \delta$ are multiplied by 10^4 ; frequency given in c/s.

3. Glasses (cont.)	T°C	$\frac{1 \times 10^2}{\epsilon'/\epsilon_0}$	$\frac{1 \times 10^3}{\epsilon'/\epsilon_0}$	$\frac{1 \times 10^4}{\epsilon'/\epsilon_0}$	$\frac{1 \times 10^5}{\epsilon'/\epsilon_0}$	$\frac{1 \times 10^6}{\epsilon'/\epsilon_0}$	$\frac{1 \times 10^7}{\epsilon'/\epsilon_0}$	$\frac{1 \times 10^8}{\epsilon'/\epsilon_0}$	$\frac{3 \times 10^8}{\epsilon'/\epsilon_0}$	$\frac{3 \times 10^9}{\epsilon'/\epsilon_0}$	$\frac{1 \times 10^{10}}{\epsilon'/\epsilon_0}$	$\frac{2.5 \times 10^{10}}{\epsilon'/\epsilon_0}$
Corning 8871 ^a	25	ϵ'/ϵ_0	8.45	8.45	8.45	8.45	8.43	---	8.40	8.34	8.05	7.82
		$\tan \delta$	13	9	7	6	7	---	14	26	49	70
Corning 9010	25	ϵ'/ϵ_0	6.51	6.49	6.48	6.45	6.43	6.42	6.40	---	6.27	---
		$\tan \delta$	50.5	36.2	26.7	22.7	22.6	30	41	---	91	---
Corning Lab. No. 1890S	25	ϵ'/ϵ_0	19.2	19.2	19.2	19.1	19.0	19.0	---	17.8	---	---
		$\tan \delta$	12.5	13	16.5	21	37	57	---	124	---	---
"E" Glass ^b	23	ϵ'/ϵ_0	6.43	6.40	6.39	6.37	6.25	6.22	---	---	6.11	---
		$\tan \delta$	42	34	27	18	17	23	---	---	60	---
Foamglas ^c	23	ϵ'/ϵ_0	90.0	82.5	68.0	44.0	9.0	---	---	---	5.49	---
		$\tan \delta$	1500	1600	2380	3200	1960	---	---	---	455	---
Fused Silica 915c ^d	25	ϵ'/ϵ_0	3.78	3.78	3.78	3.78	3.78	3.78	3.78	---	3.78	---
		$\tan \delta$	6.6	2.6	1.1	0.4	0.1	0.3	0.5	---	1.7	---
Fused Silica 915c ^{d,e}	25	ϵ'/ϵ_0	3.78	3.78	3.78	3.78	3.78	3.78	---	3.78	3.78	3.78
		$\tan \delta$	0.08	0.13	<0.05	---	---	---	---	0.6	1	2.5
Fused quartz ^f	25	ϵ'/ϵ_0	3.78	3.78	3.78	3.78	3.78	3.78	---	3.78	3.78	3.78
		$\tan \delta$	8.5	7.5	6	4	2	1	---	---	---	---
Soda-Silica Glasses ^g												
9% Na ₂ O, 91% SiO ₂	25	ϵ'/ϵ_0	6.4	6.2	5.7	---	---	---	5.1	---	5.05	4.9
		$\tan \delta$	2500	820	400	---	---	---	100	---	130	160
12% Na ₂ O, 88% SiO ₂	25	ϵ'/ϵ_0	8.2	6.7	6.1	---	---	---	5.2	---	5.15	5.04
		$\tan \delta$	1900	600	300	---	---	---	100	---	155	170
16% Na ₂ O, 84% SiO ₂	25	ϵ'/ϵ_0	9.4	7.4	6.6	6.2	5.7	---	5.5	---	5.27	---
		$\tan \delta$	3000	960	500	250	130	---	110	---	180	---
20% Na ₂ O, 80% SiO ₂	25	ϵ'/ϵ_0	10.8	8.3	7.3	6.8	6.3	---	5.9	---	5.6	6.1
		$\tan \delta$	4000	1500	670	360	180	---	140	---	200	280
25% Na ₂ O, 75% SiO ₂	25	ϵ'/ϵ_0	13	9.7	8.4	---	---	---	6.7	---	6.3	---
		$\tan \delta$	6700	2400	1000	---	---	---	170	---	220	---
30% Na ₂ O, 70% SiO ₂	25	ϵ'/ϵ_0	18	12	10.4	---	---	---	7.5	---	7.2	7.0
		$\tan \delta$	11000	3900	1300	---	---	---	190	---	240	350

a. Alkaline lead silicate. b. Owens-Corning. c. Soda-lime (Pittsburgh-Corning). d. SiO₂ (Corning). e. Sample B-135. f. SiO₂ (General Electric). g. Composition in mole % of oxides as mixed (Lab. Ins. Res.).

I. Solids, A. Inorganic (Cont.) Values for $\tan \delta$ are multiplied by 10^4 ; frequency given in c/s.

3. Classes (cont.) Alkali-silica glasses ^a	T°C	1×10^2	1×10^3	1×10^4	1×10^5	1×10^6	1×10^7	3×10^8	1×10^{10}
12.8% Li ₂ O, 87.2% SiO ₂	25	ϵ'/ϵ_0	6.54	5.45	5.1	4.95	4.92	---	4.80
		$\tan \delta$	9700	1000	310	174	124	---	102
12.8% Na ₂ O, 87.2% SiO ₂	25	ϵ'/ϵ_0	8.09	6.00	5.8	5.66	5.57	---	5.33
		$\tan \delta$	3050	450	240	159	126	---	182
12.8% K ₂ O, 87.2% SiO ₂	25	ϵ'/ϵ_0	7.53	6.25	6.17	6.09	6.02	---	5.8
		$\tan \delta$	502	200	121	90	80	---	220
12.8% K ₂ O, 87.2% SiO ₂ Quenched	25	ϵ'/ϵ_0	7.10	6.30	6.12	6.10	6.08	---	5.75
		$\tan \delta$	730	270	160	119	103	---	240
12.8% Rb ₂ O, 87.2% SiO ₂	25	ϵ'/ϵ_0	5.39	5.32	5.22	5.21	5.20	---	5.05
		$\tan \delta$	98	89	46	41	38	---	120
6.4% Li ₂ O, 6.4% Na ₂ O, 87.2% SiO ₂	25	ϵ'/ϵ_0	5.15	5.08	5.05	5.04	5.03	---	4.95
		$\tan \delta$	145	87	28	19	17	---	52
6.4% Li ₂ O, 6.4% Na ₂ O, 87.2% SiO ₂ Quenched	25	ϵ'/ϵ_0	5.15	5.09	5.05	5.04	5.02	---	4.94
		$\tan \delta$	150	87	27	19	21	---	57
3.3% Li ₂ O, 6.6% K ₂ O, 71% SiO ₂	25	ϵ'/ϵ_0	5.23	5.19	5.15	5.14	5.10	---	5.04
		$\tan \delta$	53	47	28	24	24	---	83
3.3% Li ₂ O, 6.6% K ₂ O, 91% SiO ₂ Quenched	25	ϵ'/ϵ_0	5.38	5.35	5.28	5.23	5.20	---	5.08
		$\tan \delta$	102	74	30	30	33	---	102
6.4% Na ₂ O, 6.4% K ₂ O, 87.2% SiO ₂	25	ϵ'/ϵ_0	5.69	5.62	5.58	5.56	5.54	---	5.50
		$\tan \delta$	102	75	42	25	23	---	115
6.4% Na ₂ O, 6.4% K ₂ O, 87.2% SiO ₂ Quenched	25	ϵ'/ϵ_0	5.70	5.62	5.58	5.56	5.55	---	5.53
		$\tan \delta$	129	89	36	33	34	---	160

a. Composition in mole % of oxides as mixed (Lab. Ins. Res.)

I. Solids A. Inorganic (cont.) Values for tan δ are multiplied by 10^4 ; frequency given in c/s.

4. Mica and Glass		T ^o C	ϵ'/ϵ_0	$\tan \delta$	1×10^2	1×10^3	1×10^4	1×10^5	1×10^6	1×10^7	1×10^8	3×10^8	3×10^9	1×10^{10}	2.5×10^{10}
Mycalox 2821 ^a (discontinued)		25	ϵ'/ϵ_0		7.50	7.50	7.50	7.50	7.50	7.45	7.45	-----	-----	7.09	
			$\tan \delta$		60	28	17	13	10	9	9	-----	-----	27	
Mycalox 400 ^b		25	ϵ'/ϵ_0		7.47	7.45	7.42	7.40	7.39	7.38	-----	-----	-----	7.12	
			$\tan \delta$		29	19	16	14	13	13	-----	-----	-----	33	
80			ϵ'/ϵ_0		7.64	7.59	7.54	7.52	7.50	7.47	-----	-----	-----	7.32	
			$\tan \delta$		150	85	50	25	16	14	-----	-----	-----	57	
Mycalox K10 ^c		24	ϵ'/ϵ_0		9.5	9.3	9.2	9.1	9.0	9.0	-----	-----	11.3*	11.3*	
			$\tan \delta$		170	125	76	42	26	21	-----	-----	40	40	
Mykroy Grade 8 ^d		25	ϵ'/ϵ_0		6.87	6.81	6.76	6.74	6.73	6.73	6.72	-----	6.68**	6.96**	6.66
			$\tan \delta$		95	66	43	31	26	24	25	-----	38	48	81
Mykroy Grade 38 ^d		25	ϵ'/ϵ_0		7.71	7.69	7.64	7.61	7.61	7.61	-----	-----	7.68**	8.35**	
			$\tan \delta$		43	33	27	24	21	14	-----	-----	35	40	
5. Miscellaneous Inorganics															
Ruby mica ^e		26	ϵ'/ϵ_0		5.4	5.4	5.4	5.4	5.4	5.4	5.4	-----	5.4		
			$\tan \delta$		25	6	3.5	3	3	3	2	-----	3		
Canadian mica (field I sheet)		25	ϵ'/ϵ_0		6.90	6.90	6.90								
			$\tan \delta$		15	2	1								
(field II sheet)		25	ϵ'/ϵ_0		11.5	8.7	7.3								
			$\tan \delta$		2300	980	400								
Marble S-3030 ^f (after drying over P ₂ O ₅)		25	ϵ'/ϵ_0		15.6	12.8	11.4	10.6	10.0	9.5	9.1	8.8	-----	8.6	
			$\tan \delta$		2000	1100	630	390	360	370	290	250	-----	120	
(after baking)		25	ϵ'/ϵ_0		9.45	9.42	9.29	9.25	9.07	8.98	8.85	-----	-----	8.53	
			$\tan \delta$		180	130	81	75	110	120	120	-----	-----	110	
(after 60% humidity for 3 weeks)		25	ϵ'/ϵ_0		-----	-----	-----	-----	-----	9.35	8.95				
			$\tan \delta$		-----	-----	-----	-----	-----	500	250				
Selenium, amorphous ^g		25	ϵ'/ϵ_0		6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.0	6.00	6.00	6.00
			$\tan \delta$		18	4	< 3	< 5	< 3	< 2	< 2	< 5	1.8	6.7	13
Quinterra ^h (Measured at 50% R.H.)		25	ϵ'/ϵ_0		5.75	4.80	4.1	3.3	3.1						
			$\tan \delta$		1770	1500	1240	590	250						
Quinorgo #3000 ⁱ (Measured at 50% R.H.)		25	ϵ'/ϵ_0		8.75	6.4	4.9	4.0	3.3						
			$\tan \delta$		210	2310	2150	1350	870						

a. Mica, glass (Gen. Elec.). b. Mica, glass (Mycalox). c. Mica, glass, TiO₂ (Mycalox). d. Mica, glass (Electronic Mech.).

e. Muscovite. f. Class A (Tenn. Marble). g. Amer. Smelt. and Refining. h. Asbestos fiber, chrysotile, Type I (Johns-Manville).

i. 85% chrysotile asbestos, 15% organic material (Johns-Manville).

*Not corrected for variations of density. **Samples nonhomogeneous.

I. Solids A. Inorganic (cont.)

5. Misc. Inorganics

(cont.)

Values for $\tan \delta$ are multiplied by 10^4 ; frequency given in c/s.

$T^{\circ}C$	ϵ'/ϵ_0	$\tan \delta$	1×10^2	1×10^3	1×10^4	1×10^5	1×10^6	1×10^7	1×10^8	3×10^8	1×10^{10}
25	ϵ'/ϵ_0	$\tan \delta$	3.42	2.91	2.75	2.55	2.59	2.55	2.55	2.55	2.53
25	ϵ'/ϵ_0	$\tan \delta$	.196	.08	.034	.020	.017	.016	.0100	.0062	.0036
25	ϵ'/ϵ_0	$\tan \delta$	3.23	2.72	2.50	2.50	2.50	2.50	2.50	2.50	2.50
25	ϵ'/ϵ_0	$\tan \delta$	.64	.13	.056	.030	.025	.025	.026	.03	.065
25	ϵ'/ϵ_0	$\tan \delta$	---	---	---	5.0	4.70	4.50	4.50	4.40	3.60
25	ϵ'/ϵ_0	$\tan \delta$	---	1500	---	19	1.75	.3	---	.03	.12
25	ϵ'/ϵ_0	$\tan \delta$	---	---	---	---	20	20	20	20	13
25	$\tan \delta$	$\tan \delta$	---	3425	367	---	4	.35	---	.13	.29
25	ϵ'/ϵ_0	$\tan \delta$	3.06	2.83	2.69	2.60	2.53	2.48	---	2.47	2.44
25	$\tan \delta$	$\tan \delta$	.07	.05	.035	.03	.018	.014	---	.0065	.0014
25	ϵ'/ϵ_0	$\tan \delta$	---	---	18	---	6.9	4	---	3.5	3.50
25	$\tan \delta$	$\tan \delta$	---	2.1	1.6	---	.65	.45	---	.06	.03
25	ϵ'/ϵ_0	$\tan \delta$	---	---	---	---	---	14.5	---	20	13.8
25	$\tan \delta$	$\tan \delta$	---	8490	970	---	---	1.3	---	.16	.18
25	ϵ'/ϵ_0	$\tan \delta$	4.73	3.94	3.27	2.79	2.57	2.44	---	2.38	2.16
25	$\tan \delta$	$\tan \delta$	.12	.12	.12	.10	.065	.04	---	.020	.013
25	ϵ'/ϵ_0	$\tan \delta$	---	---	---	---	---	21.6	---	20	11.3
25	$\tan \delta$	$\tan \delta$	---	7800	1000	---	---	1.7	---	.52	.25
25	μ'/μ_0	$\tan \delta$	---	---	---	---	1.09	1.09	---	1.09	1.005
25	$\tan \delta$	$\tan \delta$	---	---	---	---	---	---	---	.025	.099
25	ϵ'/ϵ_0	$\tan \delta$	3.95	3.75	3.62	3.52	3.50	3.60	---	3.50	3.50
25	$\tan \delta$	$\tan \delta$	.041	.029	.022	.017	.015	.012	---	.018	.022
25	ϵ'/ϵ_0	$\tan \delta$	---	---	---	---	12	10	---	9.0	8.3
25	$\tan \delta$	$\tan \delta$	---	---	---	---	9	1.0	---	.12	.22
25	ϵ'/ϵ_0	$\tan \delta$	---	---	---	---	---	30	---	30	30
25	$\tan \delta$	$\tan \delta$	---	---	---	---	---	4	---	.2	.32
25	ϵ'/ϵ_0	$\tan \delta$	4.34	4.32	4.30	4.30	4.30	4.29	---	---	---
25	$\tan \delta$	$\tan \delta$	.00314	.0022	.0019	.0017	.0017	.0018	---	---	---

a. Bentonite with organic binder (Aircraft Marine).

I. Solids, B. Organic, with or without inorganic components - Values for $\tan \delta$ are multiplied by 10^4 ; frequency given in c/s.

1. Crystals	T°C	ϵ'/ϵ_0	$\tan \delta$	1×10^2	1×10^3	1×10^4	1×10^5	1×10^6	1×10^7	1×10^8	3×10^8	3×10^9	1×10^{10}	2.5×10^{10}
α -Trinitrotoluene ^a	26	ϵ'/ϵ_0	$\tan \delta$	2.64	2.64	2.64	2.64	2.64	2.64					
				36	20	11	6	4.5	4					
α -Trinitrotoluene at ca. 20% humidity ^b	25	ϵ'/ϵ_0	$\tan \delta$	3.80	3.09	2.93	2.90	2.89	2.89	2.89	2.89	2.86	2.82	
Santicizer 9 ^c	25	ϵ'/ϵ_0	$\tan \delta$	4.19	3.76	3.56	3.51	3.47	3.43	3.35				3.21
				1140	560	350	185	120	110	71				28
Naphthalene ^d	25	ϵ'/ϵ_0	$\tan \delta$	-----	2.85	2.85	2.85	2.85	2.85	-----	2.8	-----	-----	-----
				-----	19	9	5	3	2	-----	2.1	-----	-----	-----
Orthoterphenyl ^e	25	ϵ'/ϵ_0	$\tan \delta$	2.8	2.8	2.8	2.8	2.8	2.8	-----	-----	-----	2.74	-----
				3.7	4.7	6.0	6.3	6	5	-----	-----	-----	2.7	-----
Metaterphenyl ^e	25	ϵ'/ϵ_0	$\tan \delta$	-----	2.86	2.86	-----	2.86	2.86	2.66	-----	2.83	-----	-----
				-----	4.5	4.5	-----	9.5	10.1	5	-----	0.7	-----	-----
Paraterphenyl ^e	25	ϵ'/ϵ_0	$\tan \delta$	-----	-----	-----	-----	-----	-----	(2.95-3.20 depending on degree of crystallization)	-----	2.95	-----	-----
				-----	2	1	< 2	< 2	< 2	< 2	-----	2.1	-----	-----
Aroclor 1268 ^f	25	ϵ'/ϵ_0	$\tan \delta$	2.64	2.64	2.64	2.64	2.64	2.64					
				14	3.5	2	< 3	< 6	< 6					
2. Simple Noncrystals														
Aroclor 5460 ^g	25	ϵ'/ϵ_0	$\tan \delta$	2.43	2.43	2.42	2.42	2.41	2.41	2.41				
				< 3	4	16	20	18	13	8				
Aroclor 4465 ^h	25	ϵ'/ϵ_0	$\tan \delta$	2.81	2.80	2.79	2.79	2.79	2.79	2.79				
				45	17	6.6	4	2.4	1.5	1.0				
3. Plastics														
a. Phenol-formaldehyde														
Bakelite BM-120 ⁱ	25	ϵ'/ϵ_0	$\tan \delta$	4.87	4.74	4.62	4.50	4.36	4.16	3.95	-----	3.70	3.68	3.55
(preformed and preheated)				300	220	200	210	280	350	380	-----	438	410	390

a. Chem. Lab. M.I.T. b. War Dept., Picatinny Arsenal. c. o- and p-toluene sulfonamides (Monsanto). d. Eastman Kodak; recryst. and resbl. Lab. Ins. Res. e. Monsanto, recryst. Lab. Ins. Res. f. Nonachlorobiphenyl (Monsanto). g. Nonachloroterphenyls (Monsanto). h. Chlorinated mixture of biphenyl and terphenyl (Monsanto). i. 46% wood flour, 8% misc. (Bakelite).

I. Solids, B. Organic (cont.)

3. Plastics (cont.)

a. Phenol-formaldehyde

(cont.)

Bakelite BM-120^a

(not preformed or
preheated)

T°C	ϵ'/ϵ_0	$\tan \delta$	1×10^2	1×10^3	1×10^4	1×10^5	1×10^6	1×10^7	1×10^8	3×10^8	3×10^9	1×10^{10}	2.5×10^{10}
27	ϵ'/ϵ_0	$\tan \delta$	5.50	5.15	4.90	4.65	4.45	4.30	---	---	3.70	3.55	
			740	460	345	320	350	415	---	---	400	500	

57

ϵ'/ϵ_0

$\tan \delta$

7.80

2950

5.70

5.30

4.90

4.65

4.5

4.15

88

ϵ'/ϵ_0

$\tan \delta$

18.2

7600

6.5

6.00

5.2

5.0

4.7

4.40

25

ϵ'/ϵ_0

$\tan \delta$

37

3000

12

7.2

5.3

5.0

5.0

320

24

ϵ'/ϵ_0

$\tan \delta$

8.2

1350

6.5

5.9

5.4

4.9

4.4

3.64

3.52

366

25

ϵ'/ϵ_0

$\tan \delta$

7.6

1000

5.4

5.1

4.9

4.8

4.7

4.6

4.5

120

25

ϵ'/ϵ_0

$\tan \delta$

4.82

140

100

70

4.60

4.59

4.58

4.57

85

4.52

25

ϵ'/ϵ_0

$\tan \delta$

5.05

160

130

90

72

60

56

82

24

ϵ'/ϵ_0

$\tan \delta$

14.2

2500

1600

880

460

340

260

240

4.37

360

22*

ϵ'/ϵ_0

$\tan \delta$

8.6

20000

5200

1800

1000

1100

4.89

1080

5.81

1910

85*

ϵ'/ϵ_0

$\tan \delta$

53.5

34

24

17

12

9.5

5.1

4.61

25**

ϵ'/ϵ_0

$\tan \delta$

6.9

6.7

6.6

6.5

6.3

5.8

878

926

a. 46% wood flour, 8% misc. (Bakelite). b. 66% asbestos fiber (Bakelite). c. 100% (Bakelite). d. Mica-filled (Bakelite).

e. 31.6% Bakelite's BV-17085, 68.4% Fiberglass (Owens Corning). f. Catalin.

* Measured December, 1943. ** Same material measured after two years at room temperature and humidity.

I. Solids, B. Organic 3. Plastics (cont.)

a. Phenol-formaldehyde

(cont.)	T°C	1x10 ²	1x10 ³	1x10 ⁴	1x10 ⁵	1x10 ⁶	1x10 ⁷	1x10 ⁸	3x10 ⁸	3x10 ⁹	1x10 ¹⁰	2.5x10 ¹⁰
Catalin 500 base, yellow ^a	22*	ε'/ε ₀	9.7	9.4	8.8	8.1	7.3	6.3	4.90	4.72		
		tan δ	280	320	400	550	760	1200	996	870		
	25**	ε'/ε ₀	4.92	4.86	4.78	4.69	4.57	4.40	4.02	3.7	3.41	
Catalin 500 base, standard ^a	25	ε'/ε ₀	20.0	15.2	12.6	10.8	9.6	8.4	620	520	360	
		tan δ	2800	1500	1000	860	940	1200	5.79	4.77	4.43	
	25*	ε'/ε ₀	94	44	16	11	8	6	1540	1250	1300	
Catalin 700 base (Frystal) ^a	25*	ε'/ε ₀	16500	8000	4100	2300	1600	1400	4.74	1530		
		tan δ	----	----	51	18.5	10.0	7.4	----	4.77		
	80*	ε'/ε ₀	----	----	13200	6600	3700	2400	----	1640		
Durez 1601, natural ^b	25**	ε'/ε ₀	58	24	14	9.6	8.0	6.6	4.1	3.7		
		tan δ	14000	6400	3100	1900	1500	1400	740	500		
	26	ε'/ε ₀	5.09	4.94	4.80	4.68	4.60	4.55	4.51	4.48	4.47	
Durite 500 ^c	24	ε'/ε ₀	270	210	132	100	80	70	64	62		
		tan δ	5.10	5.03	4.95	4.86	4.78	4.72	4.72	4.71	4.70	
	26	ε'/ε ₀	130	104	86	78	82	102	115	126	128	
Formica IX ^d (field ⊥ to laminate)	26	ε'/ε ₀	5.23	5.15	4.96	4.78	4.60	4.32	4.04	3.57***	3.55+	
		tan δ	230	165	170	230	340	490	570	600***	700+	
	26	ε'/ε ₀	6.50	5.70	5.30	5.00	4.75	4.35	3.95	3.35***	3.25+	
Formica IX ^e (field ⊥ to laminate)	26	ε'/ε ₀	1350	600	430	400	410	480	500	400***	460+	
		tan δ	3.73	3.65	3.61	3.61	3.59	3.47	3.24++	3.20	3.12	
	25	ε'/ε ₀	121	132	200	207	187	187	183++	178	173	
Grade YN-25 ^f (field to laminate)	25	ε'/ε ₀	3.87	3.77	3.68	3.61	3.55	3.47	----	----	----	
		tan δ	166	150	182	204	182	191	----	----	----	
	25	ε'/ε ₀	4.25	4.18	4.10	3.95	3.87	3.73	3.40	3.22	3.12	3.05
Panelyte Grade 776 ^g (field ⊥ to laminate)	25	ε'/ε ₀	190	150	160	200	280	370	390	370	340	310
		tan δ	----	----	----	----	----	----	----	----	----	----
		ε'/ε ₀	----	----	----	----	----	----	----	----	----	----

a. Catalin. b. 67% mica (Durez). c. 65% mica, 4% lubricants (Durite). d. 50% paper laminate (Formica). e. 40% cotton fabric (Formica). f. 50% Nylon fabric (Formica). g. Paper base (St. Regis).

*Measured December, 1943. **Same material measured after two years at room temperature and humidity. ***Rod stock in coaxial line. +Rod stock in H₁₁ (TE₁₁) mode of circular guide. ++Freq. = 1 x 10⁹.

I. Solids, B. Organic (Cont.).

3. Plastics (cont.)

a. Phenol-formaldehyde (cont.)

Micarta #254^a

T ^o C	ϵ'/ϵ_0	$\times 10^2$	$\times 10^3$	$\times 10^4$	$\times 10^5$	$\times 10^6$	$\times 10^7$	$\times 10^8$	$\times 10^8$	$\times 10^9$	$\times 10^{10}$
-13		4.9	4.7	4.5	4.4	4.2	4.0	3.4	3.4	3.34	3.13
	tan δ	250	220	240	280	370	390	370	286	215	
25	ϵ'/ϵ_0	5.30	4.95	4.81	4.66	4.51	4.20	3.85	3.78	3.43	3.25
	tan δ	760	330	260	270	360	470	550	470	505	3.21
82	ϵ'/ϵ_0	9.2	6.3	5.5	5.3	5.1	4.9	-----	-----	4.02	3.21
	tan δ	4100	1820	690	360	300	400	-----	-----	984	773

Micarta #496^b

(field $\perp$ to laminate)

Micarta #496^b

(field $\parallel$ to laminate)

Phenolic paper laminate

JH-1410^c

Resinox 10231^d

Resinox 10900^e

Taylor Grade GGG^f

(field $\parallel$ laminate)

(field $\perp$ laminate)

Dilecto (Macoboard)^g

Values for tan δ are multiplied by 10^4 ; frequency given in c/s.

a. Cresylic acid-formaldehyde, 50% α -cellulose (Westinghouse).											
c. 35% paper (Catalin).											
d. 53% filler (Monsanto).											
e. 35% mica, 18% filler (Monsanto).											
f. 40% random glass mat (Taylor).											
g. 45% cresol-phenol formaldehyde, 15% tung oil, 15% nylon (Continental Diamond).											
*Samples turned from sheet stock. **freq = 1 $\times 10^9$.											

I. Solids, B. Organic (Cont.)

3. Plastics (cont.)

a. Phenol-formaldehyde (cont.)

		Values for tan δ are multiplied by 10^4 ; frequency given in c/s.									
T ^o C		1×10^2	1×10^3	1×10^4	1×10^5	1×10^6	1×10^7	1×10^8	3×10^8	3×10^9	1×10^{10}
		ϵ'/ϵ_0	$\tan \delta$	ϵ'/ϵ_0	$\tan \delta$	ϵ'/ϵ_0	$\tan \delta$	ϵ'/ϵ_0	$\tan \delta$	ϵ'/ϵ_0	$\tan \delta$
25	Dilecto (hot punching)	14.7	8.61	6.68	5.76	5.05	4.60	4.10	3.78	3.45	3.35
90	XXX-P-26 ^a	6420	2970	1380	840	720	705	690	680	500	480
120	(Field II sheet)	-----	-----	-----	-----	-----	-----	-----	4.36	-----	3.72
		-----	-----	-----	-----	-----	-----	-----	950	-----	770
		-----	-----	-----	-----	-----	-----	-----	4.76	-----	4.27
		-----	-----	-----	-----	-----	-----	-----	990	-----	820
25	(Field I sheet)	4.29	4.21	4.14	4.01	3.89	3.73	3.56	3.35		
		137	119	137	180	250	340	390	440		
90		5.74	5.09	4.77	4.57	4.32	4.16				
120		1990	620	360	284	273	308				
		7.42	5.38	4.80	4.52	4.34	4.21				
24	Micarta #299 ^b	6700	1910	630	380	290	322	4.80			
	(field I to laminate)	5.36	5.29	5.20	5.10	5.01	4.92	170			
24	Micarta #299 ^b	270	130	115	122	138	150		4.54*	4.34*	4.59**
	(field II to laminate)	-----	-----	-----	-----	-----	-----	-----	149*	188*	230**
24	Durite #221X ^c	6.70	5.70	5.30	4.90	4.55	4.30	4.15	-----	3.65	
		2000	820	520	470	430	400	390	-----	350	
84		13.8	7.0	5.8	5.2	4.9	4.5	4.3	-----	3.72	
		9000	3300	1200	550	460	470	420	-----	800	
25	Corfoam 114 ^d	-----	-----	-----	-----	-----	-----	-----	-----	-----	1.36
		-----	-----	-----	-----	-----	-----	-----	-----	-----	750
25	Expanded plastic board	-----	-----	-----	-----	-----	-----	-----	-----	1.21	
	CP-7B ^e	-----	-----	-----	-----	-----	-----	-----	-----	80	
25	Expanded phenolic board	-----	-----	-----	-----	-----	-----	-----	-----	1.185	
	(dark) ^e	-----	-----	-----	-----	-----	-----	-----	-----	58	

a. 45% cresol-phenol formaldehyde, 15% tung oil, 40% a paper (Conti. Diamond). b. Cresylic acid-formaldehyde, 60-65% glass fabric (Westinghouse). c. Phenol-furfuraldehyde (Durite). d. Expanded phenolic, den. 0.202 (Rezolin). e. Sponge Rubber Prod.

*Stacked sheets in coaxial line. **Stacked sheets in H₁₁ (TE₁₁) mode of circular guide.

I. Solids, B. Organic (Cont.)

3. Plastics (cont.)

b. Phenol-aniline-formaldehyde

	T°C	ϵ'/ϵ_0	tan δ	Values for tan δ are multiplied by 10^4 ; frequency given in c/s.									
				1×10^2	1×10^3	1×10^4	1×10^5	1×10^6	1×10^7	1×10^8	3×10^8	1×10^9	2.5×10^{10}
Bakelite BM-262 ^a	25	ϵ'/ϵ_0	tan δ	4.95	4.80	4.74	4.72	4.67	4.66	4.65	-----	4.55	4.5
(preformed and preheated)		tan δ		98	82	75	60	55	55	57	-----	105	89
Bakelite BM-262 ^a	26	ϵ'/ϵ_0	tan δ	4.9	4.8	4.75	4.7	4.7	4.65	4.65	4.58	4.45	
(not preformed or preheated)		tan δ		235	165	113	83	70	65	80	90	104	
	84	ϵ'/ϵ_0	tan δ	5.8	5.4	5.1	5.0	4.9	4.8	4.7	4.58	-----	
		tan δ		680	440	280	210	160	135	120	120	-----	
Bakelite BM-1895 ^b	25	ϵ'/ϵ_0	tan δ	4.80	4.72	4.70	4.67	4.64	4.61	4.58	4.55	4.43	4.35
(preformed and preheated)		tan δ		87	77	80	65	52	52	80	98	102	130
Bakelite BM-1895 ^b	28	ϵ'/ϵ_0	tan δ	5.0	4.9	4.75	4.65	4.55	4.5	4.5	-----	4.44	
(not preformed or preheated)		tan δ		138	122	106	90	72	57	60	-----	91	96
	84	ϵ'/ϵ_0	tan δ	5.8	5.3	5.0	4.8	4.65	4.6	4.6	-----	4.6	
		tan δ		740	470	310	225	175	140	125	-----	132	
Durez 11863 ^c	-12	ϵ'/ϵ_0	tan δ	4.68	4.59	4.52	4.48	4.42	4.39	-----	-----	4.32	4.31
(preformed and preheated)		tan δ		97	84	66	52	43	38	-----	-----	44	47
	25	ϵ'/ϵ_0	tan δ	4.76	4.70	4.64	4.60	4.55	4.50	4.48	-----	4.45	4.42
		tan δ		108	100	82	62	52	48	52	-----	69	76
	30	ϵ'/ϵ_0	tan δ	5.26	5.03	4.87	4.74	4.63	4.55	-----	-----	4.40	4.38
		tan δ		504	290	195	145	125	113	-----	100	106	
Durez 11863 ^c	26	ϵ'/ϵ_0	tan δ	5.44	5.22	5.04	4.90	4.78	4.69	-----	-----	4.52	4.49
(not preformed or preheated)		tan δ		760	390	230	160	115	88	-----	63	63	
Formica Grade MF-66	25	ϵ'/ϵ_0	tan δ	4.53	4.50	4.43	4.38	4.31	4.24	4.11	4.09	3.90	3.85
Fiberglass		tan δ		106	95	107	102	95	109	160	195	260	300
	79	ϵ'/ϵ_0	tan δ	4.94	4.75	4.66	4.59	4.51	4.44	4.35	-----	4.20	4.10
		tan δ		350	192	135	110	105	110	130	-----	346	702
Resinox 7934 ^e	25	ϵ'/ϵ_0	tan δ	4.62	4.46	4.34	4.28	4.20	4.13	4.10	4.05	4.04	4.04
(preformed and preheated)		tan δ		220	210	178	130	99	88	85	84	84	83

a. 62% mica (Bakelite). b. 59.5% mica, 8.5% misc. (Bakelite). c. 43% mica, 5% misc.; discontinued, substitute 12810 (Durez). d. 40% glass mat (Formica). e. 60% mica (Nonsantc).

I. Solids, B. Organic (Cont.)

3. Plastics (cont.)

Values for tan δ are multiplied by 10^4 ; frequency given in c/s.

Values for tan δ are multiplied by 10 ⁴ ; frequency given in c/s.														
c. Aniline-formaldehyde		T ^o C	1x10 ²	1x10 ³	1x10 ⁴	1x10 ⁵	1x10 ⁶	1x10 ⁷	1x10 ⁸	3x10 ⁸	3x10 ⁹	1x10 ¹⁰	2.5x10 ¹⁰	
Cibanite E ^a		25	3.58	3.57	3.56	3.48	3.41	3.41	3.41	---	3.40	3.40	---	
			29	41	69	85	79	49	39	---	29	49	---	
Dilectene 100 ^b		22	3.6	3.6	3.55	3.55	3.5	3.5	3.5	---	3.44	---	3.42	
(1943 product)		84	33	45	76	90	72	41	32	---	39	---	56	
			3.6	3.6	3.6	3.6	3.55	3.5	3.5	---	3.44	---	---	
			36.5	34	37	50	90	83	61	---	47	---	---	
Dilectene 100 ^b		25	3.68	3.68	3.66	3.60	3.58	3.50	3.50	---	3.44	3.44	---	
(1944 product)			33	32	57	68	61	47	33	---	26	45	---	
d. Melamine-formaldehyde														
Formica Grade FF-41 ^c		26	6.15	6.00	5.95	5.85	5.75	5.65	5.5	---	---	---	---	
(sheet stock)			400	119	86	93	115	165	200	---	---	3.3	---	
Formica Grade FF-41 ^c		26	---	---	---	3.7	3.7	3.65	3.6	---	---	115	---	
(rod stock)			---	---	---	50	48	80	111	---	---	---	---	
Formica Grade FF-55 ^d		24	6.55	6.35	6.20	6.05	6.00	5.90	5.80	5.63	---	---	---	4.73
(field I to laminate)			400	142	85	85	108	155	220	250	---	---	---	440
Formica FF-55 ^d		24	---	---	---	---	---	---	---	5.55*	5.31*	5.4**	4.8	
(field II to laminate)			---	---	---	---	---	---	---	275*	328*	399**	345	
GMI Melamine ^e		25	8.2	7.0	6.7	6.6	6.4	6.3	6.1	---	---	---	---	
(field I to laminate)			1900	690	190	100	110	180	230	5.4	---	---	---	
GMI Melamine ^e		25	---	---	---	---	---	---	---	230	---	---	---	
(field II to laminate)			---	---	---	---	---	---	---	---	4.67	4.59	---	
Melmac Resin 592 ^f		27	6.70	6.25	5.85	5.50	5.20	4.90	4.70	---	4.10	434	---	
			590	470	410	375	347	326	360	---	---	---	---	
		57	8.15	6.95	6.35	5.85	5.40	5.10	4.90	---	4.75	---	---	
			1250	750	490	400	350	320	350	---	480	---	---	
		88	21.8	11.8	8.0	6.5	6.0	5.8	5.5	---	4.90	---	---	
			7400	3400	1650	750	520	470	380	---	520	---	---	
		28	7.00	6.90	6.75	6.50	6.20	5.90	---	---	4.8	4.7	1000	
Melmac Type 107 ^g			---	---	---	---	---	---	---	---	900	---	---	
(Ivory WB 48)			---	---	---	---	---	---	---	---	---	---	---	Class Iamicaid #6038

a. 100% (Ciba). b. 100% (Continental-Diamond). c. 55% filler (Formica). d. Glass fiber mat (Formica). e. Glass lamincoid #6038 (Mica Insulator). f. Mineral filler (Am. Cyanamid). g. 25% alpha pulp, Zn stearate (Am. Cyanamid).

*Stacked sheets in coaxial line. ** Stacked sheets in H₁₁ (TE₁₁) mode of circular guide.

I. Solids. B. Organic 3. Plastics (Cont.)			Values for tan δ are multiplied by 10^4 ; frequency given in c/s.										
d. Melamine-formaldehyde (cont.)	T $^{\circ}$ C		1×10^2	1×10^3	1×10^4	1×10^5	1×10^6	1×10^7	1×10^8	3×10^8	3×10^9	1×10^{10}	2.5×10^{10}
Melmac Molding Compound 1500 ^a	25	ϵ'/ϵ_0 tan δ	6.50 308	6.31 173	6.18 162	6.01 221	5.85 320	5.53 415	5.10 500	4.37* 523*	4.20 520	4.10 505	
Melmac Molding Compound 1502 ^b	25	ϵ'/ϵ_0 tan δ	8.43 2020	6.95 960	6.37 460	6.04 350	5.77 410	5.36 510	4.90 560	4.40* 620*	4.20 620	4.00 520	
Polyglas M ^c	24	ϵ'/ϵ_0 tan δ	5.58 140	5.53 71	5.49 64	5.40 69	5.32 93	5.22 160	-----	-----	4.86** 339**	5.22** 660**	
	80	ϵ'/ϵ_0 tan δ	8.4 4000	6.5 1400	5.9 280	5.8 95	5.8 65	5.8 110	-----	-----	5.68** 498**	5.32** 721**	
Micarta #259 ^d (field $\perp$ to laminate)	24	ϵ'/ϵ_0 tan δ	6.13 190	6.07 125	5.97 105	5.90 85	5.81 108	5.72 145	5.55 200	-----	-----	4.80** 322**	
Micarta #259 ^d (field $\parallel$ to laminate)	24	ϵ'/ϵ_0 tan δ	-----	-----	-----	-----	-----	-----	-----	4.83*** 150***	4.75*** 260***	5.12+ 380+	4.70** 400**
Panelyte 140 ^e (field $\perp$ to laminate)	24	ϵ'/ϵ_0 tan δ	6.15 135	6.05 93	6.00 120	5.93 155	5.82 155	5.70 170	5.55 215	5.5 260	-----	4.70 360	4.62 260
Panelyte 140 ^e (field $\parallel$ to laminate)	25	ϵ'/ϵ_0 tan δ	-----	-----	-----	-----	-----	-----	-----	4.95 210	4.73 250	-----	4.60 260
Plaskon Melamine ^f	24	ϵ'/ϵ_0 tan δ	7.73 190	7.57 122	7.40 150	7.26 240	7.00 410	6.45 640	6.0 850	5.73 985	4.93 1028	4.60 1100	
	80	ϵ'/ϵ_0 tan δ	9.86 1800	8.7 560	8.4 210	8.4 140	7.9 220	7.5 410	7.0 700	-----	5.5 1250	5.04 1490	
Resimene 803-A ^g (not preformed or preheated)	24	ϵ'/ϵ_0 tan δ	7.05 410	6.90 210	6.75 190	6.50 270	6.20 440	5.70 660	5.20 820	5.04 859	4.53 820	4.23 760	
Resimene 803-A ^g (powder preheated)	25	ϵ'/ϵ_0 tan δ	-----	-----	-----	-----	-----	-----	-----	-----	-----	3.75 320	3.74 300

a. 40% wood flour, 18% plasticizer (Am. Cyanamid). b. 60% melamine, formaldehyde and aniline polymer with wood flour filler (Am. Cyanamid). c. 56.5% A. Cyanamid's Melmac 7278, 43.5% Owens-Corning's Glass "E" (Hood Rubber). d. 65-70% Fiberglass (Westinghouse). e. Fiberglass (St. Regis). f. α -cellulose (Libbey-Owens-Ford). g. 40% cellulose (Monsanto).
 * Freq. = 1×10^9 . ** Sample nonhomogeneous; stacked layers. ***In coaral lines. +In $H_{11}(TE_{11})$ mode circular guide. ++In $H_{01}(TE_{01})$ mode rectangular guide.

I. Solids. B. Organic 3. Plastics (cont.) Values for $\tan \delta$ are multiplied by 10^4 ; frequency given in c/s.

e. Urea-formaldehyde Beetle Resin ^a	T°C	ϵ'/ϵ_0	$\tan \delta$	1×10^2	1×10^3	1×10^4	1×10^5	1×10^6	1×10^7	1×10^8	3×10^8	3×10^9	1×10^{10}	2.5×10^{10}
27		6.5	300	6.2	240	6.05	5.9	5.65	5.4	5.1	---	4.57	4.47	---
Plaskon Urea, natural ^b	24													
		ϵ'/ϵ_0		6.7	280	6.4	6.2	6.0	5.7	5.2	5.1	4.79	4.65	---
		$\tan \delta$		7.8	7.8	7.4	7.1	6.8	6.6	---	---	694	782	---
80		ϵ'/ϵ_0		8.8	600	420	320	300	350	---	---	5.54	4.27	---
		$\tan \delta$		9.40	6.35	6.15	6.00	5.75	5.42	---	---	819	1630	---
Plaskon Urea, brown ^b	24													
		ϵ'/ϵ_0		6.65	260	240	250	280	350	420	438	4.60	4.55	---
		$\tan \delta$		320	4.58	4.50	4.40	4.26	4.15	3.96	3.62*	3.52	3.38	---
f. Benzoguanamine-formaldehyde Benzoguanamine Resin ^c	25													
		ϵ'/ϵ_0		4.72	189	127	140	196	273	320	342*	336	318	---
		$\tan \delta$		348										---
g. Polyamide Resins Nylon 66 ^d	25													
		ϵ'/ϵ_0		3.88	3.75	3.60	3.45	3.33	3.24	3.16	---	3.03	---	---
		$\tan \delta$		144	193	233	254	257	244	210	---	128	---	---
Nylon 610 ^d	25													
		ϵ'/ϵ_0		3.60	3.50	3.35	3.24	3.14	3.05	3.0	---	2.84	---	2.3
		$\tan \delta$		155	186	208	221	218	205	200	---	117	---	105
84		ϵ'/ϵ_0		13.5	11.2	9.0	6.3	4.4	3.7	3.4	---	2.94	---	---
		$\tan \delta$		2350	1400	1580	2030	1720	1150	670	---	356	---	---
Nylon 610 ^d -90% humidity	25													
		ϵ'/ϵ_0		4.5	4.2	4.0	3.7	3.2	3.05	3.0	---	2.85	---	---
		$\tan \delta$		650	640	600	500	380	280	220	---	125	---	---
Nylon FM 10001 ^d	25													
		ϵ'/ϵ_0		3.84	3.76	3.64	3.49	3.36	3.24	3.17	3.06*	3.02	3.02	---
		$\tan \delta$		115	180	262	275	232	214	175	140*	120	107	---
Resin #908 ^e	25													
		ϵ'/ϵ_0		3.25	2.94	2.80	2.72	2.64	2.61	2.58	---	2.54	2.53	---
		$\tan \delta$		1070	500	274	165	114	92	83	---	62	57	---

h. Cellulose Derivatives

1) Acetates

IL-1 ^f	ϵ'/ϵ_0	$\tan \delta$	ϵ'/ϵ_0	$\tan \delta$	ϵ'/ϵ_0	$\tan \delta$	ϵ'/ϵ_0	$\tan \delta$	ϵ'/ϵ_0	$\tan \delta$	ϵ'/ϵ_0	$\tan \delta$	ϵ'/ϵ_0	$\tan \delta$
25	3.82	3.77	3.67	3.53	3.42	3.30	3.29	3.28	3.24	3.24	3.24	3.24	3.1	310
85	95	150	200	230	230	210	210	220	290	290	3.30	---	---	---
	3.98	3.96	3.90	3.77	3.58	3.44	---	---	---	---	---	---	---	---
	34	75	135	210	270	280	---	---	---	---	---	---	---	---

a. Cellulose (Am. Cyanamid). b. α -cellulose (Libbey-Owens-Ford). c. 28% α paper (Am. Cyanamid). d. Hexamethylene-adipamide (Dupont).

e. Code RC-2072 (General Mills). f. 55.4% acetyl (Hercules).

* Freq. = 1×10^9 .

I. Solids, B. Organic, 3. Plastics (cont.)

h. Cellulose Derivatives (cont.)

1) Acetates (cont.)	T ^o C	ϵ'/ϵ_0	$\frac{1 \times 10^2}{\epsilon'}$	$\frac{1 \times 10^3}{\epsilon'}$	$\frac{1 \times 10^4}{\epsilon'}$	$\frac{1 \times 10^5}{\epsilon'}$	$\frac{1 \times 10^6}{\epsilon'}$	$\frac{1 \times 10^7}{\epsilon'}$	$\frac{1 \times 10^8}{\epsilon'}$	$\frac{3 \times 10^8}{\epsilon'}$	$\frac{1 \times 10^9}{\epsilon'}$	$\frac{3 \times 10^9}{\epsilon'}$	$\frac{2.5 \times 10^{10}}{\epsilon'}$
Lumarith XFA-H ^a	25	ϵ'/ϵ_0	4.61	4.51	4.36	4.13	3.79	3.57	3.37	3.20*	3.13	3.08	3.08
		tan δ	152	240	340	428	480	423	380	365*	340	325	325
Fibestos 205OTVA C-1686 ^b	26	ϵ'/ϵ_0	4.75	4.53	4.30	3.82	3.60	3.52	3.35				
		tan δ	180	305	380	425	430	400	350				
Tenite I 008A H ^c	26	ϵ'/ϵ_0	4.65	4.55	4.40	4.20	3.96	3.72	3.47		3.16		3.08
		tan δ	102	173	286	370	430	465	410		310		350
Tenite I 008A H ^c	26	ϵ'/ϵ_0	4.55	4.48	4.33	4.14	3.90	3.63	3.40		3.25	3.16	3.11
		tan δ	80	175	270	345	393	405	380		310	300	300
Tenite I 008A H ^c	26	ϵ'/ϵ_0	4.97	4.86	4.70	4.52	4.25	3.88	3.57		3.24		
		tan δ	123	175	285	400	495	560	550		380		
Tenite I 008A ME ^c	26	ϵ'/ϵ_0	4.87	4.80	4.60	4.40	4.18	3.80	3.5		3.26	3.09	
		tan δ	117	170	290	380	465	525	550		370	330	
Tenite I 008A S ^c	26	ϵ'/ϵ_0	5.14	5.06	4.90	4.64	4.30	3.96	3.65		3.23		
		tan δ	100	160	280	405	530	620	580		420		
Tenite I 008A S ^c	26	ϵ'/ϵ_0	5.34	5.28	5.15	4.90	4.57	4.20	3.75		3.20		3.1
		tan δ	85	135	230	370	540	690	700		480		380
Tenite II 205A H ^d	26	ϵ'/ϵ_0	3.54	3.50	3.44	3.38	3.28	3.18	3.05		2.80		
		tan δ	78	107	158	174	178	180	190		267		
Tenite II 205A H ^d	25	ϵ'/ϵ_0	3.54	3.48	3.42	3.37	3.30	3.18	3.08	3.00	2.91	2.82	
		tan δ	50	97	156	175	178	175	170	179	280	298	
Tenite II 205A ME ^d	27	ϵ'/ϵ_0	3.60	3.56	3.50	3.40	3.30	3.22	3.10		2.87		
		tan δ	80	117	170	192	200	200	200		310		
Tenite II 205A MS ^d	27	ϵ'/ϵ_0	3.67	3.64	3.55	3.45	3.40	3.28	3.15		2.92	2.83	
		tan δ	23	115	178	213	220	227	250		370	360	
Tenite II 205A S ^d	27	ϵ'/ϵ_0	3.80	3.75	3.66	3.58	3.48	3.38	3.20		2.98		
		tan δ	82	95	155	204	225	247	300		460		
Tenite II 205A S ^d	27	ϵ'/ϵ_0	3.83	3.80	3.74	3.66	3.58	3.44	3.30		3.08		2.8
		tan δ	80	90	150	200	235	260	320		520		360

a. 28% plast. (Celanese). b. 26% plasticizer (Monsanto). c. 23-31% plasticizer, pigments, dyes (Term. Eastman). d. 5-15% plasticizer pigments, dyes (Term. Eastman).

* Freq. = 1×10^9 .

I. Solids, B. Organic 3. Plastics (cont.)

h. Cellulose Derivatives (cont.)

2) Propionate

Forticel^a

T°C	ϵ'/ϵ_0	$\tan \delta$	1×10^2	1×10^3	1×10^4	1×10^5	1×10^6	1×10^7	1×10^8	1×10^9	3×10^9	1×10^{10}	2.5×10^{10}
25	ϵ'/ϵ_0	$\tan \delta$	3.52	3.48	3.41	3.33	3.23	3.18	3.08	2.95	2.88	2.87	
			60	101	157	188	175	164	192	247	289	308	

Values for $\tan \delta$ are multiplied by 10^4 ; frequency given in c/s.

3) Nitrate

Pyralin^b

27	ϵ'/ϵ_0	$\tan \delta$	10.8	8.4	7.5	7.0	6.6	6.1	5.2	-----	3.74	3.32	
			6400	1000	450	400	640	930	1030	-----	1650	1310	

78

ϵ'/ϵ_0
 $\tan \delta$

7000

7.5
6.7

6.3
6.0

6.2
6.1

6.1
5.2

930
1030

1620

4) Methyl Cellulose

Methocel^c

22	ϵ'/ϵ_0	$\tan \delta$	7.6	6.8	6.4	6.1	5.7	4.9	4.3	-----	3.35	550	
			1280	570	330	400	650	1020	1000	-----	-----	-----	

5) Ethyl Cellulose

Ethocel LT5^c

25	ϵ'/ϵ_0	$\tan \delta$	3.11	3.09	3.05	3.02	3.01	2.96	2.90	2.77	2.74	2.70	
			75	65	63	76	113	150	160	170	210	250	

Lumarith #22361^d

24	ϵ'/ϵ_0	$\tan \delta$	3.10	3.06	3.02	2.99	2.92	2.87	2.80	-----	2.74	2.67	2.65
			48	48	52	67	115	158	160	-----	196	256	300

84

ϵ'/ϵ_0
 $\tan \delta$

3.00
78

3.00
70

2.90
66

2.85
66

2.80
90

2.80
140

2.80
200

2.79
214

2.66
402

1. Silicone Resins

Formica G7^e

(field I laminate)

(field II laminate)

25	ϵ'/ϵ_0	$\tan \delta$	3.73	3.73	3.73	3.73	3.73	3.73	3.73	3.73	3.90	3.90	
			17	16	15	14	12	15	19	-----	-----	-----	

(field I laminate)

(field II laminate)

25	ϵ'/ϵ_0	$\tan \delta$	5.18	4.72	4.37	4.09	3.99	3.95	3.94	3.92	3.90	3.90	
			790	575	570	530	97	25	22	40	55	45	

Formica G6^e

(field I laminate)

(field II laminate)

25	ϵ'/ϵ_0	$\tan \delta$	3.99	3.91	3.87	3.85	3.82	3.82	3.82	3.81	3.79	3.74	
			210	110	96	130	46	22	27	37	51	61	

25

ϵ'/ϵ_0
 $\tan \delta$

3.79
13

3.79
11.5

3.79
10.5

3.79
10

3.79
10.5

3.79
13.3

a. 8% plast. (Celanese). b. 25% camphor (DuPont). c. Dow. d. 13% plast. (Celanese). e. Fiberglass laminate (Formica).

I. Solids, B. Organic 3. Plastics (cont.) Values for $\tan \delta$ are multiplied by 10^4 ; frequency given in c/s.

1. Silicone Resins

(cont.)		$T^\circ C$	$\frac{1 \times 10^2}{\epsilon' / \epsilon_0}$	$\frac{1 \times 10^3}{\tan \delta}$	$\frac{1 \times 10^4}{\epsilon' / \epsilon_0}$	$\frac{1 \times 10^5}{\tan \delta}$	$\frac{1 \times 10^6}{\epsilon' / \epsilon_0}$	$\frac{1 \times 10^7}{\tan \delta}$	$\frac{1 \times 10^8}{\epsilon' / \epsilon_0}$	$\frac{1 \times 10^9}{\tan \delta}$	$\frac{1 \times 10^{10}}{\epsilon' / \epsilon_0}$
DC 996 cured 16 hrs. at $150^\circ C^a$		25	3.08	3.04	3.02	3.01	2.99	2.98	2.96		
DC 996 cured 16 hrs. at $250^\circ C^a$		25	2.90	2.90	2.90	2.90	2.90	2.90	2.90		
DC 2101 ^b (discontinued)		24	2.90	2.90	2.90	2.90	2.90	2.90	2.90		
Polyglas S ^c		24	3.60	3.59	3.58	3.57	3.57	3.56	3.55	3.53	
		80	3.60	3.59	3.58	3.57	3.57	3.56	3.55	3.51	
Molding Compound XM-3 ^d		25	4.03	4.00	3.99	3.98	3.95	3.93	3.92	3.85	3.85
Dilecto (Silicone glass laminates) CB-261S (field 1 sheet) ^e		25	3.83	3.82	3.81	3.80	3.80	3.79	3.79	3.76	
		90	12.8	13	13	12.3	12.9	14.8	23	57	78
		200	3.74	3.73	3.71	3.69	3.63	3.56	3.55	3.51	3.49
		25	21	20	8.5	21	39	26	3.87	3.79	3.76
		25	3.50	3.62	3.44	3.42	3.40	3.35	3.82	3.79	3.76
		25	339	74.7	32.6	22.7	31.4	30	42	57	78
		220	4.97	4.48	4.43	3.95	3.92	3.87	3.87	3.82	3.76
		25*	580	560	440	185	55	29	42	57	78
		25*	4.68	4.26	4.18	4.18	4.18	4.18	3.87**	3.87**	3.87**
		25*	1620	526	300	195	195	195	75**	75**	75**
		25*	4.05	3.93	3.90	3.85	3.85	3.85	3.85	3.85	3.85
		25*	104	60	42	31	31	31	31	31	31

a. Methyl, phenyl, and methyl phenyl polysiloxane resin (Dow Corning). b. Cross-linked organo-siloxane polymer (Dow Corning).
c. 16% DC 2101, 84% Corning's 790 glass powder (Lab. Ins. Res.). d. 35% methyl and phenyl polysilicone resin, 45% glass fibers,
19% silica filler (Dow Corning). e. 50% DC-2103, 50% staple fibre glass base (Cont. Diamond).

*After temperature run. ** 200°C.

I. Solids B. Organic 3. Plastics (cont.) Values for $\tan \delta$ are multiplied by 10^4 ; frequency given in c/s.

1. Silicone Resins (cont.)		T°C	ϵ'/ϵ_0	$\tan \delta$	$\frac{1 \times 10^2}{\epsilon'/\epsilon_0}$	$\frac{1 \times 10^3}{\tan \delta}$	$\frac{1 \times 10^4}{\epsilon'/\epsilon_0}$	$\frac{1 \times 10^5}{\tan \delta}$	$\frac{1 \times 10^6}{\epsilon'/\epsilon_0}$	$\frac{1 \times 10^7}{\tan \delta}$	$\frac{1 \times 10^8}{\epsilon'/\epsilon_0}$	$\frac{1 \times 10^9}{\tan \delta}$	$\frac{3 \times 10^9}{\epsilon'/\epsilon_0}$	$\frac{1 \times 10^{10}}{\tan \delta}$	$\frac{2.5 \times 10^{10}}{\epsilon'/\epsilon_0}$
Dilecto (silicone glass laminate) GB 1125 ^a (field 1 sheet)		25	3.56	13.5	3.56	3.56	3.56	3.55	3.54	3.54	3.54				
		90	3.41	26.4	3.39	16.2	3.38	16.1	3.38	3.38	3.38				
		200	3.18	3.18	3.18	3.18	3.18	3.17	3.15	3.10					
			236		43	23	23	195	21	15.4					
(field 11 sheet)		25	6.55	1250	5.72	910	4.94	516	3.84	3.82	3.80	3.78	3.76	3.70	
		215	10.93	2000	8.60	6.65	6.65	4.92	128	37	25	39	52	87	
		25*	5.71	2080	5.16	1800	1.54	4.92	-----	-----	-----	-----	-----	3.78	
			624	2080	5.16	1800	1410	1410	-----	-----	-----	-----	-----	80	
DC 2103 Laminate (XL-48) ^b		25	3.94	18	3.92	3.92	3.90	3.90	3.90	3.90	3.88	-----	3.88**	3.89**	
Taylor Grade GSC ^c (field 11 laminate)		25	5.07	99	4.14	16	15	14	4.03	26	37	-----	67**	99**	
(field 1 laminate)		25	3.78	13.4	3.77	72	83	44	4.04	4.01	-----	3.91	3.90	3.85	
Taylor Grade GSS ^d (field 11 laminate)		25	4.10	160	4.00	160	100	34	20	15	-----	30	39	40	
(field 1 laminate)		25	3.74	15	3.74	14	13	12	3.74	3.74	3.74	44	55	63	
DC 2104 Laminate (XL-269) ^e		25	4.14	32	4.14	29	26	22	4.13	15	22	-----	4.07**	4.06**	
									22	29	34	-----	71**	83**	
J. Polyvinyl Resins 1) Polyethylene															
Polyethylene DE-3401 ^f		25	2.26	< 2	2.26	< 2	2.26	2.26	2.26	2.26	-----	-----	2.26	2.25	
			< 2	2.25	< 2	< 2	< 2	< 2	< 2	< 2	-----	-----	3.1	3.6	
Polythene A-3305 ^g (Now replaced by Alathon)		24	2.25	5	2.25	< 3	2.25	2.25	2.25	2.25	-----	-----	2.25	2.25	2.24
		80	2.25	< 5	2.25	< 3	2.25	2.25	2.25	2.25	-----	-----	3	4	6.7
			< 5	< 3	2.25	< 3	< 3	< 5	< 4	< 3	-----	-----	2.25	2.20	
			< 5	< 3	< 3	< 3	< 3	< 5	< 4	< 3	-----	-----	7.2	8.5	

a. 50% DC-2103, 50% continuous-filament glass base (Cont. Diamond). b. 45% methyl and phenyl polysiloxane resin, 55% ECC-261 Fiberglass (Dow-Corning). c. 45-50% DC-2103, 50-55% staple fibre glass cloth (Taylor). d. 45-50% DC-2103, 50-55% staple fibre glass cloth (Taylor). e. 35% methyl and phenyl polysiloxane resin, 65% ECC-181 fiberglass (Dow-Corning). f. 0.1% antioxidant (Bakelite). g. 100% polyethylene (DuPont).

*Measured after temperature run. **field 1 laminate, at other frequencies field 1 sheet.

I. Solids, B. Organic 3. Plastics J. Polyvinyl Resins (cont.)

1) Polyethylene

(cont.)

