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**A GRAPHICAL COMPILATION OF DAMPING PROPERTIES
OF BOTH METALLIC AND NON-METALLIC MATERIALS**

L. T. LEE

UNIVERSITY OF MINNESOTA

TECHNICAL REPORT AFML-TR-66-169

MAY 1966

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AIR FORCE MATERIALS LABORATORY
RESEARCH AND TECHNOLOGY DIVISION
AIR FORCE SYSTEMS COMMAND
WRIGHT-PATTERSON AIR FORCE BASE, OHIO

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Technology
Divisions,

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FOREWORD

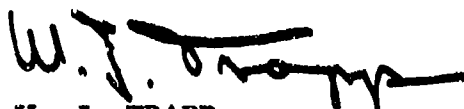
This report was prepared by the University of Minnesota, Department of Aeronautics and Engineering Mechanics, Minneapolis, Minnesota, 55455, under USAF Contract No. AF 33(615)-1055, Project No. 7351, "Metallic Materials," Task No. 735106, "Behavior of Metals." This work was administered under the direction of the Air Force Materials Laboratory, Research and Technology Division, Wright Patterson Air Force Base, with Mr. J. P. Henderson, MAMD, acting as project engineer.

This report covers work conducted from June 1963 to February 1966.

This compilation is necessarily the combined result of the work of several people and scarcely the sole product of the one under whose name the collection appears. Appreciation is due to Dr. B. J. Lazan for his assistance, contributions, and continued support throughout the endeavor. In addition appreciation is due Mr. R. Wieckowicz for assisting in collecting the data, Mr. A. Pakalns for preparing the figures, and Miss Ginny Stark for typing the complete manuscript.

Manuscript released for publication February 1966 as an RTD Technical Report.

This technical report has been reviewed and is approved.



W. J. TRAPP
Chief, Strength and Dynamics Branch
Metals and Ceramics Division

ABSTRACT

This report is a compilation of data on the damping properties of uniform materials and test specimens that has been collected from a wide range of publications. (There are 420 entries on metals and alloys of which 300 are also illustrated with figures. There are 250 entries on polymers, elastomers, wood products, composites and similar synthetic and natural nonmetallic materials of which 85 are illustrated with figures. There are 80 entries on refractories, glass, masonry, minerals, stone, natural crystals, and oxides of which 20 are illustrated with figures. In addition there are 7 entries on particle-type materials, aggregates, soils, and Earth's crust.) The earliest data included comes from a 1931 publication while the latest data comes from 1964 publications. (If possible the data for metals, alloys, and some nonmetals is given in either unit damping energy D or loss coefficient η , otherwise the data is presented in either total damping energy D_t or loss coefficient η_t of the specimen.) The data for the polymers and elastomers is usually given in complex notation (G' , G'' or E' , E''). The primary purpose of this report is to present conveniently and concisely a compilation of published test data in a consistent set of units and to provide a useful reference for engineers and designers.

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SYMBOLS

D	unit damping energy for a material
D_s	total damping energy for a specimen or part
η	loss coefficient for a material $D/2 U$
η_s	loss coefficient for a specimen $D_s/2 U_s$
E'	storage modulus of elasticity under longitudinal stress in <u>pounds per square inch</u> (psi)
E''	loss modulus under longitudinal stress in <u>pounds per square inch</u> (psi)
G'	storage modulus of elasticity under shear stress in <u>pounds per square inch</u> (psi)
G''	loss modulus under shear stress in <u>pounds per square inch</u> (psi)
σ_a	amplitude of cyclic longitudinal stress
ϵ_a	amplitude of cyclic longitudinal strain
τ_a	amplitude of cyclic shear stress
γ_a	amplitude of cyclic shear strain
σ_g	critical stress above which stress history affects damping properties
f	frequency of cyclic stress or strain in <u>cycles per second</u>
N	number of fatigue cycles prior to measurement of damping
T	testing temperature (room temperature unless otherwise indicated)
TR	annealing or other thermal treatment temperature applied before testing
U	unit strain energy of a material
U_s	total strain energy of a specimen

I. GENERAL INFORMATION

1.1 Introduction

In recent years there has been a large increase in the importance of material damping in several areas. In the materials science field "internal friction" measurements are being increasingly utilized to study submicro-, micro-, and macrostructure of crystalline materials. Likewise, rheological and damping tests are being used to determine the molecular structure and deformation mechanisms of polymers and elastomers. In the structural mechanics field damping magnitudes are needed to analyze structural response and are also used to study interface effects. In addition, the alteration of the damping of a structure or member is an important means of controlling and limiting its response to broad excitation spectrums. Damping measurements also provide a sensitive inspection tool, since damping is a very structure-sensitive property. (Preface, 65 L)*

This increased importance has led to a tremendous literature multiplication. The number of publications in the material damping field is already well over 2,700 and appears to be doubling every 9.2 years (Figure 2.7, 65 L). Thus, in order to make damping data more readily available to designers and engineers, there is a need for a reasonably complete and convenient single source of data on the properties of specific uniform materials. A first attempt at this was made in 1962 when Sun Hwan Chi compiled a summary of properties of viscoelastic materials and some miscellaneous non-metals (62 Chi). The present report, which incorporates most of Chi's data, is an attempt to provide such a single source of data for all uniform materials. Since, however, the amount of literature available with specific data is quite large and increasing very fast, no claim of completeness can be made.

1.2 Relation to Other Publications

The data tabulation sections presented here are very similar to those found in Chapter 8 of Dr. B. J. Lazan's book (65 L). They are presented here to supplement the graphical compilation in two ways. First, they provide information on materials for which the available data was not suitable for graphical presentation. And second, they provide additional information on test conditions for that data that is presented graphically.

Much of the data included here on elastomers, thermoplastics, and polymers is also included in 62 Chi.

* See Section 1.6

For a very complete bibliography of the material damping field up to 1964 see 64 Wo, 62 Chi, and 56 D. These three reports list over 2,700 publications and provide abstracts of most of them.

1.3 Damping Units Used in Data Presentation

Many different units were used in the original references from which the data in this report was obtained. These were converted to the standard units η , η_s , D , D_s , E'' , or G'' by the relations given in Figure 2.6 of Dr. B. J. Lazan's book (65 L). Whenever possible the unit values η , D , E'' , G'' of the material are given rather than the test specimen properties η_s , D_s , A_s . Unfortunately, the test data in much of the literature is given in terms of specimen values rather than in unit values for materials; the importance of stress distribution and nonlinear damping was generally not recognized. Since only rarely in reports dealing with nonlinear materials are specimen details and stress distribution data given, it is difficult - if not impossible - to reduce much of the available specimen damping values to unit damping values. In such cases the damping values are generally presented in η_s units. It should be re-emphasized, however, that for highly nonlinear materials, η may be significantly different from η_s . In view of these discrepancies caution should be exercised in utilizing "specimen data" in structural mechanics and in making comparisons between different materials.

For metals, which generally display rate-dependent linear damping at low stress and nonlinear damping at high stress, D (or D_{av}) or η (or η_s) units are used, and the dependence of damping on σ_a , w , N , T , etc. is indicated when known. Nonmetallic materials such as polymers, elastomers, foams, wood, concrete, and viscoelastic materials generally behave linearly at low strain amplitudes, and under these conditions complex notation is used (G' , G'' or E' , E''). At high strain amplitudes these materials also often exhibit nonlinearities, and the damping properties are expressed in terms of unit damping energy D whenever possible.

The elastomer industry has employed a large variety of damping tests, but many of them are primarily for rating materials and are very arbitrary. In these cases the test results often cannot be related to the "standard units" used here.

1.4 Reliability of the Data

Many examples will be observed in the following compilation where the "same" material and the "same" test conditions do not lead to the same results. These discrepancies are due mainly to: (1) variations in the material presumed to be the same, (2) deviations from nominal test conditions, and (3) unsuspected energy losses in the specimen grips and testing machine.

Since damping is very structure-sensitive property, it can be significantly changed by slight differences in composition, thermal treatment, and mechanical processing. But publications often do not include detailed information on important chemical, thermal, and mechanical features, so it is difficult to associate differences in damping with these features. Small differences in temperature and humidity may also have significant effects on damping, particularly in elastomers, polymers, and other nonmetallic materials.

Since for low damping materials the energy absorbed per cycle by the test specimen is very small compared to that generally dissipated by conventional grips, joints, and other connections within the testing apparatus, serious errors in the test results may occur. For low damping metals the lack of proper attention to grip details and machine losses may result in an apparent damping value over ten times higher than the actual damping of the specimen. Some of the very high damping values found in this compilation may be due to such unsuspected energy losses in the specimen grips and testing machine.

Since the dominant mechanisms of energy dissipation change with varying stress level, temperature, frequency, etc., interpolation or extrapolation of data given here may lead to serious errors (Chapter V, 65 L). In addition, the scope of the testing conditions are very often not clearly defined in the literature.

As a result of these factors, published data on damping properties are probably much more unreliable than published data on other properties. No effort is made here to judge the validity of the data given here or to appraise its engineering significance. The primary purpose of this report is to present, in a convenient and concise manner, a graphical compilation of published test data in a consistent set of units and provide a useful reference for engineers and designers.

1.5 Form and Order of Data Presentation

1.5.1 Data Tabulation

In each of the data tabulation sections that follow the materials that fall within that group are listed alphabetically. For each entry the name of the material is followed by additional details on composition, heat treatment, etc. as provided in the original publication. The test conditions (type of stress, stress amplitude, temperature, etc.) are given next, if available, and this data is followed by damping values (D , η , G' , E' or D_s , η_s). This is followed by any other significant information on the relation between the test variables and the damping values. For those entries that are also illustrated by a figure, this last information is unnecessary because a better idea of these relations can

be obtained from the figure. The final information given (in parentheses) is a reference to the original publication and, if necessary, a figure number.

Often an asterisk is inserted after the reference, for example (42 Bi*), to indicate that the reference cited is not the original source of the data, but includes it from an earlier publication. In a few cases both the original and the secondary references are included, for example (50 No, 61 U*).

1.5.2 Graphical Presentation

In each of the graphical sections that follow, the materials are arranged approximately in alphabetical order. However, to conserve space a few entries are out of order. Every entry in the graphical presentation is also included in the appropriate tabulation section.

In all of the graphs the damping properties are indicated as ordinate values. In all cases a logarithmic scale is used for the ordinate, with horizontal guide lines to indicate decade lines (10^2 , 10, 1, 10^{-1} , 10^{-2} , etc.) and quintuple lines (5×10^2 , 5×10 , 5, 5×10^{-1} , etc.).

Various variables are plotted along the abscissa depending on what was emphasized in the original reference. Examples of the abscissa variable are stress amplitude, mean stress, temperature, frequency of vibration, prior cold working, and number of fatigue cycles. The reference is included on each graph in parentheses, generally in the lower right-hand corner. Some information is given in the caption and elsewhere in the figure to indicate composition, treatment, type of stress, etc., but this is usually not complete. More complete information is generally included in the data tabulation sections described previously.

1.6 Coding System Used for References

Each reference cited in this compilation is denoted by a code. This code consists of two digits followed by one to four letters, for example 53 B, 41 Ki, 59 Wil, 62 Pisa. The digits are the last two digits of the publication year while the letters are the first letters in the principal author's name. Thus, the code 53 B means a 1953 article by W. J. Barber. This code is consistent with the coding system used in 65 L and 64 Wo.

All references in the bibliography are ordered chronologically by year of publication and alphabetically by principal author within each year. In a few instances a reference is coded and included under the year of the preliminary report, in which case the code and the publication date do not correspond. It must also be noted that the English spelling of Russian names often depends on the translator.

II. DAMPING DATA ON METALS AND ALLOYS
(See the list of symbols on page
for units used in following tabulation)

2.1 Data Tabulation

ALUMINUM (Pure). Axial stress. $T = 50$ to 300°K . $\eta_g = 2 \times 10^{-5}$
to 5×10^{-5} for strained case. $\eta_g = 7 \times 10^{-6}$ to 2×10^{-5} for
annealed case. (58 Mas, Figure 1)

ALUMINUM (Pure). Axial stress. $\epsilon_a = 2 \times 10^{-7}$ to 5×10^{-5} . $T =$
 25 to 440°C . $\eta_g = 3 \times 10^{-5}$ to 6×10^{-3} . 6x increase with
 ϵ_a . 35x increase with T . (58 Mas, Figure 2)

ALUMINUM (Single crystal). Axial stress. $f = 1$. $T = 400$ to 700°C .
 $\eta_g = 5 \times 10^{-4}$ to 10^{-2} . (58 Mas, Figure 3)

ALUMINUM (Single crystal). Bending. Medium strain. $f = 9$. $\eta_g =$
 6.4×10^{-4} . (41 Ki*)

ALUMINUM (Pure, annealed, single crystal). $f = 7,000$. $\epsilon < 10^{-4}$.
 $\eta_g = 2.5 \times 10^{-5}$ to 14×10^{-5} . (62 Sm*)

ALUMINUM (Polycrystal and single crystal). Torsion. $f = 1$. $T =$
 40 to 440°C . $\eta_g = 2 \times 10^{-3}$ to 8×10^{-2} for polycrystal with
40x peak at 240°C . $\eta_g = 10^{-3}$ to 10^{-2} for single crystal.
(56 Mas, Figure 11)

ALUMINUM (99.995% pure). Axial stress. $\sigma_a = 10$ to 3000 psi. $\eta_g =$
 7×10^{-4} to 3×10^{-2} . (58 Mas, Figure 4)

ALUMINUM (Pure, annealed at 500°C). Bending. Low stress. $f =$
 $2,000$. $T = 50$ to 600°C . $\eta_g = 10^{-5}$ to 2×10^{-3} . (38 Fors,
Figure 5)

ALUMINUM (99.99% pure). Torsion. $\gamma_a = 10^{-2}$ to 10^{-1} . $\eta_g = 10^{-2}$ to 8×10^{-2} with $\eta_g = 7 \times 10^{-2}$ for all $\gamma_a > 2 \times 10^{-2}$. (57 Kea, Figure 6)

ALUMINUM (99.991% pure, worked to 95% area reduction, annealed at TR = 50 to 450°C). Torsion. Low stress. T = 25 to 450°C. $\eta_g = 3 \times 10^{-3}$ to 2×10^{-1} . 30x peak at 250°C for some TR's. (50 Ke, Figure 7)

ALUMINUM (99.5% pure). f = 10,000. T = 30 to 170°C. $\eta_g = 1.3 \times 10^{-5}$ to 1.7×10^{-4} . 4x increase with T. 8x peak at T = 250°C. (42 B1*)

ALUMINUM (Pure 2S, worked to 96% area reduction, annealed at TR = 50 to 450°C). Torsion. Low stress. T = 25 to 450°C. $\eta_g = 3 \times 10^{-3}$ to 2×10^{-1} . (50 Ke, Figure 8)

ALUMINUM (Pure 2S). Axial stress. $\sigma_a = 0.04$ to 6 ksi. $\eta_g = 6 \times 10^{-4}$ to 9×10^{-1} . (58 Mas, Figure 9)

ALUMINUM (Pure 1100, slightly cold worked). Low stress. Bending mode of vibration = 1, 2, and 5. T = 100 to 1100°F. $\eta_g = 2 \times 10^{-4}$ to 3×10^{-2} . (61 Bo, Figure 10)

ALUMINUM (With iron and copper impurities). Torsion. T = 0 to 450°C. $\eta_g = 10^{-3}$ to 9×10^{-2} . 90x peak at 300°C. (58 Mas, Figure 12)

ALUMINUM (Cold worked heavily and annealed at TR = 150 to 360°C). Torsion. Low frequencies. T = 10 to 350°C. $\eta_g = 3 \times 10^{-3}$

to 2×10^{-1} . 10x change with TR. 50x increase with T. (58 Mas, Figure 13)

ALUMINUM. Torsion. Hollow tubes. Strains of 10^{-4} to 10^{-3} . $f = 20$. $\tau_a = 2.4$ ksi. $\eta_g = 7.6 \times 10^{-3}$. (41 Ki*)

ALUMINUM (Commercial). At $f = 8,000$, $\eta_g = 1.8 \times 10^{-5}$ to 8.3×10^{-5} . At $f = 0.1$ to 10 , $\eta_g = 10^{-3}$. At $f = 40,000$, $\eta_g = 2 \times 10^{-4}$. (42 Bi*)

ALUMINUM. Axial stress. Small strain. $f = 10,000$. $\eta_g = 2.0 \times 10^{-5}$ to 10^{-4} . (41 Ki*)

ALUMINUM. Torsion. $\tau_a = 2$ to 10 ksi. $\eta_g = 2 \times 10^{-3}$ to 2×10^{-2} . (53 B, Figure 15)

ALUMINUM (Stretched or annealed). Torsion. Small strain. $f = 0.25$. For stretched case, $\eta_g = 1.4 \times 10^{-5}$. For annealed case, $\eta_g = 7 \times 10^{-7}$. (41 Ki*)

ALUMINUM (Pure, annealed). $f = 1,000$ to $10,000$. $\epsilon_g < 10^{-4}$. $\eta = 1.4 \times 10^{-5}$ to 2.7×10^{-5} . (62 Sm*)

ALUMINUM (Drawn). Bending. $f = 0$ to 60 . $\eta_g = 3 \times 10^{-3}$. (56 Ml, Figure 16)

ALUMINUM. Bending. $f = 1$ to 5 . $\eta_g = 2.6 \times 10^{-4}$. (41 Ki*)

ALUMINUM. Axial stress. Small strain. $f = 45,000$. $\eta_g = 1.4 \times 10^{-4}$. (41 Ki*)

ALUMINUM (Rolled). Bending. $f = 2$. $\epsilon < 10^{-4}$. $\eta_g = 1.8 \times 10^{-4}$.
(41 Ki*)

ALUMINUM (Rolled). Rotating bending. $\epsilon_a \approx 5 \times 10^{-3}$. $\eta_g = 1.1 \times 10^{-3}$. (41 Ki*)

ALUMINUM ALLOY (Russian alloys AM-6 and AMSB, both have equal damping). Bending. $T = 100$ to 400°C . $\eta_g = 2 \times 10^{-3}$ to 4×10^{-2} .
(62 Pisa, Figure 14)

ALUMINUM ALLOY (317 STR). Axial stress. Static test. $\sigma_m = 30$ ksi. $\eta_g = 1.2 \times 10^{-3}$. (41 Ki*)

ALUMINUM ALLOY (195-T6 and 142-T75). Bending. $\sigma_a = 2$ to 5 ksi. $\eta_g = 10^{-3}$ to 3×10^{-3} for 195-T6. $\eta_g = 5 \times 10^{-4}$ to 1.5×10^{-3} for 142-T75. (57 Tr, Figure 17)

ALUMINUM ALLOY (4.7% Cu, annealed at 275°F). Torsion. $\tau_a = 1$ to 40 ksi. $\eta_g = 8 \times 10^{-4}$ to 1.5×10^{-3} . (44 B, Figure 18)

ALUMINUM ALLOY (220-T4 casting). Bending. $f = 20$ to 300 . $\eta_g = 4 \times 10^{-2}$ to 10^{-2} . (57 Ml, Figure 19)

ALUMINUM ALLOY (355-T6 and 356-T6). Bending. $\sigma_a = 2$ to 5 ksi. $\eta_g = 10^{-3}$ to 3×10^{-3} for 355-T6. $\eta_g = 7 \times 10^{-4}$ to 2×10^{-3} for 356-T6. (57 Tr, Figure 20)

ALUMINUM ALLOYS (British types). Torsion. $\tau_a = 5$ ksi. $\eta_g = 8 \times 10^{-3}$ for Hyduminium 100 (S.A.P.). $\eta_g = 6 \times 10^{-4}$ for Duralumin (HE 14). $\eta_g = 4 \times 10^{-4}$ for R.R. 57 (DTD 5004 WP). $\eta_g = 3 \times 10^{-4}$ for R.R. 58 (DTD 5014 WP). (64 B1)

ALUMINUM ALLOY (2% Mg.). $f = 17,000$ to $34,000$. $\eta_s = 7 \times 10^{-6}$.
(42 Bi*)

ALUMINUM ALLOY (2014 wire, solution-treated, quenched, aged 0.5 to 20 hrs.). $T = 24$ to 60°C . $\eta_s = 2 \times 10^{-4}$ to 5×10^{-5} .
2x change with aging time. 3x change with T . (59 Wil, Figure 21)

ALUMINUM ALLOY (2014 wire, solution-treated, quenched). Torsion. $T = 10$ to 130°C . $f = 2.2$ and 124 . $\eta_s = 10^{-4}$ to 6×10^{-4} .
1.5x increase with f . 8x increase with T . (59 Wil, Figure 22)

ALUMINUM ALLOY (2017, solution-treated, quenched). Bending. $T = -60$ to $+40^\circ\text{C}$. $f = 1,250$ and $3,400$. $\eta_s = 5 \times 10^{-6}$ to 3×10^{-5} .
8x increase with T . 1 to 1.5x change with f . (54 E, Figure 23)

ALUMINUM ALLOY (2017, solution-treated, quenched, aging TR = 20 to 60°C , aging time = 0.1 to 100 hrs.). $\eta_s = 5 \times 10^{-6}$ to 5×10^{-5} .
2 to 8x change with aging. 4x change with TR. (54 E, Figure 24)

ALUMINUM ALLOY (2017). Axial stress. $\sigma_a = 10$ to 40 ksi. $\eta = 4 \times 10^{-3}$ to 8×10^{-3} . (43 L, Figure 25)

ALUMINUM ALLOY (2017). Axial stress. $\sigma_a = 10$ to 30 ksi. $D = 10^{-1}$ to 2 . (54 Y, Figure 26)

ALUMINUM ALLOY (2017). Axial stress. $\sigma_a = 10^{-2}$ to 10 ksi. $\eta_s =$

7×10^{-4} to 3×10^{-3} . (56 Mas, Figure 27)

ALUMINUM ALLOY (2024-T4, precipitation hardened). Bending. Vibration modes = 1, 3, and 5. Low stress. $T = 100$ to 800°F .

$\eta_g = 5 \times 10^{-5}$ to 10^{-1} . 1,000x increase with T . (61 Bo, Figure 28)

ALUMINUM ALLOY (2024-T4). $\sigma_a = 0$ to 45 ksi. $N = 10^{1.3}$ to 10^4 .

$D = 10^{-2}$ to 5×10^{-1} . $D = 5 \times 10^{-1}$ at $\sigma_a = \sigma_g = 25$ ksi. 10x decrease with N . (57 A, Figure 29)

ALUMINUM ALLOY (2024, extruded, solution heat-treated at 950°F , aged at 250°F). $\sigma_a = 0$ to 15 ksi. $\sigma_m = 0$ and 18 ksi. $D = 10^{-3}$ to 10^{-1} . Little change with σ_m . (56 Pe, Figure 30)

ALUMINUM ALLOY (2024-T4). Bending. $\sigma_a < 20$ ksi. At $f = 15$, $\eta = 2.5 \times 10^{-3}$. At $f = 100$, $\eta = 7 \times 10^{-4}$. At $f = 1,500$, $\eta = 5 \times 10^{-5}$. Test values agree well with theory of thermal relaxation or transverse thermo-elastic effects. (65 Gr)

ALUMINUM ALLOY (2024-T4). Decay test. Cantilever beam specimens having a constant rectangular cross-section with an integral enlarged gripped end. Data is based on nominal longitudinal stress distribution and does not consider any stress concentration at the enlarged end, which may produce higher damping. $n = 2.01$ and $J = 3.82 \times 10^{-11}$ for $\sigma_a < 14$ ksi. (63 Al)

ALUMINUM ALLOY (2218). Bending. $\sigma_a = 1$ to 6 ksi. $\eta_g = 10^{-3}$ to 5×10^{-3} . (57 Tr, Figure 31)

ALUMINUM ALLOY (6063-T6 and 6061S-T6, both have about equal damping). Bending. $\sigma_a = 1$ to 6 ksi. $\eta_s = 5 \times 10^{-4}$ to 5×10^{-3} . (57 Tr, Figure 32)

ALUMINUM ALLOY (Hinduminium, annealed at 360°C, furnace cooled at 10°C/hr.). Torsion. $\tau_a = 0$ to 2 ksi. $\eta = 5 \times 10^{-5}$ to 2×10^{-3} . 20x increase with τ_a . (47 H, Figure 33)

ALUMINUM ALLOY (Hinduminium, solution treated at 530°C, followed by several types of quenching and aging). Torsion. $\tau_a = 4$ to 16 ksi. $\eta = 10^{-5}$ to 7×10^{-3} . 50x increase with τ_a . (47 H, Figure 34)

ALUMINUM ALLOY (Hinduminium, solution treated at 530°C, aged at 170°C). Torsion. Quenched at 100°C, $\tau_a = 6$ to 12 ksi, $\eta = 10^{-5}$ to 5×10^{-4} . Quenched at 20°C, $\tau_a = 10$ to 16 ksi, $\eta = 10^{-5}$ to 4×10^{-4} . (47 H, Figure 35)

ALUMINUM ALLOY (2.5% Cu, 0.1 to 0.9% Mg., solution treated at 460°C, water quenched, aged at 54°C, aged 0.1 to 100 hrs.). Bending. $f = 1,900$. $\eta_s = 8 \times 10^{-6}$ to 5×10^{-5} . Highest damping for 0.59% Mg. 5x increase with aging. 4x change with % Mg. (57 En, Figure 36)

ALUMINUM ALLOY (4% Cu, 0 to 3% Mg., annealed at 500°C, water quenched, aged at 58°C, aged 0.1 to 100 hrs.). Bending. $f = 1,900$. $\eta_s = 9 \times 10^{-6}$ to 6×10^{-5} . 2x change with aging. 5x change with % Mg. (57 En, Figure 37)

ALUMINUM ALLOY (Various types and conditions). $f = 10$ to $12,000$.

$$\epsilon_a < 10^{-4}. \quad \eta = 0.2 \times 10^{-5} \text{ to } 3 \times 10^{-5}. \quad (62 \text{ Sm}^*)$$

ALUMINUM ALLOYS (1% Cu, cast, extruded, heat treated at 450°C).

Torsion. Axial mean strain. $\epsilon_a = 2 \times 10^{-3}$ to 1.8×10^{-2} .

$T = 32$ to 144°C . $\eta_g = 3.5 \times 10^{-2}$ to 10^{-2} . 3x decrease with ϵ_a . 3x change with T . (56 M, Figure 38)

ALUMINUM ALLOYS (0.1 to 4.8% Cu, cast, extruded, heat treated).

Torsion. $T = 100$ to 400°C . $\eta_g = 10^{-3}$ to 10^{-1} . 100x increase with T . 10x change with % Cu. (56 M, Figure 39)

ALUMINUM ALLOY (0.08% Cu, cast, extruded, heat treated at 400°C).

Torsion. Axial mean strain. $\epsilon_a = 2 \times 10^{-3}$ to 1.6×10^{-2} .

$T = 23$ to 151°C . $\eta_g = 6 \times 10^{-2}$ to 1.4×10^{-2} . 4x decrease with ϵ_a . 2x decrease with T . (56 M, Figure 40)

ALUMINUM ALLOYS (0.1 to 5.4% Mg., cast, extruded, various heat

treatments). Torsion. $T = 100$ to 500°C . $\eta_g = 10^{-3}$ to 2×10^{-1} . 100x increase with T . 10x decrease with % Mg. (56 M, Figure 41)

ALUMINUM ALLOY (11% Mg., extruded). Torsion. $\epsilon_a = 2 \times 10^{-3}$ to

7×10^{-3} . $N = 2 \times 10^5$ to 10^8 . $\eta_g = 6 \times 10^{-6}$ to 10^{-4} . 20x increase with ϵ_a . 10x decrease with N . (46 H, Figure 42)

ALUMINUM ALLOYS (Heat-treated, wrought alloys No. 2014-T6, X2020,

2024-T4, 2219-T62, 2618-T6). Bending. At 300 psi, $\eta_g = 3 \times 10^{-3}$ to 5×10^{-3} . At 1 ksi, $\eta_g = 4 \times 10^{-3}$ to 6×10^{-3} . At 10 ksi, $\eta_g = 5 \times 10^{-3}$ to 8×10^{-3} . (62 K)

ALUMINUM ALLOYS (Cast and heat-treated alloys 319F, 319-T6, and 356-T6). Bending. $\sigma_a = 3$ to 10 ksi. $\eta_s = 4 \times 10^{-3}$ to 8×10^{-3} . (62 K)

ALUMINUM ALLOYS (Powder metallurgy type AMP alloys XAPO01, XAPO04, and M484). At 3 ksi, $\eta_s = 6 \times 10^{-3}$ to 8×10^{-3} . At 10 ksi, $\eta_s = 9 \times 10^{-3}$ to 1.5×10^{-2} . (62 K)

ALUMINUM ALLOYS (Alclad 2024-T3, 5% clad on each side, and alclad 6061-T4, 10% clad on each side). At 1 ksi, $\eta_s = 5 \times 10^{-3}$. At 10 ksi, $\eta_s = 5 \times 10^{-2}$. Damping about 10 times that of bare metal at 10 ksi. (62 K)

ALUMINUM ALLOYS (Alclad 2024-T3, 10% on each side, and alclad 6061-T4, 20% on each side). At 1 ksi, $\eta_s > 8 \times 10^{-2}$. At 10 ksi, $\eta_s = 1.2 \times 10^{-1}$. Damping 20x that of bare metal. (62 K)

ALUMINUM ALLOYS (Electrical conductor alloys, EC-H12, EC-T64, EC-H13). At 300 psi, $\eta_s = 6 \times 10^{-3}$ to 8×10^{-3} . At 5 ksi, $\eta_s = 8 \times 10^{-3}$ to 10^{-2} . At 10 ksi, $\eta_s = 2 \times 10^{-2}$ to 5×10^{-2} . (62 K)

ALUMINUM ALLOY (6061-T6). See Aluminum Alloy 2024-T4, reference 63 Ai. $n = 1.942$ and $J = 4.41 \times 10^{-11}$ for $\sigma < 15.5$ ksi. $n = 2.881$ and $J = 5.13 \times 10^{-15}$ for $\sigma > 15.5$ ksi. (63 Ai)

BERYLLIUM ALLOY (Produced by Brush Beryllium Co.; 18.6 Be, 1.5% Be O, 0.12% Fe, 0.04% Al, 0.03% Mg, 0.01% Ni; $E = 44 \times 10^6$ psi, ultimate tensile strength = 46.7 ksi, 0.2% offset yield

strength = 36.4 ksi, fatigue strength at 2×10^6 cycles = 33.0 ksi). At 2 ksi, $D = 0.005$. At 5 ksi, $D = 0.025$. At 10 ksi (cyclic stress sensitivity limit), $D = 0.1$. At 20 ksi, $D = 2.0$. At 50 ksi, $D = 130$. From 2 to 10 ksi η is approximately 0.015, from 10 to 50 ksi η increases from 0.015 to 0.9. (59 Tor)

BISMUTH. Elastic-plastic bending. $f = 1$. $N = 0$ to 800. $\eta_s = 3 \times 10^{-3}$ to 1.6×10^{-2} . $\eta_s = 1.6 \times 10^{-2}$ peak at $N = 600$. (61 Ga, Figure 43)

BISMUTH (Cast). Bending. $f = 2,000$. $\eta_s = 5.6 \times 10^{-4}$. (38 Fors)

CADMIUM (Cast). Bending. $f = 2,000$. $\eta_s = 3.5 \times 10^{-4}$. (38 Fors)

CHROMIUM (Pure, annealed at 1150°C , grain size of 2-7 microns).

Torsion. $T = 0$ or 55°C . $\sigma_m = 34$ to 232 Kg/cm^2 . $\gamma_a = 10^{-5}$ to 10^{-4} . At $T = 0^\circ\text{C}$, $\eta_s = 10^{-4}$ to 5×10^{-4} , 3x increase with γ_a , 2x increase with σ_m . At $T = 55^\circ\text{C}$, $\eta_s \approx 2.5 \times 10^{-5}$, little change with γ_a or σ_m . (61 Mort, Figures 44 and 45)

CHROMIUM (Pure, annealed at 1150°C , grain size of 2-7 microns).

Torsion. $\sigma_m = 34$ to 232 Kg/cm^2 . $T = -60$ to $+50^\circ\text{C}$. $\eta_s = 7 \times 10^{-4}$ to 3×10^{-5} . 20x decrease with T . 2x increase with σ_m . (61 Mort, Figures 46, 47, and 48)

CHROMIUM IRON (13% Cr). Range of values observed at various temperatures as stress is increased from 5 to 35 ksi. At $T = 24^\circ\text{C}$, $\eta_s = 0.7 \times 10^{-3}$ to 7×10^{-3} . At $T = 260^\circ\text{C}$, $\eta_s = 10^{-3}$

to 7×10^{-3} . At $T = 482^{\circ}\text{C}$, $\eta_g = 2 \times 10^{-3}$ to 4×10^{-3} . At $T = 566^{\circ}\text{C}$, $\eta_g = 3 \times 10^{-3}$ to 4.5×10^{-3} . (62 Sm*)

COBALT ALLOY (Stellite 31, cast, polished). Rotating bending.

$N = 10^2$ to 10^4 . At $T = 1,200^{\circ}\text{F}$ and $\sigma_a = 10$ to 60 ksi, $D = 5 \times 10^{-2}$ to 5×10^2 , with $D = 8 \times 10^{-1}$ at $\sigma_a = \sigma_g = 25$ ksi. At $T = 1,500^{\circ}\text{F}$ and $\sigma_a = 10$ to 50 ksi, $D = 6 \times 10^{-1}$ to 1.5×10^2 , with $D = 5$ at $\sigma_a = \sigma_g = 34$ ksi. In both cases there is a 5x decrease with N . (56 Po, Figures 49 and 50)

COBALT ALLOY (Nivco 10, solution treated, aged). Torsion. $T = 70$ to $1,200^{\circ}\text{F}$. $\tau_a = 3$ to 15 ksi. $\eta_g = 5 \times 10^{-3}$ to 5×10^{-2} . 10x increase with τ_a . 2x increase with T . (59 Co, Figure 51)

COBALT ALLOY (Stellite 31, cast, aged at $1,350^{\circ}\text{F}$, furnace cooled to $1,000^{\circ}\text{F}$, air cooled). Rotating bending. $N = 10^2$ to 10^5 . At $T = 1,200^{\circ}\text{F}$ and $\sigma_a = 10$ to 60 ksi, $D = 5 \times 10^{-2}$ to 8×10^1 , with $D = 2.5$ at $\sigma_a = \sigma_g = 38$ ksi. At $T = 1,500^{\circ}\text{F}$ and $\sigma_a = 10$ to 50 ksi, $D = 1.5 \times 10^{-1}$ to 5×10^1 , with $D = 4$ at $\sigma_a = \sigma_g = 30$ ksi. In both cases there is a 5 to 10x decrease with N . (56 Po, Figures 52 and 54)

COBALT ALLOY (Nivco 10, heat treated). $\tau_a = 1$ to 20 ksi. $\eta = 5 \times 10^{-3}$ to 8×10^{-2} . (59 Laza, Figure 53)

COBALT ALLOY (20% Fe). Torsion. $\gamma_a = 10^{-4}$ to 6×10^{-4} . $\eta_g = 1.5 \times 10^{-2}$ to 3×10^{-2} with no magnetic field. $\eta_g = 6 \times 10^{-4}$ to 2×10^{-3} with a magnetic field of 500 oersteds. (56 Co, Figure 55)

COBALT ALLOY (28% Ni). Torsion. $\gamma_a = 10^{-4}$ to 6×10^{-4} . $\eta_s = 4 \times 10^{-3}$ to 3×10^{-2} with no magnetic field. $\eta_s = 6 \times 10^{-4}$ to 3×10^{-3} with a magnetic field of 500 oersteds. (56 Co, Figure 56)

COBALT ALLOY (23% Ni, annealed at 1,900°F for 1 hr., air cooled). Bending. $T = 75^\circ\text{F}$. $\sigma_m = 0$ to 11 ksi. $\sigma_a = 1$ to 30 ksi. $\eta_s = 5 \times 10^{-4}$ to 7×10^{-3} . 7x increase with σ_a . 5x decrease with σ_m . (60 Cl, Figure 57)

COBALT ALLOY (35% Ni). Torsion. $\gamma_a = 10^{-4}$ to 6×10^{-4} . Under magnetic field of 500 oersted, $\eta_s = 10^{-3}$ to 4×10^{-2} . Under no magnetic field, $\eta_s = 8 \times 10^{-3}$ to 6×10^{-2} with $\eta_s = 6 \times 10^{-2}$ peak at $\gamma_a = 2.5 \times 10^{-4}$. (56 Co, Figure 58)

COBALT ALLOY (34% Ni, 2% Fe, 2% Ti, annealed at 1,900°F, air cooled). Bending. $\sigma_a = 1$ to 30 ksi. $\sigma_m = 0$ and 11 ksi. $T = 75, 600$, and $1,100^\circ\text{F}$. $\eta_s = 3 \times 10^{-4}$ to 6×10^{-3} . 20x increase with σ_a at $T = 75^\circ\text{F}$. 3x decrease with σ_m at 75°F . 5x increase with σ_a at $T = 600^\circ\text{F}$ and $\sigma_m = 11$ ksi. 8x increase with σ_a and 2x change with σ_m at $T = 1,100^\circ\text{F}$. (60 Cl, Figures 59 and 60)

COBALT ALLOY (S-816, annealed, ground, annealed at 2,300°F, water quenched, aged at 1,400°F). Rotating bending. $N = 10^{1.3}$ to 10^7 . At $T = 70^\circ\text{F}$ and $\sigma_a = 20$ to 120 ksi, $D = 10^{-1}$ to 2×10^3 , with $D = 1$ at $\sigma_a = \sigma_g = 40$ ksi. At $T = 1,350^\circ\text{F}$ and $\sigma_a = 10$ to 80 ksi, $D = 10^{-1}$ to 10^3 , with $D = 2.6$ at $\sigma_a = \sigma_g$

= 40 ksi. At $T = 1,650^{\circ}\text{F}$ and $\sigma_a = 10$ to 50 ksi, $D = 5 \times 10^{-1}$ to 2×10^2 , with $D = 2$ at $\sigma_a = \sigma_g = 24$ ksi. (56 Po, Figures 61, 62, and 64)

COBALT ALLOY (S-816, ground, annealed at $2,300^{\circ}\text{F}$, water quenched, aged at $1,400^{\circ}\text{F}$). Bending. $\sigma_a = 3$ to 50 ksi. $\sigma_m = 0$ to 42 ksi. $D = 10^{-4}$ to 5. 10x increase with σ_m . 100x increase with σ_a . (56 Pe, Figure 63)

COBALT ALLOY (30% Fe, air cooled or water quenched). Torsion. With and without magnetic field. $\tau_a = 1$ to 12 ksi. $\eta_g = 2 \times 10^{-3}$ to 3×10^{-2} . Air cooled, $\eta_g = 2 \times 10^{-3}$ to 3×10^{-3} with magnetic field, $\eta_g = 10^{-2}$ to 3×10^{-2} without magnetic field. Quenched, $\eta_g = 2.5 \times 10^{-3}$ to 8×10^{-3} without magnetic field. (53 Co, Figure 65)

COBALT ALLOY (Vitalium, 29% Cr, 5% Mo, 0.5% Mn, cast, annealed at $1,500^{\circ}\text{F}$, furnace cooled). Bending. $f = 1,000$. $\sigma_a = 5$ to 35 ksi. $T = 75$ to $1,200^{\circ}\text{F}$. $\eta_g = 5 \times 10^{-5}$ to 10^{-3} . 10x increase with T . 3x increase with σ_a . (44 Sc, Figure 66)

COPPER (Single crystal). $f = 40,000$. $\eta = 1.1 \times 10^{-5}$ for annealed crystal. $\eta_g = 10^{-3}$ for unannealed crystal. (42 Bi*)

COPPER (Pure, single crystal). Bending. $f = 10,000$. Irradiated. Time of radiation = 0 to 360 hr. $\eta_g = 3 \times 10^{-3}$ to 3×10^{-4} . (58 Mas, Figure 69)

COPPER (Pure, single crystal). Kilocycle frequency region. $\epsilon_a =$

3×10^{-7} to 35×10^{-7} . $\eta_s = 5 \times 10^{-4}$ to 7×10^{-3} . (50 Koe, Figure 68)

COPPER (Pure, single crystal, annealed). Axial stress. $T = 0$ and 23°C . $\epsilon_a = 7.5 \times 10^{-7}$ to 1.75×10^{-6} . $\eta = 6 \times 10^{-5}$ to 6×10^{-4} . Little increase with T . (41 R, Figure 72)

COPPER (Pure, annealed). $f = 2,000$. $\epsilon_a < 10^{-4}$. $\eta = 1.1 \times 10^{-3}$. (62 Sm*)

COPPER (Pure, annealed). Torsion. $T = 0$ to 400°C . At 4% cold work, $\eta_s = 3 \times 10^{-3}$ to 1.8×10^{-2} . At 55% cold work, $\eta_s = 3 \times 10^{-3}$ to 4×10^{-2} . (54 M, Figure 67)

COPPER (Pure). Torsion. $\tau_a = 2$ to 14 ksi. $\eta_s = 5 \times 10^{-3}$ to 3×10^{-2} . (53 B, Figure 70)

COPPER (Crystal). Axial stress. $f = 30,000$. $T = 10$ to 150°K . $\eta_s = 10^{-4}$ to 5×10^{-3} . 50x peak at $T = 90^\circ\text{K}$. (58 Mas, Figure 77)

COPPER (Pure, 44% reduction, annealed). Torsion. $T = 20$ to 250°C . $\gamma_a = 2 \times 10^{-5}$ to 10^{-4} . $\eta_s = 5 \times 10^{-3}$ to 10^{-1} . 10x increase with γ_a . 5x increase with T . (54 M, Figure 75)

COPPER (Pure, drawn or annealed). Bending. $f = 20$ to 550 . Drawn, $\eta_s = 2.5 \times 10^{-3}$ to 8×10^{-4} . Annealed, $\eta_s = 7 \times 10^{-3}$ to 2×10^{-3} . (56 M1, Figures 73 and 76)

COPPER (Pure). $T = 10$ to 300°K . Under bending, $f = 100$, $\eta_s =$

10^{-4} to 3×10^{-3} . Under shear, $f = 1.45 \times 10^7$, $\eta_s = 10^{-4}$ to 10^{-3} . (58 Mas, Figure 71)

COPPER (Pure, annealed). Torsion. $T = 10$ to 200°K . $\eta_s = 2 \times 10^{-3}$ to 5×10^{-4} . Peak at $T = 60^\circ\text{K}$. Minimum at $T = 120^\circ\text{K}$. (61 Ni, Figure 78)

COPPER (Pure). Torsion. $\gamma_a = 10^{-2}$ to 8×10^{-2} . $\eta_s = 3 \times 10^{-3}$ to 3.2×10^{-2} . (57 Kea, Figure 74)

COPPER (Pure, some silicon). Torsion. $T = 100$ to 600°C . $\eta_s = 2 \times 10^{-3}$ to 5×10^{-2} . (58 Mas, Figure 80)

COPPER (Annealed 30 min. at 400°C). Bending. $f = 2,000$. $\eta_s = 1.1 \times 10^{-3}$. (38 Fors)

COPPER. Small strain. Axial stress. $f = 10,000$. $\eta_s = 1.0 \times 10^{-4}$ to 1.9×10^{-3} . (41 Ki*)

COPPER. Small strains. Bending. $f = 1$ to 10 . $\eta_s = 1.0 \times 10^{-3}$. (41 Ki*)

COPPER. Torsion. $\eta_s = 5.1 \times 10^{-2}$. (41 Ki*)

COPPER (Annealed or rolled). Strain less than 10^{-4} . Bending. $f = 2$. $\eta_s = 7.6 \times 10^{-4}$ for annealed case. $\eta_s = 4.0 \times 10^{-4}$ for rolled case. (41 Ki*)

COPPER. Small strain. Axial stress. $f = 45,000$. $\eta_s = 6.4 \times 10^{-4}$. (41 Ki*)

COPPER. Bending. $f = 1$ to 5 . $\eta_s = 2.2 \times 10^{-4}$. (41 Ki*)

COPPER (Annealed). Strains of 10^{-4} to 10^{-3} . Torsion on hollow tubes. $f = 20$. $\sigma_a = 1.1$ ksi. $\eta_s = 7.6 \times 10^{-3}$. (41 Ki*)

COPPER (Pure, annealed, and cold worked). $f = 0.1$ to $10,000$. $\epsilon < 10^{-4}$. $\eta = 2.2 \times 10^{-4}$ to 6.4×10^{-4} . (62 Sm*)

COPPER (Red). Torsion. $T = 50$ to 150°C . $\eta_s = 7 \times 10^{-4}$ to 7×10^{-3} . (31 C, Figure 98)

COPPER ALLOY (2.6% Co, 0.4% Be, solution treated at 900°C , quenched, aged at 500°C). Torsion. $\tau_a = 0$ to 10 ksi. $\eta_s = 4 \times 10^{-5}$ to 2×10^{-4} . (38 F1, Figure 79)

COPPER ALLOY (2% Be, four treatments having different quenches and aging). Torsion. $\tau_a = 5$ to 25 ksi. $\eta_s = 10^{-4}$ to 5×10^{-4} . 5x increase with τ_a . 4x changes with treatments. (39 N, Figure 81)

COPPER ALLOY (2.12% Be, 0.30% Fe, 0.30% Ni, solution treated at 800°C , four different age treatments). Torsion. $\tau_a = 5$ to 20 ksi. $\eta_s = 10^{-4}$ to 6×10^{-4} . 5x increase with τ_a . 4x change with treatment. (38 F1, Figure 82)

COPPER ALLOY (0.81% Cr, 0.02% Si, solution treated at 1025°C , aged at 500°C for 20 min. to 2 hr.). Torsion. $\tau_a = 5$ to 15 ksi. $\eta_s = 3 \times 10^{-5}$ to 2×10^{-2} . 10x increase with τ_a . 1,000x change with aging. (38 F1, Figure 83)

COPPER ALLOY (Brass). Bending. $f = 50$ to 600 . $\eta_s = 3 \times 10^{-3}$ to 6×10^{-3} . $\eta_s = 6 \times 10^{-3}$ peak at $f = 400$. (49 K, Figure 84)

COPPER ALLOY (Brass, drawn). Bending. $f = 0$ to 3000 . $\eta_s = 3 \times 10^{-4}$ to 2×10^{-5} . (56 Mi, Figure 86)

COPPER ALLOY (Brass). Torsion. $\sigma_m = 2$ to 12 ksi. $\eta_s = 2 \times 10^{-4}$ to 2×10^{-3} . (62 Pisa, Figure 89)

COPPER ALLOY (2% Be, aged). $f = 1,300$. $\epsilon_a < 10^{-4}$. $\eta = 4 \times 10^{-6}$ to 1.6×10^{-5} . (62 Sm*)

COPPER ALLOY (Brass). Torsion. $\tau_a = 5$ to 30 ksi. $\eta_s = 2 \times 10^{-3}$ to 4×10^{-2} . (53 B, Figure 91)

COPPER ALLOY (Brass, 70.59% Cu, 29.39% Zn, cold drawn with 65% area reduction, annealed at 400°C , air cooled). Bending. 0 to 25% elongation. $\eta_s = 10^{-6}$ to 2×10^{-4} . (42 Ze, Figure 85)

COPPER ALLOY (α -Brass, single crystal). $f = 620$. $T = 320$ to 560°C . $\eta_s = 5 \times 10^{-4}$ to 10^{-2} . $\eta_s = 10^{-2}$ peak at $T = 420^\circ\text{C}$. (58 Mas, Figure 87)

COPPER ALLOY (α -Brass, not of high purity). Torsion. $T = 350$ to 600°C . $\eta_s = 7 \times 10^{-4}$ to 7×10^{-2} . $\eta_s = 7 \times 10^{-2}$ peak at $T = 500^\circ\text{C}$. (58 Mas, Figure 92)

COPPER ALLOY (0 to 9.7% Zn). Bending. $f = 2,000$. $\epsilon_a = 10^{-7}$ to

10^{-3} . $\eta_g = 10^{-4}$ to 10^{-2} . 10x increase with ϵ_a . 20x increase with % Zn. (58 Mas, Figure 88)

COPPER ALLOY (31.5%, 19.7%, or 11.1% Zn). Torsion. $T = 50$ to 200°C . $\eta_g = 2 \times 10^{-4}$ to 2×10^{-3} . 10x increase with T . 1.5 change with % Zn. (31 C, Figure 90)

COPPER ALLOY (38 to 47% Zn, 0 to 1% Fe, 0 to 1% Sn, 0 to 1% Mn). Torsion. $\tau_a = 1$ to 7 ksi. $\eta_g = 2 \times 10^{-4}$ to 10^{-3} . 2x increase with τ_a . 1.5x change with % Zn. (44 B, Figure 94)

COPPER ALLOY (5.42% Sn). Torsion. $\tau_a = 2$ to 7 ksi. $\eta_g = 5 \times 10^{-4}$ to 7×10^{-4} . (44 B, Figure 93)

COPPER ALLOY (9%, 6%, or 3% Sn, also 3% Sn plus 0.05% Be, annealed). Low stress. Torsion. $T = 0$ to 500°C . $\eta_g = 3 \times 10^{-4}$ to 7×10^{-2} . 200x increase with T . 5x change with composition. (54 M, Figure 97)

COPPER ALLOY (5 to 15% Sn, annealed) $f = 13,000$. $\epsilon_a < 10^{-4}$. $\eta = 1.3 \times 10^{-4}$ to 1.8×10^{-4} . (62 Sm*)

COPPER ALLOY (α -Brass, 30% Zn, annealed and cold worked up to 30%). $f = 10$ to 36,000. $\epsilon_a < 10^{-4}$. $\eta = 3 \times 10^{-6}$ to 10^{-4} . (62 Sm*)

COPPER ALLOY (British types). Torsion. $\tau_a = 5$ ksi. Hidurel 6 (as cast), $\eta_g = 19 \times 10^{-4}$. Gun metal (88% Cu., 10% Zn, 2% Sn), $\eta_g = 16 \times 10^{-4}$. Brass (B.S. 265 as extruded), $\eta_g = 7 \times 10^{-4}$. Hidurel 5 (as cast), $\eta_g = 7 \times 10^{-4}$. Hidurel 7

(as cast), $\eta_s = 5 \times 10^{-4}$. High tensile brass (E. Ih. C. 2C100, as cast), $\eta_s = 5 \times 10^{-4}$. Novaston, $\eta_s = 5 \times 10^{-5}$. (64 Bi)

COPPER ALLOY (Bronze). Torsion. $\sigma_m = 2$ to 12 ksi. $\eta_s = 1.5 \times 10^{-4}$ to 10^{-2} . (62 Pisa, Figure 95)

COPPER ALLOY (Phosphorous bronze). Torsion in hollow tubes. $f = 20$. $\gamma_a = 10^{-4}$ to 10^{-3} . $\eta_s = 1.8 \times 10^{-3}$. (41 Ki*)

COPPER ALLOY (Phosphorous bronze). Rotating bending. $\epsilon_a = 5 \times 10^{-3}$. $\eta_s = 1.2 \times 10^{-4}$. (41 Ki*)

COPPER ALLOY (Phosphorous bronze). Static tests. At $\sigma_m = 60$ ksi, $\eta_s = 5.8 \times 10^{-4}$. At $\sigma_m = 100$ ksi, $\eta_s = 2.1 \times 10^{-3}$. (41 Ki*)

COPPER ALLOY (10% Ni). Torsion. $T = 50$ to 300°C . $\eta_s = 3 \times 10^{-4}$ to 10^{-2} . (31 C, Figure 96)

GOLD (99.998% pure. Various annealing temperatures and cold working). Torsion. $f = 1$. $T = 200$ to 1200°F . Low stress. $\eta_s = 2 \times 10^{-3}$ to 5×10^{-2} . 30x increase with T . (58 Mas, Figures 99, 100, and 102)

IRON (Pure, cold drawn, heated in wet H_2 at temperature, various treatments and aging). Torsion. $\gamma_a = 0$ to 8×10^{-5} . $f = 0.83$. In various magnetic fields. $T = -150$ to 70°C . $\eta_s = 2 \times 10^{-3}$ to 2×10^{-2} . (61 Fa, Figures 103, 104, 105, 106, 108, 109, 110, and 111)

IRON (Electrolytic). Torsion. $f = 1$. $T = 100$ to 150°K . $\eta_s = 1.2 \times 10^{-2}$. Negligible change with T . (53 Ch, Figure 101)

IRON (0.003% C, heat treated, quenched). Torsion. $f = 1$. $T = -15^{\circ}\text{C}$. $\gamma_a = 10^{-5}$ to 8×10^{-5} . $\eta_s = 2 \times 10^{-3}$ to 10^{-2} . 5x increase with γ_a . 5x change with time after deformation. (61 Fa, Figures 124 and 125)

IRON (Note of high purity). Torsion. $T = 300$ to 550°C . $\eta_s = 2 \times 10^{-3}$ to 7×10^{-2} . $\eta_s = 6 \times 10^{-2}$ peak at $T = 500^{\circ}\text{C}$. (58 Mas, Figure 107)

IRON (Carbon free, heat-treated). Torsion. $T = -15^{\circ}\text{C}$. $\gamma_a = 10^{-5}$ to 7×10^{-5} . A magnetic field of 200 oersteds. $\eta_s = 2.5 \times 10^{-3}$ to 2×10^{-2} . 4x increase with γ_a . 5x increase with time after deformation. (61 Fa, Figure 112)

IRON (Various amounts of N). Torsion. $T = -80$ to $+40^{\circ}\text{C}$. $\eta_s = 3 \times 10^{-3}$ to 3×10^{-2} . 10x peak at $T = -20^{\circ}\text{C}$. 10x change with composition and treatment. (58 Mas, Figure 113)

IRON (0.0028% C, 0.0014% N, various treatments). Torsion. $\gamma_a = 10^{-4}$ to 6×10^{-4} . $\eta_s = 10^{-3}$ to 3×10^{-2} . 20x peak at $\gamma_a = 1.5 \times 10^{-4}$. 4x change with treatment. (58 Su, Figure 122)

IRON (0.04% C, three treatments). Torsion. $T = 0$ to 60°C . $\eta_s = 10^{-3}$ to 2×10^{-2} . 20x peak at 40°C . 5x change with treatment. (51 F, Figure 130)

IRON (0.02% N, two treatments). Torsion. $T = -20$ to 60°C . $\eta_s =$

10^{-3} to 2×10^{-2} . 20x peak at $T = 25^{\circ}\text{C}$. 4x change with treatment. (51 F, Figure 115)

IRON (0.001% C, cold drawn, heated in H_2 with 0.001% CH_4 , quenched from 600°C). Torsion. $f = 1$. $\gamma_a = 2 \times 10^{-5}$ to 6×10^{-5} . $\eta_s = 2 \times 10^{-3}$ to 10^{-2} . 5x increase with γ_a . 5x change with deformaging and aging. (61 Fa, Figure 120)

IRON (Annealed 30 min. at 930°C , air cooled). Bending. $f = 2,000$. $\eta_s = 1.8 \times 10^{-4}$. (38 Fors)

IRON (GBC-1, annealed, drawn, recrystallized at 750°C). Torsion. $f = 2.5$. $T = 420$ to 620°C . $\eta_s = 4 \times 10^{-2}$ to 8×10^{-2} . $\eta_s = 8 \times 10^{-2}$ peaks at $T = 500$ and 620°C . (61 Lea, Figure 121)

IRON (Pure, annealed). $f = 2,000$. $\epsilon_a < 10^{-4}$. $\eta = 1.8 \times 10^{-4}$. (62 Sm*)

IRON (GBC-4, annealed, drawn, recrystallized at 750°C). Torsion. $f = 1.79$. $T = 440$ to 600°C . $\eta_s = 3 \times 10^{-2}$ to 10^{-1} . $\eta_s = 10^{-1}$ peak at $T = 530^{\circ}\text{C}$. (61 Lea, Figure 123)

IRON (Armco, no carbon). Torsion. $\gamma_a = 10^{-2}$ to 8×10^{-2} . $\eta_s = 3 \times 10^{-3}$ to 4×10^{-2} . $\eta_s \approx 3.5 \times 10^{-2}$ for $\gamma_a > 2 \times 10^{-2}$. (57 Kea, Figure 126)

IRON (Armco, 0.020% C, annealed in vacuum at 720°C , cooled slowly). Torsion. $f = 2$. $\gamma_a = 10^{-2}$ to 8×10^{-2} . $\eta_s = 8 \times 10^{-3}$ to 3×10^{-2} . (57 Kea, Figure 127)

IRON (Armco). $\eta = 5 \times 10^{-5}$. (62 P1)

IRON (Armco, annealed in vacuum at 720°C, cooled slowly). Torsion. $f = 2$. $\gamma_a = 10^{-2}$ to 8×10^{-2} . $T = 280^\circ\text{C}$. $\eta_s = 4 \times 10^{-3}$ to 1.4×10^{-2} . (57 Kea, Figure 131)

IRON (Armco, 0.019% C, 75% and 25% drawn). $f = 1$. $T = 0$ to 400°C . $\eta_s = 10^{-3}$ to 5×10^{-3} . 4x change with T . (60 Figu, Figure 128)

IRON (Armco). Torsion. $\tau_a = 2$ to 14 ksi. $\eta_s = 2.5 \times 10^{-3}$ to 7×10^{-3} . Minimum at $\tau_a = 10$ ksi. (62 Pisa, Figure 129)

IRON (Armco, 25% and 80% cold drawn, aged). $T = 20^\circ\text{C}$. $\eta_s = 10^{-3}$ to 2×10^{-4} . 5x decrease with time after deformation. (58 Mas, Figure 132)

IRON (Armco). $\gamma_a = 10^{-4}$ to 10^{-3} . Torsion on hollow tubes. $f = 20$. $\sigma_a = 11.6$ ksi. $\eta_s = 6.4 \times 10^{-3}$. (41 K1*)

IRON (Armco, annealed). Static test. $\sigma_a = 8$ ksi. $\eta_s = 3.7 \times 10^{-3}$. (41 K1*)

IRON ALLOY (1.1% Si, 0.005% Mn, 0.005% S, 0.0035% N, 0.0034% C, annealed, quenched from 1,050°C). Torsion. $f = 0.93$. $T = 0$ to 80°C . $\eta_s = 3 \times 10^{-3}$ to 3×10^{-4} . $\eta_s = 3 \times 10^{-3}$ peak at $T = 20^\circ\text{C}$. (61 R, Figure 118)

IRON ALLOY (0.5% Mn, 0.04% C, three treatments). Torsion. $T = 0$ to 60°C . $\eta_s = 10^{-3}$ to 10^{-2} . 10x peak at $T = 40^\circ\text{C}$. 5x change with treatments. (51 F, Figure 114)

IRON ALLOY (0.5% Mn, 0.02% N, two treatments). Torsion. $T = -20$ to 60°C . $\eta_s = 10^{-3}$ to 10^{-2} . 10x peak at $T = 30^{\circ}\text{C}$. (51 F, Figure 116)

IRON ALLOY (40% Co, forged, ground, heat treated at 900°C in H_2). Torsion. $\tau_a = 5$ to 40 ksi. $\sigma_m = 0.3$ to 10 ksi. $\eta_s = 3 \times 10^{-3}$ to 7×10^{-2} . 5x increase with τ_a . 10x decrease with σ_m . (53 Coc, Figure 117)

IRON ALLOY (Steel). Bending. Strain $< 10^{-4}$. $f = 2$. $\sigma_m = 3$ ksi. $\eta_s = 4.8 \times 10^{-4}$. (41 Ki*)

IRON ALLOY (Steel). Torsion on hollow tubes. At $\sigma_m = 6$ ksi, $\eta_s = 1.4 \times 10^{-4}$. At $\sigma_m = 10$ ksi, $\eta_s = 2.4 \times 10^{-4}$. (41 Ki*)

IRON ALLOY (Steel, annealed at 800°C). Static test. $\sigma_m = 6$ ksi. $\eta_s = 1.4 \times 10^{-3}$. (41 Ki*)

IRON ALLOY (Steel, hard drawn). Small strain. Torsion. $f = 0.25$. $\eta_s = 6 \times 10^{-7}$. (41 Ki*)

IRON ALLOY (Steel). Medium strain. Bending. $f = 9$. $\eta_s = 1.3 \times 10^{-3}$. (41 Ki*)

IRON ALLOY (Steel, cold rolled). Torsion on hollow tubes. $\gamma_s = 10^{-4}$ to 10^{-3} . $f = 20$. $\sigma_a = 9.9$ ksi. $\eta_s = 5.9 \times 10^{-3}$. (41 Ki*)

IRON ALLOY (Steel, annealed at 800°C). Torsion. $f = 67$. $\sigma_m = 6$ ksi. $\eta_s = 7.6 \times 10^{-4}$. (41 Ki*)

IRON ALLOY (Bearing steel). Torsion. $\eta_s = 1.3 \times 10^{-4}$. (41 Ki*)

IRON ALLOY (Steel). Small strain. Axial stress. $f = 10,000$.