Polyethylene ^a		Values for tan δ are multiplied by 10 ⁴ ; frequency given in c/s.									
T°C	1x10 ²	1x10 ³	1x10 ⁴	1x10 ⁵	1x10 ⁶	1x10 ⁷	1x10 ⁸	3x10 ⁸	3x10 ⁹	1x10 ¹⁰	2.5x10 ¹⁰
23	ε'/ε ₀	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.24	
	tan δ	< 2	< 2	< 2	< 2	< 2	< 2	5.8	5.8	6.6	
23	ε'/ε ₀	2.26	2.26	2.26	2.26	2.26	2.26	2.26	2.25	2.25	
	tan δ	< 5	6	7	8	9	10	10.6	11.7	11.9	
-12	ε'/ε ₀	2.38	2.36	2.35	2.35	2.34	2.33	2.32	2.32	2.30	
	tan δ	24	19	18	21	28	39	36	36	22	
23	ε'/ε ₀	2.38	2.36	2.36	2.35	2.34	2.33	2.33	2.32	2.31	
	tan δ	28	27	27	28	30	42	51	50	44	

2) Polyisobutylene

Polyisobutylene^b

Run 5047-2

Copolene B^c

3) Polyvinyl chloride-

acetate

Vinylite QVNA^d

20	ε'/ε ₀	3.18	3.10	3.02	2.96	2.88	2.87	2.85	2.84		
	tan δ	130	185	225	210	160	115	81	55		
47	ε'/ε ₀	3.60	3.52	3.41	3.28	3.14	3.02	2.92	2.81		
	tan δ	100	166	240	261	228	162	110	77		
76	ε'/ε ₀	3.92	3.83	3.68	3.3	3.0	2.87	2.8	2.8		
	tan δ	180	220	320	400	350	270	190	175		
96	ε'/ε ₀	6.60	5.30	4.40	3.7	3.3	2.8	2.7	2.7	2.6	
	tan δ	1500	1400	1200	980	740	500	320	280	180	
110	ε'/ε ₀	9.9	8.6	6.8	5.6						
	tan δ	1030	1330	1780	1900						
25	ε'/ε ₀	7.72	7.20	6.40	5.25	4.13	3.45	3.05	2.99	2.82	2.80
	tan δ	570	640	1060	1500	1550	1200	650	460	185	150
Vinylite VG-5901, black ^f	ε'/ε ₀	6.5	5.5	4.6	3.9	3.4	3.1	3.0	2.94	2.88	2.83
	tan δ	1020	1180	1190	1000	740	500	280	200	106	105

a. Bakelite. b. 100% Esso Lab.). c. 61% polyisobutylene B-100, 39% Marbon B (Am. Phenolic). d. 100% polyvinyl chloride (Bakelite).

e. 40% polyvinyl chloride-acetate, 40% plast., 14% misc. (Bakelite). f. 62.5% polyvinyl chloride-acetate, 29% plast., 8.5% misc. (Bakelite).

I. Solids, B. Organic 3. Plastics J. Polyvinyl Resins (cont.) Values for $\tan \delta$ are multiplied by 10^4 ; frequency given in c/s.

3) Polyvinyl chloride

(cont.)	T°C	1×10^2	1×10^3	1×10^4	1×10^5	1×10^6	1×10^7	1×10^8	3×10^8	1×10^{10}	2.5×10^{10}
Vinylite VG-5904, black ^a	25	ϵ'/ϵ_0	8.1	7.5	6.6	5.4	4.3	3.3	3.1	2.83	
		$\tan \delta$	550	710	1060	1390	1400	670	500	320	
Vinylite VU-1900, clear ^b	24	ϵ'/ϵ_0	6.55	5.65	4.70	3.90	3.30	2.95	2.80	2.62	2.62
		$\tan \delta$	1000	1150	1300	1180	880	560	-----	104	110
	79	ϵ'/ϵ_0	10.3	8.15	7.5	6.5	5.5	4.3	3.4	2.84	2.60
		$\tan \delta$	7300	1250	720	800	1550	1550	-----	498	351
Vinylite VVH ^c	22	ϵ'/ϵ_0	3.20	3.12	3.06	3.00	2.91	2.88	2.83	2.79	
		$\tan \delta$	100	130	155	150	140	90	-----	76	
	47	ϵ'/ϵ_0	3.56	3.48	3.38	3.27	3.16	3.02	2.9	2.79	
		$\tan \delta$	110	142	190	227	206	152	114	92	
Vinylite VVMS ^d	20	ϵ'/ϵ_0	3.10	3.08	3.02	2.95	2.90	2.85	2.8	2.74	
		$\tan \delta$	115	140	170	170	140	105	80	63	
Vinylite VVM ^e	20	ϵ'/ϵ_0	3.20	3.15	3.05	2.96	2.90	2.84	2.8	2.74	
		$\tan \delta$	135	165	197	190	150	110	80	59	
Geon 2046 ^f	23	ϵ'/ϵ_0	6.95	6.10	5.05	4.13	3.55	3.15	3.00	2.89	2.83
		$\tan \delta$	820	1100	1320	1200	890	570	211	116	116
	80	ϵ'/ϵ_0	9.1	8.8	8.3	7.6	6.5	5.0	4.0	3.06	2.90
		$\tan \delta$	250	300	410	680	1540	2800	1500	484	328
Geon 80365 ^g	25	ϵ'/ϵ_0	3.67	3.65	3.58	3.52	3.42	3.39	3.34		
		$\tan \delta$	68	95	133	145	130	115	120		
Geon 80384 ^h	25	ϵ'/ϵ_0	3.43	3.34	3.23	3.14	3.05	3.96	3.95		
		$\tan \delta$	120	184	224	217	158	114	101		

a. 54% polyvinyl chloride-acetate, 41% plast., 5% misc. (Bakelite). b. 64.5% polymer of 95% vinyl chloride and 5% vinyl acetate, 32% Flexol D.O.P., 3.5% misc. (Bakelite). c. Polymer of 87% vinyl chloride and 13% vinyl acetate (Bakelite). d. Polymer of 91% vinyl chloride and 9% vinyl acetate (Bakelite). e. Polymer of 95% vinyl chloride and 5% vinyl acetate (Bakelite). f. 59% polyvinyl chloride, 30% dioctyl phosphate, 6% stabilizer, 5% filler (Goodrich). g. 71% polyvinyl chloride, 10.5% filler, 5% plasticizer, 8.5% stabilizer (Goodrich). h. 87.8% polyvinyl chloride, 10.5% stabilizer (Goodrich).

I. Solids B. Organic 3. Plastics J. Polyvinyl Resins (cont.) Values for tan δ are multiplied by 10^4 ; frequency given in c/s.

3) Polyvinyl Chloride (cont.)		T °C	Values for tan δ are multiplied by 10 ⁴ ; frequency given in c/s.										
			1x10 ²	1x10 ³	1x10 ⁴	1x10 ⁵	1x10 ⁶	1x10 ⁷	1x10 ⁸	3x10 ⁸	3x10 ⁹	1x10 ¹⁰	
Koroseal 5CS-243 ^a	27	ε'/ε ₀	6.1	5.65	5.00	4.15	3.60	3.20	2.9	2.73	2.62		
		tan δ	790	1000	1300	1250	930	560	300	112	120		
Lucoflex ^b	25	ε'/ε ₀	----	----	----	----	----	----	2.75				
		tan δ	----	----	----	----	----	----	170				
Polyvinyl chloride 1006 ^c	25	ε'/ε ₀	6.1	----	4.55	----	3.3						
		tan δ	760	----	1100	----	760						
Polyvinyl chloride 1018 ^d	25	ε'/ε ₀	6.2	----	4.95	----	3.15						
		tan δ	630	----	950	----	920						
Polyvinyl chloride 1216 ^e	25	ε'/ε ₀	6.1	----	4.4	----	3.2						
		tan δ	1170	----	1110	----	450						
Polyvinyl chloride 1406 ^f	25	ε'/ε ₀	6.05	----	4.5	----	3.6						
		tan δ	870	----	940	----	480						
Ultron Wire Compound UL300 ^g	25	ε'/ε ₀	3.31	3.22	3.10	2.98	2.85						
		tan δ	150	210	250	220	155						
Ultron Wire Compound UL1004 ^h	25	ε'/ε ₀	6.4	----	4.65	----	3.3						
		tan δ	810	----	1210	----	740						
Ultron Wire Compound UL2 4001 ^k	25	ε'/ε ₀	6.7	----	4.7	----	3.5						
		tan δ	1100	----	1210	----	700						
Polyvinyl chloride W-174 ^m	25	ε'/ε ₀	5.45	4.77	4.17	3.75	3.52	3.25	3.00				
		tan δ	815	930	880	740	550	425	415				
Polyvinyl chloride W-175 ⁿ	25	ε'/ε ₀	5.94	5.20	4.51	3.90	3.44	3.37	3.04				
		tan δ	840	960	960	865	580	430	360				
Polyvinyl chloride W-176 ^p	25	ε'/ε ₀	6.21	5.52	4.70	3.96	3.53	3.28	3.00				
		tan δ	730	940	1070	960	720	520	500				

a. 63.7% polyvinyl chloride, 33.1% di-2-ethylhexylphthalate, lead silicate (Goodrich). b. Unplasticized polyvinyl chloride (Lucoflex Plastic). c. 57.5% polymer, 12.6% fillers, 28.7% plasticizers (Monsanto). d. 52.4% polymer, 15.1% fillers, 31.4% plasticizers (Monsanto). e. 57.5% polymer, 10.4% fillers, 31.6% plasticizers (Monsanto). f. 59.4% polymer, 10.7% fillers, 29.7% plasticizers (Monsanto). g. 100% polymer (Monsanto). h. 64.7% polymer, 2% filler, 32.5% plasticizers (Monsanto). k. 60.1% polymer, 7.8% fillers, 31.2% plasticizers (Monsanto). n. 65% Geon 101, 35% Paraplex G-25 (Rohm and Haas). o. 65% Geon 101, 35% Paraplex G-50 (Rohm and Haas). p. 65% Geon, 35% Paraplex G-60 (Rohm and Haas).

I. Solids B. Organic 3. Plastics J. Polyvinyl Resins (cont.) Values for $\tan \delta$ are multiplied by 10^4 ; frequency given in c/s.

3) Polyvinyl Chloride (cont.)		$T^\circ C$									
Plasticell ^a	25	ϵ'/ϵ_0									
		1×10^2	1×10^3	1×10^4	1×10^5	1×10^6	1×10^7	1×10^8	3×10^8	1×10^9	2.5×10^{10}
		1.04	1.04	1.04	1.04	1.04	----	1.04	1.04	1.04	
		$\tan \delta$	21	11	< 15	10	----	10	18*	55	50
Ensolite M2240 ^b		25	1.51	1.36	1.29	1.24	1.16				
		$\tan \delta$	3200	610	330	340	420				
Ensolite M2239 ^b		25	1.48	1.40	1.31	1.25	1.20				
		$\tan \delta$	2850	770	280	250	340				
Ensolite 3036 ^b		25	1.30	1.24	1.19	1.17	1.16				
(field 1 plane of sample)		$\tan \delta$	368	263	187	137	111				
(field 11 plane of sample)	25	ϵ'/ϵ_0	----	----	----	----	----	----	1.14*	1.12	1.10
		$\tan \delta$	----	----	----	----	----	----	87*	86	30

4) Polyvinylidene and Vinyl chloride

Saran B-115 ^c		ϵ'/ϵ_0									
	23	4.88	4.65	4.17	3.60	3.18	2.97	2.82	----	2.71	2.70
		$\tan \delta$	450	630	885	845	310	180	----	72	51
Kel-F Grade 300 ^d		84	5.13	4.94	4.85	4.71	3.75	3.2	----	2.76	
		$\tan \delta$	800	210	130	320	1300	900	----	242	

5) Polychlorotrifluoroethylene

Kel-F ^d		ϵ'/ϵ_0									
	26	2.72	2.63	2.53	2.46	2.43	2.35	----	2.30	2.30	2.29
		$\tan \delta$	210	270	230	135	60	----	30	28	39
Kel-F Grade 300 ^d		25	2.82	2.76	2.65	2.50	2.42	2.36	2.35	2.34	2.33
		$\tan \delta$	148	225	212	140	75	54	51	66	59
Kel-F Grade 300-P25 ^e		25	2.84	2.75	2.68	2.58	2.45	2.37	2.35	2.31	2.26
		$\tan \delta$	126	207	234	204	214	186	150	93	93

6) Polytetrafluoroethylene

Dilecto (Teflon Iaminate)		ϵ'/ϵ_0									
	25	2.76	2.74	2.74	2.74	2.73	2.73	2.73			
		$\tan \delta$	8.9	6.1	6	6	6.2	11.8			
GB-112T ^f		250	2.48	2.46	2.46	2.46	2.44	----			
(field 1 laminate)		$\tan \delta$	80	36	18	14	----	2.5			
25**		ϵ'/ϵ_0	2.70	2.68	2.69	2.69					
		$\tan \delta$	4.7	3.9	4.7	4.8					

a. Expanded polyvinyl chloride (Sponge Rubber). b. Modified polyvinyl chloride (U. S. Rubber). c. Polyvinylidene and vinyl chlorides (Dow). d. Polychlorotrifluoroethylene (Kellogg). e. Plasticized polychlorotrifluoroethylene (Kellogg). f. 65-68% Teflon, 32-35% continuous-filament glass base (Cont. Diamond).

I.. Solids, B. Organic 3. Polyvinyl Resins (cont.) Values for $\tan \delta$ are multiplied by 10^4 ; frequency given in c/s.

[illegible]

a. 65-68% Teflon, 32-35% continuous-filament glass base (Cont. Diamond). b. Polytetrafluoroethylene (DuPont). c. 75% Teflon, 25% calcium fluoride (U.S.Gasket). d. 80% Teflon, 20% carbon (U.S. Gasket). e. 88% Teflon, 12% ceramic (U.S.Gasket). f. 75% Teflon, 25% Fiberglass (U.S.Gasket). g. 75% Teflon, 25% glass (U.S.Gasket). h. 75% Teflon, 25% graphite (U.S.Gasket).

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*After temperature run. **Freq. = 1 x 109. ***tan δ not multiplied by 104.

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I. Solids, B. Organic 3. Plastics J. Polyvinyl resins (cont.) Values for $\tan \delta$ are multiplied by 10^4 ; frequency given in c/s.

6) Polytetrafluoro-

ethylene (cont.)	T°C	ϵ'/ϵ_0	1×10^2	1×10^3	1×10^4	1×10^5	1×10^6	1×10^7	1×10^8	3×10^8	1×10^{10}	2.5×10^{10}
Chemelac M1418-2 ^a	25	$\tan \delta$	2.30	2.20	2.20	2.15	2.15	2.14	2.14			
(desiccated 48 hrs. P ₂ O ₅)			600	200	45	4	2	2.5	5			
(dried in oven)	25	ϵ'/ϵ_0	2.	2.15	2.15	2.15	2.15					
		$\tan \delta$	11	6	2.7	1.5	1.8					
Chemelac M1418-5 ^b	25	ϵ'/ϵ_0	2.27	2.23	2.18	2.18	2.16	2.16	2.16			
		$\tan \delta$	450	118	32	8.8	5.7	5.9	7.1			
Chemelac M1422 ^c	25	ϵ'/ϵ_0	2.72	2.72	2.72	2.72	2.72	2.72	2.72			
		$\tan \delta$	11.9	7.7	4.5	2.8	2.0	1.8	2.4			
Chemelac M1423 ^d	25	ϵ'/ϵ_0	-----	1.308	-----	-----	-----	-----	-----	1.30		
		$\tan \delta$	-----	1.81	-----	-----	-----	-----	-----	62		

7) Polyvinyl alcohol-acetate

Elvanol 51A-05 ^e	25	ϵ'/ϵ_0	8.2	7.8	7.2	6.2	5.2	4.5	-----	3.74	3.50	3.46
		$\tan \delta$	430	440	580	720	900	1000	-----	550	502	620
	85	ϵ'/ϵ_0	400	100	33	16	10	7.3	-----	4.67		
		$\tan \delta$	15000	13000	9000	3600	2300	2000	-----	1770		
	23	ϵ'/ϵ_0	14.0	10.4	8.0	6.6	5.7	5.0	-----	3.75		
		$\tan \delta$	4050	1850	1150	1000	950	900	-----	715		
	68	ϵ'/ϵ_0	85	26	14	9.5	7.5	5.8				
		$\tan \delta$	9600	8100	4000	1600	1400	1500				
	100	ϵ'/ϵ_0	3000	400	50	18	13	8.7	-----	5.6	4.1	
		$\tan \delta$	15000	22000	20000	4800	2700	2600	-----	2300	3000	
	26	ϵ'/ϵ_0	-----	-----	58	27	14	7	-----	4.12		
		$\tan \delta$	-----	-----	8200	5900	4100	2700	-----	840		
	26	ϵ'/ϵ_0	-----	-----	45.5	22.0	12.5	7.5	-----	3.89	3.8	3.8
		$\tan \delta$	-----	-----	7600	5100	3500	2500	-----	640	636	730
	25	ϵ'/ϵ_0	3.09	3.07	3.05	3.02	2.98	2.94	2.90	2.88		
		$\tan \delta$	49	50	52	56	65	49	37	28		
	85	ϵ'/ϵ_0	7.3	7.15	5.9	3.75	3.25	2.95	2.90	2.87		
		$\tan \delta$	180	590	2400	1830	830	560	200	85		

a. 90% Teflon, 10% quartz (U.S.Gasket). b. 75% Teflon, 25% quartz (U.S.Gasket). c. 80% Teflon, 20% titanium dioxide (U.S.Gasket).
d. Air-filled Teflon (U.S.Gasket). e. Polyvinyl alcohol-acetate, 11-14% acetoxy (DuPont). f. Polyvinyl alcohol-acetate, 0-1.5% acetoxy (DuPont). g. Polyvinyl acetate (DuPont).

8) Polyvinyl acetals		T°C	$\frac{1 \times 10^2}{\epsilon'/\epsilon_0}$	$\frac{1 \times 10^3}{\tan \delta}$	$\frac{1 \times 10^4}{\epsilon'/\epsilon_0}$	$\frac{1 \times 10^5}{\tan \delta}$	$\frac{1 \times 10^6}{\epsilon'/\epsilon_0}$	$\frac{1 \times 10^7}{\tan \delta}$	$\frac{1 \times 10^8}{\epsilon'/\epsilon_0}$	$\frac{3 \times 10^8}{\tan \delta}$	$\frac{3 \times 10^9}{\epsilon'/\epsilon_0}$	$\frac{1 \times 10^{10}}{\tan \delta}$	$\frac{2.5 \times 10^{10}}{\epsilon'/\epsilon_0}$		
Formvar, Type E ^a		26	ϵ'/ϵ_0	3.16	3.12	3.08	3.00	2.92	2.85	-----	2.76	-----	2.7		
			$\tan \delta$	54	100	154	190	190	165	-----	113	-----	115		
		88	ϵ'/ϵ_0	3.55	3.5	3.4	3.25	3.1	2.95	2.85	2.80	-----			
			$\tan \delta$	60	83	102	145	213	310	300	227	-----			
Alvar 11/90 ^b		25	ϵ'/ϵ_0	3.17	3.14	3.09	3.03	2.96	2.90	2.82	2.80	2.73	2.70	2.65	
			$\tan \delta$	65	70	100	140	180	160	125	119	136	175	175	
		84	ϵ'/ϵ_0	3.84	3.54	3.40	3.25	3.05	2.90	-----	2.74	-----			
			$\tan \delta$	575	390	270	195	180	225	-----	196	-----			
Butvar, Low OH ^c		27	ϵ'/ϵ_0	2.69	2.67	2.65	2.63	2.61	2.59	-----	2.51	2.48	2.46		
			$\tan \delta$	38	40	56	88	124	138	-----	111	107	99		
Butvar 55/98 ^c		27	ϵ'/ϵ_0	3.04	3.02	2.98	2.94	2.86	2.75	2.67	2.62	-----			
			$\tan \delta$	41	59	108	161	215	216	177	-----	172	-----		
9) Polyacrylates															
Lucite HM-119 ^d (now replaced by HM-140)		-12	ϵ'/ϵ_0	3.0	2.9	2.8	2.7	2.63	2.60	2.59	-----	2.58	2.57		
			$\tan \delta$	330	250	190	140	102	70	55	-----	35.4	34		
		23	ϵ'/ϵ_0	3.20	2.84	2.75	2.68	2.63	2.60	2.58	-----	2.58	2.57	2.57	
			$\tan \delta$	620	440	315	220	145	100	67	-----	51.3	49	32	
		81	ϵ'/ϵ_0	3.97	3.45	3.08	2.86	2.72	2.62	2.59	-----	2.58	2.57		
			$\tan \delta$	600	820	720	540	380	220	130	-----	77	95		
Lucite, sintered ^e (obsolete)		27	ϵ'/ϵ_0	2.29	2.12	2.01	2.00	2.00	2.00	2.00	-----	1.82	-----		
			$\tan \delta$	408	290	195	116	66	49	40	-----	52	-----		
Gafite cast polymer ^f (sheet sample)		25	ϵ'/ϵ_0	3.25	3.12	3.02	2.97	2.90	2.88	2.83	-----	-----	-----		
			$\tan \delta$	310	240	183	155	115	77	64	-----	-----	-----		
(rod sample)		25	ϵ'/ϵ_0	-----	-----	-----	-----	-----	-----	-----	2.75	2.75	2.75		
			$\tan \delta$	-----	-----	-----	-----	-----	120	-----	99	78	83		
Flexiglas ^g		27	ϵ'/ϵ_0	3.40	3.12	2.95	2.84	2.76	2.71	-----	2.66	2.60	2.59		
			$\tan \delta$	605	465	300	200	140	100	-----	62	57	67		
		80	ϵ'/ϵ_0	4.30	3.80	3.34	3.00	2.80	2.70	-----	-----	2.56	-----		
			$\tan \delta$	700	895	800	520	320	210	-----	-----	79	-----		

a. Polyvinyl formal (Shawinigan). b. Polyvinyl acetal (Shawinigan). c. Polyvinyl butyral (Shawinigan). d. Polymethyl methacrylate (DuPont). e. DuPont. f. Methyl and alpha-chloroacrylate (Gen. Aniline). g. Polymethyl methacrylate (Rohm and Haas).

I. Solids, B. Organic 3. Plastics J. Polyvinyl Resins (cont.) Values for $\tan \delta$ are multiplied by 10^4 ; frequency given in c/s.

9) Polyacrylates (cont.)		T°C	ϵ'/ϵ_0	$\tan \delta$	$\frac{1 \times 10^2}{\epsilon'/\epsilon_0}$	$\frac{1 \times 10^3}{\tan \delta}$	$\frac{1 \times 10^4}{\epsilon'/\epsilon_0}$	$\frac{1 \times 10^5}{\tan \delta}$	$\frac{1 \times 10^6}{\epsilon'/\epsilon_0}$	$\frac{1 \times 10^7}{\tan \delta}$	$\frac{1 \times 10^8}{\epsilon'/\epsilon_0}$	$\frac{3 \times 10^8}{\tan \delta}$	$\frac{3 \times 10^9}{\epsilon'/\epsilon_0}$	$\frac{1 \times 10^{10}}{\tan \delta}$	$\frac{2.5 \times 10^{10}}{\epsilon'/\epsilon_0}$
Polyethyl methacrylate ^a	22		2.90	2.75	2.65	2.60	2.55	2.53	2.53	2.53	2.53	2.53	2.51	2.50	2.5
	80		420	294	185	118	90	75	75	75	75	75	75	97	83
Polybutyl methacrylate ^a	-12		3.87	3.36	2.86	2.70	2.61	2.57	2.57	2.57	2.55	2.55	2.49	2.48	
	80		810	1060	960	710	400	260	260	260	140	140	91	135	
Polyisobutyl methacrylate ^a	24		2.50	2.46	2.44	2.42	2.41	2.40	2.40	2.40	2.40	2.40	2.38	2.36	
	81		190	120	68	42	33	25	25	25	25	25	48	46	
Polystyrene ^c	25		2.82	2.62	2.52	2.47	2.43	2.42	2.42	2.42	2.42	2.42	2.38	2.36	
	81		605	360	200	125	80	55	55	55	55	55	44	46	
Polystyrene ^c	25		3.70	3.52	3.14	2.82	2.60	2.48	2.48	2.48	2.48	2.48	2.39	2.36	
	81		150	650	1200	980	470	220	220	220	220	220	185	2.38	2.37
Polystyrene ^c	25		2.70	2.68	2.63	2.55	2.45	2.45	2.45	2.45	2.42	2.40	2.39	2.38	52
	80		111	70	50	37	35	46	46	46	52	47	31	39	
Polystyrene ^c	25		2.9	2.7	2.5	2.5	2.44	2.42	2.42	2.42	2.42	2.40	2.39	2.38	
	80		830	600	360	210	100	80	80	80	70	65	54	59	
Polystyrene ^c	25		2.58	2.52	2.52	2.52	2.52	2.52	2.52	2.48	2.47	2.47	2.46	2.46	41
	84		46	47.5	60	50	28	23	23	23	25	25	34.9	41	
Polystyrene ^c	25		2.63	2.60	2.55	2.47	2.42	2.39	2.39	2.39	2.37	2.37	2.37	2.37	
	84		150	124	98	81	68	38	38	38	32	32	49	49	

10) Polystyrene

Polystyrene^c

(commercially molded)

Sheet, Stock

25	ϵ'/ϵ_0	2.56	2.56	2.56	2.56	2.56	2.56	2.55	2.55	2.55	2.54	2.54	2.54	2.54	12
80	$\tan \delta$	< 0.5	< 0.5	< 0.5	0.5	0.7	< 2	< 1	< 1	< 1	< 1	< 1	< 1	< 1	-----
80	ϵ'/ϵ_0	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	5.3
80	$\tan \delta$	9	2	< 1	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	4.8

Rod Stock

Sample A

Sample B

Sample B

25	$\tan \delta$	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	4.8
25	$\tan \delta$	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	22
80	$\tan \delta$	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	16

a. Dupont. b. Polaroid. c. For sheet stock, various samples used for different frequencies; for rod stock, ϵ'/ϵ_0 is the same as for sheet stock (Plax).

I. Solids. B. Organic 3. Plastics J. Polyvinyl Resins (cont.) Values for $\tan \delta$ are multiplied by 10^4 ; frequency given in c/s.

10) Polystyrene (cont.)	T ^o C	ϵ'/ϵ_0	$\tan \delta$	$\times 10^2$	$\times 10^3$	$\times 10^4$	$\times 10^5$	$\times 10^6$	$\times 10^7$	$\times 10^8$	$\times 10^8$	$\times 10^9$	$\times 10^{10}$	$\times 10^{10}$
Styron C-176 ^a	25	ϵ'/ϵ_0	$\tan \delta$	2.55	2.55	2.55	2.55	2.55	2.55	2.55	2.55	2.54	2.54	2.54
	80	ϵ'/ϵ_0	$\tan \delta$	2.55	2.55	2.55	2.55	2.55	2.55	2.55	2.55	2.54	2.54	2.54
Styron C-176, 30% humidity ^b	25	ϵ'/ϵ_0	$\tan \delta$	12	12	12	12	12	12	12	12	12	12	12
Styron C-176, 50% humidity ^b	25	ϵ'/ϵ_0	$\tan \delta$	12	12	12	12	12	12	12	12	12	12	12
Styron C-176, 90% humidity ^b	25	ϵ'/ϵ_0	$\tan \delta$	12	12	12	12	12	12	12	12	12	12	12
Styron C-176 + 0.5% paraffin, 90% humidity ^b	25	ϵ'/ϵ_0	$\tan \delta$	12	12	12	12	12	12	12	12	12	12	12
Styron 411-A ^c (formerly Exp. Plastic Q-247)	22	ϵ'/ϵ_0	$\tan \delta$	2.55	2.55	2.55	2.55	2.55	2.55	2.55	2.55	2.54	2.54	2.54
	79	ϵ'/ϵ_0	$\tan \delta$	2.55	2.55	2.55	2.55	2.55	2.55	2.55	2.55	2.54	2.54	2.54
Styron 475 ^b	25	ϵ'/ϵ_0	$\tan \delta$	2.62	2.61	2.59	2.56	2.56	2.55	2.55	2.55	2.53	2.53	2.53
Styron 666 ^b	25	ϵ'/ϵ_0	$\tan \delta$	3.6	3.0	2.4	2.6	4.2	7.6	11	19*	36	17	17
Styron 671 ^b	25	ϵ'/ϵ_0	$\tan \delta$	1.75	1.1	1.1	1.1	1.1	1.2	2	2.7*	3.1	3.4	3.4
	25	ϵ'/ϵ_0	$\tan \delta$	2.55	2.55	2.55	2.55	2.54	2.54	2.54	2.54	2.54	2.54	2.54
		$\tan \delta$		.97	.64	< .5	< .5	.2	.38	.57	1.47*	1.76	2.1	2.1

a. Polystyrene (Dow). Similar values given by Dow's C-244 and Q-247.1; Catalin's Iocalin #1 Color 4000; Bakelite's IMS-4A-621, XRS-23-B10012-442, XRS-23-B10012-52Q, XRS-23-B10016-D63, XRS-23-B10012-D107; Monsanto's Samples D-277, D-279 (extra purity), D-334.

b. Polystyrene (Dow). c. Polystyrene (Dow). Similar values given by Monsanto's Lustron Res. Sample D-276.

*Freq. = 1×10^6 .

I. Solids, B. Organic 3. Plastics J. Polyvinyl Resins (cont.) Values for $\tan \delta$ are multiplied by 10^4 ; frequency given in c/s.

10) Polystyrene													
(cont.)		$T^{\circ}\text{C}$	$\frac{1 \times 10^2}{\epsilon'/\epsilon_0}$	$\frac{1 \times 10^3}{\tan \delta}$	$\frac{1 \times 10^4}{\epsilon'/\epsilon_0}$	$\frac{1 \times 10^5}{\tan \delta}$	$\frac{1 \times 10^6}{\epsilon'/\epsilon_0}$	$\frac{1 \times 10^7}{\tan \delta}$	$\frac{1 \times 10^8}{\epsilon'/\epsilon_0}$	$\frac{3 \times 10^8}{\tan \delta}$	$\frac{3 \times 10^9}{\epsilon'/\epsilon_0}$	$\frac{1 \times 10^{10}}{\tan \delta}$	$\frac{2.5 \times 10^{10}}{\epsilon'/\epsilon_0}$
Fibers Q-107 ^a		26	ϵ'/ϵ_0	2.14	2.14	2.14	2.14	2.14	2.14	---	2.11	---	---
		$\tan \delta$	7.6	6.3	4.6	3	3	4	---	6.3	---	---	
Foam Q-103, 90% humidity ^a		27	ϵ'/ϵ_0	---	---	---	---	---	---	---	1.03	---	---
		$\tan \delta$	---	---	---	---	---	---	---	<0.3	---	---	
Styrofoam 103.7 ^b		25	ϵ'/ϵ_0	1.03	1.03	1.03	1.03	1.03	---	---	1.03	1.03	---
		$\tan \delta$	<2	<1	<1	<1	<2	---	---	1	1.5	---	
Polystyrene cast in vacuo ^c		25	ϵ'/ϵ_0	2.55	2.55	2.55	2.55	2.55	---	---	2.55	---	---
		$\tan \delta$	1	1	0.5	<2	<3	---	---	2.4	---	---	
Polystyrene cast in air ^c		25	ϵ'/ϵ_0	---	2.50	2.50	2.50	2.50	---	---	2.48	---	---
		$\tan \delta$	---	9	5.5	<5	2	8	---	---	12.8	---	---
Experimental Plastic Q764.6 ^a		25	ϵ'/ϵ_0	2.63	2.58	2.58	2.58	2.58	2.58	2.58	2.55*	2.51	2.51
		$\tan \delta$	2.5	1.3	1.8	2.5	2.3	1.4	2.8	7.3*	8.2	6.5	---
Experimental Plastic Q767.2 ^a		25	ϵ'/ϵ_0	2.98	2.95	2.92	2.90	2.86	2.83	2.80	2.77*	2.75	2.75
		$\tan \delta$	62	73	80	74	65	55	43	36*	38	43	---
Styramic #18 ^d		22	ϵ'/ϵ_0	2.68	2.66	2.65	2.65	2.65	2.65	2.65	2.65	2.65	2.63
		$\tan \delta$	29	18.4	5	<2	<2	<2	1.6	1.9	2.2	2.3	4
		78	ϵ'/ϵ_0	2.7	2.7	2.67	2.65	2.65	2.65	2.65	---	2.63	---
		$\tan \delta$	91	67	25	6.5	4	4	3	---	2.0	---	---
11) Misc. Polystyrenes													
Exp. Plastic Q817.1 ^e		25	ϵ'/ϵ_0	2.60	2.60	2.60	---	2.59	2.58	2.57	2.57*	2.57	2.56
		$\tan \delta$	.7	.6	.61	---	.7	1	2.1	4.8*	4.5	3	
Exp. Plastic Q406 ^f		25	ϵ'/ϵ_0	2.60	2.59	2.58	2.57	2.56	2.55	2.52	2.50*	2.49	2.49
		$\tan \delta$	7.3	6.2	4.7	3.6	2.2	1.5	1.2	1.9*	2.0	2.6	---
Poly-p-xylylene ^g		25	ϵ'/ϵ_0	2.45	2.45	2.45	2.45	2.45	2.45	---	---	2.45	---
		$\tan \delta$	2	3.4	3.9	<2	0.7	3.7	---	---	9	---	---

a. Dow. b. 99.75% polystyrene, 0.25% filler (Dow). c. From Dow's N-100 styrene (Lab. Ins. Res.). d. 50% polystyrene, 50% chlorinated diphenyl (Monsanto). e. Poly alpha-methylstyrene (Dow). f. Polyvinyltoluene (Dow). g. Pressed fibers (Polaroid).
*Freq. = 1×10^9 .

I. Solids, B. Organic 3. Plastics J. Polyvinyl Resins (cont.) Values for tan δ are multiplied by 10^4 ; frequency given in c/s.

12) Styrene copolymers													
linear	T°C	1×10^2	1×10^3	1×10^4	1×10^5	1×10^6	1×10^7	1×10^8	3×10^8	3×10^9	1×10^{10}	2.5×10^{10}	
Styrene-2,4-dimethyl- styrene copolymer ^a	25	ϵ'/ϵ_0	2.53	2.53	2.53	2.52	2.52	2.52	2.51*	2.50	2.49		
		tan δ	1.6	1.3	0.8	0.7	0.9	1.2	1.5	4.0*	5.4	2.8	
Styrene-acrylonitrile copolymer ^a	25	ϵ'/ϵ_0	2.96	2.95	2.92	2.87	2.80	2.78	2.77*	2.77	2.76		
		tan δ	59	63	67	67	64	50	41	40*	41	45	
Darex copolymer 3 ^b	25	ϵ'/ϵ_0	2.53	2.53	2.52	2.51	2.50	2.49	-----	2.48	2.45		
		tan δ	23.7	21.5	30.9	38.9	34.8	26.8	23.8	-----	21.3	20.9	
Darex copolymer 43E ^b	25	ϵ'/ϵ_0	2.54	2.54	2.54	2.54	2.54	2.54	-----	2.54	2.53		
		tan δ	5.5	2.8	2.2	2.8	3.9	6.2	8.2	-----	9.8	13	
Darex copolymer I-34 ^c	25	ϵ'/ϵ_0	2.55	2.54	2.54	2.53	2.52	2.52	2.51	-----	2.50	2.48	
		tan δ	20.4	12.7	17.5	19.5	12	15	14	-----	11.6	12	
Darex copolymer I-43 ^b	25	ϵ'/ϵ_0	2.56	2.56	2.56	2.56	2.55	2.55	-----	2.55	2.54		
		tan δ	7.3	2.5	2.3	2.2	3	4	5.5	-----	8.9	11.6	
Styraloy 22 ^c	-12	ϵ'/ϵ_0	2.4	2.4	2.4	2.4	2.4	2.4	-----	2.4	2.4		
		tan δ	8	8	4	15	36	52	-----	28	18	2.4	
Marbon S ^d	23	ϵ'/ϵ_0	2.4	2.4	2.4	2.4	2.4	2.4	2.40	2.4	2.4	2.4	
		tan δ	9	6	5	7	12	30	52	46	32	24	
Code 7206	81	ϵ'/ϵ_0	2.4	2.4	2.4	2.4	2.4	2.4	-----	2.4	2.4	2.4	
		tan δ	16	10	8	6	6	13	-----	51	55		
Marbon S-1	25	ϵ'/ϵ_0	2.62	2.62	2.62	2.61	2.60	2.60	2.57	2.55*	2.55	2.54	
		tan δ	17.4	14.1	13.8	13.8	18.3	22.1	22.2	20.6*	20	19	
Code 7254 ^d	25	ϵ'/ϵ_0	2.55	2.55	2.54	2.54	2.54	2.54	2.53	2.52*	2.52	2.52	
		tan δ	10	6	3.5	3.9	6.1	7.9	8.3	10*	11	12.5	
Marbon 8000 ^e	25	ϵ'/ϵ_0	2.56	2.56	2.56	2.56	2.56	2.56	2.56	2.52*	2.51	2.51	
		tan δ	5.4	4	3.2	3.0	4.0	5.0	7.2	9.0*	9.7	10	
Marbon 9200 ^f	25	ϵ'/ϵ_0	2.60	2.57	2.56	2.56	2.56	2.55	2.55	2.52*	2.52	2.52	
		tan δ	5.4	3.1	3	4.9	6.7	9	10	11.8*	11.9	11.5	

a. Am. Cyanamid. b. Dewey and Almy. c. Copolymer of butadiene and styrene (Dow). d. Butadiene-styrene copolymer, ca. 10% butadiene (Marbon). e. Butadiene-styrene copolymer ca. 15% butadiene (Marbon). f. Butadiene-styrene copolymer ca. 14% butadiene (Marbon).

*Freq. = 1×10^9 .

I. Solids, B. Organic 3. Plastics J. Polyvinyl Resins (cont.) Values for tan δ are multiplied by 10^4 ; frequency given in c/s.

12) Styrene copolymers, linear (cont.)		T°C	ϵ'/ϵ_0	1×10^2	1×10^3	1×10^4	1×10^5	1×10^6	1×10^7	1×10^8	1×10^9	3×10^9	1×10^{10}	2.5×10^{10}
Piccolastic D-125 ^a		25	ϵ'/ϵ_0	2.58	2.58	2.58	2.58	2.58	2.58	2.58	2.55	2.55	2.52	
			tan δ	2	1.5	1	1	1	1.5	3	5	5		
Styrene (50%) and 1,3,5-trivinyl-2,4,6-trichlorobenzene (50%) copolymer		25	ϵ'/ϵ_0	2.70	2.70	2.70	2.70	2.70	2.70	2.70	2.66	2.65	2.65	
			tan δ	8.5	8.9	9.7	10	11	16.2	26	20	21	19	
Styrene (50%) and 1,4-di-vinyl-2,3,5,6-tetrachlorobenzene (50%) copolymer		25	ϵ'/ϵ_0	2.70	2.70	2.70	2.70	2.70	2.70	2.70	2.70	2.70	2.70	
			tan δ	6	7.4	8.2	7.8	8.2	12.0	22	13.2	13.8	13.6	
S-40 ^c		25	ϵ'/ϵ_0	2.40	2.40	2.40	2.39	2.39	2.39	2.38	2.37	2.37	2.35	
			tan δ	21	14	13	12	8	6	6	6.4	7.1		
S-60 ^c		25	ϵ'/ϵ_0	2.50	2.49	2.48	2.46	2.46	2.45	2.45	2.44	2.44	2.44	
			tan δ	27	24	20	15	10	6	4	6.5	7.4		
13) Styrene copolymers cross-linked														
Copolymer 8012 ^d		25	ϵ'/ϵ_0	2.58	2.58	2.58	2.58	2.58	2.57	2.55	2.54	2.53	2.52	
			tan δ	2.7	1.3	.87	.7	1.1	2	3.8	6.8	8.8	8.9	
Plastic EK2784 ^d		25	ϵ'/ϵ_0	2.59	2.59	2.59	2.56	2.56	2.56	2.56	2.55	2.54	2.52	
			tan δ	2.6	1.5	1.2	1.4	1.8	2.3	4.2	8.8	6.7	4.7	
Exp. Plastic Q-166 ^e		23	ϵ'/ϵ_0	3.44	3.40	3.38	3.36	3.32	3.22	3.05	2.71	2.71	2.62	
			tan δ	45	55	70	110	180	350	420	315	250		
80			ϵ'/ϵ_0	3.25	3.23	3.21	3.19	3.16	3.12	3.05	2.85	2.63		
			tan δ	550	95	41	38	55	110	250	570	550		
Exp. Plastic Q-166 ^e plus Fiberglas		23	ϵ'/ϵ_0	4.46	4.42	4.37	4.30	4.21	4.09	3.95	3.78	3.70	3.6	
			tan δ	160	110	96	120	180	250	320	241	231	200	
79			ϵ'/ϵ_0	4.5	4.4	4.4	4.3	4.2	4.1	4.0	3.8	3.7		
			tan δ	880	320	140	85	80	130	220	415	470		
Exp. Plastic Q-200.5 ^f		26	ϵ'/ϵ_0	2.55	2.55	2.55	2.55	2.55	2.55	2.55	2.55	2.55	2.54	
			tan δ	4	< 2	< 2	< 2	2	3.4	4	5.2	5.2	24	
100			ϵ'/ϵ_0	2.56	2.56	2.56	2.56	2.55	2.55	2.55	2.55	2.55*		
			tan δ	20	7	2	< 2	< 2	< 3	---	---	7.6*		

a. Methylstyrene-styrene copolymer (Penn. Ind. Chem.). b. Sprague (two different castings measured in the ranges $10^2 - 10^8$ and $10^9 - 10^{10}$ c/s.) c. Standard Oil Dev. Co. N.J. d. Catalin. e. Dow. f. Cross-linked with o-, m-, p-divinylbenzenes (Dow).

*Measurements made at 78°C.

I. Solids, B. Organic 3. Plastics J. Polyvinyl Resins (cont.) Values for $\tan \delta$ are multiplied by 10^4 ; frequency given in c/s.

13) Styrene copolymers cross-linked (cont.) T°C		1×10^2	1×10^3	1×10^4	1×10^5	1×10^6	1×10^7	1×10^8	3×10^8	1×10^{10}	2.5×10^{10}
Exp. Plastic Q-344 ^a		ϵ'/ϵ_0	$\tan \delta$	ϵ'/ϵ_0	$\tan \delta$	ϵ'/ϵ_0	$\tan \delta$	ϵ'/ϵ_0	$\tan \delta$	ϵ'/ϵ_0	$\tan \delta$
24		2.40	11	2.40	20	2.38	20	2.38	2.38	2.31	2.31
80		2.4	2.4	2.39	2.38	2.38	2.38	2.35	2.33	2.31	2.31
22		2.51	21	2.51	16	2.51	19	2.51	19	2.49	2.49
Exp. Plastic Q-475.5 ^a		ϵ'/ϵ_0	$\tan \delta$	ϵ'/ϵ_0	$\tan \delta$	ϵ'/ϵ_0	$\tan \delta$	ϵ'/ϵ_0	$\tan \delta$	ϵ'/ϵ_0	$\tan \delta$
80		2.48	4	2.48	2	2.48	2	2.48	2.47	2.47	2.47
25		2.58	6	2.58	2	2.55	2	2.55	2.53*	2.51	2.51
25		6.8	2.58	3.3	2.5	4.7	7.3	7.8	7.6*	7.2	6.7
25		2.58	2.58	2.58	2.58	2.58	2.58	2.58	2.55*	2.52	2.52
25		7.7	6	3.5	1.8	2.6	3.6	6.2	15*	8.8	7.5
25		2.58	2.58	2.58	2.58	2.58	2.58	2.58	2.53*	2.52	2.51
25		6	2.9	2.4	1.9	2	3.7	6.8	10.6*	11	8
25		2.58	2.58	2.58	2.58	2.58	2.58	2.58	2.57	2.52	2.52
25		6.6	2.8	2.1	2.1	2.1	3	5.5	16	7.6	6.3
25		2.51	2.51	2.51	2.51	2.50	2.50	2.47	2.47	2.46	2.46
25		8	10	13	27	34	31	29	30	39	39
25		2.55	2.55	2.55	2.55	2.55	2.55	2.55	2.55*	2.54	2.54
25		2.1	1.1	1	1.1	1.3	2	3.8	4.6*	4.8	4.7
25		2.64	2.64	2.62	2.62	2.62	2.62	2.62	2.60	2.59	2.59
25		20	15.6	11	7	4.7	9	11	11	5	5
25		2.59	2.59	2.59	2.58	2.58	2.58	2.58	2.58	2.58	2.57
25		4	5	8	12	16	19	20	19	17.5	17.5
23		2.64	2.64	2.64	2.63	2.62	2.62	2.62	2.62	2.62	2.62
23		6	7	11	19	33	39	34	28	28	28

a. Cross-linked polystyrene (Dow). b. Goodyear. c. Esso C oil in styrene-divinylbenzene solution (Polaroid). d. Rex Corp.

e. 32.5% polystyrene, 53.5% poly-2,5-dichlorostyrene, 13% hydrogenated terphenyl, 0.5% divinylbenzene (U.S. Bur. Stand.).

f. U. S. Rubber.

*Freq. = 1×10^9 .

I. Solids B. Organic 3. Plastics J. Polyvinyl resins (cont.) Values for tan δ are multiplied by 10^4 ; frequency given in c/s.

14) Polystyrene plus fillers		T ^o C	ϵ'/ϵ_0	1×10^2	1×10^3	1×10^4	1×10^5	1×10^6	1×10^7	1×10^8	3×10^8	3×10^9	1×10^{10}	2.5×10^{10}
Polystyrene 91%, carbon 9% ^a		26	ϵ'/ϵ_0	3.85	3.85	3.85	3.85	3.95	3.84	---	3.81	3.60	3.46	
			tan δ	17	24	30	33	32	37	---	310	386	344	
Polystyrene 70%, carbon 30% ^a		25	ϵ'/ϵ_0	---	---	---	---	---	---	---	11*	9.1	8.8	
			tan δ	---	---	---	---	---	---	---	2300*	2500	1100	
Polystyrene 50%, carbon 50% ^a		25	ϵ'/ϵ_0	---	---	---	---	---	---	---	25.9*	20.8	19.4	
(molded at 1000 p.s.i.)			tan δ	---	---	---	---	---	---	---	7300*	5600	2800	
(molded at 10000 p.s.i.)		25	ϵ'/ϵ_0	---	---	---	---	---	---	---	36*	25	24	
			tan δ	---	---	---	---	---	---	---	4600*	6200	3000	
Lustrer Loaded Glass Mat ^b		25	ϵ'/ϵ_0	3.04	3.04	3.02	3.00	2.97	2.97	2.96	---	---	---	
(field $\perp$ plane of laminate)			tan δ	13.8	8.8	7.4	7	8.3	10.6	13.8	---	---	---	
(field in plane of laminate)		25	ϵ'/ϵ_0	---	---	---	---	---	---	---	---	3.07	3.07	
			tan δ	---	---	---	---	---	---	---	---	31	36	
Polyglas P ⁺ (experimental) ^c		24	ϵ'/ϵ_0	3.36	3.36	3.36	3.36	3.36	3.36	---	---	3.35	3.33	3.32
			tan δ	8	7	7	7	7	7	---	---	7.8	8.4	14.0
		79	ϵ'/ϵ_0	3.36	3.36	3.36	3.36	3.36	3.36	---	---	3.35	3.33	
			tan δ	30	17	12	9	8	7	---	---	14	19	
Polyglas P ⁺ (technical) ^d		25	ϵ'/ϵ_0	3.38	3.38	3.38	3.38	3.38	3.38	---	3.36	3.35	3.34	
			tan δ	9	9	9	9	9	9	---	9.6	11.7	19	
15) Polychlorostyrenes														
Plastic CX-8 ^e		24	ϵ'/ϵ_0	2.61	2.61	2.60	2.60	2.60	2.60	2.6	---	2.60	---	2.59
			tan δ	< 2	< 2	< 2	< 2	< 2	2	2.5	---	3.1	---	29
		80	ϵ'/ϵ_0	2.61	2.61	2.60	2.60	2.60	2.60	2.6	---	2.60	---	
			tan δ	6	2	< 3	< 3	< 3	3	4	---	7.3	---	
Plastic CQ-10DM ^f		25	ϵ'/ϵ_0	2.70	2.70	2.70	2.70	2.70	2.70	2.69	2.67	2.66	---	
			tan δ	5	5	5	6	8	10	11	11	10.8	---	
		100	ϵ'/ϵ_0	2.66	2.65	2.65	2.65	2.65	2.65	2.65	2.65	2.65	---	
			tan δ	33	17	8	6	7	11	16	17	17	---	

a. Cabot's #9 (Lab. Ins. Res.). b. 30% fiberglass (Monsanto). c. 18.6% Dow's C-244 polystyrene, 81.4% Corning's 790-glass powder, 0.25% paraffin, 0.1% Dow Corning's Ignition Sealing Compound No. 4 (Lab. Ins. Res.). d. Id. except that Monsanto's polystyrene was used (Monsanto). e. 97% poly-2,5-dichlorostyrene (Mathieson). f. Copolymer of 50% 2,4,6-trichlorostyrene, 25% 2,3,6-trichlorostyrene, 25% 2,3,5-trichlorostyrene (Mathieson).

*Freq. = 1×10^9 .

I. Solids B. Organic 3. Plastics 1. Polyvinyl Resins (cont.) Values for $\tan \delta$ are multiplied by 10^4 ; frequency given in c/s.

15) Polychlorostyrenes												
(cont.)												
	T°C	$\frac{1 \times 10^2}{\epsilon'/\epsilon_0}$										
		$\frac{1 \times 10^3}{\tan \delta}$	$\frac{1 \times 10^4}{\epsilon'/\epsilon_0}$	$\frac{1 \times 10^5}{\tan \delta}$	$\frac{1 \times 10^6}{\epsilon'/\epsilon_0}$	$\frac{1 \times 10^7}{\tan \delta}$	$\frac{1 \times 10^8}{\epsilon'/\epsilon_0}$	$\frac{3 \times 10^8}{\tan \delta}$	$\frac{1 \times 10^9}{\epsilon'/\epsilon_0}$	$\frac{2.5 \times 10^{10}}{\tan \delta}$		
Poly-3, 4-dichloro-styrene ^a	25	2.94	2.93	2.91	2.88	2.85	2.77	---	2.72	2.70	20	
	82	3.0	2.90	2.85	2.83	2.78	2.68	---	2.65			
	103	203	157	115	77	63	55	---	32			
	153	3.08	2.92	2.85	2.81	2.8	2.75	---	2.7	2.7	60	
Exp. Plastic Q-409 ^b	24	355	275	200	120	82	70	---	60			
	90	6.0	4.9	3.7	3.3							
		850	1700	1400	750							
		2.60	2.60	2.60	2.60	2.60	2.60	---	2.60	2.60	2.60	16
Polyglas D ^c (experimental)	24	10	7	5	5	4	5	---	8.7	12		
		2.69	2.69	2.68	2.68	2.68	2.65	---	2.64	2.60		
	79	50	25	14	8	5.5	7	---	11	18		
		3.22	3.22	3.22	3.22	3.22	3.22	---	3.22	3.22	3.22	
Polyglas D ^d (technical)	24	7	6	5	5	6	7	---	8	8.5		
		3.2	3.2	3.2	3.2	3.2	3.2	---	3.2	3.2	16	
		34	17	11	8	7	8	---	13	16		
		3.25	3.25	3.25	3.25	3.25	3.24	---	3.23	3.22	3.22	14
16) Poly-2,5-dichloro-styrene plus fillers												
Poly-2,5-dichlorostyrene (58.1%), TiO ₂ (41.9%) ^e	23	5.30	5.30	5.30	5.30	5.30	5.30	---	5.30	5.30		
		26	14	8	5	3	3	---	6	8.5		
Poly-2,5-dichlorostyrene (34.7%), TiO ₂ (65.3%) ^e	24	10.2	10.2	10.2	10.2	10.2	10.2	---	10.2	10.2		
		16	8	6	4	3	3	---	7.5	13		
Poly-2,5-dichlorostyrene (18.6%), TiO ₂ (81.4%) ^e	23	23.6	23.4	23.2	23.1	23.0	23.0	---	---	23.0		
		60	41	30	20	12	8	---	---	15.6		

a. ca. 95% (Monsanto). b. Copolymer of o- and p-chlorostyrenes (Dow). c. 34.9% Monsanto's poly-2,5-dichlorostyrene; 64.9% Corning's 790 glass powder, 0.1% paraffin wax, 0.1% Dow Corning's Ignition Sealing Compound No. 4 (Lab. Ins. Res.). d. Id. (Monsanto).

e. Monsanto's Styramic HT; Titanium Alloy's Tam Ticon T, heavy grade (Lab. Ins. Res.).

I. Solids B. Organic 3. Plastics j. Polyvinyl Resins (cont.) Values for $\tan \delta$ are multiplied by 10^4 ; frequency given in c/s.

16) Poly-2,5-dichlorostyrene plus fillers (cont.) $T^\circ C$	1×10^2	1×10^3	1×10^4	1×10^5	1×10^6	1×10^7	1×10^8	3×10^8	3×10^9	1×10^{10}
Poly-2,5-dichlorostyrene 23 (38.2%), $MgTiO_3$ (61.8%) ^a	ϵ'/ϵ_0	6.10	6.10	6.09	6.09	6.08	6.05	6.01	5.91	
	$\tan \delta$	35	22	14	10	7	6	7	8.9	
Poly-2,5-dichlorostyrene 25 (63.0%), $SrTiO_3$ (37.0%) ^b	ϵ'/ϵ_0	5.20	5.20	5.19	5.18	5.17	5.15	---	4.97	4.90
	$\tan \delta$	20	10	6	4	4	5	---	11.7	14.1
Poly-2,5-dichlorostyrene 24 (40.5%), $SrTiO_3$ (59.5%) ^b	ϵ'/ϵ_0	9.65	9.65	9.63	9.62	9.60	9.57	---	---	9.36
	$\tan \delta$	41	37	16	12	9	10	---	---	23
Poly-2,5-dichlorostyrene 23 (25.2%), $SrTiO_3$ (74.8%) ^b	ϵ'/ϵ_0	17.9	17.4	17.4	17.3	17.2	17.0	---	---	15.2
	$\tan \delta$	220	130	78	42	22	23	---	---	64
Poly-2,5-dichlorostyrene 23 (14.4%), $SrTiO_3$ (80.6%) ^b	ϵ'/ϵ_0	24.5	22.8	21.6	21.2	21.0	20.8	---	---	19.5
	$\tan \delta$	780	380	180	100	40	33	---	---	50
Poly-2,5-dichlorostyrene 23 (66.6%), $BaTiO_3$ (33.4%) ^c	ϵ'/ϵ_0	4.10	4.08	4.07	4.06	4.03	4.03	---	4.02	4.02
	$\tan \delta$	24	14	8	6	3	3	---	17	38
Poly-2,5-dichlorostyrene 25 (32.8%), $BaTiO_3$ (67.2%) ^c	ϵ'/ϵ_0	9.7	9.7	9.7	9.7	9.7	9.7	---	---	9.7
	$\tan \delta$	60	42	25	14	6	6	---	---	143
Poly-2,5-dichlorostyrene 23 (23.5%), $BaTiO_3$ (75.5%) ^c	ϵ'/ϵ_0	15.8	15.8	15.8	15.8	15.7	15.7	---	---	15.5
	$\tan \delta$	30	30	25	12	7	13	---	---	214
Poly-2,5-dichlorostyrene 23 (21.0%), $BaTiO_3$ (79.0%) ^c	ϵ'/ϵ_0	19.4	19.3	19.1	18.9	18.9	18.9	---	---	18.4
	$\tan \delta$	52	35	25	16	7	8	---	---	314
Poly-2,5-dichlorostyrene (94%), Fe (6%) ^d	μ'/μ_0	---	---	---	---	---	---	---	1.02	.98
	$\tan \delta_m$	---	---	---	---	---	---	---	250	270
	ϵ'/ϵ_0	---	---	---	---	---	---	---	2.78	2.78
	$\tan \delta_d$	---	---	---	---	---	---	---	7	15
83	μ'/μ_0	---	---	---	---	---	---	---	1.04	
	$\tan \delta_m$	---	---	---	---	---	---	---	300	
	ϵ'/ϵ_0	---	---	---	---	---	---	---	2.7	
	$\tan \delta_d$	---	---	---	---	---	---	---	40	

a. Monsanto's Styramic HT; Titanium Alloy's Tam Ticon MC (Lab. Ins. Res.). b. Monsanto's Styramic HT; Titanium Alloy's Tam Ticon S (Lab. Ins. Res.). c. Monsanto's Styramic HT; Titanium Alloy's Tam Ticon B (Lab. Ins. Res.). d. Monsanto's D-1795; Plastic Metals' Plast-Iron, minus 20 mesh, annealed (Lab. Ins. Res.).

I. Solids B. Organic 3. Plastics J. Polyvinyl Resins (cont.) Values for $\tan \delta$ are multiplied by 10^4 ; frequency given in c/s.

16) Poly-2,5-dichlorostyrene

plus fillers (cont.) $T^\circ C$

Poly-2,5-dichlorostyrene 25
(60%), Fe (40%)^a

	1×10^2	1×10^3	1×10^4	1×10^5	1×10^6	1×10^7	1×10^8	3×10^8	3×10^9	1×10^{10}
ϵ'/ϵ_0	---	---	---	---	---	---	---	---	5.3	5.2
μ'/μ_0	---	---	---	---	---	---	---	---	1.16	.96
$\tan \delta_d$	---	---	---	---	---	---	---	---	270	190
$\tan \delta_m$	---	---	---	---	---	---	---	---	2300	2620

85

ϵ'/ϵ_0	---	---	---	---	---	---	---	---	5.1	---
μ'/μ_0	---	---	---	---	---	---	---	---	1.27	---
$\tan \delta_d$	---	---	---	---	---	---	---	---	---	---
$\tan \delta_m$	---	---	---	---	---	---	---	---	---	---

Poly-2,5-dichlorostyrene 25
(49.3%), Fe (50.7%)^a

ϵ'/ϵ_0	9.8	9.7	9.5	9.2	9.0	8.7	---	---	---	---
μ'/μ_0	---	3.00	---	---	---	2.70	---	---	6.93	---
$\tan \delta_d$	110	130	160	190	220	320	---	---	1.24	---
$\tan \delta_m$	---	---	---	---	---	340	---	---	644	---

Poly-2,5-dichlorostyrene 25
(40.7%), Fe (59.3%)^a

ϵ'/ϵ_0	---	---	---	---	---	---	---	---	10	---
μ'/μ_0	---	---	---	---	---	---	---	---	1.37	---
$\tan \delta_d$	---	---	---	---	---	---	---	---	1400	---
$\tan \delta_m$	---	---	---	---	---	---	---	---	4500	---

Poly-2,5-dichlorostyrene 25
(92%), Fe₃O₄ (8%)^b

ϵ'/ϵ_0	---	---	---	---	---	---	---	---	2.76	2.64
μ'/μ_0	---	---	---	---	---	---	---	---	1.03	1.03
$\tan \delta_d$	---	---	---	---	---	---	---	---	---	---
$\tan \delta_m$	---	---	---	---	---	---	---	---	---	---

Poly-2,5-dichlorostyrene 25
(83.7%), Fe₃O₄ (16.3%)^b

ϵ'/ϵ_0	---	---	---	---	---	---	---	---	---	---
μ'/μ_0	---	---	---	---	---	---	---	---	---	---
$\tan \delta_d$	---	---	---	---	---	---	---	---	---	---
$\tan \delta_m$	---	---	---	---	---	---	---	---	---	---

Poly-2,5-dichlorostyrene
(75%) Fe₃O₄ (25%)^b

ϵ'/ϵ_0	---	---	---	---	---	---	---	---	420	580
μ'/μ_0	---	---	---	---	---	---	---	---	3.44	---
$\tan \delta_d$	---	---	---	---	---	---	---	---	1.12	---
$\tan \delta_m$	---	---	---	---	---	---	---	---	26	---

a. Monsanto's D-1795; Plastic Metals' Plast-Iron, minus 200 mesh, annealed (Lab. Ins. Res.). b. Monsanto's D-1795; Mallinckrodt's magnetite (Lab. Ins. Res.).

I. Solids B. Organic 3. Plastics J. Polyvinyl Resins (cont.) Values for $\tan \delta$ are multiplied by 10^4 ; frequency given in c/s.

16) Poly-2,5-dichlorostyrene plus fillers (cont.) $T^{\circ}C$		1×10^2	1×10^3	1×10^4	1×10^5	1×10^6	1×10^7	1×10^8	3×10^8	3×10^9	1×10^{10}
Poly-2,5-dichlorostyrene 25		ϵ'/ϵ_0	----	----	----	----	----	----	4.08	4.07	
(55.9%) Fe_3O_4 (34.1%) ^a		μ'/μ_0	----	----	----	----	----	----	1.30	1.17	
		$\tan \delta_d$	----	----	----	----	----	----	42		
		$\tan \delta_m$	----	----	----	----	----	----	390	1010	
Poly-2,5-dichlorostyrene 25		ϵ'/ϵ_0	----	----	----	----	----	----	5.00	4.98	
(56.2%) Fe_3O_4 (43.8%) ^a		μ'/μ_0	----	----	----	----	----	----	1.45	1.23	
		$\tan \delta_d$	----	----	----	----	----	----	75		
		$\tan \delta_m$	----	----	----	----	----	----	560	1720	
Poly-2,5-dichlorostyrene 25		ϵ'/ϵ_0	----	----	----	----	----	----	7.4	7.3	7.3
(46.0%) Fe_3O_4 (54.0%) ^a		μ'/μ_0	----	----	----	----	----	----	1.65	1.32	.91
		$\tan \delta_d$	----	----	----	----	----	----	150		
		$\tan \delta_m$	----	----	----	----	----	----	780	2400	3500
Poly-2,5-dichlorostyrene 25		ϵ'/ϵ_0	----	----	----	----	----	----	9.8	9.5	
(35.7%) Fe_3O_4 (64.3%) ^a		μ'/μ_0	----	----	----	----	----	----	1.94	1.41	
		$\tan \delta_d$	----	----	----	----	----	----	450	180	
		$\tan \delta_m$	----	----	----	----	----	----	980	3000	
Poly-2,5-dichlorostyrene 25		ϵ'/ϵ_0	----	----	----	----	----	----	20	18	
(24.5%) Fe_3O_4 (75.5%) ^a		μ'/μ_0	----	----	----	----	----	----	2.38	1.60	
		$\tan \delta_d$	----	----	----	----	----	----	2000	300	
		$\tan \delta$	----	----	----	----	----	----	1430	3700	
Poly-2,5-dichlorostyrene 25		ϵ'/ϵ_0	24.8	16.9	11.9	7.6	5.0	----	3.76		
(38.55%) $(Mn, Fe)_3O_4$ (61.45%) ^b		μ'/μ_0	----	----	----	----	----	----	2.56		
		$\tan \delta_d$	2500	2500	2400	1900	900	----			
		$\tan \delta_m$	----	----	----	----	----	----	4000		
Poly-2,5-dichlorostyrene 25		ϵ'/ϵ_0	----	99	39	21	7.4	----	6.9	6.5	
(21.3%) $(Mn, Fe)_3O_4$ (78.7%) ^b		μ'/μ_0	----	----	----	----	----	----	4.3	1.32	
		$\tan \delta_d$	----	2700	10000	4800	930	----	90	< 50	
		$\tan \delta_m$	----	----	----	----	----	----	4900	13200	

a. Monsanto's D-1795; Mallinckrodt's magnetite (lab. Ins. Res.). b. Monsanto's D-1795; iron-manganese oxide (lab. Ins. Res.).

I. Solids B. Organic 3. Plastics J. Polyvinyl Resins (cont.) Values for $\tan \delta$ are multiplied by 10^4 ; frequency given in c/s.

17) Polyvinyl cyclohexane		T°C	ϵ'/ϵ_0	$\tan \delta$	1×10^2	1×10^3	1×10^4	1×10^5	1×10^6	1×10^7	1×10^8	3×10^8	3×10^9	1×10^{10}
Polyvinylcyclohexane ^a		24	ϵ'/ϵ_0	$\tan \delta$	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25
			$\tan \delta$		15	2	< 2	< 2	< 2	< 2	< 2	1.8	1.8	3.9
18) Poly- α -vinyl-naphthalene			ϵ'/ϵ_0	$\tan \delta$	-----	2.6	2.6	2.6	2.6	2.6	2.6			
Poly- α -vinyl-naphthalene ^b		24	ϵ'/ϵ_0	$\tan \delta$	-----	9.5	6.7	7.5	8.7	13	22			
19) Poly-2-vinylpyridine			ϵ'/ϵ_0	$\tan \delta$	4.91	4.64	4.26	3.77	3.56	3.33	3.1	3.06	2.98	
Poly-2-vinylpyridine ^b		22	$\tan \delta$		360	460	560	600	560	420	280	240	135	
2-Vinylpyridine-styrene		23	ϵ'/ϵ_0	$\tan \delta$	3.44	3.38	3.26	3.13	3.00	2.90	2.82	-----	2.76	
copolymer ^b			$\tan \delta$		168	230	270	290	260	185	120	-----	65	
20) Poly-N-vinylcarbazole			ϵ'/ϵ_0	$\tan \delta$	2.95	2.95	2.95	2.95	2.95	2.95	2.95	2.88	2.88	
Polectron #24 ^c		25	$\tan \delta$		13	9	6	5	4	5	6	-----	9.3	
		80	ϵ'/ϵ_0	$\tan \delta$	2.95	2.95	2.95	2.95	2.95	2.95	2.95	-----	-----	
			$\tan \delta$		19	10	8	9	9	7				
k. Polyesters			ϵ'/ϵ_0	$\tan \delta$	3.24	3.22	3.20	3.17	3.12	3.07	2.94	2.87*	2.83	2.82
Laminac 4115 ^d		25	$\tan \delta$		37.5	43.2	68.3	113	135	147	141	107*	93	88
Experimental Resin		25	ϵ'/ϵ_0	$\tan \delta$	4.15	4.05	3.93	3.77	3.58	3.44	3.20	-----	3.00	2.95
PDL7-669 ^d			$\tan \delta$		155	192	247	306	313	282	240	-----	155	142
Laminac PDL7-627 ^d		25	ϵ'/ϵ_0	$\tan \delta$	3.26	3.25	3.23	3.18	3.08	3.06	3.03	2.96*	2.92	2.86
			$\tan \delta$		50.5	42.8	67.8	115	140	148	135	107*	95	91.4
Laminac PDL7-650 ^d		25	ϵ'/ϵ_0	$\tan \delta$	3.02	3.00	2.98	2.95	2.89	2.82	2.78	-----	2.74	2.72
			$\tan \delta$		39.1	45.0	60.2	100	119	114	108	-----	92	96
Laminac 4-205 ^d		25	ϵ'/ϵ_0	$\tan \delta$	4.45	4.36	4.24	4.03	3.86	3.69	3.49	-----	3.21	3.15
			$\tan \delta$		147	162	219	301	360	345	340	-----	240	243
Formica Z65 ^e		25	ϵ'/ϵ_0	$\tan \delta$	5.21	5.10	5.00	4.89	4.70	4.35	-----	3.83*	3.69	3.49
(field II laminate)			$\tan \delta$		191	162	212	317	434	570	-----	485*	445	425
(field I laminate)		25	ϵ'/ϵ_0	$\tan \delta$	4.77	4.70	4.68	4.60	4.45	4.17	-----	-----	-----	-----
			$\tan \delta$		125	108	131	185	302	418				

a. Hydrogenated polystyrene (Dow). b. Lab. Ins. Res. c. Poly-N-vinylcarbazole, 1.3% HB-40 oil (Gen. Aniline). d. Amer. Cyanamid.
e. 50% Shell's DAP 85/80, 50% paper (Formica).
*Freq. = 1×10^9 .

I. Solids B. Organic 3. Plastics (cont.) Values for $\tan \delta$ are multiplied by 10^4 ; frequency given in c/s.

k. Polyesters (cont.)	T°C										
		1×10^2	1×10^3	1×10^4	1×10^5	1×10^6	1×10^7	1×10^8	3×10^8	3×10^9	1×10^{10}
Formica Z80 ^a (field II laminate)	25	ϵ'/ϵ_0	4.76	4.75	4.72	4.65	4.46	4.08	3.77	3.53*	3.41
		$\tan \delta$	175	160	210	310	420	565	500	390*	310
(field I laminate)	25	ϵ'/ϵ_0	4.52	4.42	4.38	4.33	4.15	3.91			
		$\tan \delta$	95	96	130	197	330	440			250
Glastic S ^b	26	ϵ'/ϵ_0	3.50	3.39	3.29	3.22	3.16	3.14	3.07		
		$\tan \delta$	330	250	160	98	100	105	130		
Glastic MF ^b	26	ϵ'/ϵ_0	3.92	3.82	3.76	3.72	3.65	3.57	3.53		
		$\tan \delta$	270	185	135	125	130	130	135		
Plaskon 911 ^c	24	ϵ'/ϵ_0	3.88	3.81	3.75	3.66	3.56	3.42	3.25	3.17	3.07
		$\tan \delta$	89	125	165	210	240	240	220	217	175
Marco Resin MR-21C ^d	80	ϵ'/ϵ_0	4.27	4.17	4.06	3.95	3.83	3.70	3.55	3.26	3.10
		$\tan \delta$	165	150	155	200	270	320	340	299	248
Marco Resin MR-23C ^d	25	ϵ'/ϵ_0	3.37	3.35	3.31	3.25	3.16	3.08	2.90	2.84	2.82
		$\tan \delta$	53	51	65	102	150	170	149	106	123
Marco Resin MR-25C ^d	25	ϵ'/ϵ_0	4.56	4.50	4.40	4.28	4.14	3.88	3.24	2.92	2.82
		$\tan \delta$	130	140	170	220	340	570	810	500	410
Laminating Resin MP, Glass reinforced ^e	25	ϵ'/ϵ_0	3.27	3.24	3.20	3.15	3.10	3.06	2.90	2.77	2.73
		$\tan \delta$	76	72	82	108	138	165	185	130	135
Laminating Resin MT, Glass reinforced ^f	25	ϵ'/ϵ_0	3.32	3.28	3.22	3.19	3.14	3.08	2.99	2.93	2.91
		$\tan \delta$	95	81	85	105	125	140	132	109	110
Laminate BD-44 ^g	24	ϵ'/ϵ_0									
		$\tan \delta$									

a. 52% Shell's DAP 25/50, 48% yarn fabric (Formica). b. With Fiberglass (Laminated Plastics). c. Unsaturated polyester (Libby-Ovens-Ford). d. Unsaturated polyester (Marco). e. Resin of 50% Vibron x-1039 alkyd and 50% triallyl cyanurate plus catalyst and Fiberglass ECC-181-114 (Naugatuck). f. Resin of 45% polyethylene tetraclophthate-maleate alkyd and 55% triallyl cyanurate plus catalyst and Fiberglass ECC-181-114 (Naugatuck). g. Selectron 5003, Fiberglass (Ovens-Corning).

*Freq. = 1×10^9 .

I. Solids B. Organic 3. Plastics (cont.) Values for tan δ are multiplied by 10^4 ; frequency given in c/s.

k. Polyesters (cont.)	T ^o C	ϵ'/ϵ_0	$\tan \delta$	1×10^2	1×10^3	1×10^4	1×10^5	1×10^6	1×10^7	1×10^8	3×10^8	3×10^9	1×10^{10}	2.5×10^{10}
Laminate BK 164 ^a	24	ϵ'/ϵ_0	$\tan \delta$	4.12	4.10	4.09	4.07	4.05	4.03	4.00	3.98	3.94	3.90	
Stypol 16b ^b	25	ϵ'/ϵ_0	$\tan \delta$	67	58	63	80	96	110	112	108	120	130	
Stypol 16c ^b	25	ϵ'/ϵ_0	$\tan \delta$	-----	-----	-----	-----	-----	-----	-----	-----	-----	2.88	
Stypol 16d ^b	25	ϵ'/ϵ_0	$\tan \delta$	-----	-----	-----	-----	-----	-----	-----	-----	-----	180	
Paraplex P13 ^c	25	ϵ'/ϵ_0	$\tan \delta$	-----	-----	-----	-----	-----	-----	-----	-----	-----	2.75	
Paraplex P43 ^c	25	ϵ'/ϵ_0	$\tan \delta$	-----	-----	-----	-----	-----	-----	-----	-----	-----	160	
Polydiallyl phthalate ^d	26.8	ϵ'/ϵ_0	$\tan \delta$	-----	-----	-----	-----	-----	-----	-----	-----	-----	2.81	
Allymer CR-39 ^e	24	ϵ'/ϵ_0	$\tan \delta$	-----	-----	-----	-----	-----	-----	-----	-----	-----	140	
	84	ϵ'/ϵ_0	$\tan \delta$	-----	-----	-----	-----	-----	-----	-----	-----	-----	2.77	
Allymer CR-39 laminate ^f	25	ϵ'/ϵ_0	$\tan \delta$	4.02	4.00	3.92	3.92	3.65	3.32	3.08	2.89*	2.77	2.77	
Phoresin ^g	25	ϵ'/ϵ_0	$\tan \delta$	73	108	184	310	530	590	600	440*	320	290	
		ϵ'/ϵ_0	$\tan \delta$	3.23	3.22	3.19	3.16	3.11	3.04	2.98	2.89*	2.85	2.85	
		ϵ'/ϵ_0	$\tan \delta$	33	43	68	98	130	160	160	110*	100	80	
		ϵ'/ϵ_0	$\tan \delta$	3.60	3.57	3.50	3.42	3.35	3.24	3.1	-----	2.95	2.95	
		ϵ'/ϵ_0	$\tan \delta$	104	95	118	150	200	241	195	-----	118	118	
		ϵ'/ϵ_0	$\tan \delta$	4.18	4.14	4.03	3.85	3.52	3.27	3.07	-----	2.88	-----	2.76
		ϵ'/ϵ_0	$\tan \delta$	90	120	210	380	520	460	330	-----	203	-----	165
		ϵ'/ϵ_0	$\tan \delta$	4.90	4.84	4.70	4.47	4.18	3.85	3.45	-----	3.02	-----	
		ϵ'/ϵ_0	$\tan \delta$	130	140	170	250	440	840	740	-----	370	-----	
		ϵ'/ϵ_0	$\tan \delta$	4.84	4.80	4.73	4.57	4.37	4.17	3.98	-----	3.78	-----	
		ϵ'/ϵ_0	$\tan \delta$	73	80	120	208	315	295	205	-----	140	-----	
		ϵ'/ϵ_0	$\tan \delta$	3.98	3.84	3.70	3.65	3.49	3.32	3.15	3.10	3.03	3.02	2.96
		ϵ'/ϵ_0	$\tan \delta$	260	270	320	330	280	210	165	145	171	165	164
M. Alkyd resins														
Chlorinated alkyd	25	ϵ'/ϵ_0	$\tan \delta$	-----	-----	-----	-----	-----	-----	-----	-----	-----	1.179	
diisocyanate, foamed ^h		ϵ'/ϵ_0	$\tan \delta$	-----	-----	-----	-----	-----	-----	-----	-----	-----	27	
Alkyd, diisocyanate, foamed ^k	25	ϵ'/ϵ_0	$\tan \delta$	1.223	1.223	1.223	1.223	1.218	1.205	1.20	-----	1.20	1.19	
Red Glyptal #1201 ^m	25	ϵ'/ϵ_0	$\tan \delta$	19.8	14.7	22.7	33.5	41	42	38	-----	34	22	
		ϵ'/ϵ_0	$\tan \delta$	4.9	4.5	4.1	4.0	3.9	3.8					
		ϵ'/ϵ_0	$\tan \delta$	760	600	500	400	320	290					

a. 38% polyester (Bakelite BR3-16631), 62% Fiberglas (Owens-Corning). b. Robertson. c. Rohm and Haas. d. Shell Dev. e. Allyl resin (Southern Alkali Corp.) f. 40% resin, 60% BCC-11-148 Fiberglas (Southern Alkali Corp.). g. Diallyl phenyl phosphonate resin (Victor). h. Cornell Aeronautical Labs. k. Goodyear Aircraft. m. General Electric.

*Frequency = 1×10^9 .

I. Solids B. Organic 3. Plastics (cont.) Values for $\tan \delta$ are multiplied by 10^4 ; frequency given in c/s.

m. Alkyd resins (cont.)		T°C	ϵ'/ϵ_0	$\frac{1 \times 10^2}{\tan \delta}$	$\frac{1 \times 10^3}{\epsilon'/\epsilon_0}$	$\frac{1 \times 10^4}{\tan \delta}$	$\frac{1 \times 10^5}{\epsilon'/\epsilon_0}$	$\frac{1 \times 10^6}{\tan \delta}$	$\frac{1 \times 10^7}{\epsilon'/\epsilon_0}$	$\frac{1 \times 10^8}{\tan \delta}$	$\frac{3 \times 10^8}{\epsilon'/\epsilon_0}$	$\frac{3 \times 10^9}{\tan \delta}$	$\frac{1 \times 10^{10}}{\epsilon'/\epsilon_0}$
#51 Permo Potting Compound ^a	Glastic Grade GF ^b	25	ϵ'/ϵ_0	3.18	2.95	2.83	2.74	2.70	2.64	2.59	2.55*	2.53	2.52
		25	$\tan \delta$	730	410	260	174	124	101	120	182*	125	122
Glastic Grade MM ^b	Glastic Grade MP ^b	25	ϵ'/ϵ_0	-----	-----	-----	-----	3.76					
		25	$\tan \delta$	-----	-----	-----	-----	95					
Glastic Grade A-2 ^b	Plaskon Alkyd Special ^c	25	ϵ'/ϵ_0	4.17	4.13	4.09	4.02	3.96	3.88	3.78			
		25	$\tan \delta$	102	87	84	99	115	125	136			
Plaskon Alkyd 411 ^c	Plaskon Alkyd 420 ^c	25	ϵ'/ϵ_0	-----	-----	-----	-----	3.56					
		25	$\tan \delta$	-----	-----	-----	-----	267					
Plaskon Alkyd 422 ^c	Plaskon Alkyd 440 ^c	25	ϵ'/ϵ_0	-----	-----	-----	-----	4.34					
		25	$\tan \delta$	-----	-----	-----	-----	518					
Plaskon Alkyd 440A ^c	Plaskon Alkyd 442 ^c	25	ϵ'/ϵ_0	5.32	5.10	4.96	4.90	4.76	4.65	4.55	4.54*	4.50	4.47
		25	$\tan \delta$	366	236	170	147	149	152	138	121*	108	138
Plaskon Alkyd 440A ^c	Plaskon Alkyd 442 ^c	25	ϵ'/ϵ_0	6.02	5.77	5.60	5.36	5.19	4.95	4.63	-----	4.32	4.31
		25	$\tan \delta$	340	240	220	260	310	320	288	-----	220	178
Plaskon Alkyd 442 ^c	Plaskon Alkyd 442 ^c	25	ϵ'/ϵ_0	5.50	5.35	5.24	5.10	5.03	4.90	4.82			
		25	$\tan \delta$	270	160	130	147	153	147	145			
Plaskon Alkyd 442 ^c	Plaskon Alkyd 442 ^c	25	ϵ'/ϵ_0	5.47	5.26	5.14	5.01	4.92	4.85	4.77	4.75*	4.75	4.72
		25	$\tan \delta$	365	213	151	134	120	113	110	100*	104	126
Plaskon Alkyd 442 ^c	Plaskon Alkyd 442 ^c	25	ϵ'/ϵ_0	5.13	5.04	4.95	4.85	4.73	4.61	4.50	4.42*	4.38	4.33
		25	$\tan \delta$	191	151	154	185	196	188	172	133*	137	146
Plaskon Alkyd 442 ^c	Plaskon Alkyd 442 ^c	25	ϵ'/ϵ_0	5.28	5.19	5.10	4.97	4.90	4.78	4.65	4.63*	4.62	4.61
		25	$\tan \delta$	165	133	131	143	146	146	134	124*	141	149
Plaskon Alkyd 442 ^c	Plaskon Alkyd 442 ^c	25	ϵ'/ϵ_0	5.02	4.89	4.80	4.71	4.59	4.50	4.44	4.37*	4.34	4.29
		25	$\tan \delta$	212	189	140	141	146	142	122	127*	131	141
n. Epoxy resins													
Araldite Casting Resin Type B ^d	Araldite E-134 ^d	25	ϵ'/ϵ_0	3.67	3.67	3.67	3.65	3.62	3.49	3.35	3.28	3.09	3.01
		25	$\tan \delta$	17	24	50	110	190	270	340	340	270	220
Araldite E-134 ^d	Araldite E-134 ^d	25	ϵ'/ϵ_0	7.3	6.1	5.3	4.7	4.4	4.1	3.7	3.5	3.2	3.1
		25	$\tan \delta$	1200	1050	920	760	770	1000	1300	750	460	390
Araldite Casting Resin G ^d	Araldite Casting Resin G ^d	25	ϵ'/ϵ_0	4.05	3.99	3.92	3.81	3.69	3.54	3.39	3.25*	3.15	3.10
		25	$\tan \delta$	105	104	141	210	270	288	300	311*	310	263

a. Hardman. b. Laminated Plastics. c. Libbey-Owens-Ford. d. Ciba.

I. Solids B. Organic 3. Plastics (cont.) Values for tan δ are multiplied by 10^4 ; frequency given in c/s.

n. Epox. Resins														
(cont.)		T°C	ϵ'/ϵ_0	1×10^2	1×10^3	1×10^4	1×10^5	1×10^6	1×10^7	1×10^8	3×10^8	1×10^9	1×10^{10}	2.5×10^{10}
Araldite Adhesive		25	ϵ'/ϵ_0	4.00	3.97	3.91	3.82	3.71	3.46	3.27	----	3.14	----	----
Type I Natural ^a			tan δ	29	52	120	200	300	350	340	----	230	----	----
Araldite Adhesive		25	ϵ'/ϵ_0	11.6	11.6	11.5	11.3	11.0	10.5	10.2	9.9	9.6	9.2	----
Type I Silver ^a			tan δ	38	62	120	190	300	370	360	360	520	980	----
Hysol 6000 ^b		25	ϵ'/ϵ_0	3.47	3.43	3.38	3.30	3.26	3.17	3.10	3.07	3.00	2.96	----
			tan δ	73	61	70	92	130	170	170	150	120	120	----
Hysol 6020 ^b		25	ϵ'/ϵ_0	3.96	3.90	3.82	3.67	3.54	3.42	3.29	----	3.01	2.99	----
			tan δ	68	113	206	260	272	266	299	----	274	252	----
Hysol 630 flexible		25	ϵ'/ϵ_0	6.65	6.15	5.75	5.37	4.74	4.15	3.61	----	3.20	3.11	----
Potting Compound ^b			tan δ	605	485	469	593	840	1010	900	----	380	324	----
Hysol 6000 PR ^b		25	ϵ'/ϵ_0	3.85	3.80	3.69	3.64	3.57	3.44	3.33	----	3.18	3.18	----
			tan δ	90	99	107	163	227	248	250	----	192	180	----
Hy-tuf laminate Grade		25	ϵ'/ϵ_0	4.67	4.62	4.52	4.45	4.34	4.21	4.15	----	4.08	4.05	----
GF181 ^b (field I laminate)			tan δ	92	99	125	145	212	239	242	----	177	180	----
(field II laminate)		25	ϵ'/ϵ_0	----	----	----	----	----	----	----	4.14*	4.08	4.05	----
			tan δ	----	----	----	----	----	----	----	171*	177	180	----
Epon Resin RN-48 ^c		25	ϵ'/ϵ_0	3.64	3.63	3.61	3.57	3.52	3.44	3.32	3.13*	3.04	2.91	----
			tan δ	31	38	68	111	142	191	264	220*	210	184	----
o. Miscellaneous Plastics														
E Resin ^d		23	ϵ'/ϵ_0	2.49	2.49	2.48	2.48	2.47	2.45	2.45	----	2.43	2.42	----
			tan δ	7	4	< 3	< 5	5	8	8	----	6	5	----
		80	ϵ'/ϵ_0	2.5	2.5	2.5	2.5	2.5	2.45	2.45	----	2.4	2.4	----
			tan δ	25	14	8	5	4	6	7	----	15	17	----
Same material after		25	ϵ'/ϵ_0	2.56	2.56	2.55	2.54	2.54	2.54	2.53	2.5	----	2.44	2.43
3 1/2 yrs. at room temp.			tan δ	8	11	16	19	21	22	19	16	----	7	11
and humidity														
Permalin 3256 ^e		24	ϵ'/ϵ_0	4.27	4.22	4.12	4.01	3.86	3.70	3.5	----	----	3.1	3.0
			tan δ	98	120	170	230	300	330	340	----	----	276	290
		99	ϵ'/ϵ_0	4.95	4.85	4.75	4.61	4.48	4.28	4.05	----	----	3.34	----
			tan δ	200	155	160	200	300	440	570	----	----	580	----
		125	ϵ'/ϵ_0	5.12	5.04	4.92	4.77	4.62	4.4	4.1	----	----	3.38	----
			tan δ	280	180	170	185	260	410	550	----	----	560	----
Piccopale Resin ^f		25	ϵ'/ϵ_0	2.33	2.33	2.33	----	2.33	2.33	2.33	----	2.30	----	----
			tan δ	< 3	< 3	< 3	----	< 5	2	8	----	3.5	----	----

a. Ciba. b. Houghton Labs. c. Shell Chem. d. Cross-linked addition hydrocarbon polymer (Esso Lab.). e. Cross-linked addition polymer (Gen. Elec.). f. Linear addition hydrocarbon copolymer made with aliphatic dienes and olefins (Penn. Industrial Chem.).
^gfreq. = 1×10^9 .

I. Solids, B. Organic 4. Elastomers

Values for tan δ are multiplied by 10^4 ; frequency given in c/s.

a. Natural Rubber		T°C												
Hevea rubber ^a			ϵ'/ϵ_0	$\tan \delta$	1×10^2	1×10^3	1×10^4	1×10^5	1×10^6	1×10^7	1×10^8	3×10^8	3×10^9	1×10^{10}
	-12			2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4			
	25			10	14	24	44	55	38	33				
		ϵ'/ϵ_0		2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	----	2.15	
	80			28	18	14	14	18	32	50	----	30		
		ϵ'/ϵ_0		2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4			
		$\tan \delta$		132	79	48	27	21	21	30				
	27			2.94	2.94	2.93	2.88	2.74	2.52	2.42	----	2.36		
		ϵ'/ϵ_0		48	24	62	220	446	410	180	----	47		
		$\tan \delta$		4.09	4.01	3.92	3.80	3.64	3.44	3.3	----	3.25		
	27			130	155	182	230	308	405	265	----	148		
		ϵ'/ϵ_0		----	36	27	14	9.0	7.0	6.8	----	6.3		
		$\tan \delta$		----	25000	12000	4000	2500	1600	850	----	234		
	25			----	----	----	----	----	----	----	----	1.31	1.31	
		ϵ'/ϵ_0		----	----	----	----	----	----	----	----	75	94	
		$\tan \delta$		3.46	3.39	3.28	3.18	2.96	2.80	2.72	2.63*	2.60		
	25			169	230	274	320	370	550	215	170*	180		
		ϵ'/ϵ_0		2.61	2.60	2.58	2.55	2.53	2.50	2.47	2.45	2.40	2.38	
		$\tan \delta$		5	4	9	21	42	80	120	110	60	50	
	25			2.50	2.50	2.50	2.50	2.50	2.47	2.42	2.41	2.40	2.39	
		ϵ'/ϵ_0		9	5	4	5	15	33	62	63	37	30	
		$\tan \delta$												
	27			2.5	2.5	2.5	2.5	2.5	2.5	2.45	----	2.4		
		ϵ'/ϵ_0		52	35	31	31	37	46	46	----	31		
		$\tan \delta$		2.6	2.6	2.6	2.55	2.55	2.55	----	----	----	2.5	
	25			92	98	78	60	44	33	----	----	----	33	
		ϵ'/ϵ_0												
		$\tan \delta$												

b. Gutta-percha		T°C												
Gutta-percha ^b			ϵ'/ϵ_0	$\tan \delta$	1×10^2	1×10^3	1×10^4	1×10^5	1×10^6	1×10^7	1×10^8	3×10^8	3×10^9	1×10^{10}
	25			2.61	2.60	2.58	2.55	2.53	2.50	2.47	2.45	2.40	2.38	
		ϵ'/ϵ_0		5	4	9	21	42	80	120	110	60	50	
		$\tan \delta$												

c. Balata		T°C												
Balata, precipitated ^c			ϵ'/ϵ_0	$\tan \delta$	1×10^2	1×10^3	1×10^4	1×10^5	1×10^6	1×10^7	1×10^8	3×10^8	3×10^9	1×10^{10}
	25			2.50	2.50	2.50	2.50	2.50	2.47	2.42	2.41	2.40	2.39	
		ϵ'/ϵ_0		9	5	4	5	15	33	62	63	37	30	
		$\tan \delta$												

d. Cyclized Rubbers		T°C												
Pliolite ^d			ϵ'/ϵ_0	$\tan \delta$	1×10^2	1×10^3	1×10^4	1×10^5	1×10^6	1×10^7	1×10^8	3×10^8	3×10^9	1×10^{10}
	27			2.5	2.5	2.5	2.5	2.5	2.5	2.45	----	2.4		
		ϵ'/ϵ_0		52	35	31	31	37	46	46	----	31		
		$\tan \delta$		2.6	2.6	2.6	2.55	2.55	2.55	----	----	----	2.5	
	25			92	98	78	60	44	33	----	----	----	33	
		ϵ'/ϵ_0												
		$\tan \delta$												

Pliolite GR ⁱ		T°C												
			ϵ'/ϵ_0	$\tan \delta$	1×10^2	1×10^3	1×10^4	1×10^5	1×10^6	1×10^7	1×10^8	3×10^8	3×10^9	1×10^{10}

a. Pale crepe (Rubber Res. Corp.). b. 100 pts. pale crepe, 6 pts. sulfur (Rubber Res. Corp.). c. 100 pts. pale crepe, 1 pt. stearic acid, 10 pts. United Black, 5 pts. Kadox, 0.5 pts. Captax, 3 pts. sulfur (Rubber Res. Corp.). d. 100 pts. pale crepe, 1 pt. stearic acid, 40 pts. United Black, 5 pts. Kadox, 1 pt. Captax, 3 pts. sulfur (Rubber Res. Corp.). e. Cellular Rubber Prod. f. Depolymerized rubber (Hardman). g. Palaquium Oblongifolium (Hermann Weber). h. Minusops Globosa (Hermann Weber). i. Goodyear.

*Freq. = 1×10^9 .

I. Solids B. Organic 4. Elastomers (cont.) Values for $\tan \delta$ are multiplied by 10^4 ; frequency given in c/s.

d. Cyclized Rubbers (cont.)											
T ^o C	ϵ'/ϵ_0	1×10^2	1×10^3	1×10^4	1×10^5	1×10^6	1×10^7	1×10^8	3×10^8	3×10^9	1×10^{10}
24	$\tan \delta$	14	12	9.5	7.9	6.3	4.8	4.0	----	3.76	----
	$\tan \delta$	7800	1900	850	900	2000	1900	1000	----	740	----
e. Buna Rubbers											
Air seal ^b											
24	ϵ'/ϵ_0	15.3	8.9	6.2	4.4	3.6	3.3	3.1	3.0	2.8	2.8
	$\tan \delta$	5200	3100	2300	1700	990	740	580	410	180	120
GR-S (Buna S) uncured ^c											
-12	ϵ'/ϵ_0	----	2.5	2.5	2.5	2.5	2.45	2.45	----	2.45	----
	$\tan \delta$	----	13	24	62	80	50	71	----	44	----
26	ϵ'/ϵ_0	2.5	2.5	2.5	2.5	2.50	2.45	2.45	----	2.45	----
	$\tan \delta$	6	9	10	18	38	69	71	----	44	----
80	ϵ'/ϵ_0	----	2.5	2.5	2.5	2.50	2.45	2.45	----	2.45	----
	$\tan \delta$	----	4	4	4	6	22	60	----	2.49	2.44
GR-S (Buna S) compound ^d											
26	ϵ'/ϵ_0	2.66	2.66	2.66	2.65	2.56	2.52	2.52	----	56	50
	$\tan \delta$	7	9	25	60	120	160	95	----	2.78	2.77
GR-S (Buna S) compound HXG-117-G ^e											
25	ϵ'/ϵ_0	2.98	2.97	2.95	2.93	2.91	2.88	2.82	----	57	48
	$\tan \delta$	10	24	54	100	120	128	80	----	2.69	----
80	ϵ'/ϵ_0	2.84	2.83	2.82	2.81	2.78	2.76	2.72	2.70	83	1.37
	$\tan \delta$	86	31	26	33	65	110	120	114	1.38	1.37
Hycar OR Cell-tite ^f											
25	ϵ'/ϵ_0	1.41	1.40	1.39	1.38	1.38	1.38	1.38	----	39	38
	$\tan \delta$	115	58	50	51	56	54	47	----	1.28	1.27
Marbon S, Buna S Hardboard ^g											
25	ϵ'/ϵ_0	1.31	1.31	1.31	1.30	1.30	1.30	1.29	----	17	16
	$\tan \delta$	14	12	22	36	37	28	19	----	2.35	2.35
f. Butyl Rubbers											
GR-I (butyl rubber) ^h											
25	ϵ'/ϵ_0	2.39	2.38	2.37	2.36	2.35	2.35	2.35	----	9	8
	$\tan \delta$	34	35	27	13	10	10	10	----	2.38	2.38
GR-I compound ⁱ											
25	ϵ'/ϵ_0	2.43	2.42	2.41	2.40	2.40	2.40	2.39	----	9.3	9.9
	$\tan \delta$	50	60	58	38	22	15	10	----	2.35	2.35

a. Solution and suspension of thermosetting resins and vulcanizable elastomers (Goodyear). b. Kearney. c. Copolymer of 75% butadiene and 25% styrene (Rubber Res. Corp.). d. 100 pts. GR-S, 1 pt. stearic acid, 5 pts. Kadox, 5 pts. Captax, 3 pts. Sulfur (Rubber Res. Corp.). e. Ifur, Solanac, Altax, Methyl Tuads, zinc oxide, Akroflex, Heliozone, Cumar ME, stearic acid, limestone, Marbon S-1, etc. (Gen. Cable). f. Based on butadiene polymer (Sponge Rubber Prod.). g. U.S. Rubber. h. Copolymer of 98-99% isobutylene, 1-2% isoprene (Rubber Res. Corp.). i. 100 pts. GR-I 44-7 M₂K, 5 pts. zinc oxide (from ZnCO₃), 1 pt. Tuads, 1.5 pts. sulfur (Rubber Res. Corp.).

I. Solids, B. Organic 4. Elastomers (ccmt.) Values for tan δ are multiplied by 10^4 ; frequency given in c/s.

c. Nitrile Rubbers	T°C										
		1×10^2	1×10^3	1×10^4	1×10^5	1×10^6	1×10^7	1×10^8	3×10^8	1×10^{10}	2.5×10^{10}
Kralastic BE Natural ^a	25	ϵ'/ϵ_0	4.80	4.75	4.70	4.40	4.00	3.00	2.85*	2.80	2.70
		tan δ	280	130	180	530	1100	560	240*	180	130
Kralastic BM Natural ^a	25	ϵ'/ϵ_0	4.48	4.45	4.35	4.20	3.78	2.91	2.83*	2.76	2.70
		tan δ	130	96	160	490	990	490	220*	160	110
Kralastic D Natural ^a	25	ϵ'/ϵ_0	3.54	3.54	3.51	3.44	3.20	2.78	2.68*	2.66	2.62
		tan δ	105	52	82	260	530	270	130*	93	65
Kralastic ERMU Natural ^a	25	ϵ'/ϵ_0	4.47	4.42	4.36	4.29	4.05	2.98	2.88*	2.80	2.72
		tan δ	102	75	102	230	720	760	300*	210	140
Kralastic F Natural ^a	25	ϵ'/ϵ_0	4.20	4.20	4.15	4.00	3.61	2.87	2.80*	2.70	2.63
		tan δ	140	65	120	440	940	460	190*	150	100
Royalite 149-11 ^b	25	ϵ'/ϵ_0	5.41	5.20	5.12	4.87	4.41	3.62	3.18*	3.13	3.03
		tan δ	320	165	250	590	1080	900	260*	200	190
Expanded Royalite M21982-1 ^b (field I plane of sample)	25	ϵ'/ϵ_0	1.28	1.26	1.25	1.20	1.15	-----	1.18*	1.15	1.11
		tan δ	175	108	150	240	184	-----	54*	56	36
(field II plane of sample)	25	ϵ'/ϵ_0	-----	-----	-----	-----	-----	-----	-----	-----	-----
		tan δ	-----	-----	-----	-----	-----	-----	-----	-----	-----
Expanded Royalite M22190 ^b (field I plane of sample)	25	ϵ'/ϵ_0	1.23	1.22	1.19	1.16	1.14	-----	-----	-----	-----
		tan δ	157	111	141	162	143	-----	-----	-----	-----
(field II plane of sample)	25	ϵ'/ϵ_0	-----	-----	-----	-----	-----	-----	1.15*	1.15	1.15
		tan δ	-----	-----	-----	-----	-----	-----	40*	32	31
h. Neoprene											
Neoprene GN ^c	26	ϵ'/ϵ_0	7.5	6.5	6.2	6.1	5.7	4.7	-----	2.84	-----
		tan δ	6000	860	330	300	950	2000	1600	-----	480
Neoprene compound ^d	24	ϵ'/ϵ_0	6.70	6.60	5.54	6.47	6.26	5.54	4.5	4.00	4.00
		tan δ	160	110	115	150	380	1190	900	636	339
80	80	ϵ'/ϵ_0	6.70	6.20	6.00	5.86	5.75	5.65	5.2	4.40	4.40
		tan δ	2700	430	140	92	93	320	900	1200	960

a. Naugatuck. b. Polystyrene-acrylonitrile and polybutadiene-acrylonitrile (U.S. Rubber). c. Poly-2-chlorobutadiene-1,3 stabilized with tetraethylthiuram disulfide (Du Pont). d. 38% GN, 28.4% Catalpo Clay, 14% blanc fixe, 0.4% Gastex (carbon black), 1.9% paraffin, 3.8% Circo (light process oil), 0.2% stearic acid, 0.8% Neozone A, 0.4% Parazone, 7.6% litharge (DuPont).
*Freq. = 1×10^9 .

I. Solids B. Organic 4. Elastomers (cont.) Values for $\tan \delta$ are multiplied by 10^4 ; frequency given in c/s.

1. Thiokol Thiokol, Type FA compound ^a	T°C	Values for $\tan \delta$ are multiplied by 10^4 ; frequency given in c/s.									
		1×10^2	1×10^3	1×10^4	1×10^5	1×10^6	1×10^7	1×10^8	3×10^8	3×10^9	1×10^{10}
23	ϵ'/ϵ_0	----	2260	515	200	110	70	30	24	16	14
	$\tan \delta$	----	12900	8000	5100	3900	3200	2800	2800	2200	1500
25	ϵ'/ϵ_0	----	17900	15200	7550	740	106	----	20.5*	17.1	8.4
	$\tan \delta$	----	36300	56400	88000	40000	27000	----	2600*	2300	2200
25	ϵ'/ϵ_0	----	17300	5100	600	215	90	----	17*	14.3	8.5
	$\tan \delta$	----	10000	17000	36000	18000	7600	----	3000*	3600	4000
J. Silicone Rubbers											
Silastic 120 ^d	25	ϵ'/ϵ_0	5.78	5.76	5.75	5.75	5.75	5.75	5.74	5.73	5.72
		$\tan \delta$	51	30	16	10	8	27	52	254	510
Silastic 125 ^d	25	ϵ'/ϵ_0	7.1	7.1	7.0	7.0	6.9	6.8	----	7	
		$\tan \delta$	40	26	18	13	12	14	30	430	
Silastic 150 ^e	25	ϵ'/ϵ_0	5.87	5.85	5.79	5.61	5.39	5.09	5.0	5.0	5.0
		$\tan \delta$	43	48	108	200	270	280	230	250	800
Silastic 152 ^f	25	ϵ'/ϵ_0	2.96	2.95	2.95	2.95	2.95	2.95	2.93*	2.90	2.85
		$\tan \delta$	5.8	5.2	4	3.5	5.4	10.4	20	59*	167
Silastic 160 ^g	25	ϵ'/ϵ_0	9.32	9.27	9.2	9.0	8.8	8.4	8.0	7.9	7.6
		$\tan \delta$	47	31	60	150	250	270	310	600	1400
Silastic 167 ^h	25	ϵ'/ϵ_0	8.6	8.6	8.6	8.5	8.5	8.5	8.5	8	
		$\tan \delta$	52	32	19	12	11	13	16	360	
Silastic 180 ⁱ	25	ϵ'/ϵ_0	4.66	4.60	4.56	4.53	4.53	4.52	4.5	4.5	4.5
		$\tan \delta$	67	63	54	40	30	27	35	56	320
Silastic 181 ^j	25	ϵ'/ϵ_0	3.36	3.30	3.26	3.23	3.20	3.19	3.18	3.16	3.09
		$\tan \delta$	62	67	65	58	37	28	29	36	174
Silastic 250 ^k	25	ϵ'/ϵ_0	3.19	3.18	3.17	3.16	3.10	3.07	3.05	3.04	3.00
		$\tan \delta$	55	30	69	106	64	29	28	44	200

a. 100 pts. Thiokol (organic polysulfide), 10 pts. zinc oxide, 60 pts. semi-reinforcing carbon black, 1 pt. stearic acid, 0.5 pt. diphenylguanidine, 0.35 pt. Altax (Thiokol). b. 100 pts. polysulfide copolymer of bis (2-chloroethyl) formal and ethylene dichloride, 60 pts. carbon blacks, compounding ingredients. (Thiokol). c. 100 pts. polysulfide polymer of bis (2-chloroethyl) formal, 60 pts. carbon blacks, compounding ingredients. (Thiokol). d. 50% siloxane elastomer, 50% TiO_2 (Dow Corning). e. 3% siloxane elastomer, 35% ZnO , 30% CaCO_3 . (Dow Corning). f. Dow Corning. g. 33% siloxane elastomer, 33% ZnO , 33% TiO_2 (Dow Corning). h. 33% siloxane elastomer, 67% TiO_2 (Dow Corning). i. 35% siloxane elastomer, 35% SiO_2 , 30% TiO_2 (Dow Corning). j. 45% siloxane elastomer, 55% SiO_2 (Dow Corning). k. 70% siloxane elastomer, 30% SiO_2 (Dow Corning).
*Freq. = 1×10^9 .

I. Solids, B. Organic 4. Elastomers (cont.) Values for $\tan \delta$ are multiplied by 10^4 ; frequency given in c/s.

J. Silicone Rubbers (cont.)		T°C	1x10 ²	1x10 ³	1x10 ⁴	1x10 ⁵	1x10 ⁶	1x10 ⁷	1x10 ⁸	3x10 ⁸	3x10 ⁹	1x10 ¹⁰
Silastic X4342 ^a	25	ε'/ε ₀	3.22	3.18	3.16	3.16	3.14	3.12	3.11	3.08	3.08	3.00
		tan δ	51	64	60	48	29	20	23	35	83	110
Silastic 6167 ^b	25	ε'/ε ₀	10.1	10.1	10.0	10	10	10	10	10	10	10
		tan δ	41	26	17	13	9.5	10	27	55	450	1000
Silastic 6181 ^c	25	ε'/ε ₀	3.66	3.53	3.42	3.35	3.31	3.30	3.27	3.25	3.23	3.20
		tan δ	200	250	190	100	57	34	32	36	88	160
Silastic X-6734 ^d	25	ε'/ε ₀	3.21	3.12	3.12	3.12	3.10	3.08	3.08	3.08	3.01	3.00
		tan δ	28	19	31	53	37	23	29	44	144	213
Silastic 7181 ^c	25	ε'/ε ₀	3.72	3.55	3.45	3.37	3.33	3.31	3.31	3.28	3.20	3.15
		tan δ	210	250	190	97	53	29	24	29	75	170
SE-450 ^e	25	ε'/ε ₀	3.09	3.08	3.08	3.08	3.07	3.06	3.05	3.03*	2.97	2.88
		tan δ	16	7.2	5.3	7	11	17	30	74*	158	183
SE-460 ^e	25	ε'/ε ₀	3.14	3.12	3.11	3.10	3.10	3.09	3.07	3.05*	3.02	2.94
		tan δ	56	54	44	25	12	15	23	57*	98	180
SE-550 ^e	25	ε'/ε ₀	3.14	3.12	3.10	3.10	3.10	3.08	3.06	3.02*	3.00	2.94
		tan δ	13	7.8	6.5	7	9.5	16	31	84*	143	195
SE-972 ^e	25	ε'/ε ₀	3.40	3.35	3.25	3.22	3.20	3.18	3.16	3.15*	3.13	3.08
		tan δ	64	67	58	46	30	27	32	65*	97	146
Natural Resins												
Amber ^f	25	ε'/ε ₀	2.7	2.7	2.7	2.7	2.65	2.65	-----	2.6	2.6	
		tan δ	12.5	18	31	43	56	68	-----	82	90	
	80	ε'/ε ₀	2.85	2.85	2.85	2.8	2.8	2.75	-----	2.65	2.60	
		tan δ	24	19	22	40	70	93	-----	110	115	
Stellac, natural XL ^g	28	ε'/ε ₀	3.86	3.81	3.75	3.66	3.47	3.26	3.10	-----	2.86	
		tan δ	65	74	128	225	310	350	300	-----	254	
	70	ε'/ε ₀	6.50	5.65	5.10	4.60	4.33	4.00	3.80	-----	3.45	
		tan δ	1050	860	650	460	400	540	700	-----	732	

a. 50% siloxane elastomer, 50% SiO₂ (Dow Corning). b. 33% siloxane elastomer, 67% TiO₂ (Dow Corning). c. 45% siloxane elastomer, 55% SiO₂ (Dow Corning). d. 70% siloxane elastomer, 30% SiO₂ (Dow Corning). e. General Electric. f. Fossil resin (Amber Mines). g. Contains ca. 3.5% wax (Zinsser).
*Freq. = 1×10^9 .

I. Solids B. Organic (Cont.) Values for $\tan \delta$ are multiplied by 10^4 ; frequency given in c/s.

5. Natural Resins (cont.)		T°C	ϵ'/ϵ_0	$\tan \delta$	1×10^2	1×10^3	1×10^4	1×10^5	1×10^6	1×10^7	1×10^8	3×10^9	1×10^{10}	2.5×10^{10}
Shellac, natural Zinfo ^a		27	ϵ'/ϵ_0	3.84	3.82	3.75	3.66	3.50	3.30	3.1	----	2.86		
			$\tan \delta$	58	64	132	250	313	341	345	----	290		
Shellac, pure C garnet ^b		28	ϵ'/ϵ_0	3.99	3.92	3.84	3.69	3.50	3.32	3.2	----	2.94		
			$\tan \delta$	137	102	131	205	304	347	340	----	270		
Shellac, garnet dewaxed ^c		26	ϵ'/ϵ_0	3.60	3.56	3.48	3.40	3.30	3.20	3.05	----	2.75		
			$\tan \delta$	58	64	118	205	285	317	310	----	267		
Chemlac B-3 ^d		23	ϵ'/ϵ_0	3.19	3.12	3.09	3.04	3.00	2.98	2.98	2.91	2.90	2.87	
			$\tan \delta$	105	85	86	91	100	110	118	125	135	120	
6. Asphalts and Cements														
Gilsonite ^e		26	ϵ'/ϵ_0	2.68	2.66	2.63	2.61	2.58	2.57	2.56	----	----	2.55	
			$\tan \delta$	58	35	25	19	16	13	11	----	----	2.5	9.3
Millimar ^f		22	ϵ'/ϵ_0	2.65	2.65	2.65	2.64	2.64	2.64	2.64	----	----	2.5	2.5
			$\tan \delta$	39	35	26	14	11	10	11	----	11	12	
Cenco Sealstix ^g		23	ϵ'/ϵ_0	3.90	3.75	3.55	3.37	3.23	3.13	----	----	2.96		
			$\tan \delta$	452	335	275	240	240	272	----	----	210		
Plicene Cement ^h		25	ϵ'/ϵ_0	2.48	2.48	2.48	2.48	2.48	2.48	2.47	----	2.40	2.35	
			$\tan \delta$	43.9	35.5	28.9	25.9	25.5	22.2	15	----	7.8	6.8	
7. Waxes														
Acravax C ⁱ		24	ϵ'/ϵ_0	2.60	2.58	2.57	2.55	2.54	2.53	2.52	----	2.48	2.45	2.44
			$\tan \delta$	157	68	45	30	20	15	12	----	15	19	21
85			ϵ'/ϵ_0	----	5.0	3.2	2.63	2.50	2.46	----	----	2.45		
			$\tan \delta$	----	7000	3500	560	180	130	----	----	228		
22			ϵ'/ϵ_0	2.75	2.69	2.66	2.64	2.63	2.63	----	----	2.62		
			$\tan \delta$	186	120	70	39	25	19	----	----	16		
70			ϵ'/ϵ_0	3.29	3.14	2.97	2.88	2.82	2.79	----	----	----		
			$\tan \delta$	450	420	340	210	110	61	----	----			

e. Contains ca. 3.5% wax (Zinsser). b. Natural, ca. 2% wax (Zinsser). c. Natural, wax-free (Zinsser). d. From zein and rosin (Filtered Rosin Products). e. 99.9% natural bitumen (U.S. Rubber). f. Asphaltic product (U.S. Rubber). g. De Khotinsky Cement (Central Scientific). h. Central Scientific. i. Cetylacetamide (Clyco). j. Shell Oil.

I. Solids B. Organic		(cont.) Values for $\tan \delta$ are multiplied by 10^4 ; frequency given in c/s.												
7. Waxes (cont.)	T°C	ϵ'/ϵ_0	$\frac{1 \times 10^2}{\tan \delta}$	$\frac{1 \times 10^3}{\epsilon'/\epsilon_0}$	$\frac{1 \times 10^4}{\tan \delta}$	$\frac{1 \times 10^5}{\epsilon'/\epsilon_0}$	$\frac{1 \times 10^6}{\tan \delta}$	$\frac{1 \times 10^7}{\epsilon'/\epsilon_0}$	$\frac{1 \times 10^8}{\tan \delta}$	$\frac{3 \times 10^8}{\epsilon'/\epsilon_0}$	$\frac{3 \times 10^9}{\epsilon'/\epsilon_0}$	$\frac{1 \times 10^{10}}{\tan \delta}$	$\frac{2.5 \times 10^{10}}{\epsilon'/\epsilon_0}$	
Beeswax, white ^a	23	ϵ'/ϵ_0	2.65	2.63	2.56	2.48	2.43	2.41	2.39	----	2.35	2.35	----	
		$\tan \delta$	140	118	266	190	84	68	60	----	50	48	----	
	55	ϵ'/ϵ_0	2.52	2.50	2.46	2.43	2.39	2.36	2.34	----	2.31	----	----	
		$\tan \delta$	82	44	25	25	35	58	125	----	216	----	----	
Beeswax, yellow ^b	23	ϵ'/ϵ_0	2.73	2.66	2.59	2.53	2.49	2.45	2.42	----	2.39	2.36	----	
		$\tan \delta$	240	140	240	150	92	84	90	----	75	62	----	
Cereso Wax AA ^c	24*	ϵ'/ϵ_0	2.35	2.35	2.35	2.34	2.33	2.32	----	----	2.29	2.27	----	
		$\tan \delta$	5	6	7	8	8	7	----	----	4.6	5.0	----	
	46*	ϵ'/ϵ_0	2.35	2.35	2.35	2.34	2.33	2.32	----	----	2.28	2.27	----	
		$\tan \delta$	< 5	< 3	3	5	8	10	----	----	6.2	6	----	
Cereso Wax, brown ^c	22	ϵ'/ϵ_0	----	2.28	2.28	2.28	2.28	2.28	2.27	----	2.25	----	----	
		$\tan \delta$	----	5	10	13	11	7	2	----	2.8	----	----	
Ceresin, white ^d	25	ϵ'/ϵ_0	2.3	2.3	2.3	2.3	2.3	2.3	2.3	----	2.25	2.24	----	
		$\tan \delta$	8	6	5	5	4	4	4	----	4.6	6.5	----	
Ceresin, yellow ^e	20	ϵ'/ϵ_0	----	2.25	2.25	2.25	2.25	2.25	2.25	----	2.25	2.25	----	
		$\tan \delta$	----	4	5	7	7	5	4	----	4.2	4	----	
Estavax ^f	25	ϵ'/ϵ_0	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.29	2.28	2.28	
		$\tan \delta$	7	< 2	2	4	5	4	2.5	2.3	2.9	3.7	4.6	
	80	ϵ'/ϵ_0	2.18	2.18	2.18	2.18	2.18	2.18	2.18	2.18	2.17	2.16	----	
		$\tan \delta$	11	7	3	< 2	< 2	< 4	5	6.4	7.9	8.5	----	
Halowax #1001 ^g cold-molded	26	ϵ'/ϵ_0	5.45	5.45	5.45	5.40	5.40	5.30	4.2	3.46	2.92	2.86	2.84	
		$\tan \delta$	18	17	7	8	45	450	2700	1620	583	296	200	
hot-molded	25	ϵ'/ϵ_0	3.78	3.78	3.76	3.74	3.70	3.62	3.37	3.17	2.57	----	----	
		$\tan \delta$	16	8	6	8.6	32	400	1200	1210	496	----	----	

a. Bromund. b. Candy. c. Mainly petroleum aliphatic hydrocarbons (Socony-Vacuum). d. Vegetable and mineral waxes (Kuhne-Libby).
e. Vegetable and mineral waxes (Mitchell-Rand). f. Long-chain, singly unsaturated (Lovell). g. Tri- and tetrachloronaphthalenes (Bakelite).

*Similar data were obtained after incorporation of 0.5% phenyl mercuric stearate.

I. Solids B. Organic (Cont.) Values for $\tan \delta$ are multiplied by 10^4 ; frequency given in c/s.

7. Waxes (cont.)	T ^o C	ϵ'/ϵ_0	$\tan \delta$	1×10^2	1×10^3	1×10^4	1×10^5	1×10^6	1×10^7	1×10^8	3×10^8	3×10^9	1×10^{10}	2.5×10^{10}
Halowax #11-314 ^a	23	ϵ'/ϵ_0	$\tan \delta$	3.11	3.04	3.01	2.99	2.98	2.96	2.93	2.92	2.89	2.87	
				700	110	17	5	3	7	17	38	37	9.5	
	45	ϵ'/ϵ_0	$\tan \delta$	3.11	3.04	3.01	2.99	2.98	2.96	2.93	---	---	2.87	
				700	110	17	5	3	3	5	---	---	31	
Kel-F Wax #150 ^b	25	ϵ'/ϵ_0	$\tan \delta$	3.01	2.97	2.91	2.75	2.52	2.35	2.25	2.24	2.23	2.22	
				83	93	252	510	540	425	270	218	113	90	
Opalwax ^c	24	ϵ'/ϵ_0	$\tan \delta$	13.2	10.3	7.0	4.3	3.2	2.9	2.7	---	2.55	2.52	2.5
				1250	2100	2900	2700	1450	580	270	---	167	160	160
	47	ϵ'/ϵ_0	$\tan \delta$	14.2	11.4	8.2	5.4	3.7	3.0	2.7	---	---	2.47	
				450	1300	2600	3000	2100	860	430	---	---	236	
Ozokerite ^d	20	ϵ'/ϵ_0	$\tan \delta$	2.26	2.26	2.26	2.26	2.26	2.26	2.26	---	2.26	---	
				6	6	8	10	9	7	6	---	6	---	
Paraffin Wax 132 ^o ASTM ^e	25	ϵ'/ϵ_0	$\tan \delta$	2.25	2.25	2.25	2.25	2.25	2.25	2.25	---	2.25	2.24	2.2
				< 2	< 2	< 2	< 2	< 2	< 2	< 2	---	2.0	2.1	< 3
	81	ϵ'/ϵ_0	$\tan \delta$	2.02	2.02	2.02	2.02	2.02	2.02	---	---	2.00	---	
				5	1.2	.5	< 2	< 2	< 3	---	---	5.2	---	
Paraffin Wax 135 ^o AMP ^f	24	ϵ'/ϵ_0	$\tan \delta$	2.25	2.25	2.25	2.25	2.25	2.25	2.25	---	2.25	2.22	
				12.5	5.5	< 3	< 2	< 2	< 4	---	---	1	2	
	20	ϵ'/ϵ_0	$\tan \delta$	---	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	
				---	2	2	2	3	2	1.4	1	2	2.5	
Polinel ^h	25	ϵ'/ϵ_0	$\tan \delta$	2.89	2.87	2.87	2.85	2.84	2.80	2.72	2.62*	2.59	2.58	
				67	44	36	43	82	166	240	180*	195	199	
Sealing wax, Red Express ⁱ	25	ϵ'/ϵ_0	$\tan \delta$	3.68	3.32	3.40	3.32	3.29	3.27	3.2	---	3.09	---	
				249	150	99	79	80	100	120	---	122	---	
Thermoplastic Composition 1766EX ^j	25	ϵ'/ϵ_0	$\tan \delta$	3.77	3.72	3.68	3.63	3.60	3.58	3.56	---	---	3.58	
				122	106	87	60	44	32	28	---	---	20	
Thermoplastic Composition 3738 ^j	25	ϵ'/ϵ_0	$\tan \delta$	2.65	2.60	2.57	2.56	2.55	2.54	2.54	2.52*	2.52	2.49	
				112	91	67	41	25	16	15	13*	13	13	

a. 80% 1,4-, 10% 1,5-, 10% 1,2-dichloronaphthalenes (Bakelite). b. Polychlorotrifluoroethylene (Kellogg). c. Mainly 12-hydroxystearin (DuPont). d. Natural paraffin (Allison). e. Mainly C₂₂ to C₂₉ aliphatic, saturated hydrocarbons (Stand. Oil N.J.). f. Gulf. g. Paraffin wax (Socony Vacuum). h. Lovell. i. Dennison. j. Mitchell-Rand.

*Freq. = 1×10^9 .

I. Solids		B. Organic (cont.)		Values for tan δ are multiplied by 10^4 ; frequency given in c/s.													
7. Waxes (cont.)		T ^o C		ϵ'/ϵ_0	$\tan \delta$	1×10^2	1×10^3	1×10^4	1×10^5	1×10^6	1×10^7	1×10^8	3×10^8	3×10^9	1×10^{10}	2.5×10^{10}	
Thermoplastic composition 25			25	ϵ'/ϵ_0	$\tan \delta$	2.84	2.79	2.76	2.64	2.59	2.54	2.51	2.48	2.45	2.45		
3767A ^a					140	160	170	120	98	78	69	59	32	27			
Vistavar ^b			25	ϵ'/ϵ_0	$\tan \delta$	2.34	2.34	2.34	2.34	2.34	2.32	2.30	2.27	2.26			
					2	3	9.2	12.1	13.3	13.6	13.3	9.0	5				
Wax 3760 ^c			25	ϵ'/ϵ_0	$\tan \delta$	2.36	2.36	2.36	2.36	2.36	2.36	2.36	2.31*	2.31	2.31	2.31	
					21.7	8.8	7.1	5.6	4.3	2.7	2.6	3.6*	4.9	14.2			
Wax S-1167 ^d			25	ϵ'/ϵ_0	$\tan \delta$	19.9	10.2	5.9	4.1	3.3	3.1	2.9	2.6	2.6	2.6	2.6	
					7200	3900	2300	1700	1000	600	470	300	190	92			
Wax S-1184 ^d			25	ϵ'/ϵ_0	$\tan \delta$	2.43	2.43	2.43	2.40	2.40	2.40	2.37	2.34*	2.30	2.21	2.21	
					29.4	21.5	21.5	16.4	11.3	9.3	13.8	20*	24	54			
Wax Compound F-590 ^e			26	ϵ'/ϵ_0	$\tan \delta$	2.37	2.34	2.32	2.32	2.32	2.32	2.32	2.32	2.32	2.32	2.32	2.32
					80	99	78	44	20	8	5	6.2	6.2	6.2	6.2	6.2	
Wax Compound #1340 ^e			26	ϵ'/ϵ_0	$\tan \delta$	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.25	2.25	2.25	2.25
					1	2	2	< 5	4	4	4	4	4.2	4.2	4.2	4.2	
8. Woods																	
Balsa			26	ϵ'/ϵ_0	$\tan \delta$	1.4	1.4	1.4	1.4	1.37	1.35	1.30	1.22	1.22	1.20	1.20	
					50	40	43	77	120	135	135	135	100	83	83	83	
Yellow Birch			25	ϵ'/ϵ_0	$\tan \delta$	2.91	2.88	2.82	2.78	2.70	2.60	2.47	2.40	2.13	1.95	1.95	1.87
(field 1 to grain)					72	90	140	220	290	360	400	390	330	280	260	260	
Fir, Douglas			25	ϵ'/ϵ_0	$\tan \delta$	2.04	2.00	1.97	1.95	1.93	1.90	1.88	1.86	1.82	1.80	1.80	1.78
(field 1 to grain)					48	80	130	190	260	310	330	320	270	290	320	320	
Fir, Douglas, plywood			25	ϵ'/ϵ_0	$\tan \delta$	2.1	2.1	2.05	1.95	1.90	1.80	1.78	1.7	1.7	1.7	1.5	1.5
(field 1 to grain)					115	105	130	170	230	320	320	360	700	550	220	220	
Fir, Douglas, staypak			25	ϵ'/ϵ_0	$\tan \delta$	7.3	7.05	6.9	6.65	6.3	5.6	4.6	4.0	3.5	3.3	3.2	3.2
(field 1 to grain)					82	130	200	320	500	750	800	850	700	550	460	460	
Mahogany			25	ϵ'/ϵ_0	$\tan \delta$	2.42	2.40	2.36	2.30	2.25	2.17	2.07	2.01	1.88	1.7	1.6	1.6
(field 1 to grain)					86	120	150	195	250	310	320	300	250	210	200	200	
Poplar, yellow			25	ϵ'/ϵ_0	$\tan \delta$	1.84	1.79	1.78	1.76	1.75	1.70	1.60	1.50	1.42	1.4	1.4	1.4
(field 1 to grain)					42	54	83	133	190	220	200	150	200	170	170	170	

a. Mitchell-Rand. b. Polybutene (Cantol Wax). c. Mitchell-Rand. d. Glyco. e. Zophar Mills.
*Freq. = 1×10^9 .