$\eta_s = 2.4 \times 10^{-5}$ to 2.4×10^{-4} . (41 Ki*)

IRON ALLOY (Steel). Torsion. $\eta_s = 2.9 \times 10^{-2}$. (41 Ki*)

IRON ALLOY (Ball bearing steel). Torsion. $\sigma_m = 30$ ksi. $\eta_s = 6.7 \times 10^{-4}$. (41 Ki*)

IRON ALLOY (SAE 1018 Steel, soft cold rolled, strip). Uniaxial stress for beams. Biaxial stress for plate. $\sigma_a = 0.1$ to 8 ksi. $\eta_s = 10^{-4}$ to 2×10^{-3} . 10x increase with σ_a . 2x change with rolling direction. (61 W, Figure 133)

IRON ALLOY (SAE 1020 Steel). $\sigma_a = 2$ to 40 ksi. $N = 10^{1.3}$ to 10^6 . $D = 10^{-2}$ to 5×10^1 . 4,000x increase with σ_a . 10x increase with N . (57 A, Figure 134)

IRON ALLOY (SAE 1020 Steel, hot rolled). Bending. $f = 1,000$. $\sigma_a = 5$ to 35 ksi. $T = 75$ to 500°F . $\eta_s = 5 \times 10^{-4}$ to 3×10^{-3} . 9x increase with σ_a . 3x change with T . (44 Sc, Figure 135)

IRON ALLOY (SAE 1020 Steel, hot rolled). Bending. $\sigma_a = 5$ to 35 ksi. $\sigma_m = 0$ to 21 ksi. $D = 10^{-3}$ to 10^{-1} . 20x increase with σ_a . 10x increase with σ_m . (56 Pe, Figure 136)

IRON ALLOY (SAE 1020 Steel). Torsion. $\tau_a = 10$ to 35 ksi. $\eta_s = 10^{-3}$ to 4×10^{-2} . (53 B, Figure 137)

IRON ALLOY (1020 Steel, annealed). See Aluminum Alloy 2024-T4, reference 63 A1. $n = 2.286$ and $J = 2.626 \times 10^{-13}$ for $\sigma_a < 15$ ksi. (63 A1)

IRON ALLOY (0.21% C Steel, 0.37% Mn, normalized, then cold worked by 90° permanent set, aged 10 min. to 1 yr.). Torsion. $\tau_a = 5$ to 25 ksi. $\eta_s = 2 \times 10^{-3}$ to 5×10^{-2} . 10x increase with aging. 10x increase with τ_a . (38 C, Figure 138)

IRON ALLOY (Mild steel). Bending. $\sigma_a = 2.5$ to 5.5 ksi. $\eta_s = 9 \times 10^{-4}$ to 1.4×10^{-3} . (57 Tr, Figure 139)

IRON ALLOY (Mild steel, cold rolled). Strains of about 5×10^{-3} . Rotating bending. $\eta_s = 1.6 \times 10^{-3}$. (41 K1*)

IRON ALLOY (0.70% C Steel, annealed, or pickled, or both). $f = 1$. $T = 100$ to 150°K . $\eta_s = 10^{-3}$ to 2×10^{-3} . Little change with T . 2x increase with treatment. (53 Ch, Figure 140)

IRON ALLOY (SAE 1020 Steel). Under axial stress, $\sigma_a = 4$ to 18 ksi, $D = 3 \times 10^{-2}$ to 3. Under shear, $\tau_a = 8$ to 40 ksi, $D = 3 \times 10^{-2}$ to 10. (57 Y, Figure 141)

IRON ALLOY (SAE 1025 Steel, seam-welded tubing). Axial stress. $\sigma_a = 5$ to 40 ksi. $D = 10^{-2}$ to 3×10^{-1} . (46 Ro, Figure 142)

IRON ALLOY (0.28% C Steel, 0.79% Mn, 0.20% Si, 0.44% other, annealed in vacuum at 625°C). Magnetic field of 0 and 200 oersted. Torsion. $f = 20$. $\gamma_a = 2 \times 10^{-4}$ to 16×10^{-4} . $\eta_s = 10^{-4}$ to 5×10^{-3} . 100x increase with magnetization. (58 Su, Figure 143)

IRON ALLOY (0.38% C Steel, 0.85% Mn, normalized, then cold worked by 90° permanent set, aged 10 min. to 60 days). Torsion.

$\tau_a = 5$ to 10 ksi. $\eta_s = 2.5 \times 10^{-3}$ to 2×10^{-2} . 5x increase with τ_a . 10x increase with aging. (38 C, Figure 144)

IRON ALLOY (0.40% C Steel, normalized from 850°C, drawn at 650°C). Torsion. $\tau_a = 1$ to 15 ksi. $\eta_s = 8 \times 10^{-4}$ to 4×10^{-3} . (38 F1, Figure 145)

IRON ALLOY (0.40% C Steel, air cooled from 1,560°F, drawn at 1,200°F). Torsion. With and without magnetic field. $\tau_a = 4$ to 18 ksi. $\eta_s = 5.5 \times 10^{-4}$ to 4×10^{-3} . 2x increase with τ_a . 5x increase with magnetization. (40 P, Figure 146)

IRON ALLOY (0.17% C mild steel, normalized, En 3). Torsion. $\tau_a = 5$ ksi. $\eta_s = 2.4 \times 10^{-3}$. (64 B1)

IRON ALLOY (Three silvers steels, B.S. 1407). Torsion. $\tau_a = 5$ ksi. Spheroidized, $\eta_s = 1.2 \times 10^{-3}$. Water quenched at 800°C, $\eta_s = 8 \times 10^{-4}$. Water quenched at 800°C and aged 1.5 hrs. at 100°C, $\eta_s = 3 \times 10^{-4}$. (64 B1)

IRON ALLOY (Steel B.S. S62, 12% Cr, 0.2% C, quenched and tempered to 225 B.H.N.). Torsion. $\tau_a = 5$ ksi. $\eta_s = 6 \times 10^{-3}$. (64 B1)

IRON ALLOY (Cr-Ni steels, solution treated 1,050°C and water quenched). Torsion. $\tau_a = 5$ ksi. For En 58B (18% Cr, 8% Ni, 0.6% Ti, 0.1% C), $\eta_s = 3 \times 10^{-3}$. For NMC (0.62% C, 3.86% Cr,

8.6% Ni, 7.3% Mn), $\eta_s = 1.3 \times 10^{-3}$. For En 58A (18% Cr, 8% Ni, 0.1% C), $\eta_s = 6 \times 10^{-4}$. (64 B1)

IRON ALLOY (0.40% C Steel, water quenched, tempered at 650°C).

Torsion. $\tau_a = 5$ to 20 ksi. $\eta_s = 2 \times 10^{-3}$ to 5×10^{-3} . (51 Fer, Figure 264)

IRON ALLOY (Steel). Bending. $f = 20$ to 200. $\eta_s = 2.5 \times 10^{-3}$ to 6×10^{-3} . $\eta_s = 6 \times 10^{-3}$ peaks at $f = 40$ and 160. (49 K, Figure 147)

IRON ALLOY (0.30% C Steel, carbide-forming 25-20 type austenitic).

Low stress. Torsion. $T = 0$ to 800°C. $\eta_s = 10^{-4}$ to 2×10^{-3} . Peaks at 300 and 650°C. (53 Ro, Figure 148)

IRON ALLOY (Steel, normalized at 1,650°F, various compositions)

Torsion. $\tau_a = 4$ to 12 ksi. $\eta_s = 1.5 \times 10^{-3}$ to 7×10^{-3} . 3x increase with stress. 3x change with composition. (44 B, Figure 149)

IRON ALLOY (SAE 1045 Steel). Torsion. $\tau_a = 5$ to 40 ksi. $\eta_s = 2 \times 10^{-3}$ to 4×10^{-2} . (53 B, Figure 150)

IRON ALLOY (SAE 1095 Steel). Torsion. $\tau_a = 5$ to 40 ksi. $\eta_s = 2 \times 10^{-3}$ to 3×10^{-2} . (53 B, Figure 151)

IRON ALLOY (0.42% C Steel, 0.99% Mn, 0.32% Si). $f = 20$. A magnetic field of 0 and 200 oersteds. $\eta_s = 6 \times 10^{-5}$ to 2×10^{-3} . 10x increase with magnetic field. 10x increase with f . (58 Su, Figure 152)

IRON ALLOY (0.92% C Steel, 0.24% Mn, 0.26% Si, annealed at 1100°C, quenched from TR = 660 to 730°C). Low stress. Torsion. $f = 1$. $T = 0$ to 300°C. $\eta_s = 10^{-3}$ to 10^{-2} . 10x change with T . 10x change with TR. Peaks at $T = 40$ and 200°C. (61 Shu, Figure 153)

IRON ALLOY (Russian steel 8). Torsion. $\tau_a = 2$ to 10 ksi. $\eta_s = 9 \times 10^{-3}$ to 2×10^{-2} . (62 Pisa, Figure 154)

IRON ALLOY (Russian Steel 2). Torsion. Wire specimens of 10 to 20 mm diameter. $\tau_a = 2$ to 10 ksi. $\eta_s = 3 \times 10^{-4}$ to 2×10^{-2} . 20x increase with τ_a . 10x increase with diameter. (62 Pisa, Figure 155)

IRON ALLOY (Russian Steel U7A, 0.47% Mn, 0.34% Si, quenched in vacuum from 900°C, two treatments). $f = 1.1$. $T = 20$ to 400°C. $\eta_s = 2 \times 10^{-3}$ to 1.4×10^{-2} . $\eta_s = 1.4 \times 10^{-2}$ peak at 220°C. (60 Pigu, Figure 156)

IRON ALLOY (0.62% C Steel, 1.14% Mn, normalized, then cold worked by 90° permanent set, aged 10 min. to 1 yr.). Torsion. $\tau_a = 5$ to 30 ksi. $\eta_s = 2 \times 10^{-3}$ to 2×10^{-2} . 3x increase with τ_a . 5x increase with aging. (38 C, Figure 157)

IRON ALLOY (Russian Steels SCHX-9, EU-612, 40X, and carbon steel). Torsion. $\tau_a = 2$ to 18 ksi. $\eta_s = 3 \times 10^{-4}$ to 6×10^{-3} . (62 Pisa, Figure 158)

IRON ALLOY (0.61% C Steel, 1.12% Mn, normalized, then cold worked by 90° permanent set, aged 10 min. to 14 days, or normalized).

Torsion. $\tau_a = 5$ to 30 ksi. $\eta_s = 2 \times 10^{-3}$ to 2×10^{-2} . 5x increase with τ_a . 6x increase with aging. (38 C, Figure 159)

IRON ALLOY (SAE 1112 Steel, deformed, aged at room temperature or annealed). Torsion. $\tau_a = 10$ to 160 ksi. $\eta_s = 2 \times 10^{-3}$ to 1.5×10^{-2} . 6x increase with τ_a . 6x change with treatment. (39 N, Figure 160)

IRON ALLOY (Russian Steel U9A, 0.02% C, 0.26% Si, 0.24% Mn, quenched from 670 or 720°C). $f = 0.85$. $T = 20$ to 300°C. $\eta_s = 8 \times 10^{-4}$ to 4×10^{-3} . Peak at 50 and 200°C. Little change with treatment. (60 Pigu, Figure 161)

IRON ALLOY (0.8% C Steel, drawn). Bending. $f = 0$ to 300. $\eta_s = 3 \times 10^{-3}$ to 3×10^{-4} . Most of decrease in η_s is for $f < 20$. (56 Mi, Figure 162)

IRON ALLOY (Russian Steel U12A, 1.16% C, quenched from 900°C, two treatments). $f = 1.1$. $T = 0$ to 400°C. $\eta_s = 2 \times 10^{-3}$ to 1.6×10^{-2} . $\eta_s = 1.6 \times 10^{-2}$ peak at $T = 250^\circ\text{C}$. Little change with treatment. (60 Pigu, Figure 163)

IRON ALLOY (Russian Steel 45). Axial or bending stress. $\sigma_a = 4$ to 30 ksi. $\eta_s = 10^{-3}$ to 5×10^{-3} . 3x increase with σ_a . 2x increase with axial stress. (62 Pisa, Figure 164)

IRON ALLOY (Sandvik Steel, normalized). $\sigma_a = 5$ to 75 ksi. $N = 10^{1.3}$ to 10^4 . $D = 7 \times 10^{-3}$ to 3×10^{-2} . $D = 1$ at $\sigma_a = \sigma_g = 55$ ksi. 4x increase with N . (57 A, Figure 165)

IRON ALLOY (Sandvik Steel, quenched, tempered). $\sigma_a = 30$ to 120 ksi. $N = 10^{1.3}$ to 10^4 . $D = 2 \times 10^{-1}$ to 4×10^2 . $D = 3$ at $\sigma_a = \sigma_g = 100$ ksi. 40x increase with N . (57 A, Figure 166)

IRON ALLOY (Chromium alloys, 4 to 30% Cr). $\sigma_a = 4$ to 10 ksi. $\eta_g = 2 \times 10^{-3}$ to 1.3×10^{-2} . Peaks at 12% Cr. 4x increase with σ_a . (58 Co, Figure 167)

IRON ALLOY (13% Cr alloy, 0.06 to 0.13% C, 0.25 to 0.80% Mn, oil quenched from 950°C , air cooled from 600°C). Bending. $f = 1,000$. $\sigma_a = 5$ to 35 ksi. $T = 75$ to $1,050^\circ\text{F}$. $\eta_g = 6 \times 10^{-4}$ to 7×10^{-3} . 10x increase with σ_a . 2x change with T . (44 Sc, Figures 168 and 169)

IRON ALLOY (5.0% Cr Steel, 0.20% C, 0.50% Mn, annealed). Torsion. Steady and alternating magnetic fields. $\tau_a = 2$ to 16 ksi. $\eta_g = 10^{-3}$ to 1.5×10^{-2} . 10x change with magnetic fields. 5x increase with τ_a . (40 P, Figure 170)

IRON ALLOY (13% Cr alloy, forged, swaged). Torsion. $\tau_a = 5$ to 30 ksi. $\sigma_m = 0.37$ to 7.7 ksi. With and without magnetic field. $\eta_g = 6 \times 10^{-3}$ to 6×10^{-2} . 1.5x change with τ_a . 2x decrease with σ_m . (53 Coc, Figure 171)

IRON ALLOY (Stainless steel, about 0.12% C, 18% Cr, 8% Ni). Torsion. $\tau_a = 10$ to 70 ksi. $\eta_g = 2 \times 10^{-3}$ to 1.5×10^{-2} . (53 B, Figure 172)

IRON ALLOY (Stainless steel, 13% Cr, 0.12% C, about 1% other, oil

quenched, two treatments). Torsion. $\tau_a = 4$ to 12 ksi. $\eta_s = 1.5 \times 10^{-3}$ to 1.5×10^{-2} . 3x increase with τ_a . 10x change with treatment. (44 B, Figure 173)

IRON ALLOY (12.5% Cr Steel, 0.5% Ni, 0.1% C, forged at 1,950°F, annealed at 1,750°C). Torsion. With and without magnetic field. $\tau_a = 1$ to 12 ksi. $\eta_s = 1.3 \times 10^{-3}$ to 1.5×10^{-2} . 10x change with magnetic field. 4x change with τ_a . (53 Co, Figure 174)

IRON ALLOY (Stainless steel). Bending. $\sigma_a = 3$ to 6 ksi. $\eta_s = 4 \times 10^{-4}$ to 8×10^{-4} . (57 Tr, Figure 175)

IRON ALLOY (Stainless steel, 13 to 26% Cr, quenched or air cooled). Torsion. $\tau_a = 3$ to 12 ksi. $\eta_s = 5 \times 10^{-4}$ to 10^{-2} . 2x increase with τ_a . 10x change with composition. (44 B, Figure 191)

IRON ALLOY (17-7 PH Stainless Steel, annealed). See Aluminum Alloy 2024-T4, reference 63 A1. $n = 2.359$ and $J = 1.688 \times 10^{-13}$ for $\sigma_a < 14$ ksi. $n = 3.534$ and $J = 2.34 \times 10^{-18}$ for $\sigma_a > 14$ ksi. (63 A1)

IRON ALLOY (17-4 PH Stainless Steel, annealed). See Aluminum Alloy 2024-T4, reference 63 A1. $n = 2.124$ and $J = 1.088 \times 10^{-13}$ for $\sigma_a < 45$ ksi. (63 A1)

IRON ALLOY (410 Stainless Steel, R"C"24). See Aluminum Alloy 2024-T4, reference 63 A1. $n = 2.441$ and $J = 2.317 \times 10^{-13}$

for $\sigma_a < 15.92$ ksi. $n = 2.128$ and $J = 4.725 \times 10^{-12}$ for
 $15.92 \text{ ksi} < \sigma_a < 27.95 \text{ ksi}$. $n = 1.702$ and $J = 3.758 \times 10^{-10}$
for $\sigma_a > 27.95$ ksi. (63 Ai)

IRON ALLOY (AISI 403 steel). Bending. $\sigma_a = 1$ to 35 ksi. $\sigma_m =$
0 to 19 ksi. $\eta_s = 2 \times 10^{-4}$ to 9×10^{-3} . 10x increase with
 σ_a . 9x decrease with σ_m . (57 H, Figure 176)

IRON ALLOY (AISI 403 steel, annealed at 1,850°F, air cooled, an-
nealed at 1,300°F, air cooled). Bending. $\sigma_m = 0$ or 19 ksi.
 $\sigma_a = 1$ to 30 ksi. $T = 75$ or 1,000°F. $\eta_s = 2 \times 10^{-4}$ to $7 \times$
 10^{-3} . 10x change with σ_m . 10x change with σ_a . (60 Cl, Fig-
ures 177 and 178)

IRON ALLOY (AISI 403 steel, heat-treated). $\tau_a = 2$ to 20 ksi. $\eta =$
 7×10^{-3} to 1.5×10^{-2} . $\eta = 1.5 \times 10^{-2}$ peak at $\tau_a = 10$ ksi.
(59 Laza, Figure 179)

IRON ALLOY (AISI 403 steel). Torsion. $\sigma_m = 0.9$ or 51 ksi. $T =$
70 to 1,300°F. $\gamma_a = 0.5 \times 10^{-3}$ to 2.4×10^{-3} . $\eta_s = 2 \times 10^{-3}$
to 7×10^{-2} . 4x increase with γ_a . 20x change with T . (55
Co, Figures 180 and 181)

IRON ALLOY (AISI 403 steel). Brinell hardness from 220 to 380.
Bending. $\sigma_m = 0$ and 19 ksi. $\eta_s = 4 \times 10^{-4}$ to 10^{-2} . 9x
change with σ_m . 20x decrease with hardness. (57 H, Figure
182)

IRON ALLOY (AISI 403 steel, hot rolled, annealed at 1,750°F, oil

quenched, tempered at 1,050°F, air cooled). Rotating bending. $\sigma_a = 5$ to 80 ksi. $N = 10^{1.3}$ to 10^4 . At $T = 70^\circ\text{F}$, $D = 5 \times 10^{-2}$ to 10^3 , with $D = 1.4$ at $\sigma_a = \sigma_g = 60$ ksi, and a 10x increase with N . At $T = 700^\circ\text{F}$, $D = 5 \times 10^{-2}$ to 3×10^2 , with $D = 1.6$ at $\sigma_a = \sigma_g = 50$ ksi, and a 10x increase with N . At $T = 900^\circ\text{F}$, $D = 5 \times 10^{-2}$ to 10^2 , with $D = 5$ at $\sigma_a = \sigma_g = 40$ ksi, and a 5x increase with N . (56 Po, Figures 183 and 184)

IRON ALLOY (AISI 403 steel, hot-rolled, annealed at 1,750°F, oil quenched, tempered at 1,050°F, air cooled). Bending. $\sigma_a = 5$ to 50 ksi. $\sigma_m = 0$ to 40 ksi. $D = 2 \times 10^{-3}$ to 5×10^{-1} . 250x increase with σ_a . 20x decrease with σ_m . (56 Pe, Figure 185)

IRON ALLOY (AISI 403 steel, tempered at 1,200 to 1,350°F or not tempered). Torsion. $\tau_a = 1$ to 28 ksi. $\eta_g = 2 \times 10^{-3}$ to 2×10^{-2} . 15x increase with tempering. 8x change with τ_a . Peak at $\tau_a = 8$ ksi. (58 Co, Figure 186)

IRON ALLOY (Lapealloy, 12.2% Cr, forged at 2,035 to 1,750°F, annealed at 1,275°F, air cooled, salt bath, quenched, reheated, air cooled). Rotating bending. $\sigma_a = 5$ to 80 ksi. $N = 10^{1.3}$ to 10^5 . At $T = 70^\circ\text{F}$, $D = 4 \times 10^{-2}$ to 10^2 , with $D = 1.6$ at $\sigma_a = \sigma_g = 65$ ksi, and a 10x increase with N . At $T = 900^\circ\text{F}$, $D = 5 \times 10^{-1}$ to 10^2 , with $D = 5$ at $\sigma_a = \sigma_g = 40$ ksi, and a 10x increase with N . (56 Po, Figures 187 and 188)

IRON ALLOY (Ni steel). Small strains. Bending. $f = 1$ to 10. $\eta_g = 5.4 \times 10^{-4}$. (41 K1*)

IRON ALLOY (Ni steel, swaged). Strains of about 5×10^{-3} . Rotating bending. $\eta_s = 7.3 \times 10^{-4}$. (41 Ki*)

IRON ALLOY (Ni steel, oil quenched, tempered, two treatments). Torsion. $\tau_a = 4$ to 12 ksi. $\eta_s = 7 \times 10^{-4}$ to 1.6×10^{-3} . (44 B, Figure 189)

IRON ALLOY (Ni-Cr steel, air cooled or oil quenched, tempered, two treatments). Torsion. $\tau_a = 4$ to 12 ksi. $\eta_s = 6 \times 10^{-4}$ to 10^{-3} . (44 B, Figure 190)

IRON ALLOY (3.5% Ni steel, 0.38 to 0.43% C, 0.8% Mn, oil quenched from 900°C, air cooled from 625°C). Bending. $f = 1,000$. $\sigma_a = 5$ to 40 ksi. $T = 75$ to 1,200°F. $\eta_s = 2 \times 10^{-4}$ to 3×10^{-3} . 10x increase with T . 9x increase with σ_a . (44 Sc, Figures 192 and 193)

IRON ALLOY (SAE 3140 steel). Torsion. $\tau_a = 10$ to 40 ksi. $\eta_s = 2 \times 10^{-3}$ to 2×10^{-2} . (53 B, Figure 194)

IRON ALLOY (2.2% Ni steel, 0.38% C, 0.6% Cr, quenched in oil, tempered at 650°C). Torsion. $\tau_a = 5$ to 30 ksi. $\eta_s = 5 \times 10^{-4}$ to 4×10^{-3} . (51 Fer, Figure 195)

IRON ALLOY (2.2% Ni steel, 0.38% C, 0.6% Cr, two treatments). Torsion. $\tau_a = 5$ to 20 ksi. $\eta_s = 2 \times 10^{-4}$ to 2.5×10^{-3} . 3x increase with τ_a . 6x change with treatment. (51 Fer, Figure 196)

IRON ALLOY (SAE X4130 steel, seam-tubing, normalized). Axial

stress. $\sigma_a = 5$ to 50 ksi. $D = 5 \times 10^{-2}$ to 5. (46 Ro, Figure 197)

IRON ALLOY (SAE 4130 steel). Axial stress or shear. $\sigma_a = 5$ to 40 ksi. $D = 4 \times 10^{-2}$ to 5. 20x increase with shear. 100x increase with σ_a . (54 Y, Figure 198)

IRON ALLOY (SAE 4140 steel, annealed at 950°C, air cooled, tempered at 600°C, air cooled). Bending. $f = 1,000$. $\sigma_a = 10$ to 40 ksi. $T = 75$ to 1,200°F. $\eta_g = 3 \times 10^{-4}$ to 2×10^{-3} . 4x increase with σ_a . 3x increase with T . (44 Sc, Figures 199 and 200)

IRON ALLOY (High temperature Russian Steels, 3N-415, 3N-4376, 3N-766A, 3N-617, 3N-612). $T = 100$ to 700°C. $\eta_g = 10^{-3}$ to 4×10^{-2} . (62 Pisa, Figure 201)

IRON ALLOY (4340 Steel, R"C"40). See Aluminum Alloy 2024-T4, reference 63 Ai. $n = 3.343$ and $J = 2.153 \times 10^{-17}$ for $\sigma_a < 38$ ksi. $n = 5.360$ and $J = 1.224 \times 10^{-26}$ for $\sigma_a > 38$ ksi. (63 Ai)

IRON ALLOY (4340 Steel, R"C"52). See Aluminum Alloy 2024-T4, reference 63 Ai. $n = 2.166$ and $J = 4.750 \times 10^{-13}$ for $\sigma_a < 55$ ksi. $n = 2.579$ and $J = 5.290 \times 10^{-15}$ for $\sigma_a > 55$ ksi. (63 Ai)

IRON ALLOY (4340 Steel, annealed). See Aluminum Alloy 2024-T4, reference 63 Ai. $n = 2.765$ and $J = 5.37 \times 10^{-15}$ for $\sigma_a < 14.5$ ksi. $n = 3.502$ and $J = 3.548 \times 10^{-16}$ for $\sigma_a > 14.5$ ksi. (63 Ai)

IRON ALLOY (Cr-V steel). Torsion. $\sigma_m = 30$ ksi. $\eta_s = 2.7 \times 10^{-3}$.
(41 Ki*)

IRON ALLOY (Cr-Mo-V steel, C < 0.5%, 0.4 to 0.7% Mn, 0.8 to 1.1% Cr, 0.45 to 0.65% Mo, 0.25 to 0.35% V, annealed at 900°C, oil quenched, tempered at 675°C, air cooled). Bending. $f = 1,000$. $\sigma_a = 5$ to 40 ksi. $T = 75$ to 1,050°F. $\eta_s = 1.4 \times 10^{-4}$ to 1.2×10^{-3} . 4x increase with σ_a . 5x increase with T . (44 Sc, Figure 202)

IRON ALLOY (Cr-Ni-W-Mo steel). Torsion. $\sigma_m = 30$ ksi. $\eta_s = 3.2 \times 10^{-3}$. (41 Ki*)

IRON ALLOY (Ni-Cr-Mo steel, oil quenched, tempered). Torsion. $\tau_a = 5$ to 20 ksi. $\eta_s = 3.5 \times 10^{-4}$ to 9×10^{-4} . (44 B, Figure 203)

IRON ALLOY (Cr-Ni-Mo steel). Torsion. $\sigma_m = 30$ ksi. $\eta_s = 1.1 \times 10^{-2}$. (41 Ki*)

IRON ALLOY (SAE 4615 steel). Torsion. $\tau_a = 10$ to 30 ksi. $\eta_s = 1.5 \times 10^{-3}$ to 10^{-2} . (53 B, Figure 204)

IRON ALLOY (SAE 6145 steel). Torsion. $\tau_a = 10$ to 60 ksi. $\eta_s = 7 \times 10^{-4}$ to 1.5×10^{-2} . (53 B, Figure 205)

IRON ALLOY (N-153, Fe-Ni-Cr-Co Alloy, annealed at 2,175°F, for 15 min., water quenched, cold worked at 1,400°F, annealed at 1,500°F for 2 hrs., air cooled). Bending. $f = 1,000$. $\sigma_a =$

10 to 30 ksi. $T = 75$ to $1,300^{\circ}\text{F}$. $\eta_g = 2 \times 10^{-4}$ to 10^{-3} .
3x increase with σ_a . 2x change with T . (44 Sc, Figures 206
and 207)

IRON ALLOY (Steel, martensite with a little austenite). $\eta = 6 \times 10^{-5}$ to 10^{-4} . (62 P1)

IRON ALLOY (Three different steels: troostite with a little martensite, sorbite with a little ferrite, perlite in fine globules). $\eta = 3 \times 10^{-5}$. (62 P1)

IRON ALLOY (0.2% C steel). At $T = 24^{\circ}\text{C}$ and at stress of 5 to 35 ksi, $\eta_g = 0.3 \times 10^{-3}$ to 1.8×10^{-3} . At $T = 260^{\circ}\text{C}$ and at stress of 5 to 25 ksi, $\eta_g = 0.6 \times 10^{-3}$ to 3×10^{-3} . At $T = 371^{\circ}\text{C}$ and stress of 5 to 15 ksi, $\eta_g = 1.6 \times 10^{-3}$ to 2.4×10^{-3} . (62 Sm*)

IRON ALLOY (3.5% nickel). Range of values as stress is increased from 5 to 35 ksi. At $T = 24^{\circ}\text{C}$, $\eta_g = 0.2 \times 10^{-3}$ to 1.6×10^{-3} . At $T = 260^{\circ}\text{C}$, $\eta_g = 0.2 \times 10^{-3}$ to 2×10^{-3} . At $T = 482^{\circ}\text{C}$, $\eta_g = 0.3 \times 10^{-3}$ to 3×10^{-3} . At $T = 649^{\circ}\text{C}$, $\eta_g = 2 \times 10^{-3}$ to 3.3×10^{-3} . (62 Sm*)

IRON ALLOY (19.7% Ni, 14.2% Cr, plus W, Mo, and Nb). At $T = 24^{\circ}\text{C}$ and at stress of 5 to 35 ksi, $\eta_g = 10^{-4}$ to 10^{-3} . At $T = 260^{\circ}\text{C}$ and at stress of 15 to 35 ksi, $\eta_g = 0.7 \times 10^{-3}$ to 2.9×10^{-3} . At $T = 482^{\circ}\text{C}$ and at stress of 5 to 35 ksi, $\eta_g = 0.2 \times 10^{-3}$ to 0.4×10^{-3} . At $T = 649^{\circ}\text{C}$ and at stress of 15 to 25 ksi, $\eta_g = 0.3 \times 10^{-3}$. At $T = 760^{\circ}\text{C}$ and at stress of 15 to 25 ksi, $\eta_g = 0.4 \times 10^{-3}$. (62 Sm*)

IRON ALLOY (15% Ni, 15% Cr, 12% Co, plus W, Mo, and Nb). At $T = 24^{\circ}\text{C}$ and at stress of 15 to 35 ksi, $\eta_s = 0.3 \times 10^{-3}$ to 1.2×10^{-3} . At $T = 260^{\circ}\text{C}$ and at stress of 15 to 25 ksi, $\eta_s = 0.3 \times 10^{-3}$. At $T = 566^{\circ}\text{C}$ and at stress of 15 to 25 ksi, $\eta_s = 0.2 \times 10^{-3}$. At $T = 704^{\circ}\text{C}$ and at stress of 5 to 25 ksi, $\eta_s = 0.2 \times 10^{-3}$ to 0.4×10^{-3} . (62 Sm*)

IRON ALLOY (S-495, Fe-Ni-Cr Alloy, annealed at $2,175^{\circ}\text{F}$ for 15 min., water quenched, cold worked at $1,400^{\circ}\text{F}$, annealed at $1,500^{\circ}\text{F}$ for 2 hrs., air cooled). Bending. $f = 1,000$. $\sigma_a = 5$ to 40 ksi. $T = 75$ to $1,400^{\circ}\text{F}$. $\eta_s = 10^{-4}$ to 2×10^{-3} . 5x change with T . 5x increase with σ_a . (44 Sc, Figures 208 and 209)

IRON ALLOY (0.95% Cr, 0.2% Mo). Range of values as stress is increased from 15 to 35 ksi. At $T = 24^{\circ}\text{C}$, $\eta_s = 5 \times 10^{-4}$ to 12×10^{-4} . At $T = 260^{\circ}\text{C}$, $\eta_s = 8 \times 10^{-4}$ to 17×10^{-4} . At $T = 480^{\circ}\text{C}$, $\eta_s = 1.3 \times 10^{-3}$ to 2×10^{-3} . At $T = 650^{\circ}\text{C}$, $\eta_s = 1.7 \times 10^{-3}$ to 2×10^{-3} . (62 Sm*)

IRON ALLOY (0.95% Cr, 0.55% Mo, 0.3% V). Range of values as stress is increased from 5 to 25 ksi. At $T = 24^{\circ}\text{C}$, $\eta_s = 10^{-4}$ to 2×10^{-4} . At $T = 260^{\circ}\text{C}$, $\eta_s = 2 \times 10^{-4}$ to 4×10^{-4} . At $T = 480^{\circ}\text{C}$, $\eta_s = 2 \times 10^{-4}$ to 12×10^{-4} . At $T = 566^{\circ}\text{C}$, $\eta_s = 3 \times 10^{-4}$ to 10^{-3} . (62 Sm*)

IRON ALLOY (Cast iron, Lamellar). For various cast irons having graphite content from 1.8 to 3.3%. (ASTM classification A1 to A8), $\eta = 1.9 \times 10^{-3}$ to 16×10^{-3} . (62 P1)

IRON ALLOY (Cast Iron with spheroidal graphite). For various cast irons having graphite content from 2.5 to 3.3%. $\eta = 1.4 \times 10^{-4}$ to 6.3×10^{-4} . (62 P1)

IRON ALLOY (Cast Iron, Malleable). $\eta = 4 \times 10^{-4}$. (62 P1)

IRON ALLOY (Cast Iron, varying engineering types). $f = 10$. $\epsilon < 10^{-4}$. $\eta = 6.3 \times 10^{-3}$ to 10^{-2} . (62 Sm*)

IRON ALLOY (Cast iron, Meehanite GA). Shear. $\tau_a = 6$ to 20 ksi. $D = 3 \times 10^{-1}$ to 10^1 . (54 Y, Figure 211)

IRON ALLOY (Cast iron, 3.26 to 3.71% C). $\tau_a = 2$ to 8 ksi. $\eta_s = 10^{-2}$ to 7×10^{-2} . 2x change with composition. 3x change with τ_a . (44 B, Figure 212)

IRON ALLOY (Cast iron). Bending. $\sigma_a = 1$ to 4 ksi. $\eta_s = 7 \times 10^{-3}$ to 2.5×10^{-2} . (57 Tr, Figure 213)

IRON ALLOY (Cast iron, cut from a cast block, then annealed or tested as is). Bending. $f = 100$ to 2,000. $\eta_s = 1.2 \times 10^{-3}$ to 3×10^{-3} . (56 M1, Figure 214)

IRON ALLOY (Cast iron, machined from cast bars, various compositions). Torsion. $\tau_a = 4$ to 24 ksi. $\eta_s = 10^{-2}$ to 4×10^{-2} . Little change with composition. (40 Lor, Figure 215)

IRON ALLOY (Cast iron, 2.9 to 3.2% C, 1.6% Si, 0 to 3.0% Cu, 0.6% Mn). Bending. $\sigma_a = 0.1$ to 1 ksi. $\eta_s = 1.2 \times 10^{-2}$ to 3.8×10^{-2} . (57 Tr, Figure 216)

IRON ALLOY (Cast iron, about 3.3% C, 1.1% Si, 0 to 3.0% Cu, 0.5% Mn). Torsion. $\tau_a = 4$ to 20 ksi. $\eta_s = 1.2 \times 10^{-2}$ to 5×10^{-2} . (40 Lor, Figure 217)

IRON ALLOY (High carbon, inoculated flake iron, 2.5% T.C., 1.9% Si, 1% Mn, 20.7% Ni, 1% Cr, 0.13% P). Torsion. $\tau_a = 5$ ksi. $\eta_s = 2.8 \times 10^{-2}$. (64 B1)

IRON ALLOY (Spun cast iron, 3.5% T.C., 3.4% G.C., 1.9% Si, 0.4% Mn, 0.4% , 0.38% P). Torsion. $\tau_a = 5$ ksi. $\eta_s = 1.9 \times 10^{-2}$. (64 B1)

IRON ALLOY (3.3% T.C., 2.2% Si, 0.5% Mn, 0.14% P, 0.03% S). Torsion. $\tau_a = 5$ ksi. For inoculated flake iron, $\eta_s = 6.4 \times 10^{-3}$. For non-inoculated flake iron $\eta_s = 10^{-2}$. (64 B1)

IRON ALLOY (Austenitic flake iron, 2.5% T.C., 1.9% Si, 1% Mn, 20.7% Ni, 1.9% Cr, 0.03% P, 0.03% S). Torsion. $\tau_a = 5$ ksi. $\eta_s = 1.1 \times 10^{-2}$. (64 B1)

IRON ALLOY (Alloyed flake graphite, 3.14% T.C., 2% Si, 0.6% Mn, 0.7% Ni, 0.4% Mo, 0.14% P, 0.03% S). $\eta_s = 9.5 \times 10^{-3}$. (64 B1)

IRON ALLOY (Nickel-copper austenitic flake, 2.55% T.C., 1.9% Si, 1.25% Mn, 15.2% Ni, 7.3% Cu, 2% Cr, 0.03% P, 0.04% S). $\eta_s = 6 \times 10^{-3}$. (64 B1)

IRON ALLOY (Undercooled flake graphite, titanium/CO₂ treated, 3.27% T.C., 2.2% Si, 0.6% Mn, 0.35% Ti, 1.4% P, 0.03% S). $\eta_s = 6 \times 10^{-3}$. (64 B1)

IRON ALLOY (Annealed ferritic nodular, 3.7% T.C., 1.8% Si, 0.4% Mn, 0.76% Ni, 0.06% Mg, 0.03% P, 0.01% S, < 0.003% Ce). $\eta_s = 4 \times 10^{-3}$. (64 Bi)

IRON ALLOY (Pearlitic malleable). $\eta_s = 3 \times 10^{-3}$. (64 Bi)

IRON ALLOY (Blackheart malleable). $\eta_s = 3 \times 10^{-3}$. (64 Bi)

IRON ALLOY (Cast pearlitic nodular). $\eta_s = 3 \times 10^{-3}$. (64 Bi)

IRON ALLOY (Cast iron, magnesium treated, nodular, heated 15 hrs. at 1,400°F, cooled to 1,000°F in 3 hrs., then air cooled). Under static bending, $\sigma_a = 30$ to 60 ksi, $\eta_s = 1.6 \times 10^{-2}$ to 7×10^{-2} . Under torsion, $\tau_a = 10$ to 30 ksi, $\eta_s = 10^{-3}$ to 2.5×10^{-2} . Under static axial stress, $\sigma_a = 20$ to 50 ksi, $\eta_s = 1.5 \times 10^{-2}$ to 9×10^{-2} . (52 M, Figure 219)

IRON ALLOY (Gray cast iron). Torsion. $\tau_a = 2$ to 18 ksi. $\eta_s = 3 \times 10^{-2}$ to 9×10^{-2} . (53 B, Figure 218)

IRON ALLOY (Gray cast iron). $\sigma_a = 1$ to 20 ksi. $N = 10^{1.3}$ to 10^4 . $D = 5 \times 10^{-2}$ to 5. At $\sigma_a = \sigma_g = 12$ ksi, $D = 5 \times 10^{-1}$. 3x decrease with N. (57 A, Figure 119)

LEAD (Single crystal, annealed). $f = 40,000$. $\eta_s = 9 \times 10^{-5}$. (42 Bi*)

LEAD (99.999% pure single crystal). Axial stress. $T = -80$ to 220°C . $\epsilon_a = 0$ to 1.2×10^{-5} . $\eta_s = 2 \times 10^{-3}$ to 7×10^{-2} . 9x increase with ϵ_a . 30x increase with T. (58 Mas, Figure 220)

LEAD (99.995% pure or 99% pure, polycrystalline). Axial stress.

$\sigma_a = 0.01$ to 1 ksi. $\eta_s = 2 \times 10^{-3}$ to 2×10^{-1} . Little change with purity. (58 Mas, Figure 221)

LEAD (99.99% pure). $\epsilon_a = 10^{-6}$ to 10^{-3} . $\eta_s = 5 \times 10^{-4}$ to 3×10^{-2} . (58 Mas, Figure 222)

LEAD. Axial stress. $f = 10,000$ or $26,500,000$. $T = 10$ to 300°K . $\eta_s = 10^{-5}$ to 10^{-3} . 40x increase with T . 6x change with f . (58 Mas, Figure 223)

LEAD (Polycrystalline). Elastic-plastic bending. $T = 20$ to 250°C . $N = 820$ to $1,920$. $\eta_s = 4 \times 10^{-3}$ to 1.4×10^{-2} . 1.5 increase with T . 2.5 increase with N . (61 Ga, Figure 224)

LEAD (Polycrystalline). At $f = 10,000$, $\eta_s = 5 \times 10^{-3}$ to 2.7×10^{-2} . At $f = 1,000$, $\eta_s = 1.5 \times 10^{-3}$. (42 Bi*)

LEAD (Commercially and chemically pure grades, single crystals). Small strains. Axial stress. $f = 10,300$. $T = 10$ to 140°K . $\eta_s = 2 \times 10^{-5}$ to 9×10^{-5} . Little change with purity. (58 Mas, Figure 225)

LEAD. Bending. $f = 20$ to 160 . $\eta_s = 8 \times 10^{-3}$ to 1.4×10^{-2} . (49 K, Figure 226)

LEAD (Pure, cast). $\epsilon < 10^{-4}$. $f = 2,000$ to $10,000$. $\eta = 10^{-4}$ to 1.9×10^{-2} . (62 Sm*)

LEAD (Cast). Bending. $f = 2,000$. $\eta_s = 1.4 \times 10^{-3}$. (38 Fors)

MAGNESIUM (99% pure, casting). Bending. $f = 60$ to 400 . $\eta_s = 6 \times 10^{-2}$ to 1.4×10^{-2} . (57 Mi)

MAGNESIUM (K1X1 alloy, casting). Bending. $f = 60$ to 400 . $\eta_s = 1.5 \times 10^{-1}$ to 5×10^{-2} . (57 Mi, Figure 227)

MAGNESIUM (99.99% pure, annealed at 550°C). Bending. Low stress. $f = 2,000$. $T = 50$ to 500°C . $\eta_s = 6 \times 10^{-5}$ to 10^{-2} . (38 Fors, Figure 229)

MAGNESIUM (99% pure, sheet). Bending. $f = 40$ to 200 . $\eta_s = 2 \times 10^{-1}$ to 4×10^{-2} . (57 Mi, Figure 231)

MAGNESIUM (Not of high purity). Torsion. $T = 100$ to 400°C . $\eta_s = 3 \times 10^{-3}$ to 6×10^{-2} . $\eta_s = 6 \times 10^{-2}$ peak at $T = 220^\circ\text{C}$. (58 Mas, Figure 232)

MAGNESIUM (Pure, annealed). $f = 2,000$ to $10,000$. $\epsilon < 10^{-4}$. $\eta = 4 \times 10^{-5}$ to 6.7×10^{-4} . (62 Sm*)

MAGNESIUM ALLOY (J-1). Under axial stress, $\sigma_a = 4$ to 11 ksi, $D = 3 \times 10^{-2}$ to 6×10^{-1} . Under shear, $\tau_a = 2$ to 6 ksi, $D = 3 \times 10^{-2}$ to 9×10^{-1} . (54 Y, Figure 228)

MAGNESIUM ALLOY (J-1, extruded). Bending. $\sigma_a = 1$ to 5 ksi. $\sigma_m = 0$ and 6 ksi. $D = 3 \times 10^{-4}$ to 5×10^{-3} . 2x decrease with σ_m . (56 Pe, Figure 238)

MAGNESIUM ALLOY (British types). Torsion. $\tau_a = 3$ ksi. Mg-Zn-Zr-Th alloy DTD 5005, $\eta_s > 1.2 \times 10^{-2}$. Mg-Zn-Mn alloy BS1278,

$\eta_s = 2.5 \times 10^{-3}$. Mn-Zn-Zr alloy DTD 721A, $\eta_s = 1.3 \times 10^{-3}$.
Elektron MSR alloy (Mg-Ag-Zr), $\eta_s = 8 \times 10^{-4}$. (64 Bi)

MAGNESIUM ALLOY (J). Torsion. $\tau_a = 3$ to 8 ksi. $\eta_s = 6 \times 10^{-3}$
to 7×10^{-2} . $N = 0$ to 3×10^5 . 5x increase with τ_a . 2x
change with N and stress history. (43 Ku, Figure 239)

MAGNESIUM ALLOY (J). $\sigma_a = 1$ to 30 ksi. $N = 10^2$ to 10^5 . $D = 10^{-2}$
to 10^1 . $D = 10^{-1}$ at $\sigma_a = \sigma_g = 5$ ksi. 5x decrease with N .
(57 A, Figure 241)

MAGNESIUM ALLOY (J-1, extruded tubing). Axial stress. $\sigma_a = 4$ to
10 ksi. $D = 4 \times 10^{-2}$ to 8×10^{-1} . (46 Ro, Figure 242)

MAGNESIUM ALLOY (EM-52-T6, extrusion, and M-1-A, forging). Bend-
ing. $\sigma_a = 1$ to 5 ksi. $\eta_s = 5 \times 10^{-4}$ to 10^{-2} . (57 Tr, Fig-
ure 230)

MAGNESIUM ALLOY (AZ-63-A and AM-80-A). Bending. $\sigma_a = 1$ to 4 ksi.
 $\eta_s = 5 \times 10^{-4}$ to 10^{-2} . (57 Tr, Figure 233)

MAGNESIUM ALLOY (Extruded or sand cast). Torsion. $\tau_a = 0.75$ to
2.25 ksi. $\eta_s = 5 \times 10^{-4}$ to 5×10^{-3} . 5x increase with τ_a .
2x increase with sand cast. (44 B, Figure 234)

MAGNESIUM ALLOY (AZ-81-A, sand cast). Bending. $\epsilon_a = 10^{-4}$ to 10^{-3} .
 $\eta = 2 \times 10^{-3}$ to 3×10^{-2} . (58 Wei, Figure 235)

MAGNESIUM ALLOY (A-15 and die cast AZ-91-C). Bending. $\sigma_a = 1$ to
6 ksi. $\eta_s = 6 \times 10^{-4}$ to 8×10^{-3} . (57 Tr, Figure 236)

MAGNESIUM ALLOY (AZ-92-A and AZ-92A-T6). Bending. $\sigma_a = 1$ to 5 ksi. $\eta_s = 5 \times 10^{-4}$ to 10^{-2} . (57 Tr, Figure 237)

MAGNESIUM ALLOY (AZ-31-B-H24, T6). See Aluminum Alloy 2024-T4, reference 63 A1. $n = 1.986$ and $J = 5.56 \times 10^{-11}$ for $\sigma_a < 2.35$ ksi. $n = 2.297$ and $J = 4.915 \times 10^{-12}$ for $\sigma_a > 2.35$ ksi. (63 A1)

MAGNESIUM ALLOY (HK-31-A, 3% Th, 1% Zr). Bending. $f = 50$ to 400. $\eta_s = 8 \times 10^{-2}$ to 2×10^{-2} . (57 M1, Figure 240)

MAGNESIUM ALLOY (K1X1, die cast or sand cast). Bending. $\epsilon_a = 10^{-4}$ to 12×10^{-4} . $\eta = 10^{-2}$ to 2×10^{-1} . 5x increase with ϵ_a . 3x increase with sand cast. (58 Wei, Figure 243)

MAGNESIUM ALLOY (7.5% Al, 1.1% Zn, forged and annealed). $f = 500$ to 12,000. $\epsilon < 10^{-4}$. $\eta = 3 \times 10^{-6}$ to 10^{-4} . (62 Sm*)

MAGNESIUM ALLOY (1 to 15% Al). Bending. $\sigma_a = 1$ to 6 ksi. $\eta_s = 10^{-3}$ to 10^{-2} . 10x increase with σ_a . 2x change with % Al. (57 Tr, Figure 244)

MAGNESIUM ALLOY (0). Torsion. $N = 0$ to 4.5×10^5 . $\tau_a = 2$ to 8 ksi. $\eta_s = 5 \times 10^{-3}$ to 8×10^{-2} . 10x increase with τ_a . 3x change with N . (43 Ku, Figure 245)

MAGNESIUM ALLOY (M1A-0, M1A-H24, and AZ-61A-H24). Bending. $\sigma_a = 1$ to 6 ksi. $\eta_s = 10^{-4}$ to 10^{-2} . (57 Tr, Figure 246)

MAGNESIUM ALLOY (1.07 and 1.2% Al). Bending. $\sigma_a = 1$ to 3 ksi. $\eta_s = 7 \times 10^{-4}$ to 10^{-2} . (57 Tr, Figure 247)

MAGNESIUM ALLOY (0.7% Si). Rotating bending. $N = 10^{1.3}$ to 10^5 .

$\sigma_a = 1$ to 10 ksi. $D = 5 \times 10^{-2}$ to 1.6 . $D = 3 \times 10^{-1}$ at $\sigma_a =$
 $\sigma_g = 3$ ksi. $1.6\times$ decrease with N . (57 A, Figure 255)

MANGANESE ALLOY (12 to 64% Cu, cold worked, quenched, reheated to
TR = 350 to 700°C). Low axial stress. $\eta = 10^{-2}$ to 1 . 5 to
 $40\times$ peaks at TR $\approx 450^\circ\text{C}$. (41 D, Figures 248 and 249)

MANGANESE ALLOY (4 to 50% Cu, cold worked, quenched, reheated to
TR = 500 to 700°C). Low axial stress. $\eta = 2 \times 10^{-2}$ to $3 \times$
 10^{-1} . $20\times$ decrease with TR. Little change with % Cu. (41 D,
Figures 250 and 251)

MANGANESE ALLOY (10-50% Cu, solution treated, quenched, and sta-
bilized). $\epsilon < 10^{-4}$. $\eta = 4.8 \times 10^{-3}$ to 6.4×10^{-3} . (62 Sm*)

MAGNESIUM ALLOY (Cast Alloys, K1A-F and SD10A-F). At $\sigma_a = 0.1$ ksi,
 $\eta_s = 2 \times 10^{-2}$ to 3×10^{-2} . At $\sigma_a = 1$ ksi, $\eta_s = 3 \times 10^{-2}$ to
 6×10^{-2} . At $\sigma_a = 10$ ksi, $\eta_s = 9 \times 10^{-2}$ to 17×10^{-2} . (62 K)

MAGNESIUM ALLOY (Cast Alloys; ZK51A-T5, AZ-92A-T4, AM100A-T4, and
EZ-334-T5). At $\sigma_a = 2$ ksi, $\eta_s = 3 \times 10^{-3}$ to 6×10^{-3} . At
 $\sigma_a = 10$ ksi, $\eta_s = 8 \times 10^{-3}$ to 50×10^{-3} . (62 K)

MAGNESIUM ALLOY (50-90% Mn, 50 to 10% Cu). Torsion. $\tau_a = 5$ ksi.
At 90% Mn, $\eta_s = 3.4 \times 10^{-2}$. At 85% Mn, $\eta_s = 4.4 \times 10^{-2}$.
At 80% Mn, $\eta_s = 3.5 \times 10^{-2}$. At 70% Mn, $\eta_s = 7.0 \times 10^{-2}$.
At 60% Mn, $\eta_s = 7.0 \times 10^{-2}$. At 50% Mn, $\eta_s = 5.3 \times 10^{-2}$.
(64 B1)

MANGANESE ALLOY (70% Mn, 30% Cu, solution treated for 2 hrs. at 750°C, water quenched and aged at 450°C, water quenched).

Torsion. $\tau_a = 5$ ksi. At -60 to 0°C, $\eta_s = 5.6 \times 10^{-2}$. At 50°C, $\eta_s = 1.7 \times 10^{-2}$. At 100°C, $\eta_s = 1.1 \times 10^{-3}$. (64 Bi)

MANGANESE ALLOY (Chicago Devel. Corp., Riverdale, Maryland, Alloy 780; 80% manganese and 20% copper; ultimate strength = 68 ksi, yield strength = 24 ksi, proportional limit = 13 ksi, fatigue strength at 10^8 cycles as reported by Chicago Devel. Corp. = 17 ksi, fatigue strength at 10^5 cycles as measured at Univ. of Minn. = 40 ksi). At $\sigma_a = 6$ ksi, $D = 1$. At $\sigma_a = 10$ ksi, $D = 3$. At $\sigma_a = 20$ ksi, $D = 18$. At $\sigma_a = 50$ ksi, $D = 100$. (59 Tor)

MANGANESE ALLOY (30% Cu, 5% Ni, solution treated, quenched and stabilized). $\epsilon < 10^{-4}$. $\eta = 2.7 \times 10^{-3}$. (62 Sm*)

MANGANESE ALLOY (6 to 8% Cu, cold worked, quenched, reheated to TR = 350 to 550°C). Low axial stress. $\eta = 10^{-1}$ to 7×10^{-1} . 3x change with % Cu. Peaks at TR $\approx 450^\circ\text{C}$. (41 D, Figure 252).

MANGANESE ALLOY (20 to 90% Cu, solution treated or aged). $\sigma_a = 5$ ksi. Solution treated, $\eta_s = 10^{-3}$ to 2×10^{-2} . Aged, $\eta_s = 5 \times 10^{-2}$ to 3×10^{-2} . (55 Ro, Figure 253)

MANGANESE ALLOY (33% Cu, heat-treated, swaged or heat-treated, quenched, aged at 450°C for 2 hrs.). Rotating bending. $N = 10^{1.3}$ to 10^4 . $\sigma_a = 1$ to 50 ksi. $D = 2 \times 10^{-2}$ to 10^2 . $D = 12$ at $\sigma_a = \sigma_g = 20$ ksi. (57 A, Figure 254)

MOLYBDENUM (Sintered, annealed at 900°C). Low stress. Bending. $f = 2,000$. $T = 50$ to 600°C. $\eta_s = 1.6 \times 10^{-4}$ to 7×10^{-4} . (38 Fors, Figure 256)

MOLYBDENUM (Arc-cast). Torsion. $f = 1$. $T = 225$ to 300°K. $\eta_s = 5.5 \times 10^{-3}$. (53 Ch, Figure 257)

MOLYBDENUM (Swaged). Rotating bending. Strains of about 5×10^{-3} . $\eta_s = 2.1 \times 10^{-3}$. (41 K1*)

MOLYBDENUM (Sintered). $f = 2,000$. $\epsilon_a < 10^{-4}$. $\eta = 1.6 \times 10^{-4}$. (62 Sm*)

NICKEL (99.5% pure, cast). Torsion. $\tau_a = 1.5$ to 7 ksi. $\eta_s = 1.5 \times 10^{-4}$ to 4×10^{-3} . (51 Fer, Figure 258)

NICKEL (A, 99.47% Ni, heat-treated at 1,400°F, air cooled). Bending. $\sigma_m = 0$ to 11 ksi. $\sigma_a = 1$ to 40 ksi. $\eta_s = 2 \times 10^{-4}$ to 10^{-2} . 20x increase with σ_a . 2x decrease with σ_m . (57 H, Figure 259)

NICKEL (Polycrystalline). Torsion. $f = 10$ to 180. $\eta_s = 10^{-2}$ to 3.5×10^{-2} . (58 Mas, Figure 260)

NICKEL (Pure, annealed). $\epsilon < 10^{-4}$. $f = 2,000$. $\eta = 2.3 \times 10^{-3}$. (62 Sm*)

NICKEL (Polycrystalline, well annealed). Axial stress. A magnetic field of 0 to 200 oersteds. $\eta_s = 2.5 \times 10^{-2}$ to 6×10^{-4} . (51 Bozo, Figure 261)

NICKEL (Polycrystalline, annealed at 1,100°C). Axial stress. $f = 20$ to 160. $\eta_s = 4.5 \times 10^{-3}$. Negligible change with f . (51 Bozo, Figure 262)

NICKEL (Annealed at TR = 1,300 to 2,400°F). $T = 100$ to 680°F. $\eta_s = 4 \times 10^{-2}$ to 10^{-4} . η_s approaches 0 as T approaches 680°F. 25x decrease with TR. (58 Co, Figure 263)

NICKEL (Cold worked or annealed). A magnetic field of 0 to 300 oersteds. $\eta_s = 10^{-5}$ to 10^{-3} . 40x decrease with magnetic field. 10x decrease with anneal. (58 Co, Figure 267)

NICKEL (Rolled). Strain less than 10^{-4} . Bending. $f = 2$. $\eta_s = 5.4 \times 10^{-4}$. (41 Ki*)

NICKEL (Unstretched or stretched). Medium strain. Bending. $f = 9$. Unstretched, $\eta_s = 5.7 \times 10^{-3}$. Stretched, $\eta_s = 1.3 \times 10^{-3}$. (41 Ki*)

NICKEL (Rolled). Rotating bending. Strains of about 5×10^{-3} . $\eta_s = 1.0 \times 10^{-3}$. (41 Ki*)

NICKEL (Annealed 30 min. at 700°C). Bending. $f = 2,000$. $\eta_s = 2.3 \times 10^{-3}$. (38 Fors)

NICKEL. $f = 10,000$. $\eta_s = 10^{-4}$ to 5×10^{-4} . (42 Bi*)

NICKEL ALLOY (Inconel, 74% Ni, 15 Cr, 6.7 Fe, 2.4% Ti). Range of values as stress is increased from 5 to 35 ksi. At $T = 24^{\circ}\text{C}$, $\eta_s = 10^{-4}$. At $T = 260^{\circ}\text{C}$, $\eta_s = 1.5 \times 10^{-4}$. At $T = 480^{\circ}\text{C}$, $\eta_s = 2.5 \times 10^{-4}$. At $T = 650^{\circ}\text{C}$, $\eta_s = 2 \times 10^{-4}$. (62 Sm*)

NICKEL ALLOY (Inconel, annealed at $1,975^{\circ}\text{F}$, water quenched, reheated to $1,300^{\circ}\text{F}$ for 15 hrs., air cooled). Bending. $f = 1,000$. $\sigma_a = 5$ to 40 ksi. $T = 75$ to $1,200^{\circ}\text{F}$. $\eta_s = 10^{-4}$ to 4×10^{-4} . 4x change with T . Little change with σ_a . (44 Sc, Figures 265 and 266)

NICKEL ALLOY (Inconel X). See Aluminum Alloy 2024-T4, reference 63 A1. $n = 2.224$ and $J = 4.586 \times 10^{-13}$ for $\sigma_a < 33$ ksi. $n = 2.531$ and $J = 1.565 \times 10^{-14}$ for $\sigma_a > 33$ ksi. (63 A1)

NICKEL ALLOY (Monel, 67% Ni, 30% Cu, 1.4% Fe, 1.0% Mn). Under axial stress, $\sigma_a = 8$ to 27 ksi, $D = 4 \times 10^{-2}$ to 1 . Under shear, $\tau_a = 5$ to 22 ksi, $D = 4 \times 10^{-2}$ to 5 . (54 Y, Figure 268)

NICKEL ALLOY (Monel). Strains of 10^{-4} to 10^{-3} . Torsion on hollow tubes. $f = 20$. $\sigma_a = 1.6$ ksi. $\eta_s = 6.4 \times 10^{-3}$. (41 Ki*)

NICKEL ALLOY (Monel). Rotating bending. Strains of about 5×10^{-3} . $\eta_s = 4.4 \times 10^{-4}$. (41 Ki*)

NICKEL ALLOY (Nitinol, 55% Ni, 45% Ti). Torsion. $\tau_a = 10$ ksi. $\eta_s = 4.2 \times 10^{-2}$. (64 Bi)

NICKEL ALLOY (2% Thoria). Torsion. $\tau_a = 10$ ksi. $\eta_s = 2 \times 10^{-2}$. (64 Bi)

NICKEL ALLOY (Refractaloy 26, aged or unaged). Torsion. $\gamma_a = 0.5 \times 10^{-3}$ to 3.2×10^{-3} . At $\sigma_m = 0.91$ ksi, aged, $\eta_s = 3 \times 10^{-4}$ to 7×10^{-4} . At $\sigma_m = 0.91$ ksi, unaged, $\eta_s = 2 \times 10^{-3}$ to 5×10^{-3} . At $\sigma_m = 51$ ksi, aged, $\eta_s = 10^{-3}$ to 2×10^{-3} . At $\sigma_m = 51$ ksi, unaged, $\eta_s = 2 \times 10^{-3}$ to 5×10^{-3} . At $T = 750$ to $1,300^\circ\text{F}$, $\sigma_m = 0.91$ or 51 ksi, $\eta_s = 10^{-3}$ to 2×10^{-2} , 5x increase with γ_a , 6x increase with T . (55 Co, Figures 269 and 270)

PLATINUM (Pure). $\epsilon < 10^{-4}$. $\eta = 8 \times 10^{-5}$. (62 Sm*)

RHENIUM (Annealed at $1,500^\circ\text{C}$ for 1 hr. followed by 1 hr. at $1,800^\circ\text{C}$). Torsion. $T = 900$ to $1,600^\circ\text{C}$. $\eta_s = 2 \times 10^{-2}$ to 10^{-1} . (59 Sc, Figure 278)

SILVER (Single crystal, annealed or unannealed). Low axial stress. $T = 25$ to 250°K . Unannealed, $\eta_s = 3 \times 10^{-5}$ to 10^{-4} . Annealed, $\eta_s = 5 \times 10^{-6}$ to 9×10^{-6} . (58 Mas, Figure 276)

SILVER (Spectroscopically pure, annealed at 700°C). Torsion. $f = 0.5$ to 1.5 . $T = 10$ to 600°C . $\eta_s = 3 \times 10^{-4}$ to 3×10^{-2} . 1.5x change with f . 10x increase with T . 8x change with grain size. (53 Pe, Figure 271)

SILVER (Pure). $f = 10,000$. $\epsilon = 10^{-4}$. $\eta = 1.5 \times 10^{-4}$ to 2.3×10^{-4} . (62 Sm*)

SILVER (Annealed at 500°C). Bending. $f = 0$ to 900 . $\eta_s = 3 \times 10^{-3}$ to 6×10^{-4} . (56 Mi, Figure 272)

SILVER. $f = 10,000$. $\eta_s = 2 \times 10^{-4}$. (42 Bi*)

SILVER (Drawn). Bending. $f = 0$ to 900 . $\eta_s = 5 \times 10^{-3}$ to 3×10^{-3} . (56 Mi, Figure 273)

SILVER ALLOY (0.9 to 32.4 atomic % Cd, annealed at 600°C). Torsion. $f = 1.5$. $T = 0$ to 550°C . $\eta_s = 4 \times 10^{-4}$ to 7×10^{-2} . 100x increase with T . 3x change with % Cd. (53 Pe, Figures 274 and 275)

SILVER ALLOY (3.1 or 8.1 atomic % In, annealed at 600°C). Torsion. $f = 1.5$. $T = 0$ to 550°C . $\eta_s = 3 \times 10^{-4}$ to 6×10^{-2} . 100x increase with T . Little change with % In. (53 Pe, Figure 277)

SILVER ALLOY (0.9 or 3.1 atomic % Sn, annealed at 600°C). Torsion. $f = 1.5$. $T = 0$ to 550°C . $\eta_s = 3 \times 10^{-4}$ to 8×10^{-2} . 200x increase with T . Little change with % Sn. (53 Pe, Figure 279)

STRONTIUM (99.93% pure). Torsion. $T = 100$ to 700°C . $\eta_s = 1.5 \times 10^{-3}$ to 1.6×10^{-2} . (61 Dash, Figure 281)

TANTALUM (Annealed at $1,850^\circ\text{C}$). Torsion. $T = 1,000$ to $1,500^\circ\text{C}$. Annealed, $\eta_s = 3 \times 10^{-2}$ to 6×10^{-2} . Large grains, $\eta_s = 4 \times 10^{-3}$ to 2×10^{-2} . (59 Sc, Figure 282)

TIN (Single crystal, annealed). $f = 40,000$. $\eta_s = 2.2 \times 10^{-5}$. (42 Bi*)

TIN (99.992% pure, polycrystalline or single crystal, annealed).