I. Solids B. Organic (cont.) Values for $\tan \delta$ are multiplied by 10^4 ; frequency given in c/s.

		T°C	$\frac{1 \times 10^2}{\epsilon'/\epsilon_0}$	$\frac{1 \times 10^3}{\tan \delta}$	$\frac{1 \times 10^4}{\epsilon'/\epsilon_0}$	$\frac{1 \times 10^5}{\tan \delta}$	$\frac{1 \times 10^6}{\epsilon'/\epsilon_0}$	$\frac{1 \times 10^7}{\tan \delta}$	$\frac{1 \times 10^8}{\epsilon'/\epsilon_0}$	$\frac{3 \times 10^8}{\tan \delta}$	$\frac{3 \times 10^9}{\epsilon'/\epsilon_0}$	$\frac{1 \times 10^{10}}{\tan \delta}$	$\frac{2.5 \times 10^{10}}{\epsilon'/\epsilon_0}$
9. Miscellaneous													
Paper, Royalgrey ^a		25	ϵ'/ϵ_0	3.30	3.22	3.10	2.99	2.86	2.77	2.75	2.70	2.62	
			$\tan \delta$	58	117	200	380	570	660	660	560	403	
		82	ϵ'/ϵ_0	3.57	3.49	3.40	3.31	3.14	3.08	3.00	2.94	2.84	
			$\tan \delta$	170	61	85	230	440	630	720	800	827	
Leather, sole, dried		25	ϵ'/ϵ_0	4.1	3.6	3.4	3.2	3.1	3.1				
			$\tan \delta$	450	300	280	280	300	380				
Leather, sole, ca. 1 3/4 moisture		25	ϵ'/ϵ_0	38	9.3	6.9	5.6	4.9	4.5				
			$\tan \delta$	14000	3700	2200	1400	1000	1000				
Soap, Ivory ^b		25	ϵ'/ϵ_0	----	----	----	----	----	----	----	2.96		
			$\tan \delta$	----	----	----	----	----	----	----	1765		
Steak (bottom round)		25	ϵ'/ϵ_0	----	24400	----	197	50	----	50	40	30	15
			$\tan \delta$	----	405000	----	610000	260000	----	7800	3000	3700	4000
Suet		25	ϵ'/ϵ_0	----	210	----	14	4.5	2.6	2.5	2.5	2.5	2.4
			$\tan \delta$	----	25000	----	17000	9300	1500	1200	700	500	500

a. Rogers. b. Procter and Gamble.

II. LIQUIDS

Values for $\tan \delta$ are multiplied by 10^4 ; frequency given in c/s.

A. Inorganic		T°C	Water, conductivity ^a																														
			1.5	5		15		25		35		45		55		65		75		85		95											
		ε'/ε ₀	tan δ	ε'/ε ₀	tan δ	ε'/ε ₀	tan δ	ε'/ε ₀	tan δ	ε'/ε ₀	tan δ	ε'/ε ₀	tan δ	ε'/ε ₀	tan δ	ε'/ε ₀	tan δ	ε'/ε ₀	tan δ	ε'/ε ₀	tan δ	ε'/ε ₀	tan δ										
		1.5	87.0	1900	87.0	87	87	86.5	80.5	38	15	87.0	190	85.5	220	81.7	310	78.2	400	74.8	485	71.5	590	68.2	720	64.8	865	61.5	1030	58	12400	55	1430
		5	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
		15	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
		25	78.2	4000	78.2	78.2	78	77.5	76.7	55	34	78.2	400	74.0	160	1570	5400	2650	41	2150	46	2750	60	3600	59	3200	57	2800	54	2600	52	470	
		35	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
		45	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
		55	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
		65	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
		75	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
		85	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
		95	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---

a. Research Laboratory of Physical Chemistry, M.I.T. b. NaCl, Mallinckrodt's Analytical Reagent.

*. ϵ'/ϵ_0 of conductivity water assumed for purpose of calculating $\tan \delta$ from conductivity measurements.

** Data of Collie, Hasted and Ritson, Proc. Phys. Soc. 60, 145 (1948).

II. Liquids B. Organic

Values for $\tan \delta$ are multiplied by 10^4 ; frequency given in c/s.

1. Aliphatic	T°C	ϵ'/ϵ_0	$\tan \delta$	1×10^2	1×10^3	1×10^4	1×10^5	1×10^6	1×10^7	1×10^8	3×10^8	3×10^9	1×10^{10}
Heptane ^a	25	ϵ'/ϵ_0	$\tan \delta$	1.971	1.971	1.971	---	---	---	---	1.97	1.97	1.97
		$\tan \delta$	$\tan \delta$	< 3	< 0.4	< 0.4	---	---	---	---	< 2.5	1	16
Methyl alcohol ^b	25	ϵ'/ϵ_0	$\tan \delta$	---	---	---	---	31	31.0	31.0	30.9	23.9	8.9
		$\tan \delta$	$\tan \delta$	---	---	---	---	2000	260	380	800	6400	8100
Ethyl alcohol ^c	25	ϵ'/ϵ_0	$\tan \delta$	---	---	---	---	24.5	24.1	23.7	22.3	6.5	1.7
		$\tan \delta$	$\tan \delta$	---	---	---	---	900	330	620	2700	2500	680
n-Propyl alcohol ^d	25	ϵ'/ϵ_0	$\tan \delta$	---	---	---	---	20.1	20.1	19.0	16.0	3.7	2.3
		$\tan \delta$	$\tan \delta$	---	---	---	---	180	170	2000	4200	6700	900
n-Butyl alcohol ^d	25	ϵ'/ϵ_0	$\tan \delta$	---	---	---	17.4	17.4	17.4	14.8	11.5	3.5	
		$\tan \delta$	$\tan \delta$	---	---	---	1000	95	240	2700	5500	4700	
Ethylene Glycol ^e	25	ϵ'/ϵ_0	$\tan \delta$	---	---	42	41	41	41	41	39	12	7
		$\tan \delta$	$\tan \delta$	---	---	30000	3000	300	80	450	1600	10000	7800
Butyraldehyde ^e	25	ϵ'/ϵ_0	$\tan \delta$	---	6.7	6.7	---	6.7	---	---	---	---	---
		$\tan \delta$	$\tan \delta$	---	51000	5200	---	50	---	---	---	---	---
Dibutyl sebacate ^f	26	ϵ'/ϵ_0	$\tan \delta$	4.92	4.73	4.63	4.60	4.58	4.56	---	4.55	3.80	---
		$\tan \delta$	$\tan \delta$	790	110	14	3	3	16	---	383	2120	---
Diethyl sebacate ^f	26	ϵ'/ϵ_0	$\tan \delta$	4.05	4.05	4.03	4.02	4.01	4.00	---	3.77	2.15	---
		$\tan \delta$	$\tan \delta$	85	12	5	4	7	55	---	1040	1290	---
Carbon tetrachloride ^g	25	ϵ'/ϵ_0	$\tan \delta$	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17
		$\tan \delta$	$\tan \delta$	60	8	0.4	< 0.4	< 0.4	< 2	< 2	< 1	4	16
Tetrachloroethylene ^h	25	ϵ'/ϵ_0	$\tan \delta$	2.28	2.28	2.28	2.28	2.28	2.28	---	---	2.28	---
		$\tan \delta$	$\tan \delta$	15	2	0.7	1	2	2	---	---	10	---
Hexachlorobutadiene ⁱ	25	ϵ'/ϵ_0	$\tan \delta$	2.55	2.55	2.55	2.55	2.55	2.55	2.55	2.55	2.51	2.47
		$\tan \delta$	$\tan \delta$	3	1.5	1	< 1	< 1	2	16	55	240	130

a. Practical (Solvents Supply Laboratory, M.I.T.). b. Absolute, analytical grade (Mallinckrodt). c. Absolute (U.S. Industrial Chemicals). d. Eastman Kodak. Dried and refractionated, Lab. Ins. Res. e. Eastman Kodak. f. Resinous Products. g. Purified, Lab. Ins. Res. h. Eastman Kodak, fractionated Lab. Ins. Res. i. Hooker, fractionated Lab. Ins. Res.

Values for tan δ are multiplied by 10^4 ; frequency given in c/s.

II. Liquids B. Organic (cont.)

1. Aliphatic (Cont.)	T°C	1×10^2	1×10^3	1×10^4	1×10^5	1×10^6	1×10^7	1×10^8	3×10^8	1×10^9	3×10^9	1×10^{10}
Dichloropentanes #40 ^a	25	ϵ'/ϵ_0	334	17.1	8.65	----	7.76	----	7.57	----	6.81	----
		tan δ	5200000	1060000	135000	----	2700	----	840	----	1980	----
Dichloropentanes #14 ^a	25	ϵ'/ϵ_0	----	8.24	8.06	8.05	8.05	----	----	----	----	----
		tan δ	----	7500	720	85	16	----	----	----	----	----
Kel-F Oil, Grade #1 ^b	25	ϵ'/ϵ_0	2.61	2.61	2.60	2.61	2.61	2.58	2.53	----	2.34	2.15
		tan δ	22	.3	1.3	2.0	17	140	380	----	870	860
Kel-F Oil, Grade #3 ^b	25	ϵ'/ϵ_0	2.73	2.73	2.73	2.73	2.73	----	2.48	----	2.22	2.12
		tan δ	7.9	.8	1.3	7.3	65	----	930	----	696	420
Kel-F Oil, Grade #10 ^b	25	ϵ'/ϵ_0	2.83	2.83	2.83	2.83	2.78	----	2.40	----	2.26	2.13
		tan δ	2.1	.45	1.1	6.1	393	----	820	----	300	274
Kel-F Grease #40 ^b	25	ϵ'/ϵ_0	2.88	2.88	2.86	2.78	2.57	----	2.25	----	2.20	2.19
		tan δ	5.4	3.8	18	111	570	----	350	----	140	106
Perfluorodihexyl ether (experimental) ^c	25	ϵ'/ϵ_0	1.871	1.871	----	1.87	1.87	----	1.86	----	1.86	1.85
		tan δ	0.8	0.3	< .4	.3	3.5	----	55	----	122	920
Heptacosafuorotributyl amine (exp.) ^c	25	ϵ'/ϵ_0	1.853	1.853	1.853	1.85	1.85	1.85	1.85	----	1.85	1.85
		tan δ	.15	< .1	< .1	< .1	1.2	11	25	----	28	20

2. Aromatic

HB-40 oil ^d	25	ϵ'/ϵ_0	2.59	2.59	2.59	2.59	2.57	2.54	2.48	----	2.40	2.34
		tan δ	1.3	< .4	< .3	13	76	160	93	----	30	17
Pyranol 1467 ^e	25	ϵ'/ϵ_0	4.42	4.40	4.40	4.40	4.40	4.08	3.19	----	2.84	2.62
		tan δ	36	3	3.6	25	260	1300	1500	----	1200	740
Aroclor 1221 ^f	25	ϵ'/ϵ_0	----	----	----	4.55	4.53	4.35	3.85	3.10	2.75	2.65
		tan δ	----	----	----	9	80	800	2000	1900	1030	590
Aroclor 1232 ^g	25	ϵ'/ϵ_0	----	----	----	5.88	5.85	4.60	3.65	3.00	2.82	2.75
		tan δ	----	----	----	22	220	2600	3240	2000	95	51
Aroclor 1242 ^h	25	ϵ'/ϵ_0	----	----	----	5.89	5.85	3.50	2.93	2.80	2.72	2.69
		tan δ	----	----	----	70	700	3000	1850	780	400	223
Aroclor 1248 ⁱ	25	ϵ'/ϵ_0	----	----	5.58	5.57	5.10	2.80	2.76	2.78	2.71	2.68
		tan δ	----	----	26	260	1900	1000	410	300	151	118
Aroclor 1254 ^j	25	ϵ'/ϵ_0	----	5.05	5.04	3.70	2.90	2.75	2.72	2.71	2.70	2.69
		tan δ	----	42	415	2380	1130	170	78	52	44	40

a. Sharples. b. Polychlorotrifluoroethylene (Kellogg). c. Minn. Mining. d. Monsanto. e. Chlorinated benzenes and diphenyls (Gen. Elec.). f. Monochlorobiphenyl (Monsanto). g. Dichlorobiphenyl (Monsanto). h. Trichlorobiphenyl (Monsanto). i. Tetrachlorobiphenyl (Monsanto). j. Pentachlorobiphenyl (Monsanto).

II. Liquids B. Organic (cont.)

2. Aromatic

Values for $\tan \delta$ are multiplied by 10^4 ; frequency given in c/s.

(cont.)	$T^\circ C$	ϵ'/ϵ_0	$\tan \delta$	1×10^2	1×10^3	1×10^4	1×10^5	1×10^6	1×10^7	1×10^8	3×10^8	3×10^9	1×10^{10}
Pyranol 1476 ^a	26	ϵ'/ϵ_0	$\tan \delta$	5.04	5.04	5.04	4.91	3.85	2.81	---	2.74	2.70	2.70
		$\tan \delta$		6	6	54	480	2500	1100	---	130	42	38
Aroclor 1260 ^b	25	ϵ'/ϵ_0	$\tan \delta$	4.33	4.26	3.46	2.89	2.83	2.79	---	2.73	---	2.72
		$\tan \delta$		86	593	1500	645	185	37	---	4.6	---	9.4
Aroclor 1262 ^c	25	ϵ'/ϵ_0	$\tan \delta$	4.03	3.44	2.86	2.76	2.75	2.75	---	---	2.75	2.75
		$\tan \delta$		392	1400	683	186	46	15.7	---	---	6.0	4.9
Aroclor 5442 ^d	25	ϵ'/ϵ_0	$\tan \delta$	---	---	---	---	---	---	---	---	2.78	2.78
		$\tan \delta$		---	---	---	---	---	---	---	---	7.2	7.2
Halowax oil 1000 ^e	25	ϵ'/ϵ_0	$\tan \delta$	4.77	4.76	4.76	4.75	4.74	---	---	4.67	3.52	2.99
		$\tan \delta$		490	50	5	< 1	< 2	---	---	500	2500	1900
	80	ϵ'/ϵ_0	$\tan \delta$	4.30	4.30	4.30	4.29	4.26	---	---	4.16	3.96	3.30
		$\tan \delta$		7800	930	80	15	11	---	---	170	1400	2800
Nitrobenzene ^f	25	ϵ'/ϵ_0	$\tan \delta$	---	---	36	36	35.6	34.4	---	---	31.1	---
		$\tan \delta$		---	---	3900	350	80	90	---	---	1660	---
Styrene N-100 ^g	22	ϵ'/ϵ_0	$\tan \delta$	2.40	2.40	2.40	2.40	2.40	2.40	---	---	2.40	2.36
		$\tan \delta$		38	5	< 1	< 3	< 3	< 3	---	---	20	58
Styrene N-100, purified ^h	25	ϵ'/ϵ_0	$\tan \delta$	2.40	2.40	2.40	2.40	---	---	---	---	2.38	2.38
		$\tan \delta$		15	1.8	< 0.5	< 3	---	---	---	---	13	37
Styrene N-100, ^g sat. with water	27	ϵ'/ϵ_0	$\tan \delta$	2.40	2.40	2.40	---	---	---	---	---	2.40	---
		$\tan \delta$		47	4.8	1.8	---	---	---	---	---	14	---
Styrene dimer ^g	25	ϵ'/ϵ_0	$\tan \delta$	---	---	---	2.7	2.7	2.7	2.7	---	2.5	---
		$\tan \delta$		---	---	---	9	3	2	18	---	110	---
2,5-Dichlorostyrene ⁱ	24	ϵ'/ϵ_0	$\tan \delta$	2.58	2.58	2.58	2.58	2.58	2.58	---	2.58	2.52	---
		$\tan \delta$		85	9	1	< 5	< 3	< 3	---	37	114	---
Pyranol 1478 ^j	26	ϵ'/ϵ_0	$\tan \delta$	4.55	4.53	4.53	4.53	4.53	4.53	---	4.50	3.80	---
		$\tan \delta$		150	14	2	< 5	2	12	---	381	2310	---
β -chloroethyl-2,5- dichlorobenzene ^k	24	ϵ'/ϵ_0	$\tan \delta$	---	6.05	5.45	5.22	5.20	5.20	5.20	5.18	3.31	---
		$\tan \delta$		---	---	5000	25	5	30	430	1100	3240	---
Ethylpolychlorobenzene ^m (discontinued)	25	ϵ'/ϵ_0	$\tan \delta$	4.12	4.12	4.12	4.12	4.12	4.12	4.10	3.84	2.70	2.55
		$\tan \delta$		13.6	1.3	1	< 2	6	55	550	1400	1260	660
	100	ϵ'/ϵ_0	$\tan \delta$	3.62	3.62	3.62	3.62	3.62	3.62	---	3.46	3.12	2.59
		$\tan \delta$		380	40	3.7	< 1	1	5	---	220	1720	3800

a. Isomeric pentachlorodiphenyls (Gen. Elec.). b. Hexachlorodiphenyl (Monsanto). c. Heptachlorodiphenyl (Monsanto). d. Pentachloroterphenyls (Monsanto). e. 50% mono-, 40% di- and trichloronaphthalenes (Bakelite). f. Purified Lab. Ins. Res. g. Dow Chemical Co. h. Fractionated (Lab. Ins. Res.). i. Monsanto (fractionated Lab. Ins. Res.). j. Isomeric trichlorobenzenes (Gen. Elec.). k. Monsanto. m. DuPont.

II. Liquids, B. Organic (cont.) Values for $\tan \delta$ are multiplied by 10^4 ; frequency given in c/s.

3. Petroleum Oils	T ^o C	ϵ'/ϵ_0	$\tan \delta$	$\frac{1 \times 10^2}{\epsilon'/\epsilon_0}$	$\frac{1 \times 10^3}{\tan \delta}$	$\frac{1 \times 10^4}{\epsilon'/\epsilon_0}$	$\frac{1 \times 10^5}{\tan \delta}$	$\frac{1 \times 10^6}{\epsilon'/\epsilon_0}$	$\frac{1 \times 10^7}{\tan \delta}$	$\frac{1 \times 10^8}{\epsilon'/\epsilon_0}$	$\frac{3 \times 10^8}{\tan \delta}$	$\frac{3 \times 10^9}{\epsilon'/\epsilon_0}$	$\frac{1 \times 10^{10}}{\tan \delta}$
Aviation gasoline	25	ϵ'/ϵ_0	$\tan \delta$	----	----	----	----	----	----	----	----	----	----
100 octane													
Aviation gasoline	25	ϵ'/ϵ_0	$\tan \delta$	----	----	----	----	----	----	----	----	----	----
91 octane													
Jet fuel JP-1	25	ϵ'/ϵ_0	$\tan \delta$	----	----	----	----	----	----	----	----	----	----
Jet fuel JP-3	25	ϵ'/ϵ_0	$\tan \delta$	----	----	----	----	----	----	----	----	----	----
Kerosene	25	ϵ'/ϵ_0	$\tan \delta$	----	----	----	----	----	----	----	----	----	----
Vaseline	25	ϵ'/ϵ_0	$\tan \delta$	----	----	----	----	----	----	----	----	----	----
Cable Oil 5314 ^a	80	ϵ'/ϵ_0	$\tan \delta$	----	----	----	----	----	----	----	----	----	----
Cable Oil FL101270 ^b	26	ϵ'/ϵ_0	$\tan \delta$	----	----	----	----	----	----	----	----	----	----
Transil Oil 100 ^a	26	ϵ'/ϵ_0	$\tan \delta$	----	----	----	----	----	----	----	----	----	----
Bayol-D ^c	24	ϵ'/ϵ_0	$\tan \delta$	----	----	----	----	----	----	----	----	----	----
Bayol-F ^d	24	ϵ'/ϵ_0	$\tan \delta$	----	----	----	----	----	----	----	----	----	----
Marcol ^e	24	ϵ'/ϵ_0	$\tan \delta$	----	----	----	----	----	----	----	----	----	----

a. Aliphatic and aromatic hydrocarbons (Gen. Elec.). b. California Res. Corp. c. 77.6% paraffins, 22.4% naphthenes (Stanco).
d. 74.5% paraffins, 25.5% naphthenes (Stanco). e. 72.4% paraffins, 27.6% naphthenes (Stanco).

II. Liquids, B. Organic (cont.) Values for $\tan \delta$ are multiplied by 10^4 ; frequency given in c/s.

3. Petroleum Oils (cont.)		T°C	1×10^2	1×10^3	1×10^4	1×10^5	1×10^6	1×10^7	1×10^8	3×10^8	1×10^{10}	2.5×10^{10}
Bayol ^a		24	ϵ'/ϵ_0	2.14	2.14	---	---	---	---	2.14	2.14	---
			$\tan \delta$	2	< 1	---	---	---	---	9.3	18	---
Bayol-16 ^b		24	ϵ'/ϵ_0	2.15	2.15	2.15	2.15	2.15	---	2.15	2.15	---
			$\tan \delta$	7.7	1	< 1	< 2	< 3	---	9.9	13.5	---
Fractol A ^c		26	ϵ'/ϵ_0	2.17	2.17	2.17	---	2.17	---	2.17	2.16	2.12
			$\tan \delta$	< 1	< 1	< 2	---	< 3	---	7.2	11.3	19
Primol-D ^d		24	ϵ'/ϵ_0	2.17	2.17	2.17	2.17	2.17	---	2.17	2.16	---
			$\tan \delta$	< 1	< 1	< 1	< 2	< 3	---	7.7	10.6	---
Diala Oil 15 ^e		25	ϵ'/ϵ_0	2.16	2.16	2.16	2.16	2.16	2.16	2.16	2.16	2.12
			$\tan \delta$	< 0.8	< 0.8	< 0.4	< 5	< 3	10	16.3	18.6	20
4. Silicones												
DC500		-15	ϵ'/ϵ_0	2.20	2.20	2.20	2.20	2.20	---	2.20	---	---
			$\tan \delta$	< 5	< 3	< 3	< 3	< 2	---	18.6	---	---
0.65 cs. at 25°C ^f		22	ϵ'/ϵ_0	2.20	2.20	2.20	2.20	2.20	---	2.20	2.19	2.13
			$\tan \delta$	1	< 0.4	< 0.4	< 3	< 2	---	1.4	30	60
DC500		23	ϵ'/ϵ_0	2.66	2.66	2.66	2.66	2.66	---	---	2.65	2.48
			$\tan \delta$	12	1.5	< 0.4	< 3	3	---	---	68	410
10 cs. at 25°C ^f		22	ϵ'/ϵ_0	2.76	2.76	2.76	---	---	---	2.75	2.72	2.61
			$\tan \delta$	0.4	< 0.4	< 0.4	---	---	---	94	240	390
DC200		23	ϵ'/ϵ_0	2.76	2.76	2.76	---	---	---	---	---	---
			$\tan \delta$	0.8	0.4	< 0.4	---	---	---	2.76	2.70	2.55
100 cs. at 25°C ^f		22	ϵ'/ϵ_0	2.78	2.78	2.78	2.78	2.78	---	---	2.74	2.74
			$\tan \delta$	0.8	0.8	0.6	< 3	< 2	---	96	320	550
1000 cs. at 25°C ^f		-17	ϵ'/ϵ_0	2.90	2.90	2.90	2.90	2.90	---	2.87	---	---
			$\tan \delta$	< 5	< 3	< 3	< 3	2	---	130	---	---
7600 cs. at 130°C ^f		23	ϵ'/ϵ_0	2.75	2.75	2.75	2.75	2.75	---	2.74	2.69	---
			$\tan \delta$	0.5	0.2	< 0.4	< 5	2	---	11	103	225
		83	ϵ'/ϵ_0	2.56	2.56	2.56	2.56	2.56	---	---	---	---
			$\tan \delta$	< 5	< 3	< 3	< 3	2	---	---	---	---

a. 72.0% paraffins, 28.0% naphthenes (Stanco). b. 68.9% paraffins, 31.1% naphthenes (Stanco). c. 57.4% paraffins, 42.6% naphthenes (Stanco). d. 49.4% paraffins, 50.6% naphthenes (Stanco). e. Petroleum hydrocarbons, mainly naphthenes (Shell). f. Methyl or ethyl siloxane polymer (Dow Corning).

II. Liquids, B. Organic (cont.)		Values for $\tan \delta$ are multiplied by 10^4 ; frequency given in c/s.										
4. Silicones (cont.)		T°C	1×10^2	1×10^3	1×10^4	1×10^5	1×10^6	1×10^7	1×10^8	3×10^8	3×10^9	1×10^{10}
DC550 ^a		25	ϵ'/ϵ_0	2.90	2.90	2.90	2.90	2.88	---	2.88	2.77	2.60
			$\tan \delta$	170	18	3.7	3.8	12	---	130	210	220
DC710 ^a		25	ϵ'/ϵ_0	2.98	2.98	2.98	2.98	2.97	---	2.93	2.79	2.60
			$\tan \delta$	13	.7	3	10	50	---	200	140	170
Ignition Sealing Compound #4 ^b		25	ϵ'/ϵ_0	2.75	2.75	2.75	2.75	2.75	2.74	2.72	2.65	2.49
			$\tan \delta$	15	6	4	4	6	15	28	92	270
SF96-40 ^c		80	ϵ'/ϵ_0	2.6	2.6	2.6	2.6	---	---	---	2.54	
			$\tan \delta$	64	18	6	< 4	---	---	---	47	
SF96-100 ^c		25	ϵ'/ϵ_0	2.71	2.71	2.71	2.71	2.71	---	2.71	2.70	2.67
			$\tan \delta$	< .3	< .03	< .03	< 1	< 1	---	11	95	186
SF96-1000 ^c		25	ϵ'/ϵ_0	2.73	2.73	2.73	2.73	2.73	---	2.73	2.71	2.69
			$\tan \delta$	< .6	< .06	< .03	< 1	< 1	---	11	107	200
		25	ϵ'/ϵ_0	2.73	2.73	2.73	2.73	2.73	---	2.73	2.71	2.695
			$\tan \delta$	< .3	< .03	< .03	< 1	.8	---	13	106	203

a. Methyl and methyl phenyl polysiloxane (Dow Corning). b. Organosiloxane polymer (Dow Corning). c. Gen. Elec.

Supplementary High-Temperature Data on Plastics

	T°C		Frequency given in c/s.						
			10 ²	10 ³	10 ⁴	4x10 ⁴	10 ⁵	10 ⁶	3x10 ⁹
Formica FF-41 (after 5 yrs. storage, various samples)	25	ϵ'/ϵ_0	6.27	6.19	6.12	6.08	5.97	---	3.87
		tan δ	.018	.0085	.0081	.0090	.012	---	.0143
	100	ϵ'/ϵ_0	---	11.2	6.73	6.23	6.07	---	4.00
		tan δ	---	.50	.18	.055	.040	---	.0144
Formica IE (after 5 yrs. storage)	25	ϵ'/ϵ_0	5.92	5.32	5.01	4.87	4.86	4.85	3.63
		tan δ	.112	.057	.038	.036	.040	.042	.037
	100	ϵ'/ϵ_0	---	16.0	8.16	6.69	6.22	5.84	4.10
		tan δ	---	.42	.29	.173	.151	.080	.067
Formica MF-66	200	ϵ'/ϵ_0	---	12.8	7.17	6.4	---	---	4.94
		tan δ	---	.847	.245	.134	---	---	.059
Formica XI	100	ϵ'/ϵ_0	9.77	6.66	5.87	5.66	5.61	5.44	4.09
		tan δ	.42	.195	.073	.046	.035	.029	.102
Micarta 259	100	ϵ'/ϵ_0	9.39	6.75	6.14	6.03	---	---	---
		tan δ	.44	.16	.043	.022	---	---	5.2
Micarta 299	200	ϵ'/ϵ_0	12.8	6.7	5.0	4.8	4.75	4.6	4.4
		tan δ	.59	.36	.158	.081	.046	.015	.016
Micarta 496 (after 5 yrs. storage)	25	ϵ'/ϵ_0	7.31	6.35	5.89	5.73	---	---	---
		tan δ	.16	.074	.045	.041	---	---	---
	100	ϵ'/ϵ_0	---	15.5	8.53	7.42	7.26	6.31	---
		tan δ	---	.68	.305	.178	.116	.064	---

Supplementary High-Humidity Data

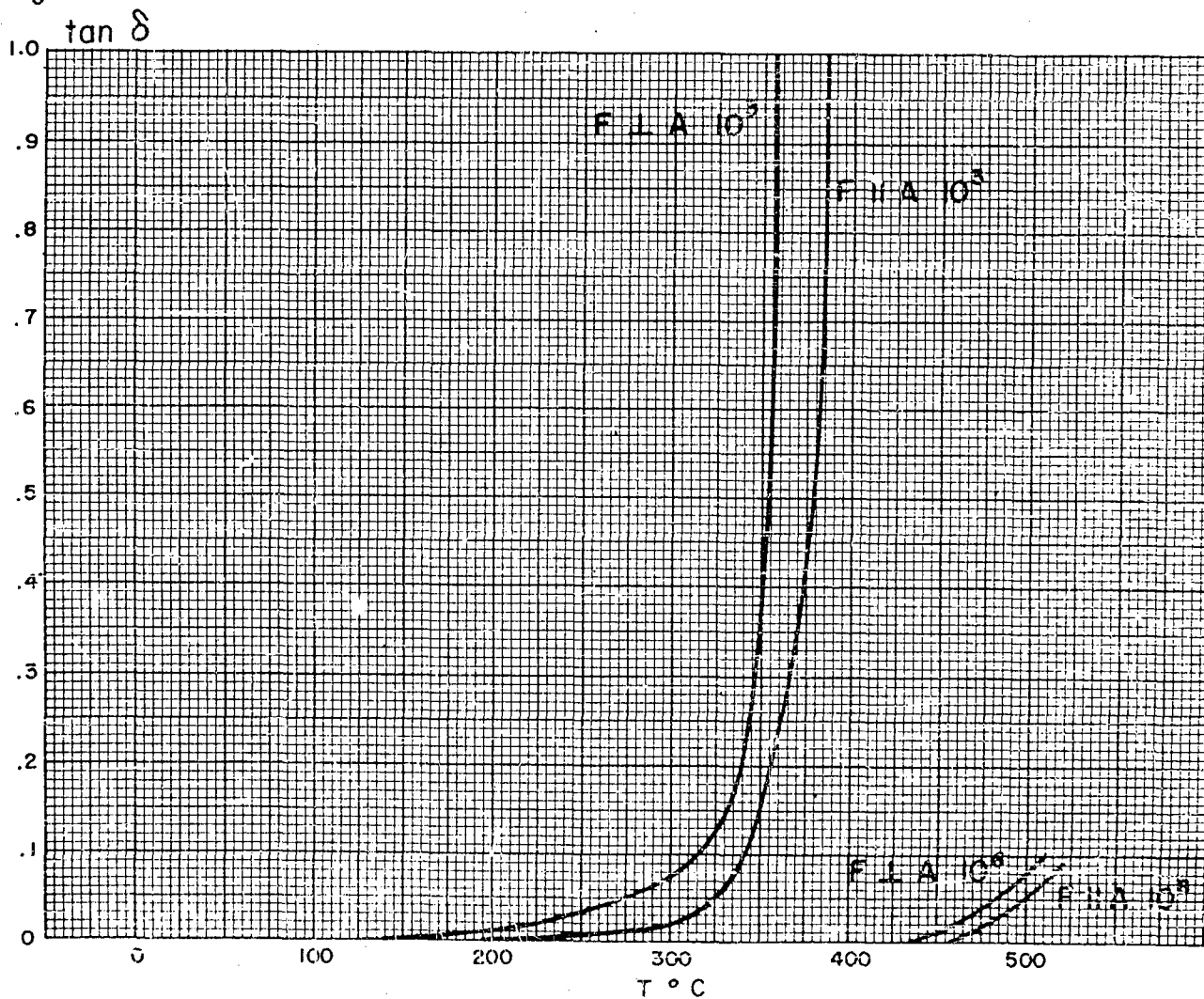
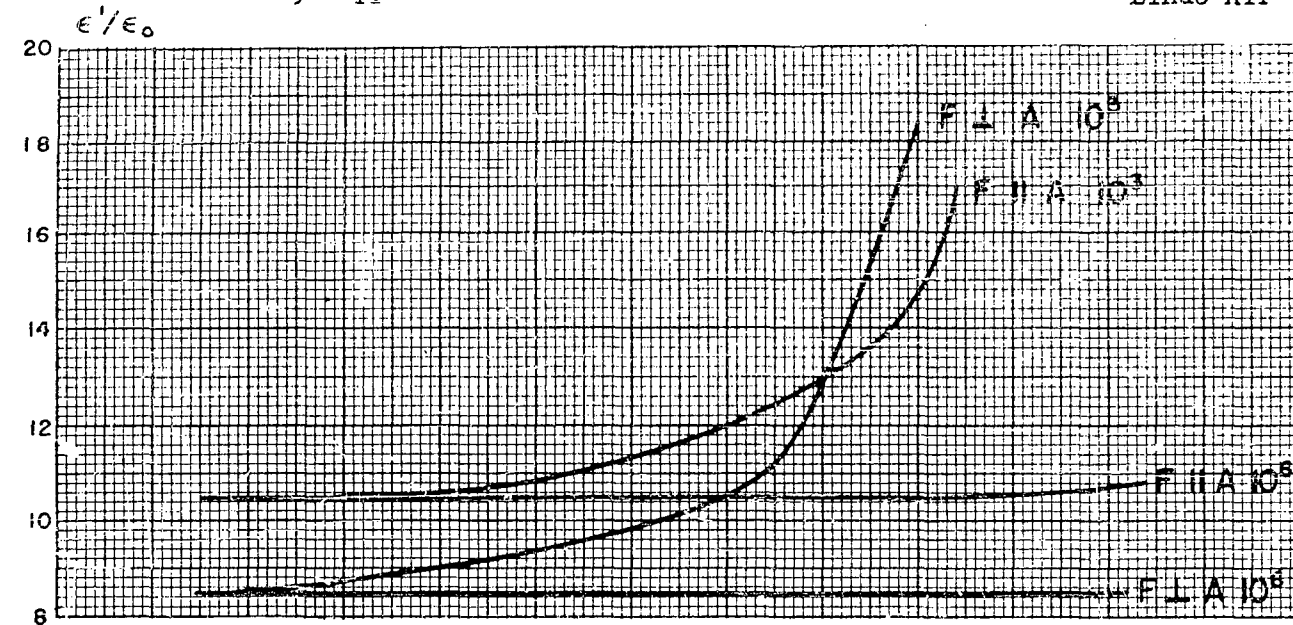
[illegible]

Data at Fixed Frequency as a Function of Temperature

Inorganic Crystals

Aluminum oxide, sapphire*

Linde Air

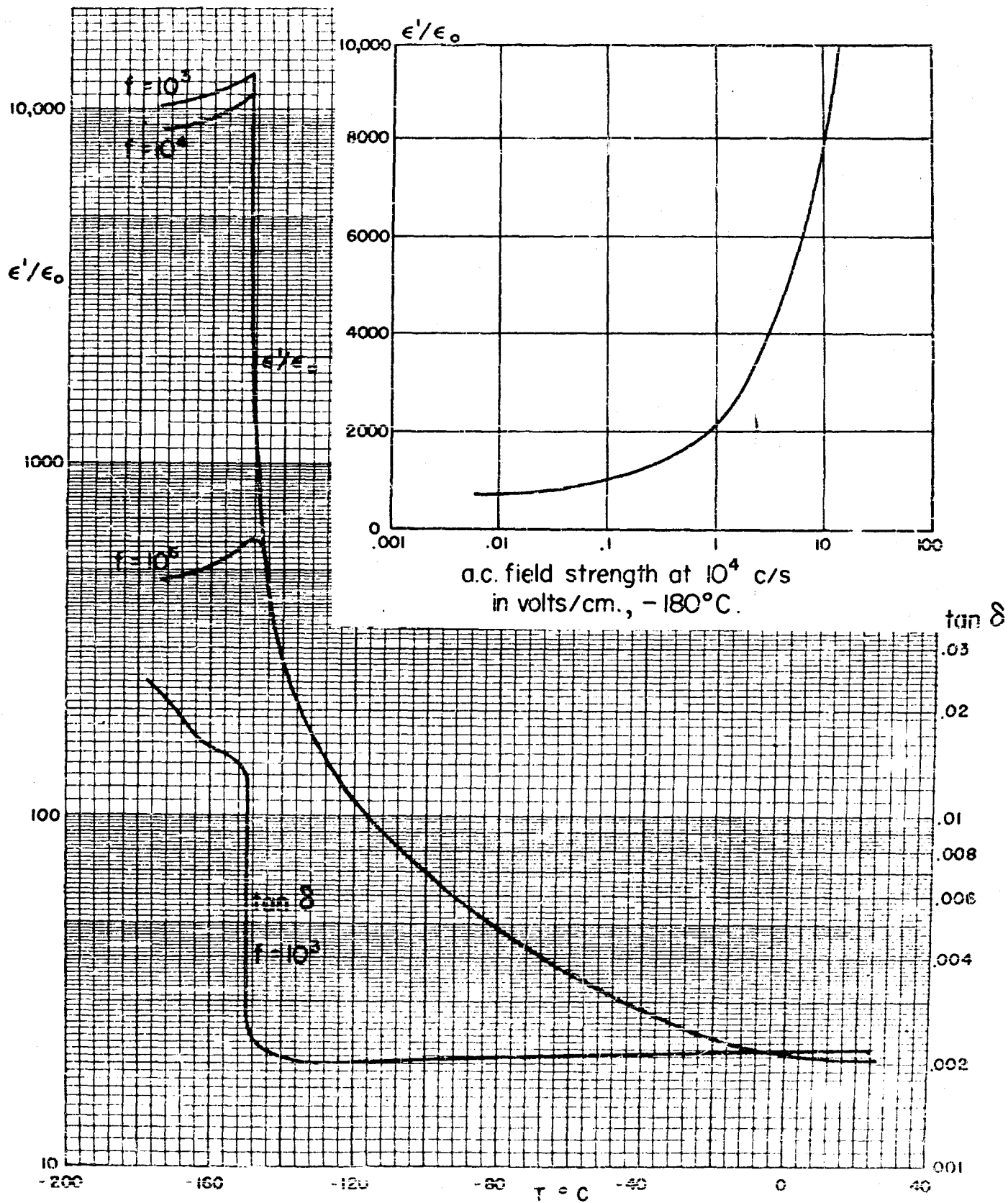


*Field I. to optic axis and field II to optic axis.

Inorganic Crystals (cont.)

Potassium dihydrogen phosphate*

Brush

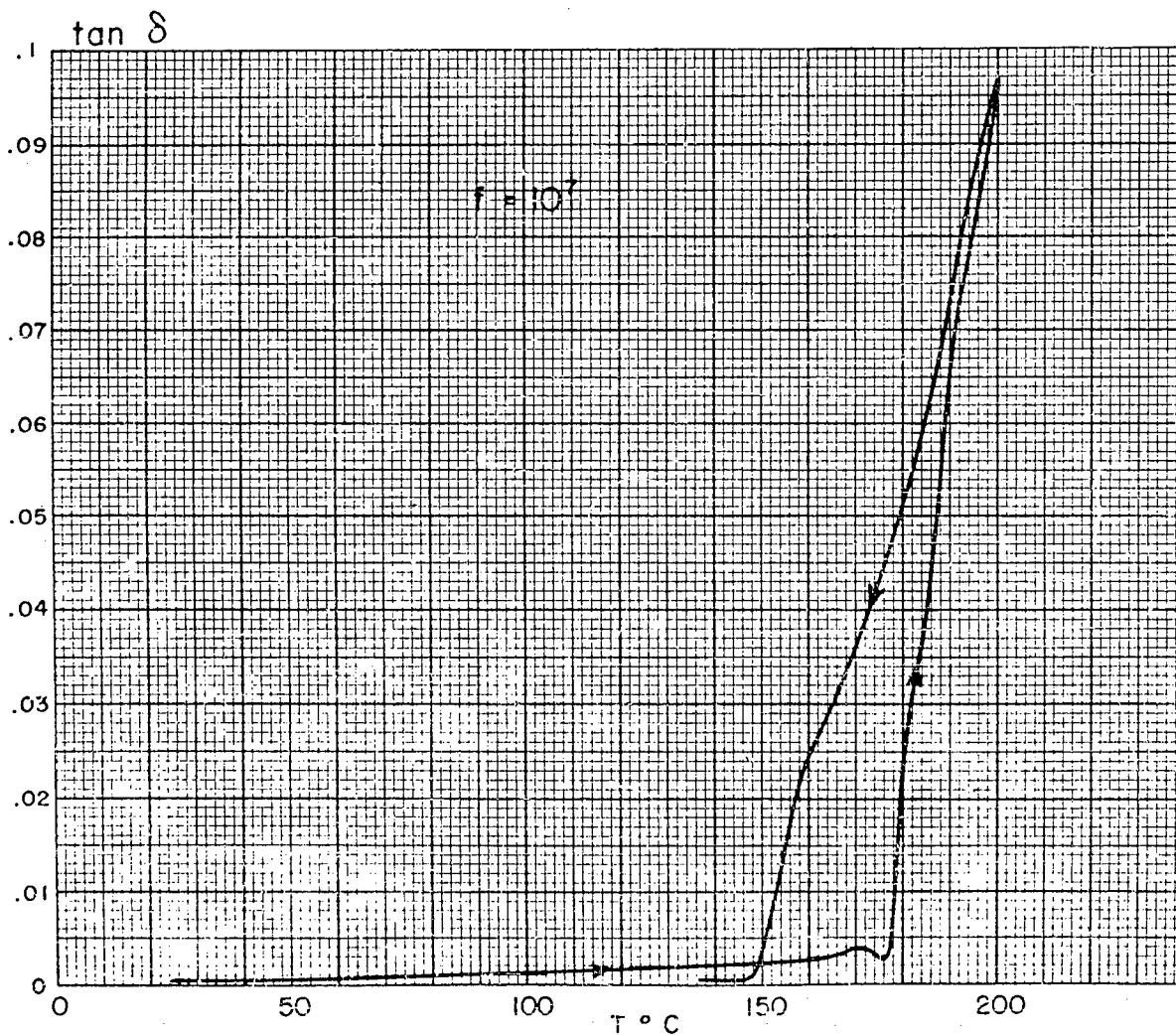
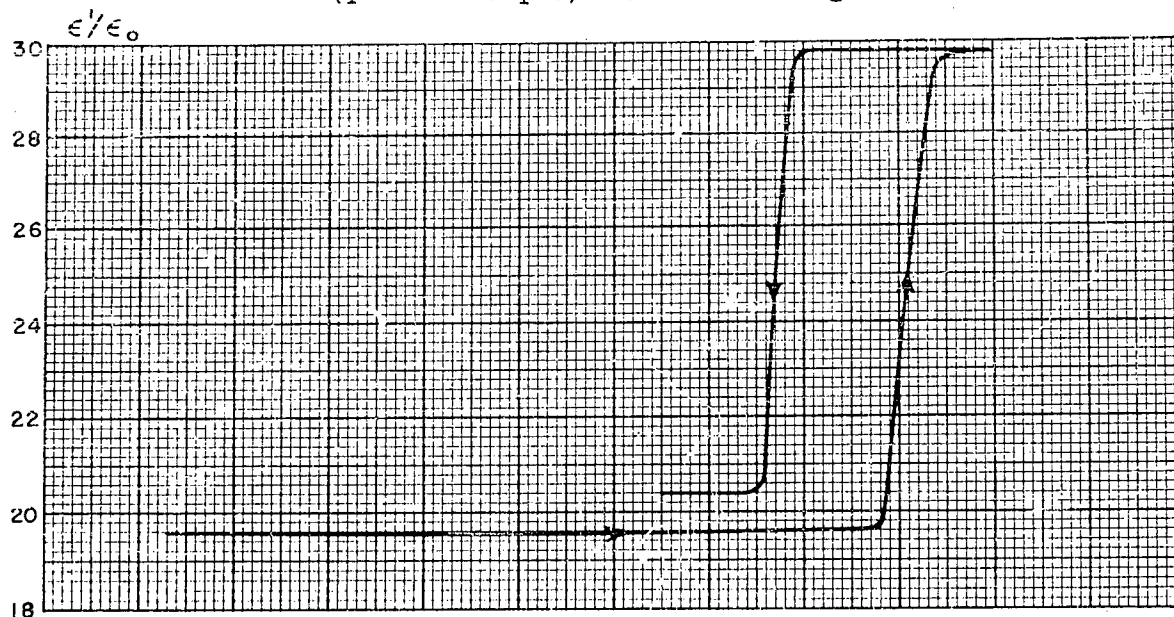


*Field || to optic axis, 15 volts/cm.

Inorganic Crystals (cont.)

Thallium iodide (pressed sample)

Eng. Res. and Dev. Lab.



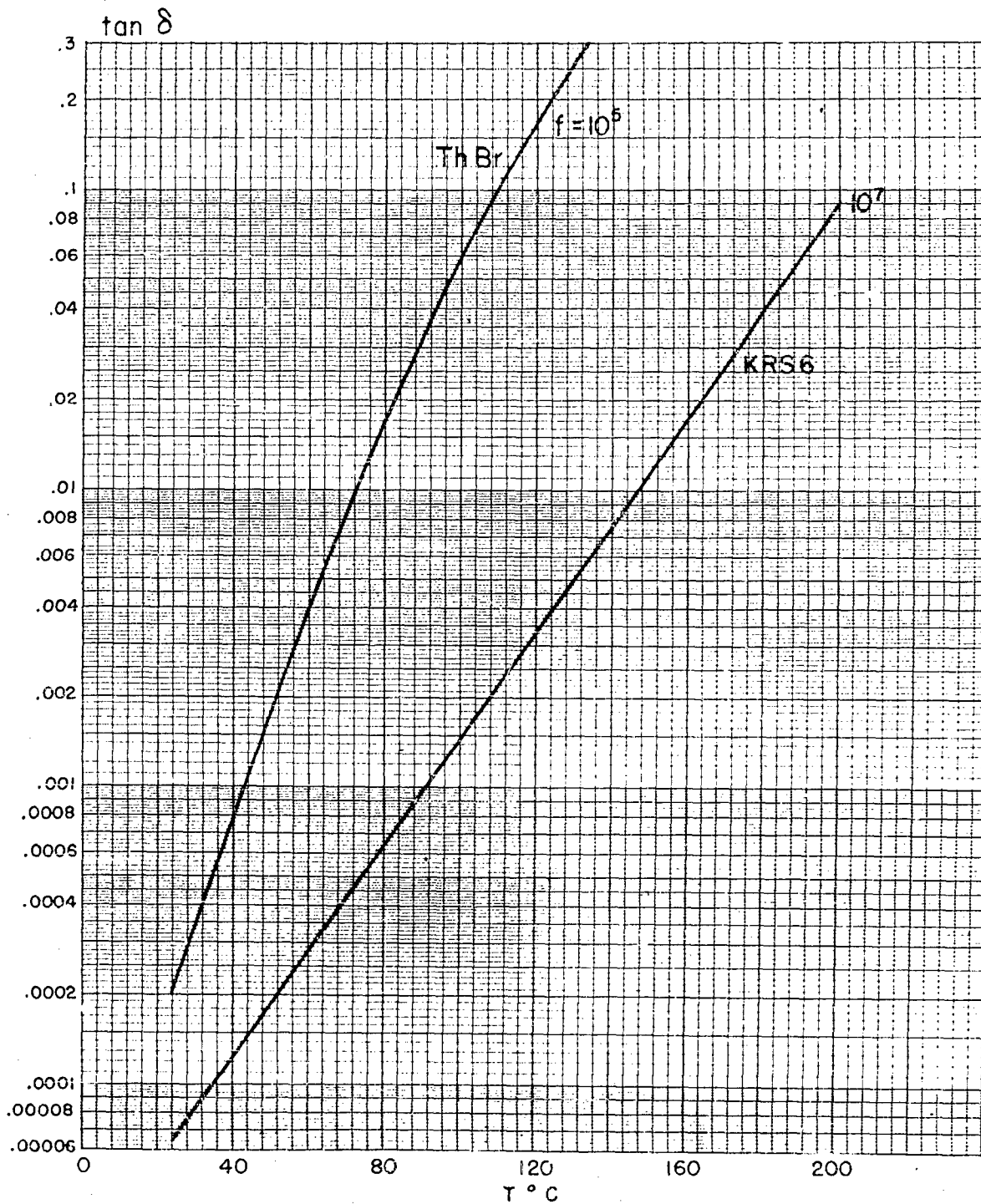
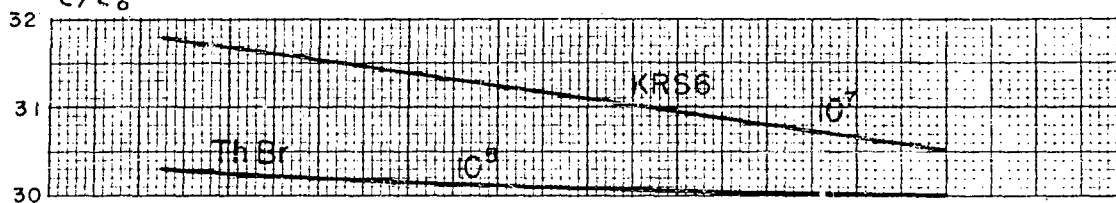
Inorganic Crystals (cont.)

KRS-6 (ThCl, 40%, ThBr, 60%)

Eng. Res. and Dev. Lab.

Thallium bromide

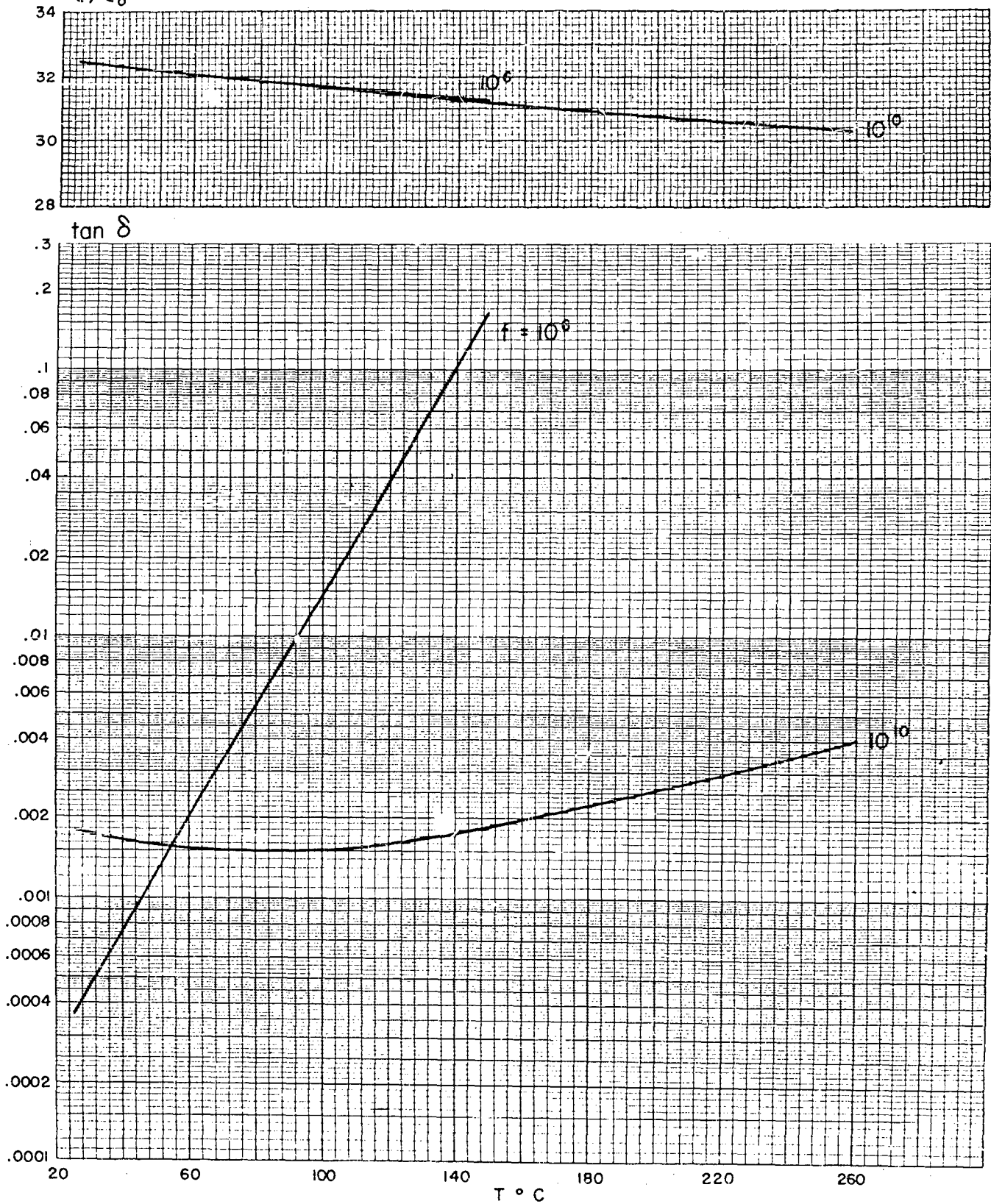
ϵ/ϵ_0



Inorganic Crystals (cont.)

KRS-5 (ThBr, 42%, ThI, 58%)
 ϵ'/ϵ_0

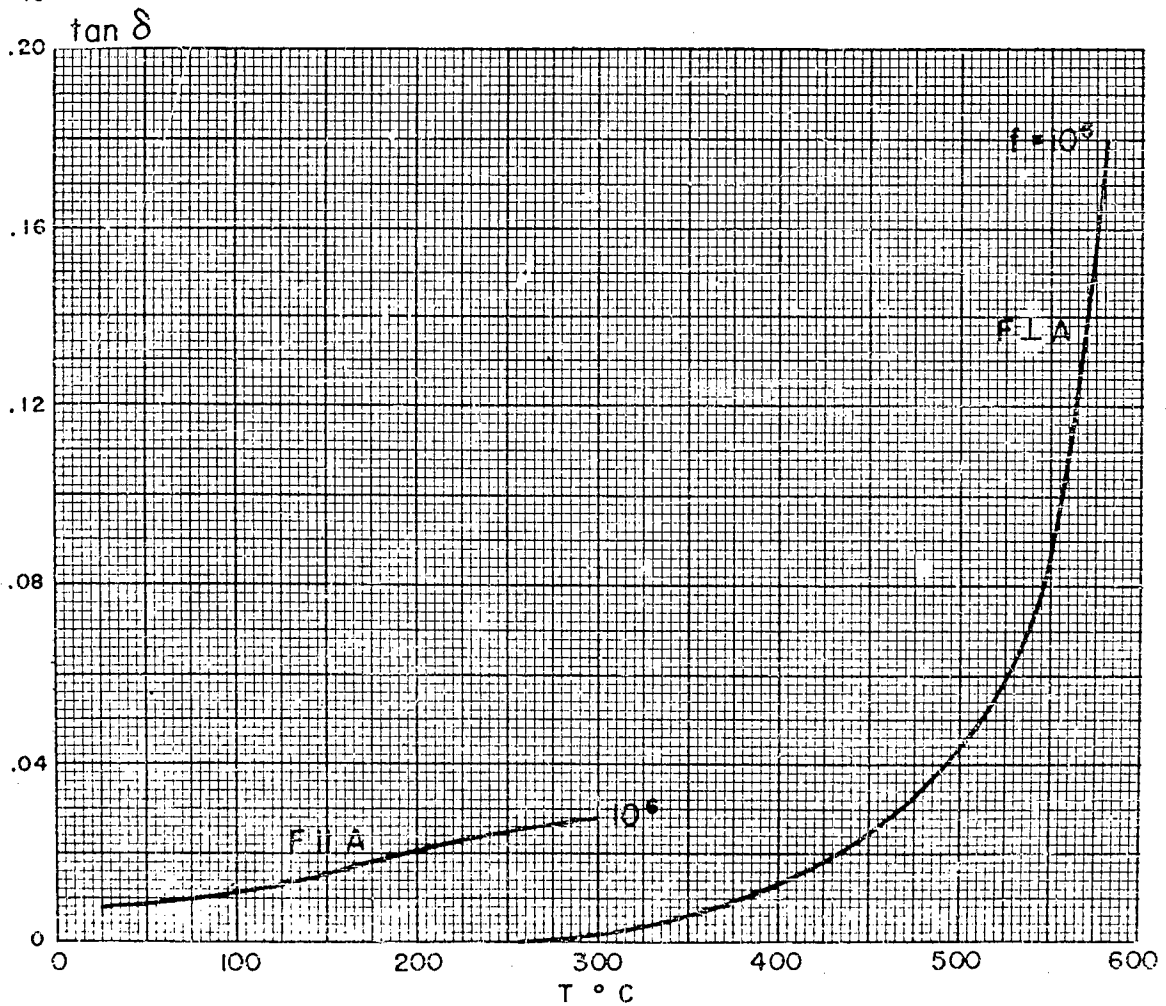
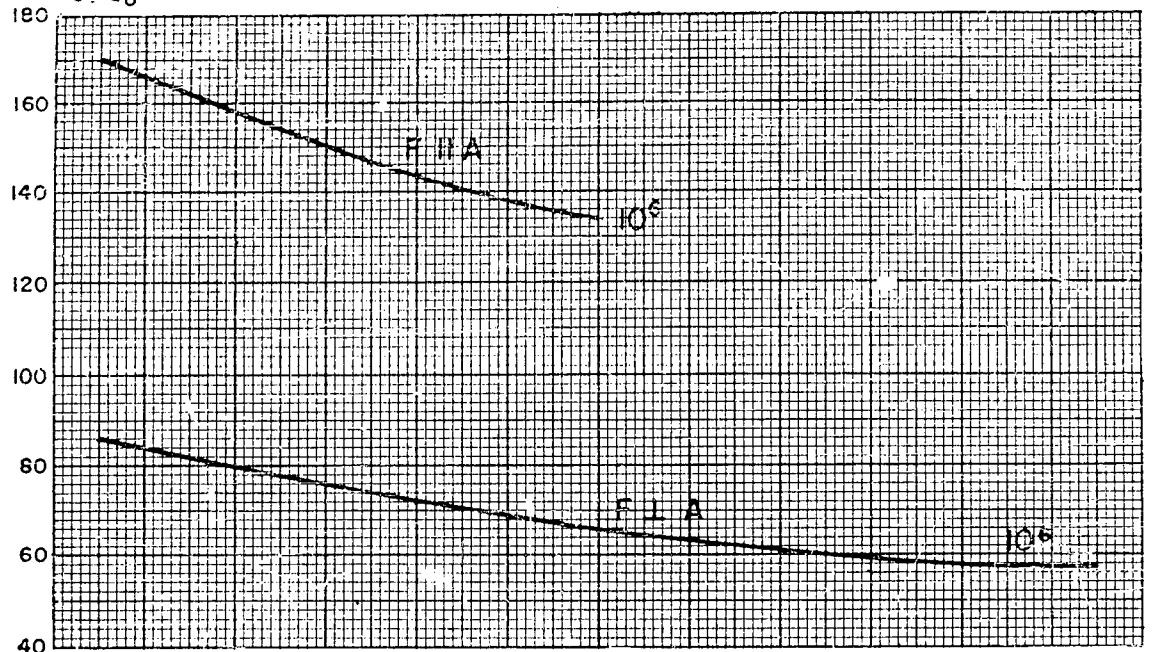
Eng. Res. and Dev. Lab.



Inorganic Crystals (cont.)

Titanium dioxide, rutile*

Linde Air

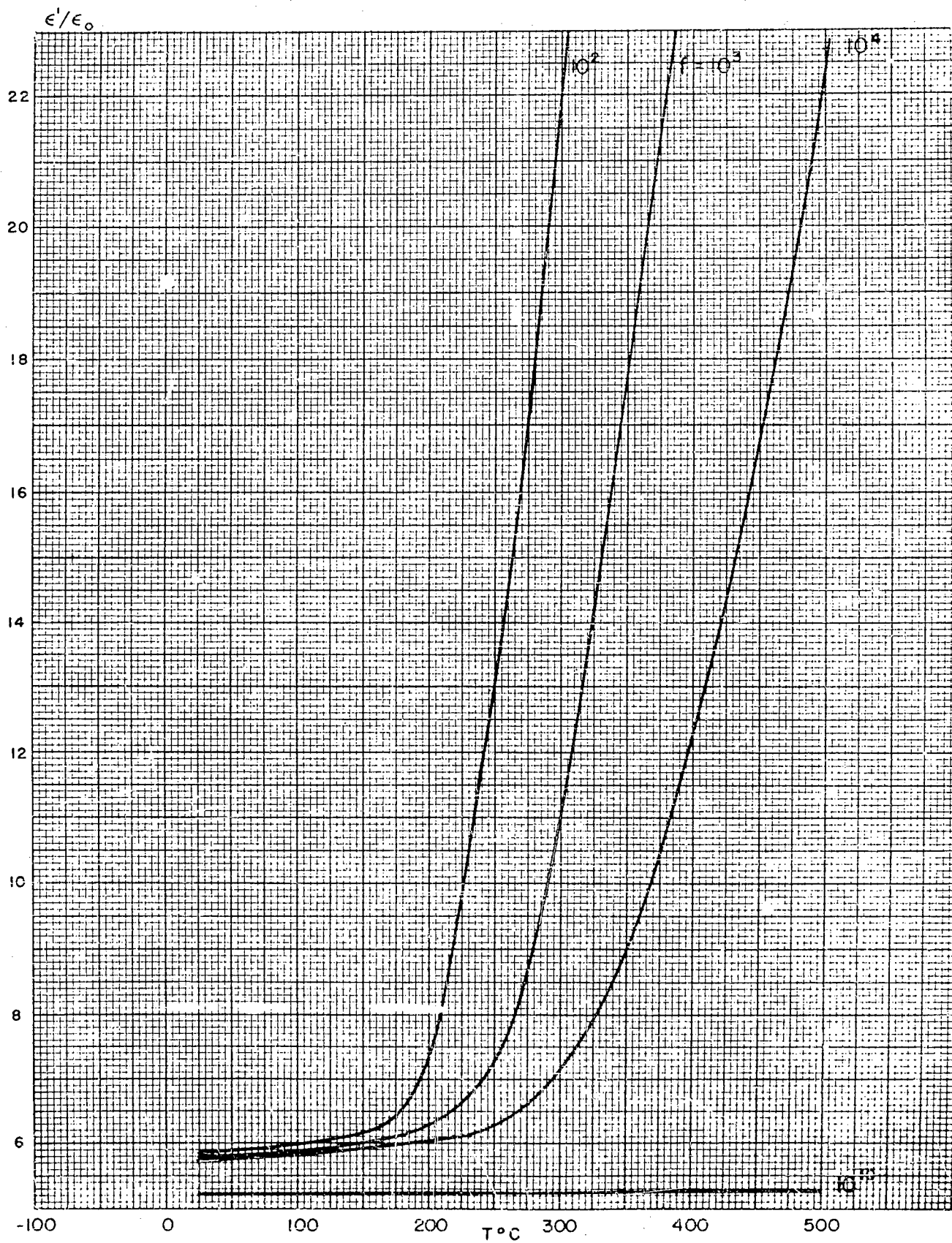


*Field $\perp$ to optic axis and field $\parallel$ to optic axis.