Bending. $T = 20$ to 160°C . Polycrystalline, $\eta_s = 2 \times 10^{-3}$ to 6×10^{-3} . Single crystal, $\eta_s = 4 \times 10^{-4}$ to 10^{-3} . (51 Rot, Figure 280)

TIN. $f = 1,000$. $\eta_s = 2 \times 10^{-3}$. (Bi*)

TIN. Bending. $f = 100$ to 600 . $\eta_s = 8 \times 10^{-6}$ to 10^{-5} . (46 K, Figure 283)

TIN. Bending. $f = 1$ to 5 . $\eta_s = 4.1 \times 10^{-3}$. (41 Ki*)

TIN (Cast). Bending. $f = 2,000$. $\eta_s = 1.7 \times 10^{-3}$. (38 Fors)

TIN. Small strain. Torsion. $f = 0.25$. $\eta_s = 2 \times 10^{-5}$. (41 Ki*)

TIN (Pure, cast). $f = 2,000$ to $10,000$. $\epsilon < 10^{-3}$. $\eta = 1.6$ to 2.4×10^{-6} . (62 Sm*)

TIN ALLOY (Solder, 33% Pb). Torsion. $\tau_a = 0.2$ to 0.7 ksi. $\eta_s = 4 \times 10^{-2}$ to 6×10^{-2} . (44 B, Figure 284)

TITANIUM (99.8% pure). Torsion. $f = 0.5$. For 0.019 mm grain size, $T = 400$ to 650°C , $\eta_s = 10^{-3}$ to 7×10^{-2} . For large grains, $T = 500$ to 800°C , $\eta_s = 10^{-3}$ to 7×10^{-2} . (54 Pr, Figure 285)

TITANIUM. Bending. Tuning fork specimen. $T = 200$ to $1,000^{\circ}\text{F}$. $\eta_s = 8 \times 10^{-5}$ to 3×10^{-3} . 3x change with specimen size. 20x increase with T . (56 Hun, Figure 287)

TITANIUM (1.5 to 4.5 atomic % oxygen, heated to obtain oxide coat, annealed). Torsion. $f = 0.5$ or 4.5 . $T = 350$ to 800°C .

$\eta_s = 10^{-4}$ to 5×10^{-2} . 500x increase with T . Little change with % oxygen. (54 Pr, Figure 295)

TITANIUM (Arc melted). Stress = 5 to 25 ksi. At $T = 24^{\circ}\text{C}$, $\eta_s = 8 \times 10^{-5}$ to 10^{-4} . At $T = 316^{\circ}\text{C}$, $\eta_s = 10^{-4}$ to 4×10^{-4} . At $T = 482^{\circ}\text{C}$, $\eta_s = 2 \times 10^{-4}$ to 4×10^{-4} . At $T = 566^{\circ}\text{C}$, $\eta_s = 5 \times 10^{-4}$ to 6×10^{-4} . (62 Sm*)

TITANIUM ALLOY (A110 AT, 4.5% Al, 2.16% Sn, hot-rolled, twice annealed at 500°F , furnace cooled). Bending. $\sigma_a = 1$ to 30 ksi. $T = 75$ to 525°F . $\eta_s = 8 \times 10^{-5}$ to 10^{-3} . 4x change with σ_a . 10x change with T . (60 Cl, Figure 286)

TITANIUM ALLOY (90-6Al-4V, annealed). See Aluminum Alloy 2024-T4, reference 63 Al. $n = 1.969$ and $J = 3.382 \times 10^{-12}$ for $\sigma_a < 16$ ksi. $n = 2.091$ and $J = 1.035 \times 10^{-12}$ for $\sigma_a > 16$ ksi. (63 Al)

TITANIUM ALLOY (90-6Al-4V, sintered). See Aluminum Alloy 2024-T4, reference 63 Al. $n = 2.032$ and $J = 3.493 \times 10^{-12}$ for $\sigma_a < 26.5$ ksi. $n = 2.488$ and $J = 3.360 \times 10^{-14}$ for $\sigma_a > 26.5$ ksi. (63 Al)

TITANIUM ALLOY (RC 130 B, annealed at $1,300^{\circ}\text{F}$, furnace cooled). Rotating bending. $N = 10^{1.3}$ to 10^4 . At $T = 70^{\circ}\text{F}$, $\sigma_a = 50$ to 150 ksi, $D = 3 \times 10^{-1}$ to 10^3 , with $D = 2.5$ at $\sigma_a = \sigma_g = 100$ ksi, and a 20x increase with N . At $T = 600^{\circ}\text{F}$, $\sigma_a = 15$

to 100 ksi, $D = 10^{-1}$ to 10^3 , with $D = 1.4$ at $\sigma_a = \sigma_g = 50$ ksi, and a 20x increase with N . (56 Po, Figures 289 and 290)

TITANIUM ALLOY (RC 55, forged at 1,700 to 1,800°F, hot-rolled, annealed at 1,300°F). Rotating bending. $\sigma_a = 1$ to 30 ksi. $\sigma_m = 5$ to 20 ksi. $D = 2 \times 10^{-4}$ to 2×10^{-2} . 5x increase with σ_m . 10x increase with σ_a . (56 Pe, Figure 288)

TITANIUM ALLOY (RC 55, forged at 1,750°F, hot-rolled at 1,450°F, annealed at 1,300°F). Rotating bending. $N = 10^{1.3}$ to 10^4 . At $T = 70^\circ\text{F}$, $\sigma_a = 10$ to 50 ksi, $D = 3 \times 10^{-2}$ to 3×10^2 , with $D = 1.2 \times 10^{-1}$ at $\sigma_a = \sigma_g = 24$ ksi, and a 20x increase with N . At $T = 600^\circ\text{F}$, $\sigma_a = 5$ to 30 ksi, $D = 2 \times 10^{-2}$ to 2×10^2 , with $D = 6 \times 10^{-2}$ at $\sigma_a = \sigma_g = 10$ ksi, and a 20x increase with N . (56 Po, Figures 291 and 294)

TITANIUM ALLOY (RC 55, forged, hot-rolled, annealed at 1,350°F, air cooled, cold drawn, heated to 1,300°F, air cooled). Rotating bending. $N = 10^{1.3}$ to 10^5 . At $T = 70^\circ\text{F}$, $\sigma_a = 10$ to 70 ksi, $D = 3 \times 10^{-2}$ to 3×10^2 , with $D = 4 \times 10^{-2}$ at $\sigma_a = \sigma_g = 15$ ksi, and a 10x change with N . At $T = 600^\circ\text{F}$, $\sigma_a = 5$ to 30 ksi, $D = 3 \times 10^{-2}$ to 2×10^2 , with $D = 5 \times 10^{-1}$ at $\sigma_a = \sigma_g = 20$ ksi, and a 10x change with N . (56 Po, Figures 292 and 293)

TUNGSTEN (Annealed at $TR = 1,580$ or $2,000^\circ\text{C}$). Torsion. $T = 800$ to $1,800^\circ\text{F}$. $\eta_g = 10^{-2}$ to 10^{-1} . 2x change with TR . 10x increase with T . (59 Sc, Figure 297)

TUNGSTEN (Pure). $f = 0.1$. $\epsilon < 10^{-3}$. $\eta = 2.2 \times 10^{-4}$. (62 Sm*)

TUNGSTEN (Annealed at 1,410, 1,750, or 2,300°C, also large grains).

Torsion. $T = 800$ to $1,800^\circ\text{F}$. $\eta_s = 2 \times 10^{-3}$ to 1.5×10^{-1} .

20x increase with T . 10x change with anneal or grain size.

(59 Sc, Figure 298)

TUNGSTEN (Swaged). Strains of about 5×10^{-3} . Rotating bending.

$\eta_s = 5.2 \times 10^{-3}$. (41 Ki*)

TUNGSTEN CARBIDES (Sintered tungsten with 13 or 6% Co). Torsion.

$\tau_a = 8$ to 16 ksi. $\eta_s = 10^{-3}$ to 3×10^{-3} . Little change with % Co. (44 B, Figure 210)

URANIUM (99.95% pure). Axial stress. Tension only, $N = 50$ to 200 ,

$\sigma_a = 48$ ksi, $D \approx 1.5 \times 10^1$. Compression only, $N = 10$ to 100 ,

$\sigma_a = 70$ ksi, $D = 2.5 \times 10^1$ to 1.7×10^1 . Compression only,

$N = 50$ to 300 , $\sigma_a = 56$ ksi, $D \approx 4.5$. (53 Jo, Figure 296)

ZINC (Single crystal, annealed). $f = 40,000$. $\eta_s = 7 \times 10^{-6}$ to 3×10^{-6} . (42 Bi*)

ZINC (99.999% pure single crystals, annealed). Axial stress. $f =$

$39,000$. $\epsilon_a = 10^{-6}$ to 10^{-5} . $\eta = 5 \times 10^{-6}$ to 2×10^{-4} . 10x

orientation effect. 10x increase with ϵ_a . (41 R, Figure

299)

ZINC (99.999% pure single crystals, not annealed). Axial stress.

$f = 39,000$. $\eta = 5 \times 10^{-3}$ to 10^{-3} as crystal ages for 130

hrs. (41 R, Figure 300)

ZINC (99.99% pure, extruded, annealed at 200°C). Bending. $f = 2,000$. $\eta_s = 2.4 \times 10^{-4}$. (38 Fors)

ZINC. Bending. $f = 50$ to 400 . $\eta_s = 4 \times 10^{-3}$ to 9×10^{-3} . 2x peak at $f = 150$. (49 K, Figure 301)

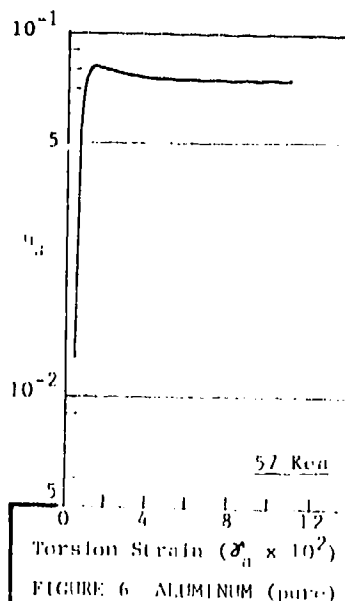
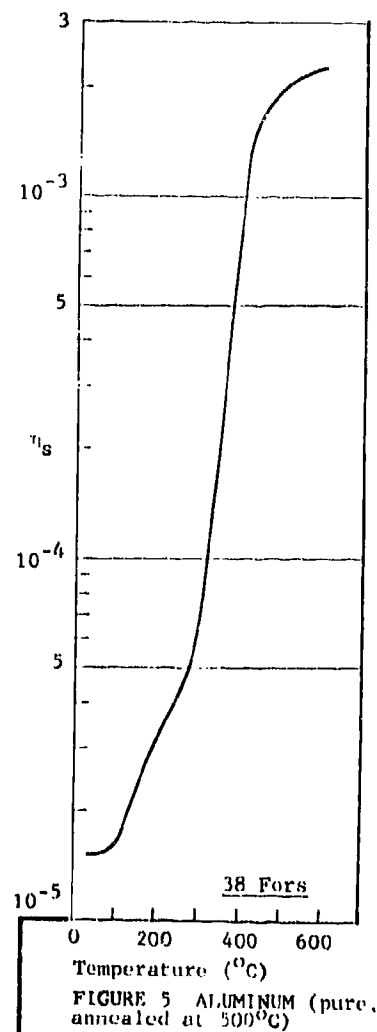
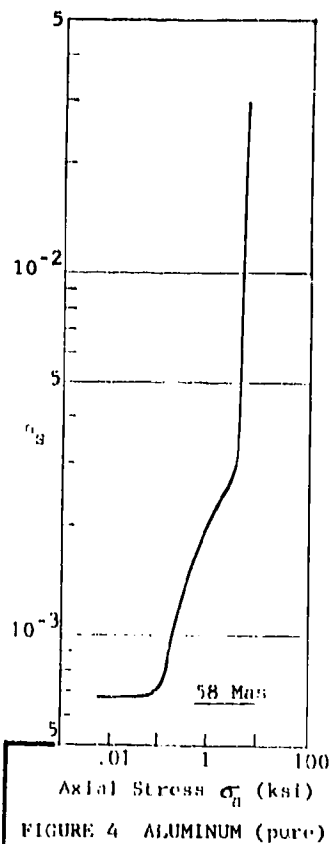
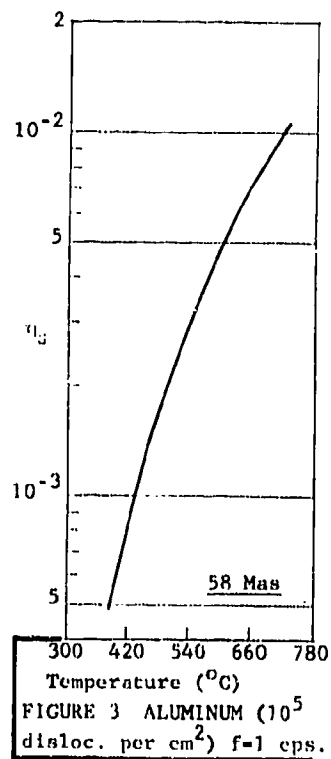
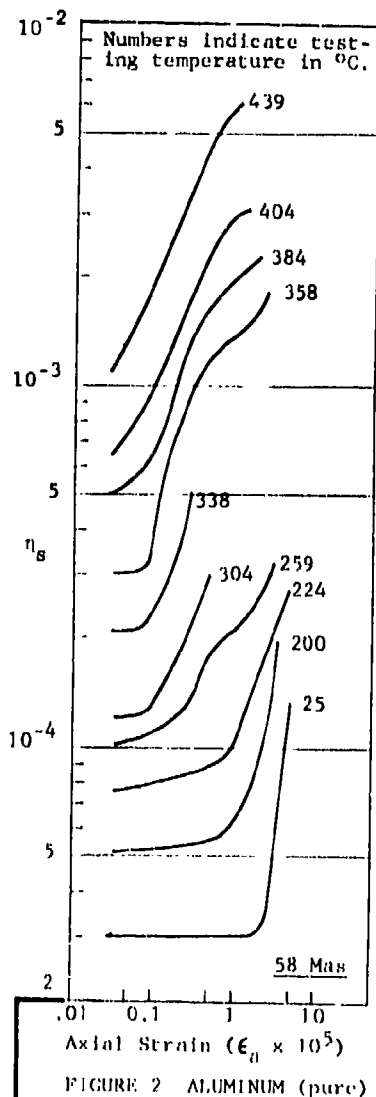
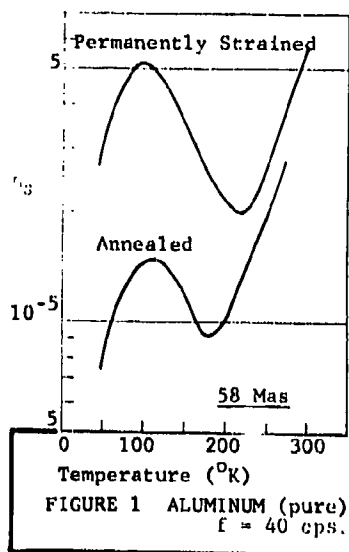
ZINC (Pure, annealed). $\epsilon < 10^{-4}$. $f = 200$ to $12,000$. $\eta = 0.7 \times 10^{-4}$ to 2.5×10^{-4} . (62 Sm*)

ZINC (Annealed or rolled). Strain less than 10^{-4} . Bending. $f = 2$. Annealed, $\eta_s = 5.4 \times 10^{-4}$. Rolled, $\eta_s = 1.6 \times 10^{-3}$. (41 Ki*)

ZINC. Bending. $f = 1$ to 5 . $\eta_s = 1.9 \times 10^{-3}$. (41 Ki*)

ZINC (0.07 mm grain size). $f = 180$. At $T = 20^\circ\text{C}$, $\eta_s = 5 \times 10^{-4}$. At $T = 100^\circ\text{C}$, $\eta_s = 4 \times 10^{-3}$. (42 Bi*)

ZINC (0.04 mm grain size). $f = 180$. At $T = 20^\circ\text{C}$, $\eta_s = 1.2 \times 10^{-3}$. At $T = 100^\circ\text{C}$, $\eta_s = 8 \times 10^{-3}$. (42 Bi*)



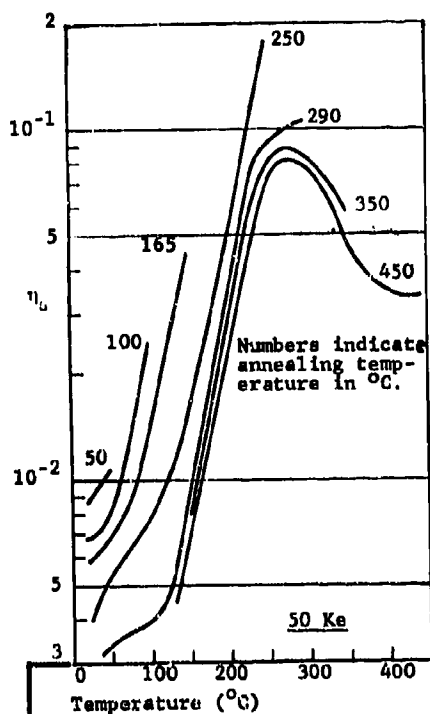


FIGURE 7 ALUMINUM (pure, worked, annealed)

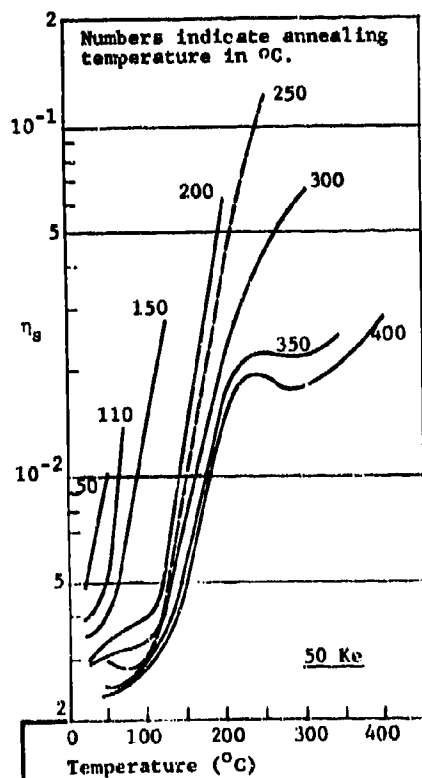


FIGURE 8 ALUMINUM (pure, 2S, worked)

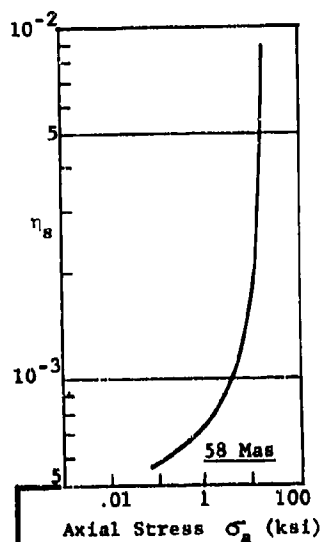


FIGURE 9 ALUMINUM (pure 2S)

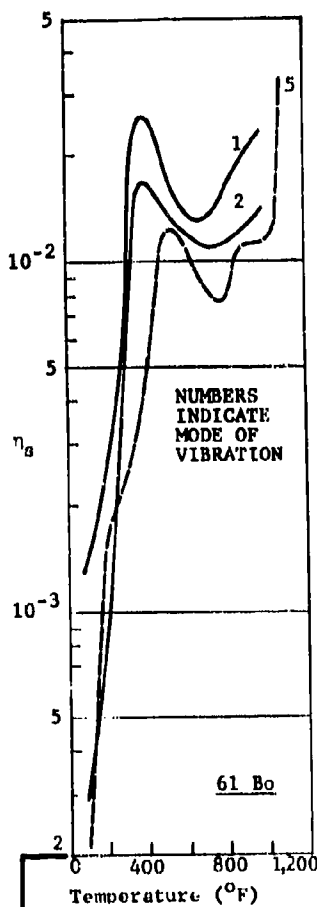


FIGURE 10 ALUMINUM (pure 1100, worked)

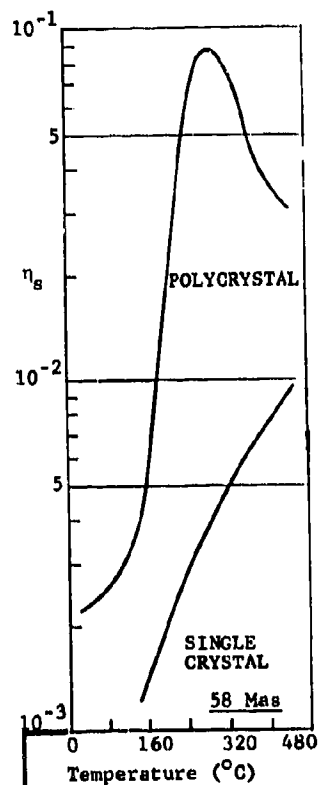


FIGURE 11 ALUMINUM

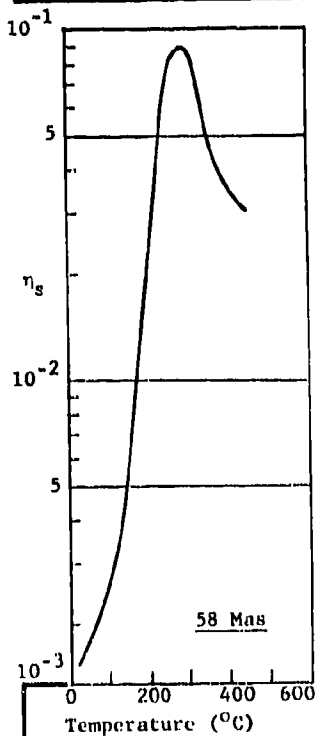
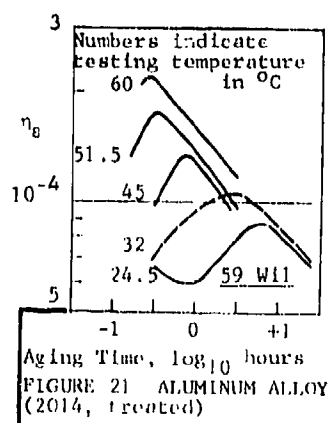
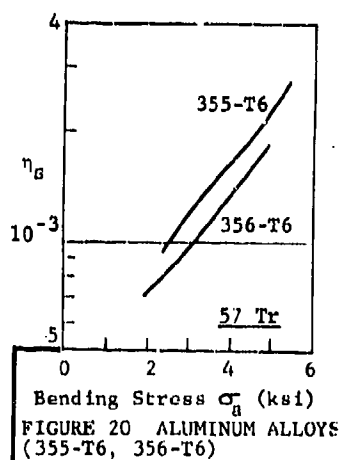
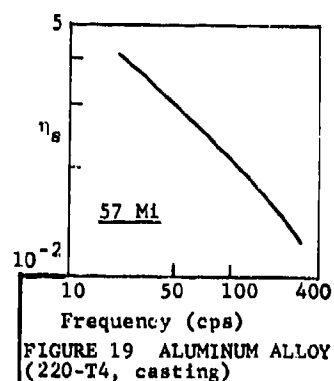
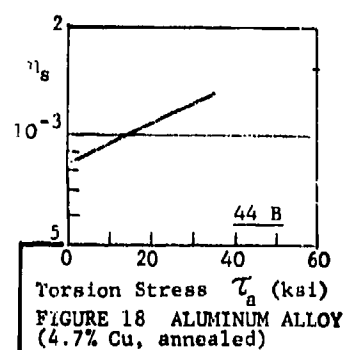
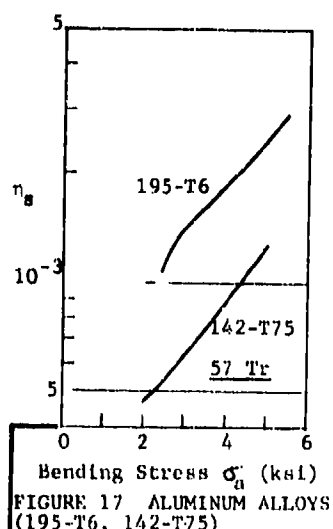
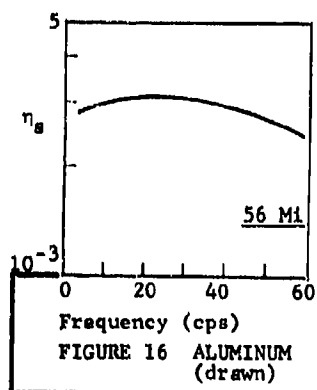
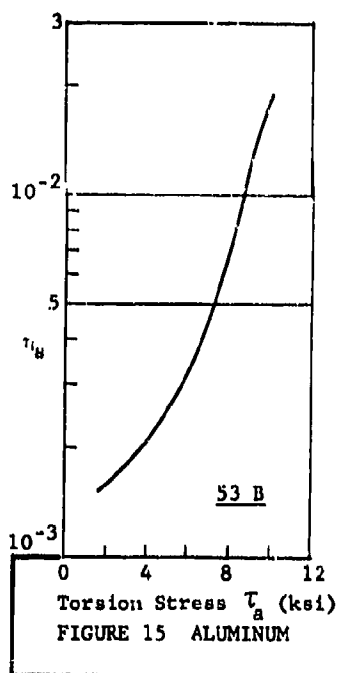
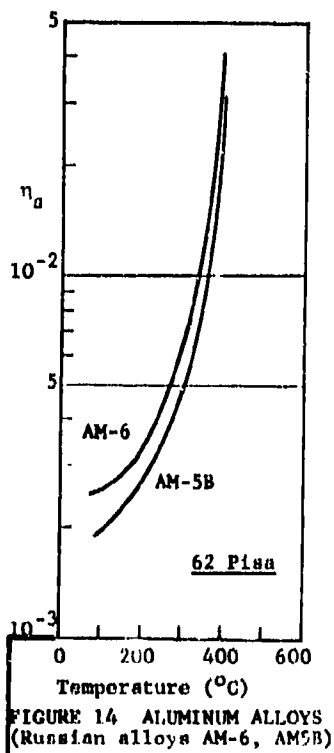
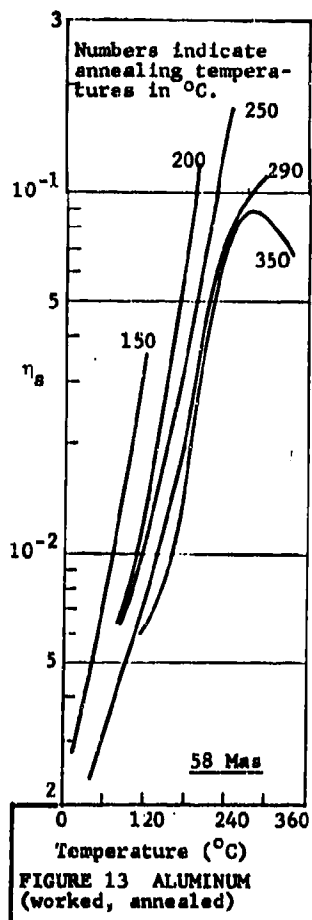
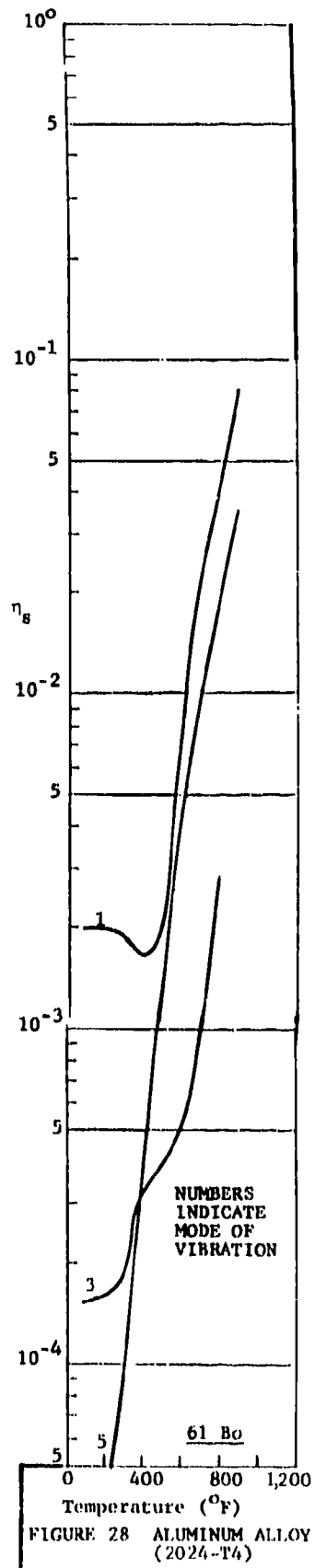
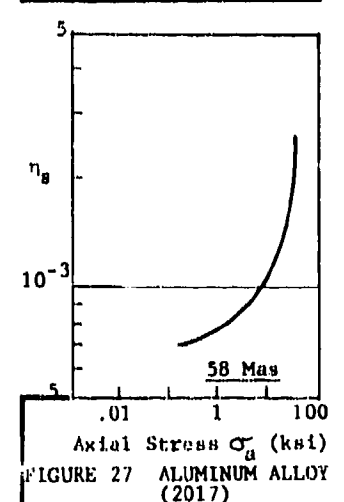
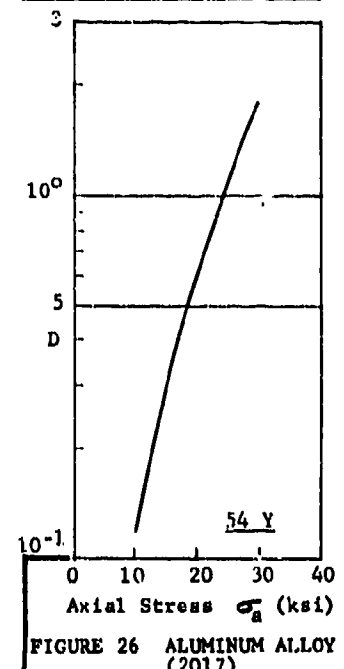
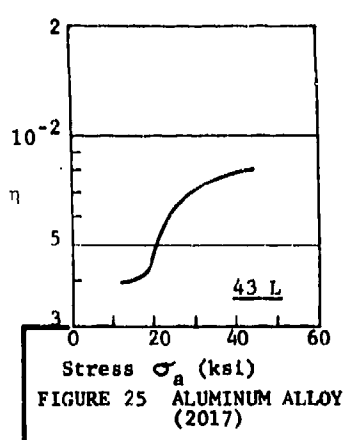
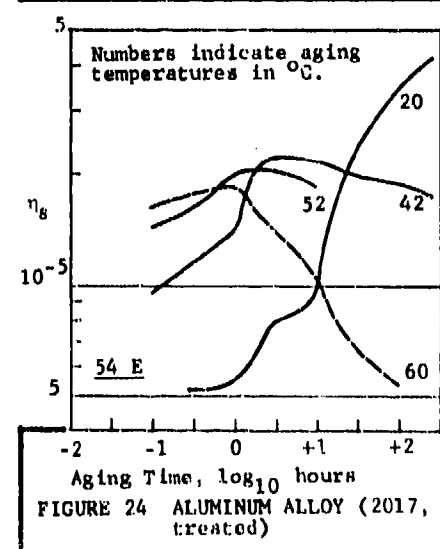
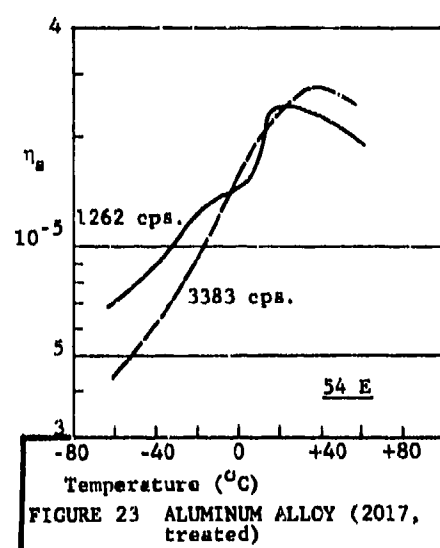
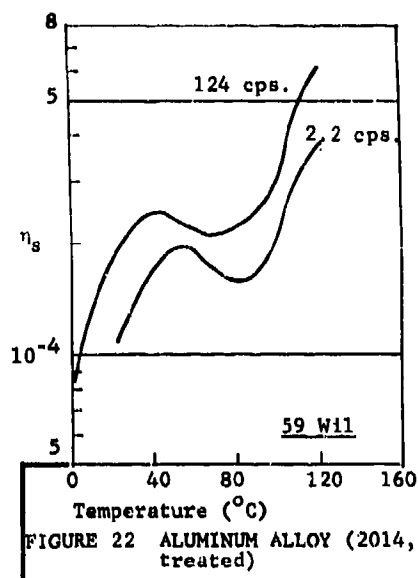
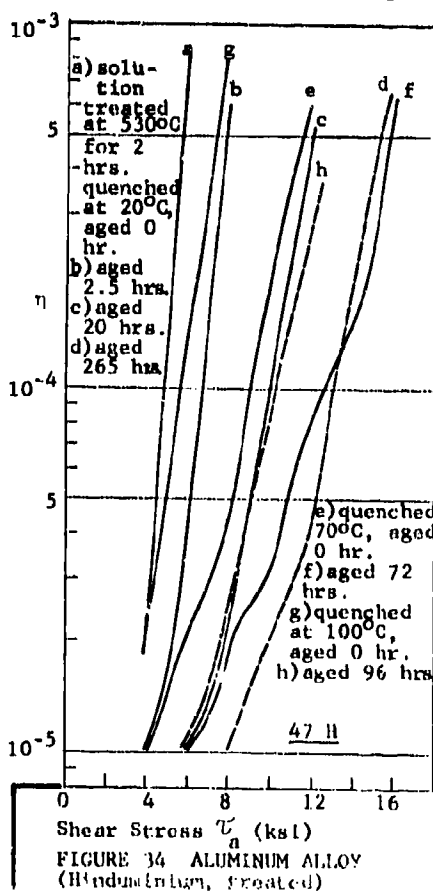
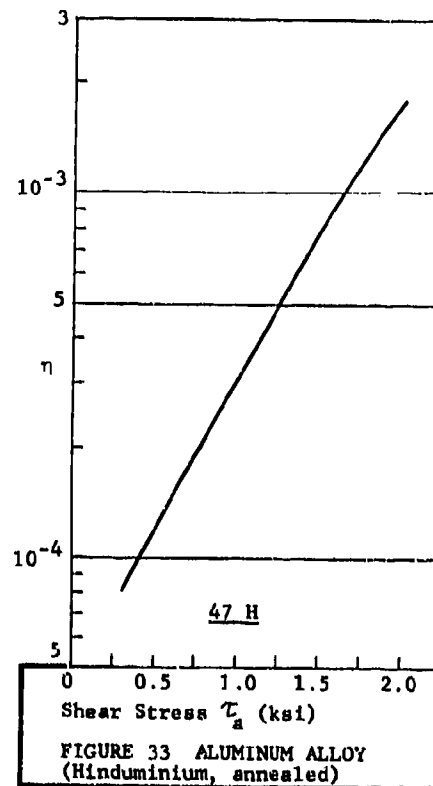
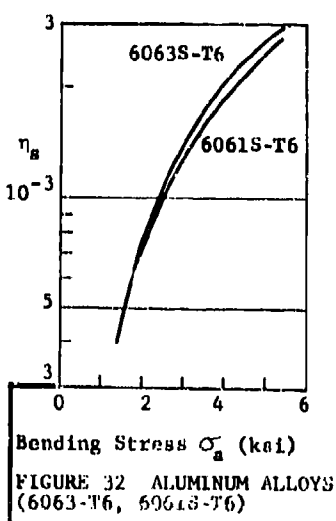
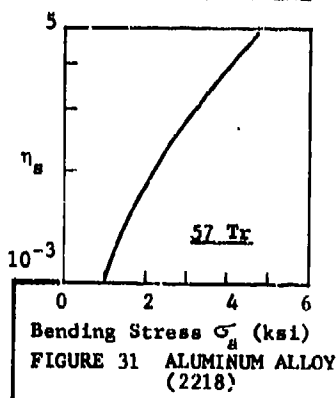
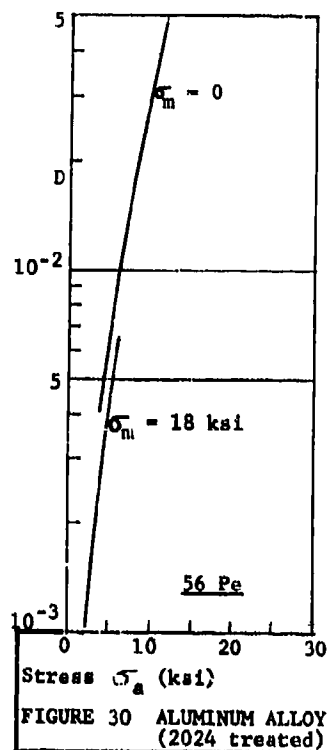
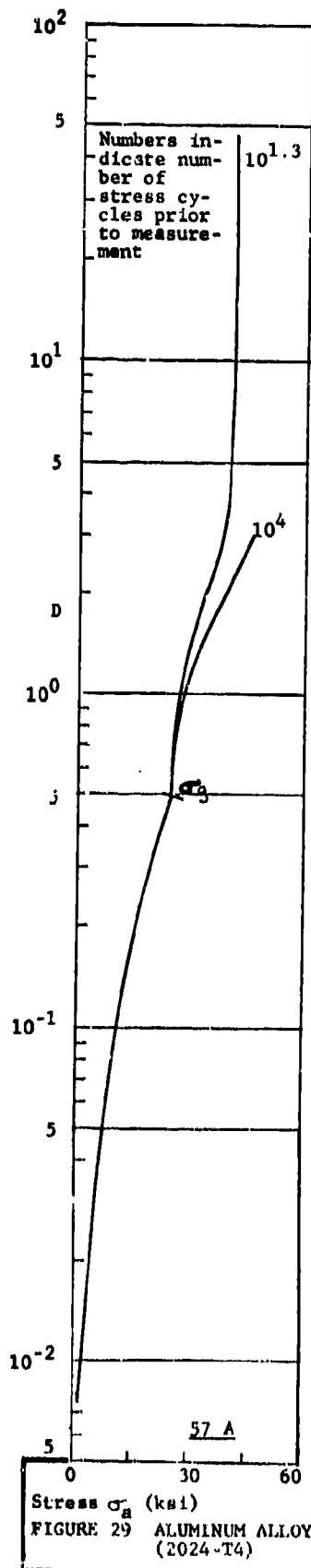
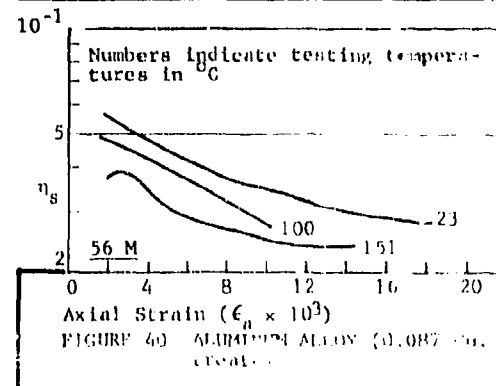
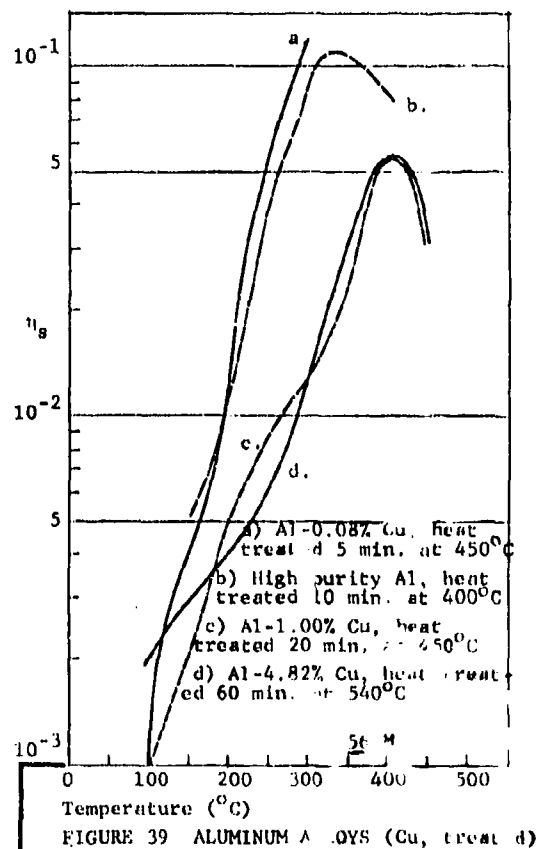
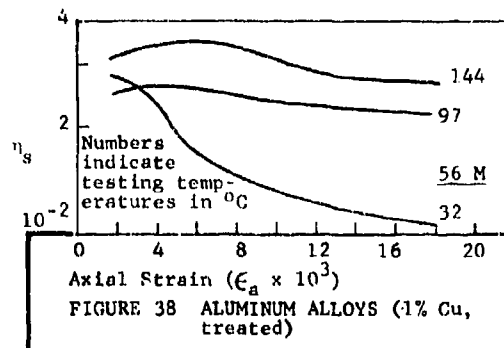
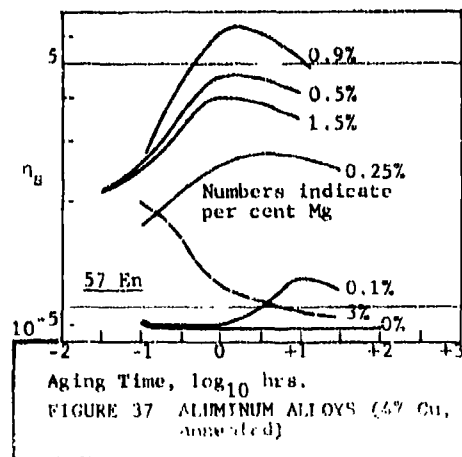
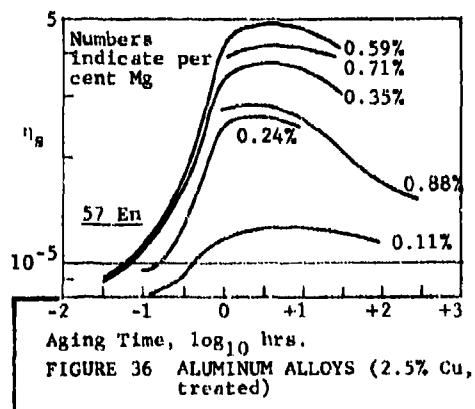
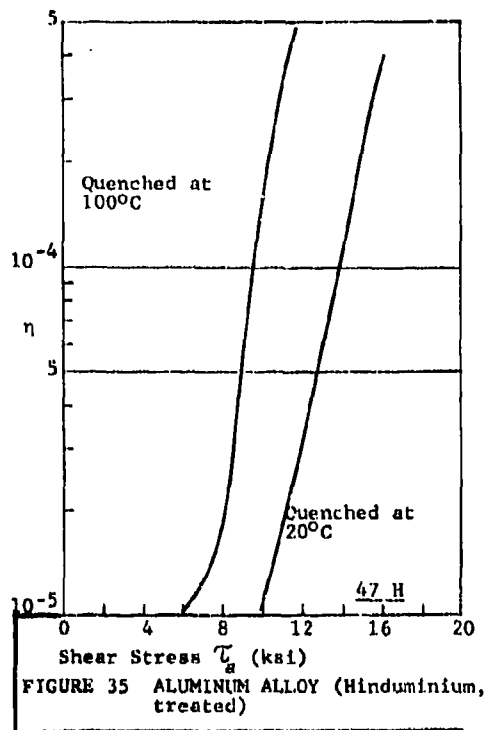


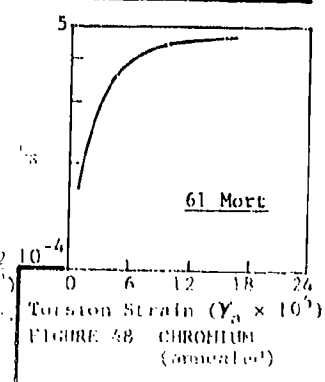
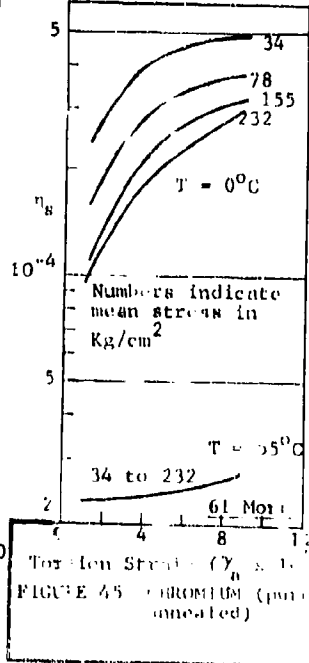
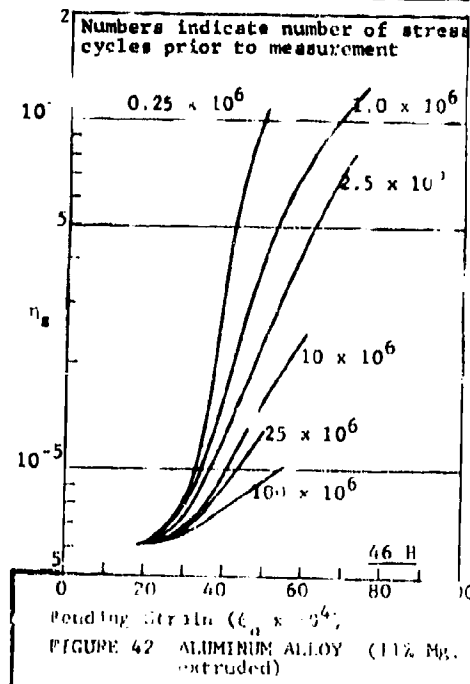
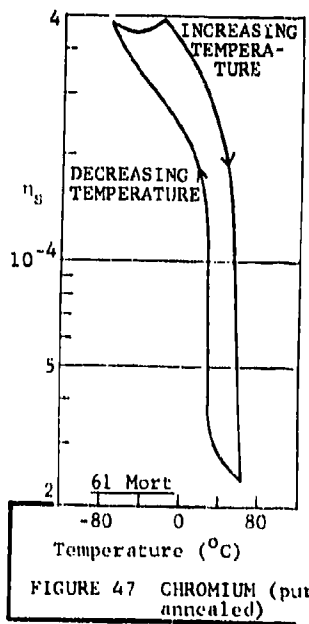
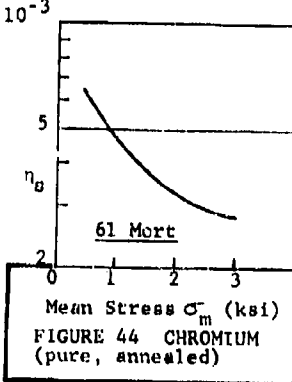
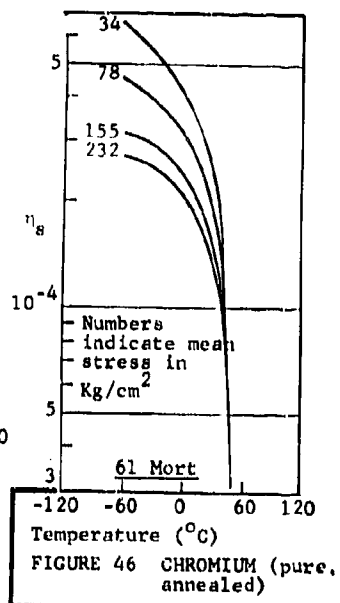
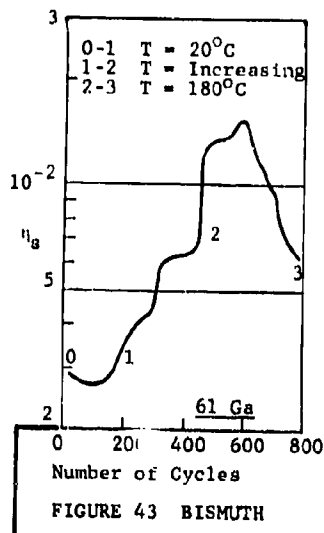
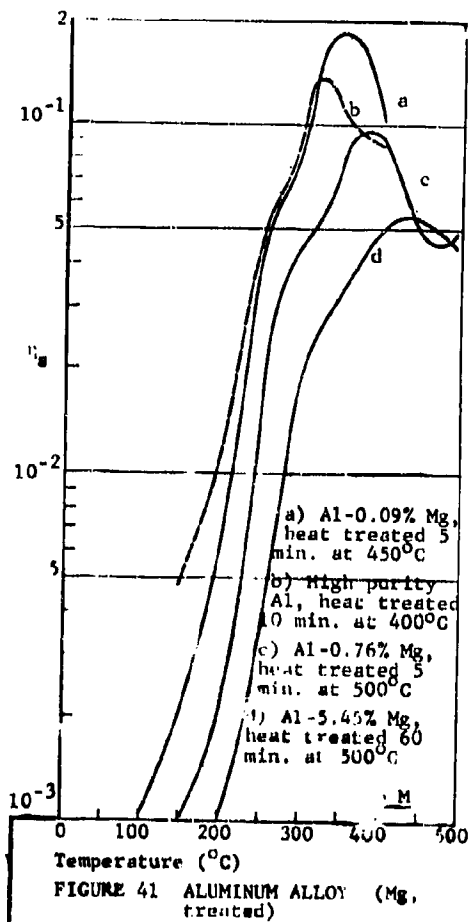
FIGURE 12 ALUMINUM (iron and copper impurities)

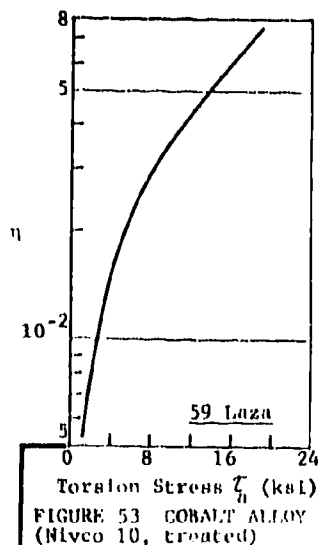
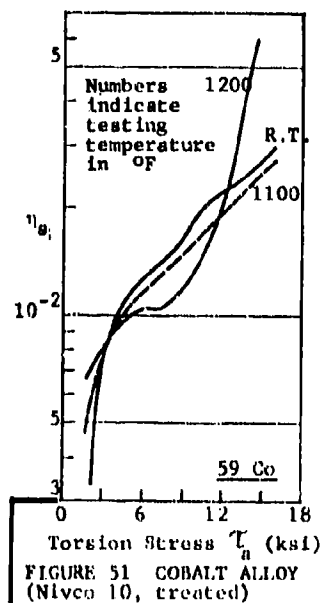
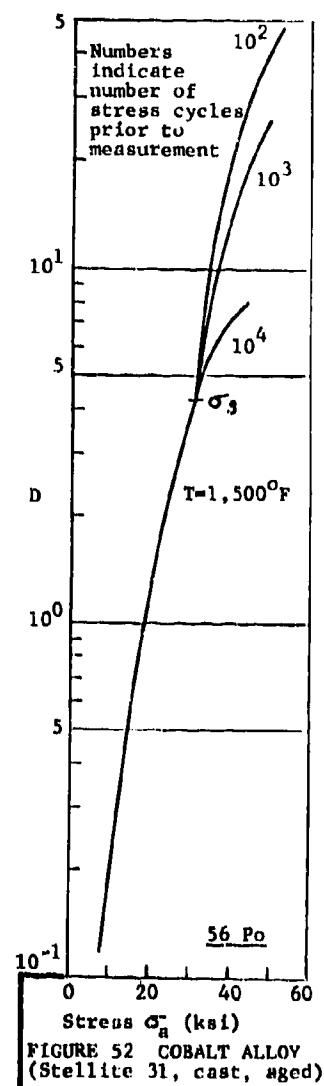
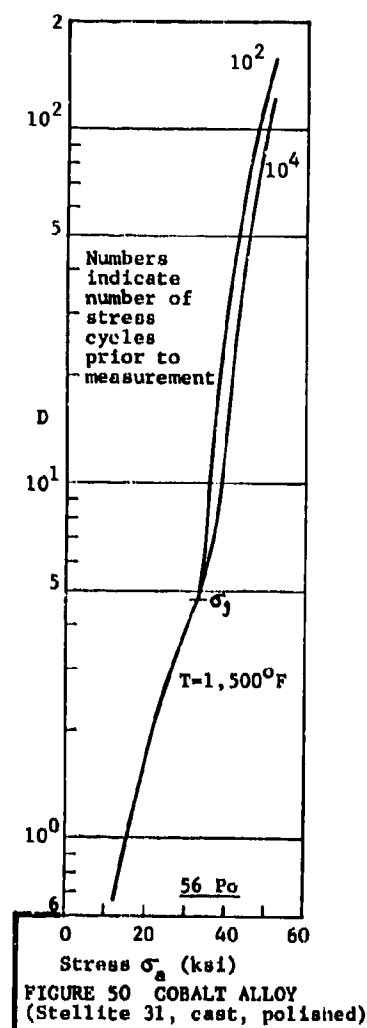
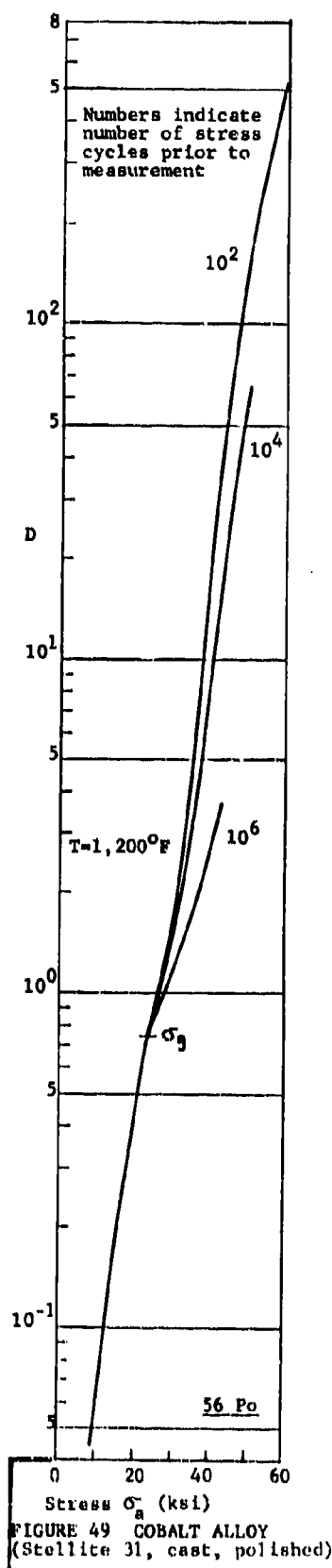


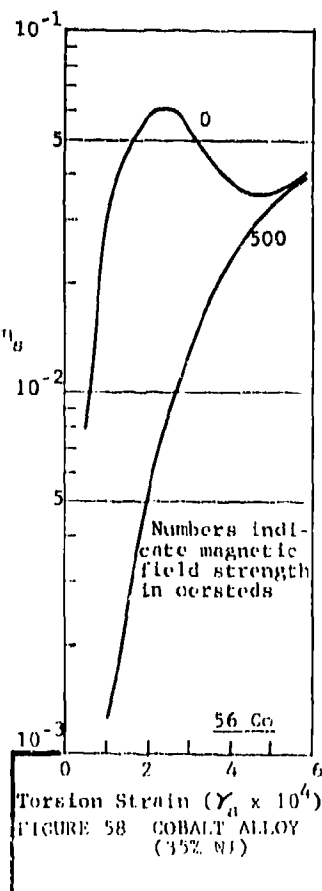
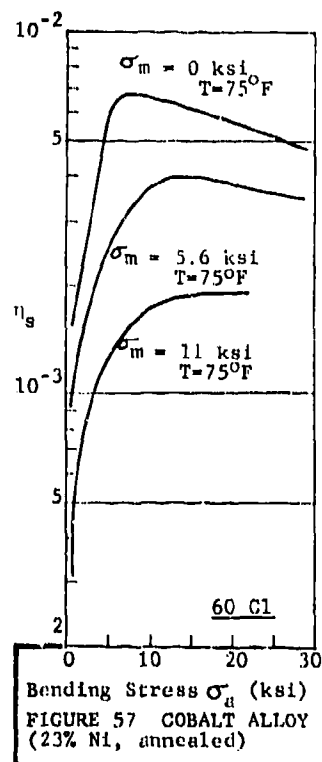
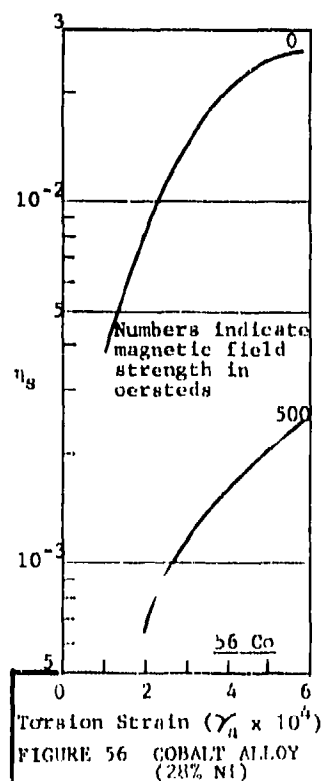
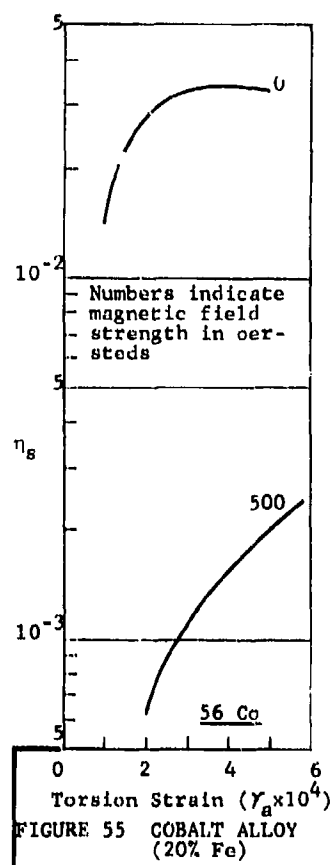
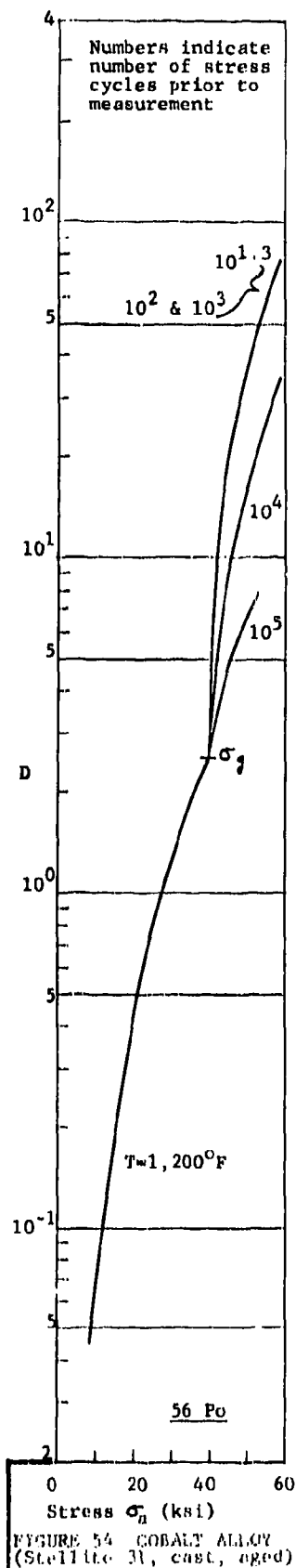