Steatite Bodies

AlSiMag A-196

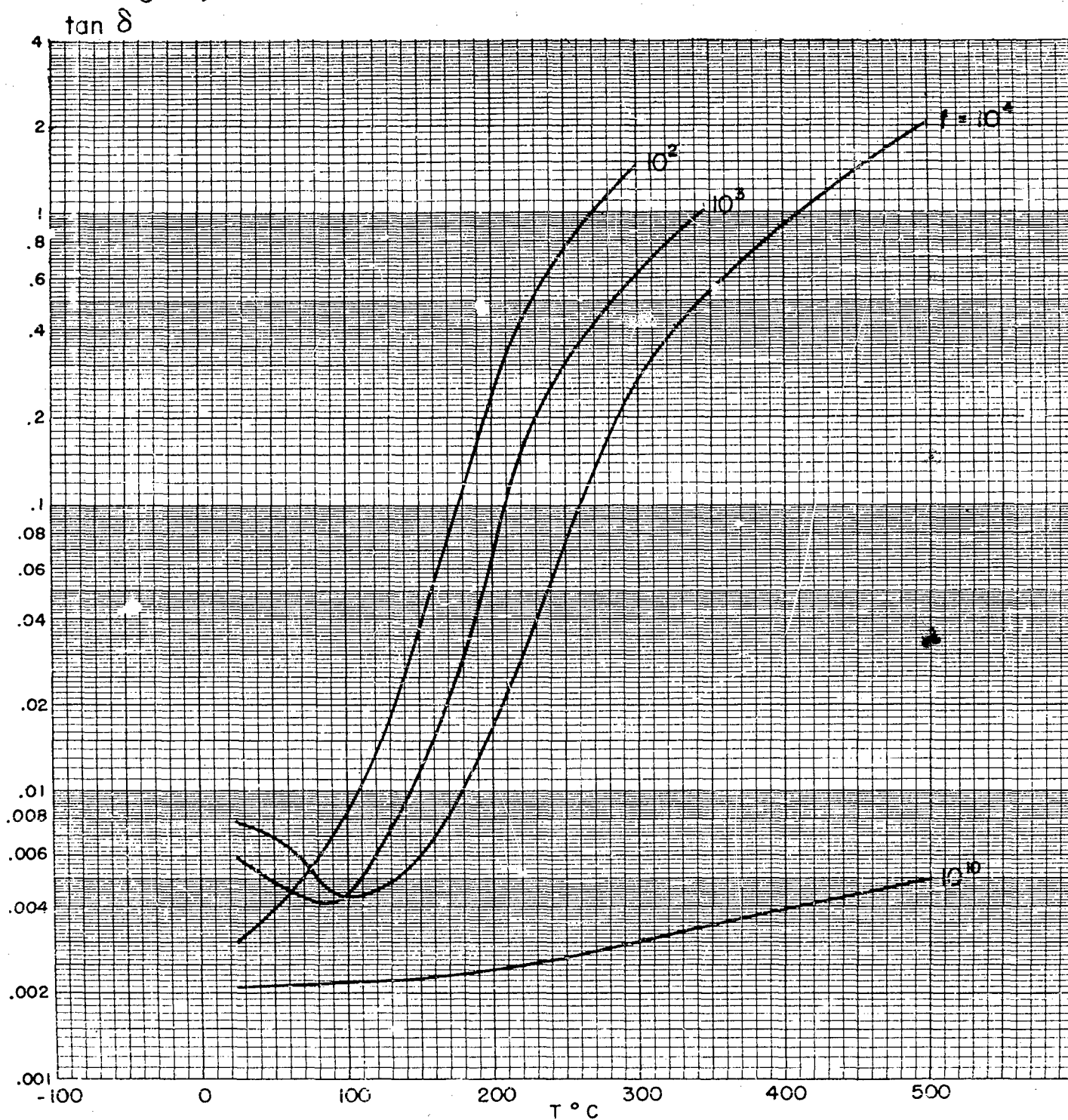
Amer. Lava



Steatite Bodies (cont.)

AlSiMag A-196

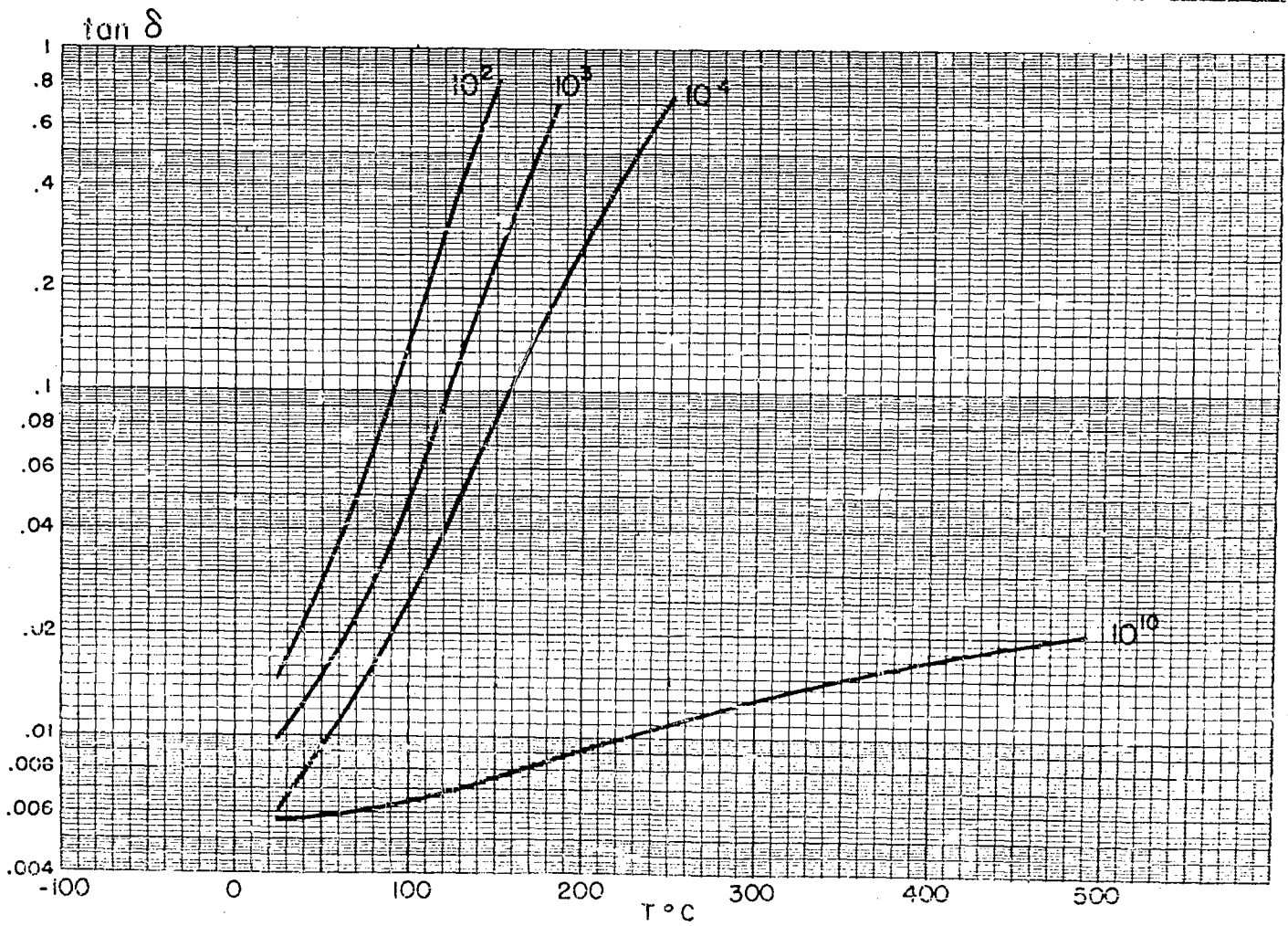
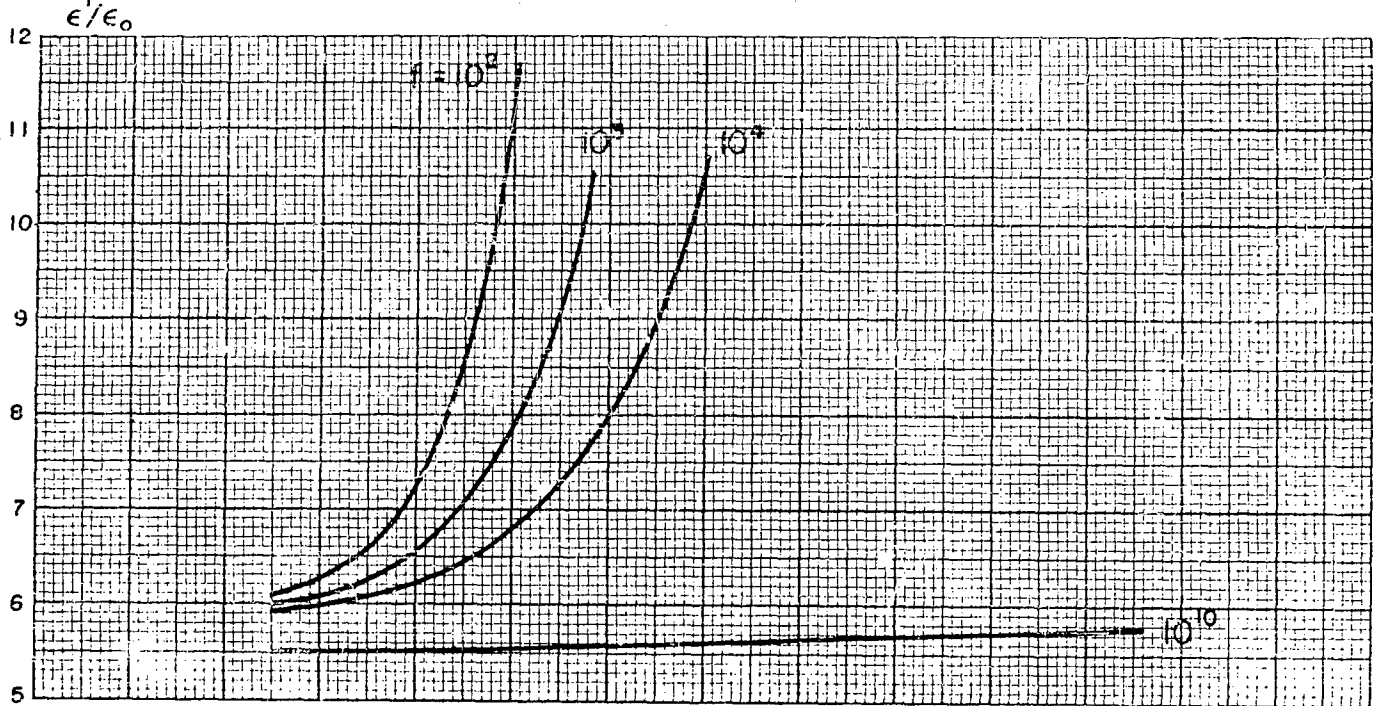
Amr. Lava



Steatite Bodies (cont.)

AlSiMag A-35

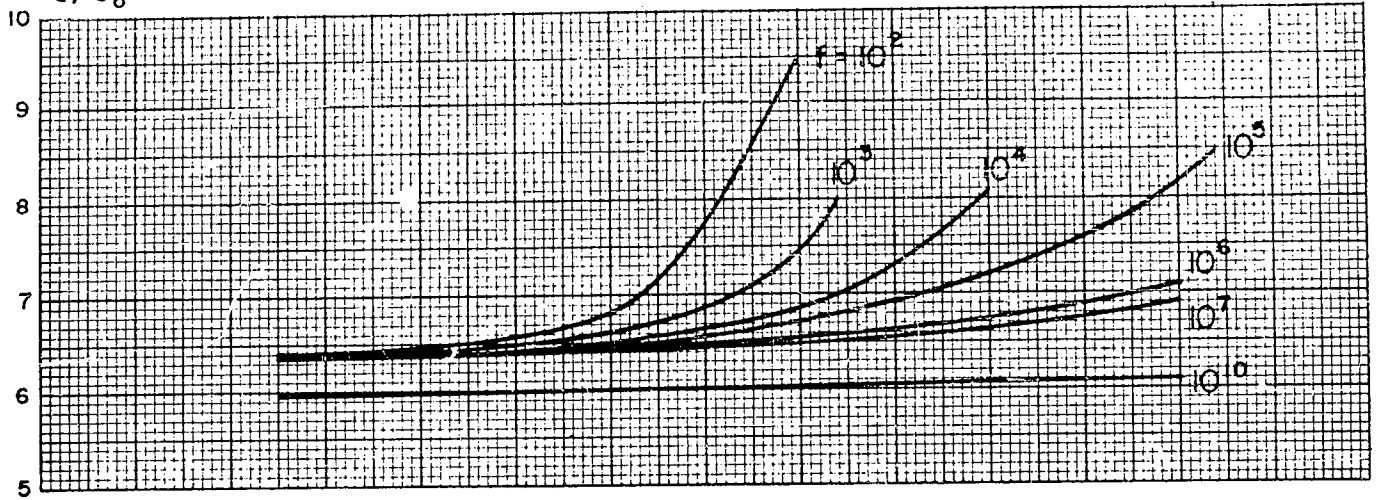
Amer. Lava



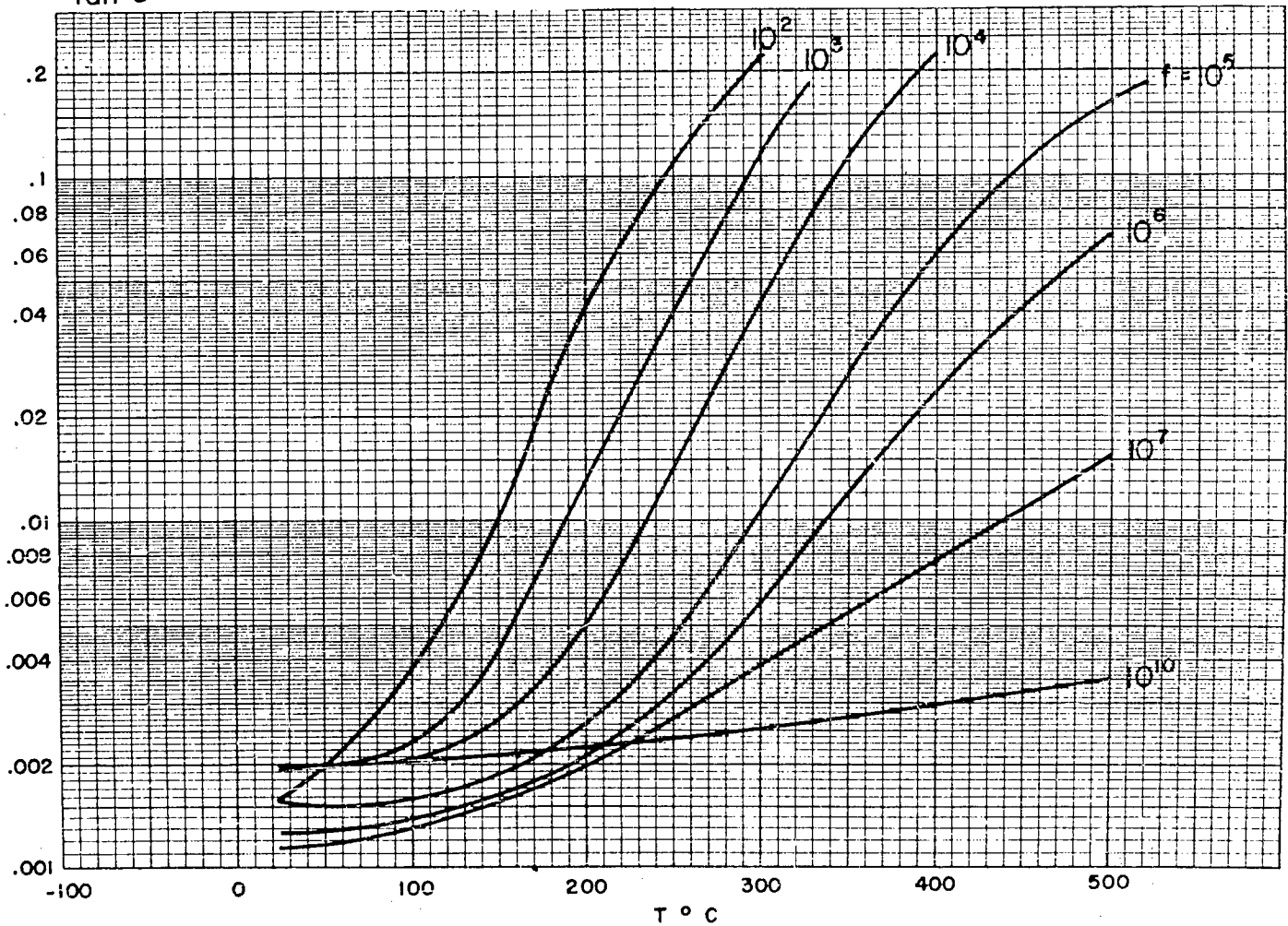
Steatite Bodies (cont.)

Amer. Lava

AlSiMag 228
 ϵ'/ϵ_0



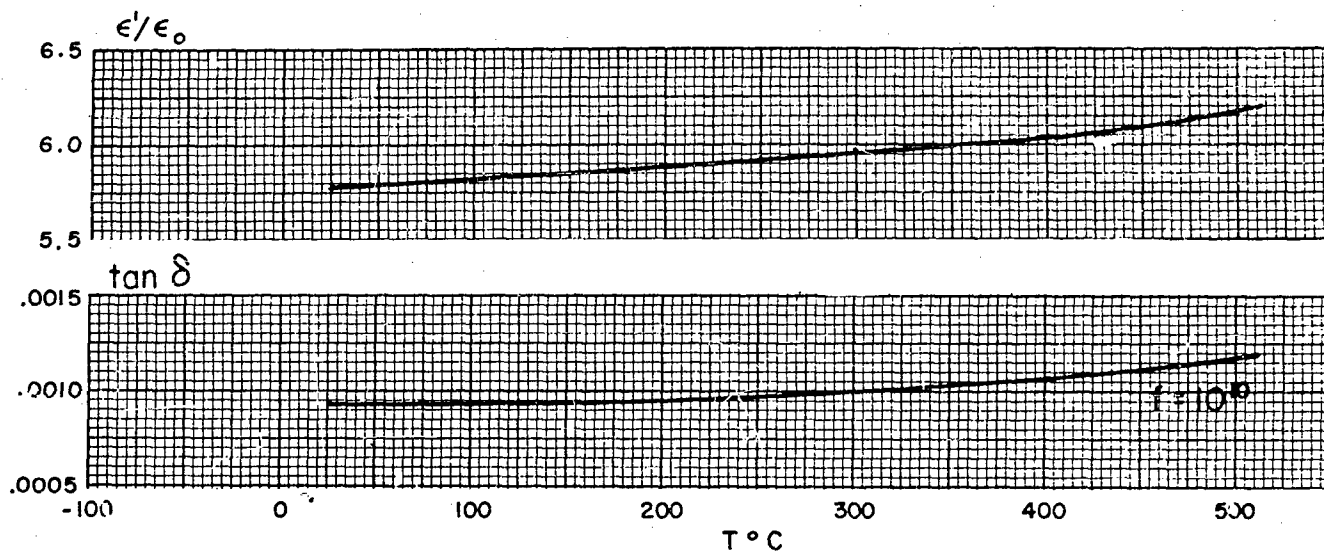
$\tan \delta$



Steatite Bodies (cont.)

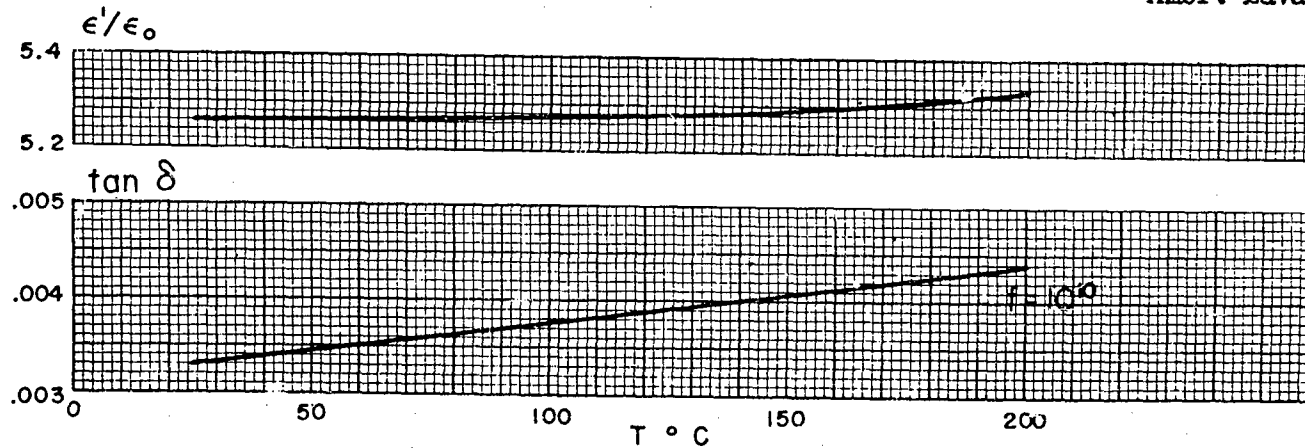
AlSiMag 243

Amer. Lava



AlSiMag 505

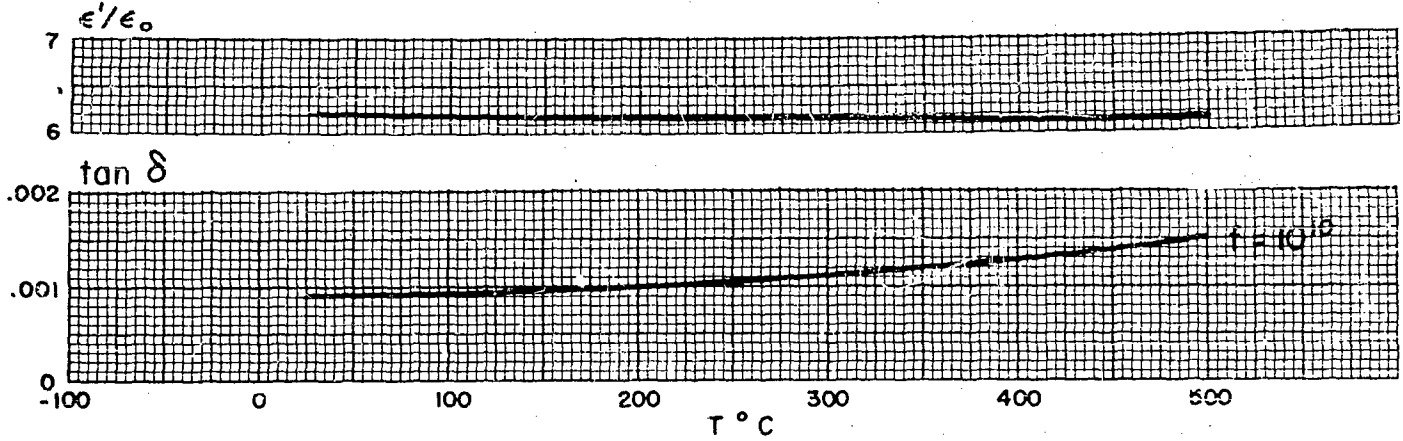
Amer. Lava



Steatite Bodies (cont.)

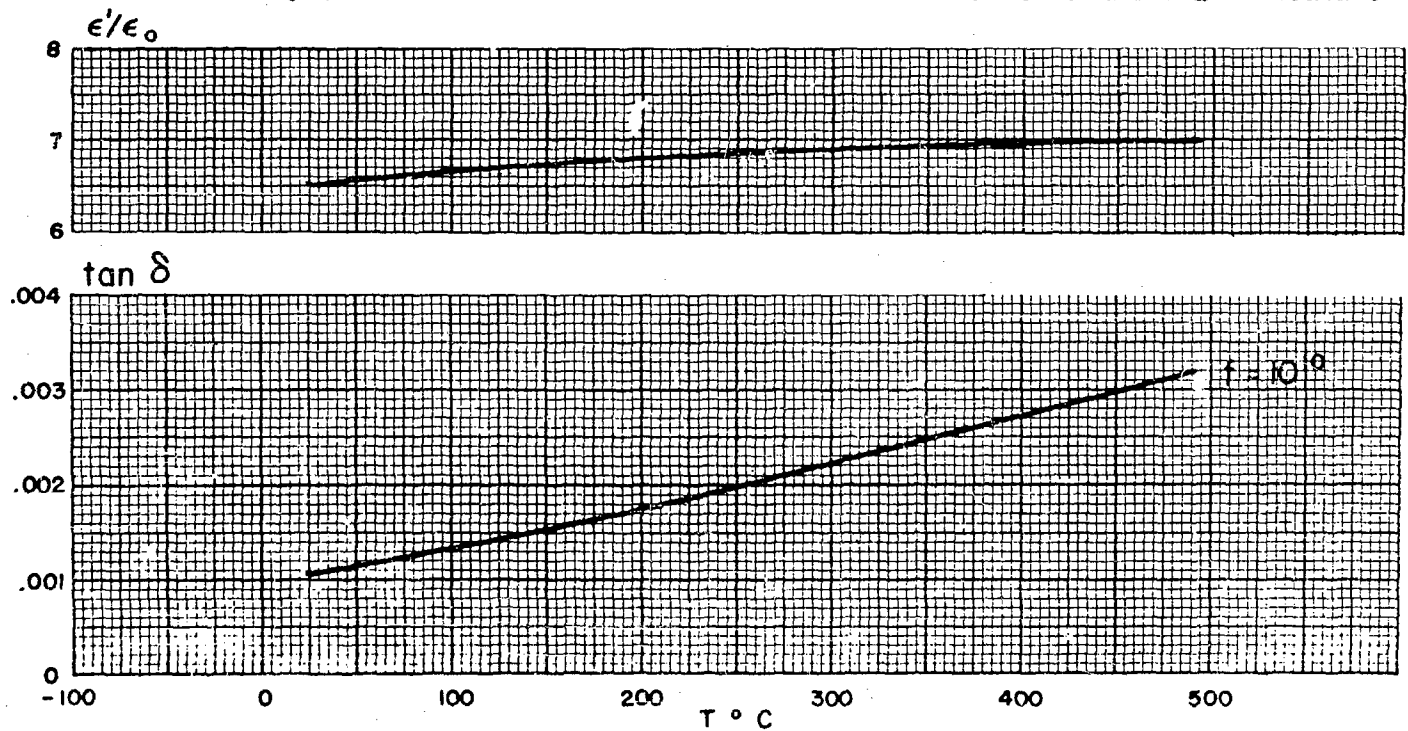
Ceramic F-66

Bell



Steatite Body 7292

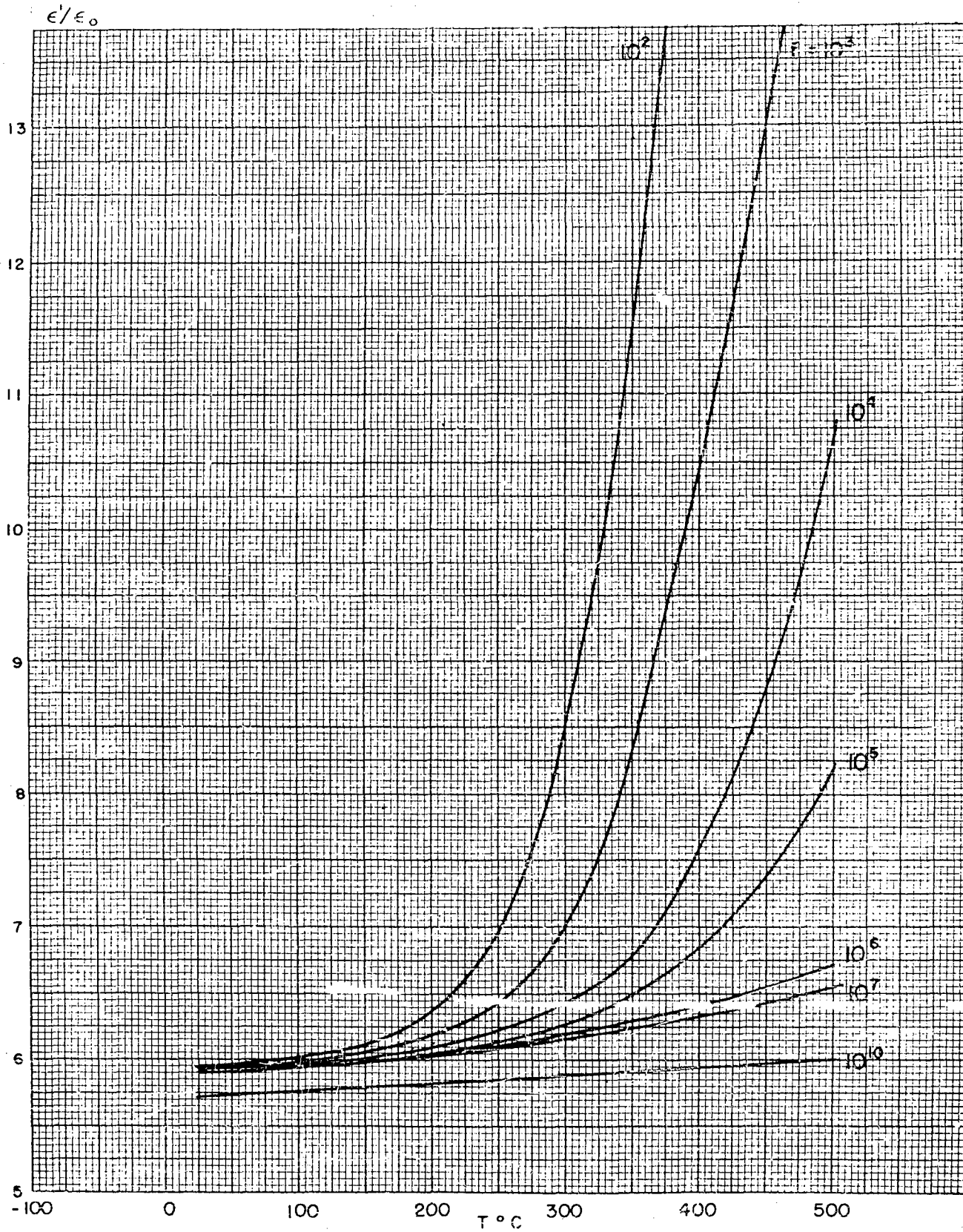
Gen. Ceramics and Steatite



Steatite Bodies (cont.)

Steatite Type 302

Centralab

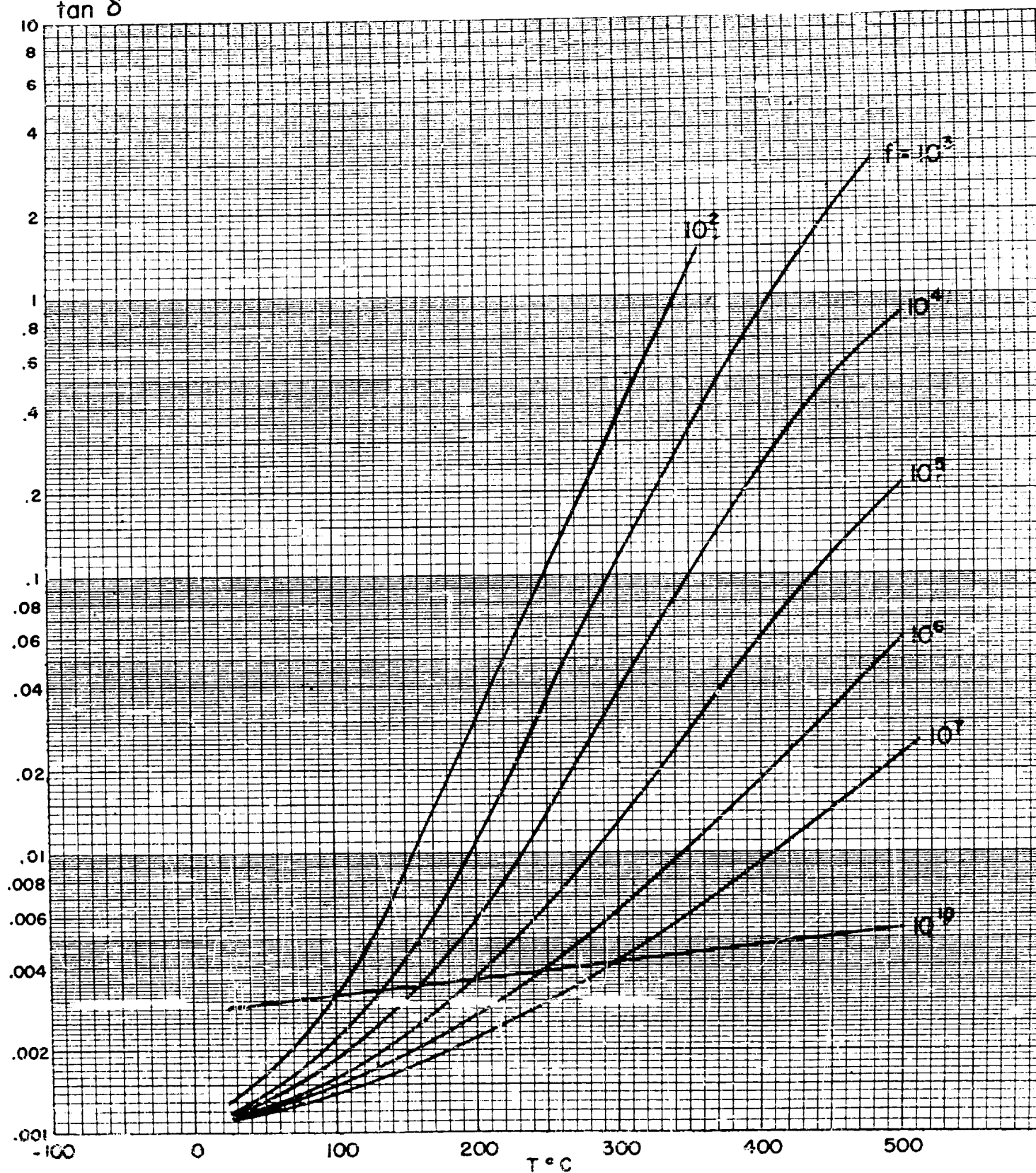


Steatite Bodies (cont.)

Centralab

Steatite Type 302

$\tan \delta$

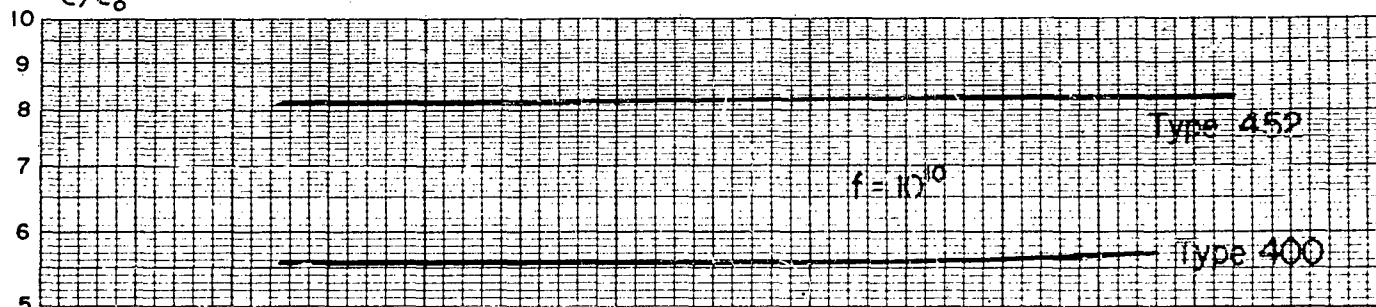


Steatite Bodies (cont.)

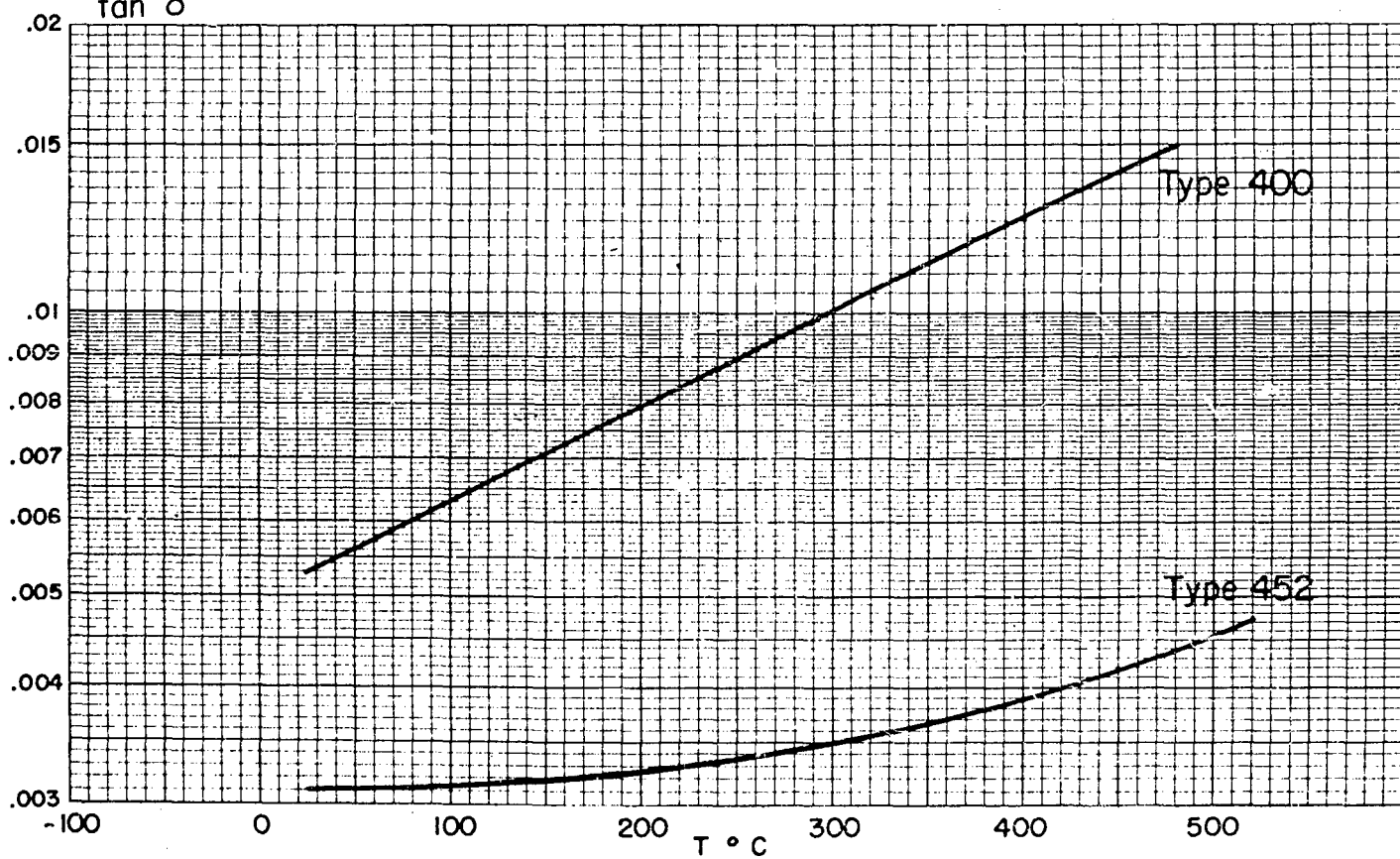
Steatite Type 400, 452

Centralab

ϵ'/ϵ_0



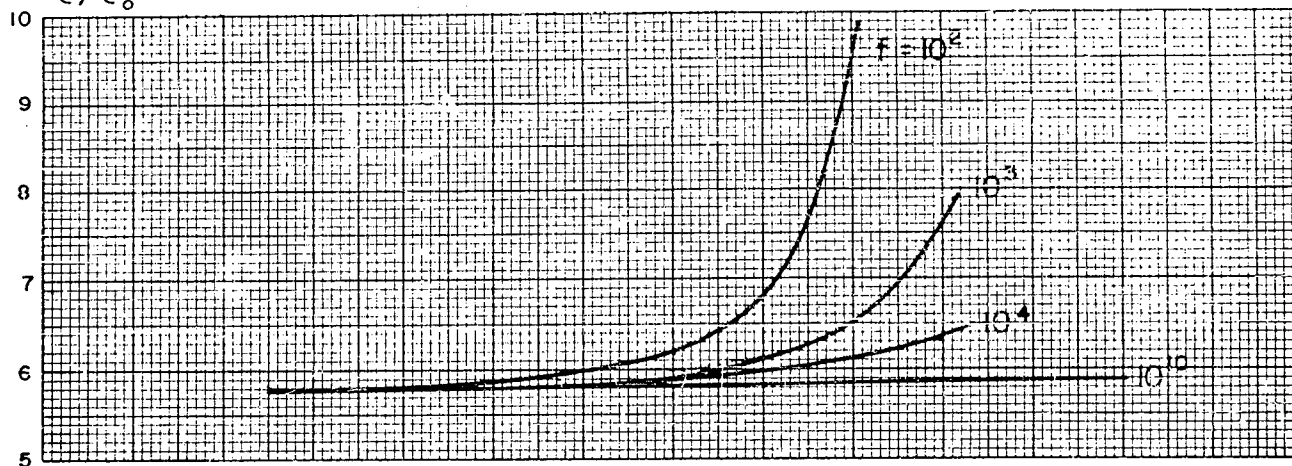
$\tan \delta$



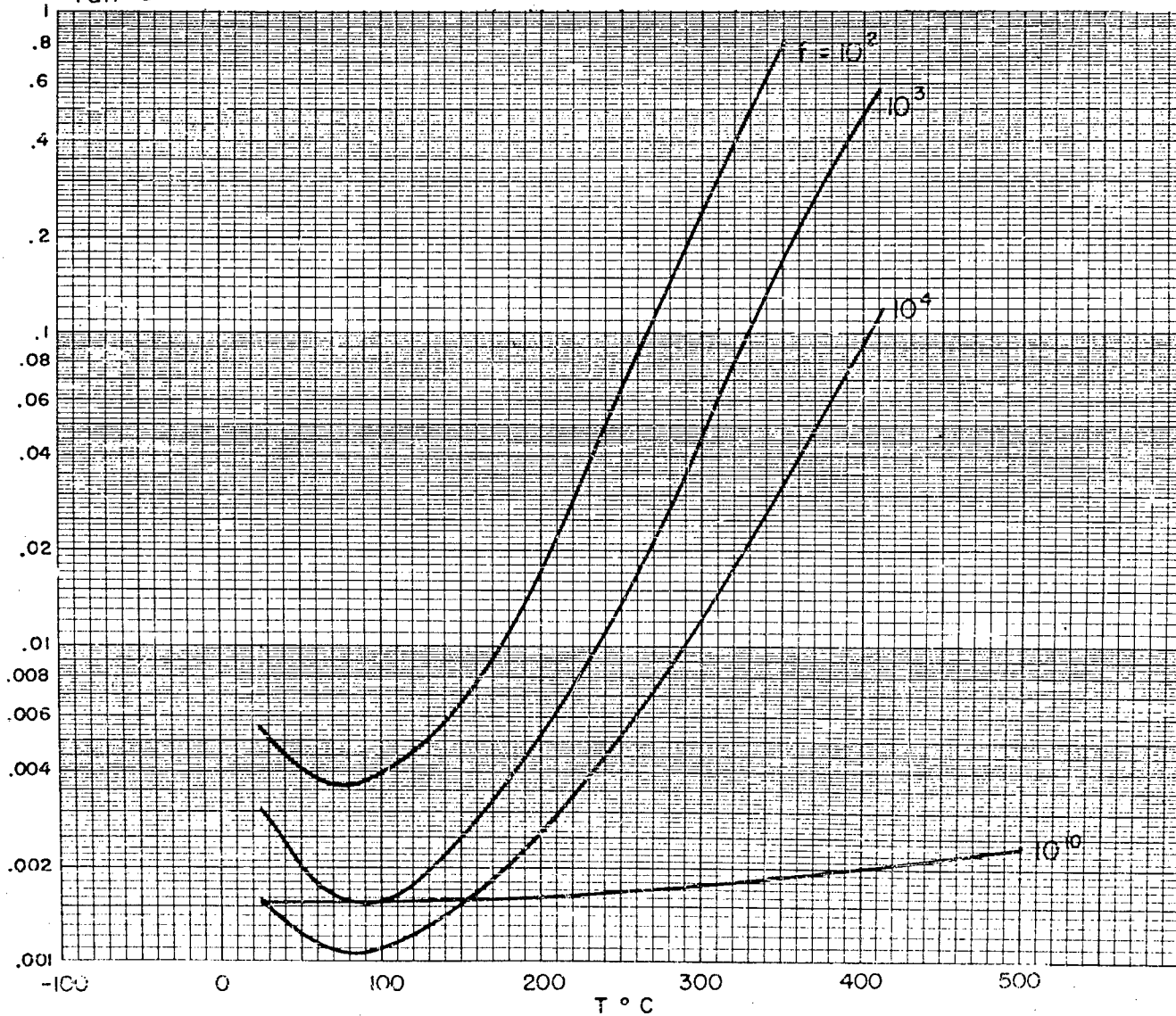
Steatite Bodies (cont.)

Steatite Type 410
 ϵ/ϵ_0

Centralab



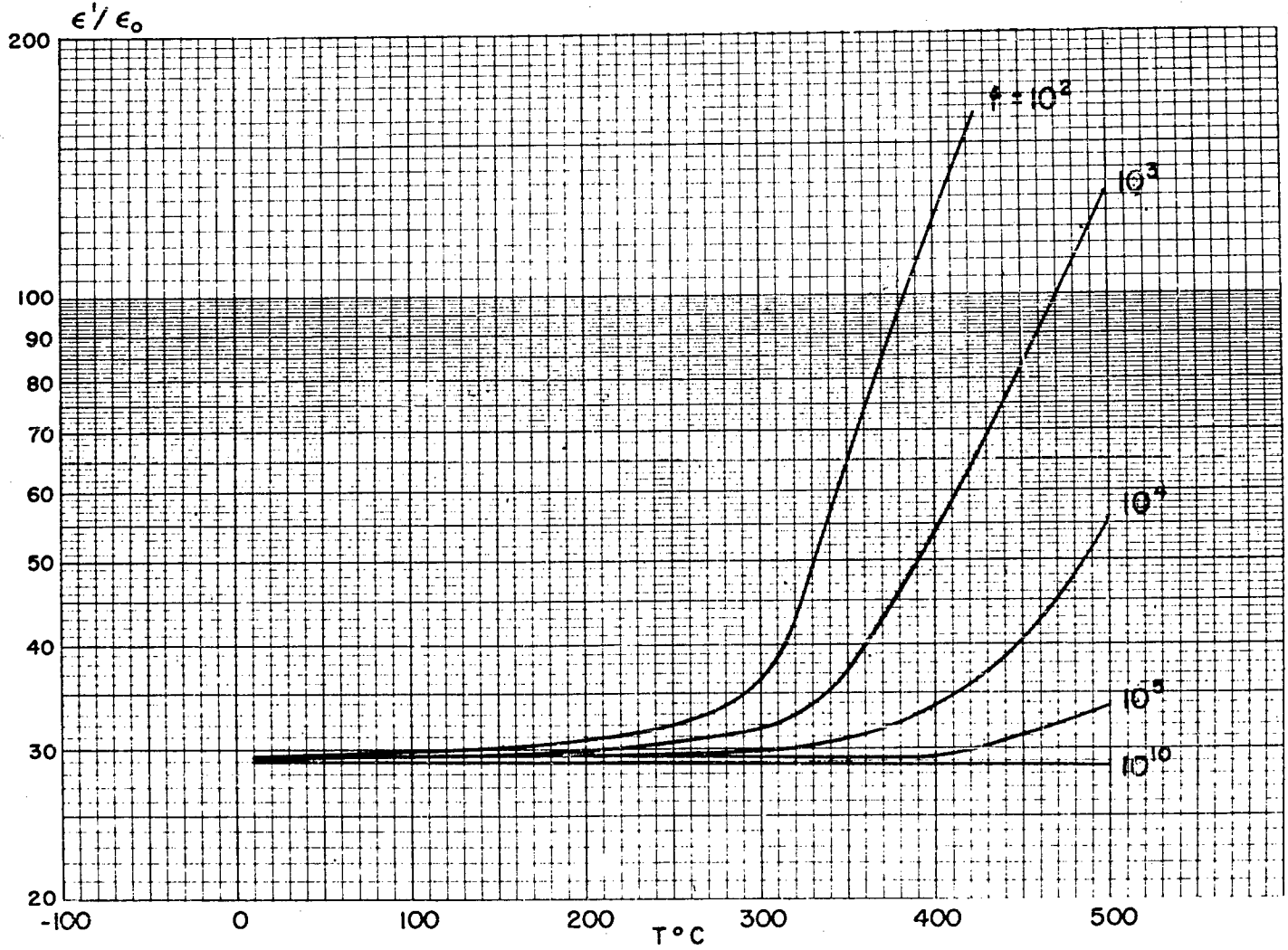
$\tan \delta$



Titania and Titanate Bodies

Ceramic NPOT 96

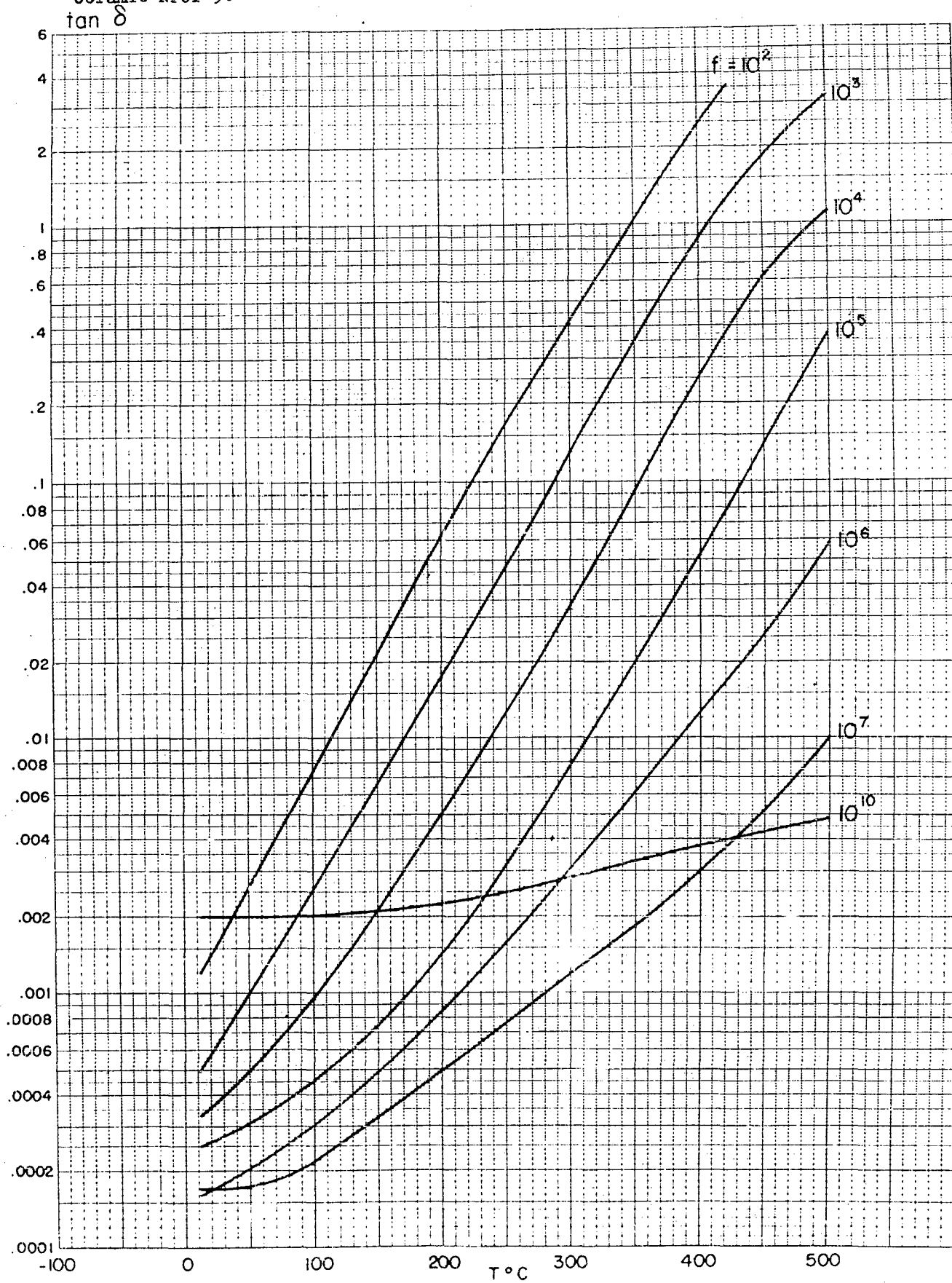
Amer. Lava



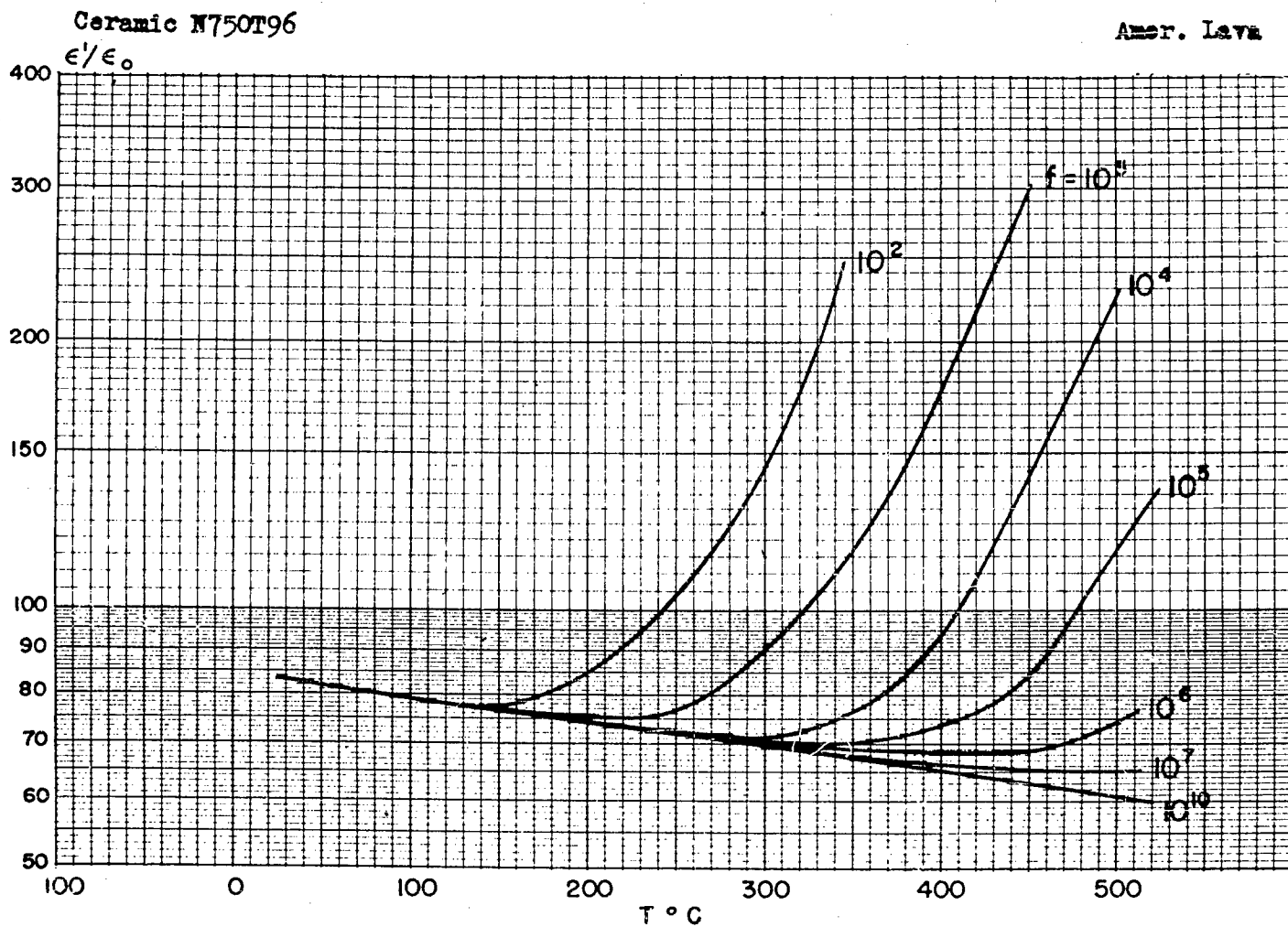
Titania and Titanate Bodies (cont.)

Ceramic NPOT 96

Amer. Lava



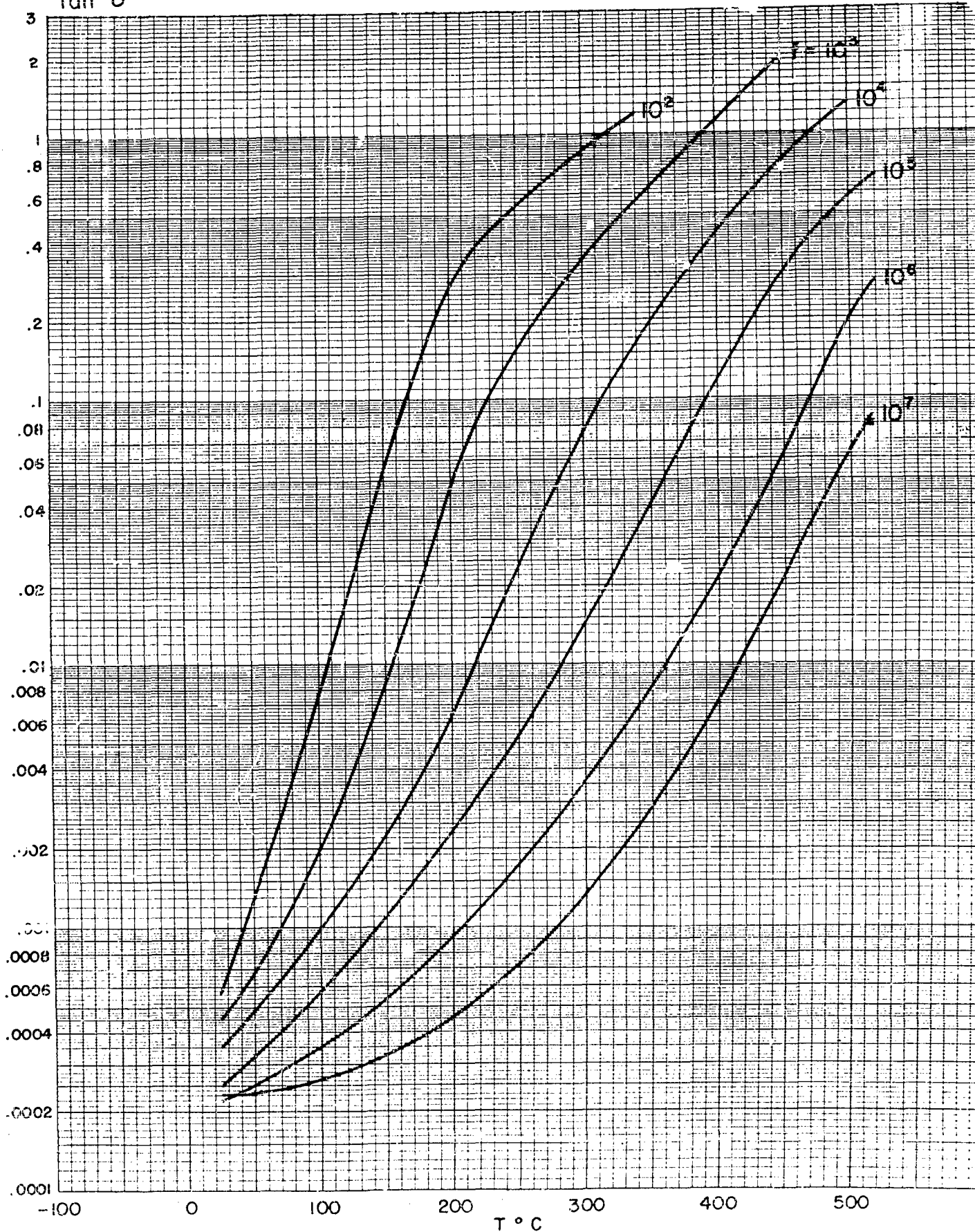
Titania and Titanate Bodies (cont.)