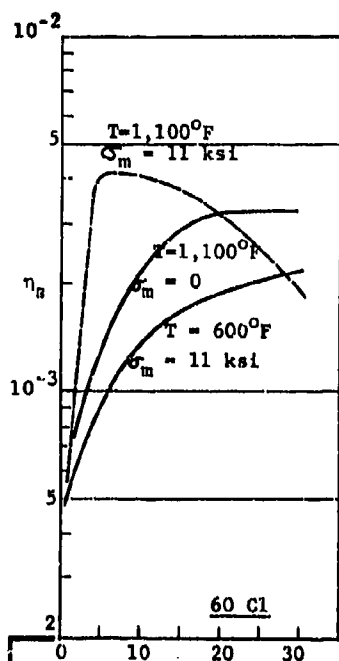




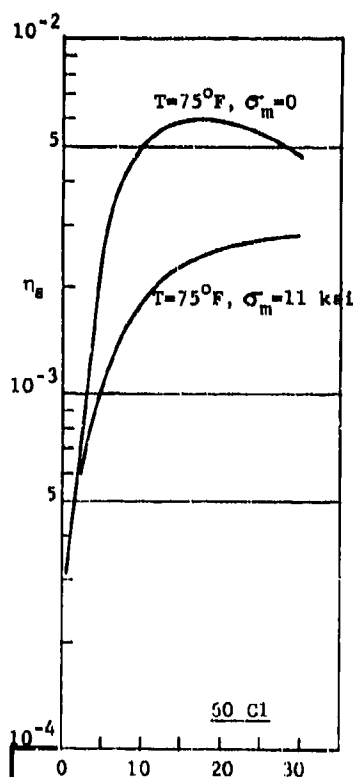




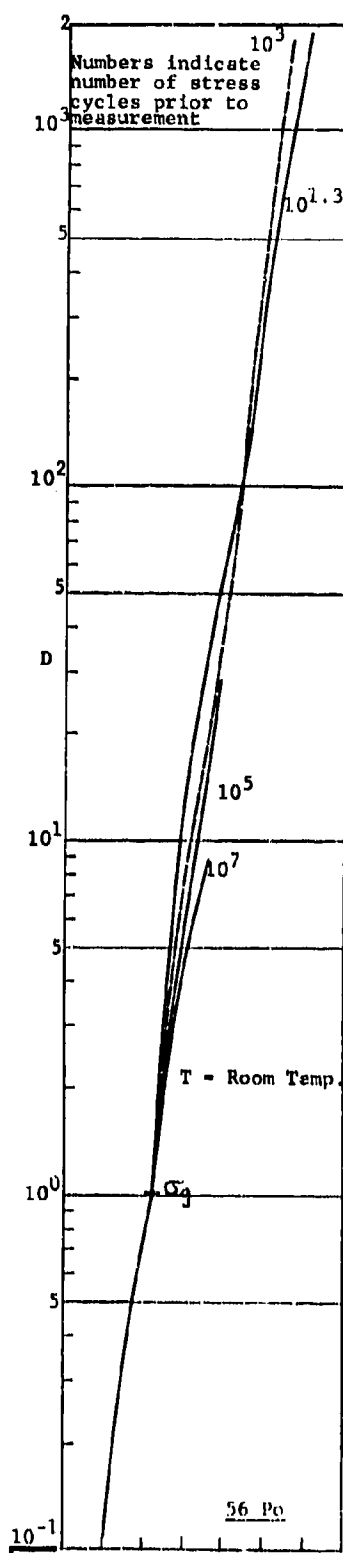




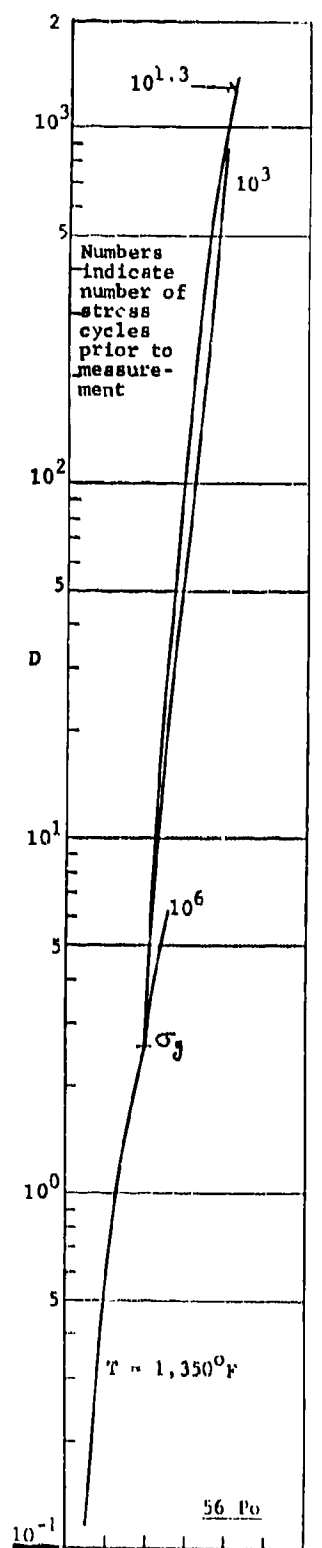
Bending Stress σ_a (ksi)
 FIGURE 59 COBALT ALLOY (34% Ni, 2% Fe, 2% Ti, annealed)



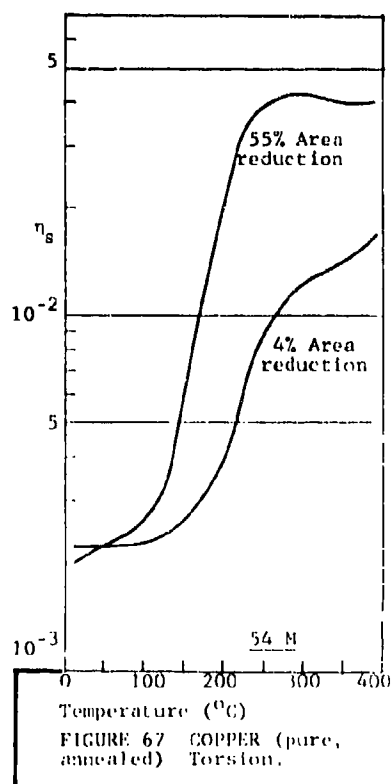
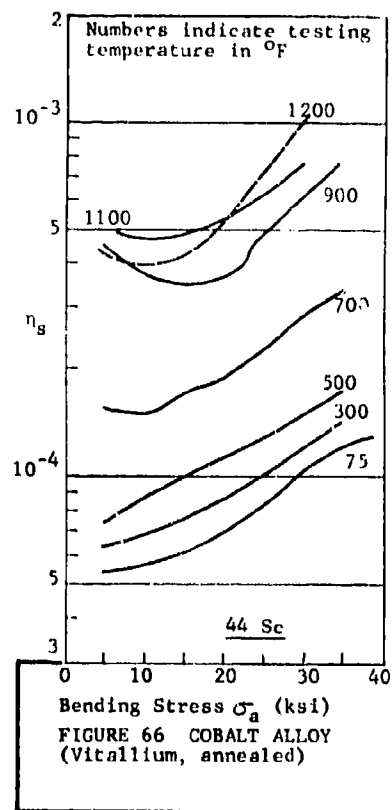
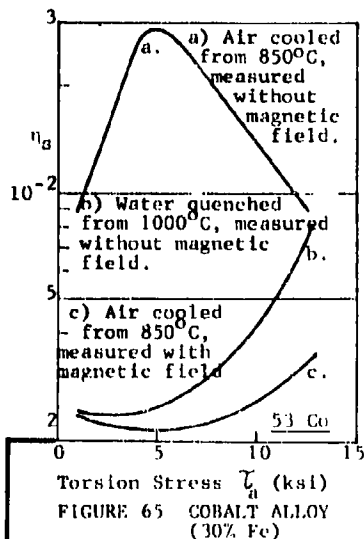
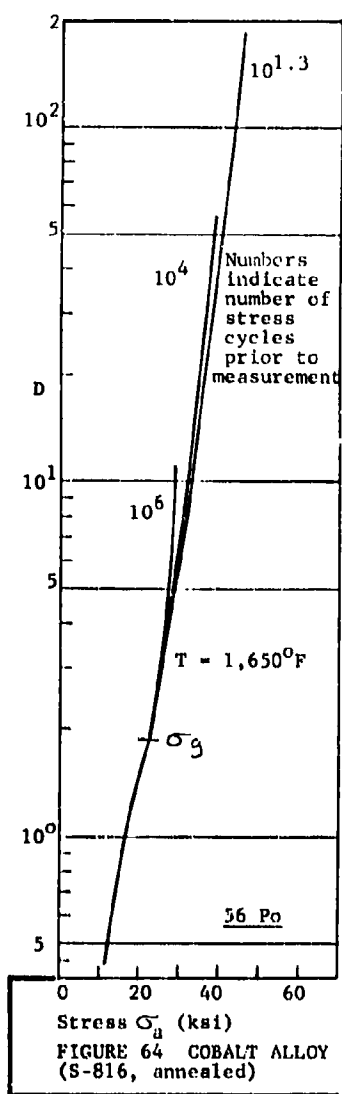
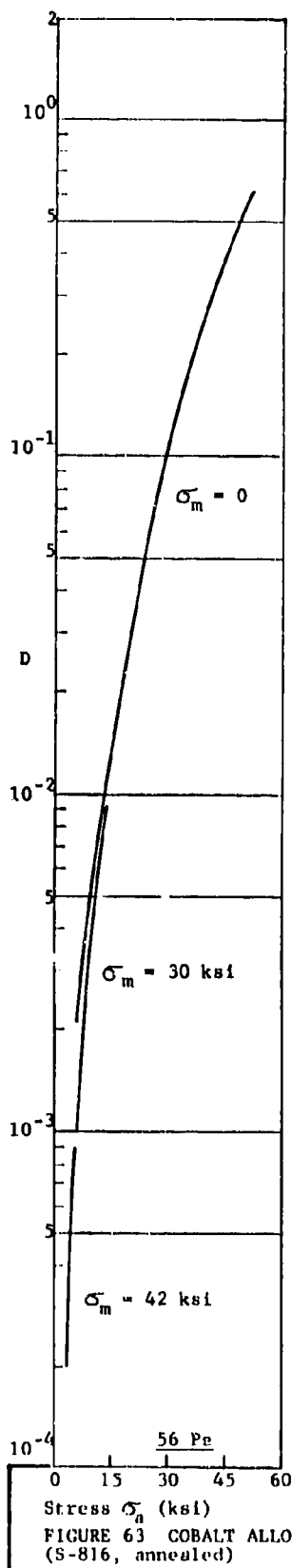
Bending Stress σ_a (ksi)
 FIGURE 60 COBALT ALLOY (34% Ni, 2% Fe, 2% Ti, annealed)

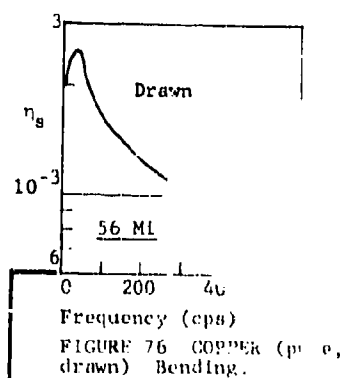
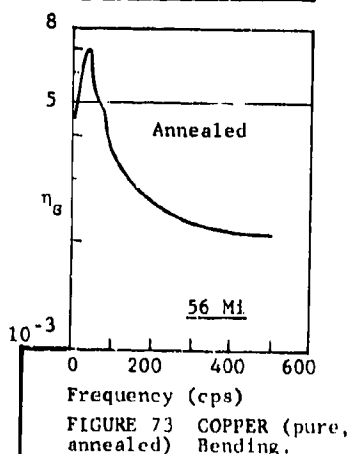
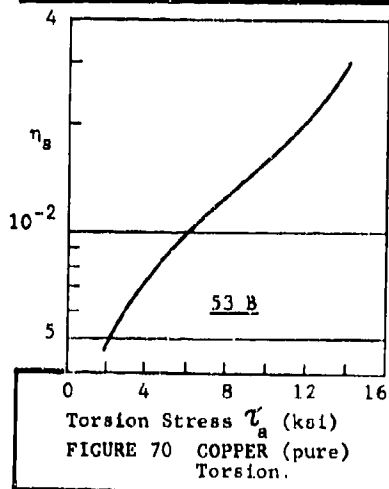
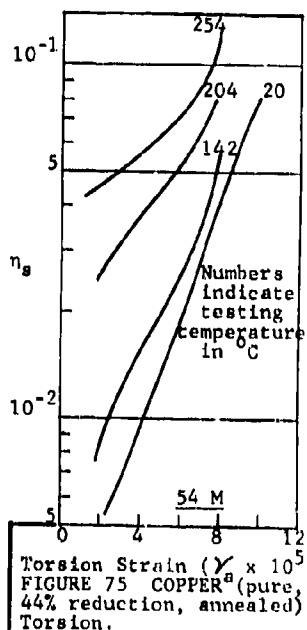
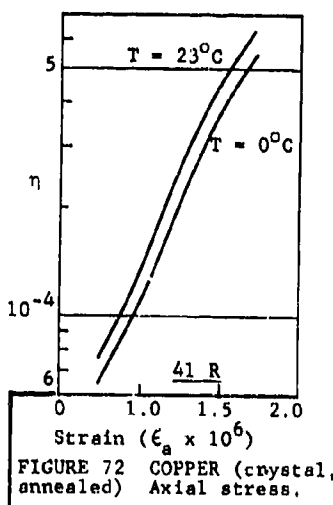
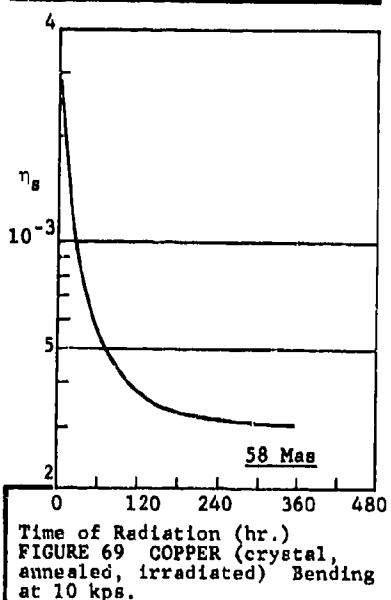
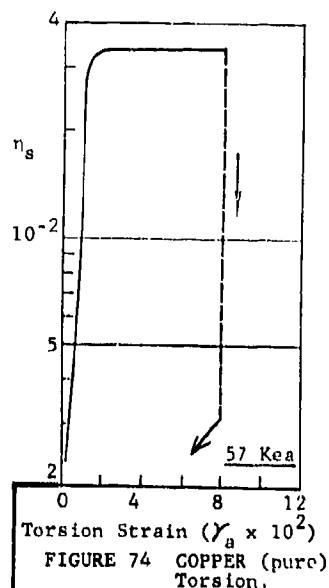
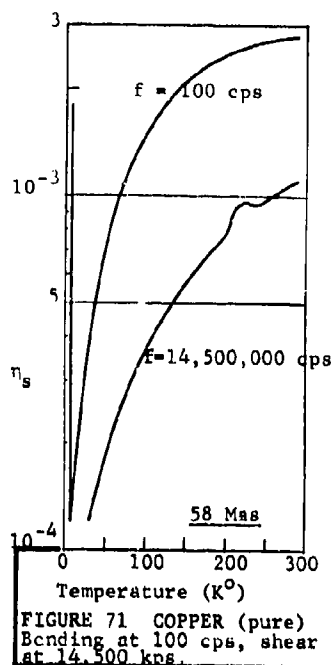
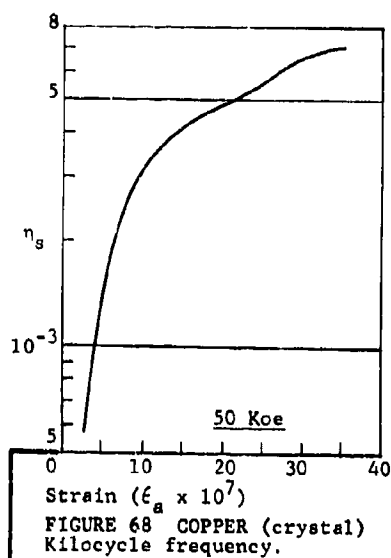


Stress σ_a (ksi)
 FIGURE 61 COBALT ALLOY (S-816, annealed)



Stress σ_a (ksi)
 FIGURE 62 COBALT ALLOY (S-816, annealed)





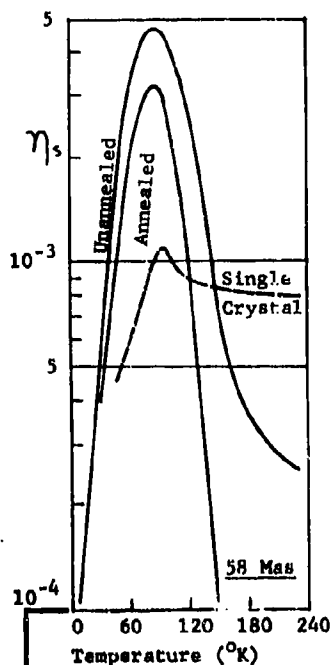


FIGURE 77 COPPER (Crystal)
Axial stress at 30 kps.

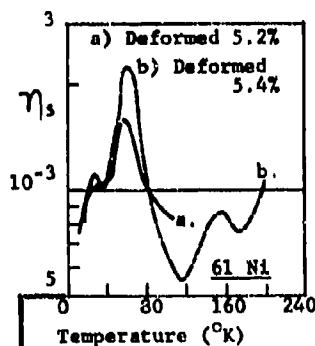


FIGURE 78 COPPER (pure, annealed) Torsion.

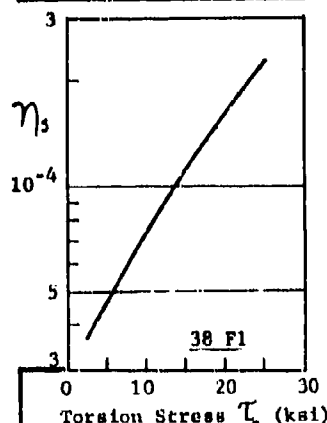


FIGURE 79 COPPER ALLOY
(2.6% Co, 0.4% Be, treated)

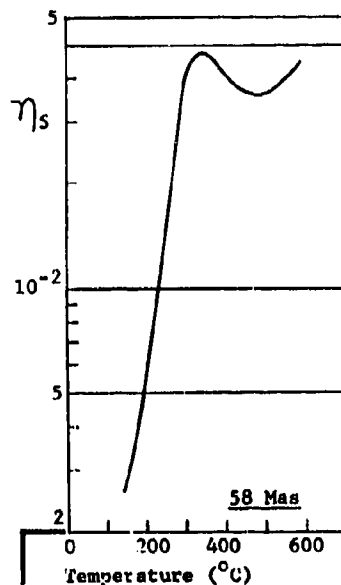


FIGURE 80 COPPER (Pure, some silicon) Torsion.

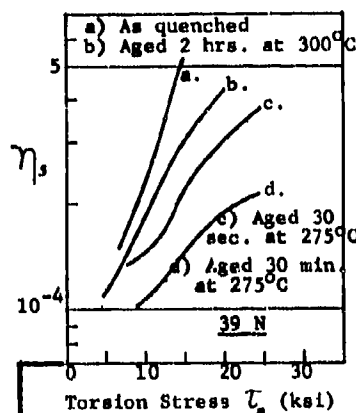


FIGURE 81 COPPER ALLOY
(2% Be)

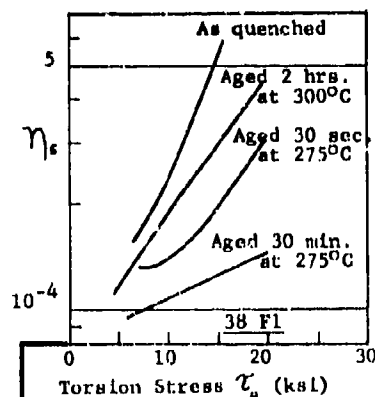


FIGURE 82 COPPER ALLOY (2.12% Be, Fe, N1, treated)

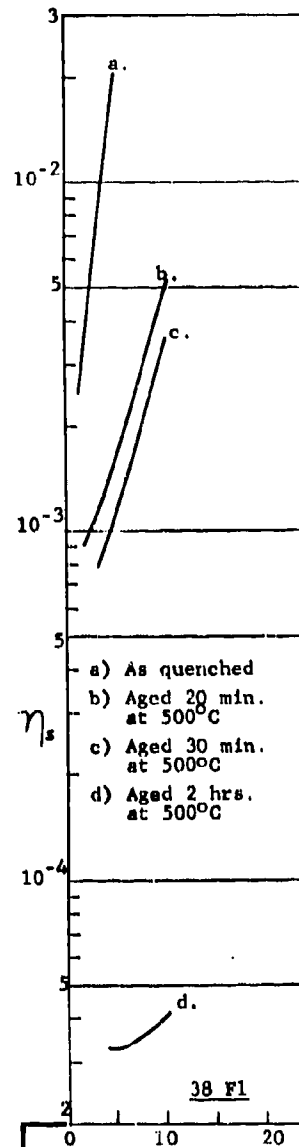


FIGURE 83 COPPER ALLOY
(0.81% Cr, 0.02% Si, treated)

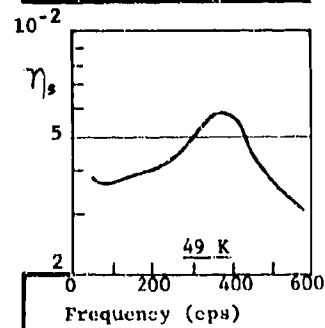
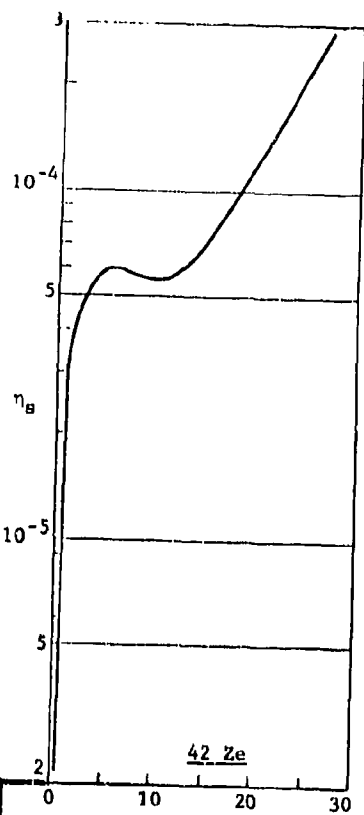
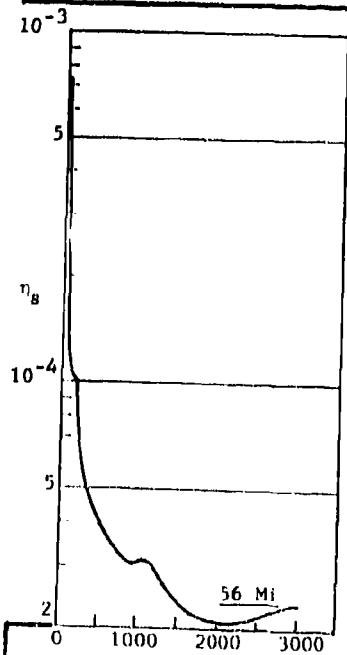


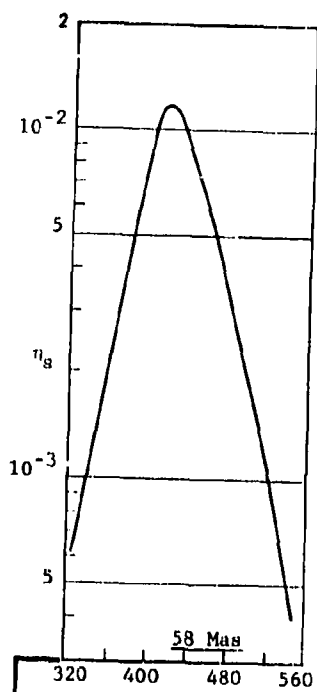
FIGURE 84 COPPER ALLOY
(Brass)



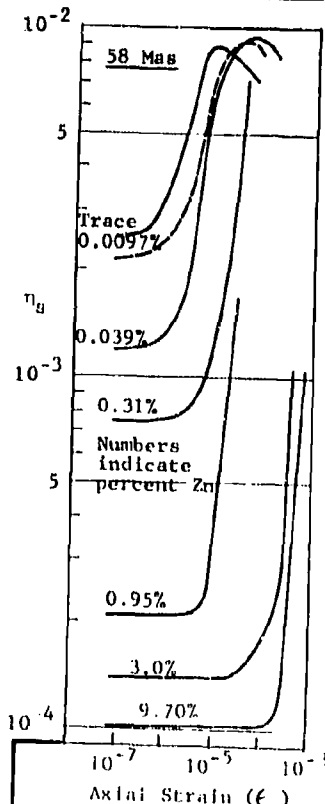
Percent Elongation
FIGURE 85 COPPER ALLOY
(Brass, drawn)



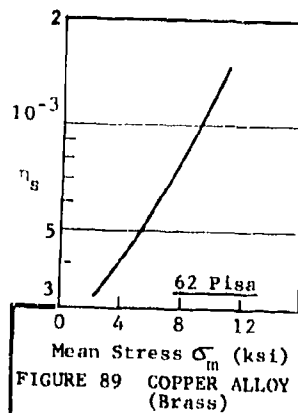
Frequency (cps)
FIGURE 86 COPPER ALLOY
(Brass, drawn)



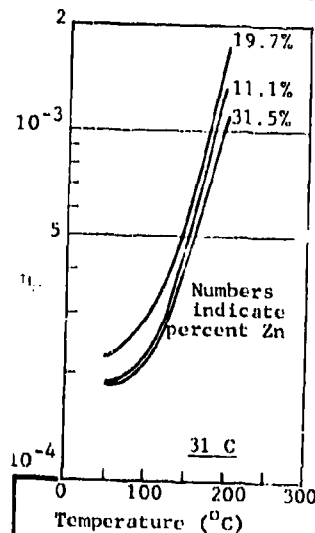
Temperature (°C)
FIGURE 87 COPPER ALLOY
(a-Brass, crystal)



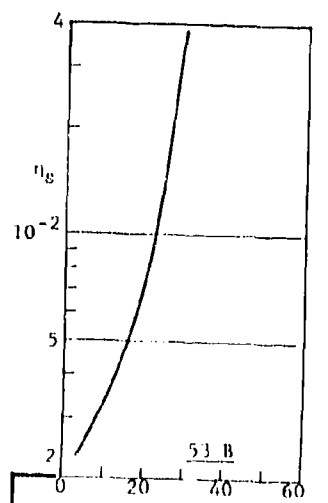
Axial Strain (ϵ_a)
FIGURE 88 COPPER ALLOYS
(Zn)



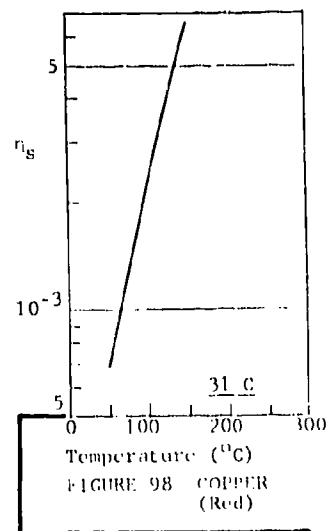
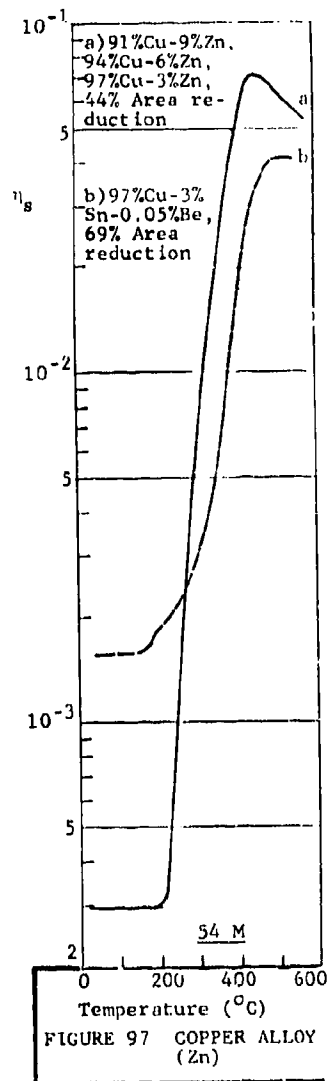
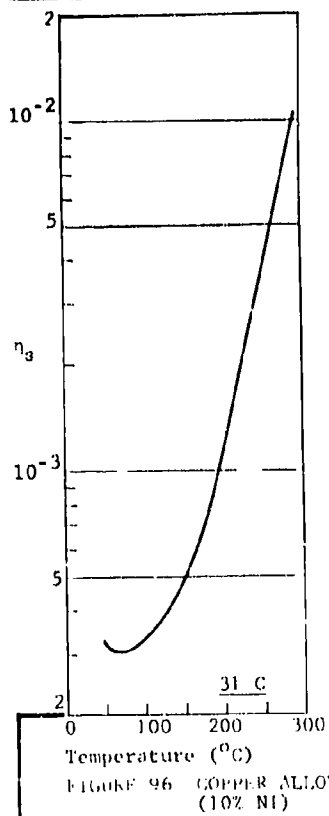
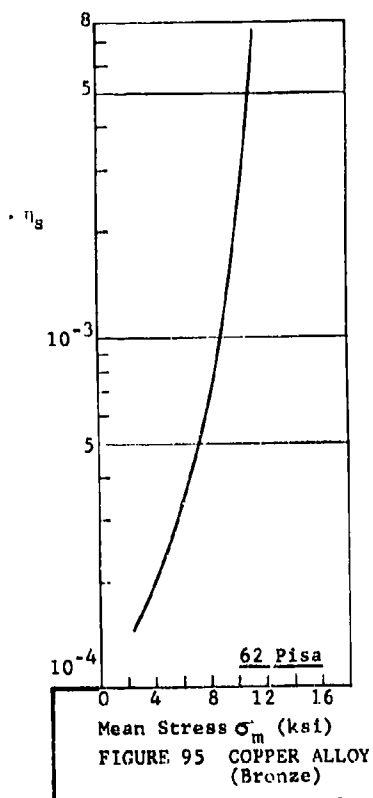
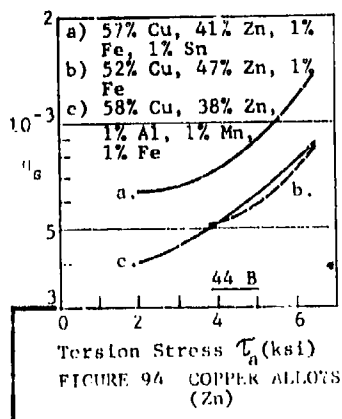
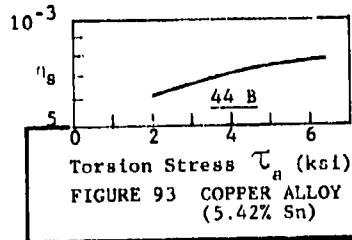
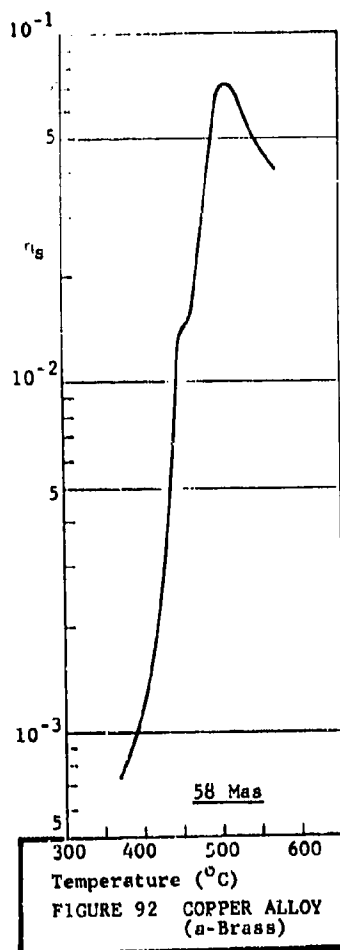
Mean Stress σ_m (ksi)
FIGURE 89 COPPER ALLOY
(Brass)

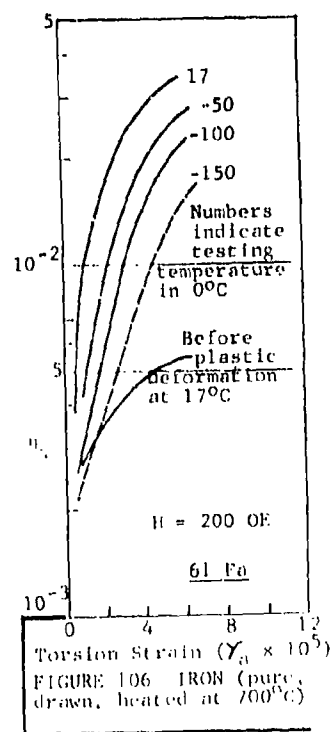
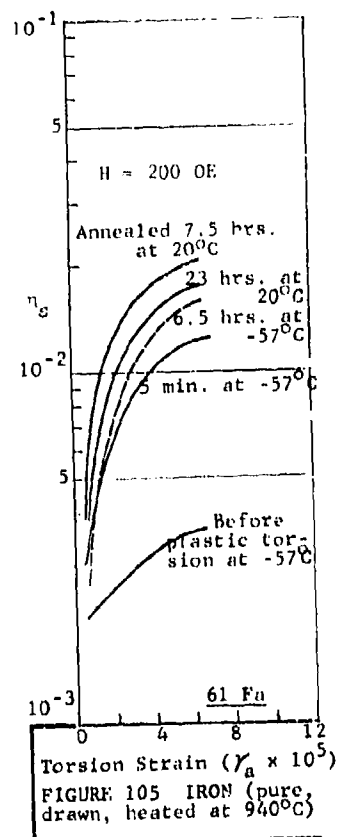
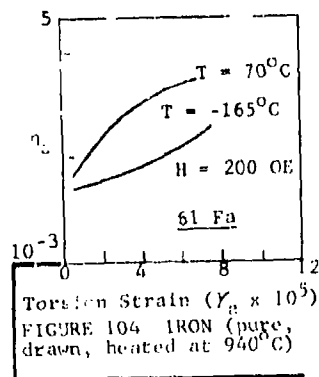
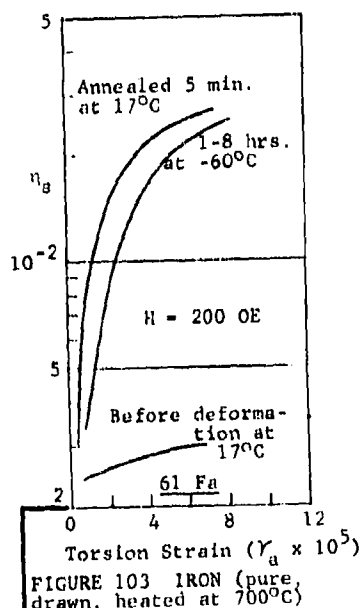
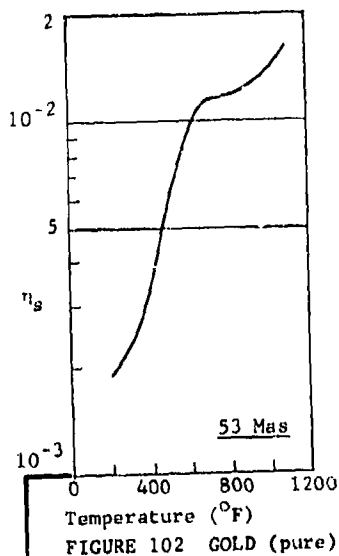
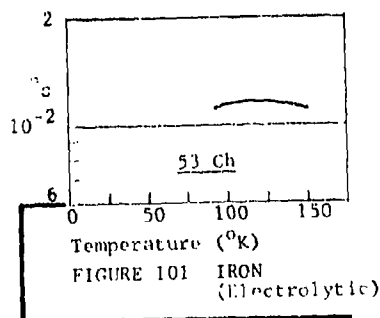
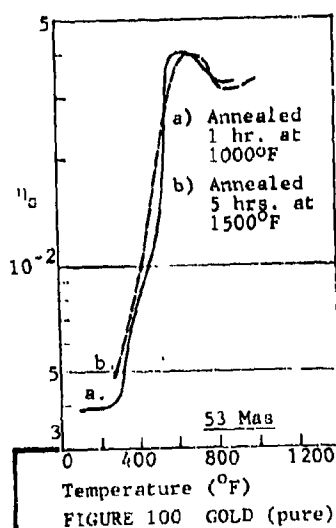
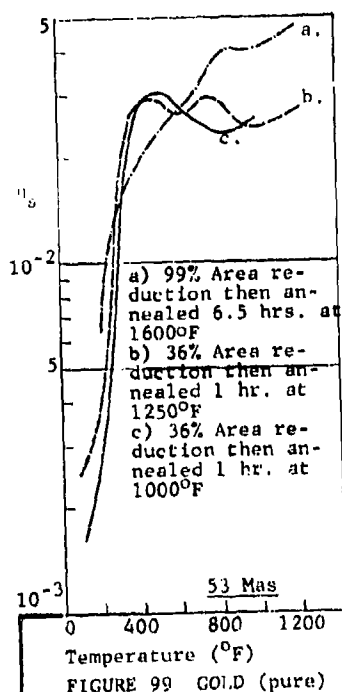


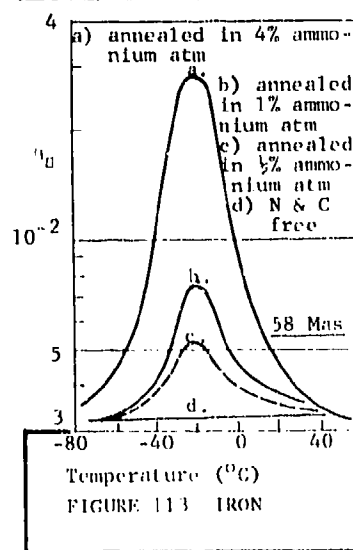
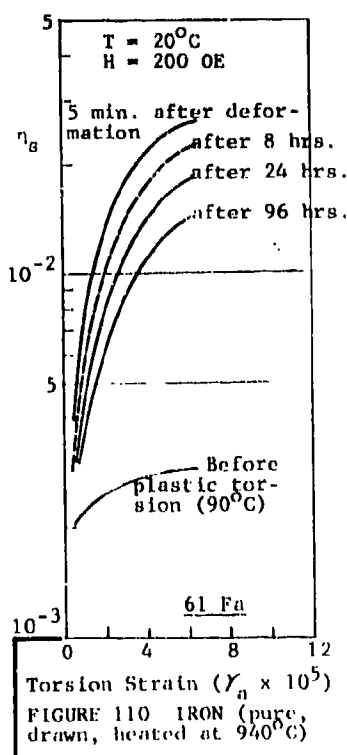
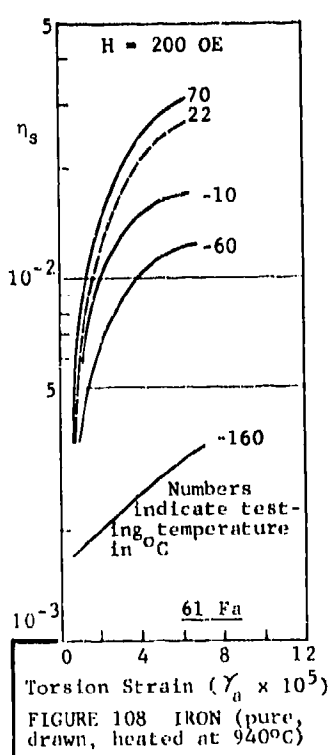
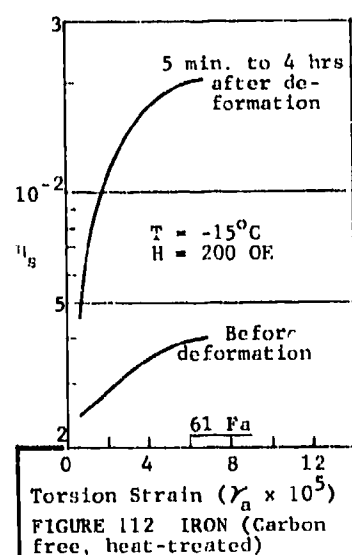
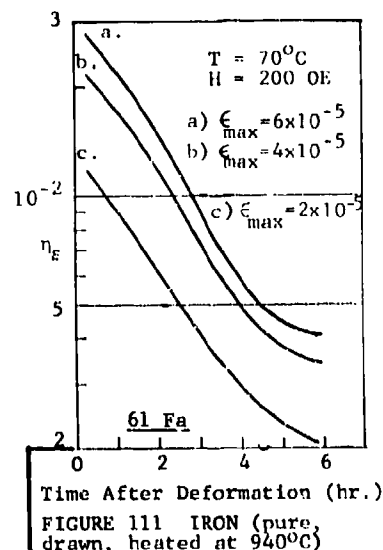
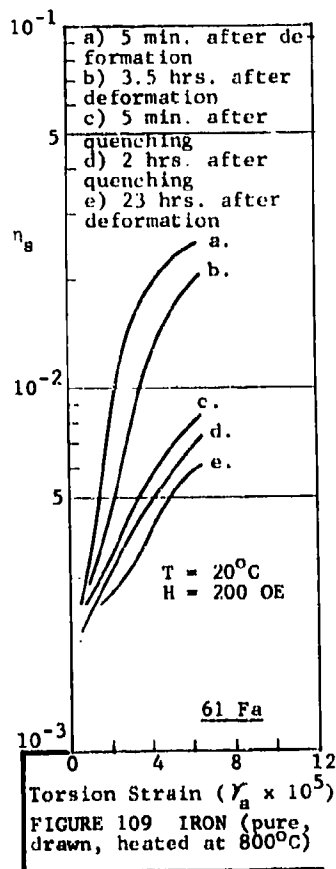
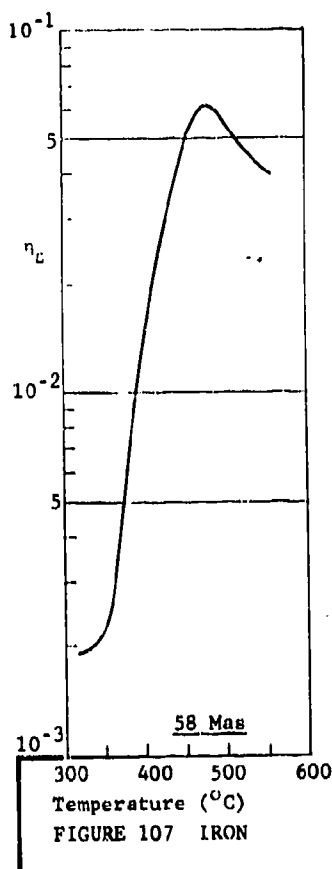
Temperature (°C)
FIGURE 90 COPPER ALLOYS
(Zn)

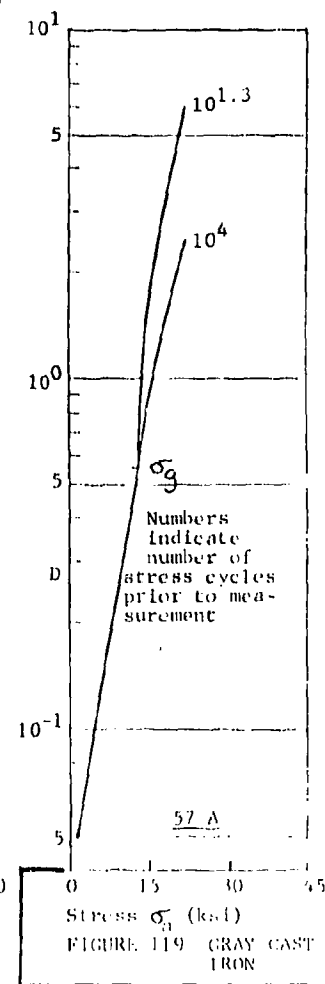
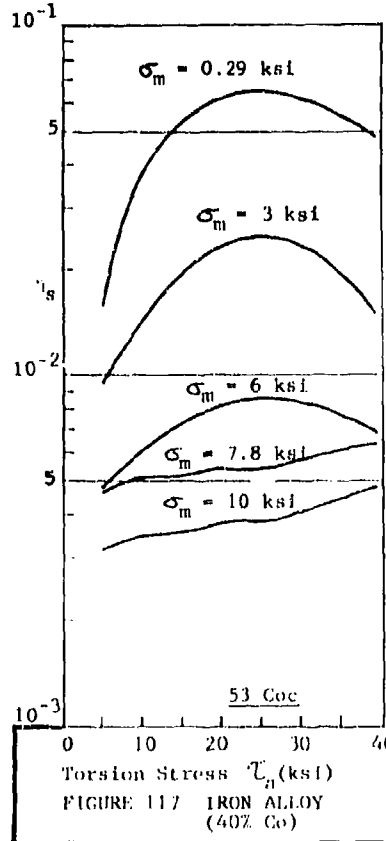
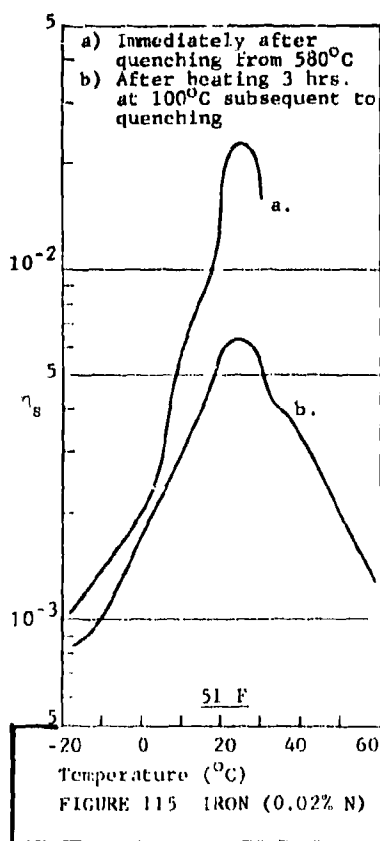
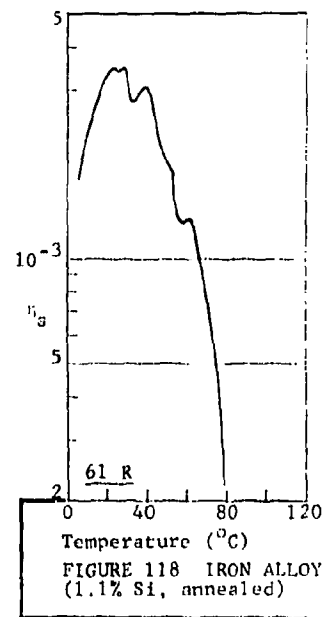
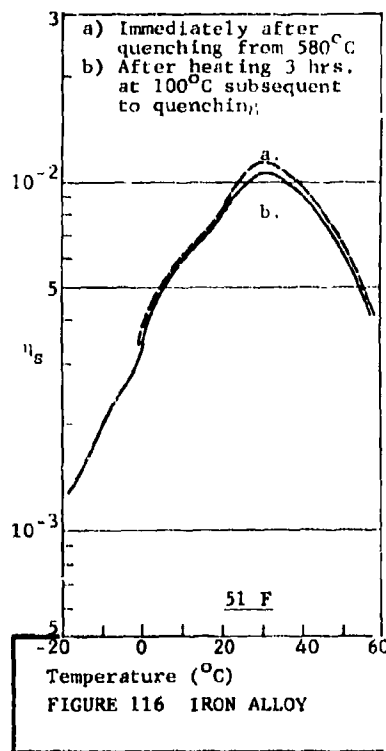
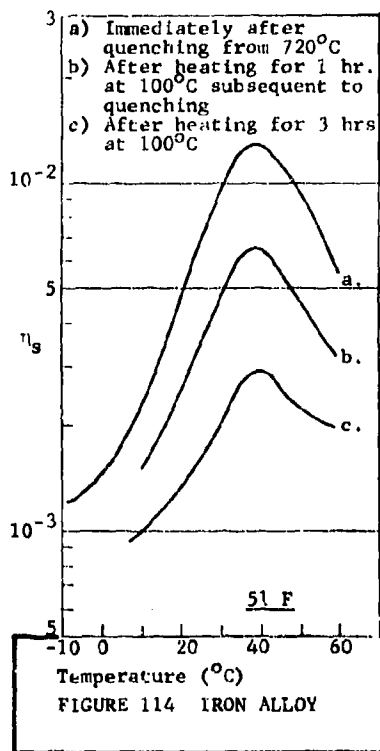


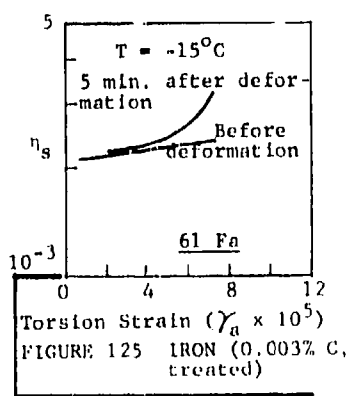
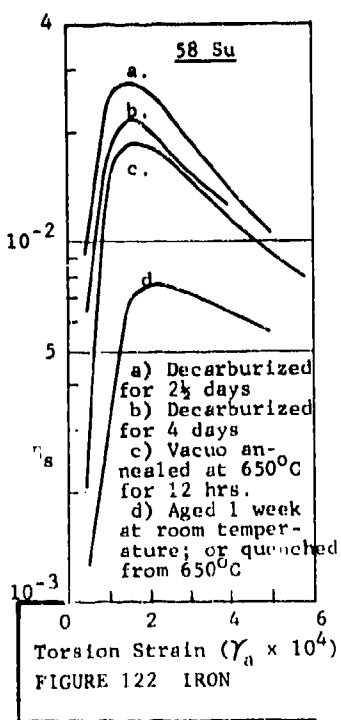
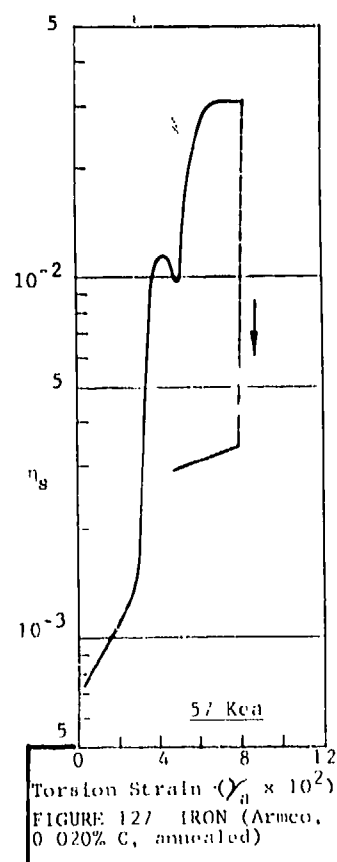
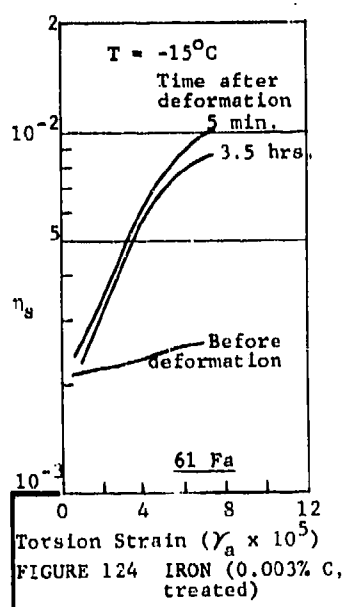
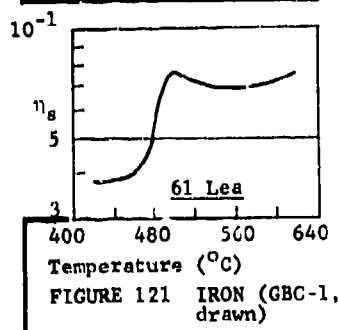
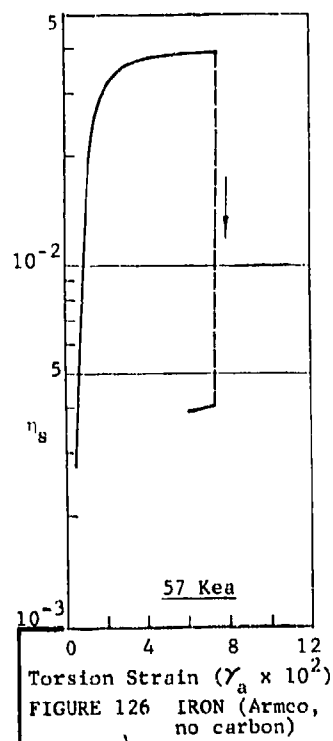
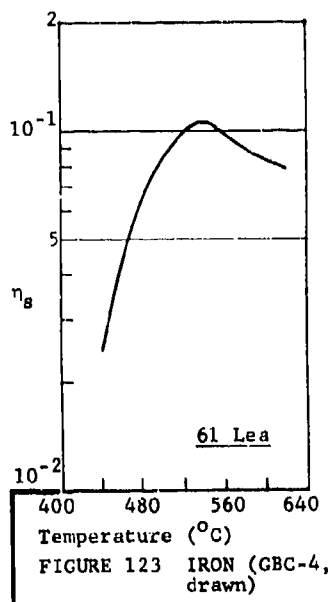
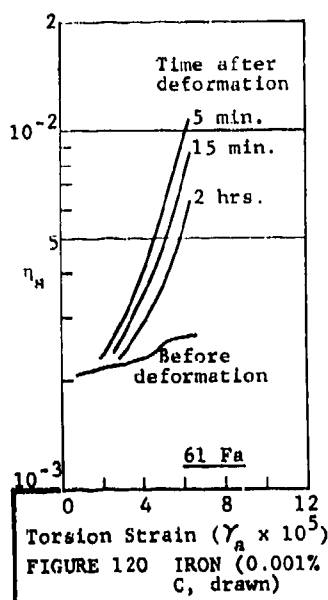
Torsion Stress τ_{31} (ksi)
FIGURE 91 COPPER ALLOY
(Brass)

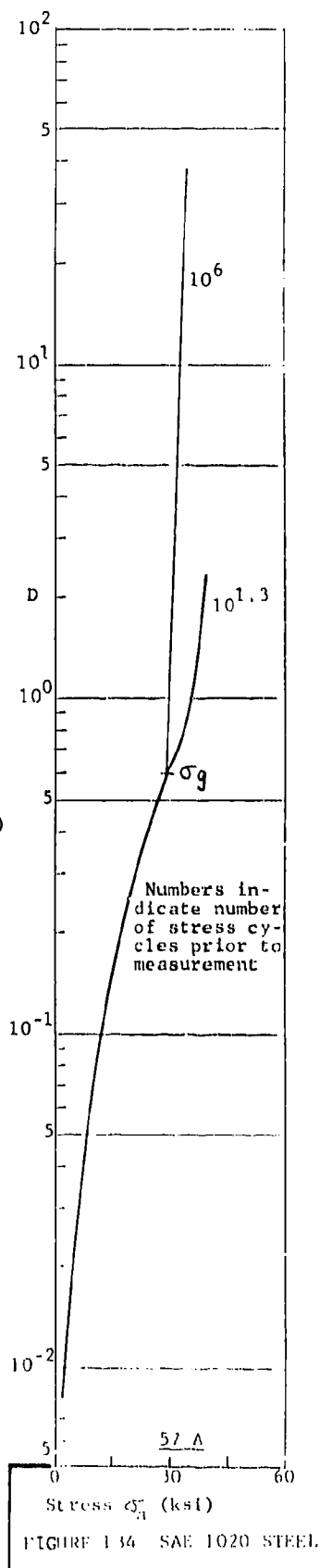
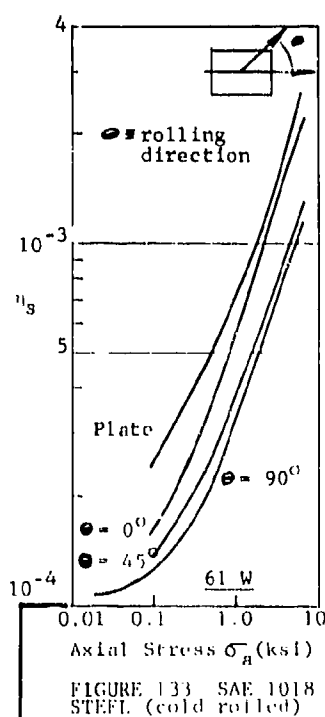
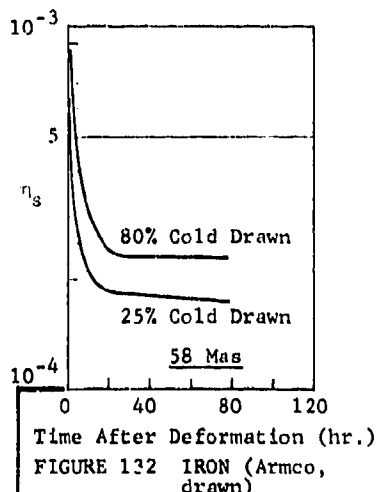
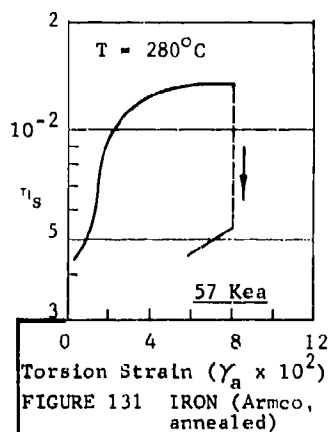
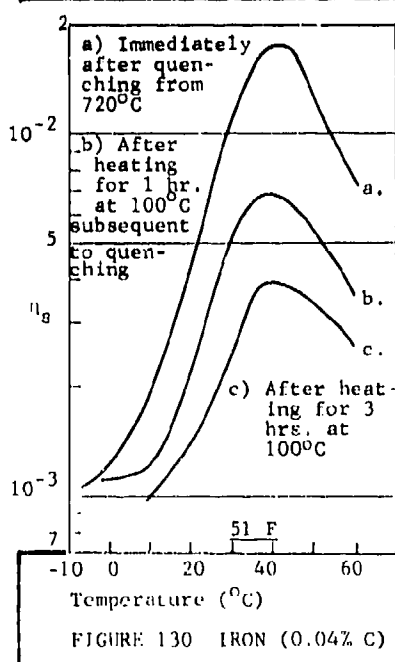
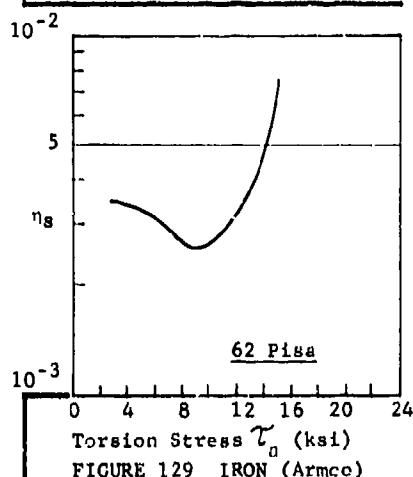
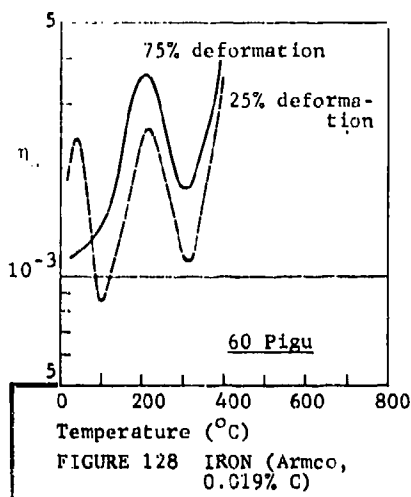


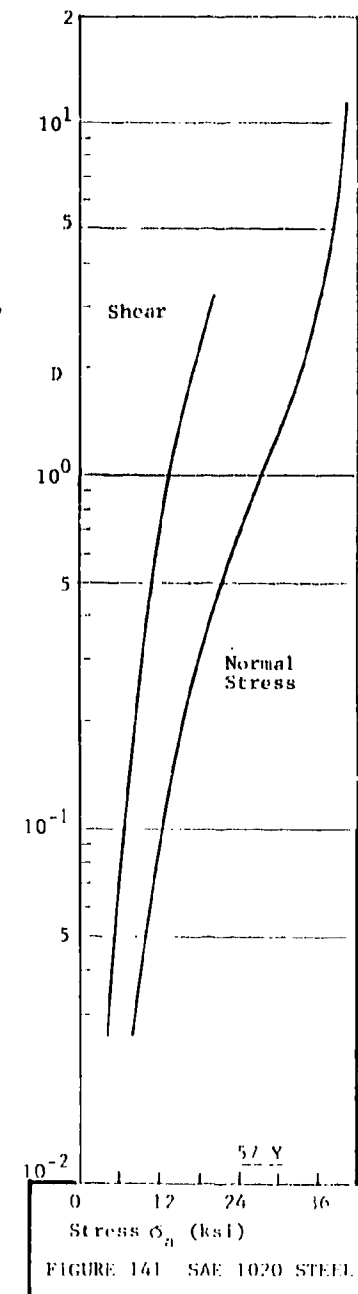
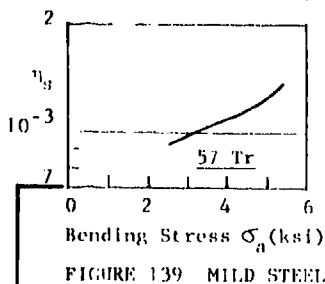
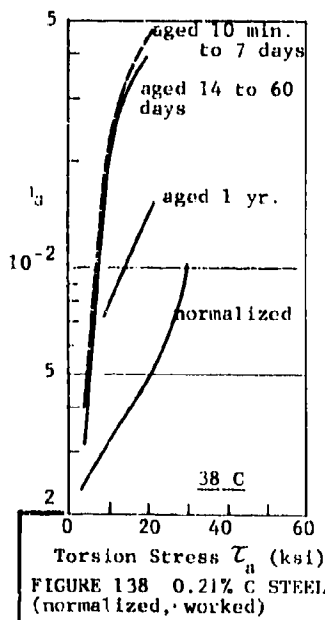
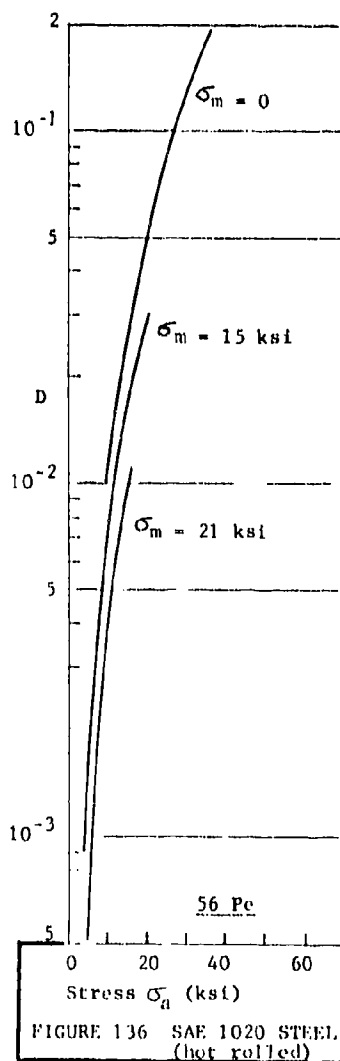
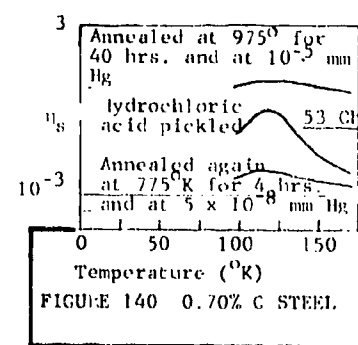
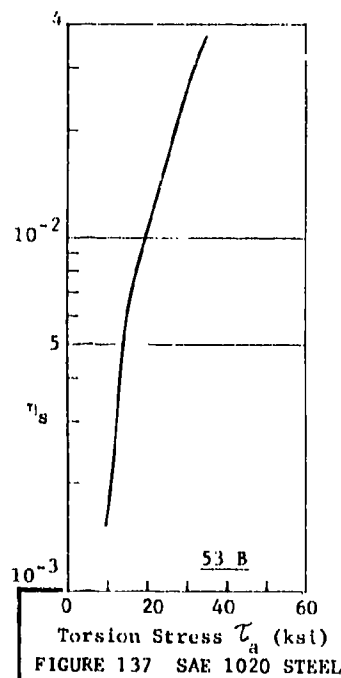
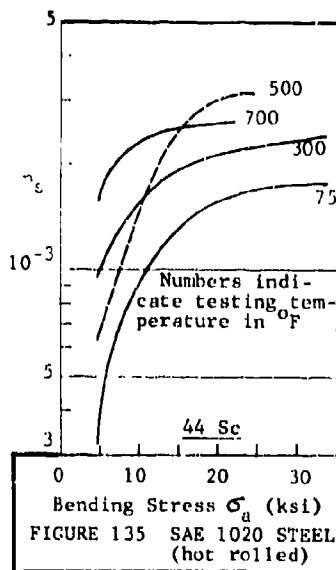












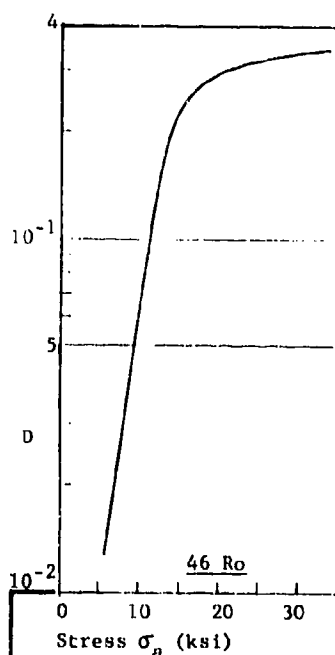


FIGURE 142 SAE 1025 STEEL

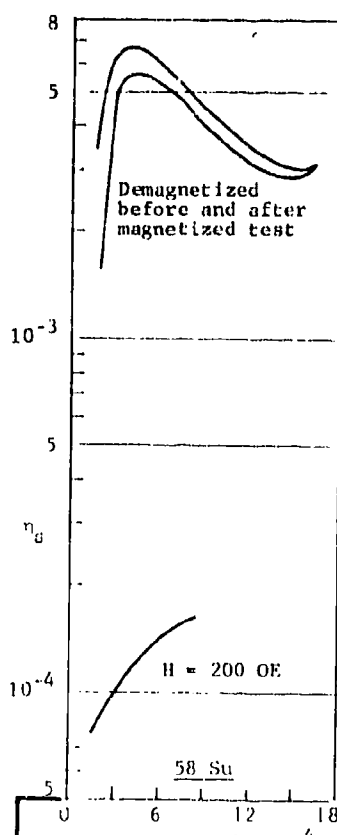


FIGURE 143 0.28% C STEEL (annealed)

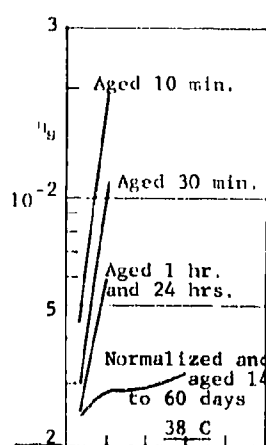


FIGURE 144 0.38% C STEEL (worked)

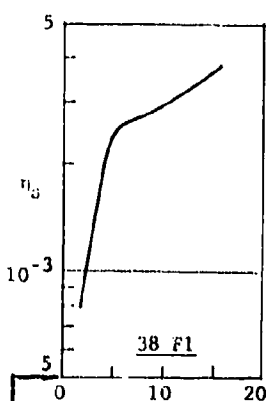


FIGURE 145 0.40% C STEEL (drawn, normalized)

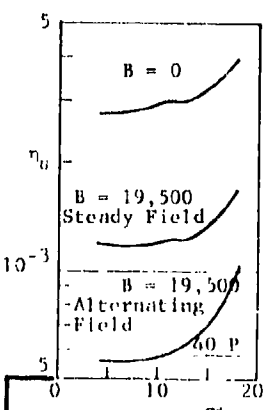


FIGURE 146 0.40% C STEEL (drawn)

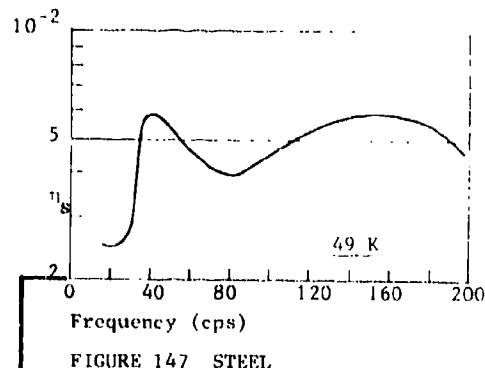


FIGURE 147 STEEL

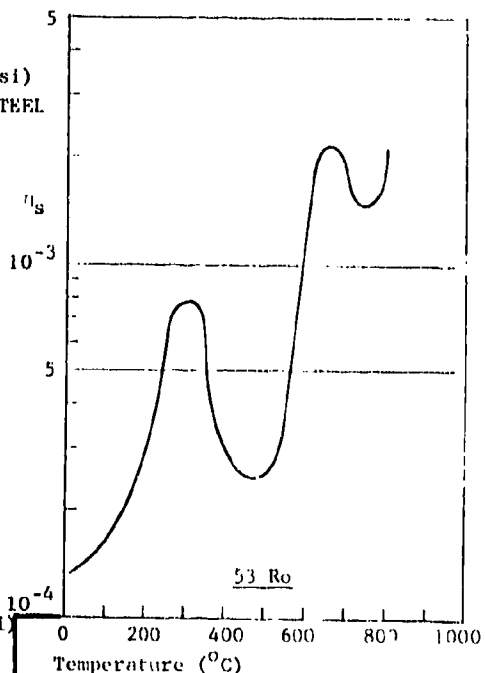


FIGURE 148 0.30% C STEEL

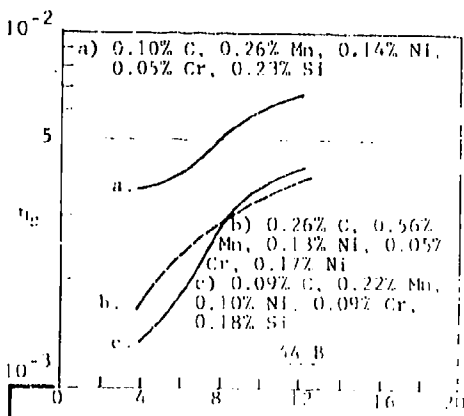
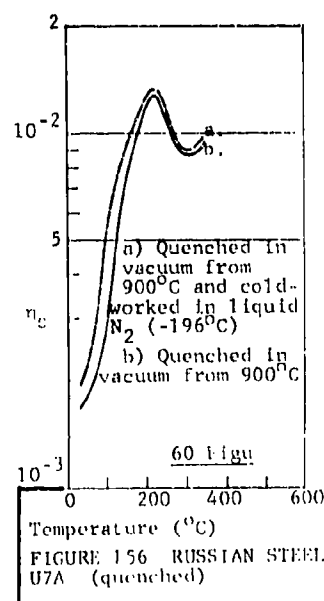
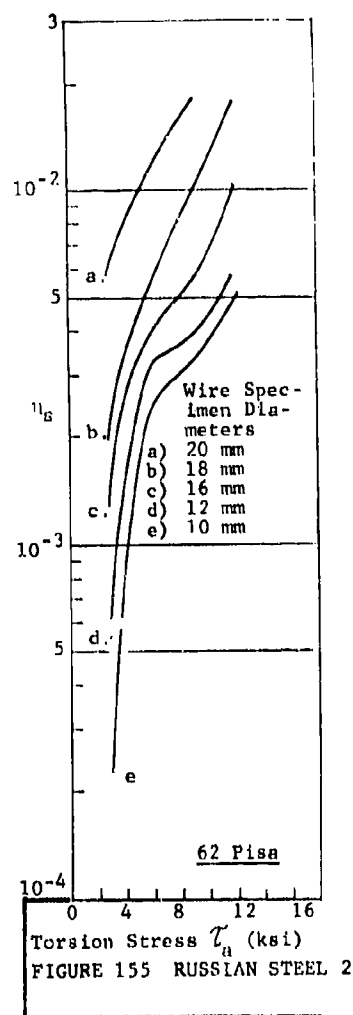
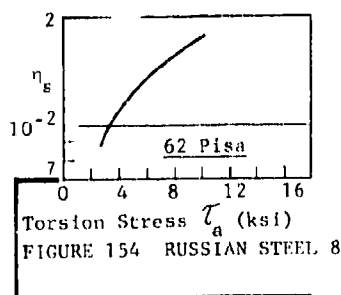
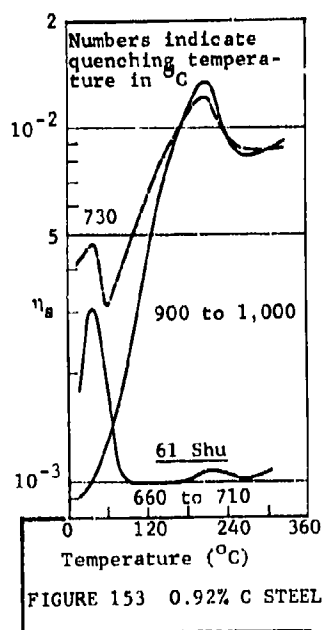
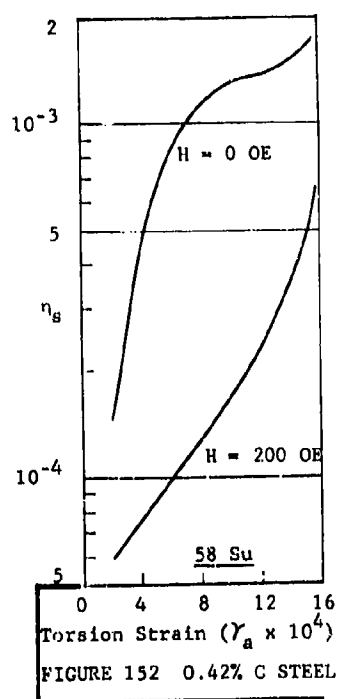
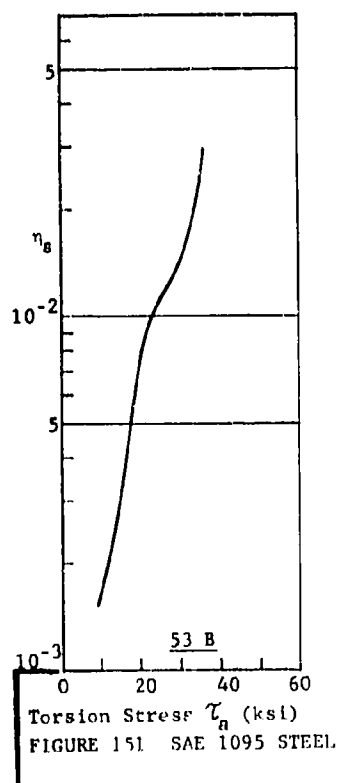
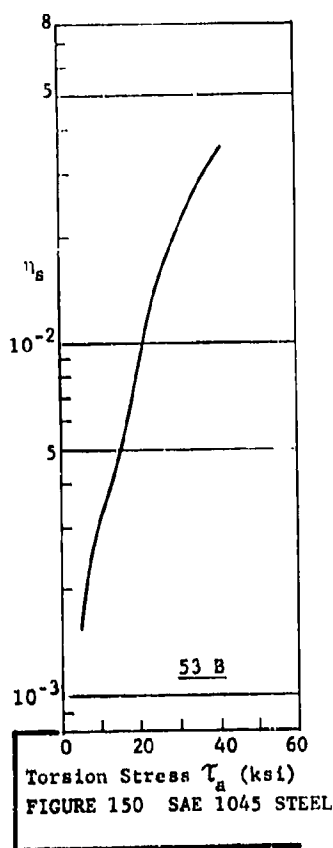
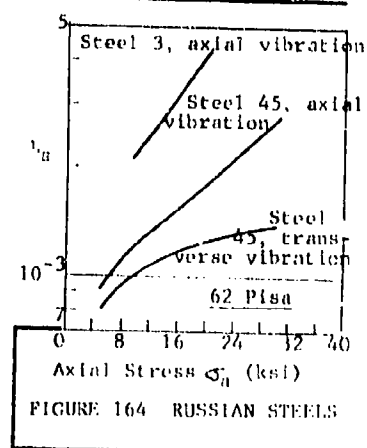
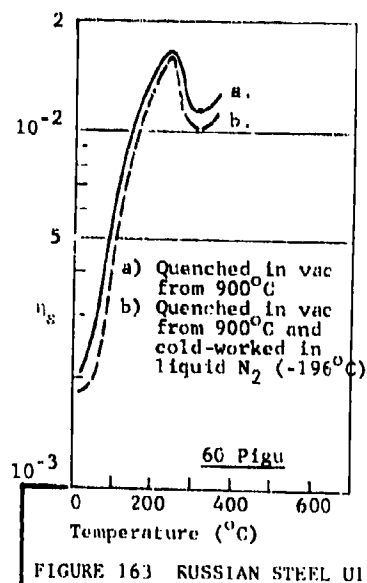
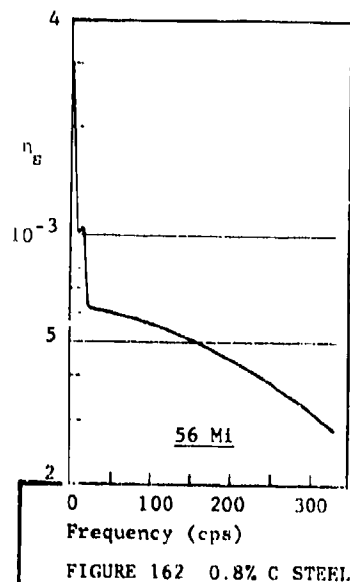
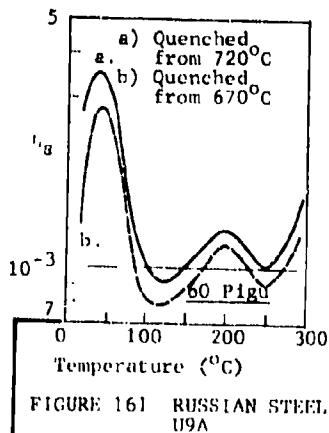
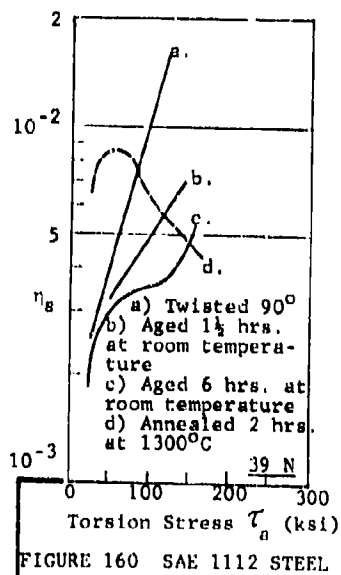
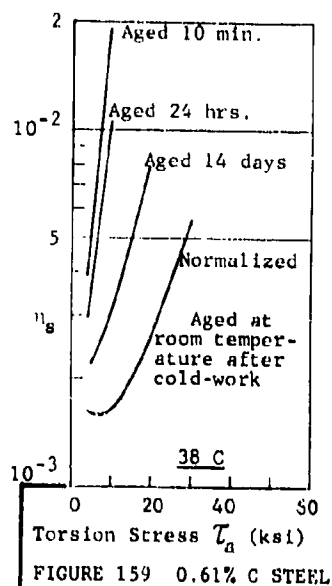
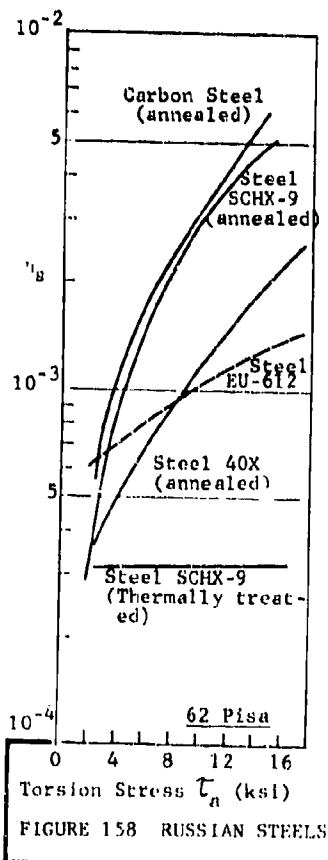
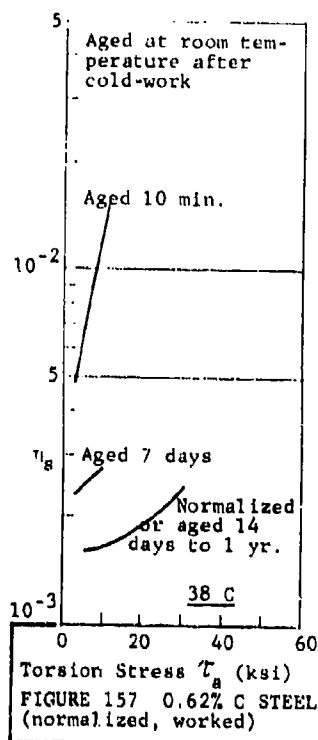


FIGURE 149 STEEL (normalized)





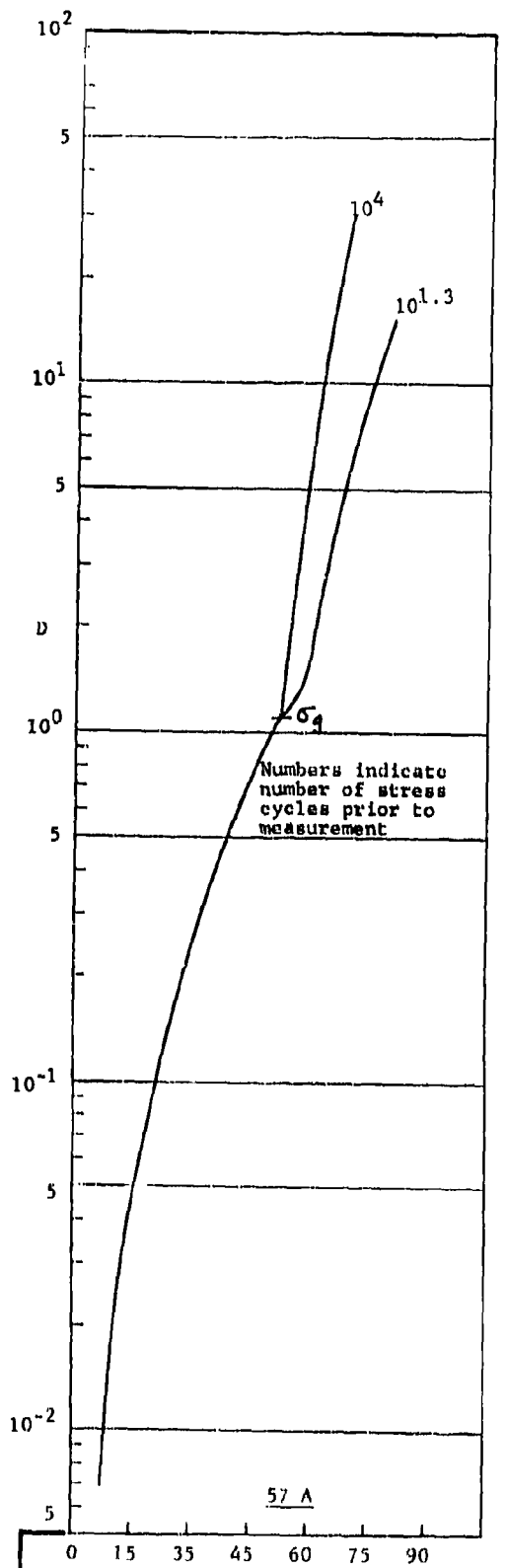


FIGURE 165 SANDVIK STEEL (normalized)

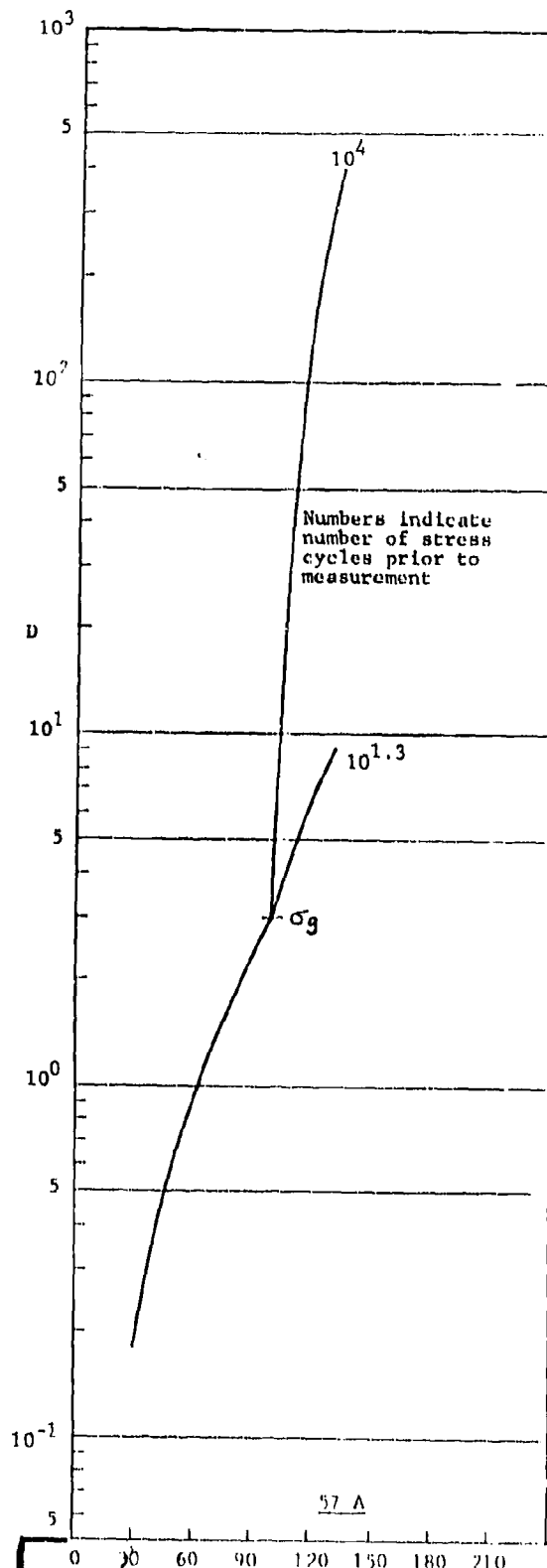
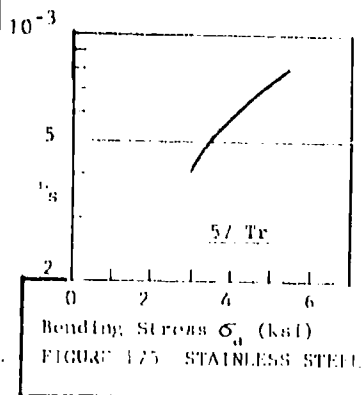
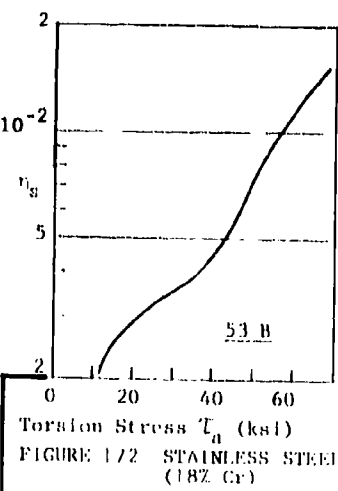
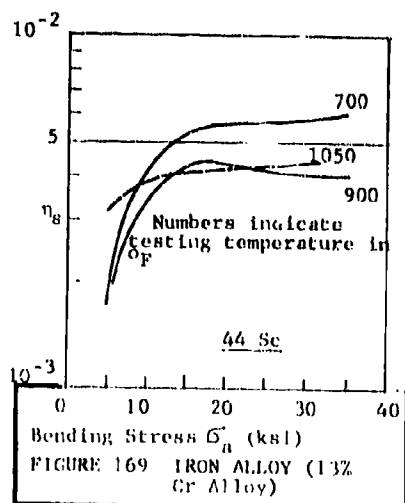
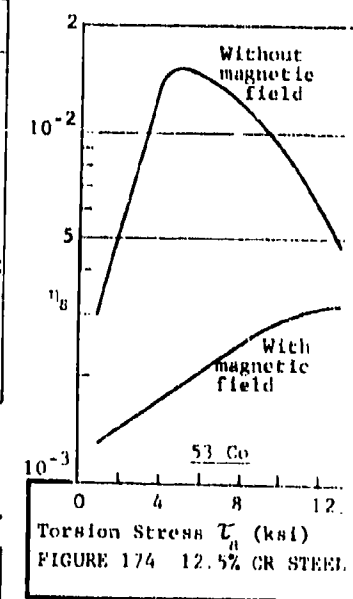
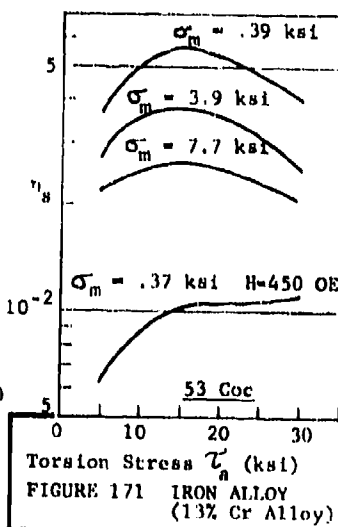
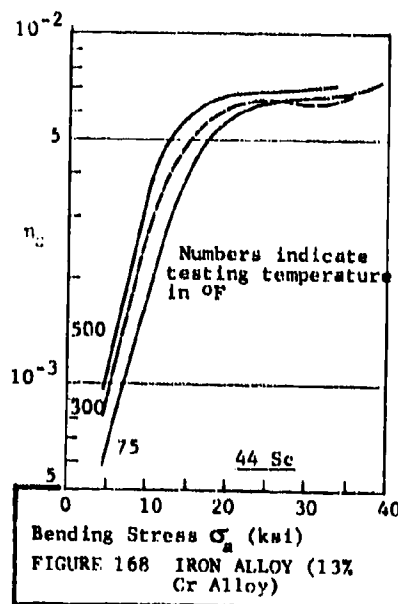
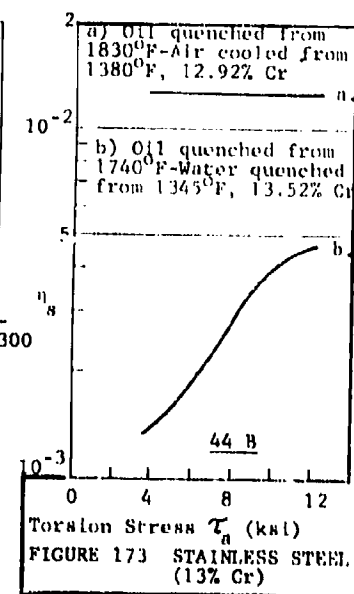
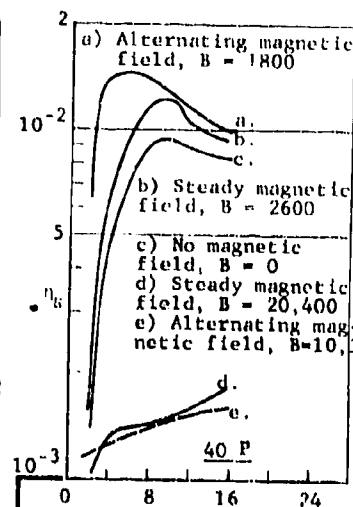
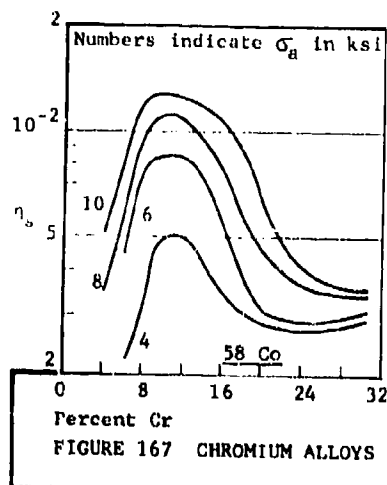
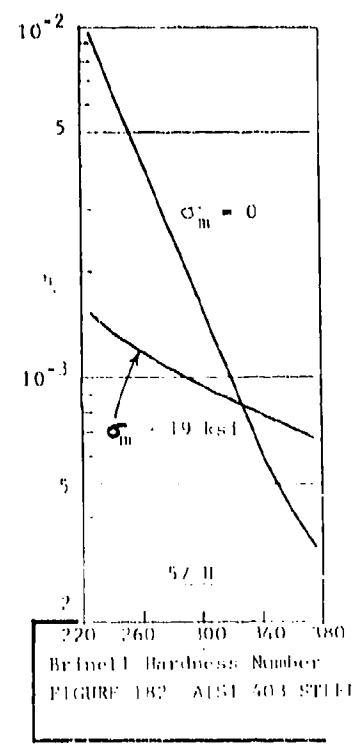
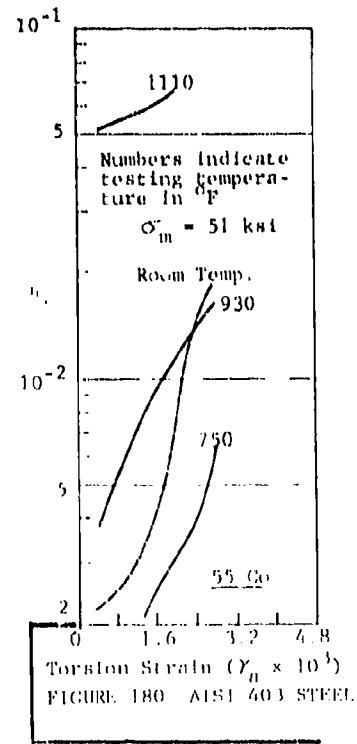
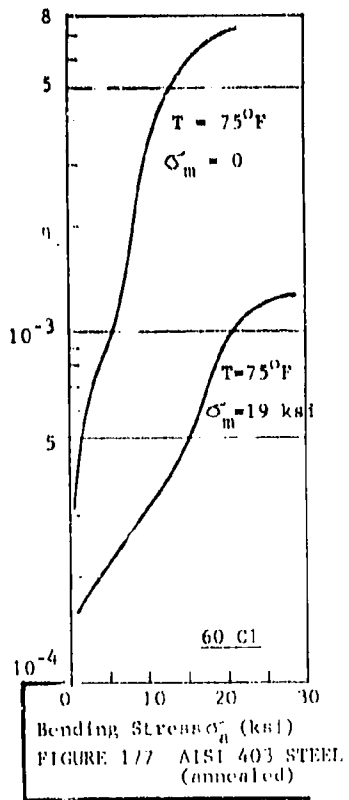
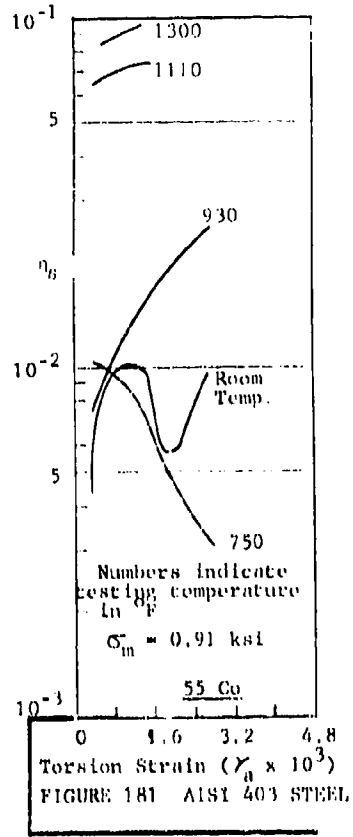
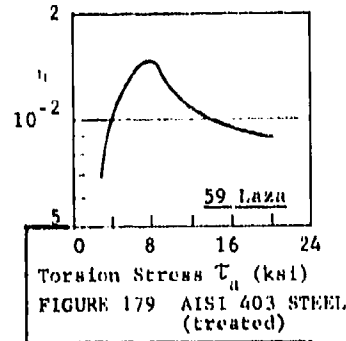
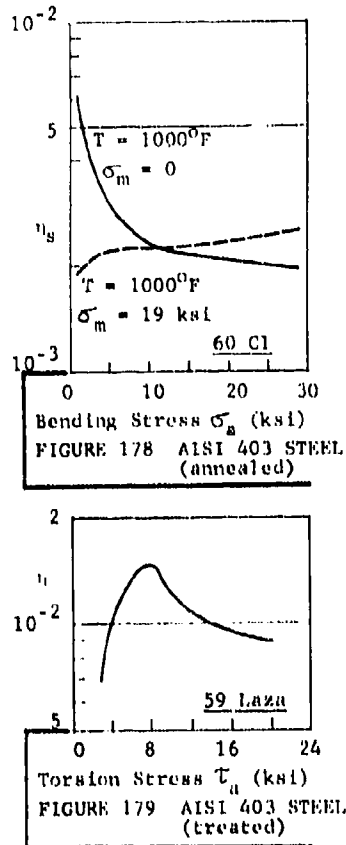
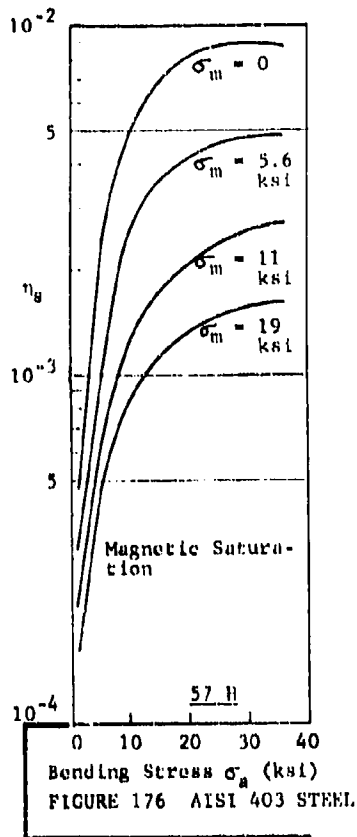


FIGURE 166 SANDVIK STEEL (quenched, tempered)





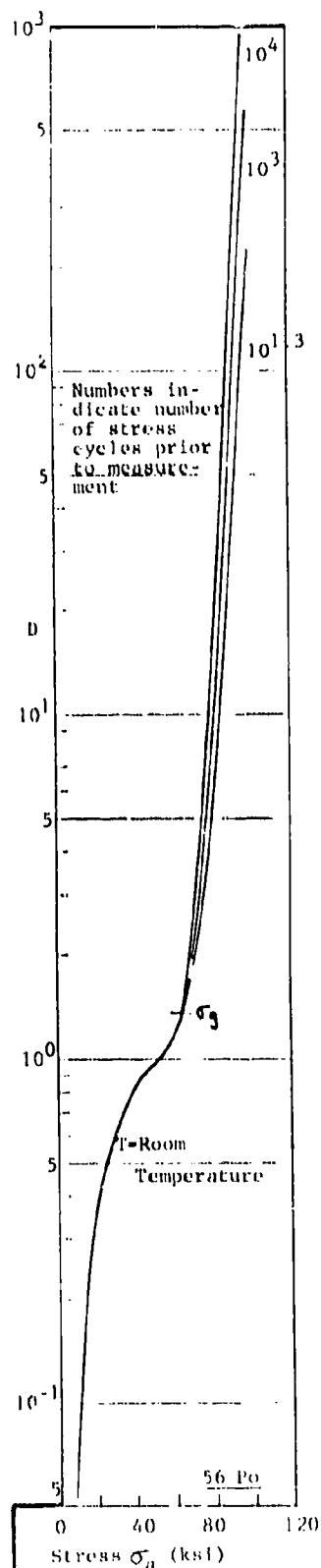


FIGURE 183 AISI 403 STEEL (hot rolled, annealed)

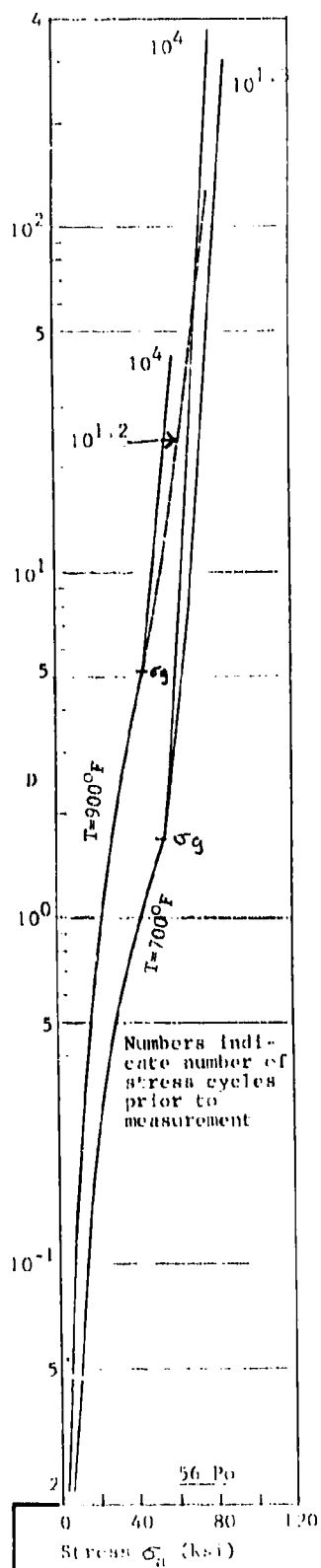


FIGURE 184 AISI 403 STEEL (hot rolled, annealed)

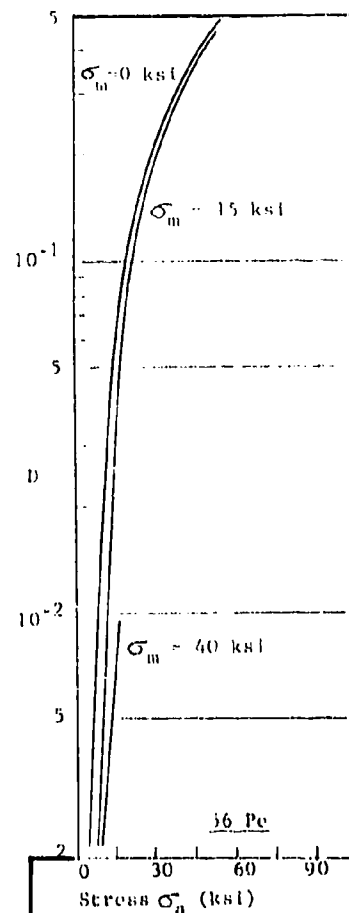


FIGURE 185 AISI 403 STEEL (hot rolled, annealed)

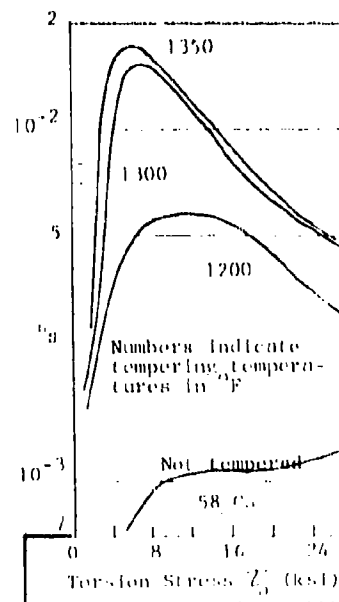
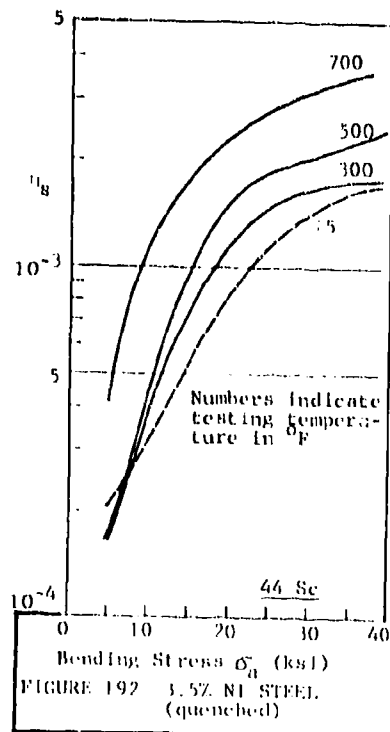
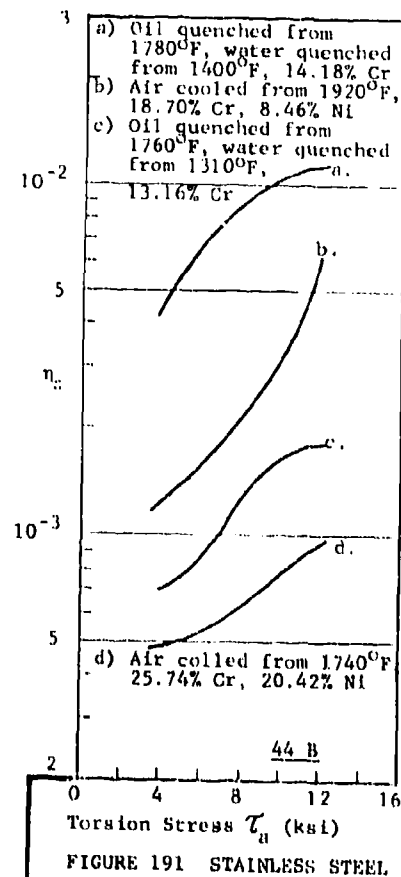
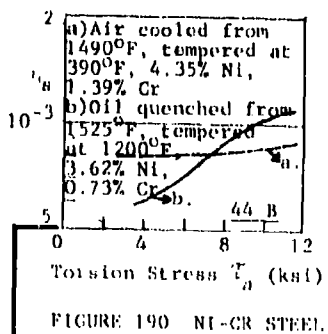
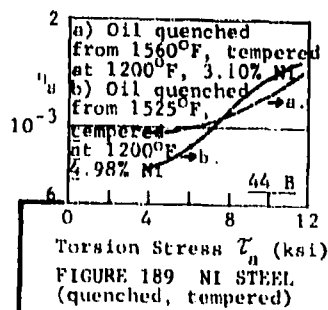
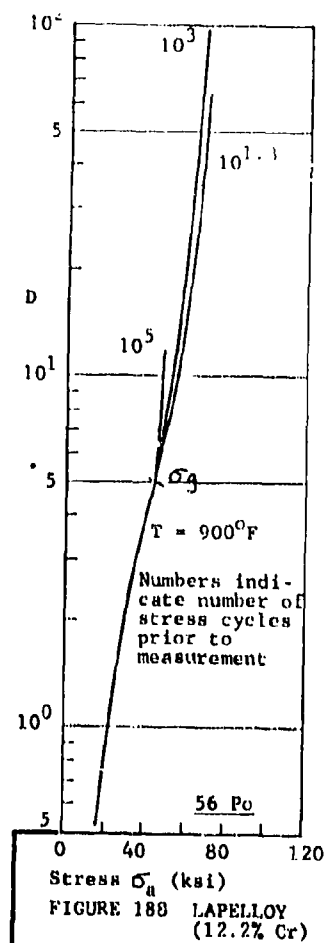
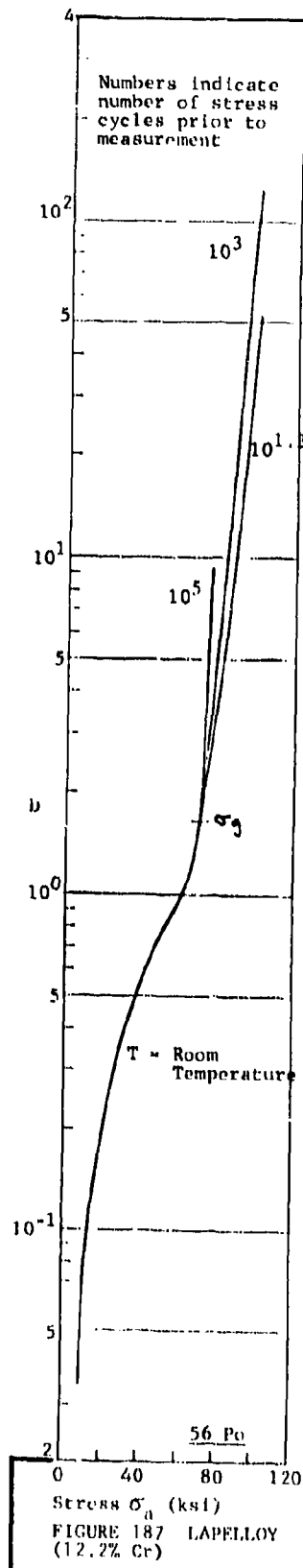
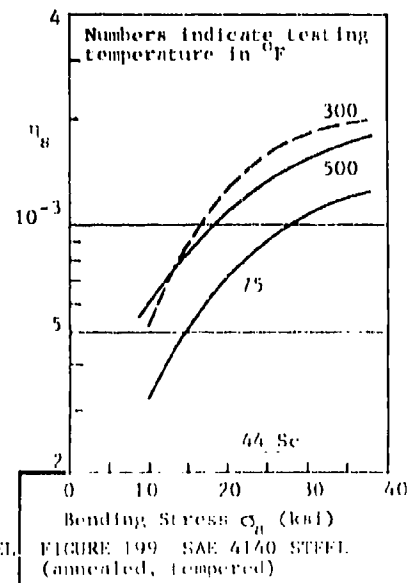
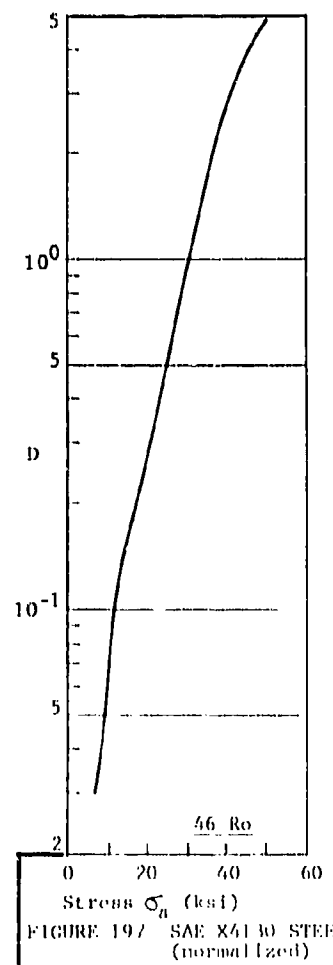
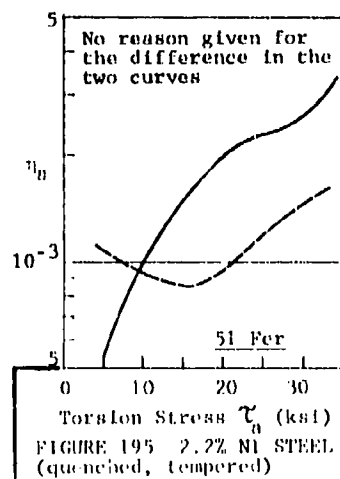
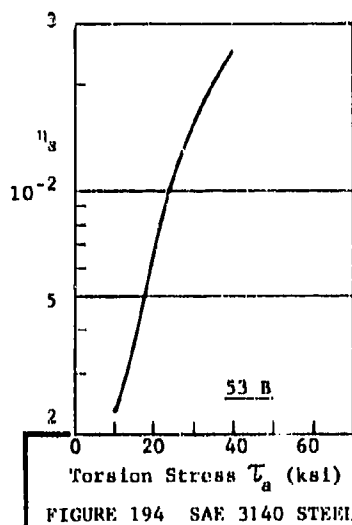
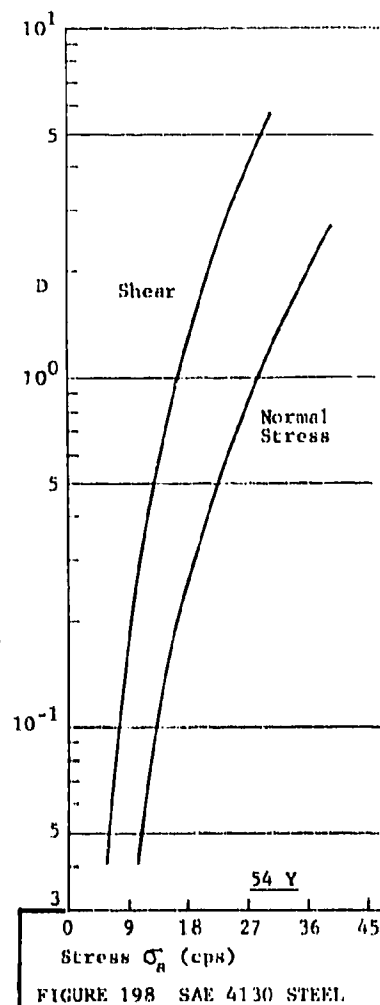
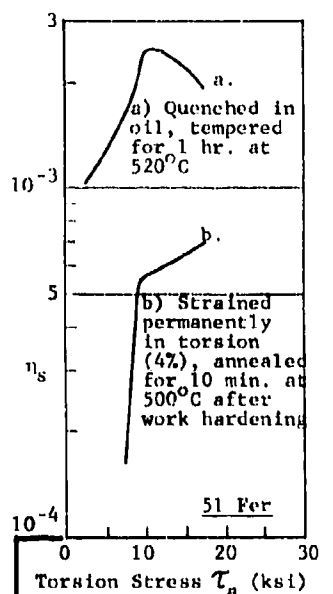
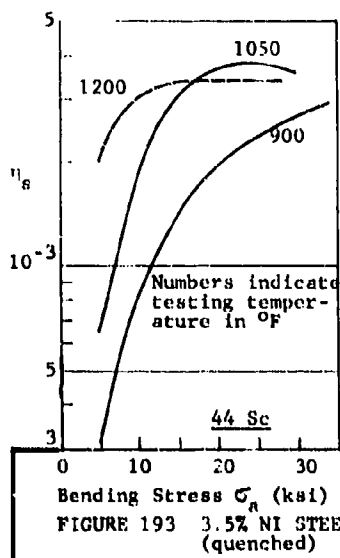
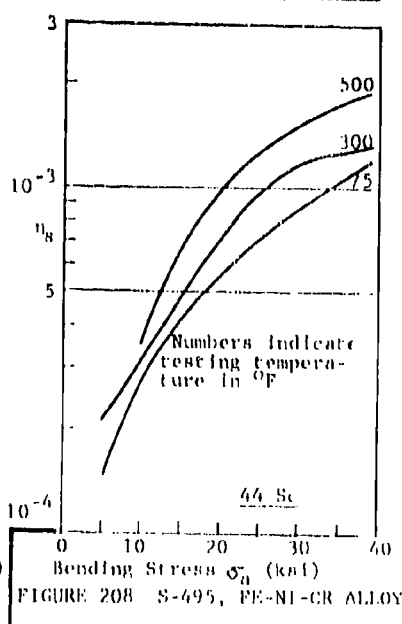
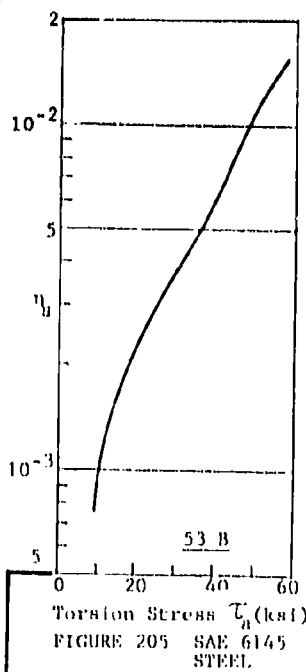
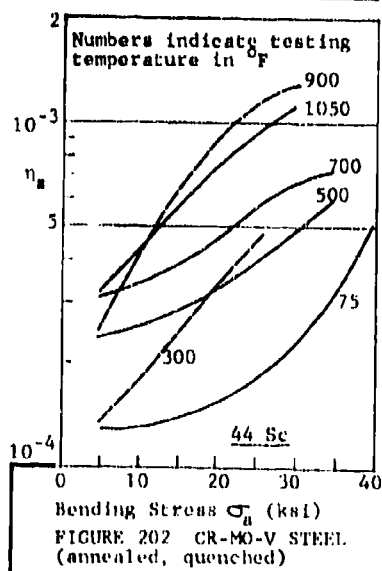
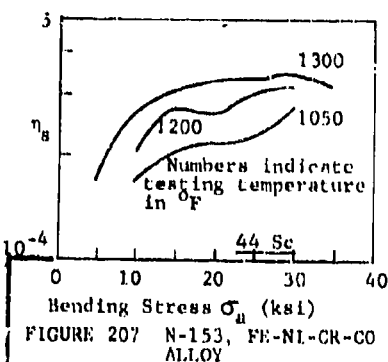
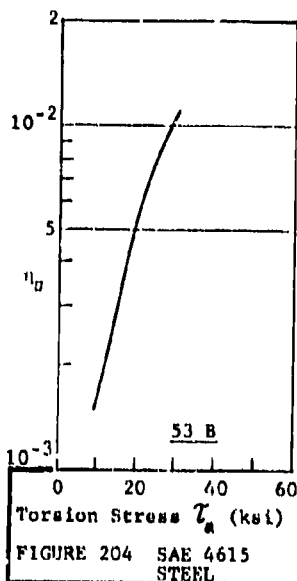
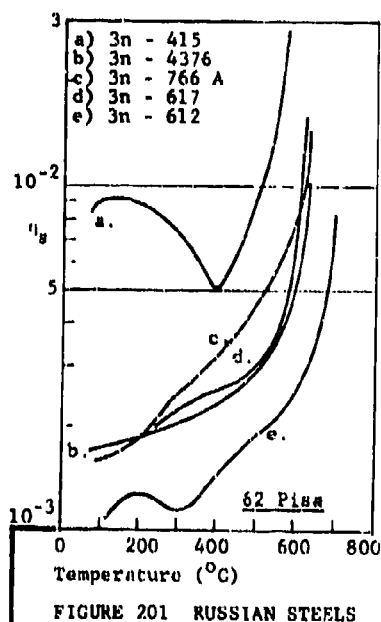
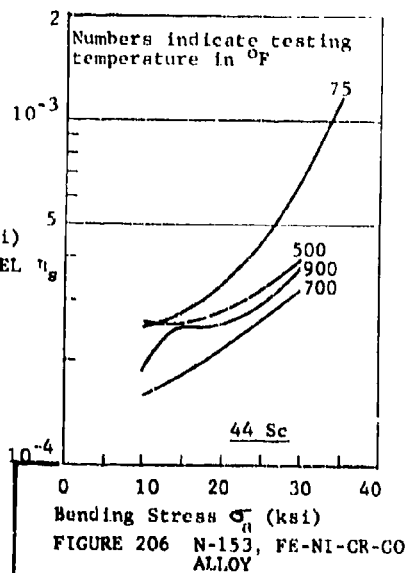
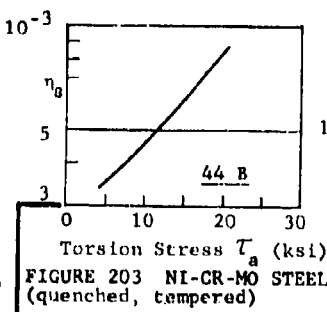
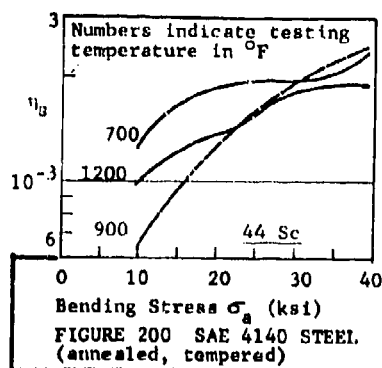
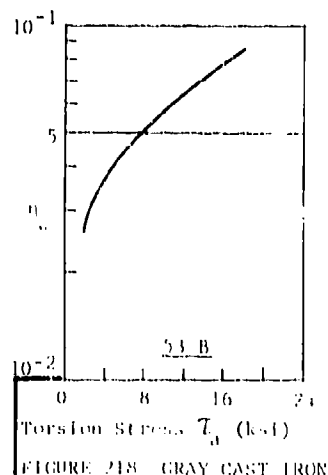
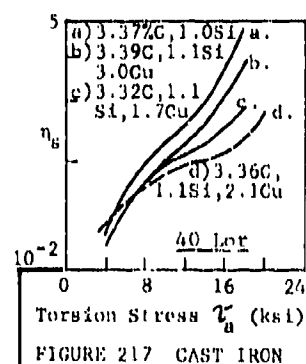
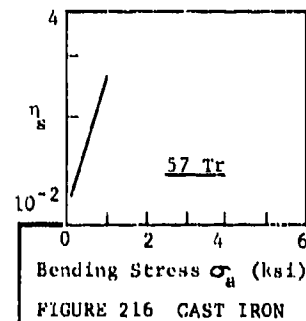
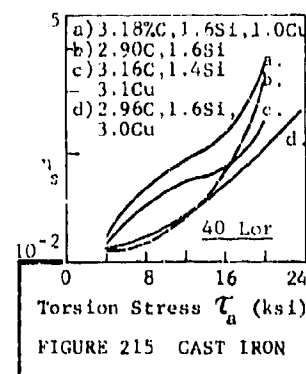
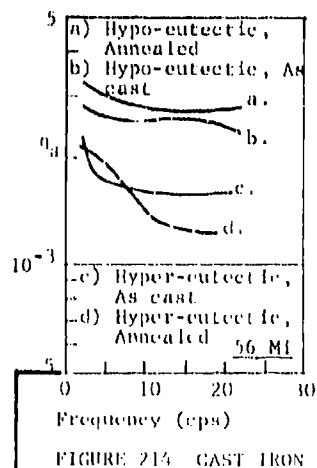
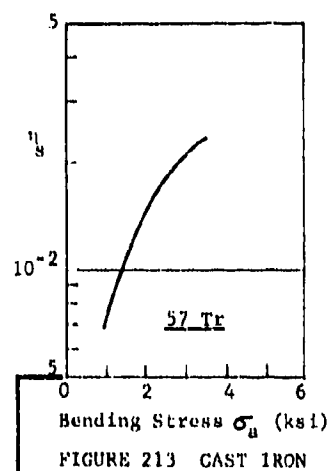
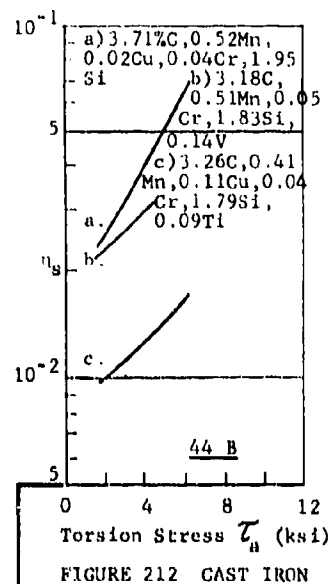
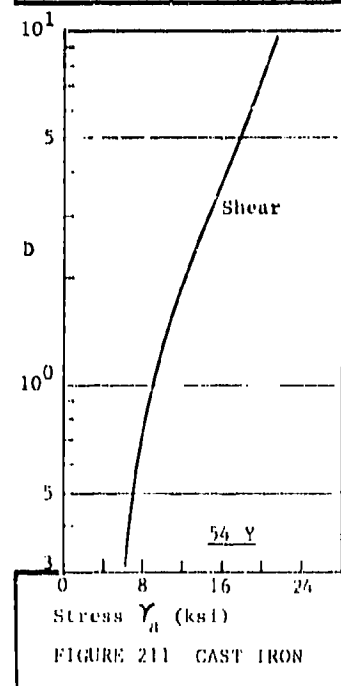
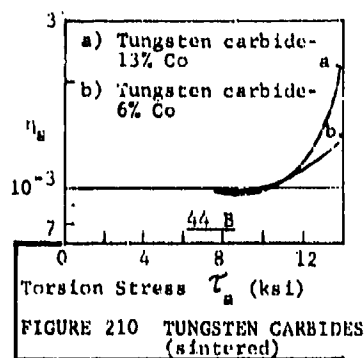
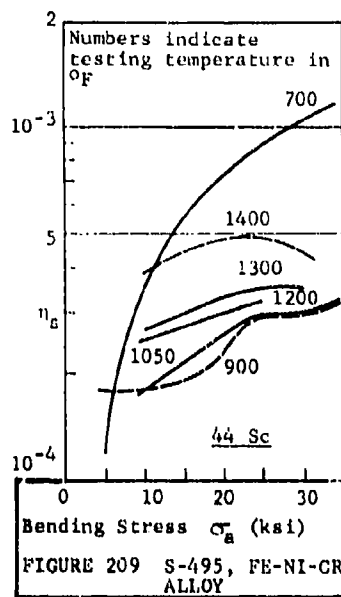