Titania and Titanate Bodies (cont.)

Ceramic N750T96
tan δ

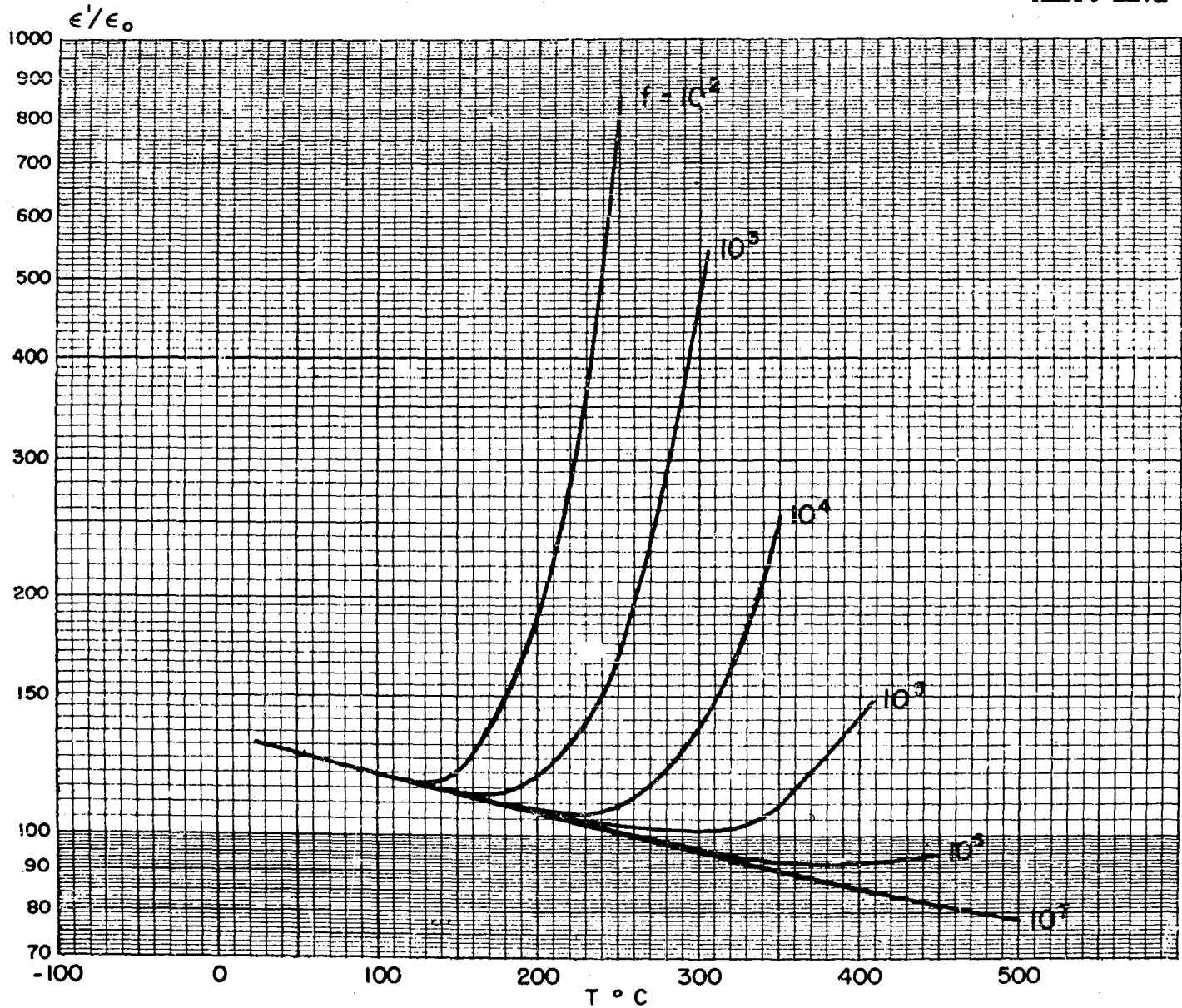
Amer. Lava



Titania and Titanate Bodies (cont.)

Ceramic N1400T110

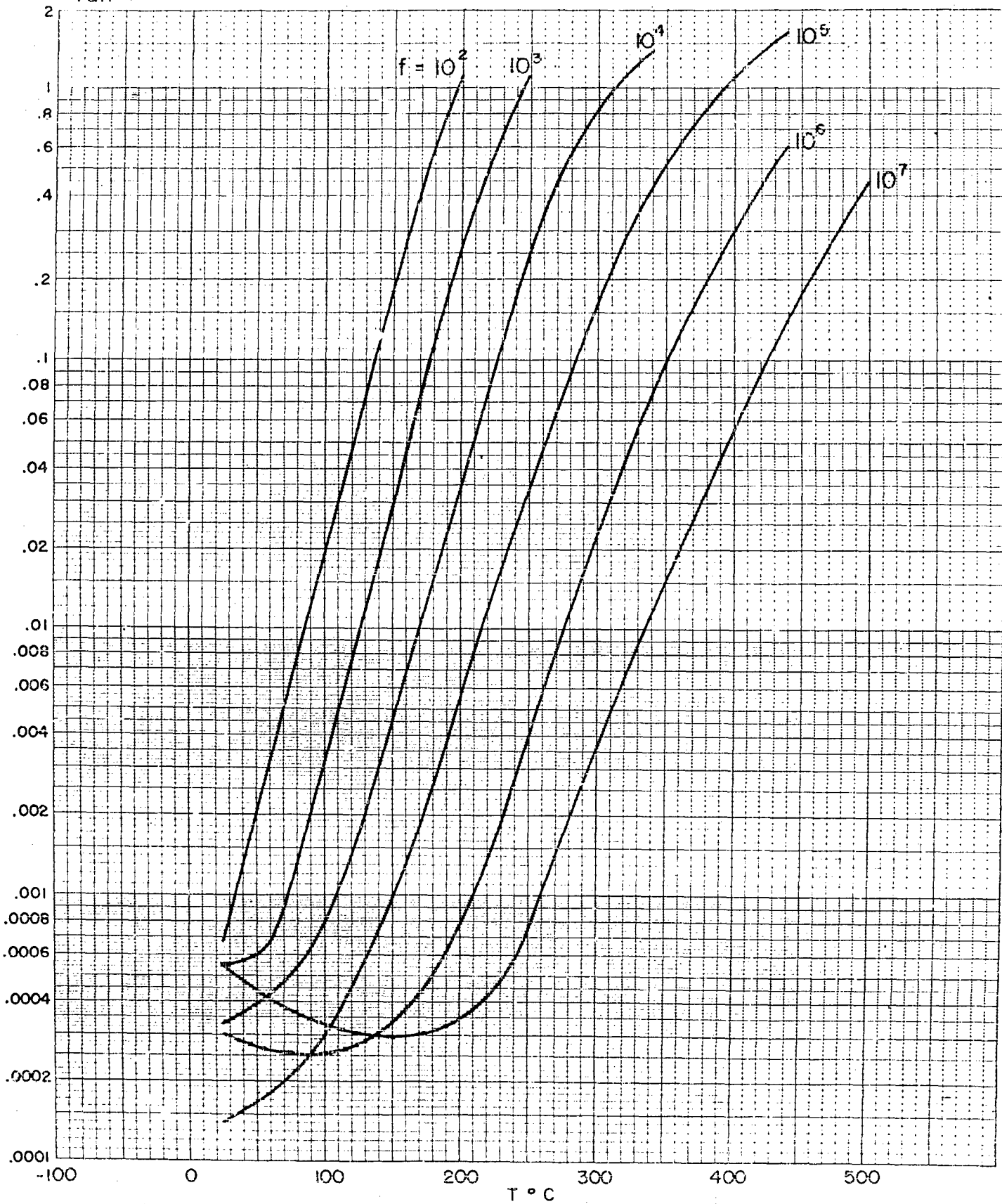
Amer. Lava



Titania and Titanate Bodies (cont.)

Ceramic N1400T110
 $\tan \delta$

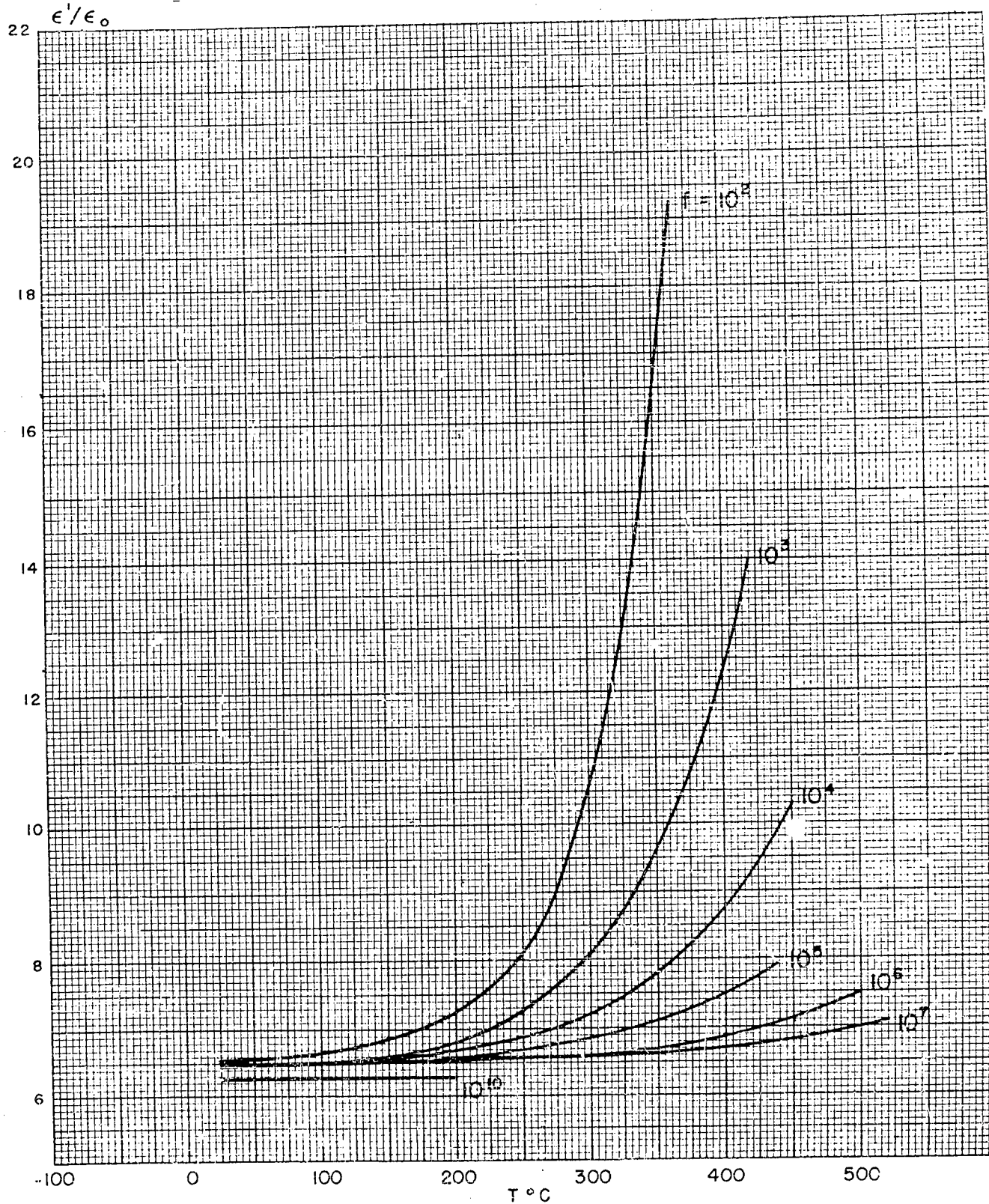
Amer. Lava



Porcelains

Zirconium porcelain Z1-4

Coors

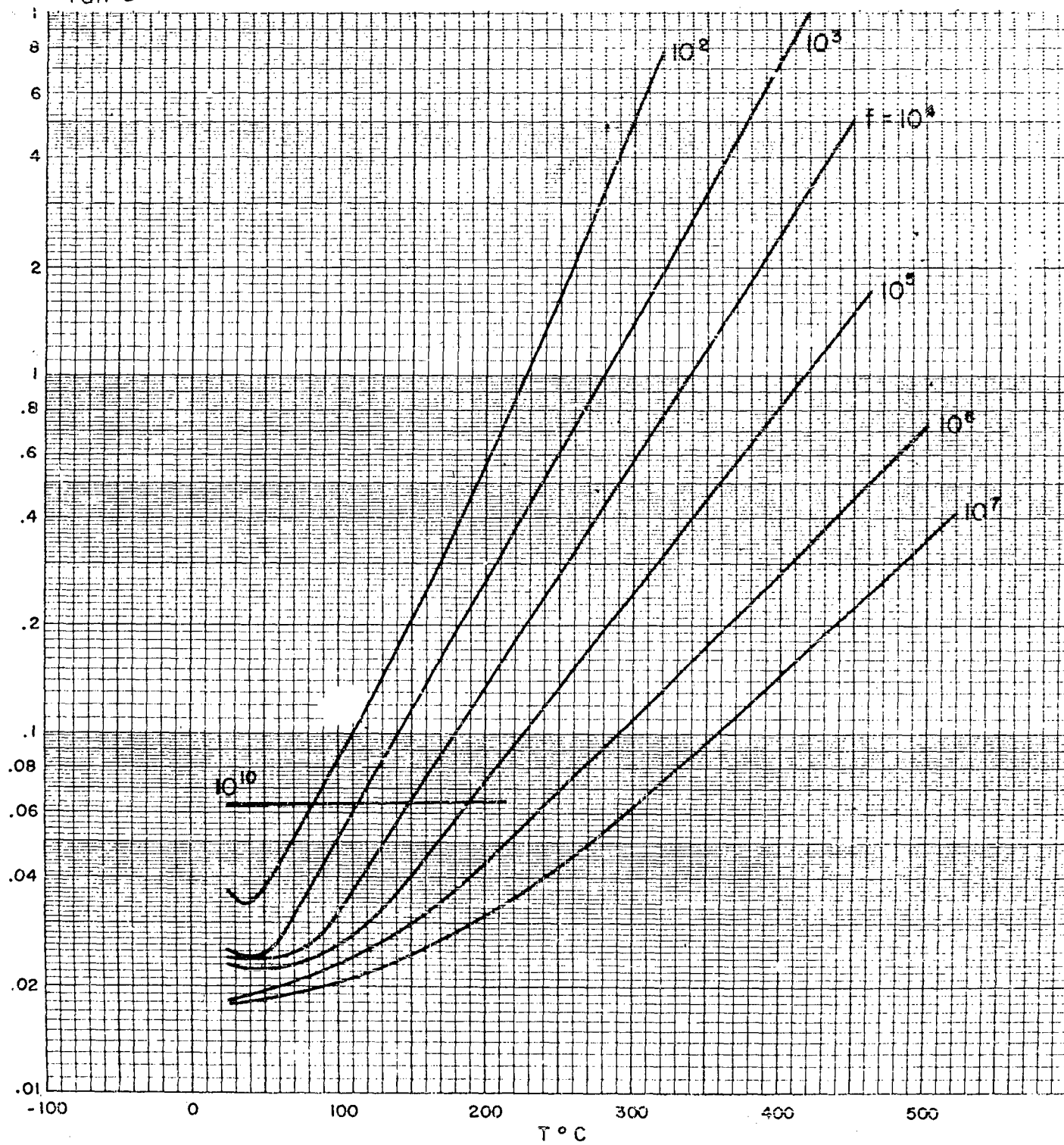


Porcelains (cont.)

Zirconium porcelain Zi-4

Coors

$\tan \delta$

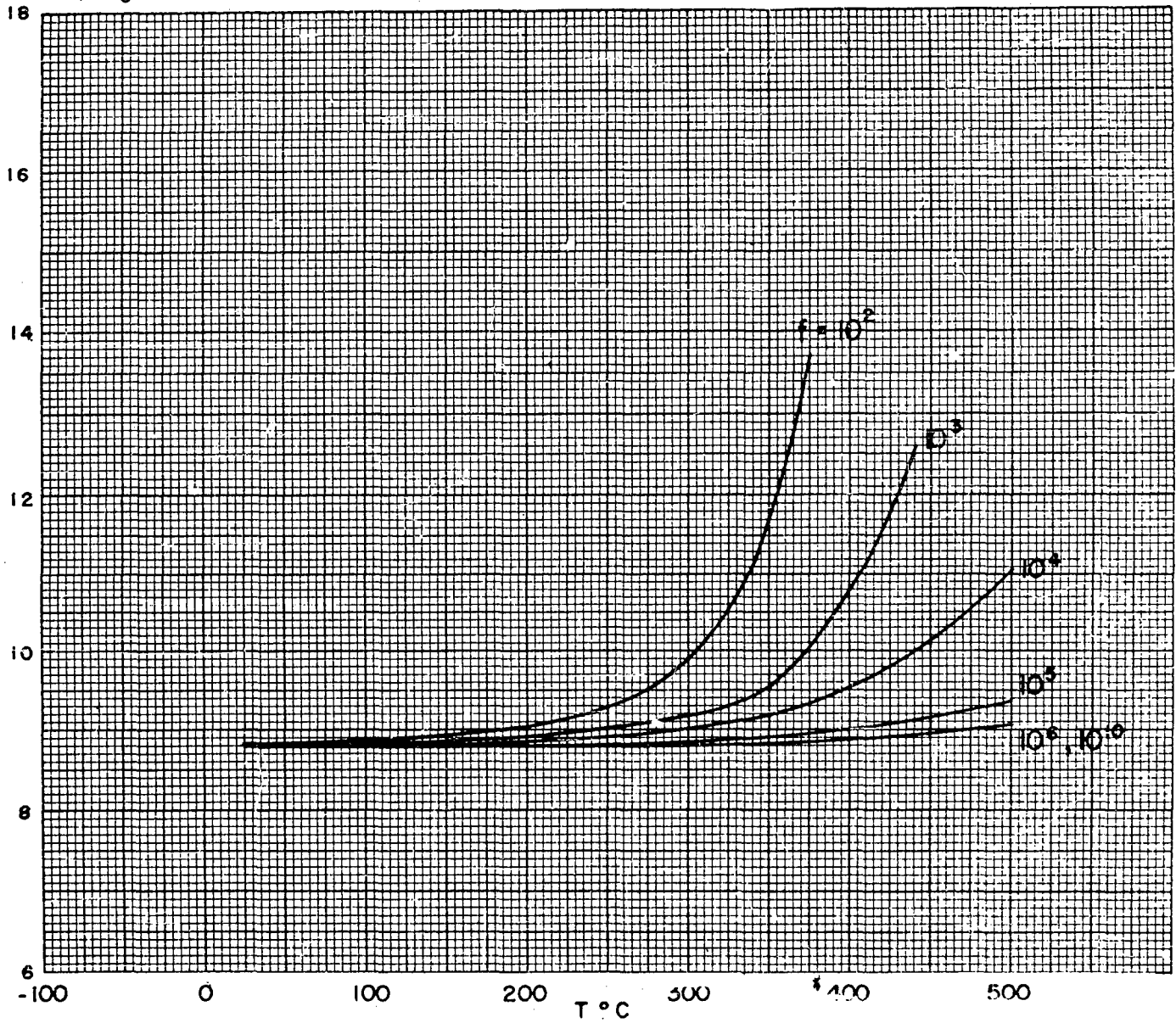


Porcelains (cont.)

Coors AI-200

Coors

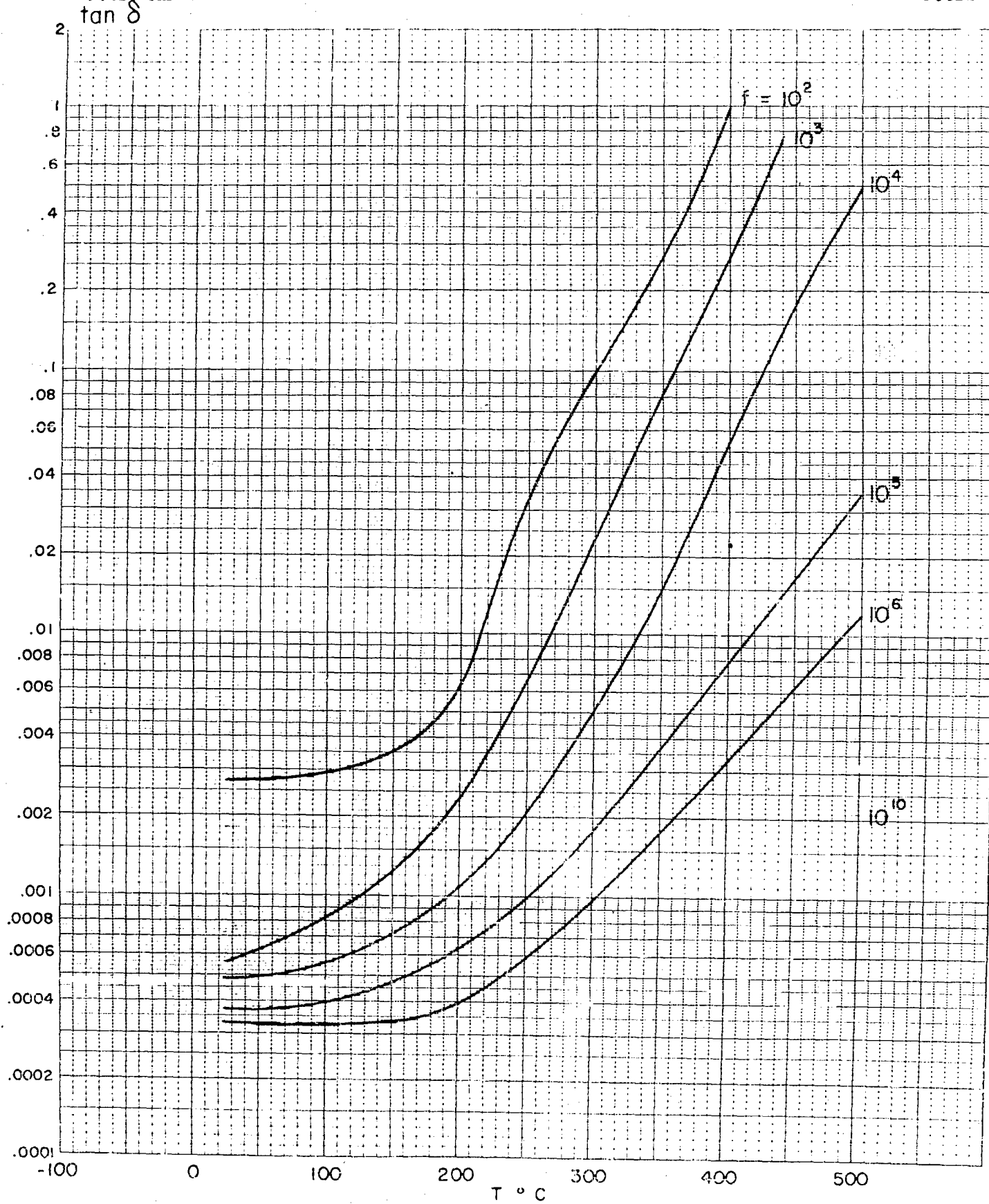
ϵ'/ϵ_0



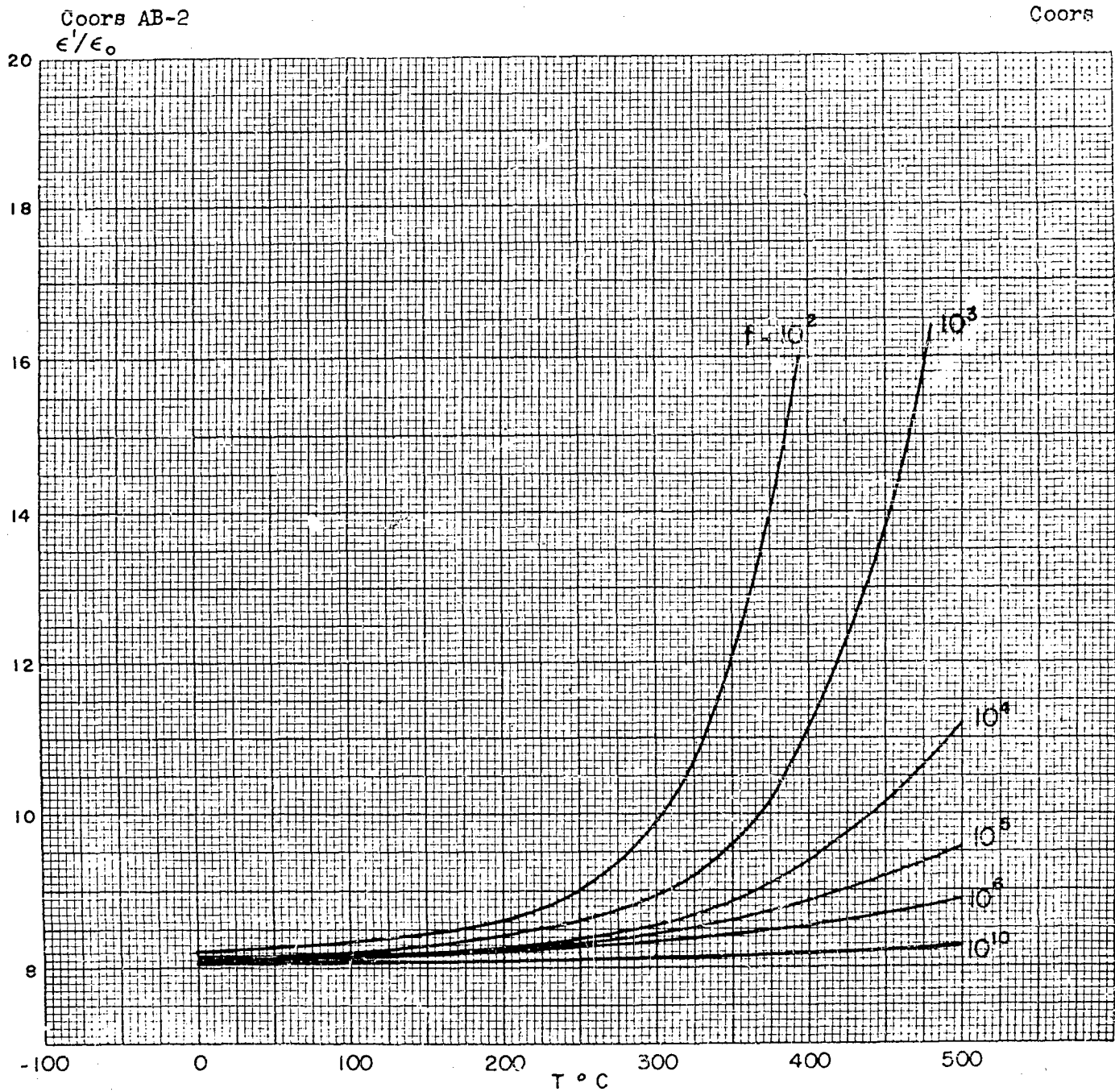
Porcelains (cont.)

Coors AI-200

Coors



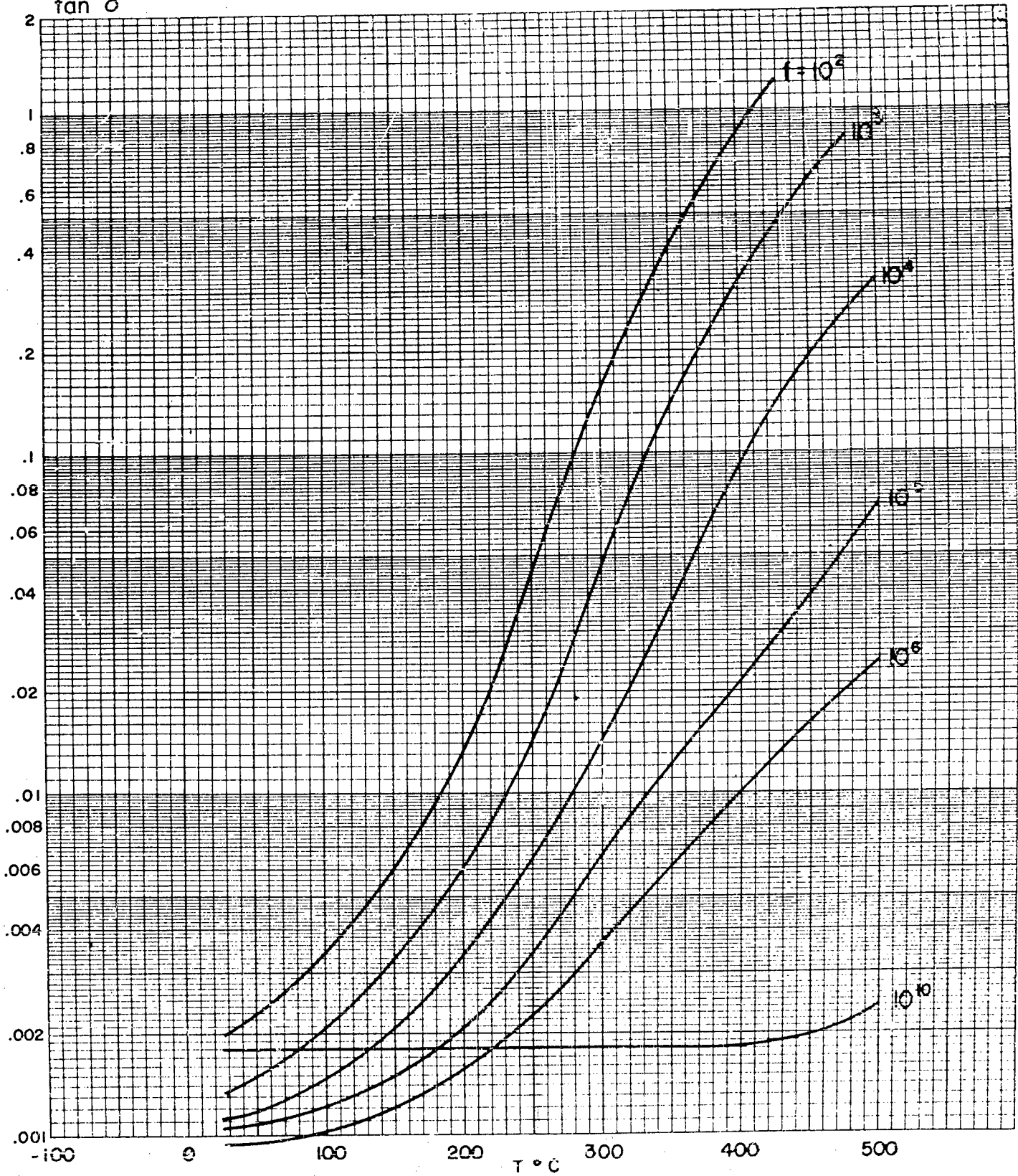
Porcelains (cont.)



Porcelains (cont.)

Coors

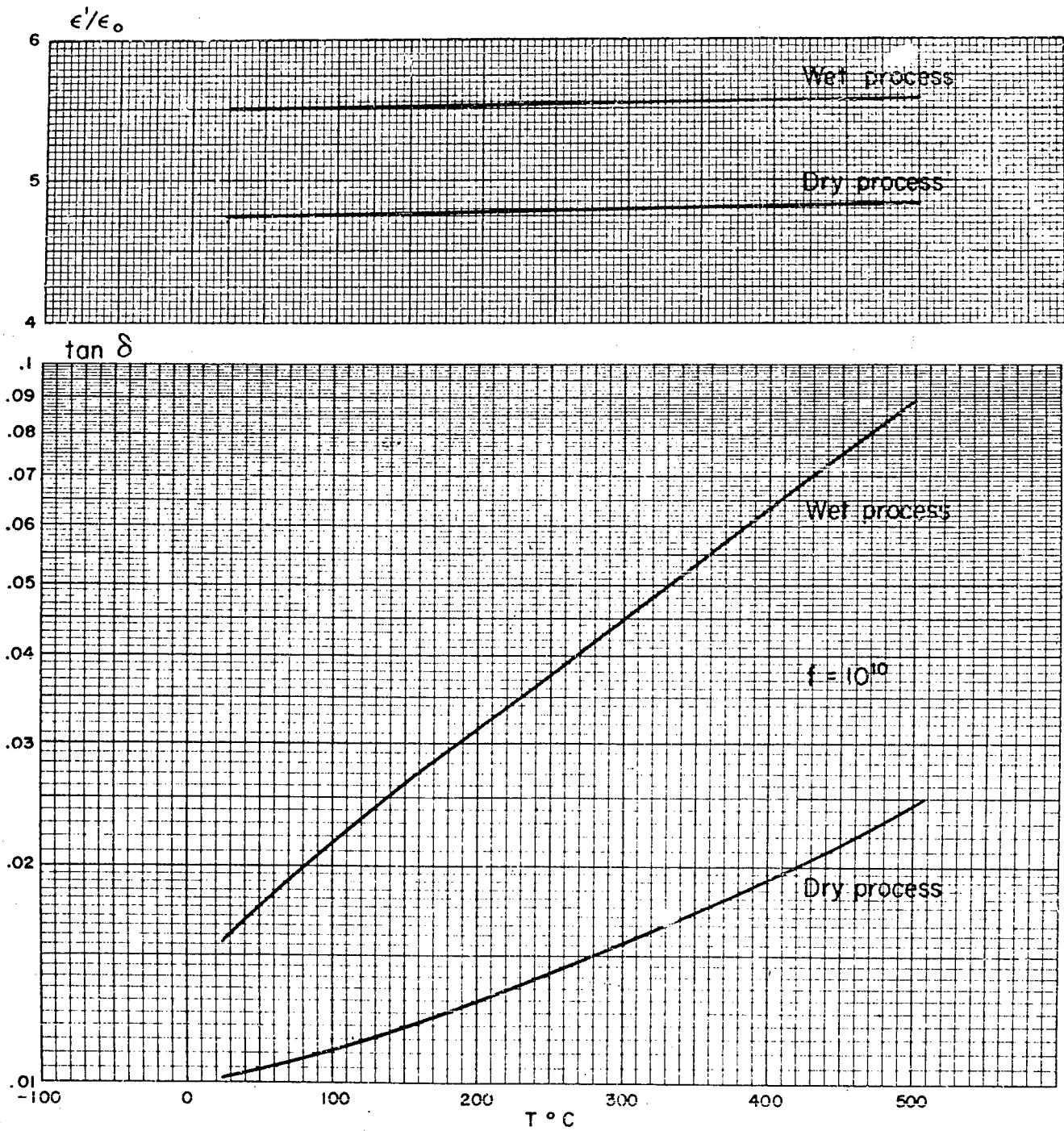
Coors AB-2
tan δ



Porcelains (cont.)

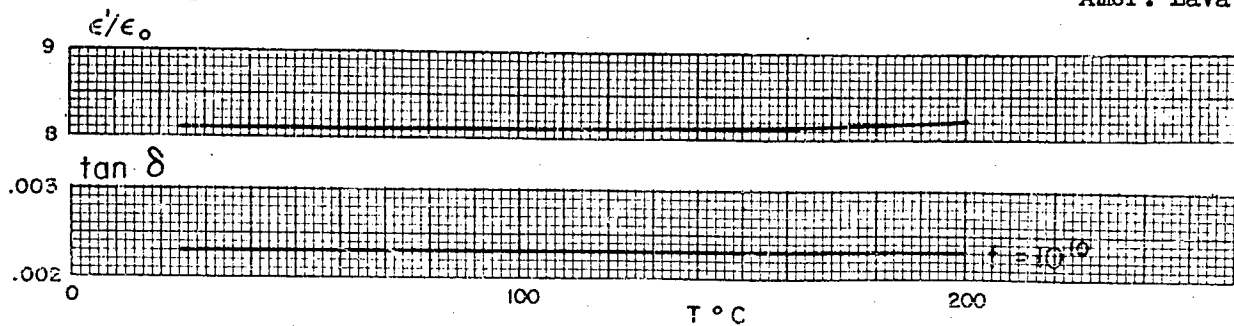
Porcelain, wet process; dry process

Knox



AlSiMag 491

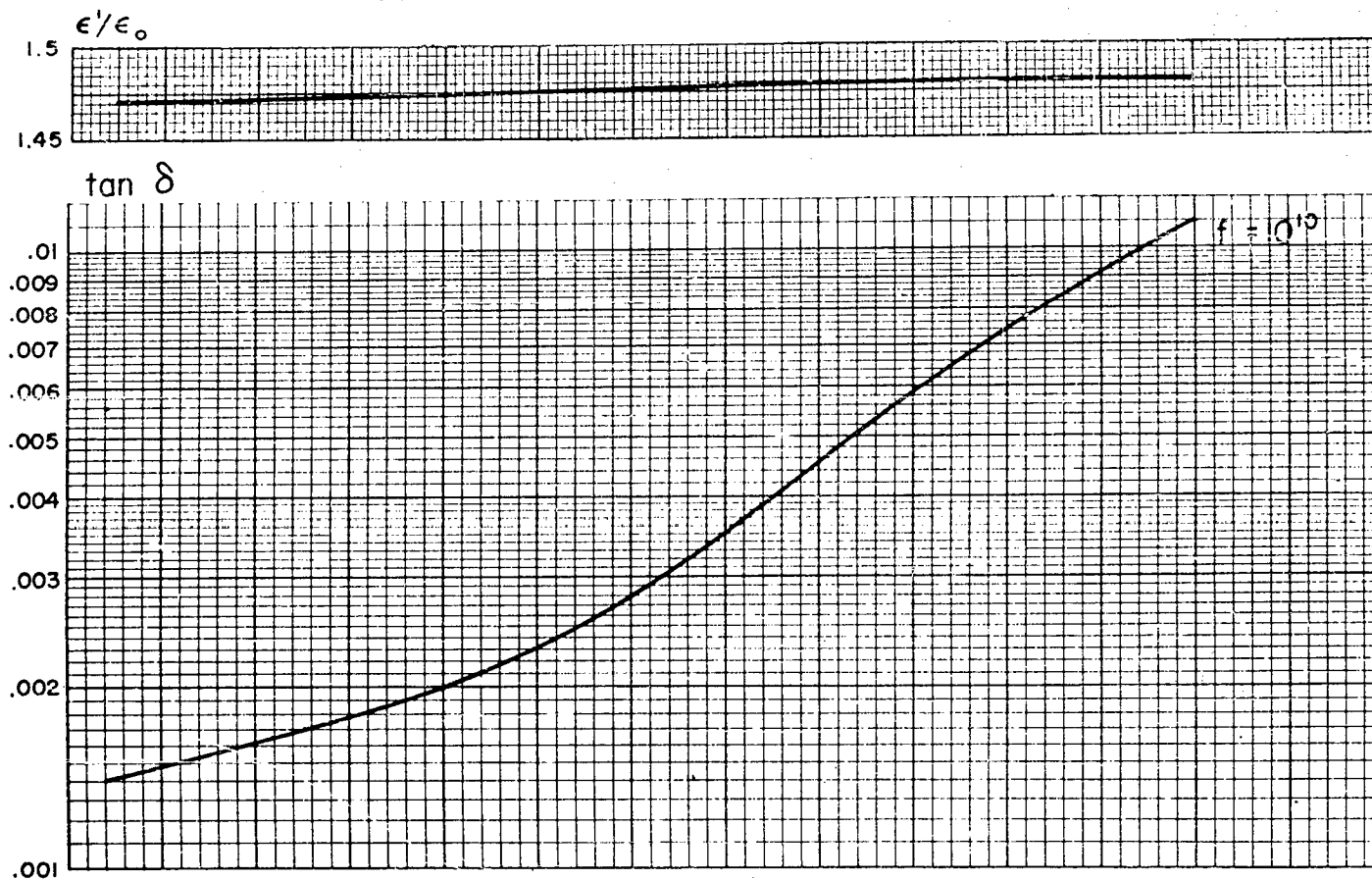
Amer. Lava



Miscellaneous Ceramics

Porous Ceramic AF-497

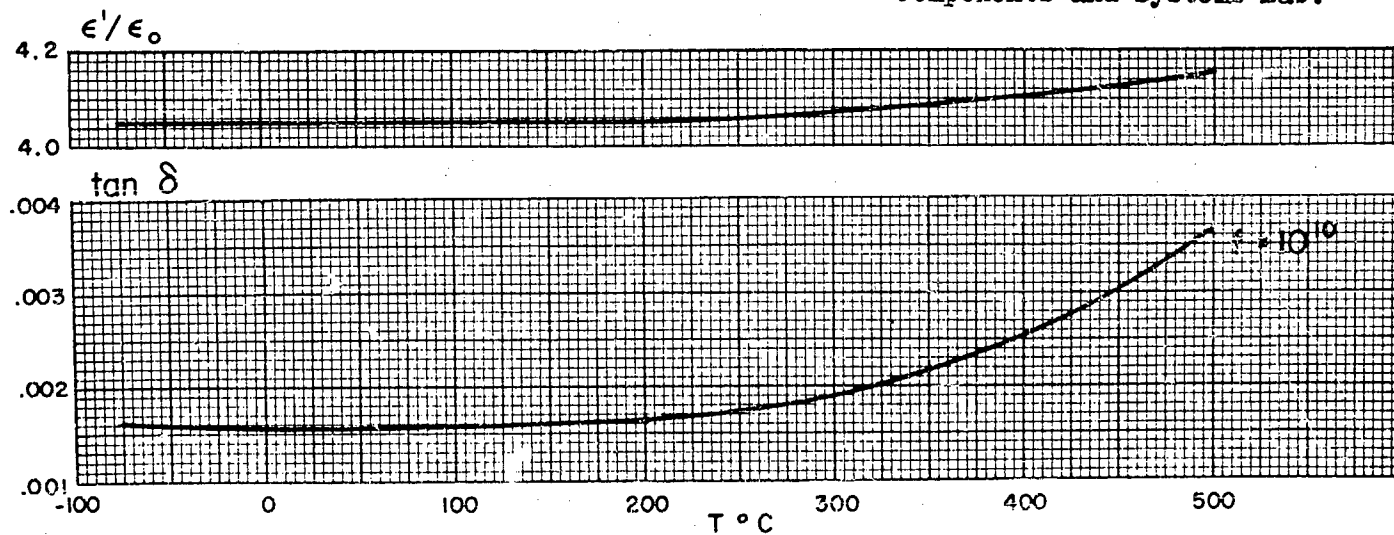
Stupakoff



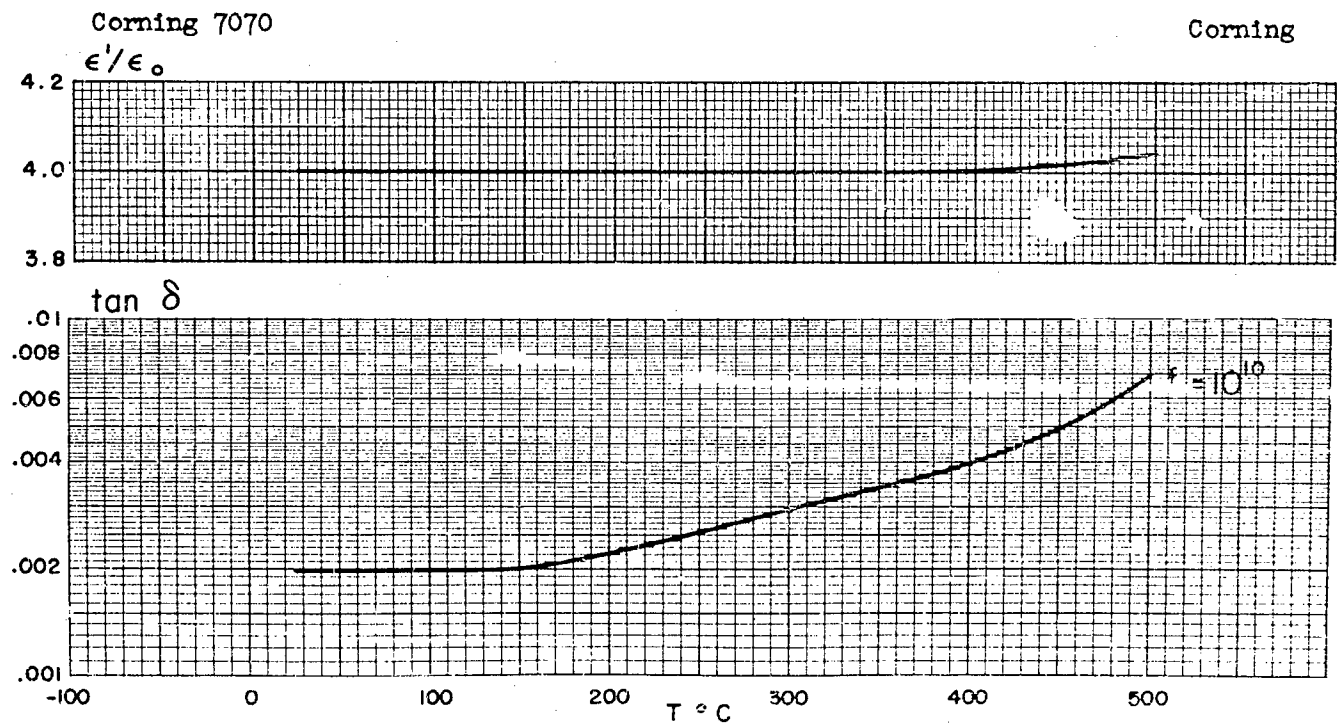
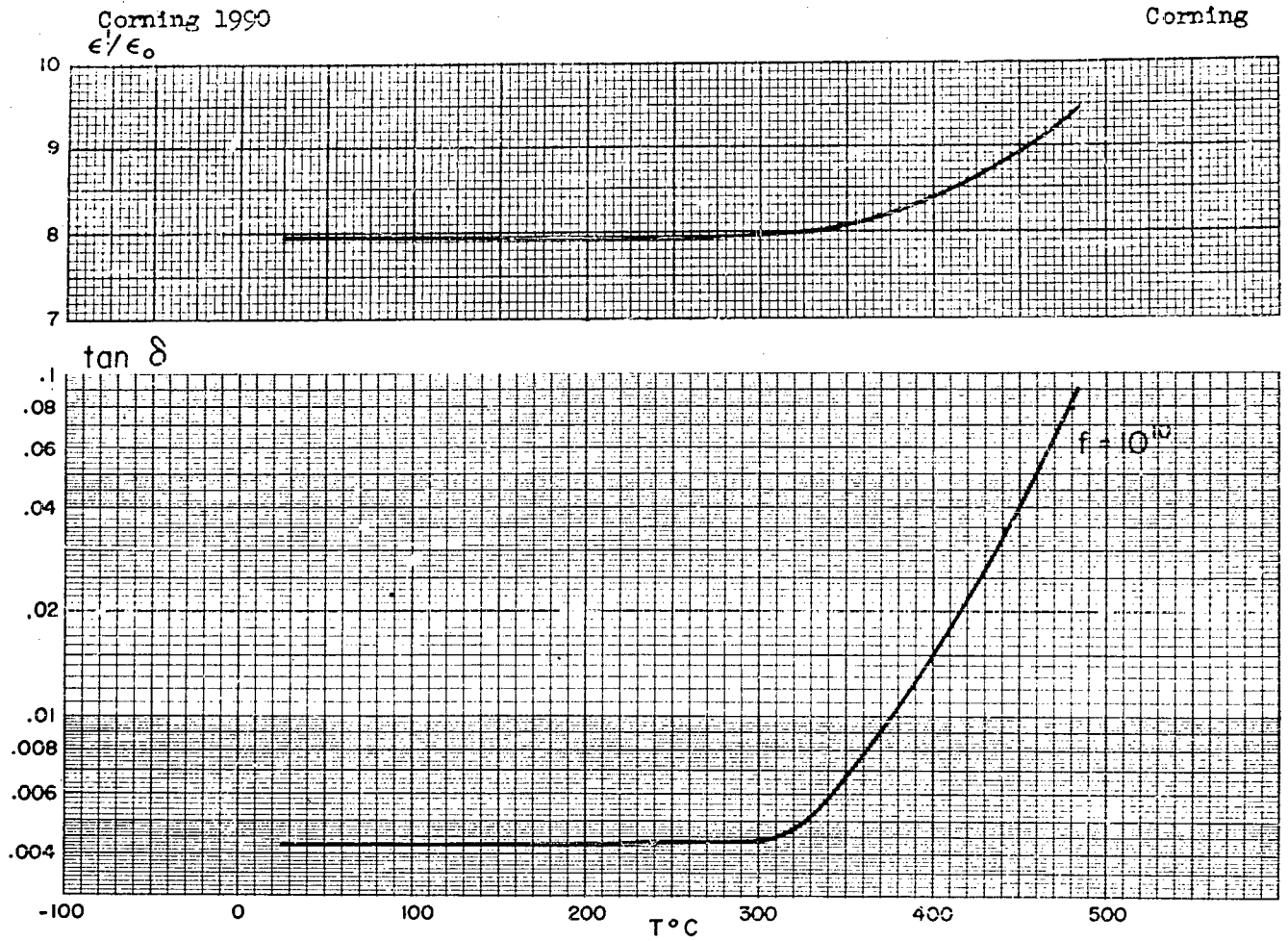
Glasses

Borosilicate Glass

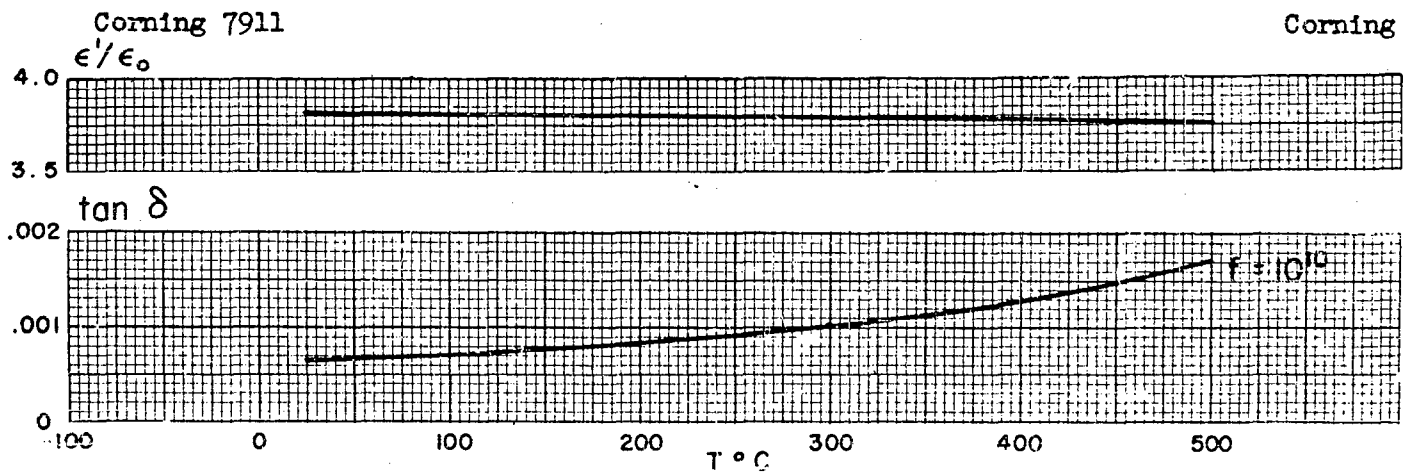
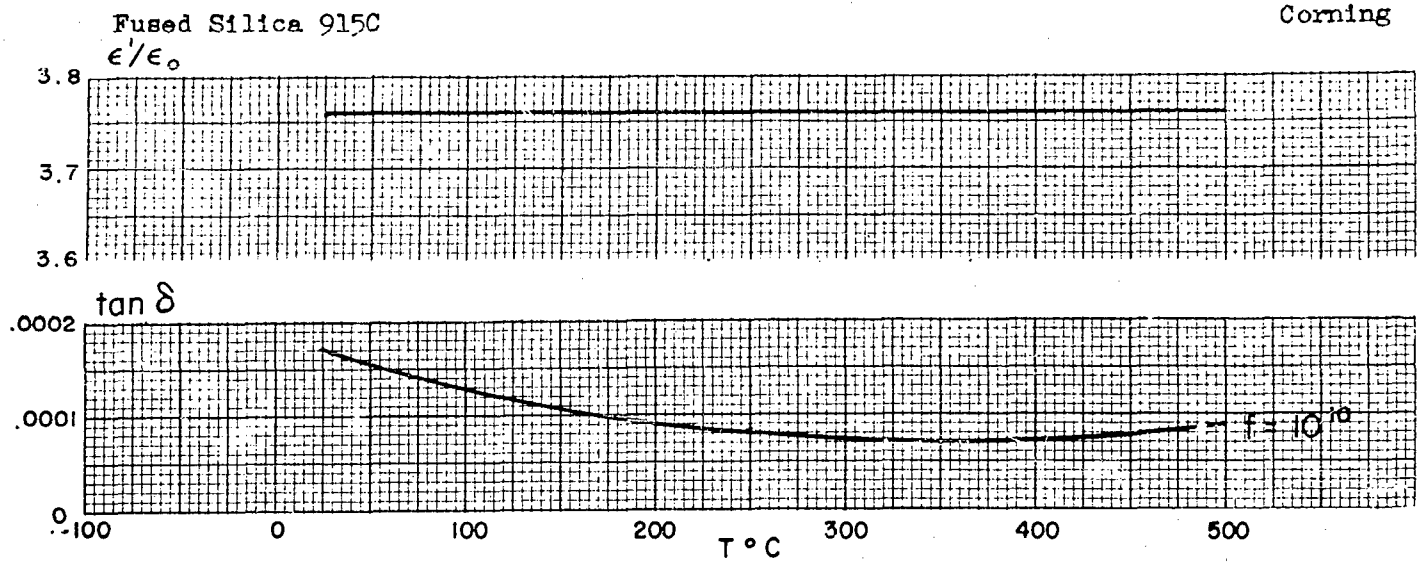
Components and Systems Lab.



Glasses (cont.)



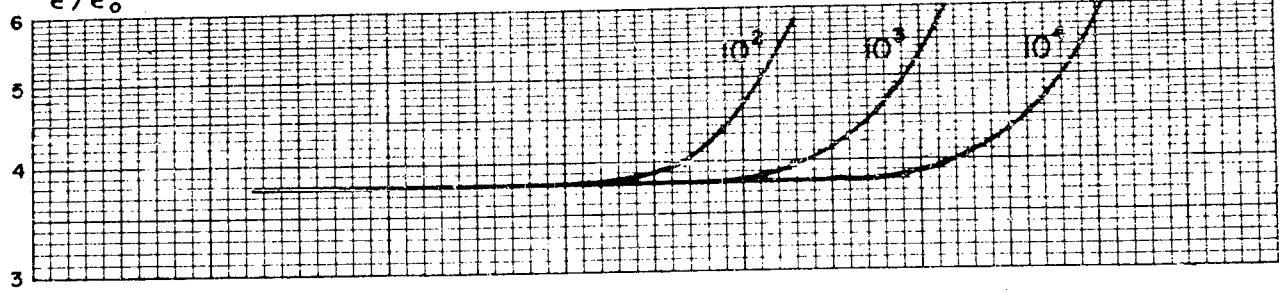
Glasses (cont.)



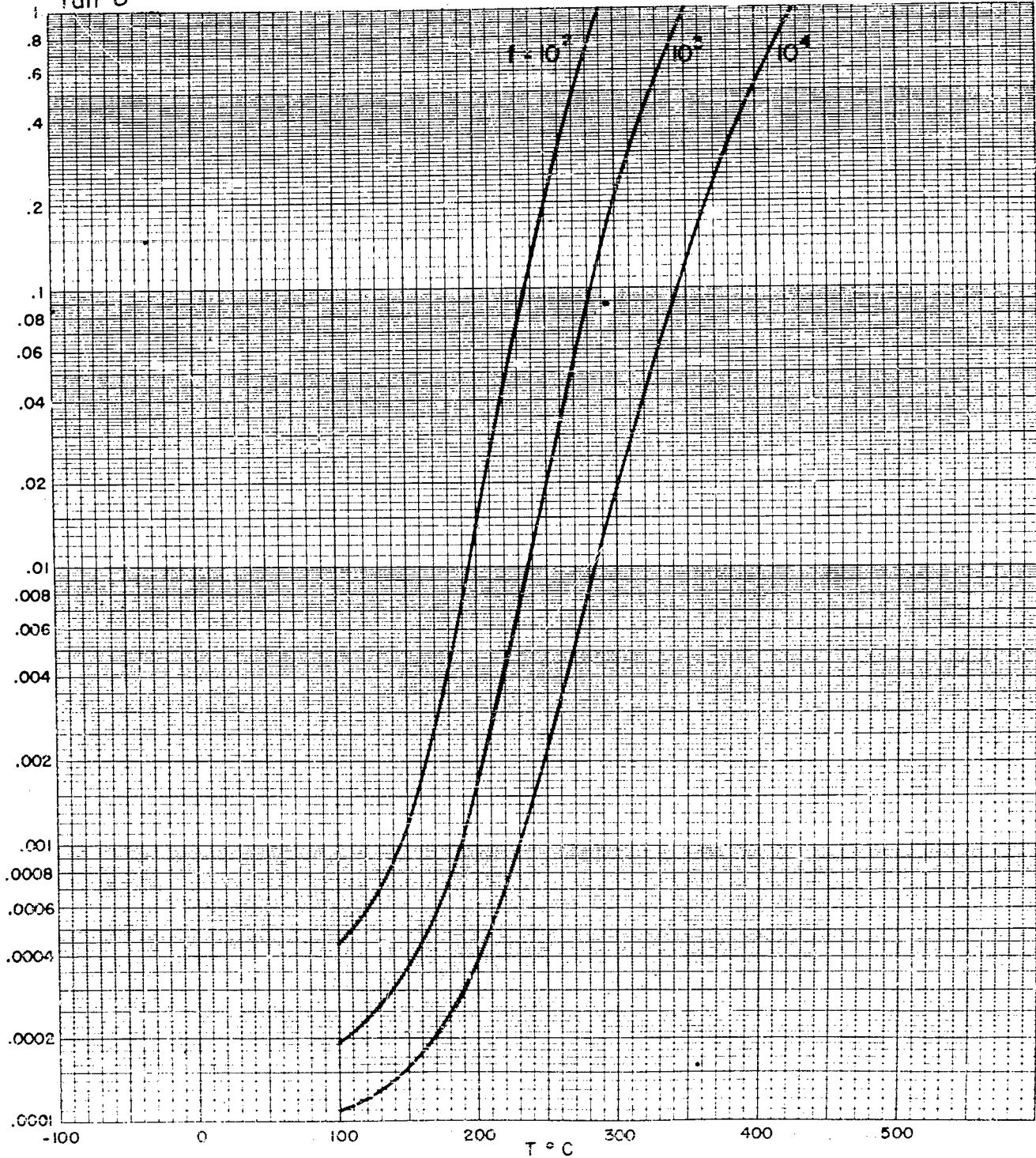
Glasses (cont.)