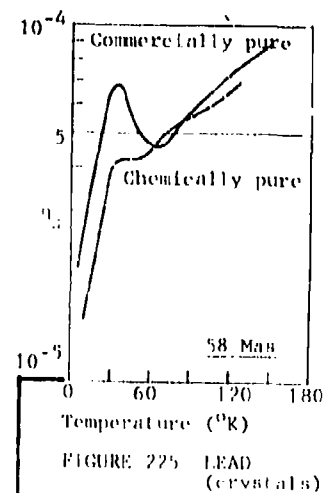
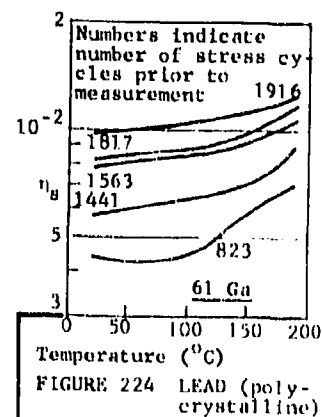
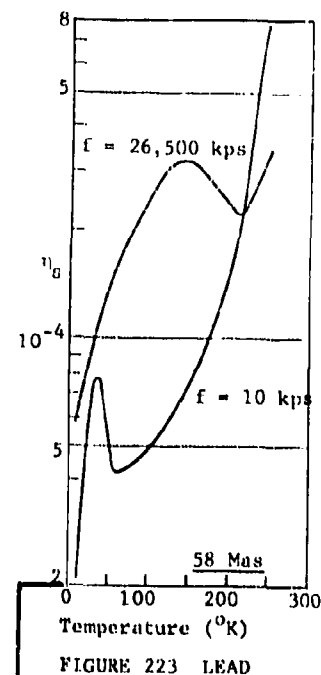
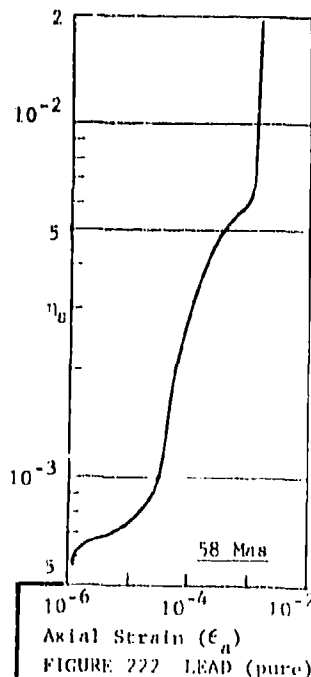
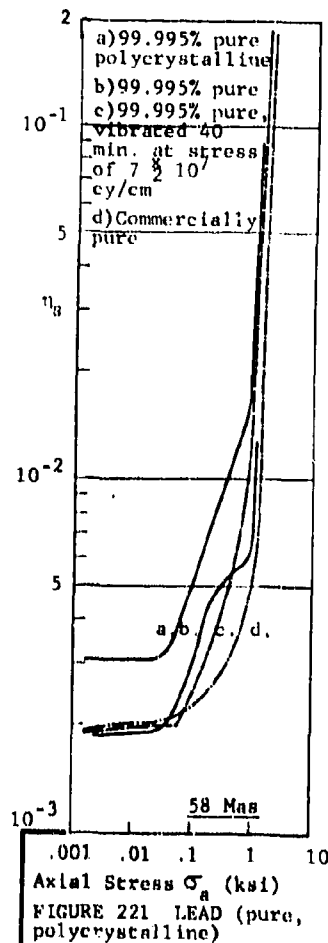
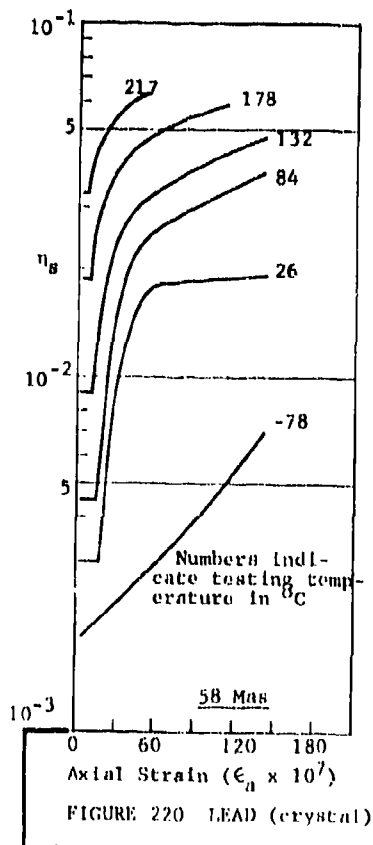
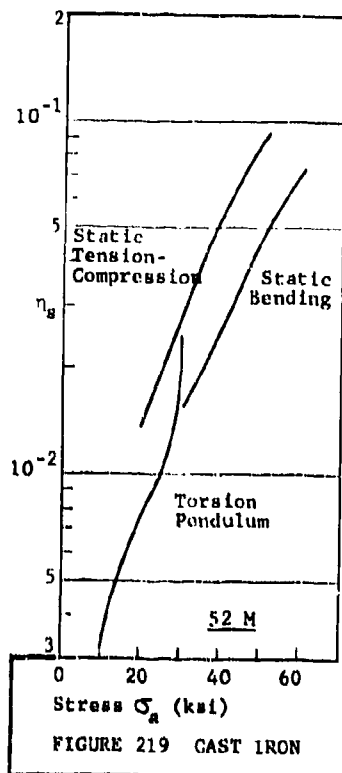
FIGURE 186 AISI 403 STEEL

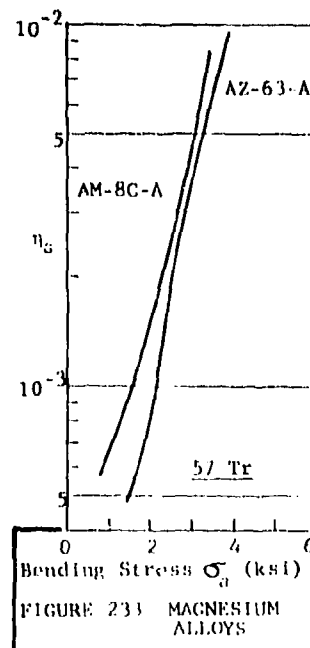
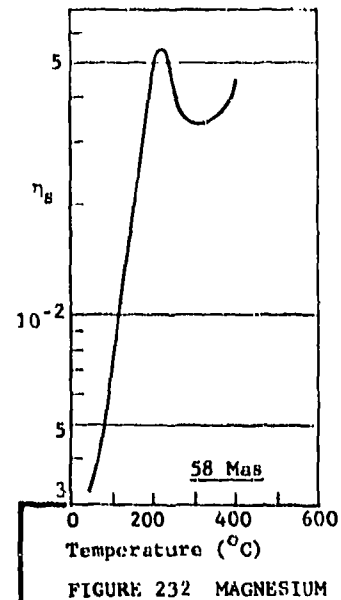
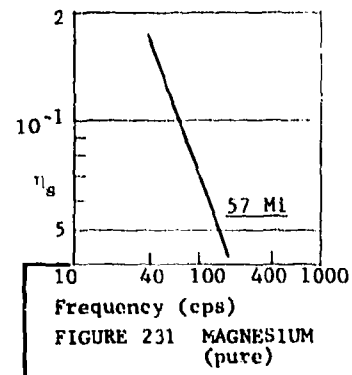
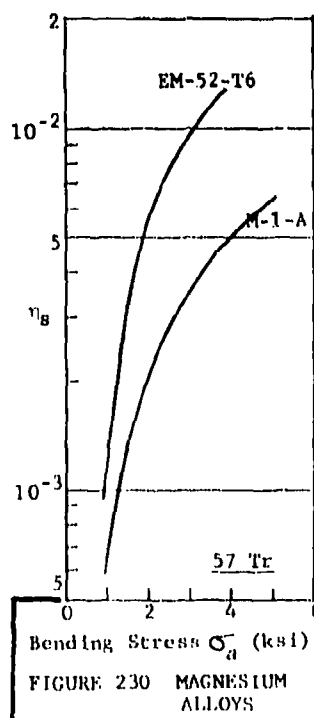
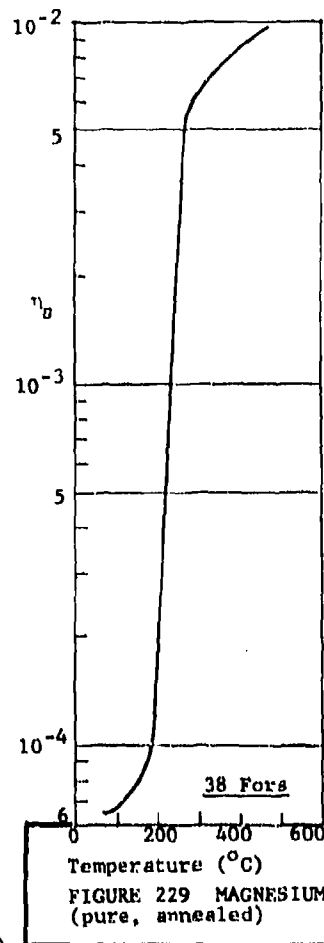
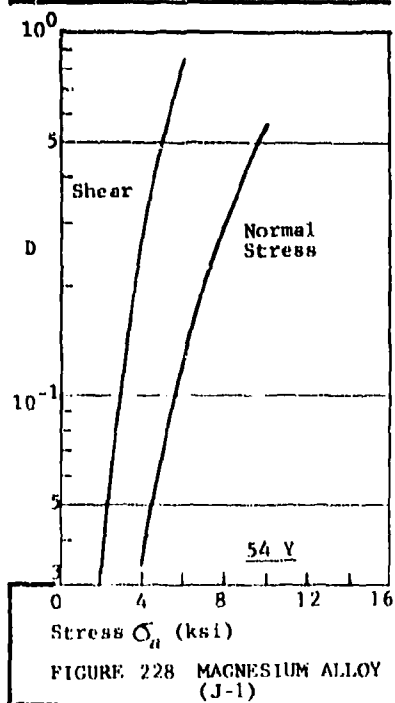
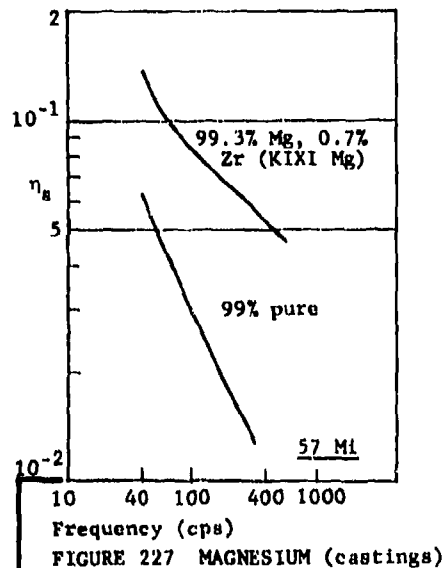
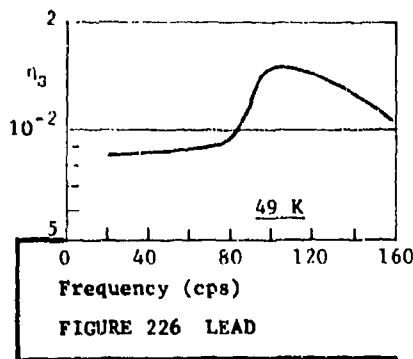


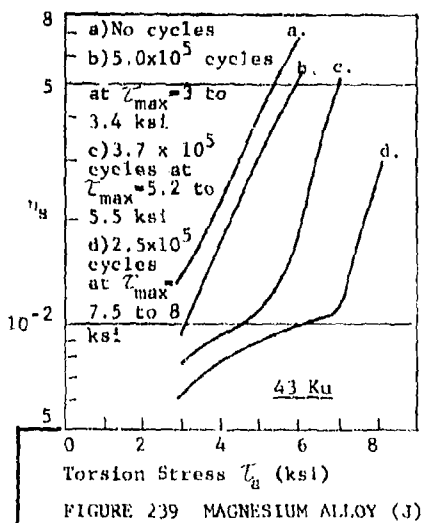
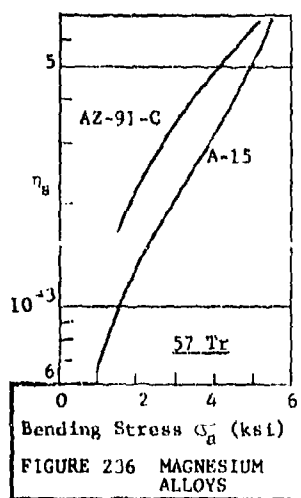
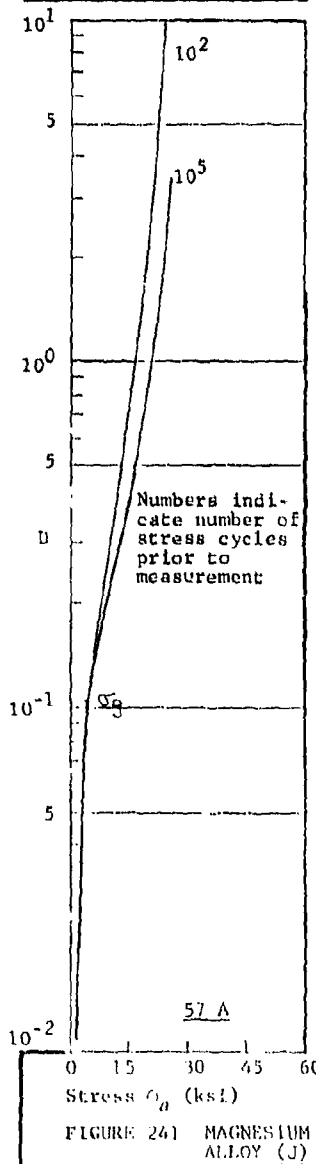
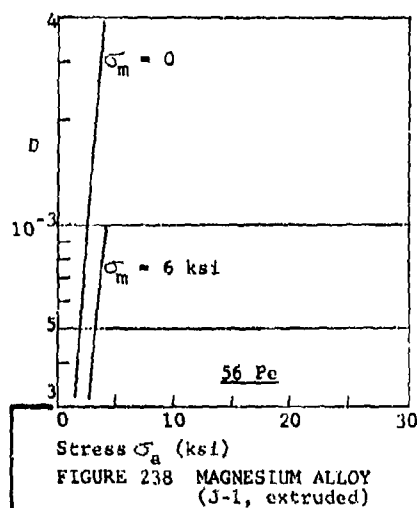
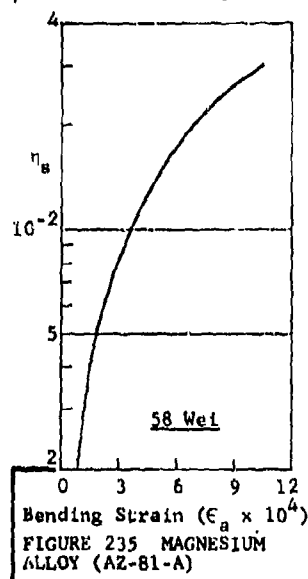
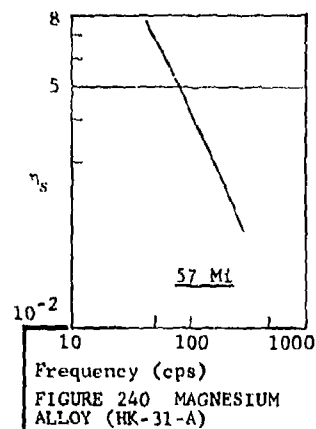
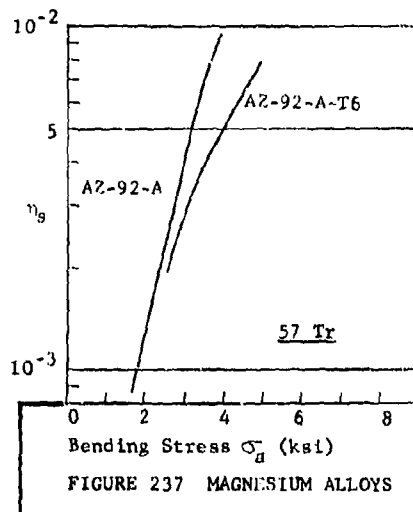
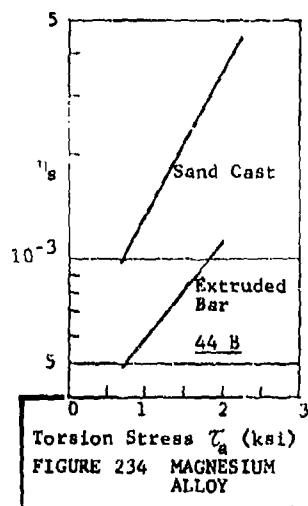












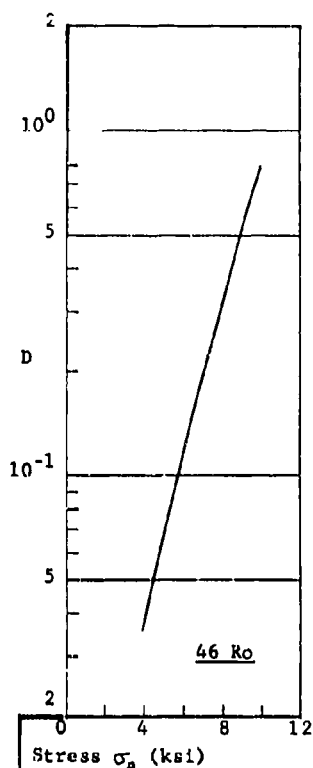


FIGURE 242 MAGNESIUM ALLOY (J-1, extruded)

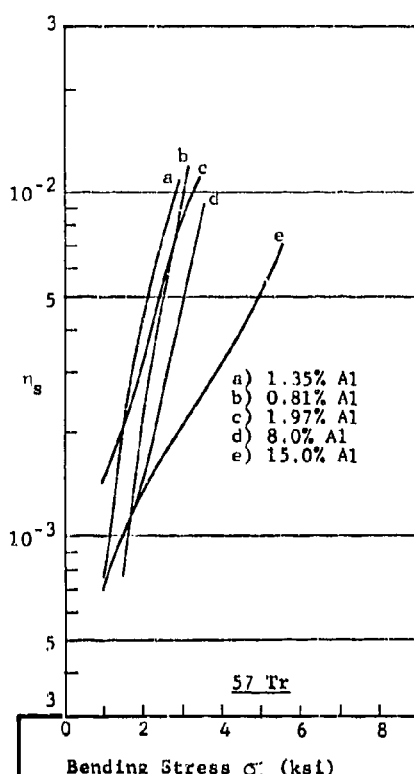


FIGURE 244 MAGNESIUM ALLOYS (Al) 10^{-4}

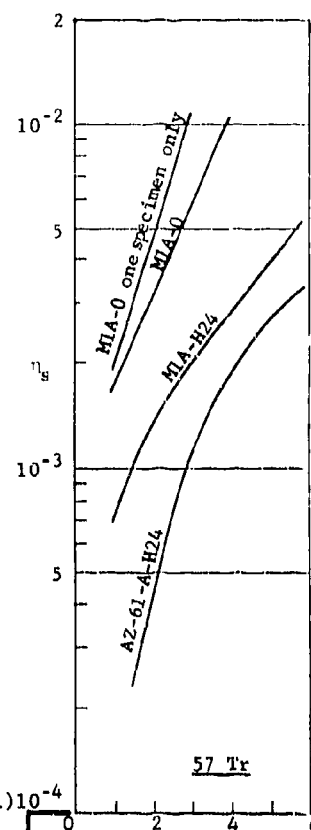


FIGURE 246 MAGNESIUM ALLOYS

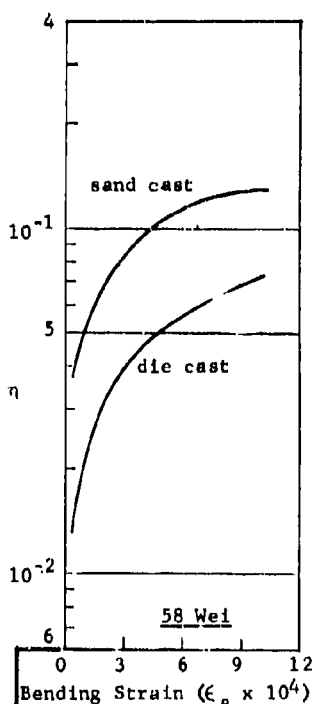


FIGURE 243 MAGNESIUM ALLOY (XIXI)

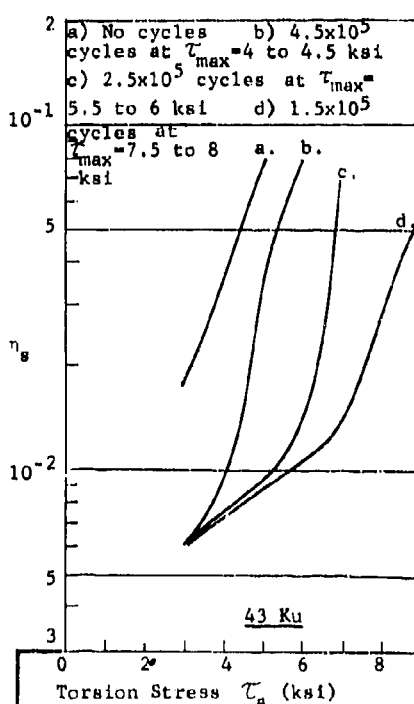


FIGURE 245 MAGNESIUM ALLOY (O)

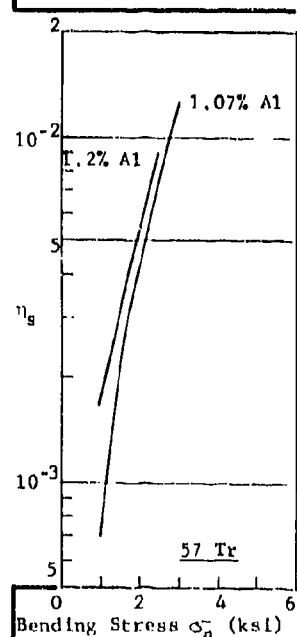


FIGURE 247 MAGNESIUM ALLOYS (Al)

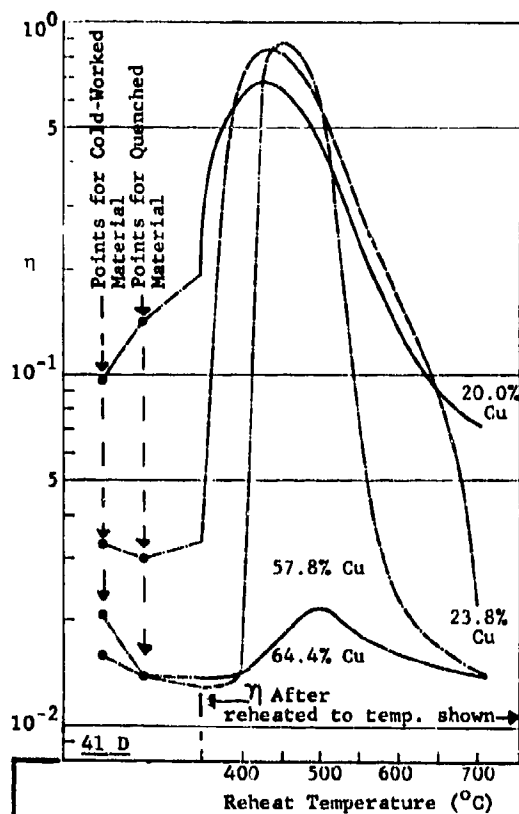


FIGURE 248 MANGANESE ALLOYS (Cu, worked)

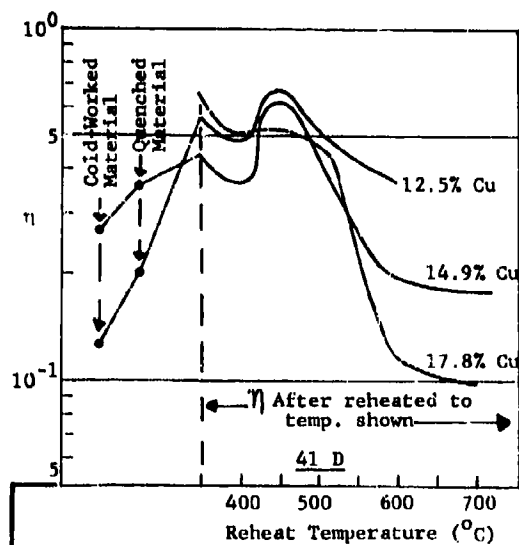


FIGURE 249 MANGANESE ALLOYS (Cu, worked)

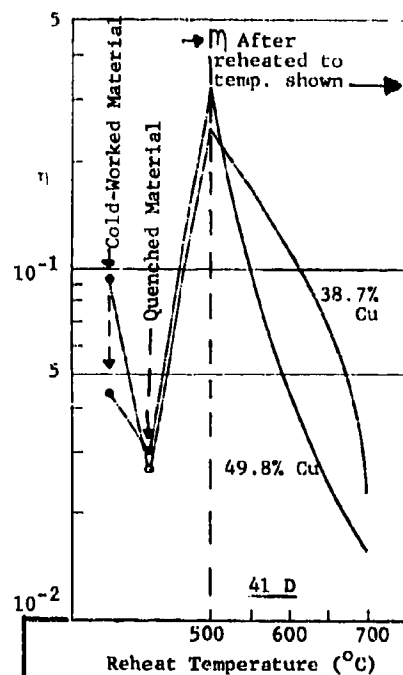


FIGURE 250 MANGANESE ALLOYS (Cu, worked)

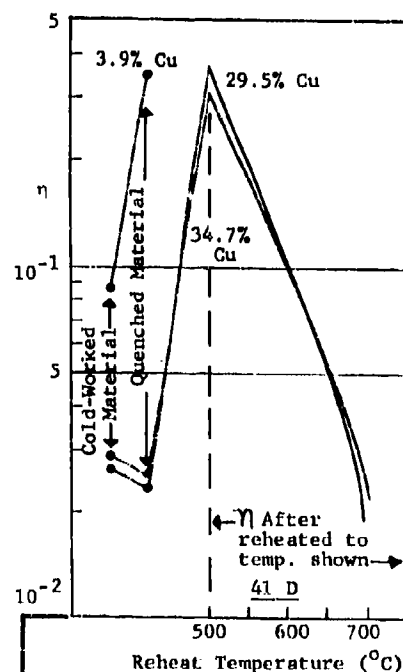


FIGURE 251 MANGANESE ALLOYS (Cu, worked)

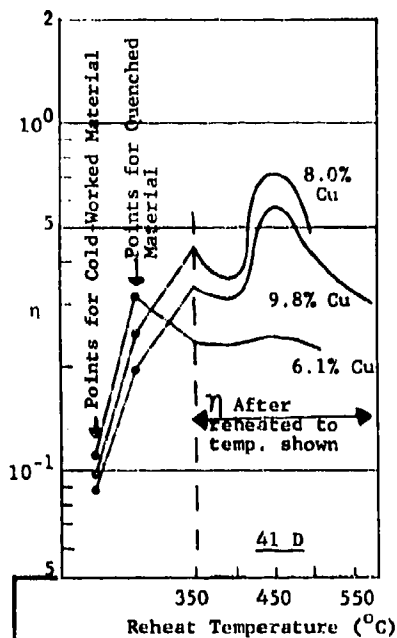


FIGURE 252 MANGANESE ALLOYS (Cu, worked)

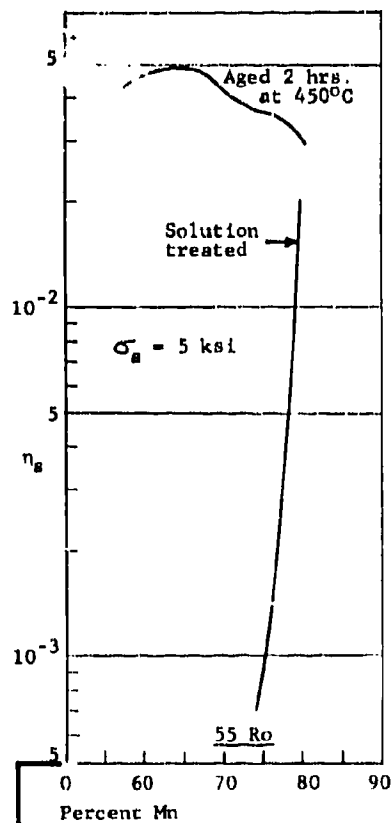


FIGURE 253 MANGANESE ALLOYS (Cu)

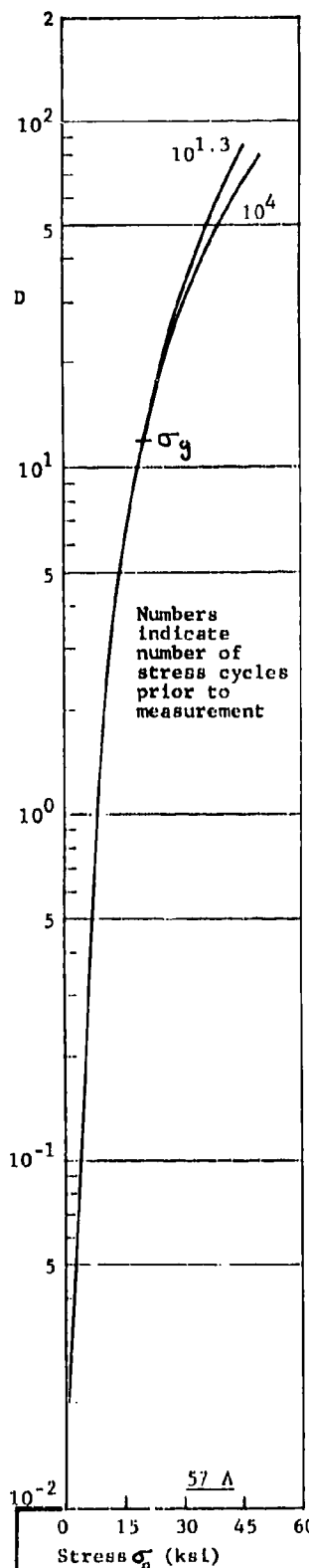


FIGURE 254 MANGANESE ALLOY (33% Cu, treated)

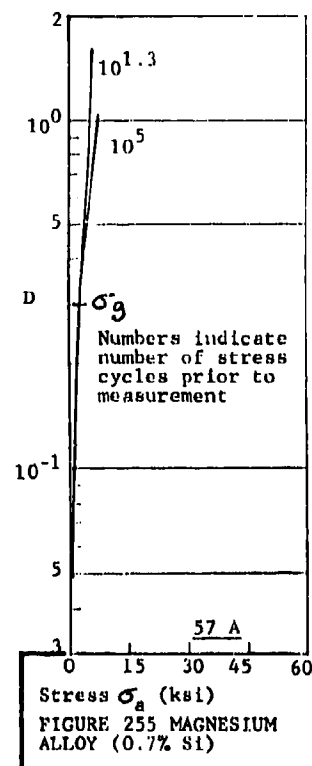


FIGURE 255 MAGNESIUM ALLOY (0.7% Si)

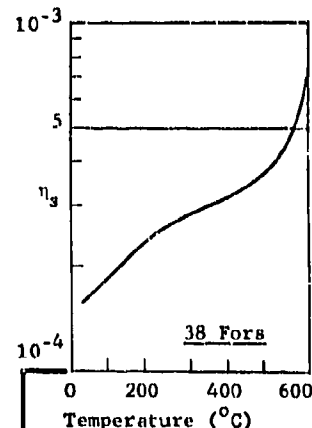


FIGURE 256 MOLYBDENUM (sintered, annealed)

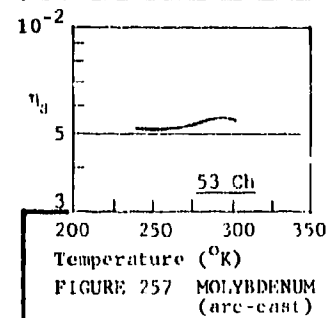
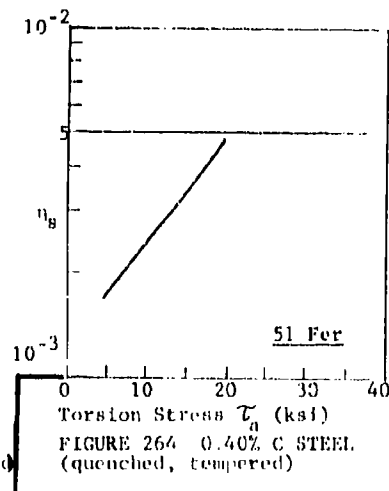
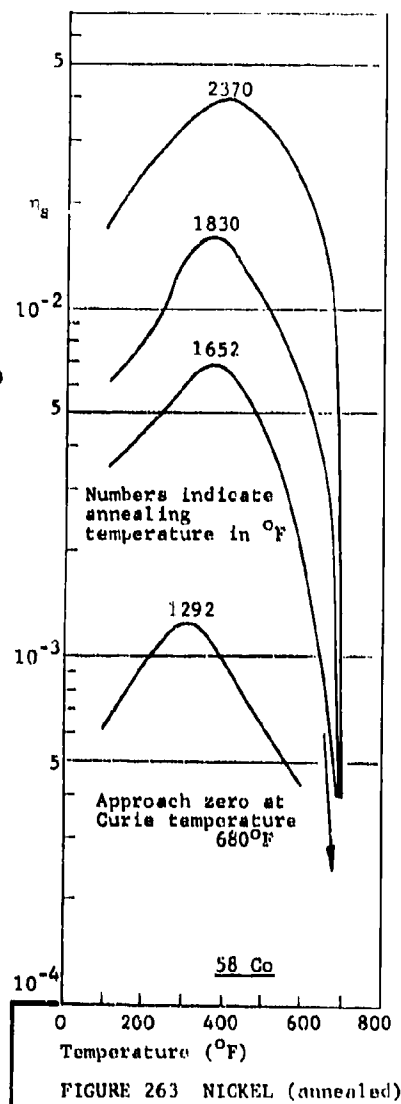
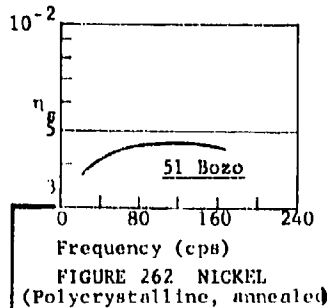
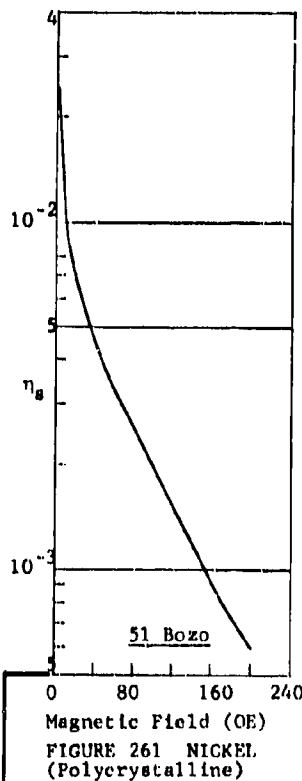
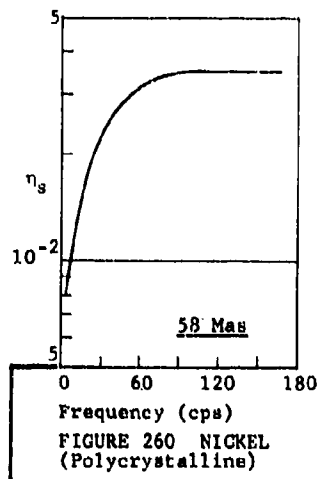
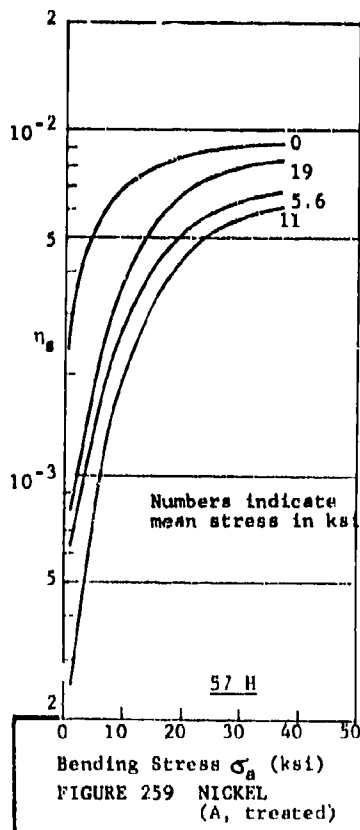
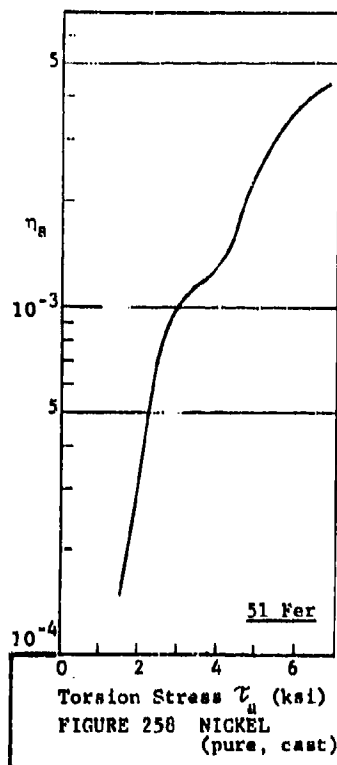
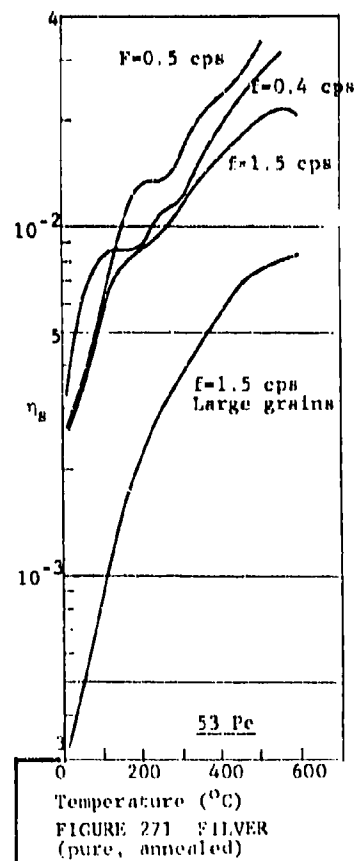
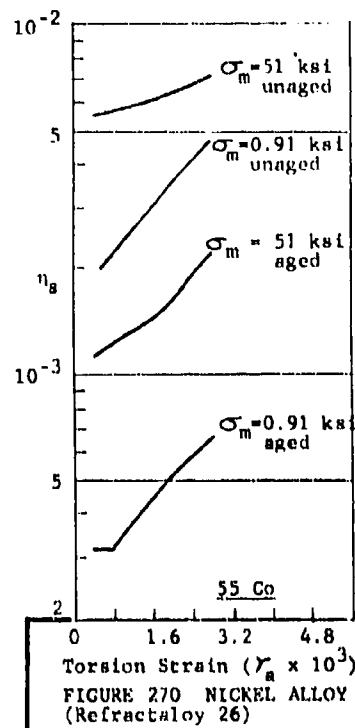
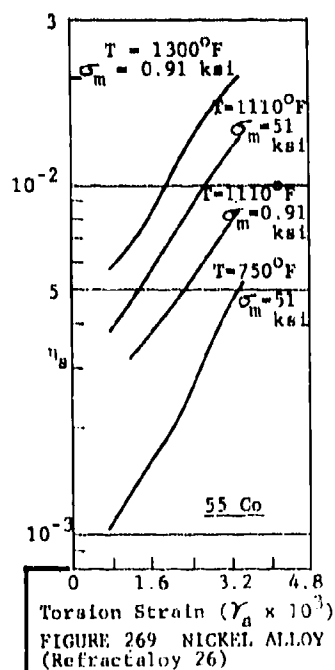
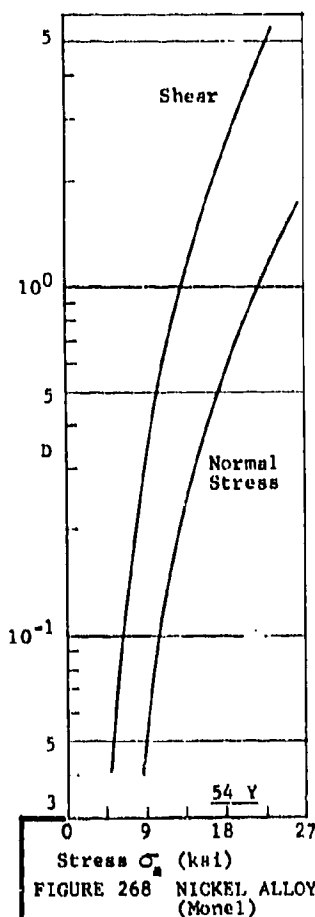
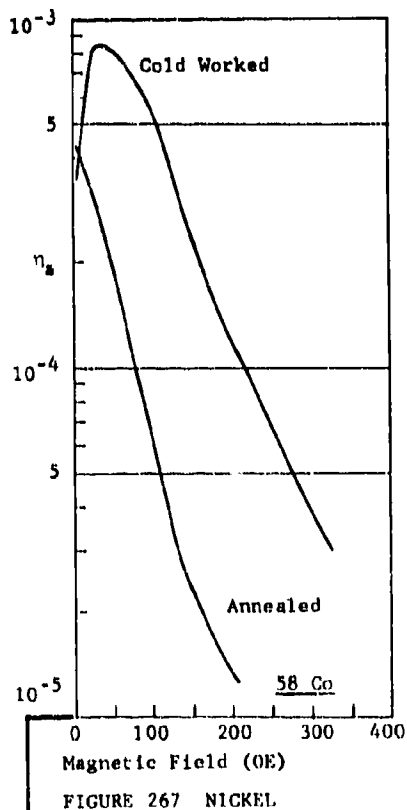
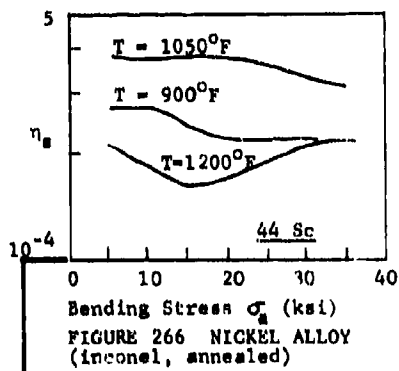
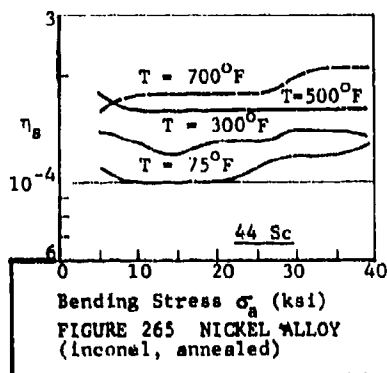
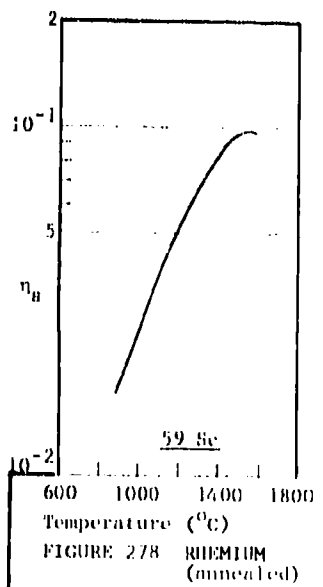
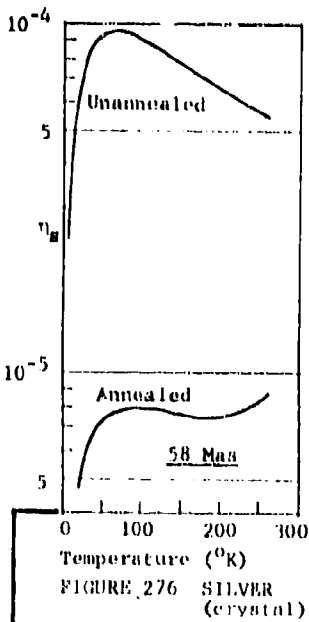
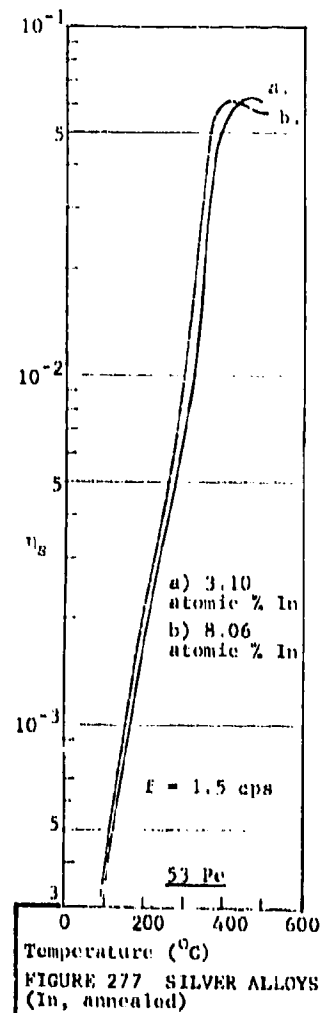
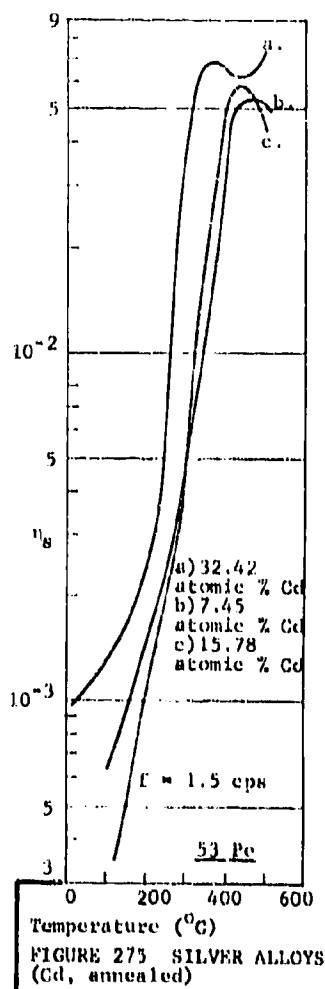
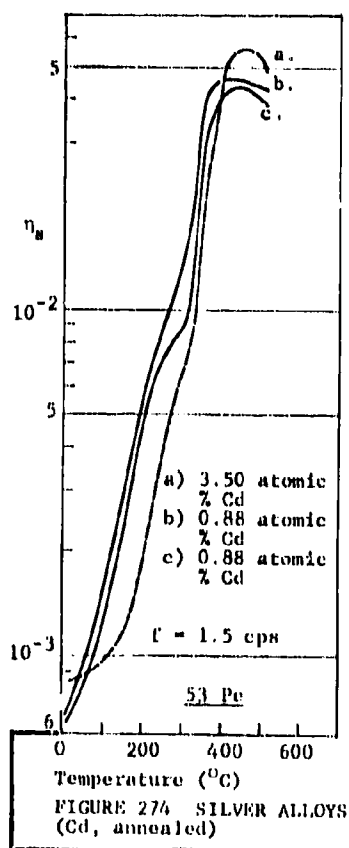
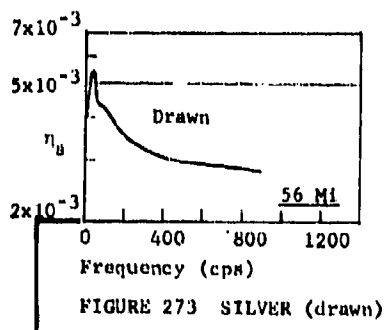
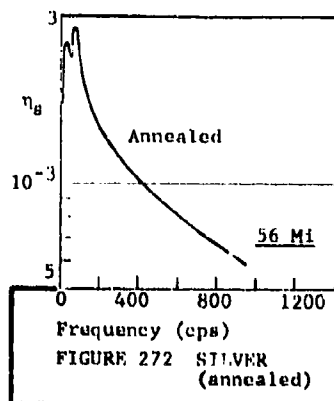
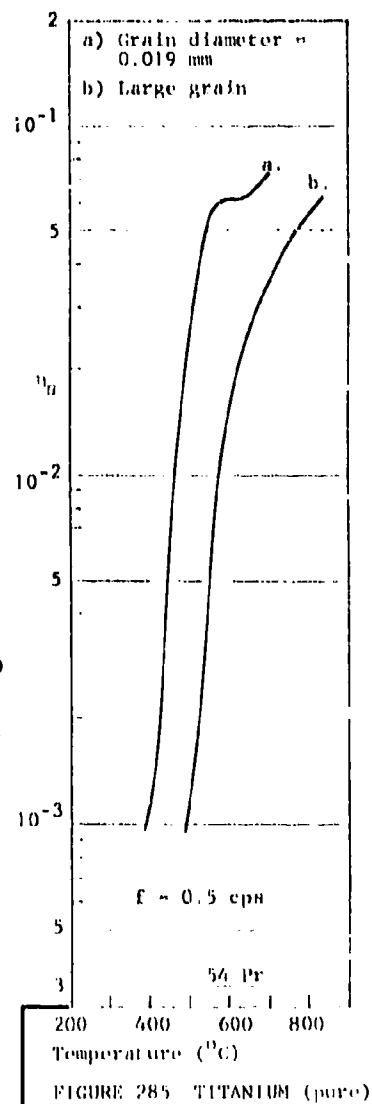
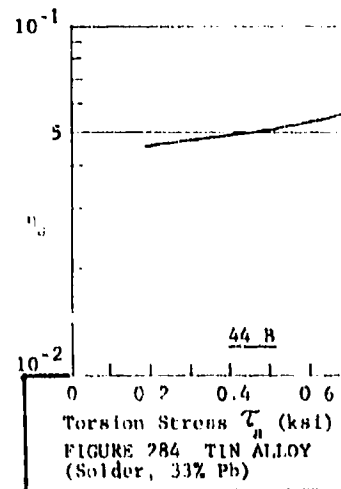
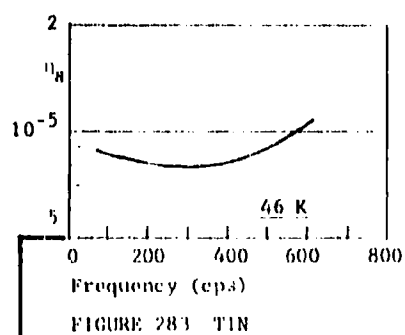
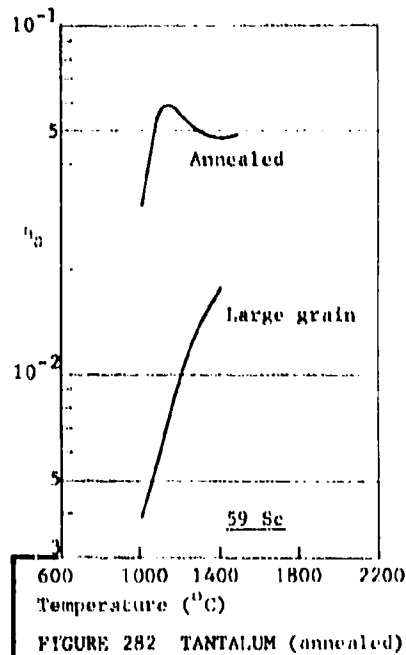
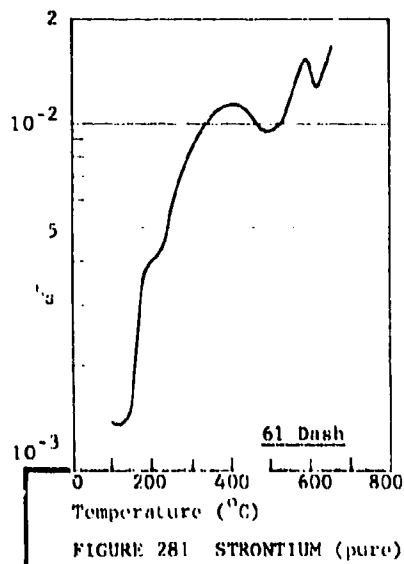
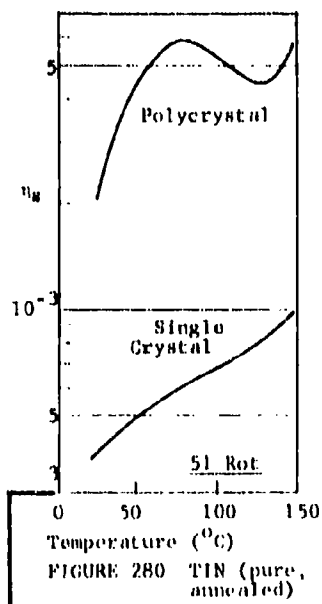
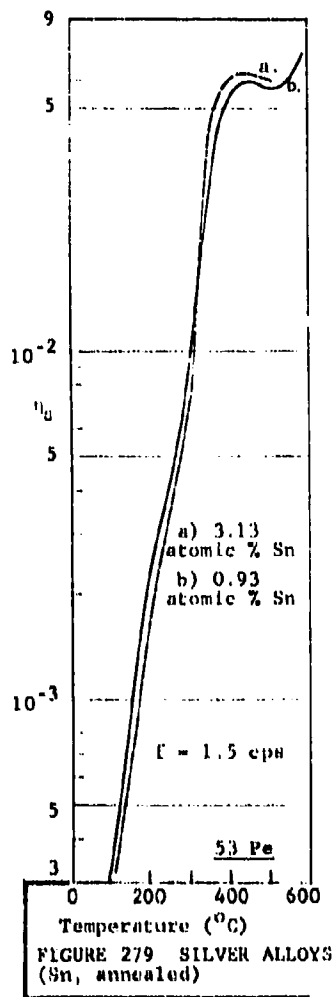


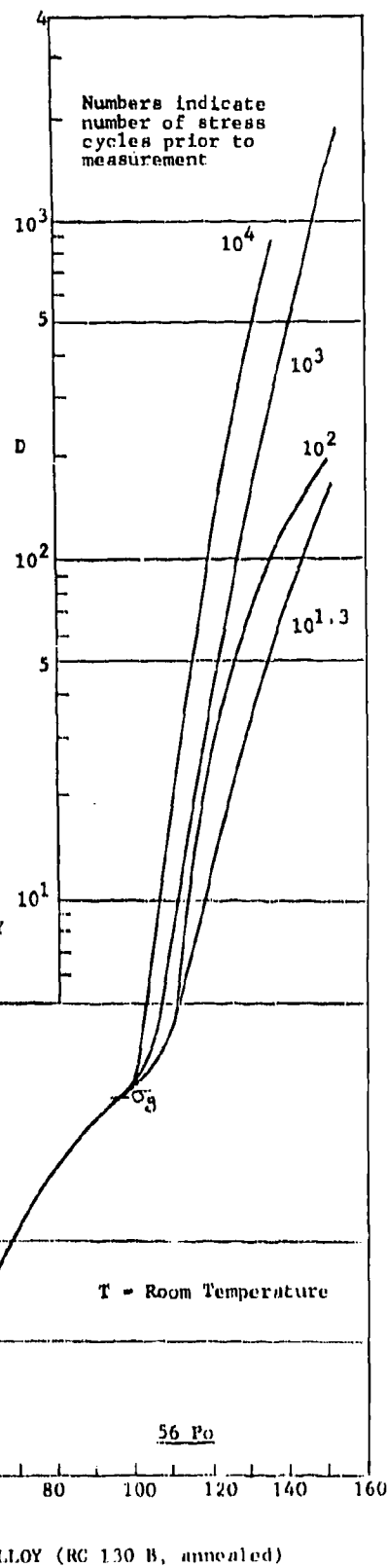
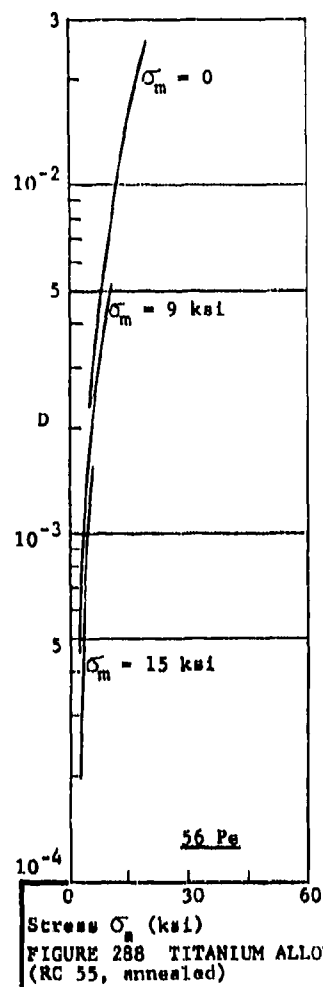
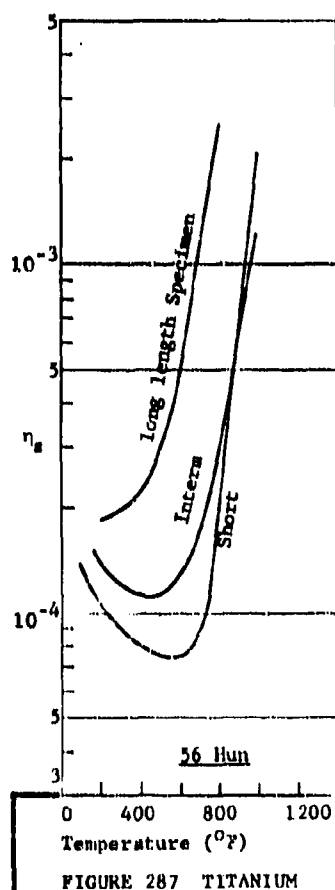
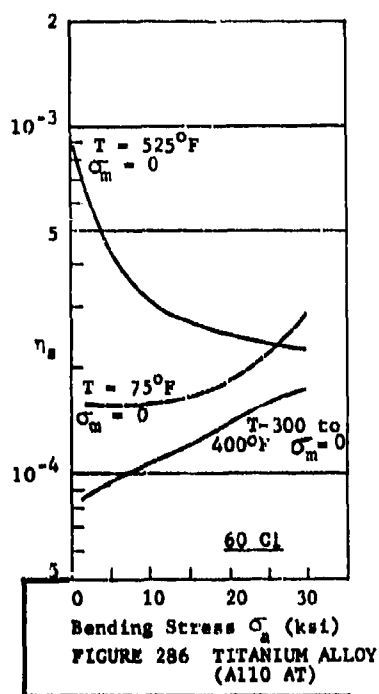
FIGURE 257 MOLYBDENUM (arc-cast)