General Electric

Fused Quartz
 ϵ/ϵ_0



$\tan \delta$

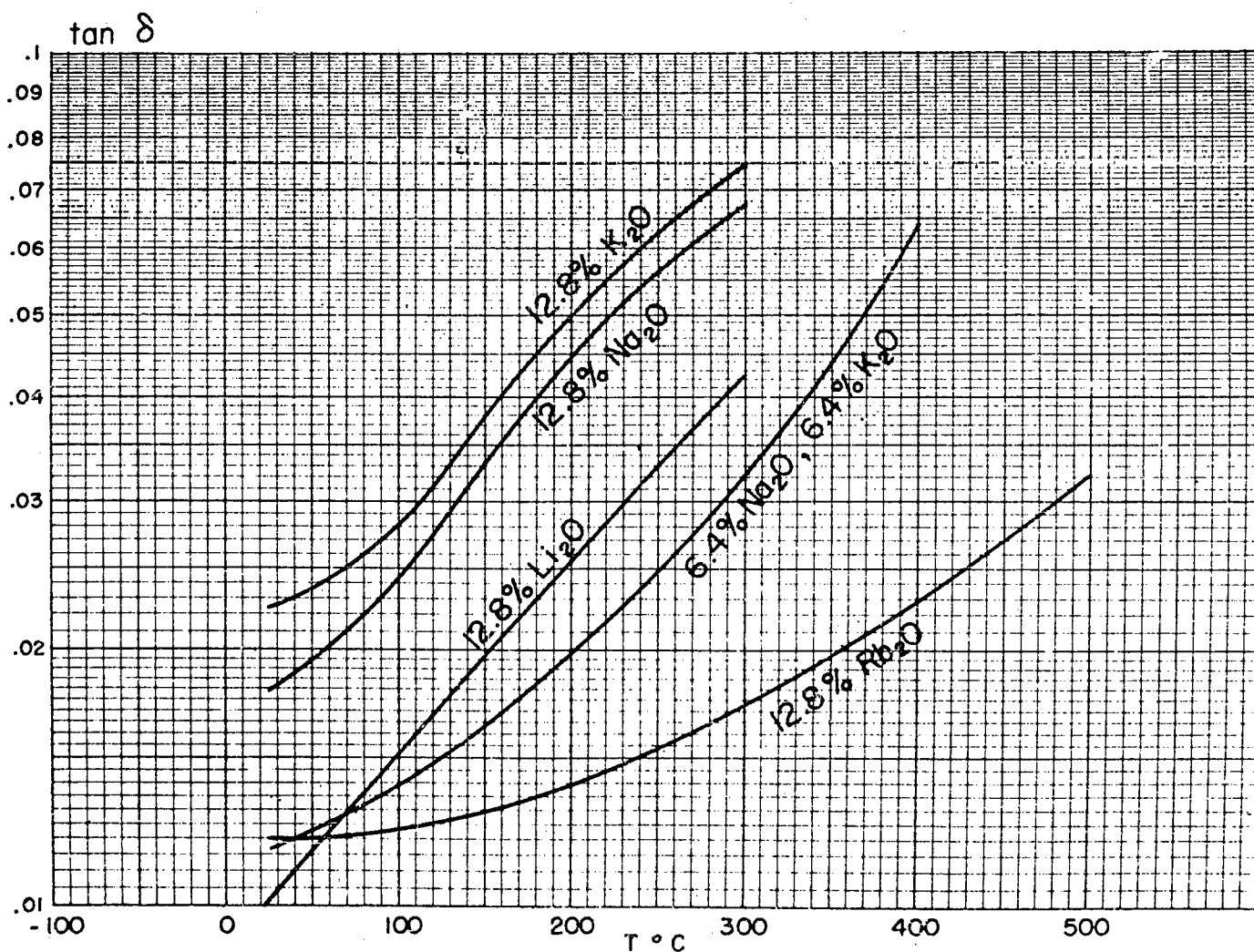
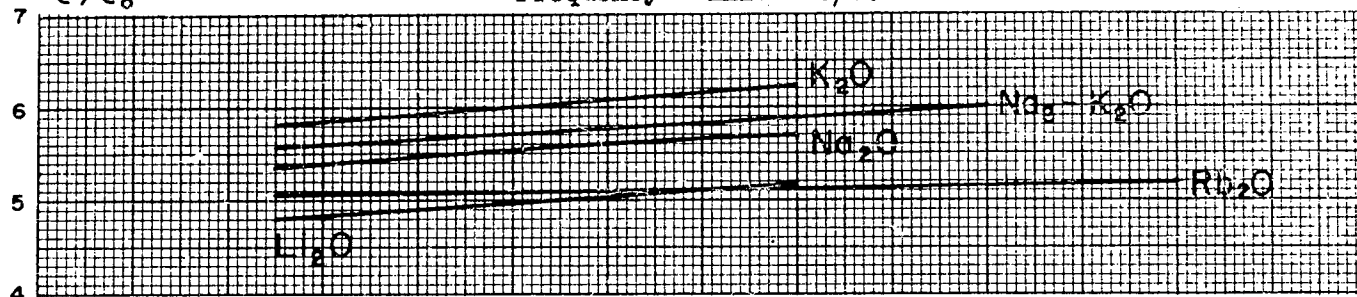


Glasses (cont.)

Alkali-silica-glasses
 ϵ'/ϵ_0

Frequency = 1×10^{10} c/s.

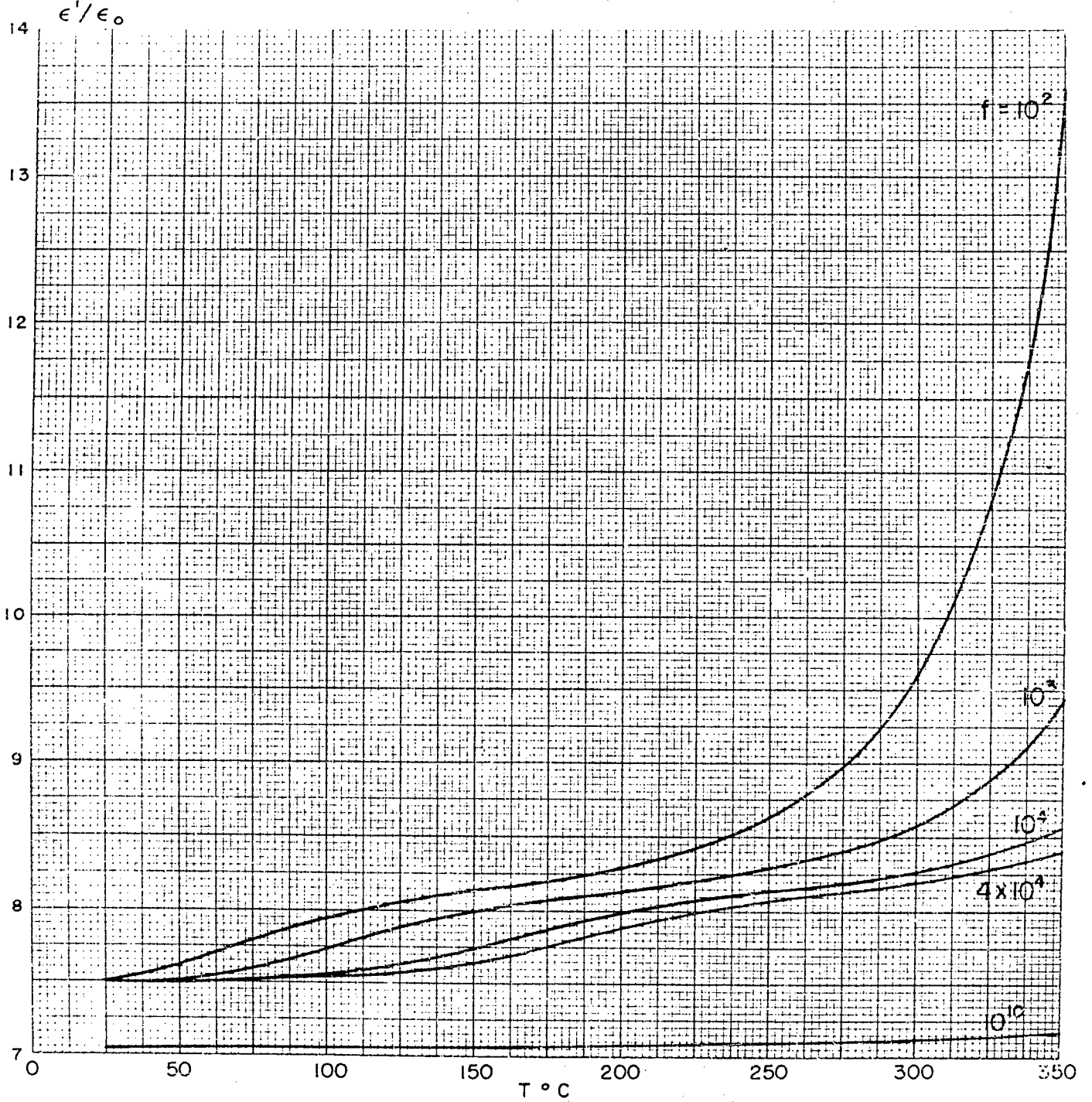
Lab. Ins. Res.



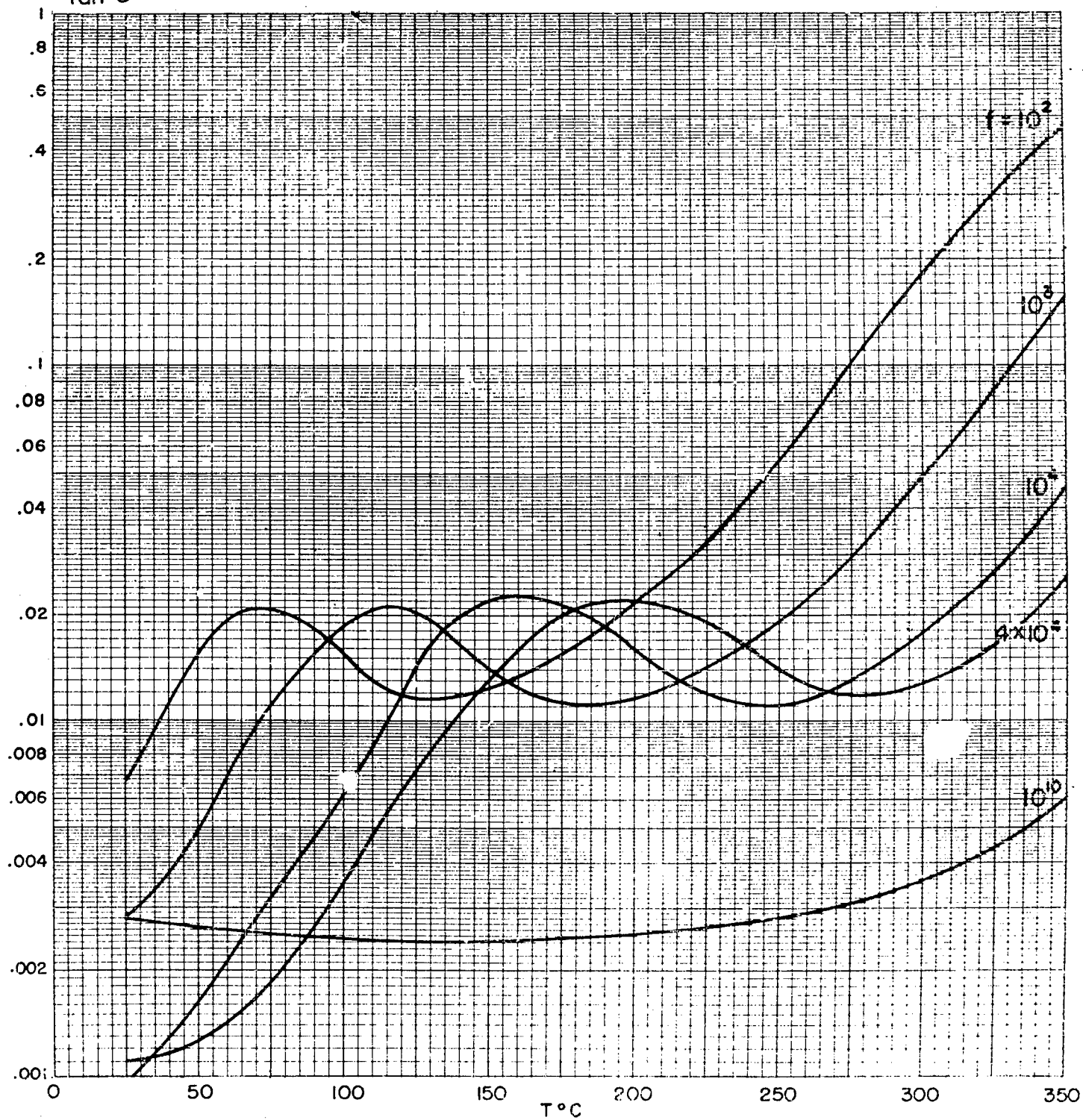
Mica and Glass

Mycalex 2821

General Electric



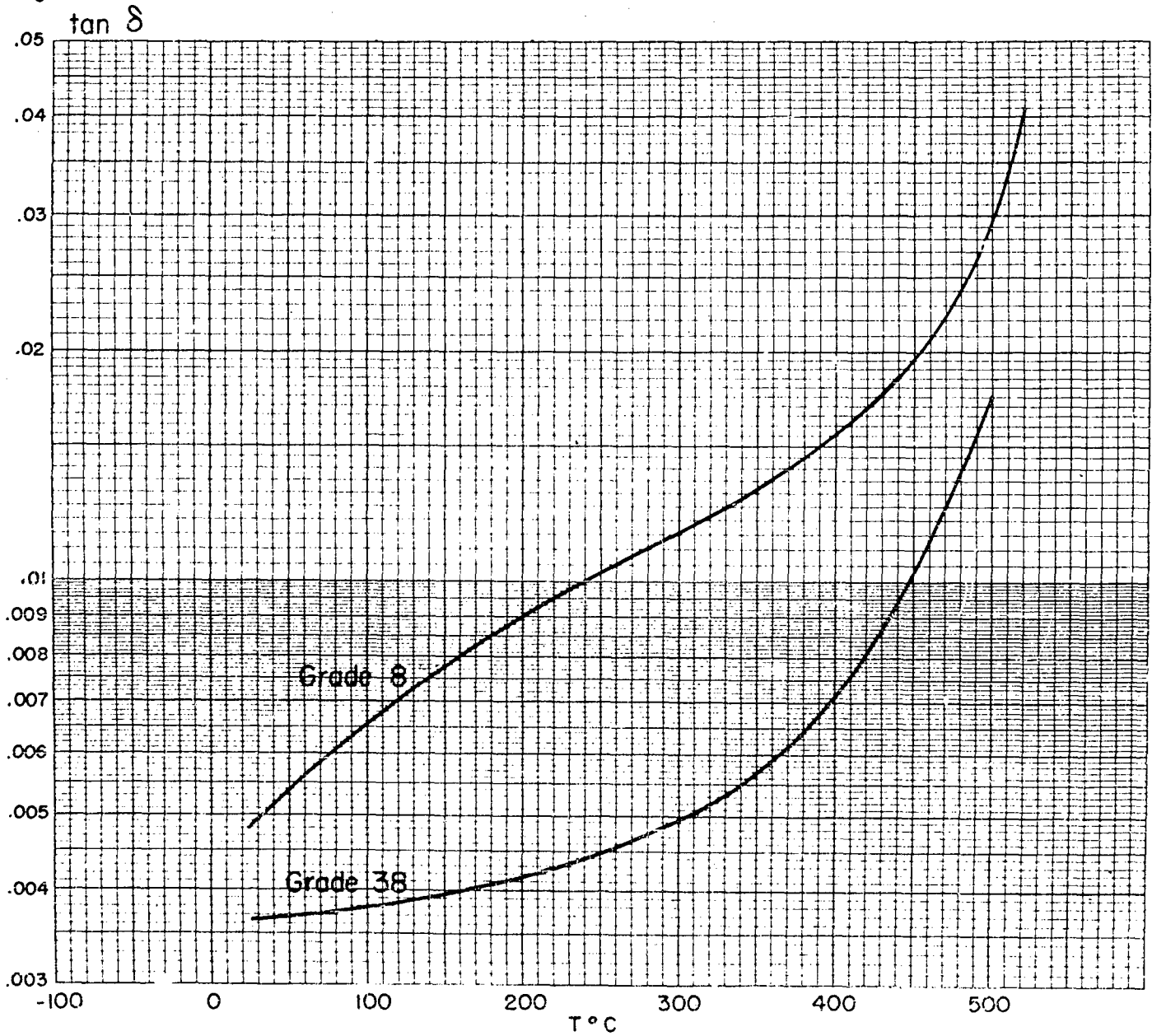
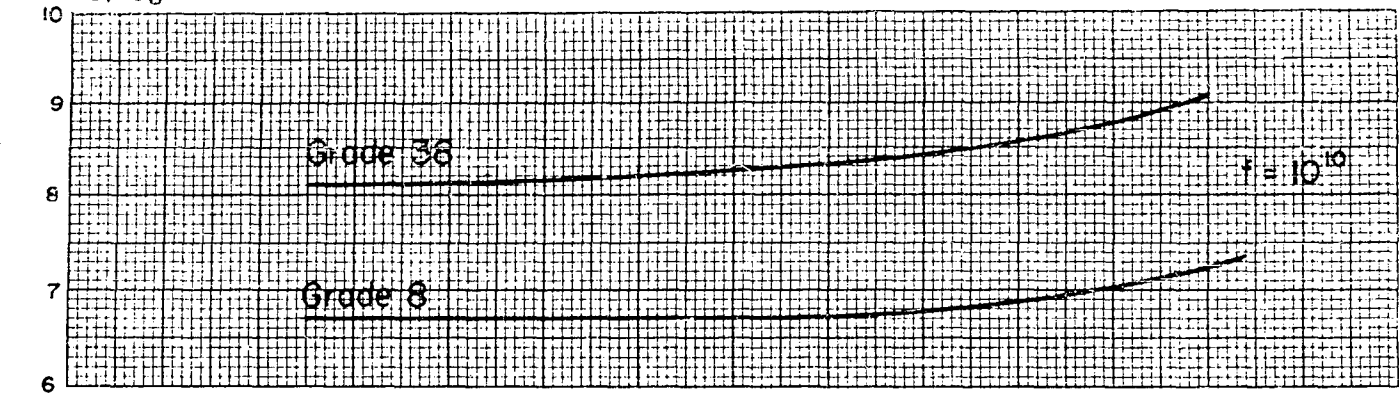
General Electric



Mica and Glass (cont.)

Mykroy Grade 8, Grade 38
 ϵ/ϵ_0

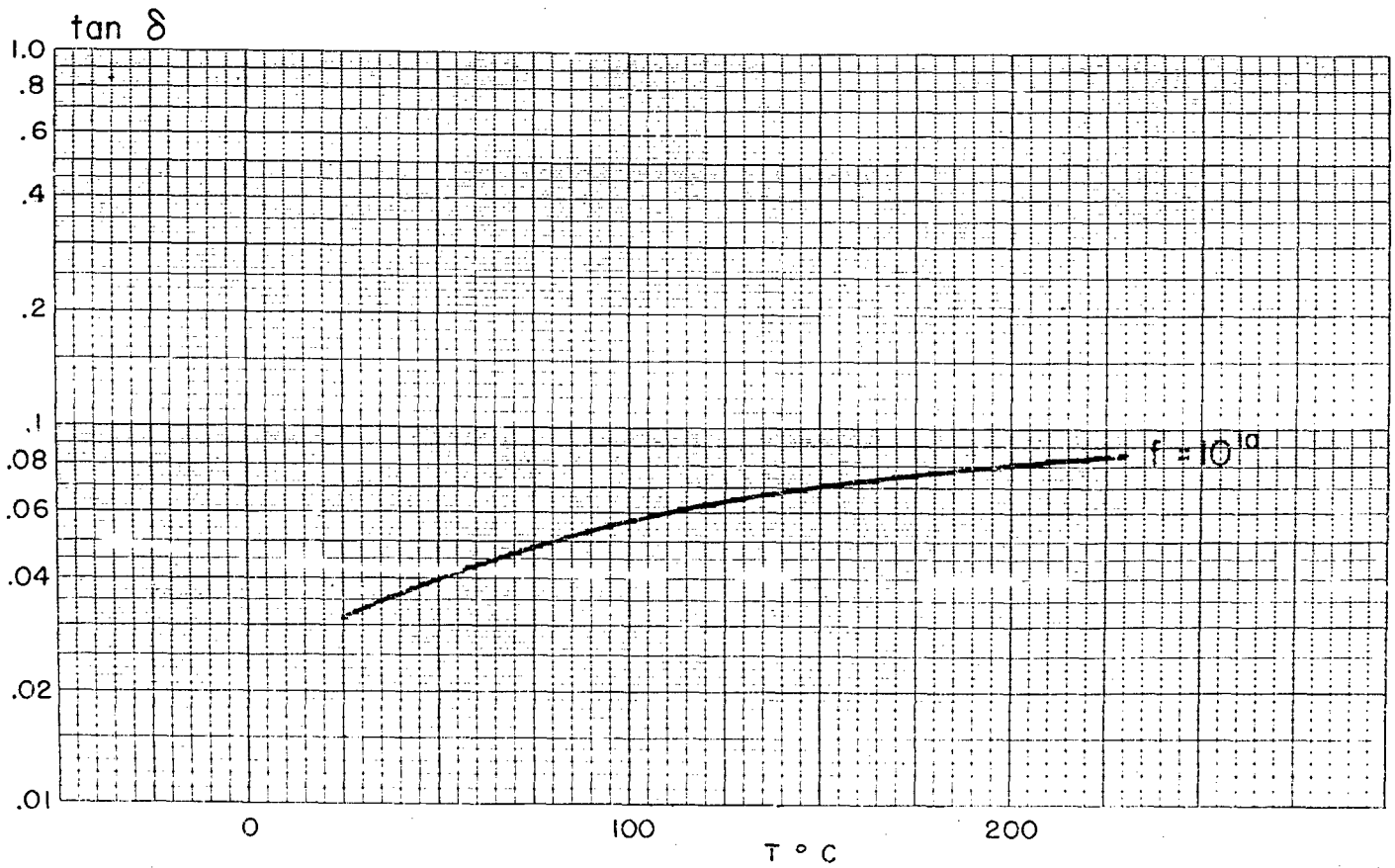
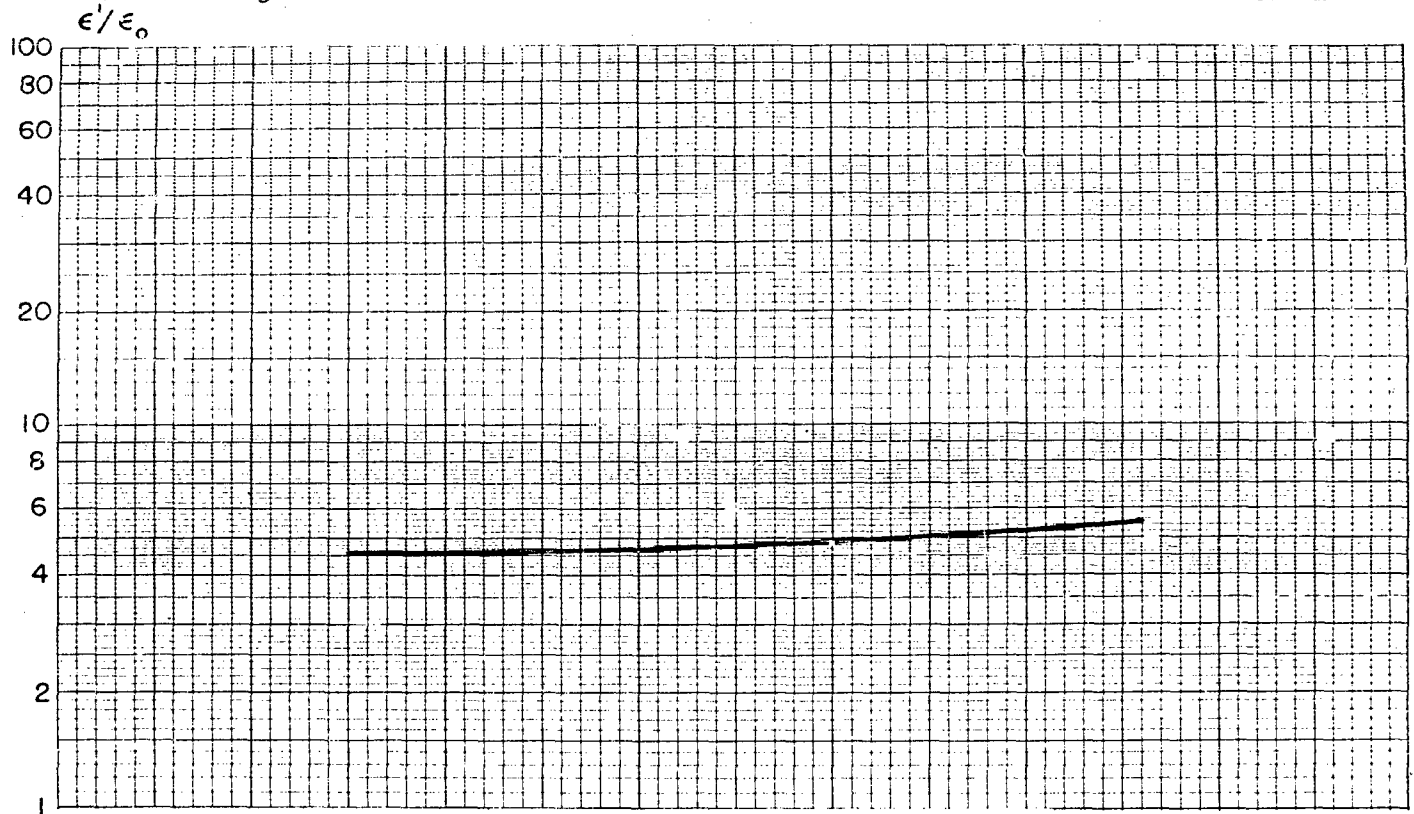
Electronic Mech.



Phenol-formaldehyde Resins

Resinox 10231

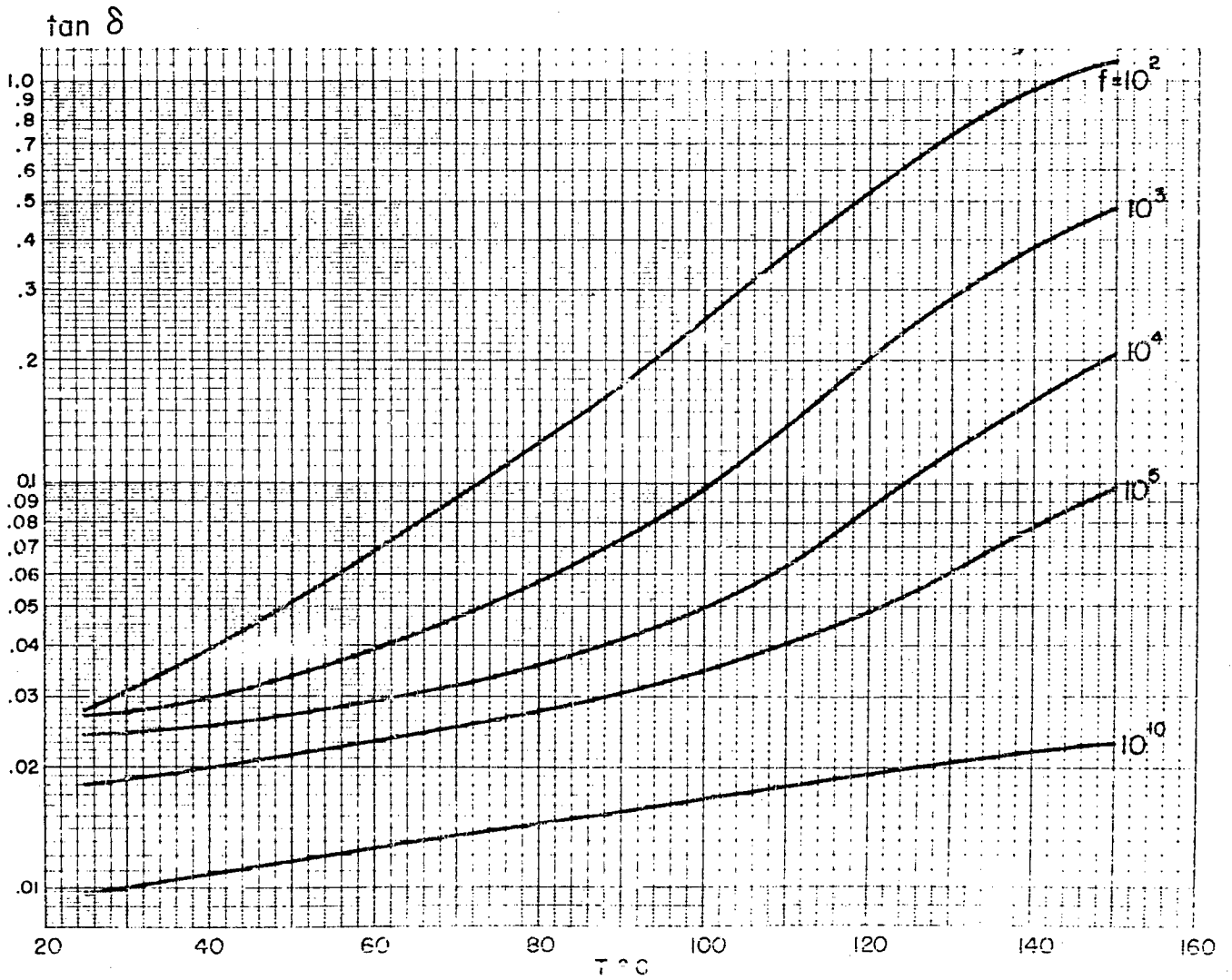
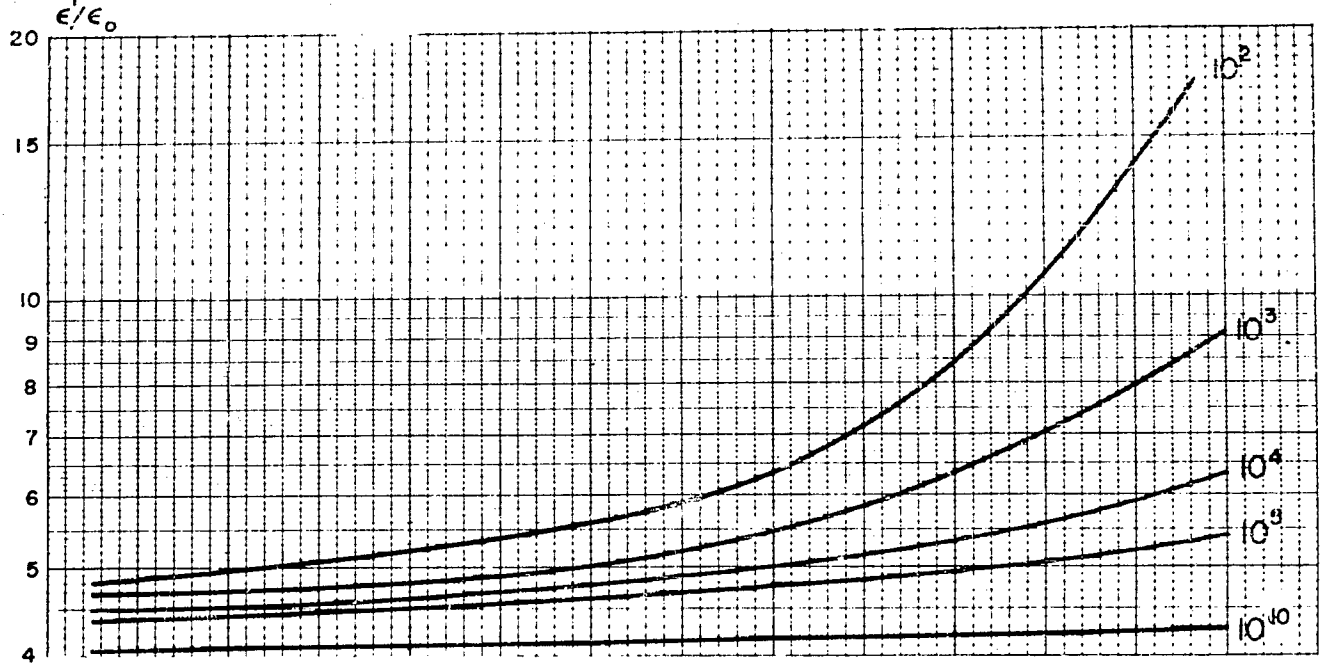
Monsanto



Phenol-formaldehyde Resins (cont.)

Monsanto

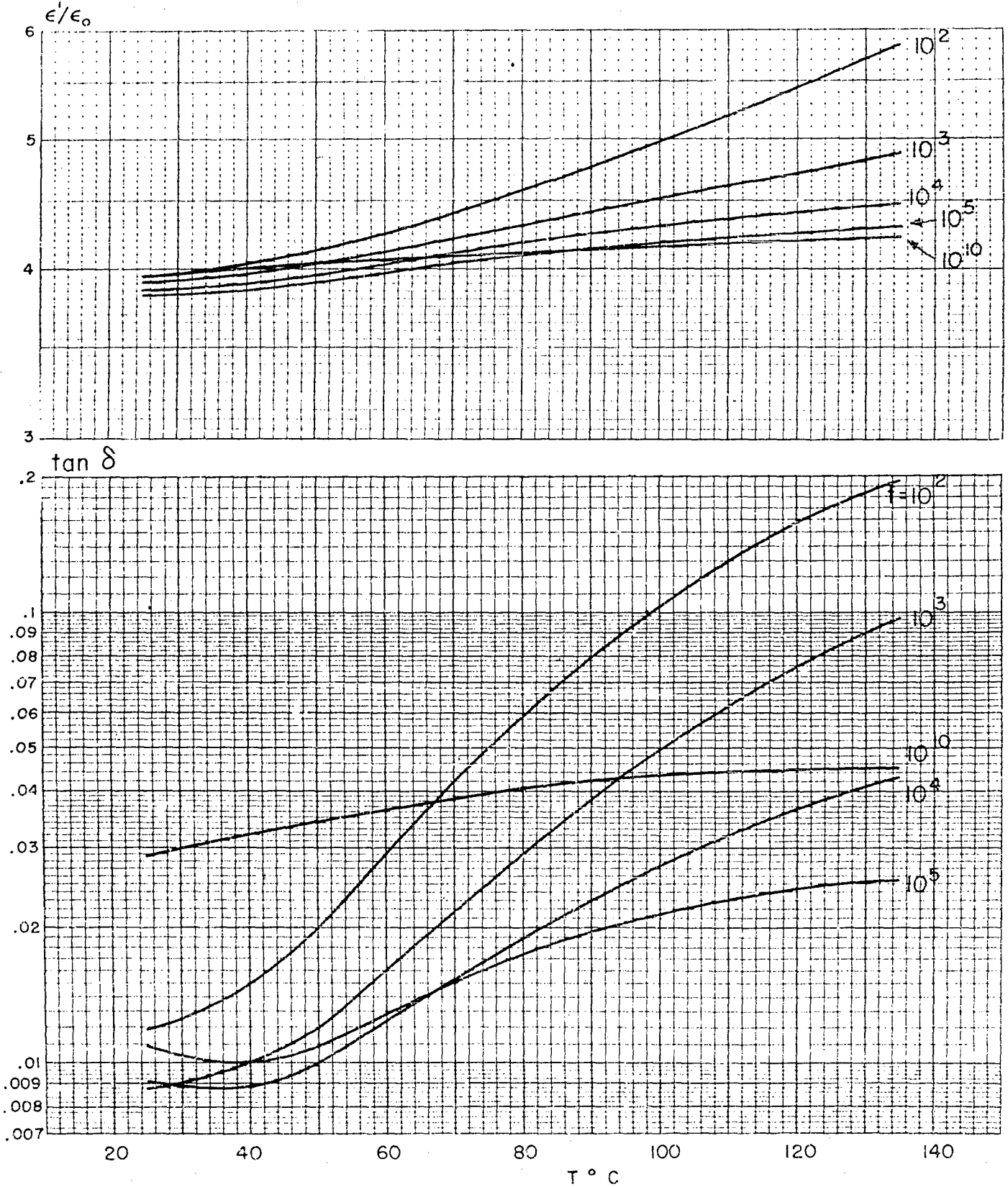
Resinox 10900



Phenol-formaldehyde Resins (cont.)

Taylor Grade GGG

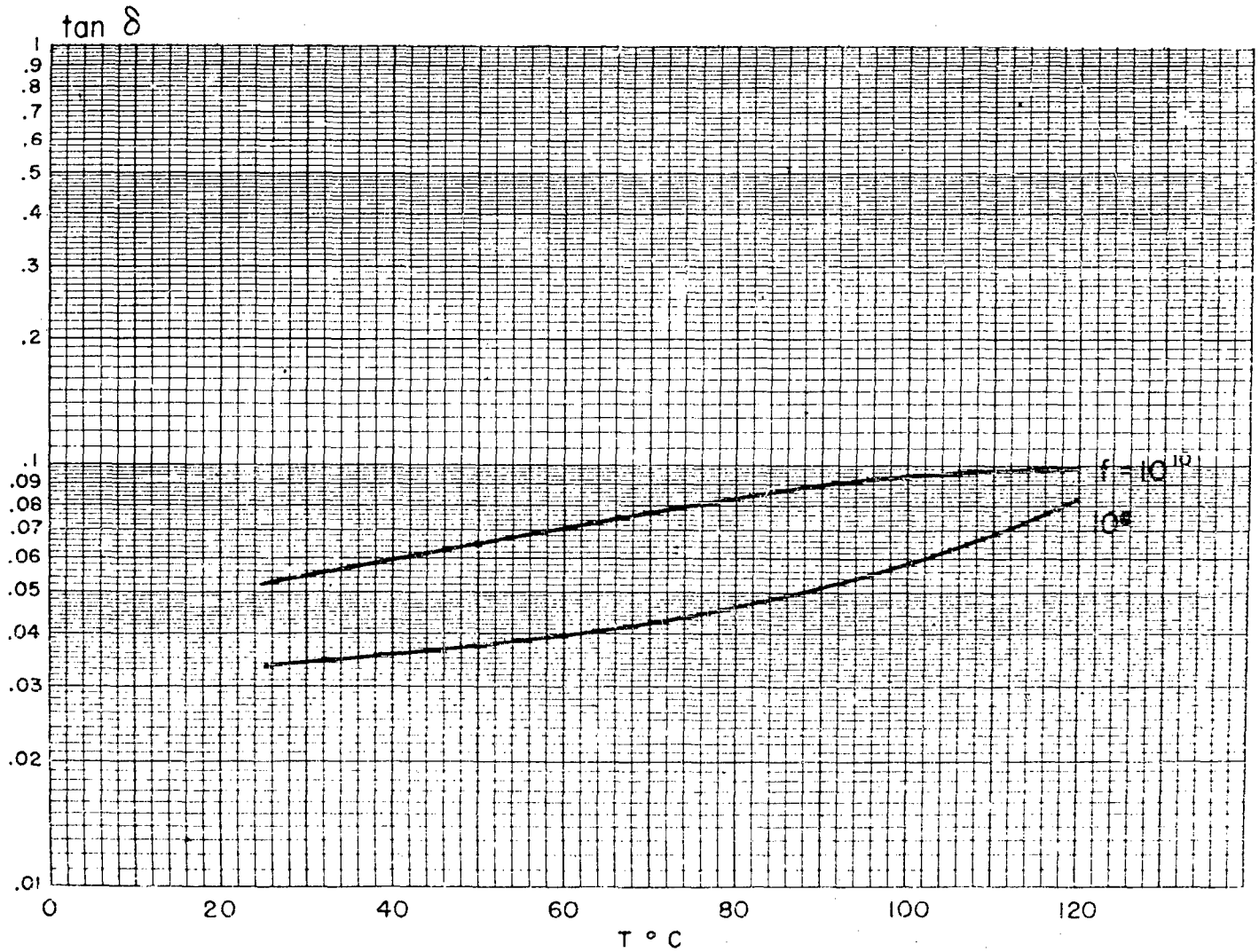
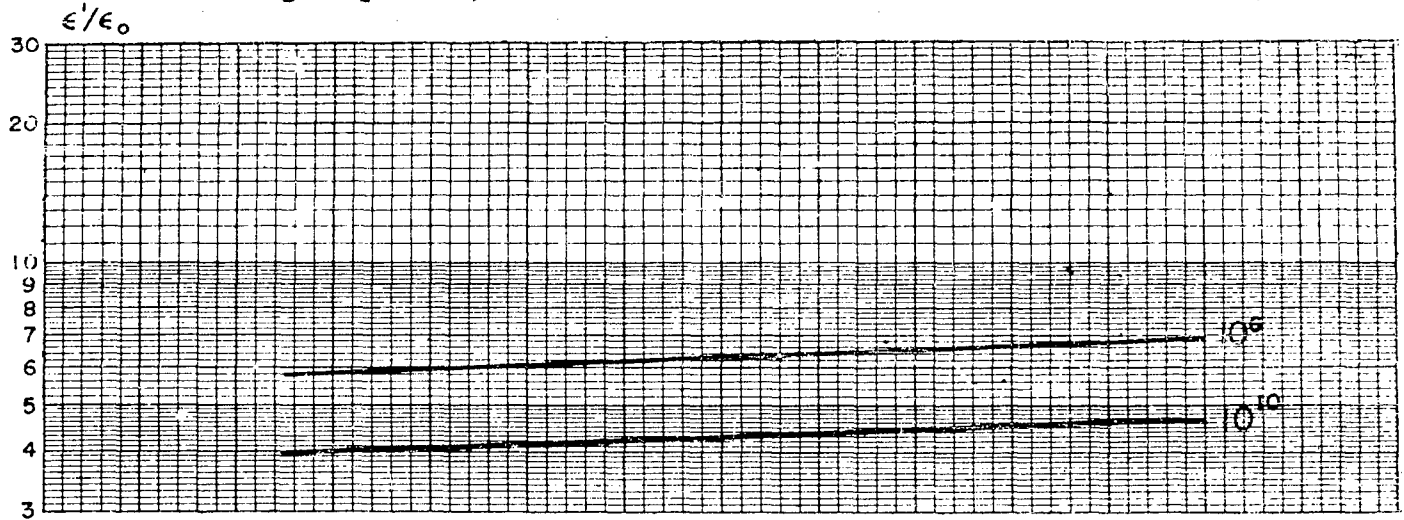
Taylor



Melamine-formaldehyde Resin

Melmac Molding Compound 1502

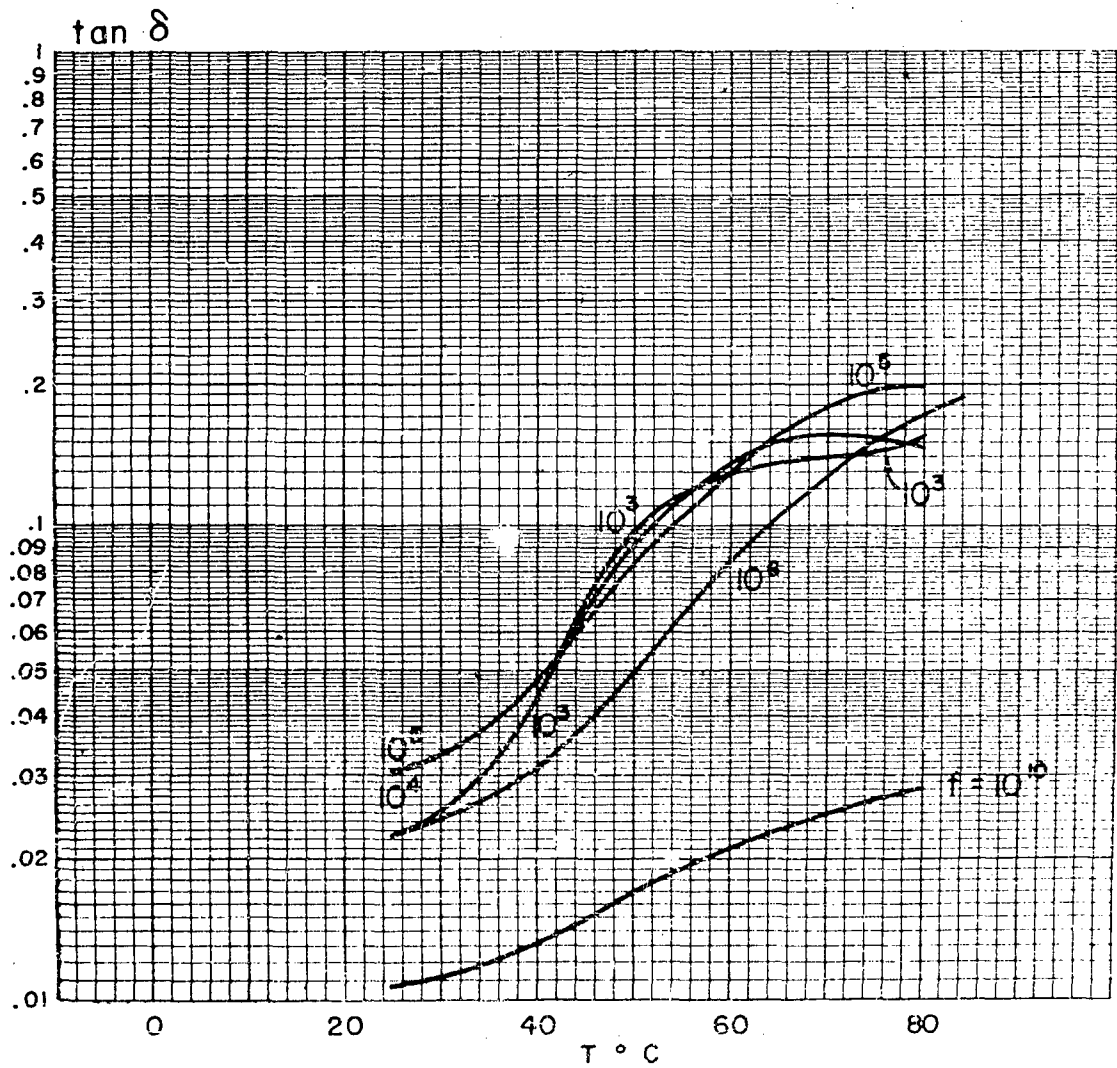
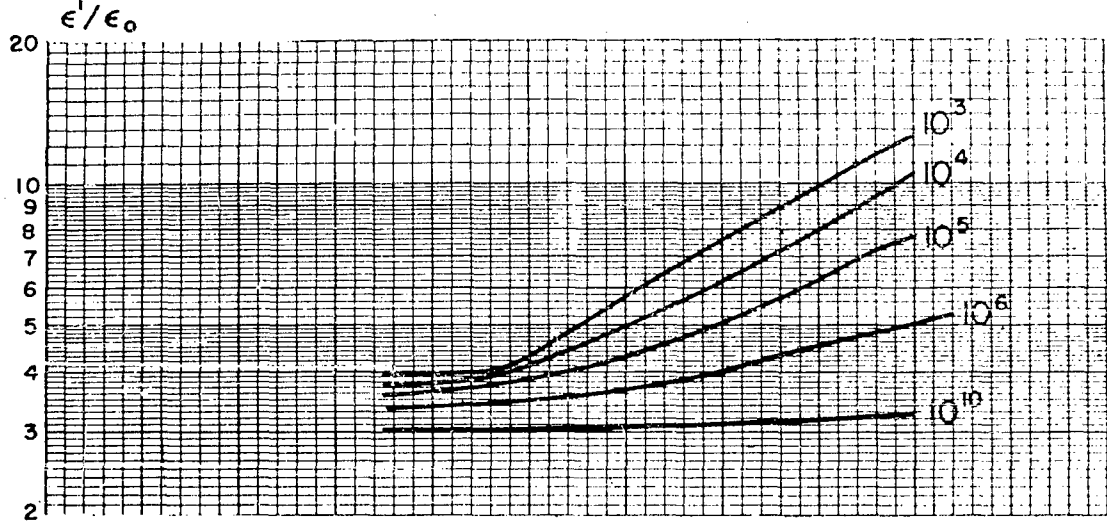
Amer. Cyanamid



Polyamide Resin

Nylon FM 10,001

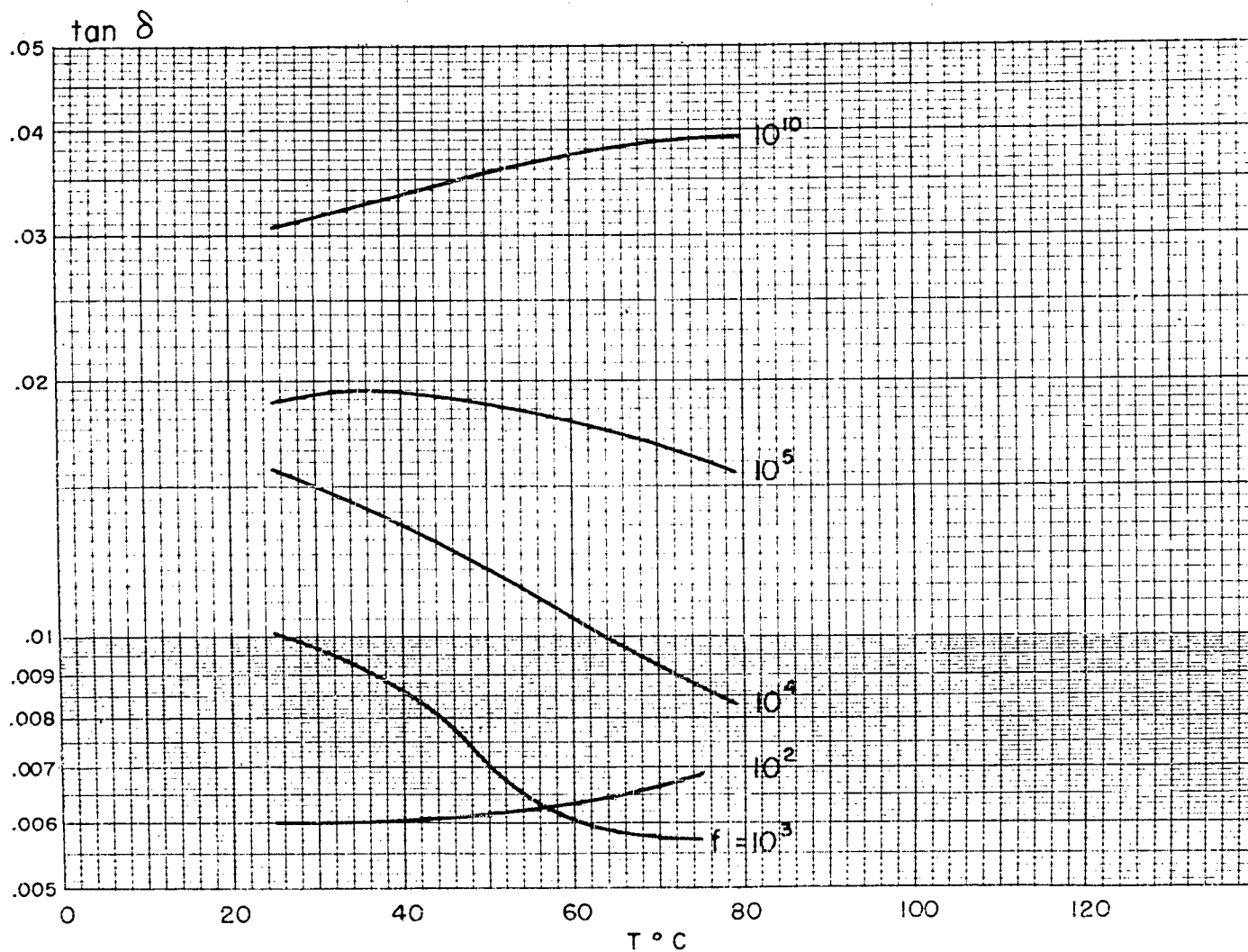
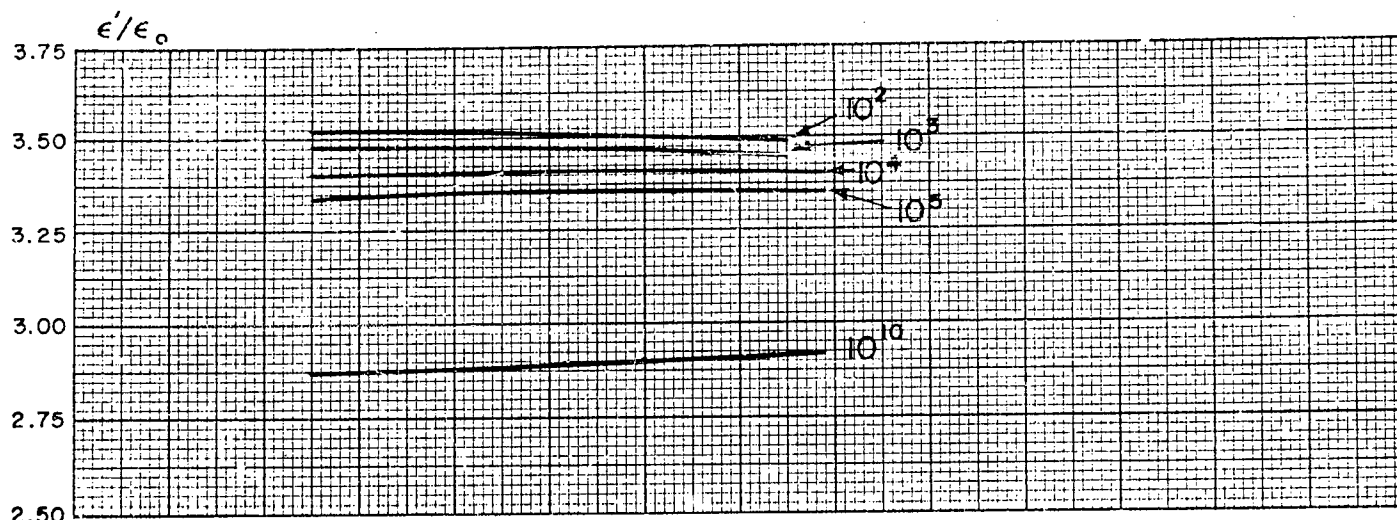
DuPont



Cellulose Propionate

Forticel

Celanese

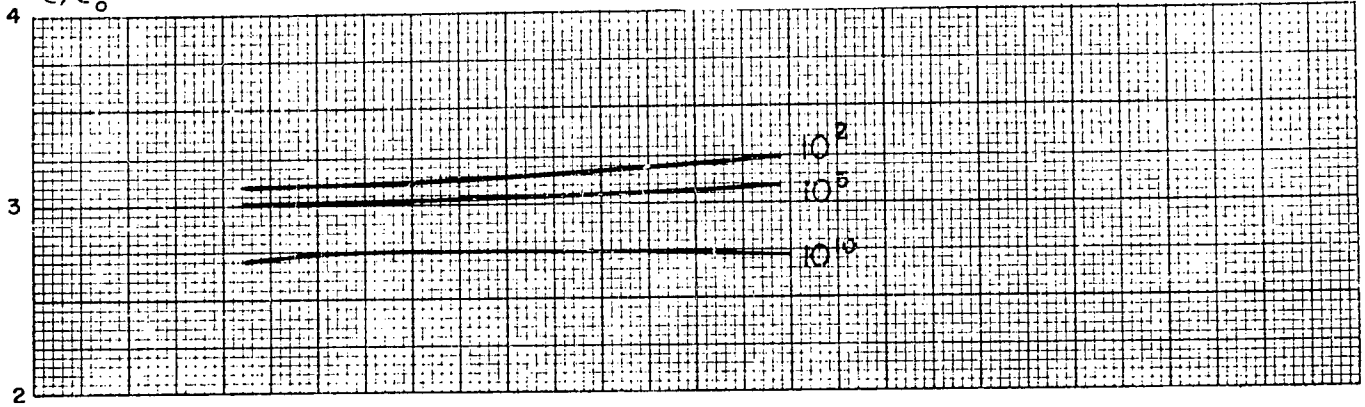


Ethyl Cellulose

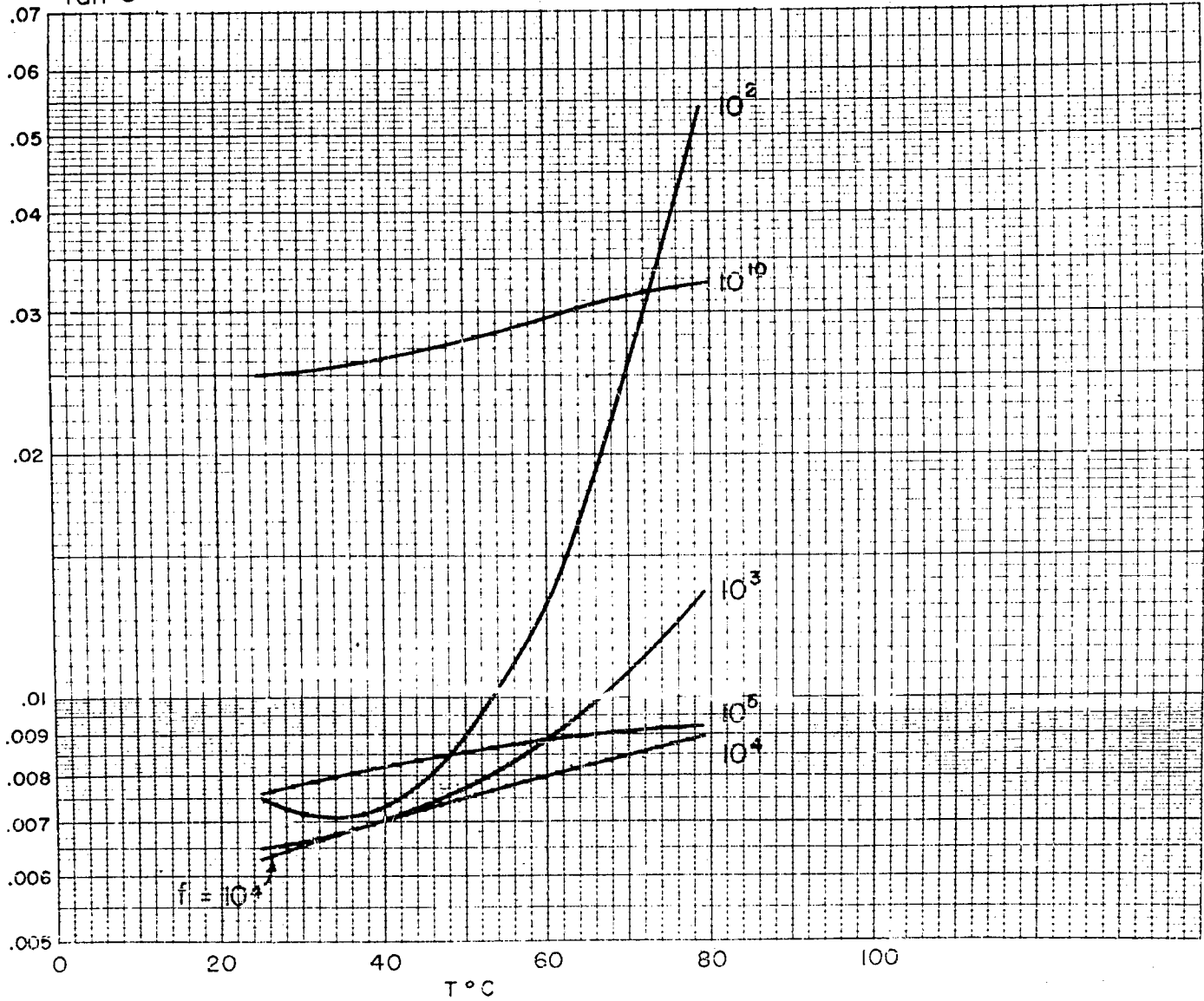
Ethocel LT5

Celanese

ϵ'/ϵ_0



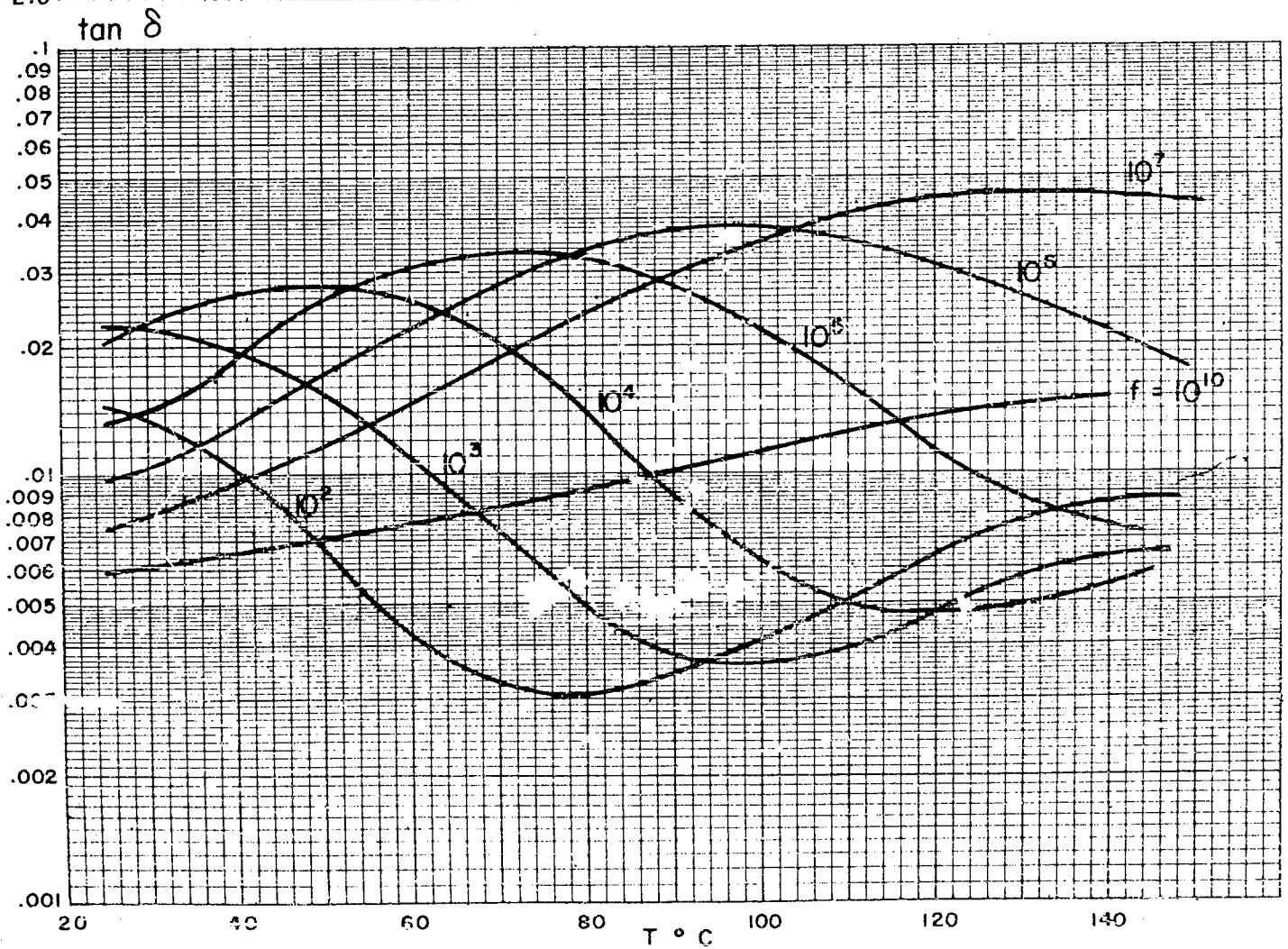
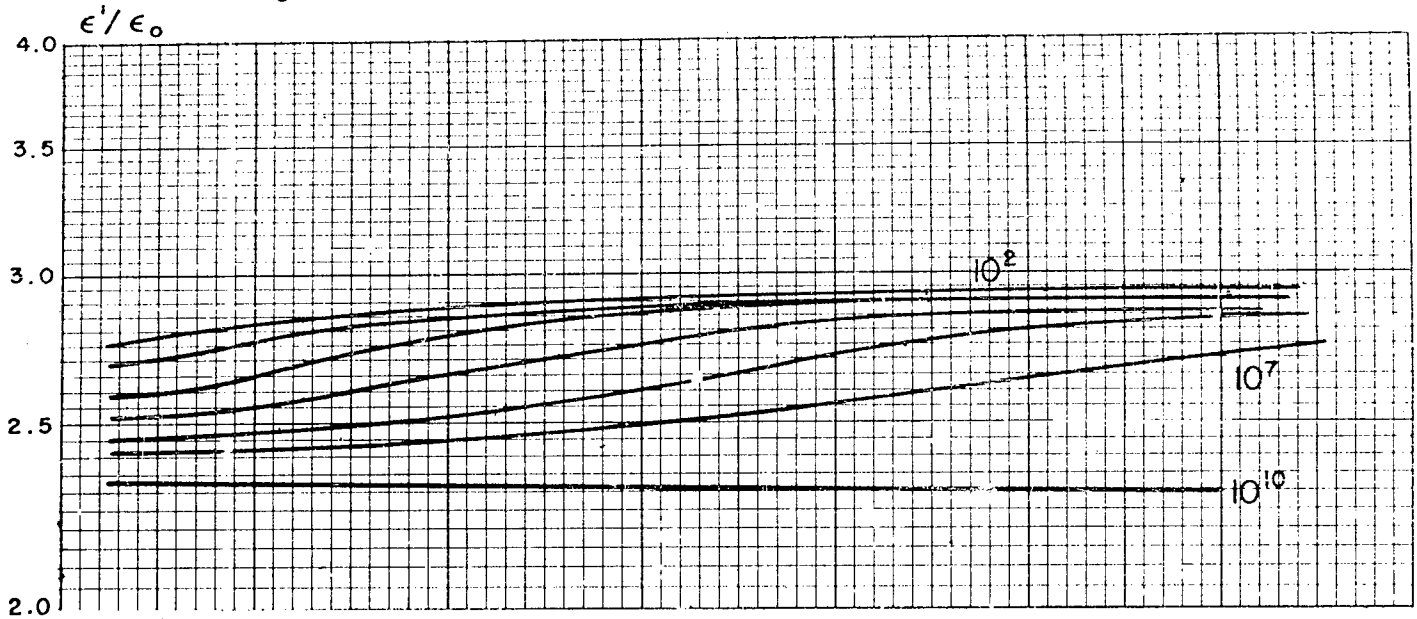
$\tan \delta$