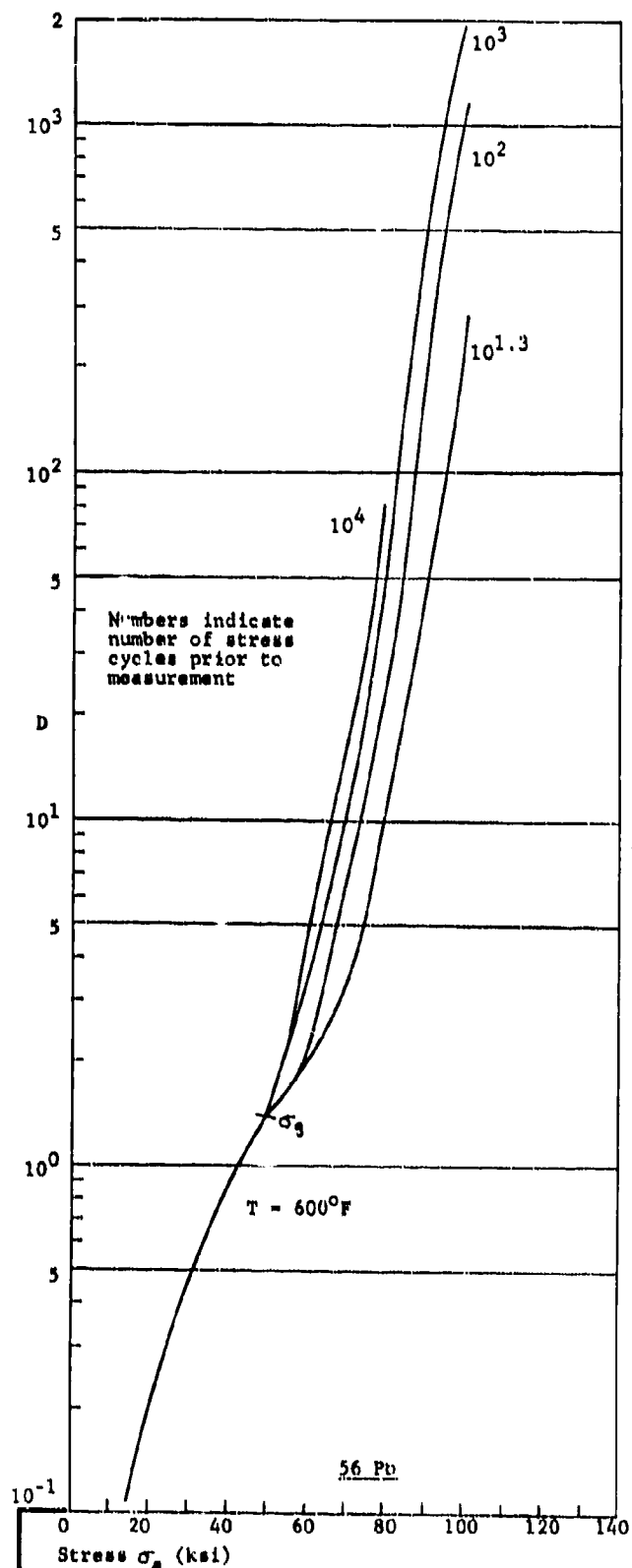


FIGURE 290 TITANIUM ALLOY (RC 130 B, annealed)

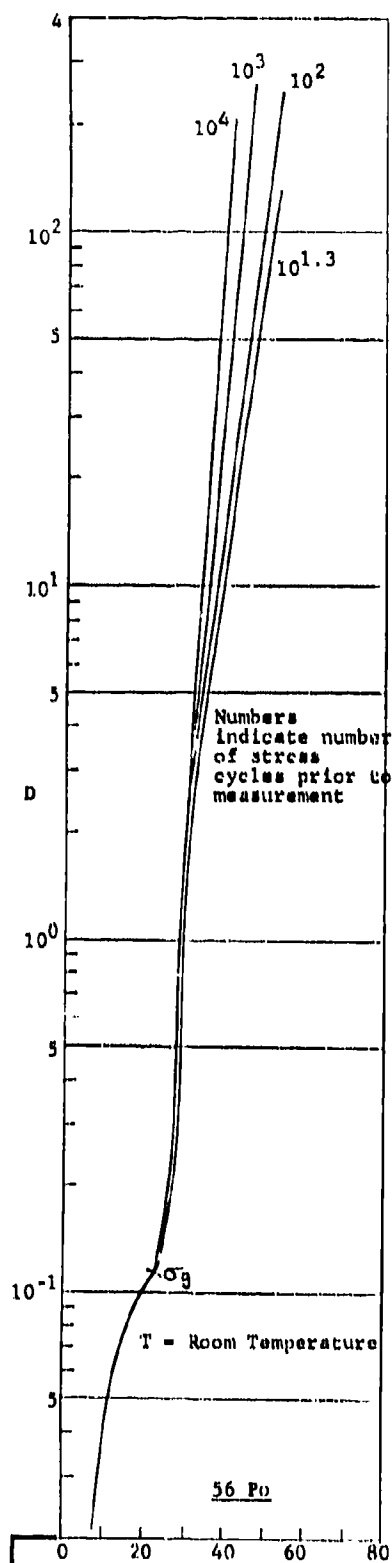
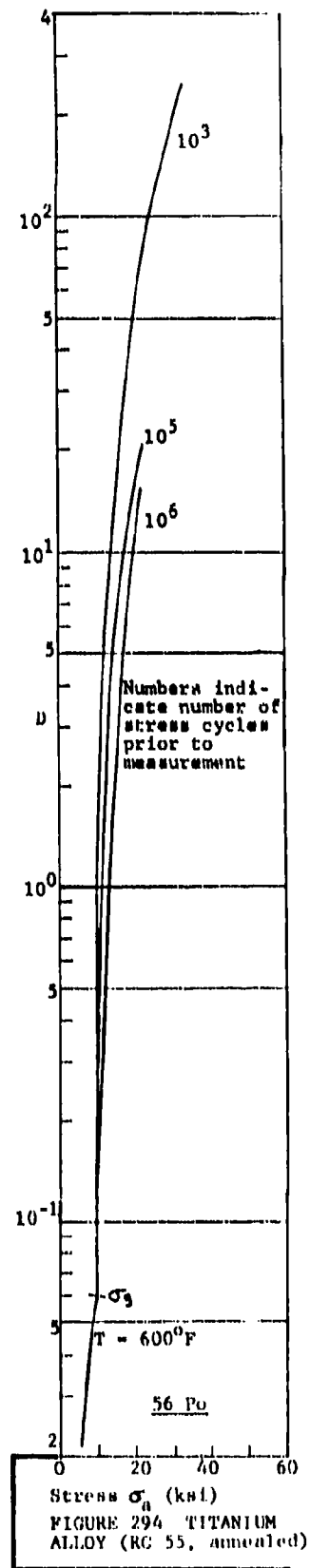
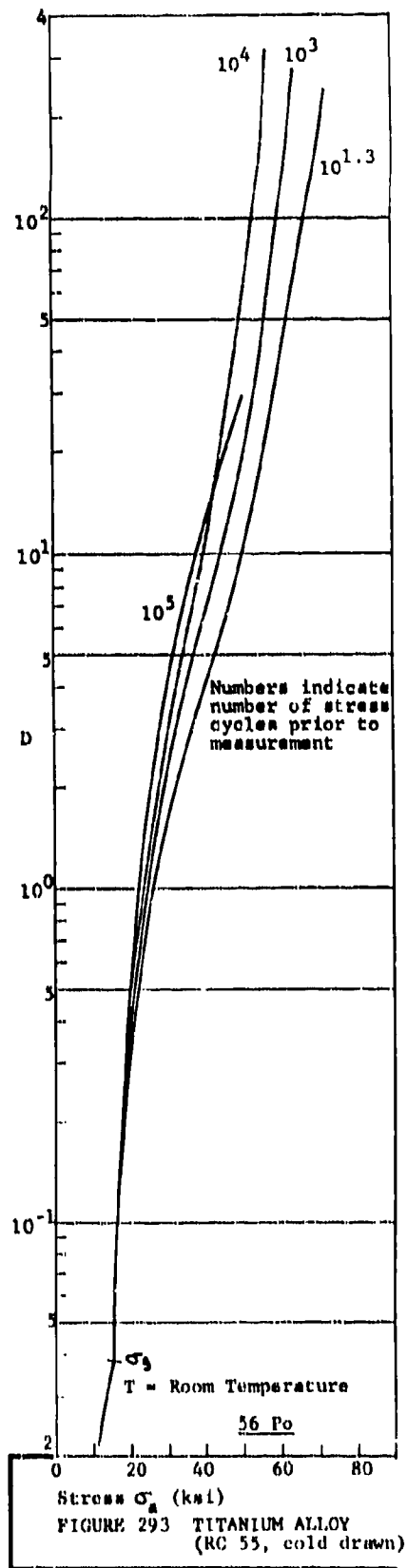
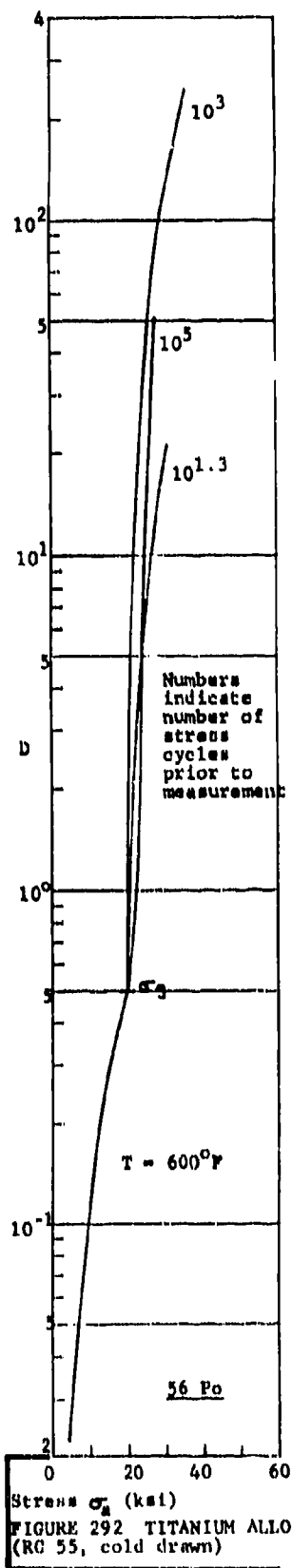
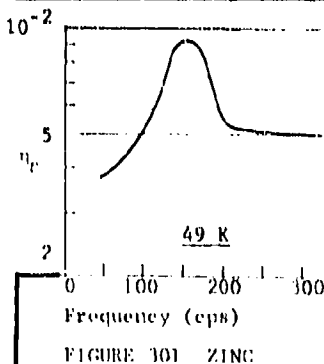
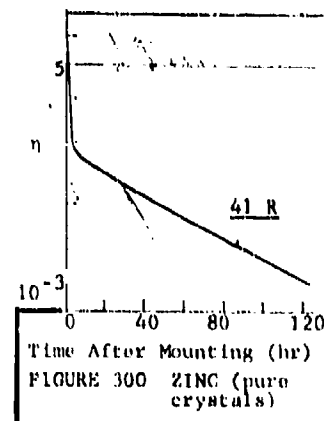
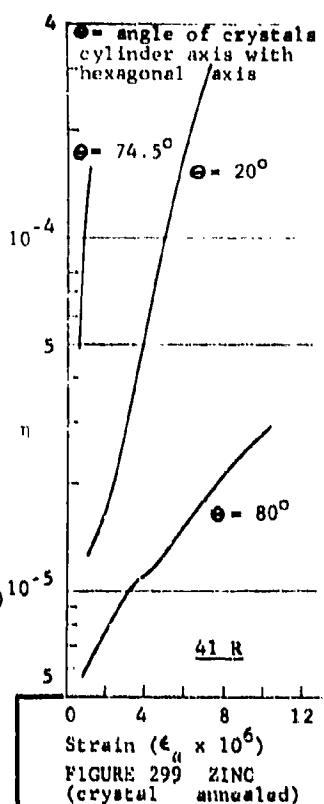
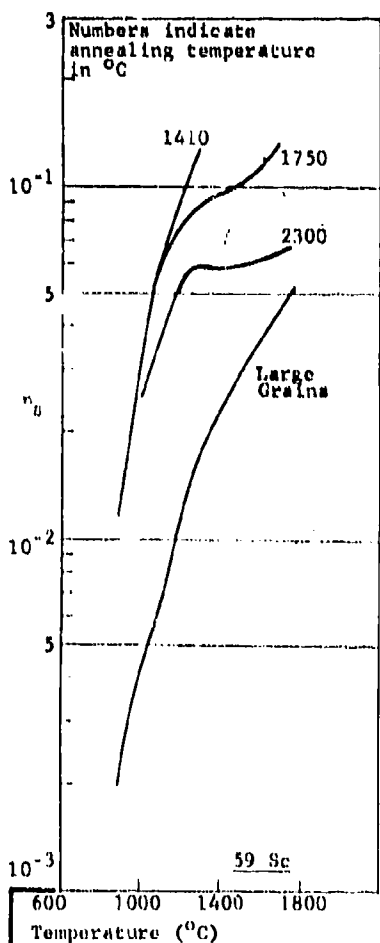
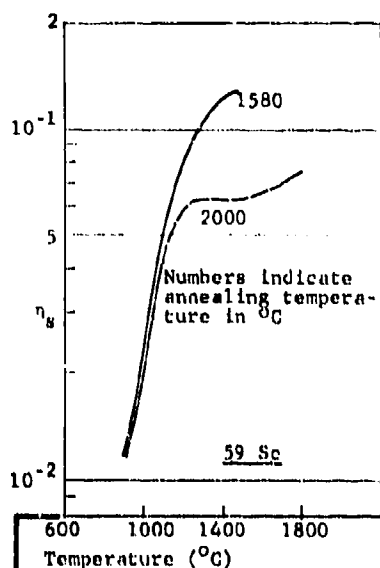
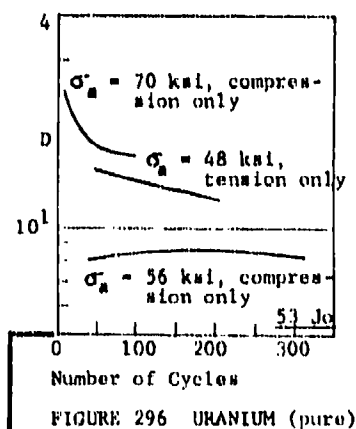
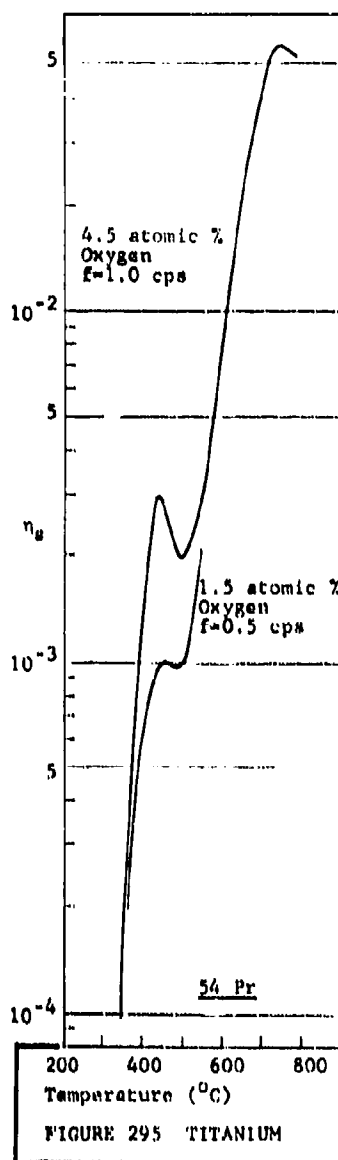


FIGURE 291 TITANIUM ALLOY (RC 55, annealed)





III. POLYMERS, ELASTOMERS, WOOD PRODUCTS, COMPOSITES, AND SIMILAR SYNTHETIC AND NATURAL NON-METALLIC MATERIALS

3.1 Data Tabulation

Since the differences between a soft viscoelastic polymer and a liquid becomes indistinct, it is arbitrarily assumed in this compilation that if G^* is roughly greater than 1 psi the material may be identified as a viscoelastic material. The units of G' , G'' , E' , E'' are pounds per square inch.

ADHESIVE (3M Tape #466). $T = 25^{\circ}\text{C}$. At $f = 2$, $G' = 45$ and $G'' = 18$. At $f = 10$, $G' = 49$ and $G'' = 41$. At $f = 40$, $G' = 60$ and $G'' = 52$. (57 D)

ADHESIVE (3M Transfer tape #466). $T = 25^{\circ}\text{C}$. $f = 10^{-1}$ to 10^5 . $G' = 8$ to 5,000 and $G'' = 4$ to 7,000. (63 D, Figure 344)

BAKELITE. Torsion. $\sigma_m = 2$ ksi. $\eta_s = 4.8 \times 10^{-2}$. (41 Ki*)

CELLULOID. Strains of about 5×10^{-3} . Rotating bending. $\eta_s = 1.4 \times 10^{-2}$. (41 Ki*)

CELLULOSE ACETATE (Butyrate, made from medium hard grades Tenite II, 201 and 203). $\sigma_a = 0.1$ to 1.0 ksi. $D = 4 \times 10^{-3}$ to 7×10^{-1} . (49 Saue, Figure 303)

CELLULOSE ACETATE (FM 6). Axial stress. $\sigma_a = 0.2$ to 2 ksi. $D = 2 \times 10^{-2}$ to 1. (54 Y, Figure 302-a)

CELLULOSE ACETATE (FM 6, made from compression molded rod, medium soft, 40 parts triacetin plasticizer). $\sigma_a = 0.1$ to 1.0 ksi. $D = 5 \times 10^{-3}$ to 7×10^{-1} . (49 Saue, Figure 302-b)

COTTON (11/4/2). $T = 25^\circ\text{C}$. $f = 180$. $G' = 1.49 \times 10^6$ and $G'' = 8.6 \times 10^4$. (49 Ly)

EBONITE. $T = 25^\circ\text{C}$. $f = 0.0022$ to 612 . $G' \approx 1.3 \times 10^5$ and $G'' = 1.2 \times 10^3$ to 4.4×10^3 . $G'' = 3 \times 10^3$ peak at $f = 40$. $G'' = 3.2 \times 10^3$ minimum at $f = 30$. (50 Leth, Figure 368)

EBONITE. In torsion, $\eta_s = 9.2 \times 10^{-3}$. In bending, $\eta_s = 2.7 \times 10^{-2}$. (41 Ki*)

FIBER (Dupont A). $T = 21^\circ\text{C}$. $f = 180$. $E' = 2.4 \times 10^5$ and $E'' = 1.39 \times 10^5$. (49 Ly)

FIBER (Dupont V 75/16/2). $T = 21^\circ\text{C}$. $f = 180$. $E' = 1.59 \times 10^6$ and $E'' = 5.15 \times 10^4$. (49 Ly)

FOAM (3M Double coated polyurethane tape, 4000 series). $T = 25^\circ\text{C}$. $f = 1$ to 10^9 . $G' = 15$ to 800 and $G'' = 4$ to 110 . (63 Da, Figure 346)

GLASS-RESIN COMPOSITE (1002 Crossply "Scotchply", reinforced plastic with glass filaments linearly aligned in two directions) Rotating bending. $f = 0.33$. $\sigma_a = 1$ to 30 ksi. $D = 10^{-2}$ to 10 . $D = 2.6 \times 10^{-1}$ at $\sigma_a = \sigma_g = 10$ ksi. (58 A, Figure 353)

GLASS-RESIN COMPOSITE (Glass fabric laminate plastic, CTL-91-LD resin, 181-114 fiberglass). Axial stress. $T = 70^\circ\text{F}$. $\sigma_a =$

3 to 16 ksi. $D = 2 \times 10^{-2}$ to 1.5×10^1 . (56 Po, Figure 358)

GLASS-RESIN COMPOSITE (Glass fabric laminate plastic, CTL-91-LD resin, 181-114 fiberglass). $\sigma_a = 1$ to 5 ksi. $\sigma_m = 0$ to 7 ksi. $D = 5 \times 10^{-2}$ to 2×10^{-1} . No change with σ_m . (56 Pe, Figure 359)

GLASS-RESIN COMPOSITE (Scotchply, Type 100 Unicore Spring). $T = 23^\circ\text{C}$. At $f = 1$, $E' = 1.30 \times 10^6$ and $E'' = 3.10 \times 10^4$. At $f = 10$, $E' = 1.32 \times 10^6$ and $E'' = 1.32 \times 10^4$. At $f = 40$, $E' = 1.35 \times 10^6$ and $E'' = 1.35 \times 10^4$. (58 K)

GLASS-RESIN COMPOSITE (Scotchply, Type 1000 resin). $T = 23^\circ\text{C}$. At $f = 1$, $E' = 3.1 \times 10^5$ and $E'' = 5,300$. At $f = 10$, $E' = 3.2 \times 10^5$ and $E'' = 6,400$. At $f = 40$, $E' = 3.3 \times 10^5$ and $E'' = 6,300$. (58 K)

HYCAR 1014. $T = 20^\circ\text{C}$. $f = 100$ to 1,850. $\eta = 0.40$ to 0.76. At maximum η , $G' = 200$. (56 Mo, 61 U*)

KAROLITH. $T = 25^\circ\text{C}$. At $f = 46,000$, $E' = 8.95 \times 10^5$ and $E'' = 47.0 \times 10^5$. At $f = 61,000$, $E' = 8.96 \times 10^5$ and $E'' = 55.0 \times 10^5$. (41 Ri)

KAROLITH. $T = 75^\circ\text{C}$. At $f = 44,000$, $E' = 7.45 \times 10^5$ and $E'' = 26.0 \times 10^5$. At $f = 59,000$, $E' = 7.45 \times 10^5$ and $E'' = 32.0 \times 10^5$. (41 Ri)

LAMINATED PLASTIC (Bakelite, grade X). Torsion. $\tau_a = 0$ to 4.5 ksi. $\eta = 3.7 \times 10^{-2}$ to 2×10^{-1} . (43 L, Figure 343)

LAMINATED PLASTIC (Bakelite, grade X). Axial stress. Resonant vibration. $\sigma_a = 1$ to 3 ksi. $\eta = 5 \times 10^{-2}$ to 10^{-1} . (43 L, Figure 347)

LAMINATED PLASTIC (Bakelite, closely packed cotton cord reinforcement running parallel to the axis). Torsion. $\tau_a = 0.3$ to 3 ksi. $\eta_s = 3 \times 10^{-2}$ to 7×10^{-2} . (39 L, Figure 348)

LAMINATED PLASTIC (Bakelite X199, filled with fabric snippings impregnated with phenol-formaldehyde resin and molded). Torsion. $\tau_a = 0.3$ to 3 ksi. $\eta_s = 3 \times 10^{-2}$ to 5×10^{-2} . (39 L, Figure 349)

LAMINATED PHENOLIC (Bakelite, grade X, paper base). Axial stress. $\sigma_a = 0.5$ to 3 ksi. $D = 10^{-2}$ to 2. (46 Ro, Figure 350)

LAMINATED PHENOLIC (Various types: bakelite, wood flour, paper, fine and coarse fabric filler). Torsion. $\tau_a = 0.1$ to 0.8 ksi. $\eta_s = 3 \times 10^{-2}$ to 4×10^{-2} . Little change with composition. (44 B, Figure 351)

LAMINATED PHENOLIC (Bakelite, commercial molding material with wood-flour filler). Torsion. $\tau_a = 0.3$ to 3 ksi. $\eta_s = 2 \times 10^{-2}$ to 5×10^{-2} . (39 L, Figure 352)

LAMINATED PLASTIC (Phenolics: asbestos base and army duck, fast curing phenol-formaldehyde resin). $\sigma_a = 0.5$ to 2 ksi. $D = 10^{-2}$ to 2×10^{-1} . Little change with composition. (49 Saue, Figure 354)

LAMINATED PLASTIC (Phenolic with canvas). Axial stress. Resonant vibration. $\sigma_a = 2$ to 5 ksi. $\eta = 3 \times 10^{-2}$ to 10^{-1} . (43 L, Figure 355)

LAMINATED PLASTIC (Phenolic with canvas). Torsion. $\tau_a = 1$ to 3.5 ksi. $\eta_s = 4 \times 10^{-2}$ to 10^{-1} . (43 L, Figure 356)

LAMINATED PLASTIC (Phenolic with cotton, grade CE). Bending. $f = 10$ to 200. $\eta_s = 10^{-1}$ to 3×10^{-2} . (57 Mi, Figure 357)

LAMINATED PLASTIC (Phenolic, synthane L, fine weave fabric base). $\sigma_a = 0.2$ to 1.0 ksi. $D = 10^{-3}$ to 5×10^{-2} . (49 Saue, Figure 360)

LAMINATED PLASTIC (Phenolic, paper base, grade XX). Axial stress. $\sigma_a = 0.5$ to 4.0 ksi. $D = 5 \times 10^{-3}$ to 2×10^{-1} . (54 Y, Figure 361)

LAMINATED PLASTIC (Phenolic, synthane XX, paper base). Rod specimens. $\sigma_a = 0.5$ to 2.0. $D = 10^{-2}$ to 3×10^{-1} . (49 Saue, Figure 362)

LAMINATED PLASTIC (Phenolic, Mitcherlich paper and fast curing phenol-formaldehyde). $\sigma_a = 1$ to 4 ksi. $D = 10^{-2}$ to 3×10^{-1} . (49 Saue, Figure 363)

LAMINATED PLASTIC (Phenolic, rayon-cotton fabric). $\sigma_a = 0.5$ to 3 ksi. $D = 7 \times 10^{-3}$ to 4×10^{-1} . (49 Saue, Figure 364)

LD-400 VISCOELASTIC DAMPING MATERIAL (Developed jointly by Monsanto

Company and Lord, formerly DC-400). $f = 75$ to $1,000$. At $T = 40^{\circ}\text{F}$, $E' = 10 \times 10^5$ to 20×10^5 and $\eta = 0.1$ to 0.08 . At $T = 60^{\circ}\text{F}$, $E' = 8 \times 10^5$ to 14×10^5 and $\eta = 0.4$ to 0.2 . At $T = 80^{\circ}\text{F}$, $E' = 3 \times 10^5$ to 8×10^5 and $\eta = 0.8$ to 0.7 . At $T = 100^{\circ}\text{F}$, $E' = 0.8 \times 10^5$ to 2×10^5 and $\eta = 0.6$ to 0.8 .

METHYL METHACRYLATE (Made from "Type 1-General Purpose" cast plexiglass). $\sigma_a = 0.1$ to 1.0 ksi. $D = 2 \times 10^{-3}$ to 4×10^{-1} . (49 Saue, Figure 320)

METHYL METHACRYLATE (Lucite). Axial stress. $f = 48$ and 68 . $\sigma_a = 0.5$ to 2.0 ksi. $D = 5 \times 10^{-2}$ to 3 . (46 Ro, Figure 316)

METHYL METHACRYLATE (Lucite). Resonant vibration. Stress = 0.5 to 2.0 ksi. Under axial stress, $\eta \approx 1.6 \times 10^{-1}$. Under torsion, $\eta = 10^{-1}$ to 1.4×10^{-1} . (43 L, Figure 318)

METHYL METHACRYLATE (Plexiglass). Axial stress. $\sigma_a = 0.1$ to 1 ksi. $D = 10^{-2}$ to 5×10^{-1} . (54 Y, Figure 319)

NYLON. $T = 30^{\circ}\text{C}$. $f = 10^{-3}$ to 10^2 . $E' = 3.0 \times 10^5$ to 5.1×10^5 and $E'' = 2.28 \times 10^4$ to 2.45×10^4 . (56 Maxw, Figure 307)

NYLON. $T = 23^{\circ}\text{C}$. $f = 180$. $E' = 1.27 \times 10^6$ and $E'' = 3.6 \times 10^4$. (49 Ly)

NYLON. Torsion. $\tau_a = 100$ psi. $\eta = 4.8 \times 10^{-2}$. (64 B1)

NYLON. $T = 25^{\circ}\text{C}$. At $f = 10$, $G' = 87.5 \times 10^4$ and $G'' = 4.57 \times 10^4$. At $f = 40$, $G' = 87.5 \times 10^4$ and $G'' = 2.74 \times 10^4$. (51 Du)

NYLON. $T = 26^{\circ}\text{C}$. At $f = 400$, $E' = 4.7 \times 10^5$ and $E'' = 13.9 \times 10^3$.
At $f = 1,000$, $E' = 4.7 \times 10^5$ and $E'' = 9.3 \times 10^3$. (57 Fit)

NYLON. $T = 0^{\circ}\text{C}$. $f = 10^5$. $E' = 57,000$ and $E'' = 199$. (57 Ya)

PERSPEX. $T = 25^{\circ}\text{C}$. $f = 0.0033$ to 800 . $G' = 1.61 \times 10^5$ to 2.78×10^5 and $G'' = 6.06 \times 10^3$ to 14.0×10^3 . $G'' = 14.0 \times 10^3$ peak at $f = 10$. (50 Leth, Figure 309)

PHENOL-FORMALDEHYDE RESIN (White, transparent, and unfilled).

Torsion. $\tau_a = 0.3$ to 3 ksi. $\eta_s = 9 \times 10^{-3}$ to 1.5×10^{-2} .
(39 L, Figure 349)

PHENOLIC (BM 6260). $T = -40$ to 40°C . At $f = 40$, $E' = 118 \times 10^4$ and $E'' = 2.27 \times 10^4$. At $f = 100$, $E' = 118 \times 10^4$ and $E'' = 1.79 \times 10^4$. At $f = 400$, $E' = 118 \times 10^4$ and $E'' = 1.18 \times 10^4$.
(56 Stre)

PHENOLIC RESINS. $T = 0^{\circ}\text{C}$. $f = 10^5$. $E' = 10,200$ and $E'' = 204$.
(57 Ya)

PLASTIC (LKF-1, Russian manufacture). Bending. $\sigma_a = 0.2$ to 1.5 ksi. At $T = -60^{\circ}\text{C}$, $\eta_s = 2 \times 10^{-2}$ to 3×10^{-2} . At $T = 60^{\circ}\text{C}$, $\eta_s = 5 \times 10^{-2}$ to 7×10^{-2} . (62 Pisa, Figure 338)

PLASTICIZED CELLULOSE NITRATE. $T = 65^{\circ}\text{C}$. $f = 100$ to $5,250$. $G' = 87$ to 555 and $G'' = 57$ to 545 . (51 Ho, Figure 304)

PLASTICIZED CELLULOSE NITRATE. $T = 20^{\circ}\text{C}$. At $f = 400$, $G' = 1,045$ and $G'' = 657$. At $f = 1,000$, $G' = 1,595$ and $G'' = 881$. At $f =$

4,000, $G' = 3,100$ and $G'' = 1,820$. (51 Ho)

PLASTICIZED POLYVINYL ACETATE. At $T = 5^{\circ}\text{C}$: $G' = 61$ and $G'' = 67$ at $f = 1$, $G' = 450$ and $G'' = 900$ at $f = 10$, $G' = 2,030$ and $G'' = 5,280$ at $f = 100$, $G' = 1.45 \times 10^4$ and $G'' = 2.32 \times 10^4$ at $f = 1,000$. At $T = 35^{\circ}\text{C}$: $G' = 12$ and $G'' = 4.8$ at $f = 10$, $G' = 26$ and $G'' = 18.2$ at $f = 100$, $G' = 130$ and $G'' = 195$ at $f = 1,000$, $G' = 1,020$ and $G'' = 2,450$ at $f = 10,000$. (64 Sno*)

PLASTICIZED POLYVINYL ACETATE. For all f and T . Maximum $\eta = 2.6$ and $G' = 2,180$ at $f = 50$, $T = 5^{\circ}\text{C}$. (61 U*)

PLASTICIZED POLYVINYL BUTYRAL RESIN. $T = 23^{\circ}\text{C}$. $f = 0.1$ to $1,000$. $G' = 290$ to $13,050$ and $G'' = 320$ to $5,220$. (64 Sno*)

PLASTICIZED POLYVINYL CHLORIDE (Koroseal). For all f and T . Maximum $\eta = 1.4$ and $G' = 3,470$ at $f = 660$, $T = 50^{\circ}\text{C}$. (61 U*)

PLASTICIZED POLYVINYL CHLORIDE (33.3% Diphthalate). $T = 20^{\circ}\text{C}$. $f = 40$ to 350 . $E' = 4.3 \times 10^4$ and $E'' = 1.93 \times 10^4$. (54 D11)

PLASTICIZED POLYVINYL CHLORIDE. $T = 25^{\circ}\text{C}$. $f = 10$ to $1,000$. $G' = 720$ to $7,250$ and $G'' = 550$ to $6,380$. (51 Ro, Figure 332)

PLASTICIZED POLYVINYL CHLORIDE (33.3% Diphthalate). $T = 50^{\circ}\text{C}$. $f = 40$ to 350 . $E' = 2,150$ and $E'' = 3,400$. (54 D11)

PLASTICIZED POLYVINYL CHLORIDE (VU-1913). $T = 25^{\circ}\text{C}$. $f = 0.001$ to 10 . $E' = 900$ to $7,000$ and $E'' = 720$ to $3,500$. (54 Ph, Figure 334)

PLASTICIZED POLYVINYL CHLORIDE (VU-1920). $T = 25^{\circ}\text{C}$. $f = 0.001$ to 10. $E' = 2,000$ to $20,000$ and $E'' = 1,000$ to $12,000$. $E' = 6,000$ peak at $f = 0.1$. $E'' = 4,000$ peak at $f = 0.1$ (54 Ph, Figure 335)

PLYWOOD (Birch, Sp.Gr. = 0.87). Axial stress. $\sigma_a = 0.5$ to 6 ksi. $D = 4 \times 10^{-3}$ to 1. (54 Y, Figure 387)

PLYWOOD (Birch, cross-laminated). Axial stress. Resonant vibration. $\sigma_a = 0.5$ to 3 ksi. $D = 10^{-2}$ to 1. (44 Yor, Figure 326)

PLYWOOD (Birch, Sp.Gr. = 1.05, resin-bonded). Axial stress. $\sigma_a = 0.5$ to 4 ksi. $D = 2 \times 10^{-3}$ to 1. (46 Ro, Figure 314)

POLY B-CHLOROETHYL METHACRYLATE. $T = 20^{\circ}\text{C}$. Bending. $f = 200$. $E' = 61.2 \times 10^4$ and $E'' = 1.84 \times 10^4$. (55 Ho)

POLYCAPRONE AND FIBER (Reinforced plastic). Bending. At $T = 20^{\circ}\text{C}$, $\eta_s = 1.2 \times 10^{-1}$. At $T = -70^{\circ}\text{C}$, $\eta_s = 4 \times 10^{-2}$ to 6×10^{-2} . (62 Pisa, Figure 365)

POLYCYCLOHEXL CHLOROACRYLATE. $T = 20^{\circ}\text{C}$. Bending. $f = 200$. $E' = 43.8 \times 10^4$ and $E'' = 0.65 \times 10^4$. (55 Ho)

POLYCYCLOHEXYL METHACRYLATE. $T = 20^{\circ}\text{C}$. Bending. $f = 200$. $E' = 321.0 \times 10^3$ and $E'' = 6.4 \times 10^3$. (55 Ho)

POLYESTER. $T = 43^{\circ}\text{C}$. At $f = 10$, $E' = 51.0 \times 10^4$ and $E'' = 1.46 \times 10^4$. At $f = 100$, $E' = 58.5 \times 10^4$ and $E'' = 1.17 \times 10^4$. At

$f = 1,000$, $E' = 58.5 \times 10^4$ and $E'' = 1.32 \times 10^4$. At $f = 10,000$, $E' = 58.5 \times 10^4$ and $E'' = 1.52 \times 10^4$. (55 Be)

POLYESTER. $f = 10$ to $10,000$. At $T = 4^\circ\text{C}$, $E' = 6.27 \times 10^5$ and $E'' = 5.4 \times 10^3$ to 11.3×10^3 . At $T = 72^\circ\text{C}$, $E' = 4.1 \times 10^5$ to 5.8×10^5 and $E'' = 4.4 \times 10^4$ to 7.0×10^4 . At $T = 108^\circ\text{C}$, $E' = 6.7 \times 10^3$ to 1.12×10^5 and $E'' = 2.6 \times 10^3$ to 68.6×10^3 . (55 Be, Figures 340, 341, and 342)

POLYESTER. For all f and T . Maximum $\eta = 1.1$ and $G' = 10,100$ at $f = 200$, $T = 108^\circ\text{C}$. (61 U*)

POLYESTER (G-651). $T = 25^\circ\text{C}$. At $f = 0.1$, $G' = 0.0016$ and $G'' = 0.036$. At $f = 1$, $G' = 0.0088$ and $G'' = 0.29$. At $f = 10$, $G' = 0.0073$ and $G'' = 10.2$. (54 Ph)

POLYETHYL CHLOROACRYLATE. $T = 20^\circ\text{C}$. Bending. $f = 200$. $E' = 58.3 \times 10^4$ and $E'' = 1.16 \times 10^4$. (55 Ho)

POLYETHYLENE. $f = 12$. $T = 30$ to 80°C . $G' = 2,900$ at $\eta_{\text{maximum}} = 0.23$. (61 U*)

POLYETHYL METHACRYLATE. $T = 150^\circ\text{C}$. $f = 40$ to $1,000$. $G' = 35$ to 284 and $G'' = 90$ to 228 . (57 Fe, Figure 315)

POLYETHYL METHACRYLATE. $T = 20^\circ\text{C}$. Bending. $f = 200$. $E' = 32.1 \times 10^4$ and $E'' = 2.25 \times 10^4$. (55 Ho)

POLYETHYLENE TEREPHTHALAL. $T = -15$ to 200°C . At $f = 1,000$, $E' = 18.1 \times 10^5$ and $E'' = 5.22 \times 10^5$. At $f = 4,000$, $E' = 19.85 \times$

10^5 and $E'' = 1.20 \times 10^5$. At $f = 10,000$, $E' = 2.22 \times 10^5$ and $E'' = 1.38 \times 10^5$. (49 B)

POLYGLYCOL METHACRYLATE. $T = 20^\circ\text{C}$. Bending. $f = 200$. $E' = 43.8 \times 10^4$ and $E'' = 1.32 \times 10^4$. (55 Ho)

POLYHEXANE. $T = 6^\circ\text{C}$. $f = 40$ to $1,000$. $E' = 63$ to 265 and $E'' = 51$ to 189 . (57 Kur, Figure 308)

POLYISOBUTYLENE. For all f and T . Maximum $\eta > 2.0$ and $G' = 290$ at $f = 6,000$, $T = 25^\circ\text{C}$. (61 U*)

POLY-ISO-PROPYL CHLOROACRYLATE. $T = 20^\circ\text{C}$. Bending. $f = 200$. $E' = 73.0 \times 10^4$ and $E'' = 0.73 \times 10^4$. (55 Ho)

POLY-ISO-PROPYL METHACRYLATE. $T = 20^\circ\text{C}$. Bending. $f = 200$. $E' = 45.5 \times 10^4$ and $E'' = 1.80 \times 10^4$. (55 Ho)

POLYMERIZED TUNG OIL (X-6). $T = 20^\circ\text{C}$. At $f = 400$, $G' = 812$ and $G'' = 840$. At $f = 1,000$, $G' = 1,600$ and $G'' = 1,185$. At $f = 4,000$, $G' = 2,610$ and $G'' = 2,560$. (51 Ho)

POLYMERIZED TUNG OIL (X-6). $T = 65^\circ\text{C}$. $f = 100$ to $5,250$. $G' = 184$ to $1,180$ and $G'' = 158$ to $1,040$. (51 Ho, Figure 305)

POLYMERIZED TUNG OIL (X-7). $T = 20^\circ\text{C}$. At $f = 1,000$, $G' = 2,470$ and $G'' = 1,365$. At $f = 4,000$, $G' = 5,370$ and $G'' = 2,970$. (51 Ho)

POLYMERIZED TUNG OIL (X-7). $T = 65^\circ\text{C}$. $f = 100$ to $5,250$. $G' = 154$ to $2,380$ and $G'' = 214$ to $1,870$. (51 Ho, Figure 306)

POLYMETHYL CHLOROACRYLATE. $T = 20^{\circ}\text{C}$. Bending. $f = 200$. $E' = 90.6 \times 10^4$ and $E'' = 1.81 \times 10^4$. (55 Ho)

POLYMETHYL CHLORIDE ACETATE. $T = 20^{\circ}\text{C}$. At $f = 100$, $G' = 297$ and $G'' = 212$. At $f = 400$, $G' = 463$ and $G'' = 328$. At $f = 1,000$, $G' = 985$ and $G'' = 805$. (51 Ho)

POLYMETHYL CHLORIDE ACETATE. $T = 65^{\circ}\text{C}$. At $f = 100$, $G' = 99$ and $G'' = 22$. At $f = 400$, $G' = 93$ and $G'' = 22$. At $f = 1,240$, $G' = 121$ and $G'' = 37$. At $f = 5,250$, $G' = 155$ and $G'' = 91$. (51 Ho)

POLYMETHYL METHACRYLATE. For all f and T . Maximum $\gamma = 1.5$ and $G' = 1.45 \times 10^4$ at $f = 1,200$, $T = 142^{\circ}\text{C}$. (61 U*)

POLYMETHYL METHACRYLATE. $T = 50^{\circ}\text{C}$. $f = 0.083$ to 83 . $E' \approx 6 \times 10^5$ and $E'' \approx 6 \times 10^4$. (57 K)

POLYMETHYL METHACRYLATE. $T = 25^{\circ}\text{C}$. $f = 0.083$ to 83 . $E' = 7.5 \times 10^5$ to 8.0×10^5 and $E'' = 3.7 \times 10^4$ to 5.6×10^4 . (57 K, Figure 311)

POLYMETHYL METHACRYLATE. $T = 25^{\circ}\text{C}$. $f = 0.001$ to 400 . $E' = 4.35 \times 10^5$ to 7.39×10^5 and $E'' = 9.3 \times 10^3$ to 14.5×10^3 . $E'' = 14.5 \times 10^3$ peak at $f = 50$. (54 Fine, Figure 312)

POLYMETHYL METHACRYLATE. $T = 70^{\circ}\text{C}$. $f = 0.083$ to 83 . $E' = 4.8 \times 10^5$ to 4.0×10^5 and $E'' = 9.6 \times 10^4$ to 8.0×10^4 . (57 K, Figure 313)

POLYMETHYL METHACRYLATE. $T = 30^{\circ}\text{C}$. $f = 0.001$ to 1 . $E' = 4.4 \times 10^5$ and $E'' = 9.8 \times 10^3$ to 26.5×10^3 . (56 Maxw, Figure 317)

POLYMETHYL METHACRYLATE. $T = 20^{\circ}\text{C}$. $f = 200$. $E' = 38.0 \times 10^4$ and $E'' = 2.28 \times 10^4$. (55 Ho)

POLYMETHYL METHACRYLATE. $T = 50^{\circ}\text{C}$. At $f = 40$, $G' = 98.2$ and $G'' = 137$. At $f = 100$, $G' = 146$ and $G'' = 292$. (55 W11)

POLYMETHYL METHACRYLATE. $T = 25^{\circ}\text{C}$. At $f = 100$, $G' = 6.70 \times 10^4$ and $G'' = 1.85 \times 10^4$. At $f = 400$, $G' = 7.91 \times 10^4$ and $G'' = 1.85 \times 10^4$. (55 W11)

POLYMETHYL METHACRYLATE. $T = 30^{\circ}\text{C}$. At $f = 10$, $E' = 55.0 \times 10^4$ and $E'' = 3.24 \times 10^4$. At $f = 100$, $E' = 61.0 \times 10^4$ and $E'' = 2.80 \times 10^4$. (56 Maxw)

POLYMETHYL METHACRYLATE. $T = 92^{\circ}\text{C}$. At $f = 0.083$, $E' = 5.5 \times 10^4$ and $E'' = 3.0 \times 10^4$. At $f = 0.83$, $E' = 10.0 \times 10^4$ and $E'' = 4.0 \times 10^4$. At $f = 8.3$, $E' = 15.0 \times 10^4$ and $E'' = 3.5 \times 10^4$. (57 K)

POLYMETHYL METHACRYLATE. $T = 0^{\circ}\text{C}$. $f = 10^5$. $E' = 550$ and $E'' = 190$. (57 Ya)

POLY-N-BUTYL CHLOROACRYLATE. Bending. $T = 20^{\circ}\text{C}$. $f = 200$. $E' = 29.2 \times 10^4$ and $E'' = 0.44 \times 10^4$. (55 Ho)

POLY-N-BUTYL METHACRYLATE. Bending. $T = 20^{\circ}\text{C}$. $f = 200$. $E' = 16.0 \times 10^4$ and $E'' = 2.08 \times 10^4$. (55 Ho)

POLY-N-BUTYL METHACRYLATE. $T = 40^{\circ}\text{C}$. At $f = 400$, $G' = 42,200$ and $G'' = 47,700$. At $f = 1,000$, $G' = 47,700$ and $G'' = 1,460$. (57 Ch)

POLY-N-HEXYL METHACRYLATE. $T = 19^{\circ}\text{C}$. $f = 40$ to $1,000$. $G' = 5.9 \times 10^3$ to 24.3×10^3 and $G'' = 4.9 \times 10^3$ to 10.6×10^3 . (57 Chi, Figure 337)

POLY-N-PROPLY CHLOROACRYLATE. Bending. $T = 20^{\circ}\text{C}$. $f = 200$. $E' = 46.7 \times 10^4$ and $E'' = 0.93 \times 10^4$. (55 Ho)

POLY-N-PROPYL METHACRYLATE. Bending. $T = 20^{\circ}\text{C}$. $f = 200$. $E' = 29.2 \times 10^4$ and $E'' = 2.92 \times 10^4$. (55 Ho)

POLYNEOPENTYL METHACRYLATE. Bending. $T = 20^{\circ}\text{C}$. $f = 200$. $E' = 321.0 \times 10^3$ and $E'' = 8.0 \times 10^3$. (55 Ho)

POLYPHENYL METHACRYLATE. Bending. $T = 20^{\circ}\text{C}$. $f = 200$. $E' = 55.5 \times 10^4$ and $E'' = 1.67 \times 10^4$. (55 Ho)

POLYPINACOLYL METHACRYLATE. Bending. $T = 20^{\circ}\text{C}$. $f = 200$. $E' = 321.0 \times 10^3$ and $E'' = 4.5 \times 10^3$. (55 Ho)

POLYPROPYLENE. $T = -20^{\circ}\text{C}$. At $f = 10$, $E' = 58.5 \times 10^4$ and $E'' = 1.17 \times 10^4$. At $f = 100$, $E' = 58.5 \times 10^4$ and $E'' = 1.40 \times 10^4$. At $f = 1,000$, $E' = 58.5 \times 10^4$ and $E'' = 1.40 \times 10^4$. (59 Boh)

POLYPROPYLENE. $T = 0^{\circ}\text{C}$. At $f = 10$, $E' = 41.0 \times 10^4$ and $E'' = 2.40 \times 10^4$. At $f = 100$, $E' = 44.0 \times 10^4$ and $E'' = 3.08$. At $f = 1,000$, $E' = 48.0 \times 10^4$ and $E'' = 3.84 \times 10^4$. (59 Boh)

POLYPROPYLENE. $T = 20^{\circ}\text{C}$. At $f = 10$, $E' = 19.0 \times 10^4$ and $E'' = 1.80 \times 10^4$. At $f = 100$, $E' = 21.9 \times 10^4$ and $E'' = 2.85 \times 10^4$. At $f = 1,000$, $E' = 24.8 \times 10^4$ and $E'' = 4.1 \times 10^4$. (59 Boh)

POLYPROPYLENE SEBACATE. $T = 20^{\circ}\text{C}$. At $f = 400$, $G' = 189$ and $G'' = 62$. At $f = 1,000$, $G' = 203$ and $G'' = 61$. At $f = 4,000$, $G' = 261$ and $G'' = 109$. (51 Ho)

POLYPROPYLENE SEBACATE. $T = 65^{\circ}\text{C}$. At $f = 100$, $G' = 65.7$ and $G'' = 23$. At $f = 400$, $G' = 81.7$ and $G'' = 66$. At $f = 1,240$, $G' = 132$ and $G'' = 47$. At $f = 5,250$, $G' = 115$ and $G'' = 106$. (51 Ho)

POLY-SEC-BUTYL CHLOROACRYLATE. Bending. $T = 20^{\circ}\text{C}$. $f = 200$. $E' = 40.8 \times 10^4$ and $E'' = 0.82 \times 10^4$. (55 Ho)

POLY-SEC-BUTYL METHACRYLATE. Bending. $T = 20^{\circ}\text{C}$. $f = 200$. $E' = 32.1 \times 10^4$ and $E'' = 1.28 \times 10^4$. (55 Ho)

POLYSTEARYL METHACRYLATE. Bending. $T = 20^{\circ}\text{C}$. $f = 200$. $E' = 36.7 \times 10^4$ and $E'' = 1.83 \times 10^4$. (55 Ho)

POLYSTYRENE. For all f and T . Maximum $\eta > 2.0$ and $G' = 1.45 \times 10^4$ at $f = 2,000$, $T \approx 140^{\circ}\text{C}$. (61 U*)

POLYSTYRENE. $T = 25^{\circ}\text{C}$. At $f = 0.01$, $E' = 80.0 \times 10^4$ and $E'' = 1.6 \times 10^4$. At $f = 0.1$, $E' = 86.0 \times 10^4$ and $E'' = 1.7 \times 10^4$. At $f = 1$, $E' = 90.0 \times 10^4$ and $E'' = 1.8 \times 10^4$. At $f = 10$, $E' = 95.0 \times 10^4$ and $E'' = 1.86 \times 10^4$. At $f = 100$, $E' = 95.0 \times 10^4$ and $E'' = 1.9 \times 10^4$. (57 K)

POLYSTYRENE. $T = -70$ to 90°C . At $f = 5 \times 10^4$, $E' = 3.19 \times 10^5$ and $E'' = 7,000$. At $f = 10^5$, $E' = 2.61 \times 10^5$ and $E'' = 5,740$. (57 Ya)

POLYSTYRENE. $T = 30^{\circ}\text{C}$. $f = 0.001$ to 100 . $E' = 4.8 \times 10^5$ to 5.2×10^5 and $E'' = 4.8 \times 10^3$ to 10.2×10^3 . $E'' = 10.2 \times 10^3$ peak at $f = 1$. (56 Maxw, Figure 323)

POLYSTYRENE. $T = 25^{\circ}\text{C}$. $f = 0.0024$ to 703 . $G' = 1.69 \times 10^5$ to 1.90×10^5 and $G'' = 1.14 \times 10^3$ to 2.30×10^3 . $G'' = 2.3 \times 10^3$ peak at $f = 1$. (50 Leth, Figure 324)

POLYSTYRENE. $\sigma_a = 0.1$ to 2.0 ksi. $D = 5 \times 10^{-3}$ to 5×10^{-1} . (49 Saue, Figure 325)

POLYSTYRENE (Lustrex). Axial stress. $\sigma_a = 0.1$ to 2.0 ksi. $D = 10^{-2}$ to 4×10^{-1} . (54 Y, Figure 321)

POLYSTYRENE (Styrone). $\sigma_a = 0.1$ to 1.0 ksi. $D = 2 \times 10^{-3}$ to 2×10^{-1} . (49 Saue, Figure 322)

POLY-TERT-BUTYL METHACRYLATE. Bending. $T = 20^{\circ}\text{C}$. $f = 200$. $E' = 43.8 \times 10^4$ and $E'' = 1.75 \times 10^4$. (55 Ho)

POLYTETRAFLUOROETHYLENE. 1.4% Static deflection. $T = 23^{\circ}\text{C}$. At $f = 100$, $G' = 10,800$ and $G'' = 800$. At $f = 1,000$, $G' = 13,600$ and $G'' = 1,790$. (57 Fit)

POLYTETRAFLUOROETHYLENE. $T = 21^{\circ}\text{C}$. At $f = 100$, $E' = 18.5 \times 10^4$ and $E'' = 1.31 \times 10^4$. At $f = 400$, $E' = 11.5 \times 10^4$ and $E'' =$

0.77×10^4 . At $f = 1,000$, $E' = 10.7 \times 10^4$ and $E'' = 0.79$.
(57 Fit)

POLYTETRAFLUORETHYLENE (Teflon-TFE). For all f and T . Maximum
 $\eta = 1.0$ and $G' = 5,800$ at $f = 400$, $T = 23^\circ\text{C}$. (61 U*)

POLYTHENE. $T = 20^\circ\text{C}$. $f = 3,000$. $E' = 1.69 \times 10^5$ and $E'' = 324$.
(49 H1)

POLYTHENE. $T = 30^\circ\text{C}$. At $f = 1,000$, $G' = 22,300$ and $G'' = 4,800$.
At $f = 10,000$, $G' = 17,350$ and $G'' = 10,850$. (49 H1)

POLYTHENE. $T = 25^\circ\text{C}$. At $f = 0.0018$ to 19.1 , $G' = 9,300$ to $22,000$.
At $f = 0.0018$ to 1.0 , $G'' \approx 1,800$; and at $f = 1.0$ to 19.1 ,
 $G'' = 1,800$ to 130 . (50 Leth, Figure 327)

POLYTRIFLUORO-ISOPROPYL METHACRYLATE. Bending. $T = 20^\circ\text{C}$. $f =$
 200 . $E' = 32.0 \times 10^4$ and $E'' = 1.24 \times 10^4$. (55 Ho)

POLYTRIFLUOROCHLOROETHYLENE. $T = -50^\circ\text{C}$. At $f = 10$, $E' = 58.5 \times$
 10^4 and $E'' = 1.75 \times 10^4$. At $f = 100$, $E' = 62.8 \times 10^4$ and $E'' =$
 2.50×10^4 . At $f = 1,000$, $E' = 65.7 \times 10^4$ and $E'' = 4.27 \times$
 10^4 . (59 Boh)

POLYTRIFLUOROCHLOROETHYLENE. $T = 0^\circ\text{C}$. At $f = 10$, $E' = 36.5 \times$
 10^4 and $E'' = 4.4 \times 10^4$. At $f = 100$, $E' = 42.4 \times 10^4$ and $E'' =$
 4.6×10^4 . At $f = 1,000$, $E' = 48.0 \times 10^4$ and $E'' = 4.7 \times 10^4$.
(59 Boh)

POLYTRIFLUOROCHLOROETHYLENE. $T = 50^\circ\text{C}$. At $f = 10$, $E' = 3.0 \times 10^4$

and $E'' = 0.18 \times 10^4$. At $f = 100$, $E' = 7.3 \times 10^4$ and $E'' = 0.60 \times 10^4$. At $f = 1,000$, $E' = 14.6 \times 10^4$ and $E'' = 2.50 \times 10^4$. (59 Boh)

POLYTRIFLUOROCHLOROETHYLENE. $T = 20^\circ\text{C}$. At $f = 10$, $E' = 26.3 \times 10^4$ and $E'' = 2.20 \times 10^4$. At $f = 100$, $E' = 32.1 \times 10^4$ and $E'' = 3.85 \times 10^4$. At $f = 1,000$, $E' = 41.0 \times 10^4$ and $E'' = 6.87 \times 10^4$. (59 Boh)

POLYTRIFLUOROCHLOROETHYLENE (Fluoroethene). $f = 3.3$. $T = 90$ to 120°C . $G' = 11,600$ at η maximum $= 0.42$. (61 U*)

POLYVINYL ACETATE (23.8% concentration). $T = 10^\circ\text{C}$. At $f = 500$, $G' = 1.77$ and $G'' = 0.86$. At $f = 1,000$, $G' = 1.95$ and $G'' = 1.27$. (50 Fe)

POLYVINYL ACETATE (35.1% concentration). $T = 10^\circ\text{C}$. At $f = 500$, $G' = 5.2$ and $G'' = 3.16$. At $f = 1,000$, $G' = 6.28$ and $G'' = 2.72$. (50 Fe)

POLYVINYL ACETATE (Plasticized by tri-m-cresyl). $T = 25^\circ\text{C}$. $f = 40$ to $1,000$. $G' = 1,300$ to $7,800$ and $G'' = 1,300$ to $13,800$. (55 W1, Figure 328)

POLYVINYL BUTYRATE. $T = 25^\circ\text{C}$. $f = 10$ to $1,000$. $G' = 435$ to $7,530$ and $G'' = 456$ to $4,550$. (55 R, Figure 329)

POLYVINYL BUTYRAL. $T = -40$ to 100°C . $f = 10$ to $1,000$. $\eta = 0.14$ to 2.0 . At maximum η , $f = 2$ and $G' = 29,000$. (61 U*)

POLYVINYLCARBAZOL. $f = 10$. $T = 200$ to 220°C . $G' = 1,200$ at η
maximum > 1.6 . (61 U*)

POLYVINYL CHLORIDE. For all f and T . Maximum $\eta = 1.8$ and $G' =$
 $3,330$ at $f = 20$, $T = 92^{\circ}\text{C}$. (61 U*)

POLYVINYL CHLORIDE. $T = 20^{\circ}\text{C}$. $f = 10$ to 400 . $G' = 35$ to 100 and
 $G'' = 40$ to 300 . $G' = 100$ peak at $f = 100$. (55 W1, Figure
331)

POLYVINYL CHLORIDE. $T = 30^{\circ}\text{C}$. $f = 0.01$ to 10 . $E' \approx 4.0 \times 10^5$
and $E'' = 1.2 \times 10^3$ to 12.9×10^3 . (56 Maxw, Figure 336)

POLYVINYL CHLORIDE (With Di-phthalate 25% DOP). $T = 80^{\circ}\text{C}$. $f =$
 40 to 350 . $E' = 2,150$ and $E'' = 1,775$. (54 D11)

POLYVINYL CHLORIDE (With Di-phthalate 25% DOP). $T = 20^{\circ}\text{C}$. $f =$
 40 to 350 . $E' = 77,500$ and $E'' = 7,300$. (54 D11)

POLYVINYL CHLORIDE (With Di-phthalate 25% DOP). $T = 50^{\circ}\text{C}$. $f =$
 40 to 350 . $E' = 1.76 \times 10^4$ and $E'' = 1.53 \times 10^4$. (54 D11)

POLYVINYL CHLORIDE. $T = 50^{\circ}\text{C}$. At $f = 400$, $G' = 9.1 \times 10^4$ and
 $G'' = 4.27 \times 10^4$. At $f = 1,000$, $G' = 11.0 \times 10^4$ and $G'' = 3.48$
 $\times 10^4$. (54 W1)

POLYVINYL CHLORIDE (17% concentration). $T = 25^{\circ}\text{C}$. At $f = 400$,
 $G' = 1.01$ and $G'' = 0.38$. At $f = 1,000$, $G' = 1.21$ and $G'' =$
 0.55 . (50 Fe)

POLYVINYL CHLORIDE (24.1% concentration). $T = 25^{\circ}\text{C}$. $f = 400$.
 $G' = 1.05$ and $G'' = 0.96$. (50 Fe)

POLYVINYL CHLORIDE DIMETHYL-THIEN-THRENE. $T = 25^{\circ}\text{C}$. $f = 40$ to 1,000. $G' = 2.8$ to 8.7 and $G'' = 1.4$ to 13.1 . (53 Fit, Figure 333)

POLYVINYL CHLORIDE (Plasticized by tri-m-cresyl). $T = -1^{\circ}\text{C}$. $f = 40$ to 1,000. $G' = 1,000$ to $8,500$ and $G'' = 900$ to $9,100$. (55 Wi, Figure 330)

POLYVINYL CHLORIDE. Shear. At $T = 35^{\circ}\text{F}$: $G' = 3,000$ at $f = 20$, $G' = 10^5$ to 2×10^5 at $f = 1,000$, $G' = 10^5$ at $f = 5,000$, $G' = 10^5$ at $f = 10^5$. At $T = 65^{\circ}\text{F}$: $G' = 3,000$ and $G'' = 1,000$ at $f = 20$, $G' = 6 \times 10^4$ and $G'' = 6 \times 10^3$ at $f = 100$, $G' = 10^5$ and $G'' = 10^4$ at $f = 1,000$. At $T = 130^{\circ}\text{F}$: $G' = 2,000$ and $G'' = 700$ at $f = 20$, $G' = 4,000$ and $G'' = 2,000$ at $f = 100$, $G' = 10^4$ and $G'' = 6 \times 10^3$ at $f = 1,000$. (65 B1)

POLYVINYLFLUORIDE. $f = 1.7$. $T = 20$ to 60°C . $G' = 5,800$ at η maximum = 0.36 . (61 U*)

POLYVINYL-N-BUTYL ETHER. $f = 0.8$. $T = -40$ to -20°C . $G' = 1,500$ at η maximum > 1.6 . (61 U*)

POLYVINYL-ISOBUTYL ETHER. $f = 1.2$. $T = -15$ to 10°C . $G' = 1,500$ at η maximum > 1.6 . (61 U*)

POLYVINYL-TERT-BUTYL ETHER. $f = 1.7$. $T = 70$ to 90°C . $G' = 1,500$ at η maximum > 1.6 . (61 U*)

RAMIE (3-ply cord). $T = 21^{\circ}\text{C}$. $f = 180$. $E' = 4.66 \times 10^6$ and $E'' = 1.27 \times 10^5$. (49 Ly)

RAYON (Viscous yarn). $T = 25^{\circ}\text{C}$. At $f = 10$, $E' = 1.46 \times 10^6$ and $E'' = 5.50 \times 10^4$. At $f = 40$, $E' = 1.46 \times 10^6$ and $E'' = 3.66 \times 10^4$. (51 Du)

RAYON (Viscous yarn). $T = 21^{\circ}\text{C}$. $f = 180$. $E' = 2.22 \times 10^6$ and $E'' = 6.6 \times 10^4$. (49 Ly)

RUBBER (Buna N, B-1, vulcanized). For all f and T . Maximum $\eta = 1.5$ and $G' = 1,450$ at $f = 4,000$, $T = 20^{\circ}\text{C}$. (61 U*)

RUBBER (Buna N, B-5, carbon filled, vulcanized). $T = 20^{\circ}\text{C}$. $f = 10$ to $10,000$. $\eta = 0.4$ to 1.6 . At maximum η , $G' = 1,500$ to $4,400$. (50 No, 61 U*)

RUBBER (Buna N, B-5, carbon filled, vulcanized). $f = 50$. $T = 0$ to 10°C . $G' = 2.9 \times 10^4$ at η maximum $= 0.15$. (50 No, 61 U*)

RUBBER (Butyl, unvulcanized). $f = 1$. $T = -20$ to $+20^{\circ}\text{C}$. $G' = 1.5 \times 10^4$ at η maximum $= 1.2$. (61 U*)

RUBBER (Butyl). At $T = 1^{\circ}\text{C}$: $E' = 2,480$ and $E'' = 4,950$ at $f = 1,000$, $E' = 6,570$ and $E'' = 12,500$ at $f = 3,000$. At $T = 22^{\circ}\text{C}$: $E' = 1,020$ and $E'' = 917$ at $f = 1,000$, $E' = 1,390$ and $E'' = 2,570$ at $f = 3,000$. At $T = 41^{\circ}\text{C}$: $E' = 583$ and $E'' = 320$ at $f = 1,000$, $E' = 875$ and $E'' = 1,100$ at $f = 3,000$. (49 Wit)

RUBBER (Butyl, Enjay 9-262-1). $T = 21^{\circ}\text{C}$. $f = 100$ to $10,000$. $\eta = 0.55$ to 2.56 . At maximum η , $f = 3,000$ and $G' = 2,900$. (61 U*)

RUBBER (Butyl, Enjay 9-262-4). $T = 21^{\circ}\text{C}$. $f = 100$ to $10,000$.