Polychlorotrifluoroethylene

Kel-F Grade 300

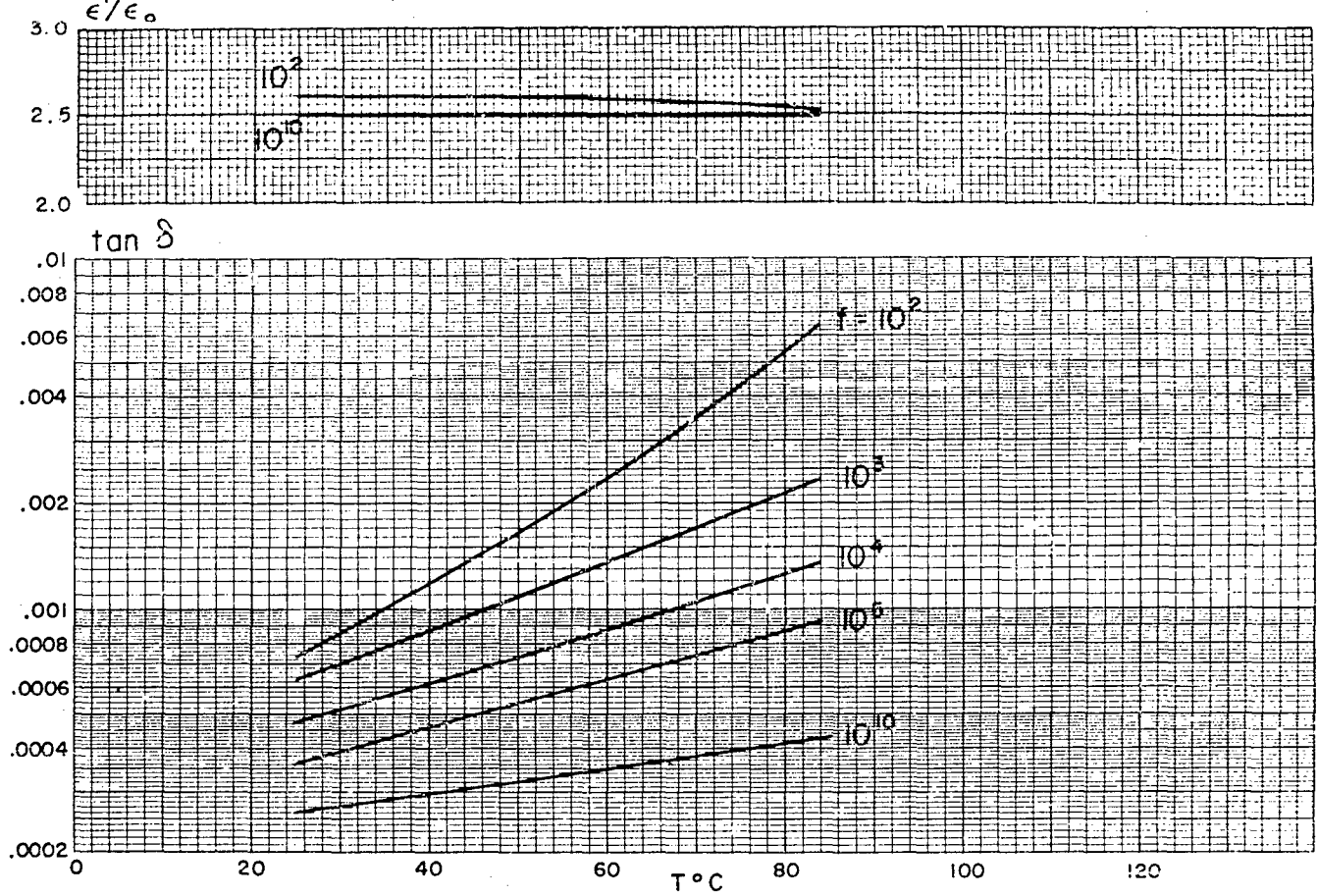
Kellogg



Miscellaneous Vinyls

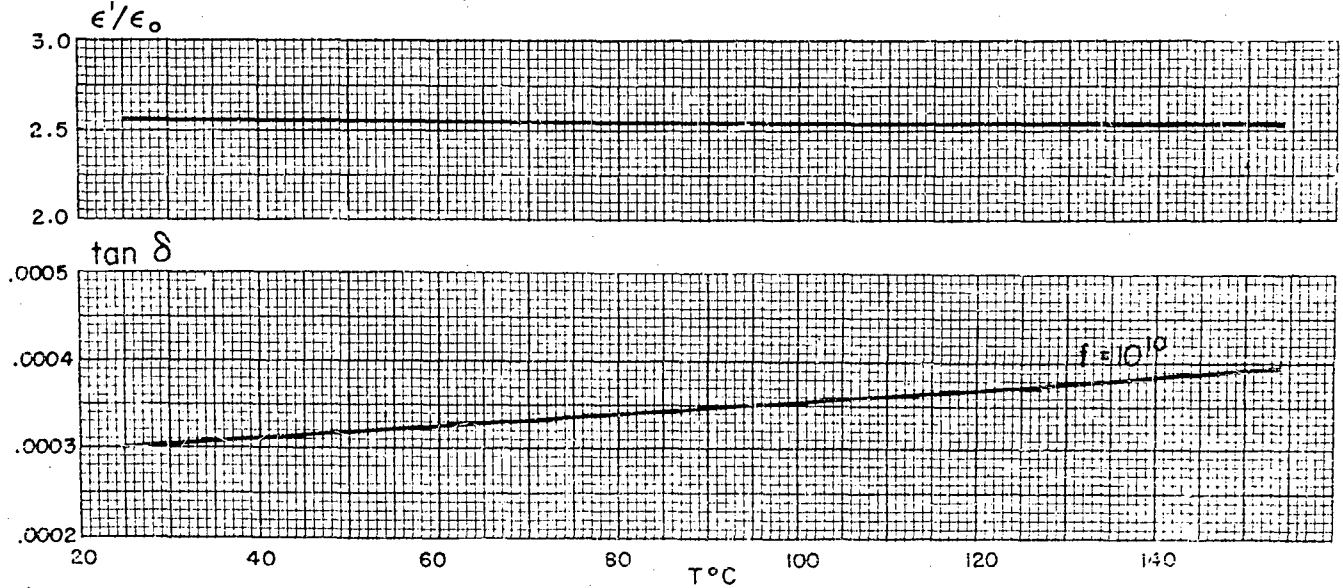
Experimental Plastic Q406

Dow



Experimental Plastic Q817.1

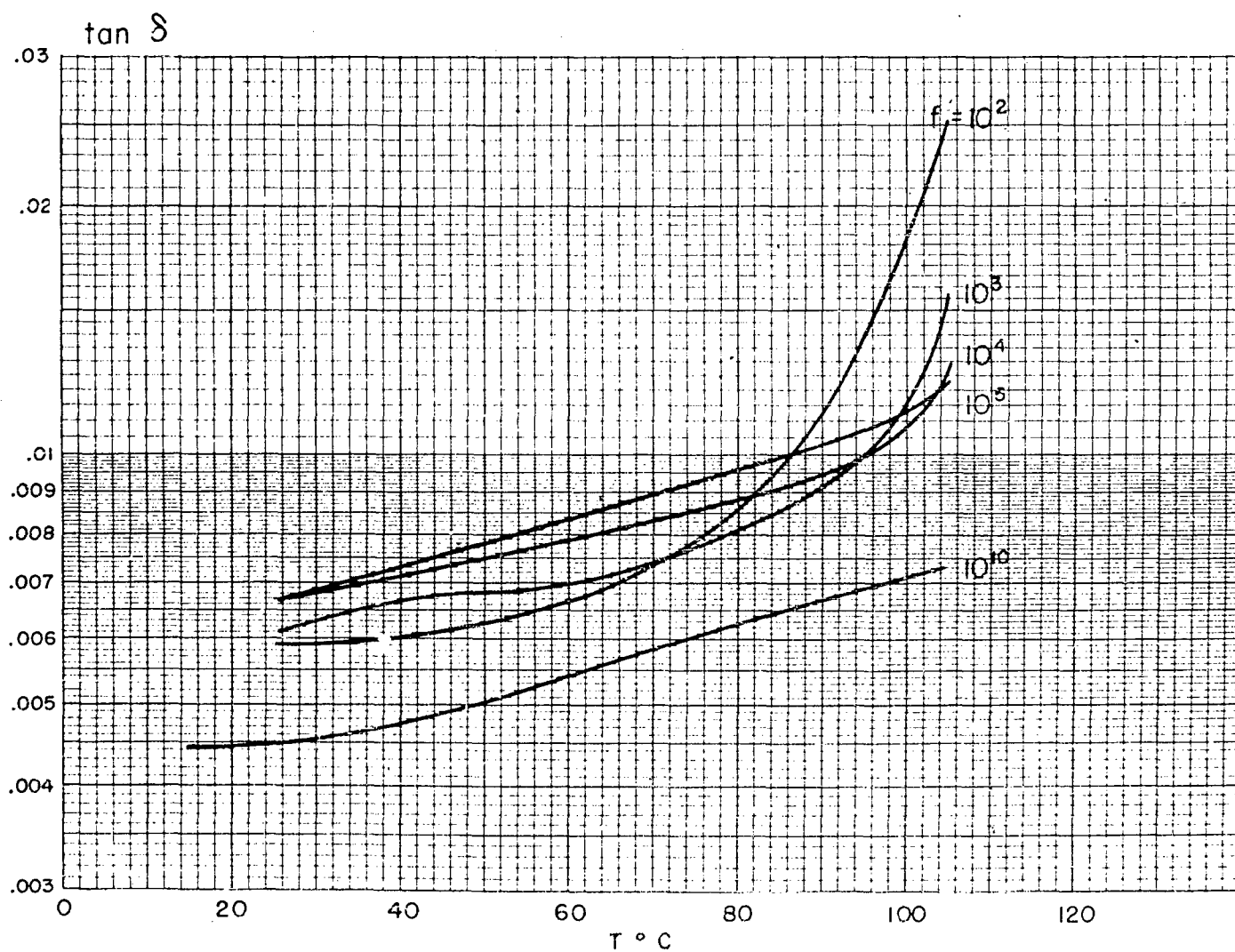
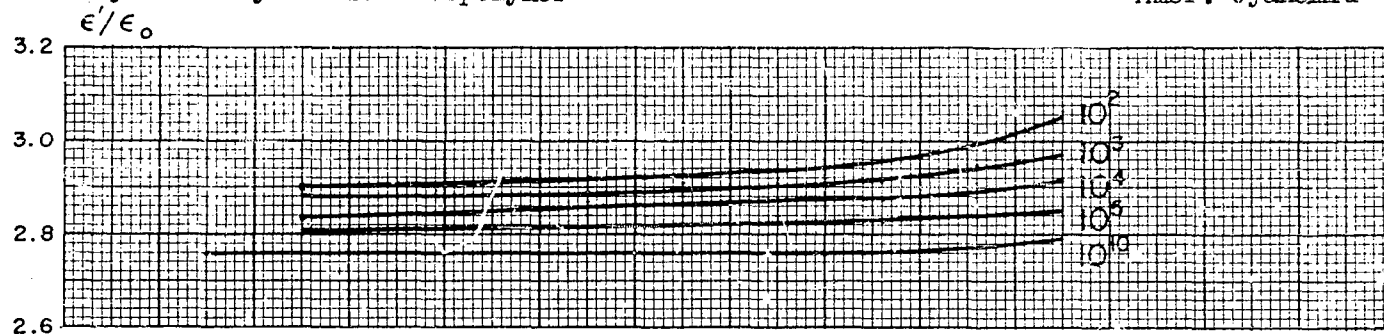
Dow



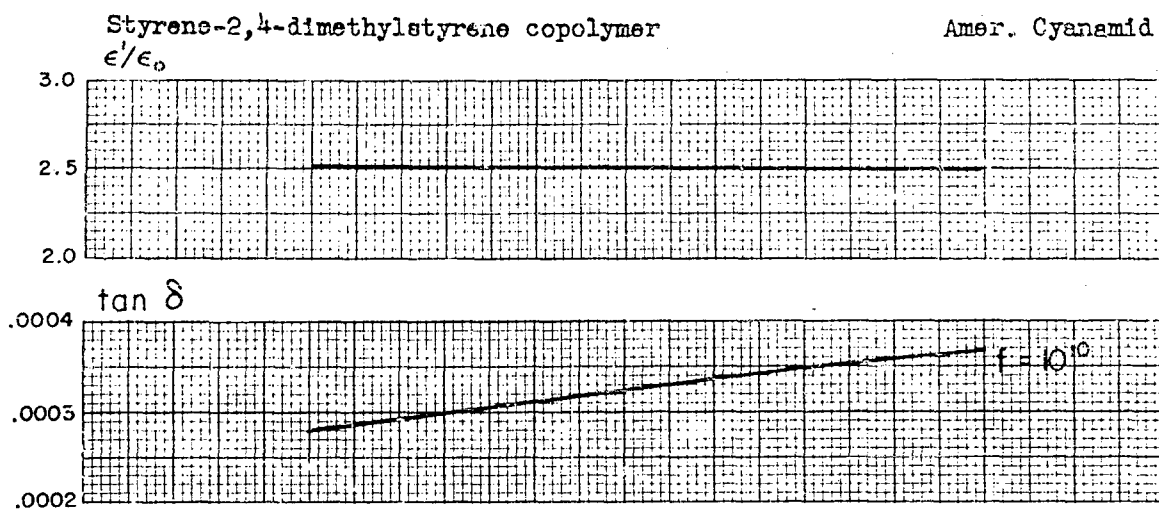
Styrene Copolymers, Linear

Styrene-acrylonitrile copolymer

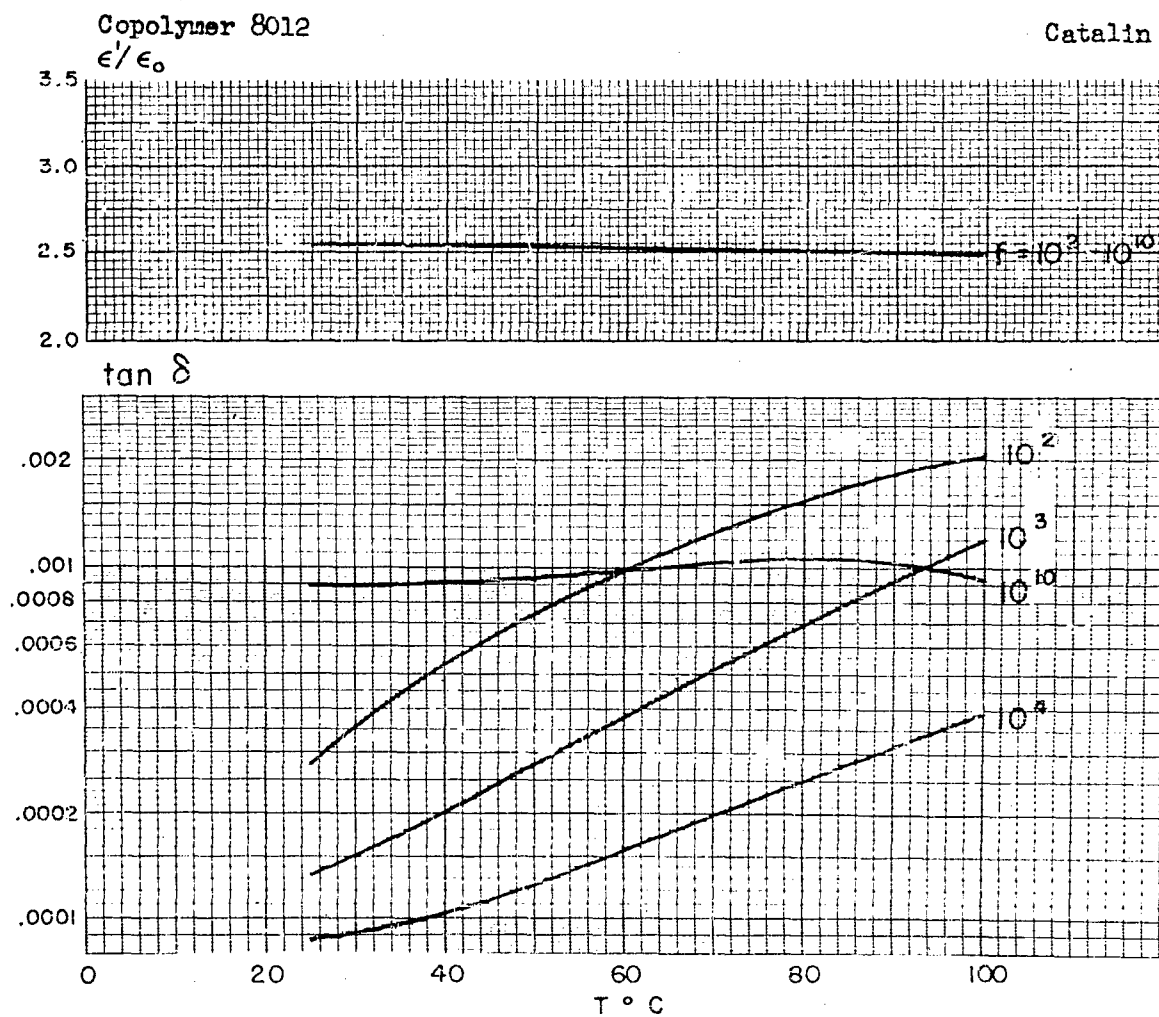
Amer. Cyanamid



Styrene Copolymers, Linear (cont.)



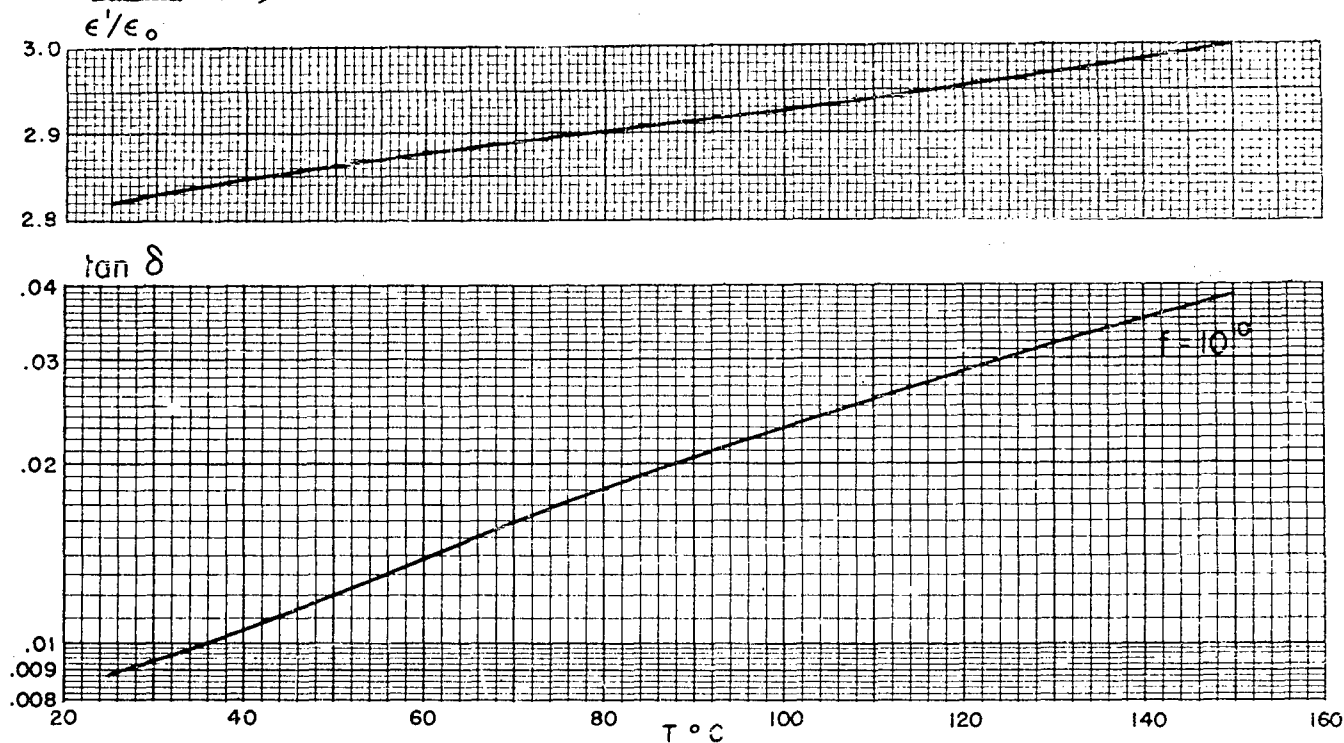
Styrene Copolymers, Cross-linked



Polyesters

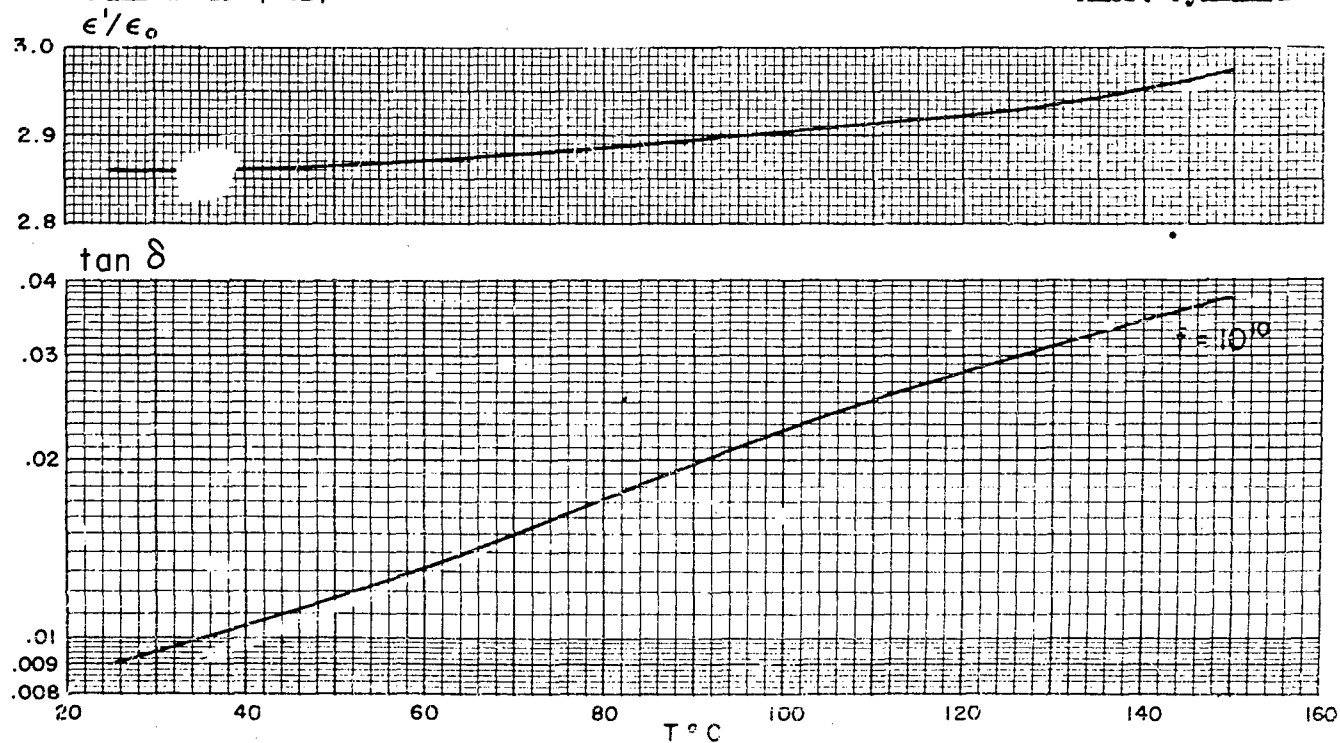
Laminac 4115

Amer. Cyanamid

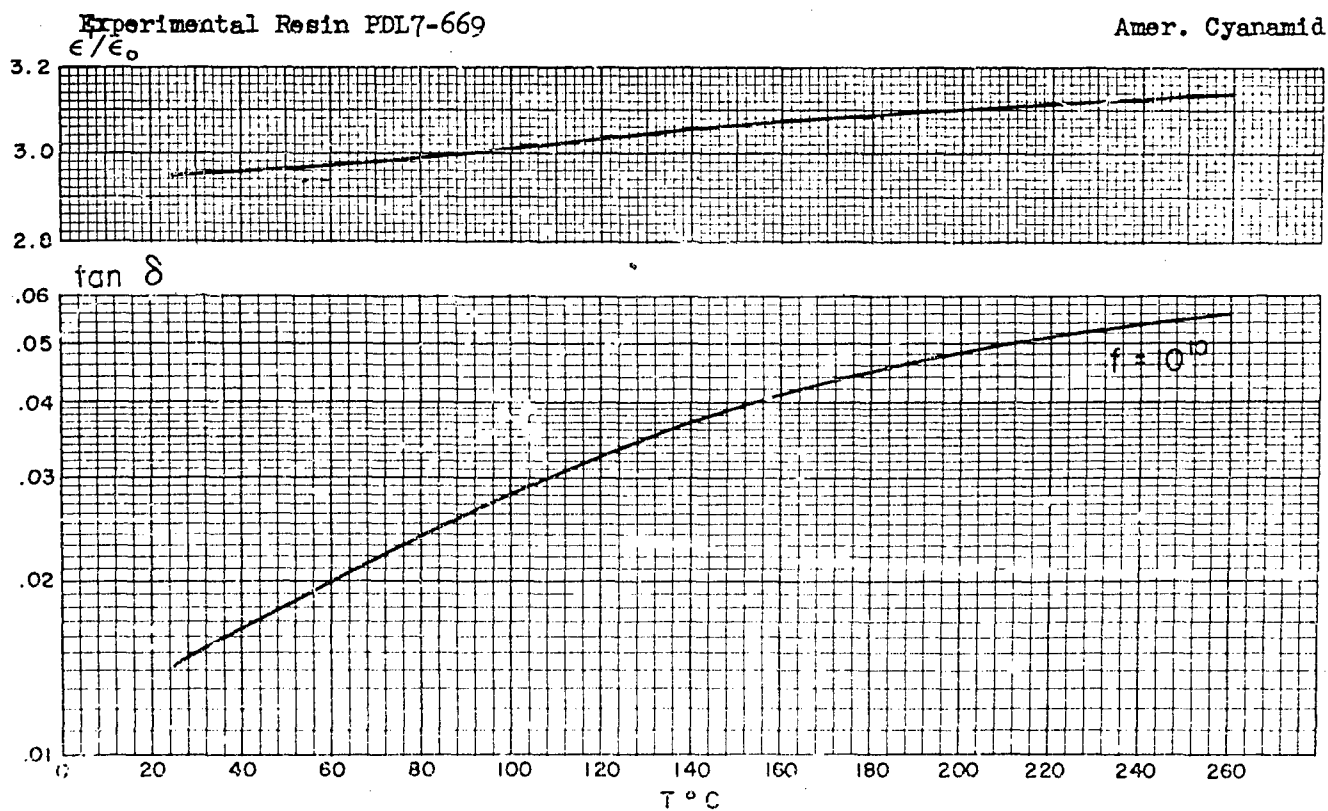
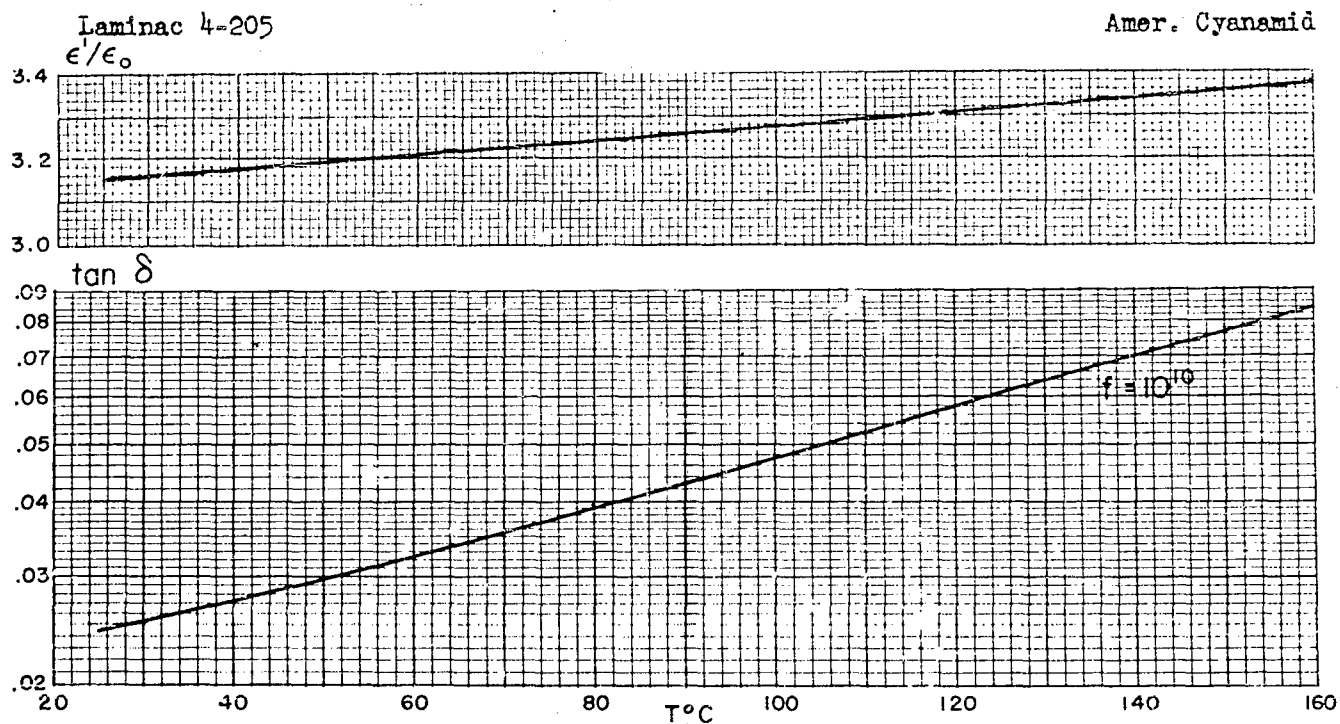


Laminac PDL7-627

Amer. Cyanamid



Polyesters (cont.)

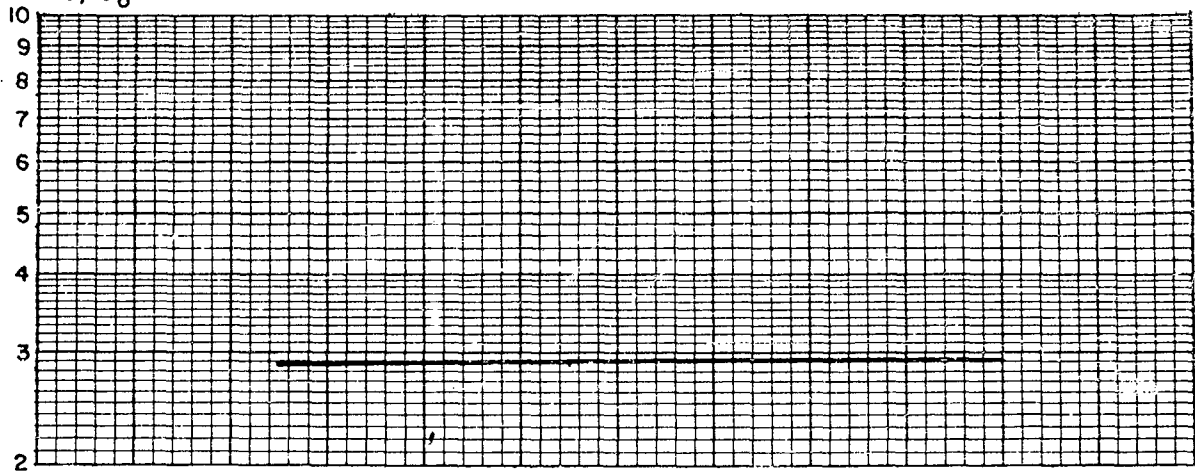


Polyesters (cont.)

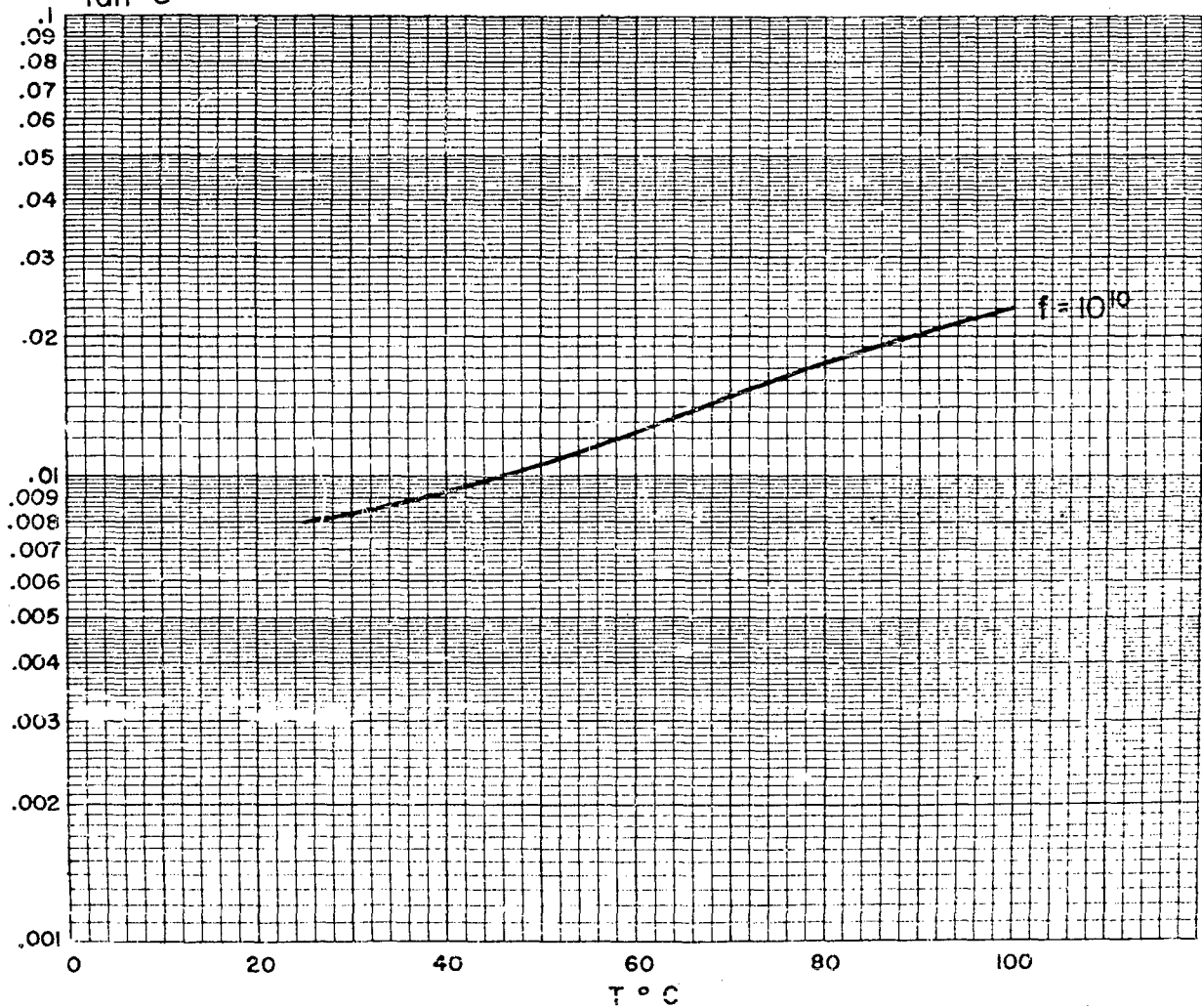
Paraplex P43

Rohm and Haas

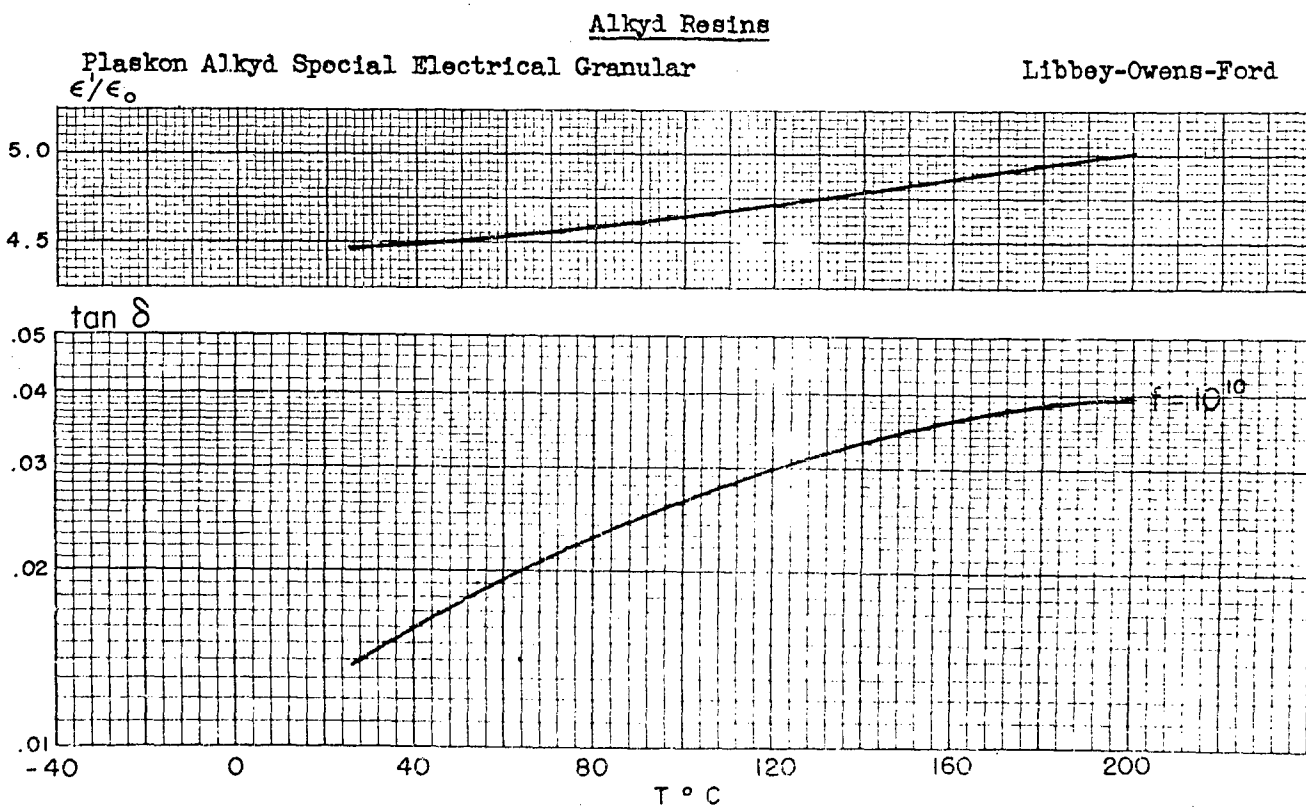
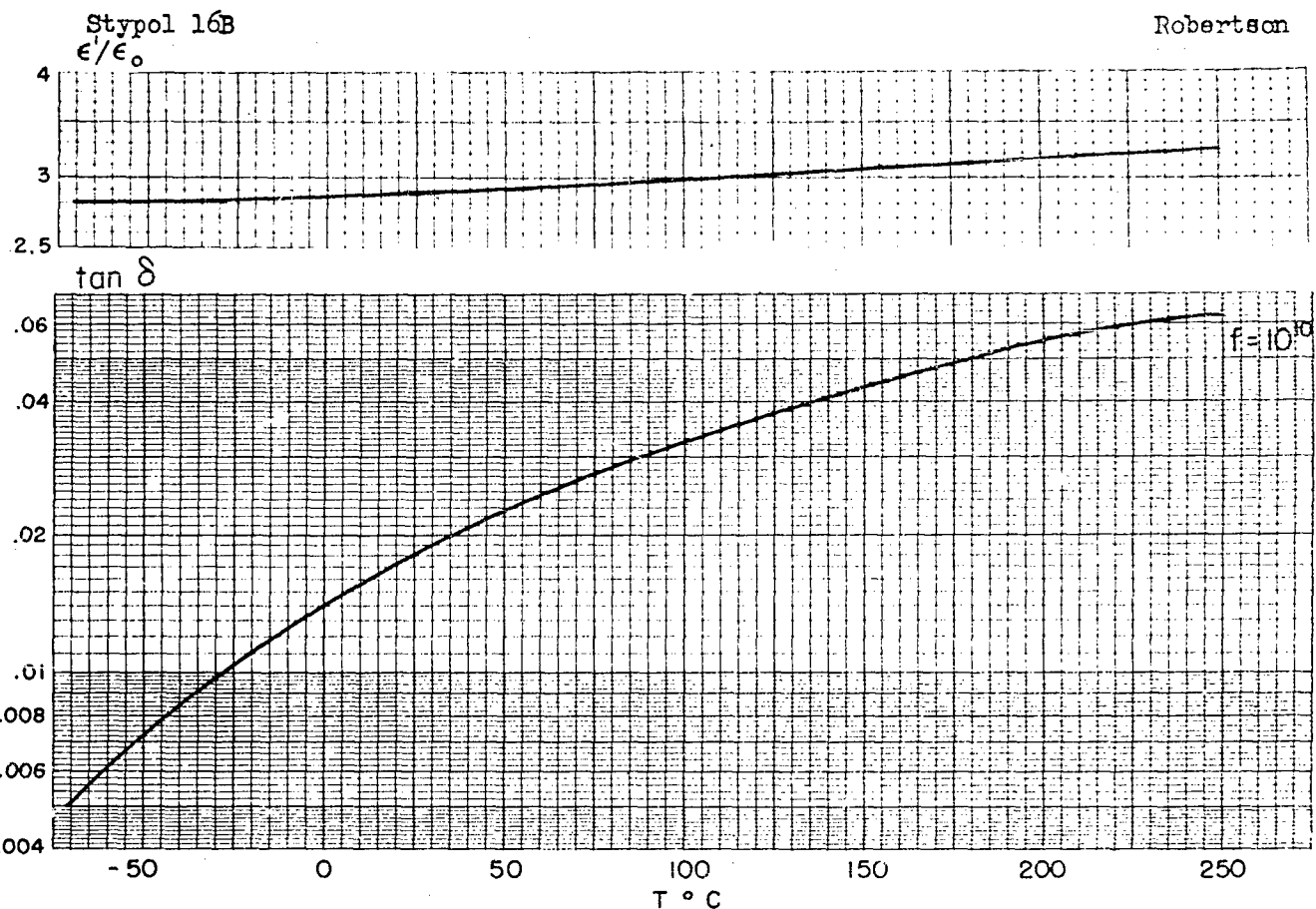
ϵ'/ϵ_0



$\tan \delta$



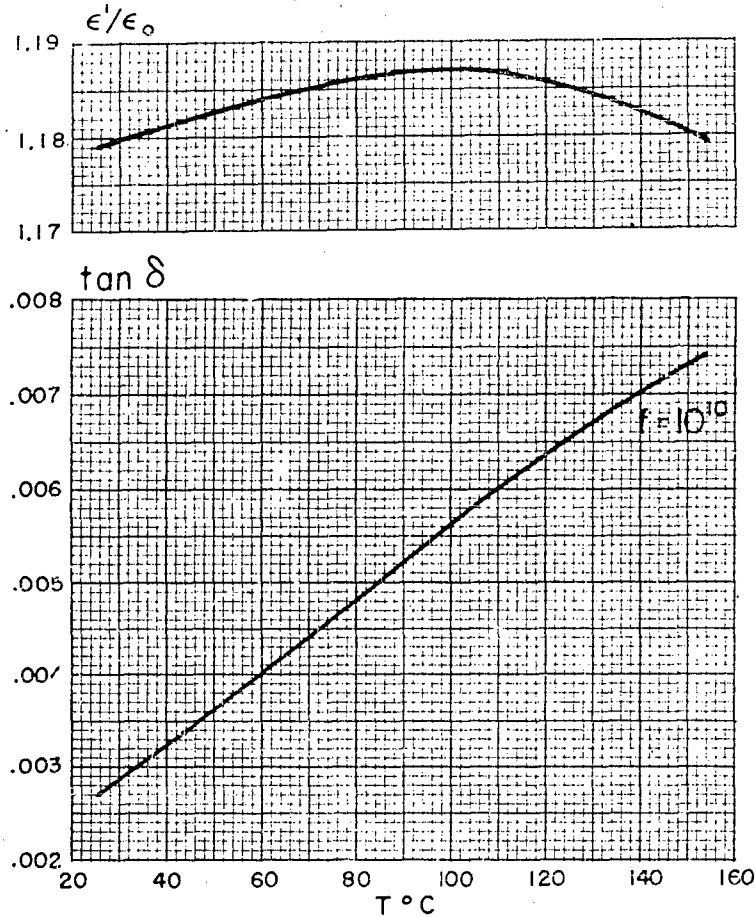
Polyesters (cont.)



Alkyd Resins (cont.)

Chlorinated alkyd
diisocyanate, foamed

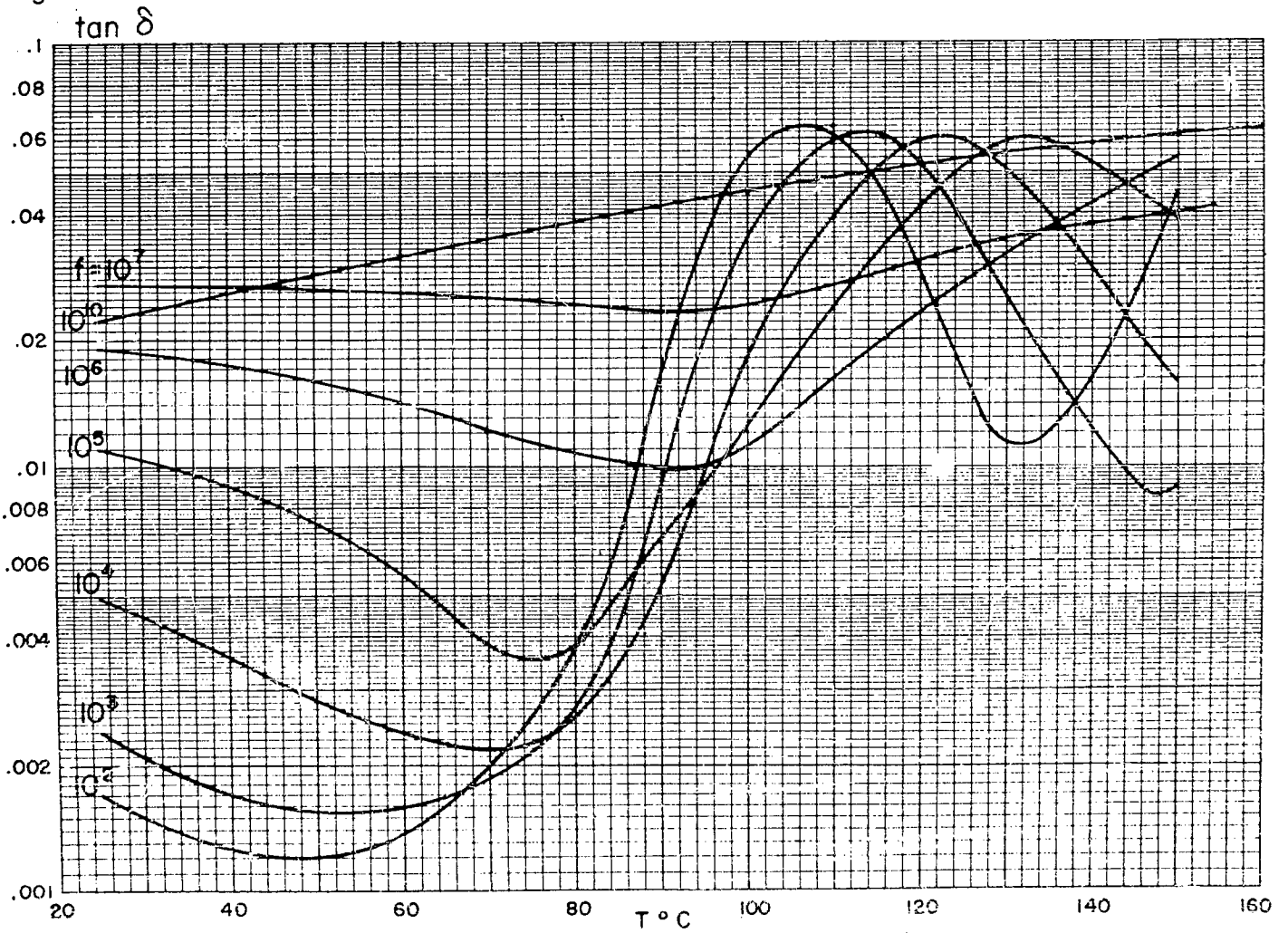
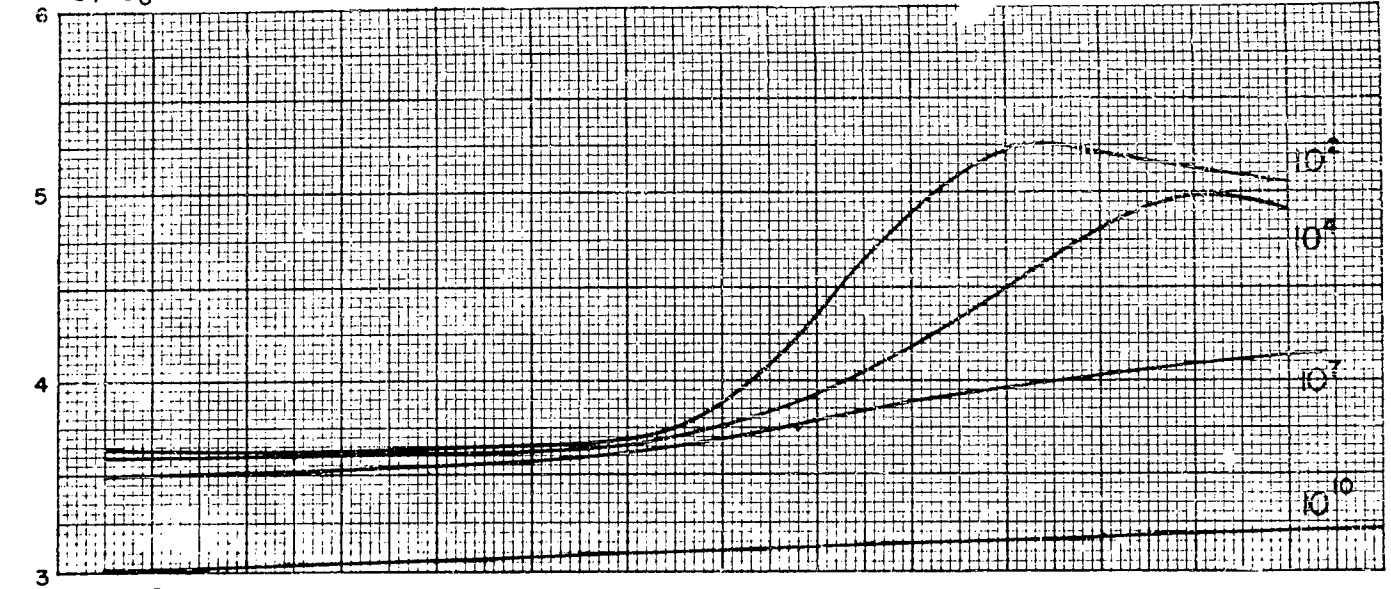
Cornell Aero-
nautical Labs.



Epoxy Resin

Araldite Casting Resin Type B
 ϵ/ϵ_0

Ciba

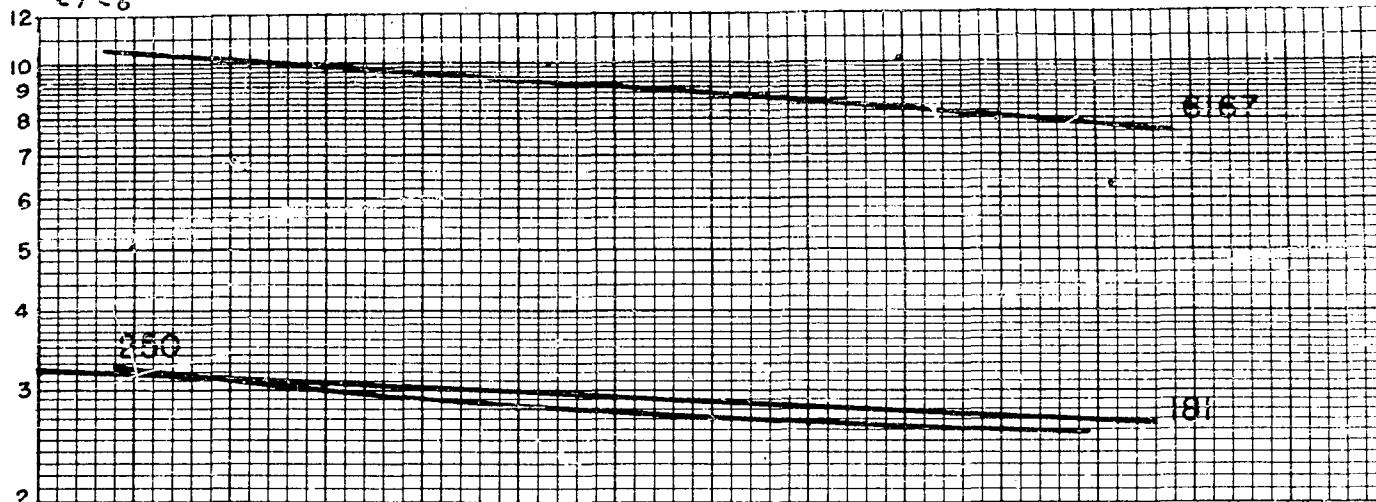


Silicone Rubbers

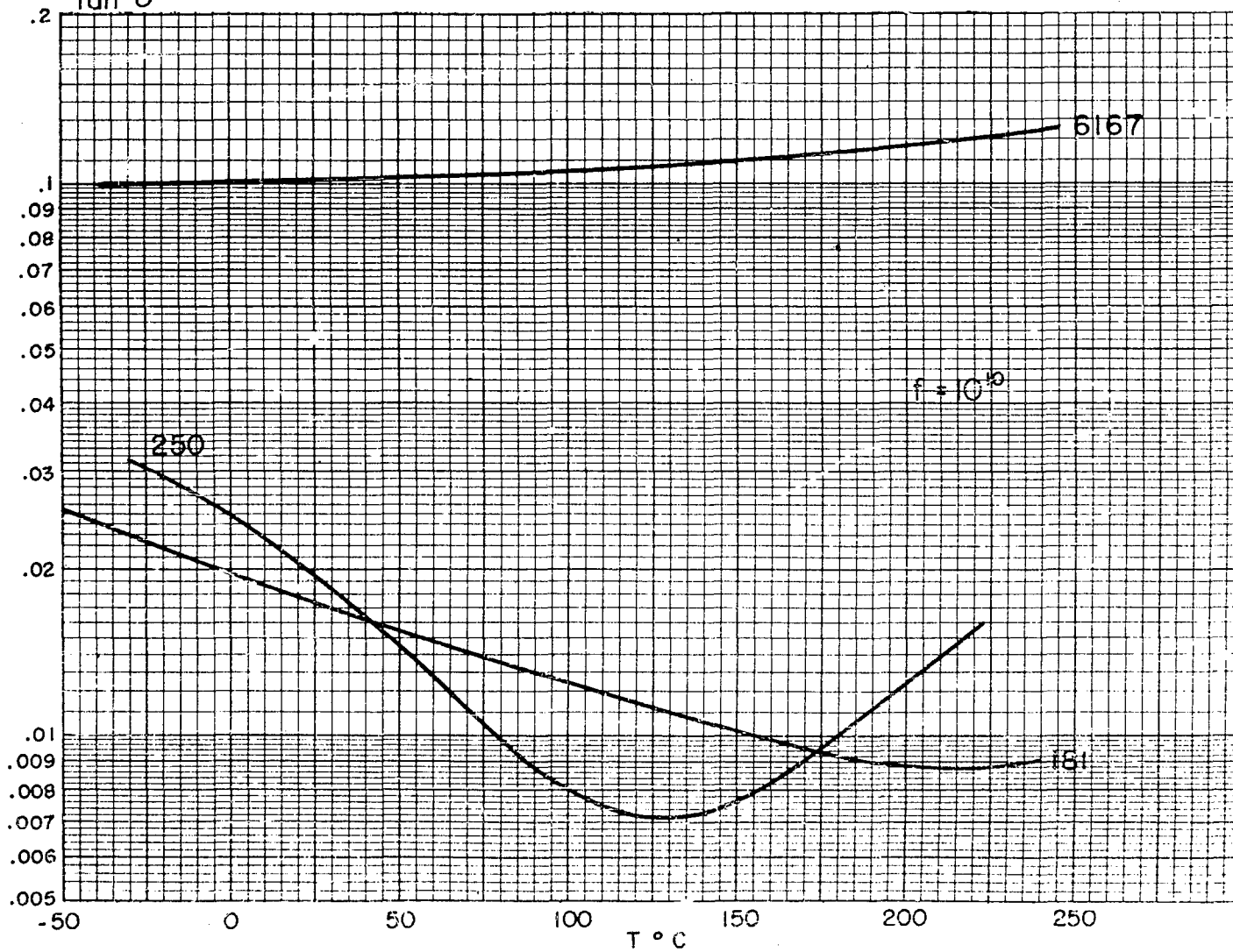
Silastic 181, 250, 6167

Dow Corning

ϵ'/ϵ_0



$\tan \delta$



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