$\eta = 0.4$ to 4.0 . At maximum η , $f = 3,100$ and $G' = 1,500$.

(61 U*)

RUBBER (Butyl, Enjay 9-262-3). $T = 24^{\circ}\text{C}$. $f = 100$ to $10,000$.

$\eta = 0.45$ to 2.2 . At maximum η , $f = 3,000$ and $G' = 2,900$.

(61 U*)

RUBBER (Butyl). $T = 20^{\circ}\text{C}$. At $f = 1$, $E' = 109$ and $E'' = 163$. At

$f = 10$, $E' = 319$ and $E'' = 575$. (50 No)

RUBBER (Butyl). $T = 25^{\circ}\text{C}$. At $f = 40$, $G' = 50$ and $G'' = 27$. At

$f = 100$, $G' = 58$ and $G'' = 42$. At $f = 400$, $G' = 59$ and $G'' =$

98 . (50 M)

RUBBER (Butyl). $T = 20^{\circ}\text{C}$. At $f = 400$, $G' = 128$ and $G'' = 128$. At

$f = 1,000$, $G' = 218$ and $G'' = 201$. At $f = 4,000$, $G' = 432$ and

$G'' = 475$. (51 Ho)

RUBBER (Butyl). $T = 40^{\circ}\text{C}$. At $f = 1,000$, $G' = 73$ and $G'' = 36$.

At $f = 4,000$, $G' = 113$ and $G'' = 84$. (52 Fer)

RUBBER (Butyl). $T = 20^{\circ}\text{C}$. $f = 10$ to $10,000$. $E' = 580$ to $1,595$

and $E'' = 88$ to 797 . (49 I, Figure 374)

RUBBER (Butyl, M.W. $= 1.2 \times 10^6$). $T = 25^{\circ}\text{C}$. At $f = 105$, $G' =$

$3,620$ and $G'' = 1,820$. At $f = 106$, $G' = 14,500$ and $G'' = 8,910$.

At $f = 107$, $G' = 50,700$ and $G'' = 46,500$. (52 Mc)

RUBBER (Butyl, M.W. $= 1.2 \times 10^6$). $T = 70^{\circ}\text{C}$. At $f = 1,000$, $G' =$

57 and $G'' = 11$. At $f = 4,000$, $G' = 40.8$ and $G'' = 22.9$. (52 Fer)

RUBBER (Butyl, M.W. $= 1.2 \times 10^6$). $T = 20^\circ\text{C}$. At $f = 10$, $G' = 3.1$ and $G'' = 0.8$. At $f = 100$, $G' = 16.8$ and $G'' = 6.6$. (53 Fe)

RUBBER (Butyl, M.W. $= 1.2 \times 10^6$). $T = 0^\circ\text{C}$. At $f = 100$, $G' = 19.0$ and $G'' = 27$. At $f = 400$, $G' = 55.5$ and $G'' = 73$. At $f = 1,000$, $G' = 94.8$ and $G'' = 128$. (53 Fi)

RUBBER (Butyl, M.W. $= 1.2 \times 10^6$). $T = 50^\circ\text{C}$. At $f = 100$, $G' = 55$ and $G'' = 12$. At $f = 400$, $G' = 58$ and $G'' = 36$. At $f = 1,000$, $G' = 80$ and $G'' = 73$. (53 Fi)

RUBBER (Butyl, M.W. $= 1.2 \times 10^6$). $T = 25^\circ\text{C}$. At $f = 160$, $G' = 219$ and $G'' = 321$. At $f = 1.6 \times 10^4$, $G' = 7,300$ and $G'' = 8,750$. At $f = 1.6 \times 10^6$, $G' = 87,500$ and $G'' = 73,000$. (53 Le)

RUBBER (Butyl, M.W. $= 1.2 \times 10^6$). $T = 30^\circ\text{C}$. At $f = 65$, $E' = 20$ and $E'' = 39$. At $f = 79$, $E' = 29$ and $E'' = 22$. At $f = 135$, $E' = 85$ and $E'' = 118$. (55 Th)

RUBBER (Butyl, M.W. $= 1.2 \times 10^6$). $T = -30^\circ\text{C}$. At $f = 1$, $G' = 623$ and $G'' = 995$. At $f = 10$, $G' = 2,465$ and $G'' = 3,280$. (57 F1)

RUBBER (Butyl, M.W. $= 1.2 \times 10^6$). $T = 25^\circ\text{C}$. $f = 2 \times 10^{-5}$ to 16. $G' = 7.3$ to 75.8 and $G'' = 7.3$ to 48.2. Both G' and G'' constant at maximum value for $f > 0.1$. (53 Le, Figure 369)

RUBBER (Butyl, M.W. $= 1.2 \times 10^6$). $T = -30$ to 75°C . $f = 0.001$ to

100. $G' = 19$ to 95 and $G'' = 6.1$ to 32.2 . $G'' < 6.5$ for $f < 10$. (53 Ph, Figure 370)

RUBBER (Butyl, M.W. = 1.2×10^6). $T = 25^\circ\text{C}$. $f = 10$ to 400 . $G' = 72.5$ to 174 and $G'' = 32$ to 455 . (53 F1, Figure 373)

RUBBER (Filled Butyl). $T = 65^\circ\text{C}$. $f = 100$ to $5,250$. $G' = 555$ to $1,210$ and $G'' = 104$ to 642 . $G' = 400$ minimum at $f = 500$. (51 Ho, Figure 372)

RUBBER (Filled Butyl). $T = 26^\circ\text{C}$. $f = 100$ to $5,250$. $G' = 760$ to $2,150$ and $G'' = 310$ to $1,440$. (51 Ho, Figure 376)

RUBBER (Filled Butyl, 40 parts by weight of MPC carbon black). $f = 1$ to $10,000$. At $T = 5^\circ\text{C}$, $G' = 145$ to $5,800$ and $G'' = 32$ to $9,860$. At $T = 35^\circ\text{C}$, $G' = 145$ to $1,090$ and $G'' = 580$ to $1,410$. (64 Sno*)

RUBBER (Butyl, M-169A-Butyl Gum). $T = 65^\circ\text{C}$. $f = 100$ to $5,250$. $G' = 55$ to 120 and $G'' = 12$ to 106 . (51 Ho, Figure 371)

RUBBER (GR-S). $T = 50^\circ\text{C}$. At $f = 100$, $G' = 522$ and $G'' = 796$. At $f = 400$, $G' = 522$ and $G'' = 811$. (44 D)

RUBBER (GR-S). $T = 5^\circ\text{C}$. At $f = 1,000$, $E' = 985$ and $E'' = 532$. At $f = 4,000$, $E' = 1,630$ and $E'' = 1,310$. (49 Wit)

RUBBER (GR-S). $T = 54^\circ\text{C}$. At $f = 1,000$, $E' = 627$ and $E'' = 643$. At $f = 4,000$, $E' = 700$ and $E'' = 1,095$. (49 Wit)

RUBBER (GR-S, type S-50, carbon filled, vulcanized). $T = 20^\circ\text{C}$. At $f = 4,000$, $E' = 1,390$ and $E'' = 278$. At $f = 10,000$, $E' =$

1,610 and $E'' = 1,370$. (50 No, 61 U*)

RUBBER (GR-S). $T = 30$ to 75°C . At $f = 0.001$, $G' = 212$ and $G'' = 35$. At $f = 0.01$, $G' = 262$ and $G'' = 42$. At $f = 0.1$, $G' = 283$ and $G'' = 49$. At $f = 1.0$, $G' = 427$ and $G'' = 71$. (53 Ph)

RUBBER (GR-S). $T = 30$ to 75°C . At $f = 10$, $G' = 637$ and $G'' = 113$. At $f = 40$, $G' = 708$ and $G'' = 142$. At $f = 100$, $G' = 850$ and $G'' = 170$. At $f = 400$, $G' = 990$ and $G'' = 212$. (53 Ph)

RUBBER (GR-S). $T = 3^{\circ}\text{C}$. At $f = 0.1$, $G' = 12$ and $G'' = 19$. At $f = 1.0$, $G' = 133$ and $G'' = 58$. At $f = 10.0$, $G' = 217$ and $G'' = 79$. (57 F1)

RUBBER (GR-S). $T = 20^{\circ}\text{C}$. $f = 10$ to $10,000$. $E' = 218$ to 854 and $E'' = 54$ to $1,130$. $E' \approx 800$ for $f > 600$. (49 I, 61 U*, Figure 375)

RUBBER (GR-S). $f < 10$. $T = -60$ to -40°C . $G' = 7,200$ at η maximum ≈ 0.5 . (61 U*)

RUBBER (GR-S, Krylene). $T = 20^{\circ}\text{C}$. $f = 1$ to $10,000$. $\eta = 0.11$ to 0.30 . At maximum η , $G' = 100$. (61 U*)

RUBBER (GR-S, 3% Styrene). $T = 51^{\circ}\text{C}$. $f = 365$ to $1,368$. $E' = 351$ to 453 and $E'' = 98$ to 178 . (56 Mo, 61 U*, Figure 377)

RUBBER (GR-S, 13% Styrene). $T = 51^{\circ}\text{C}$. $f = 473$ to $1,735$. $E' = 597$ to 816 and $E'' = 143$ to 269 . (56 Mo, Figure 378)

RUBBER (GR-S, 23% Styrene). $T = 50^{\circ}\text{C}$. $f = 472$ to $1,736$. $E' = 583$ to 717 and $E'' = 175$ to 337 . (56 Mo, Figure 379)

RUBBER (GR-S, 23.5% Styrene). $T = 5^{\circ}\text{C}$. $f = 422$ to $1,530$. $E' = 481$ to 598 and $E'' = 140$ to 311 . (56 Mo, 61 U*, Figure 380)

RUBBER (Hevea, filled). $T = 20^{\circ}\text{C}$. $f = 1$ to $10,000$. $\eta = 0.11$ to 0.25 . At maximum η , $G' = 870$. (61 U*)

RUBBER (Hevea, vulcanized). $T = 20^{\circ}\text{C}$. $f = 1$ to $10,000$. $\eta = 0.03$ to 0.20 . At maximum η , $G' = 870$. (61 U*)

RUBBER (Natural, gum stock, Type N-1). $T = 20^{\circ}\text{C}$. $f = 1$ to $1,000$. $\eta = 0.04$ to 0.30 . At maximum η , $G' = 150$. (61 U*)

RUBBER (Natural, gum stock). $T = 50^{\circ}\text{C}$. At $f = 100$, $G' = 47$ and $G'' = 2.1$. At $f = 400$, $G' = 50$ to $G'' = 2.5$. (44 D)

RUBBER (Natural, gum stock). $T = 20^{\circ}\text{C}$. At $f = 0.01$, $E' = 24$ and $E'' = 1.9$. At $f = 0.1$, $E' = 29$ and $E'' = 4.3$. At $f = 1.0$, $E' = 43$ and $E'' = 18.7$. (50 No)

RUBBER (Natural, gum stock). $T = 79^{\circ}\text{C}$. At $f = 100$, $G' = 91$ and $G'' = 14.6$. At $f = 400$, $G' = 100$ and $G'' = 19.8$. At $f = 1,000$, $G' = 100$ and $G'' = 19.8$. (57 Fit)

RUBBER (Natural, gum stock). $T = 60^{\circ}\text{C}$. At $f = 100$, $G' = 98$ and $G'' = 13.3$. At $f = 400$, $G' = 107$ and $G'' = 15.2$. At $f = 1,000$, $G' = 109$ and $G'' = 21.3$. (57 Fit)

RUBBER (Natural, gum stock). $T = 25^{\circ}\text{C}$. At $f = 100$, $G' = 100$ and $G'' = 13.3$. At $f = 400$, $G' = 106$ and $G'' = 16.1$. At $f = 1,000$, $G' = 114$ and $G'' = 30.1$. (57 Fit)

RUBBER (Natural, gum stock). $T = 65^{\circ}\text{C}$. $f = 100$ to $5,280$. $G' = 51$ to 74 and $G'' = 6.8$ to 11.5 . $G'' \approx 6.8$ for $f < 1,000$.
(51 Ho, Figure 366)

RUBBER (Natural, gum stock). $T = 26^{\circ}\text{C}$. $f = 100$ to $5,280$. $G' = 43$ to 80 and $G'' = 3.2$ to 20.7 . $G' \approx 50$ for $f < 100$. (51 Ho, Figure 367)

RUBBER (Natural, high M.W.). $f < 10$. $T = -70$ to -50°C . $G' = 1,500$ at η maximum ≈ 0.5 . (61 U*)

RUBBER (Natural, tire tread stock). $T = 25 \pm 50^{\circ}\text{C}$. $f = 1$ to 500 .
 $\eta = 0.16$ to 0.20 . At maximum η , $G' = 150$. (61 U*)

RUBBER (Natural). $f = 1$ to $10,000$. At $T = 5^{\circ}\text{C}$, $G' = 67$ to 116 and $G'' = 1.5$ to 52.2 . At $T = 35^{\circ}\text{C}$, $G' = 67$ to 72 and $G'' = 1.5$ to 5.8 . (64 Sno*)

RUBBER (Filled natural, 50 parts by weight of HAF carbon black).
 $f = 1$ to $10,000$. At $T = 5^{\circ}\text{C}$, $G' = 1,020$ to $1,520$ and $G'' = 112$ to 608 . At $T = 35^{\circ}\text{C}$, $G' = 870$ to $1,380$ and $G'' = 96$ to 248 . (64 Sno*)

RUBBER (Filled). For all f and T . Maximum $\eta = 0.5$ and $G' = 3.33 \times 10^4$ at $f = 140$, $T = -23^{\circ}\text{C}$. (61 U*)

RUBBER (Hard). For all f and T . Maximum $\eta = 1.0$ and $G' = 1.01 \times 10^4$ at $f = 40$, $T = 60^{\circ}\text{C}$. (61 U*)

RUBBER (Neoprene). $T = 20^{\circ}\text{C}$. $f = 3,000$. $E' = 97,000$ and $E'' = 450$. (49 H1)

RUBBER (Neoprene, GN-50, vulcanized). $T = 20^{\circ}\text{C}$. $f = 1,000$ to $10,000$. $\eta = 0.7$ to 1.1 . At maximum η , $G' = 290$. (50 No, 61 U*)

RUBBER (Neoprene). $T = 28^{\circ}\text{C}$. At $f = 40$, $G' = 0.0022$ and $G'' = 0.28$. At $f = 100$, $G' = 0.0023$ and $G'' = 0.21$. (42 St)

RUBBER (Neoprene). $T = 20^{\circ}\text{C}$. 10% static deflection. At $f = 4,000$, $E' = 12,400$ and $E'' = 34,800$. At $f = 10,000$, $E' = 15,900$ and $E'' = 71,500$. (50 No)

RUBBER (Neoprene). $T = 20^{\circ}\text{C}$. 35% static deflection. At $f = 4,000$, $E' = 10,700$ and $E'' = 38,500$. At $f = 10,000$, $E' = 11,700$ and $E'' = 70,000$. (50 No)

RUBBER (Neoprene). $T = 20^{\circ}\text{C}$. 5% static deflection. At $f = 4,000$, $E' = 700$ and $E'' = 196$. At $f = 10,000$, $E' = 990$ and $E'' = 845$. (50 No)

RUBBER (Neoprene). $T = 30^{\circ}\text{C}$. $f = 461$ to $1,775$. $E' = 612$ to 671 and $E'' = 409$ to 790 . (56 Mo, 61 U*, Figure 382)

RUBBER (Neoprene). $T = 25^{\circ}\text{C}$. $f = 1$ to $10,000$. $G' = 116$ to 160 and $G'' = 12.8$ to 48.0 . (64 Sno*)

RUBBER (Neoprene). Shear properties measured by one to four methods. At $T = 35^{\circ}\text{F}$: $G' = 10^3$ to 10^4 and $G'' = 2 \times 10^3$ at $f = 50$, $G' = 10^4$ to 10^5 and $G'' = 10^4$ at $f = 1,000$. At $T = 60^{\circ}\text{F}$: $G' = 100$ to 600 and $G'' = 20$ to 400 at $f = 3$, $G' = 400$ and $G'' = 300$ to 10^3 at $f = 100$, $G' = 10^3$ to 2×10^4 and $G'' = 10^3$ to

10^4 at $f = 1,000$. At $T = 130^\circ\text{F}$: $G' = 60$ to 200 and $G'' = 10$ to 40 at $f = 30$, $G' = 200$ to 700 and $G'' = 40$ to 70 at $f = 100$, $G' = 300$ to $2,000$ and $G'' = 70$ to 700 at $f = 1,000$. (65 B1)

RUBBER (Nitrile). For all f and T . Maximum $\eta = 0.8$ and $G' = 1.59 \times 10^4$ at $f = 1,800$, $T = 20^\circ\text{C}$. (61 U*)

RUBBER (Nitrile). $T = 10^\circ\text{C}$. At $f = 2 \times 10^6$, $G' = 5.38 \times 10^5$ and $G'' = 1.88 \times 10^5$. At $f = 5 \times 10^6$, $G' = 5.38 \times 10^5$ and $G'' = 1.56 \times 10^5$. At $f = 10^7$, $G' = 5.38 \times 10^5$ and $G'' = 1.35 \times 10^5$. (52 No)

RUBBER (Nitrile). $T = 0^\circ\text{C}$. At $f = 2 \times 10^6$, $G' = 5.9 \times 10^5$ and $G'' = 1.12 \times 10^5$. At $f = 5 \times 10^6$, $G' = 5.9 \times 10^5$ and $G'' = 1.12 \times 10^5$. At $f = 10^7$, $G' = 5.9 \times 10^5$ and $G'' = 0.94 \times 10^5$. (52 No)

RUBBER (Nitrile). $T = -10^\circ\text{C}$. At $f = 2 \times 10^6$, $G' = 6.18 \times 10^5$ and $G'' = 7.4 \times 10^4$. At $f = 5 \times 10^6$, $G' = 6.18 \times 10^5$ and $G'' = 8.0 \times 10^4$. At $f = 10^7$, $G' = 6.18 \times 10^5$ and $G'' = 6.8 \times 10^4$. (52 No)

RUBBER (Nitrile). $T = 0^\circ\text{C}$. At $f = 1$, $E' = 870$ and $E'' = 392$. At $f = 10$, $E' = 1,335$ and $E'' = 1,600$. (54 Hu)

RUBBER (Nitrile). $T = 20^\circ\text{C}$. $f = 0.01$ to 10 . $E' = 133$ to $1,320$ and $E'' = 5.5$ to 224 . (50 No, Figure 381)

RUBBER (SBR). $f = 1$ to $10,000$. At $T = 5^\circ\text{C}$, $G' = 87$ to 157 and

$G'' = 10.4$ to 126 . At $T = 35^{\circ}\text{C}$, $G' = 78$ to 130 and $G'' = 7.8$ to 24.7 . (64 Sno*)

RUBBER (Silicone). $T = 20^{\circ}\text{C}$. At $f = 100$, $G' = 7.3$ and $G'' = 2.7$. At $f = 400$, $G' = 11.6$ and $G'' = 3.9$. At $f = 1,000$, $E' = 11.9$ and $G'' = 5.6$. (51 Ho)

RUBBER (Silicone). $T = 65^{\circ}\text{C}$. At $f = 100$, $G' = 10.2$ and $G'' = 2.5$. At $f = 400$, $G' = 13.1$ and $G'' = 2.9$. (51 Ho)

RUBBER (Silicone, P.S. C-269). $T = 25^{\circ}\text{C}$. At $f = 2$, $G' = 14.3$ and $G'' = 36$. At $f = 10$, $G' = 22.3$ and $G'' = 51$. At $f = 20$, $G' = 28.7$ and $G'' = 48$. (57 D)

RUBBER (Silicone filled). $T = 25^{\circ}\text{C}$. $f = 100$ to $5,250$. $G' = 292$ to 394 and $G'' = 37$ to 86 . (51 Ho, Figure 383)

RUBBER (Silicone filled). $T = 65^{\circ}\text{C}$. $f = 100$ to $5,250$. $G' = 165$ to 292 and $G'' = 28$ to 48 . (51 Ho, Figure 384)

RUBBER (Thiokol). $T = 19^{\circ}\text{C}$. At $f = 0.1$, $G' = 87$ and $G'' = 20$. At $f = 1.0$, $G' = 130$ and $G'' = 52$. (52 F1)

RUBBER (Thiokol). $T = 35^{\circ}\text{C}$. At $f = 1$, $G' = 82$ and $G'' = 14$. At $f = 10$, $G' = 104$ and $G'' = 49$. (57 F1)

RUBBER (Thiokol). $T = -30$ to 75°C . $f = 0.001$ to 100 . $G' = 64$ to 121 and $G'' = 7.8$ to 156 . (53 Ph, 61 U*, Figure 385)

RUBBER (Thiokol). $T = 30^{\circ}\text{C}$. $f = 359$ to $1,312$. $E' = 423$ to 555 and $E'' = 191$ to 294 . (56 Mo)

RUBBER (Thiokol RD). For all f and T . Maximum $\eta = 1.9$ and $G' = 10^4$ at $f = 7$, $T = 5^\circ\text{C}$. (61 U*)

RUBBER (Thiokol RD). At $T = 5^\circ\text{C}$: $G' = 390$ and $G'' = 585$ at $f = 1$, $G' = 1,230$ and $G'' = 2,214$ at $f = 10$. At $T = 35^\circ\text{C}$: $G' = 72$ and $G'' = 9.36$ at $f = 1$, $G' = 1.16$ and $G'' = 51.0$ at $f = 100$, $G' = 4.35$ and $G'' = 740$ at $f = 10,000$. (64 Sno*)

RUBBER (Thiokol H-5). $T = 25 \pm 50^\circ\text{C}$. $f = 1$ to $1,000$. $\eta = 0.17$ to 5.0 . At maximum η , $G' = 1,500$. (61 U*)

RUBBER (Thiokol ST). $T = 20^\circ\text{C}$. $f = 100$ to $1,300$. $\eta = 0.40$ to 0.53 . At maximum η , $G' = 160$. (61 U*)

RUBBER (Urethane, 82% Pb powder filler). $T = 25^\circ\text{C}$. $f = 100$ to $3,000$. $\eta = 0.4$ to 1.4 . At maximum η , $G' = 2,500$. (61 U*)

RUBBER (Urethane, Disogrin IDSA-7560). $T = 25^\circ\text{C}$. $f = 100$ to $4,250$. $\eta = 0.1$ to 0.5 . At maximum η , $G' = 1,500$. (61 U*)

RUBBER (Urethane, Disogrin IDSA-9250). $T = 25^\circ\text{C}$. $f = 100$ to $10,000$. $\eta = 0.1$ to 2.6 . At maximum η , $f = 3,000$ and $G' = 2,900$. (61 U*)

RUBBER (Urethane, Shore 80-A). For all f and T . Maximum $\eta = 0.8$ and $G' = 2,320$ at $f = 30$, $T = -8^\circ\text{C}$. (61 U*)

RUBBER (Urethane, Shore 94-A). For all f and T . Maximum $\eta = 0.4$ and $G' = 4.35 \times 10^4$ at $f = 140$, $T = -23^\circ\text{C}$. (61 U*)

SILK (Raw). $T = 25^\circ\text{C}$. $f = 10$. $G' = 1.31 \times 10^6$ and $G'' = 1.38 \times 10^4$. (51 Du)

SILK (Degummed). $T = 25^{\circ}\text{C}$. At $f = 10$, $G' = 2.34 \times 10^6$ and $G'' = 4.57 \times 10^4$. At $f = 40$, $G' = 2.34 \times 10^6$ and $G'' = 9.20 \times 10^4$. (51 Du)

SLP-83311 (Cured). $T = 25^{\circ}\text{C}$. $f = 2$ to 10 . $G' = 420$ and $G'' = 306$. (57 D)

SLP-83311 (Uncured). $T = 25^{\circ}\text{C}$. At $f = 1$, $G' = 62$ and $G'' = 92.5$. At $f = 10$, $G' = 108$ and $G'' = 230$. (57 D)

VELON (0.012 monofoil). $T = 21^{\circ}\text{C}$. $f = 180$. $E' = 9.35 \times 10^5$ and $E'' = 1.56 \times 10^5$. (49 Ly)

VINYON N (300 den yarn). $T = 21^{\circ}\text{C}$. $f = 180$. $E' = 1.55 \times 10^6$ and $E'' = 6.25 \times 10^4$. (49 Ly)

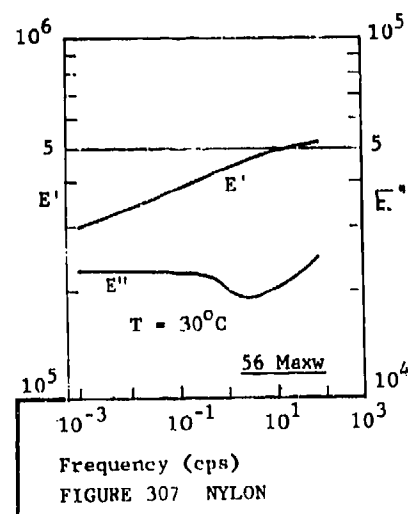
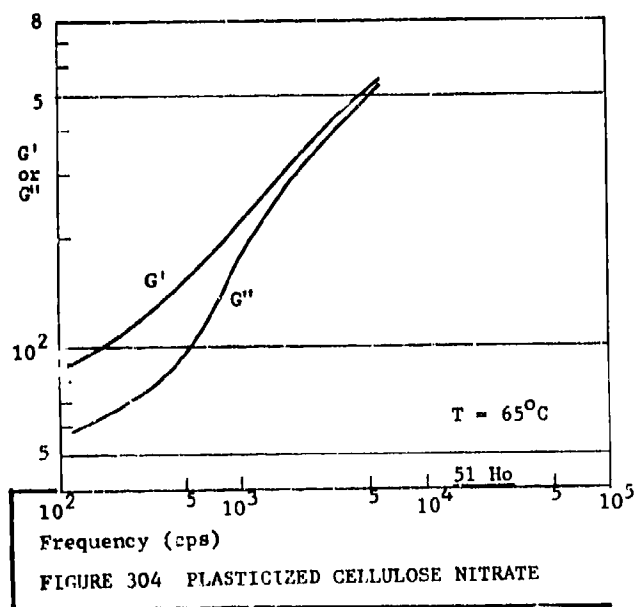
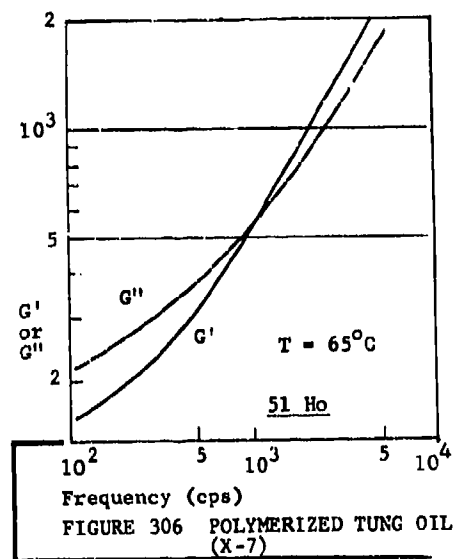
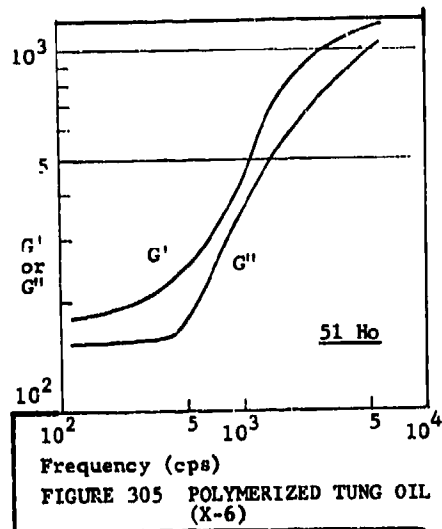
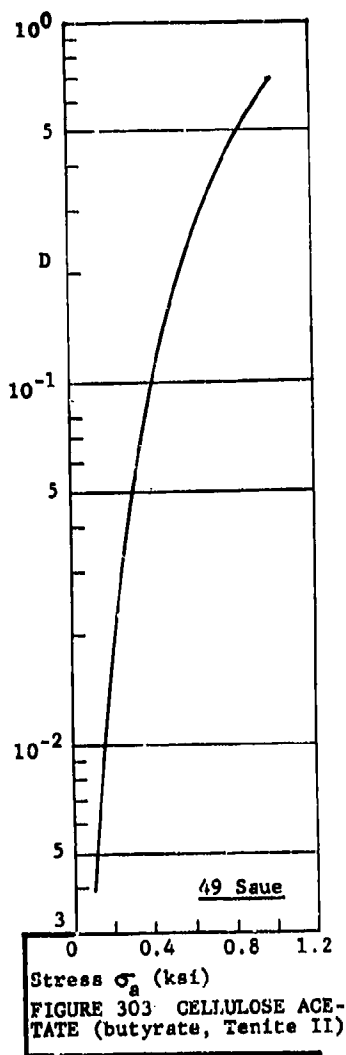
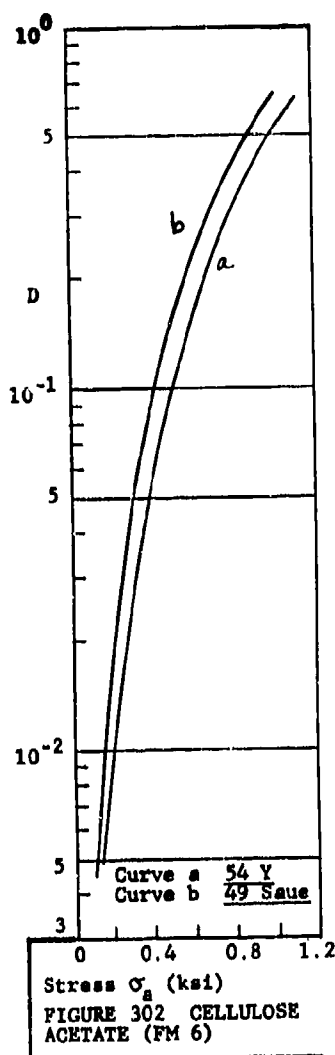
VINYPLASTA (A Russian plastic). Bending. At $T = 20^{\circ}\text{C}$, $\eta_s = 1.5 \times 10^{-2}$. At $T = -70^{\circ}\text{C}$, $\eta_s = 4 \times 10^{-2}$. (62 Pisa, Figure 339)

WOOD (Birch, Sp.Gr. = 0.74, along grain). Axial stress. $\sigma_a = 0.5$ to 6 ksi. $D = 3 \times 10^{-3}$ to 1 . (54 Y, Figure 386)

WOOD (Beech). Torsion. $\eta_s = 1.6 \times 10^{-2}$. (41 Ki*)

WOOD (Maple). Strains of about 5×10^{-3} . Rotating bending. $\eta_s = 6.7 \times 10^{-3}$. (41 Ki*)

WOOD. Bending. $f = 1$ to 10 . $\eta_s = 8.6 \times 10^{-3}$. (41 Ki*)



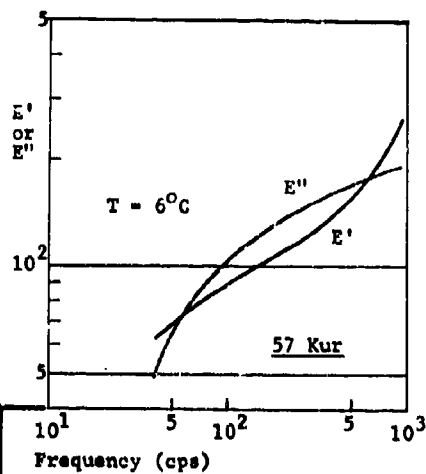


FIGURE 308 POLYHEXANE

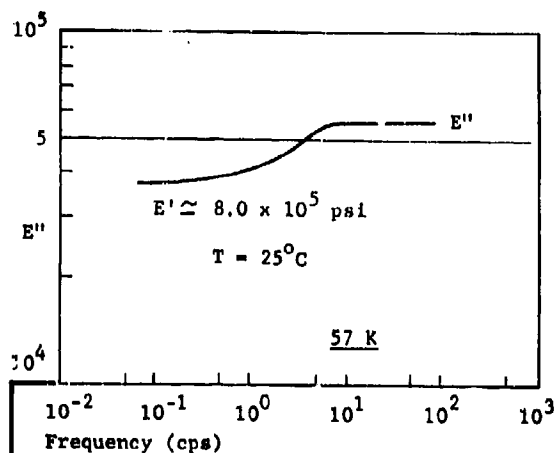


FIGURE 311 POLYMETHYL METHACRYLATE

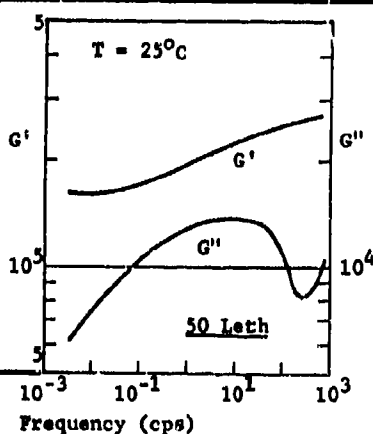


FIGURE 309 PERSPEX

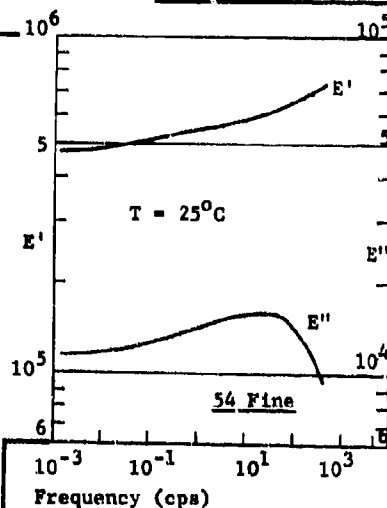


FIGURE 312 POLYMETHYL METHACRYLATE

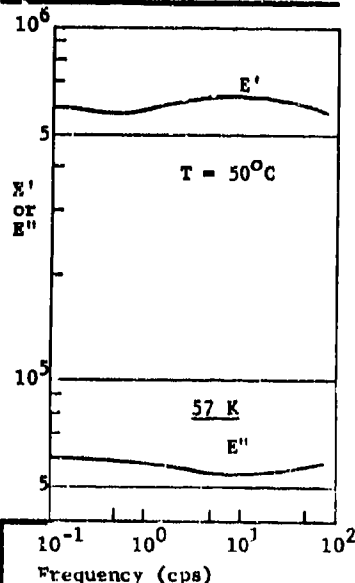


FIGURE 310 POLYMETHYL METHACRYLATE

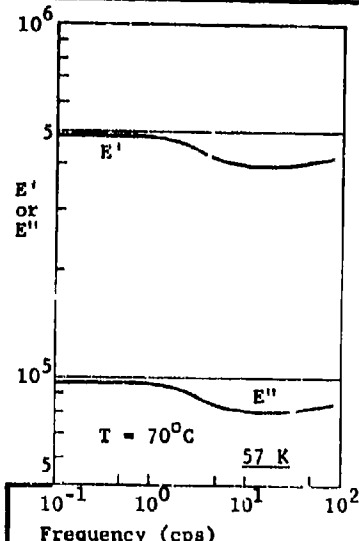


FIGURE 313 POLYMETHYL METHACRYLATE

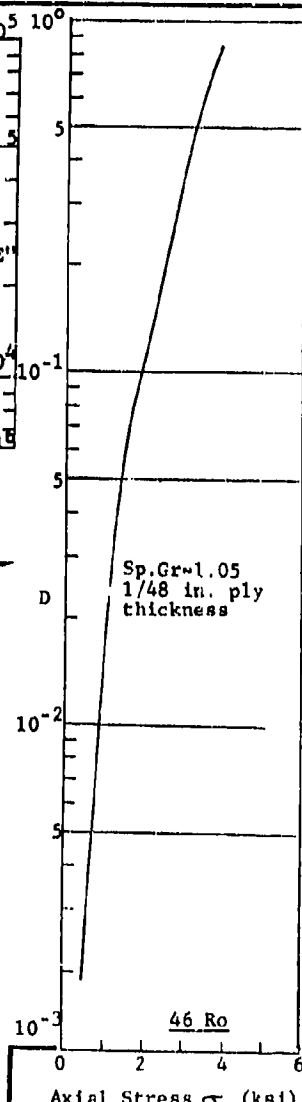
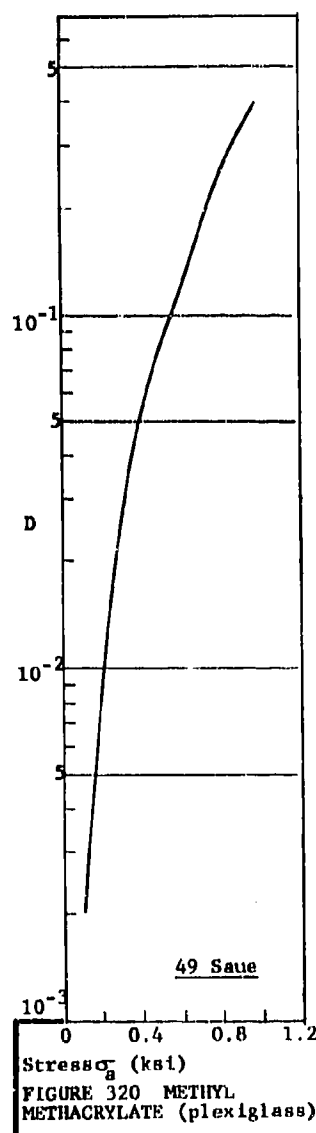
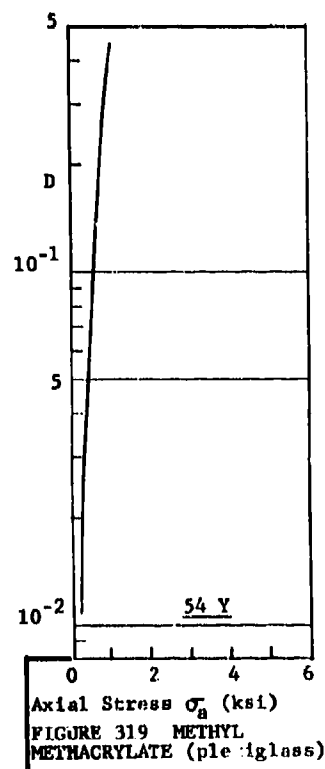
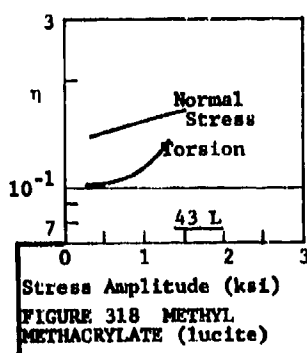
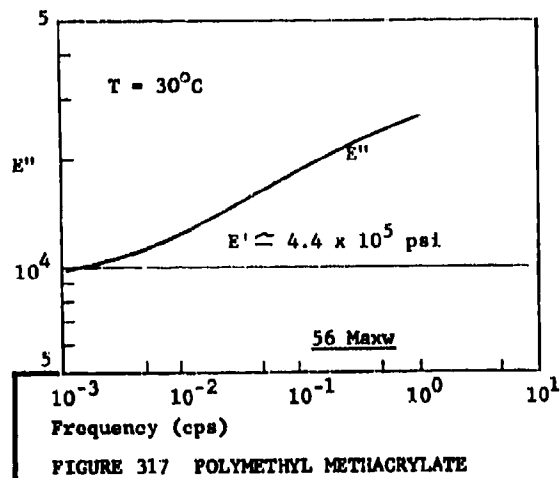
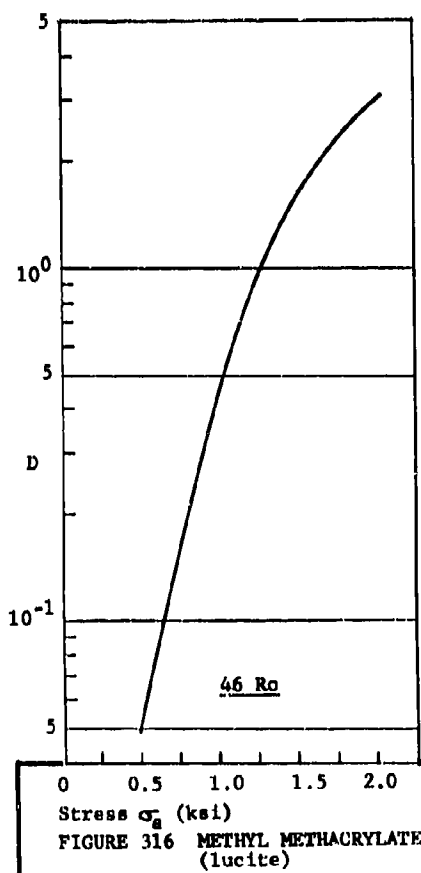
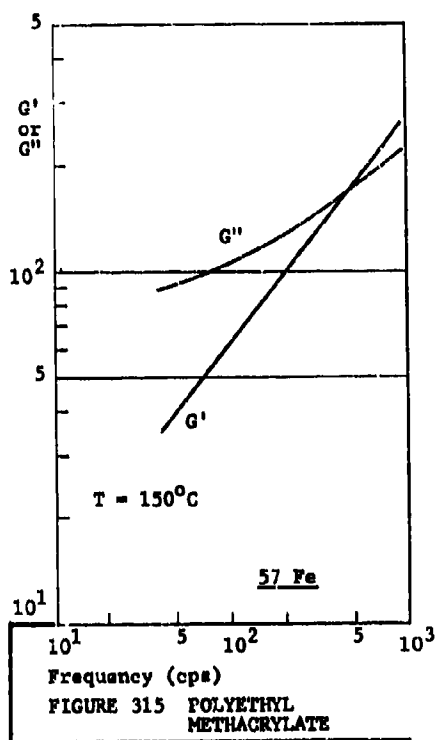
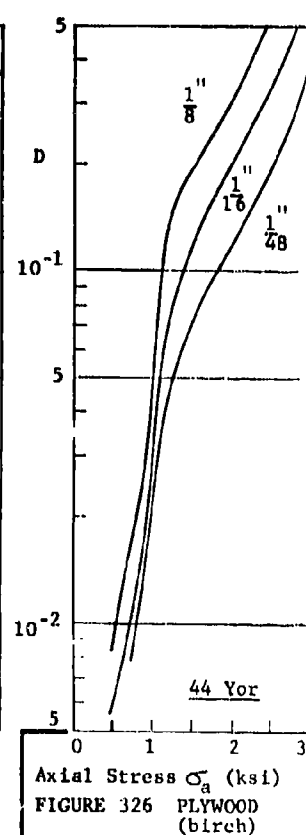
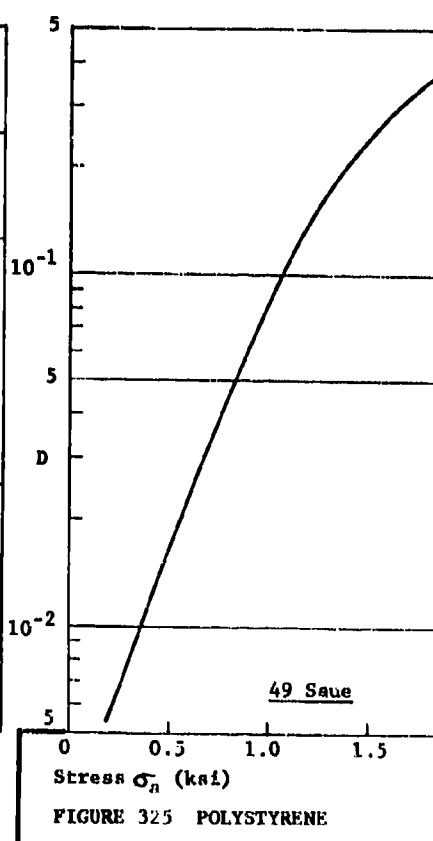
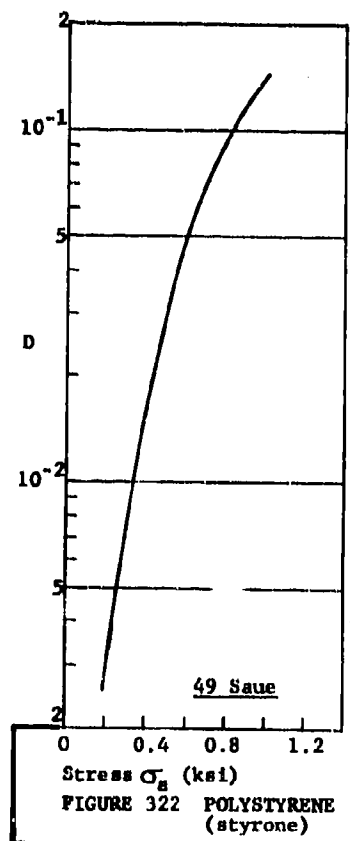
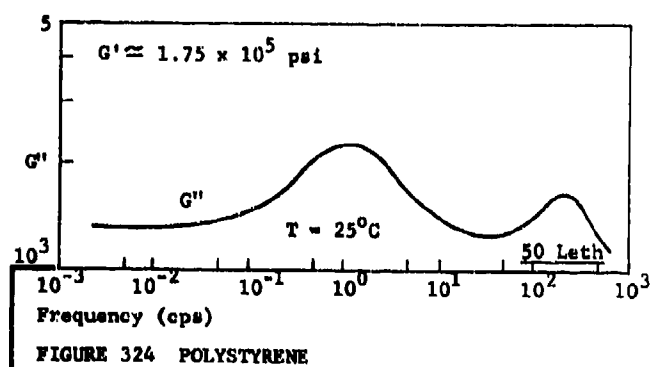
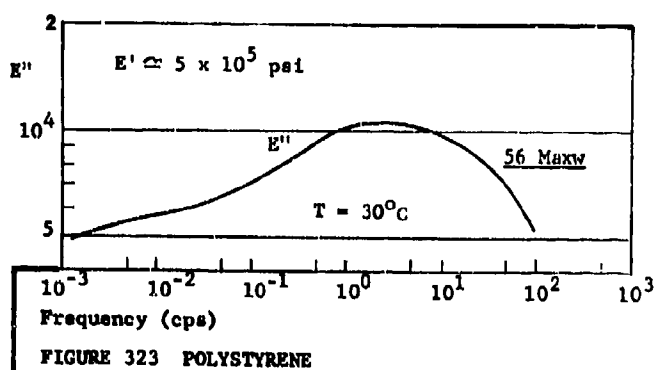
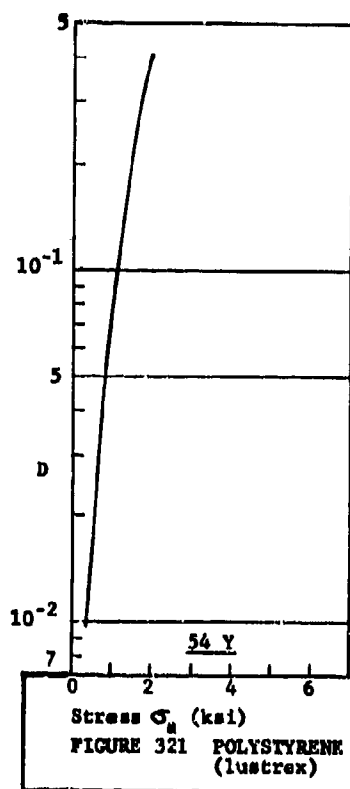
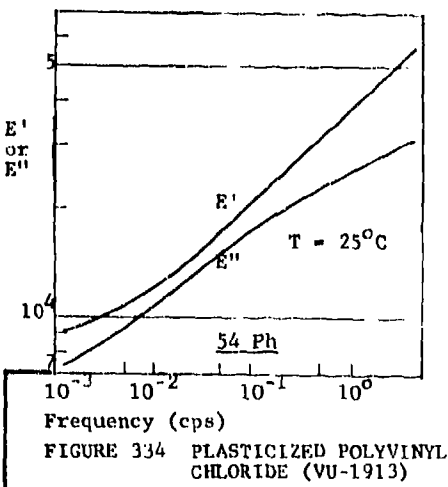
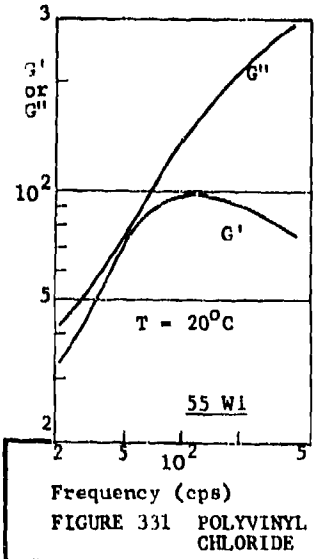
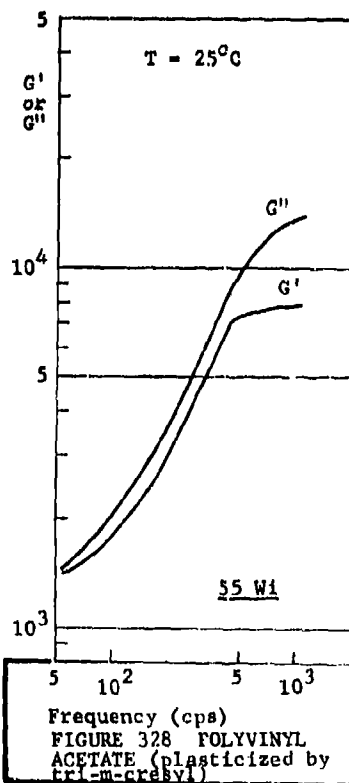
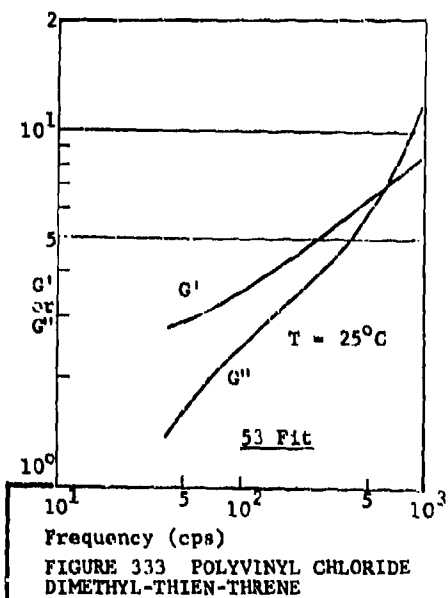
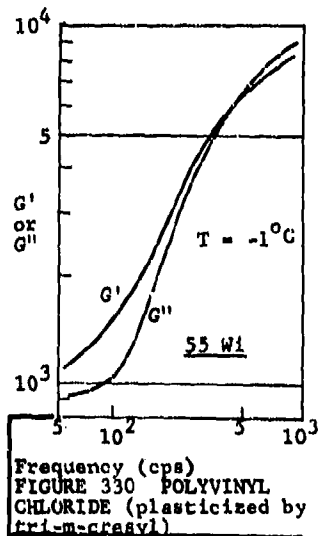
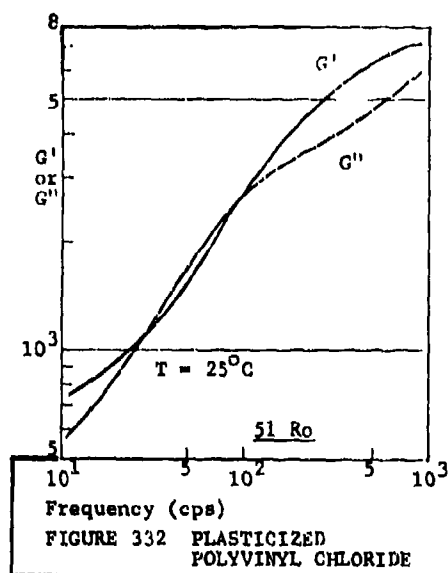
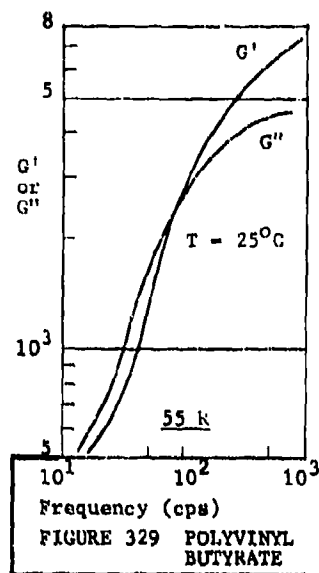
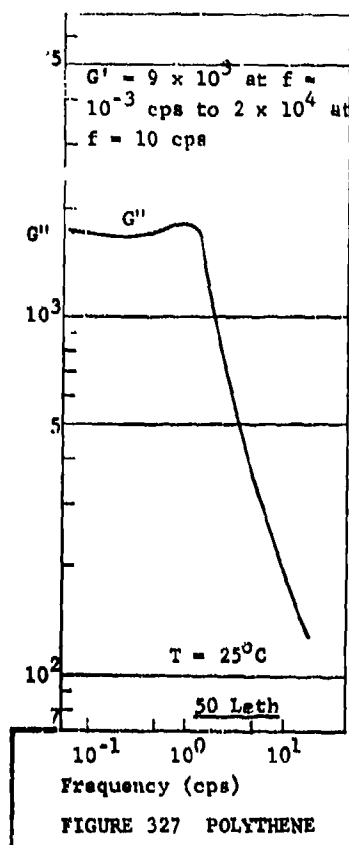
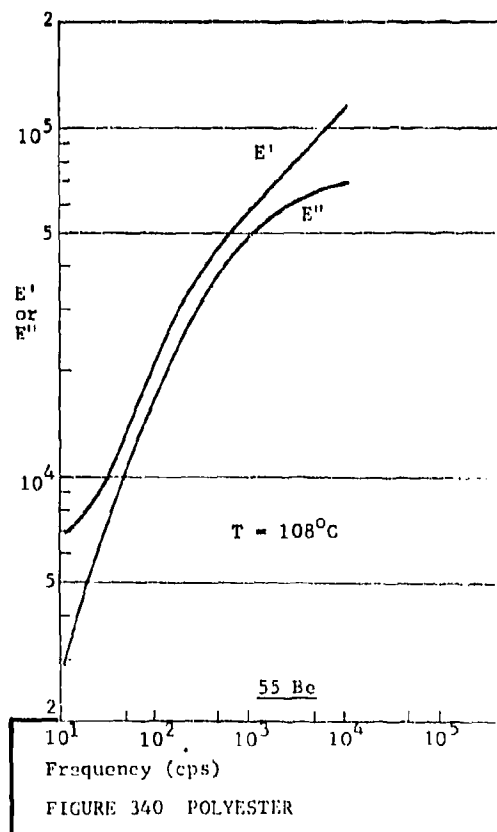
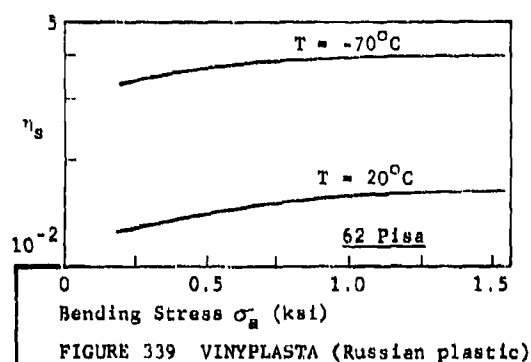
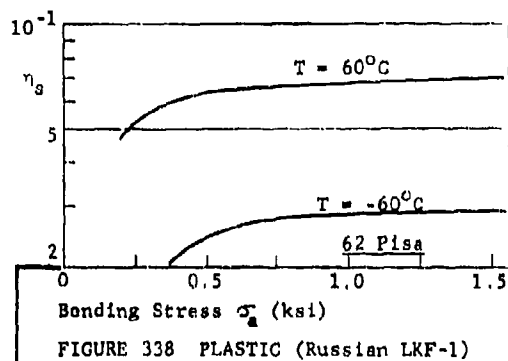
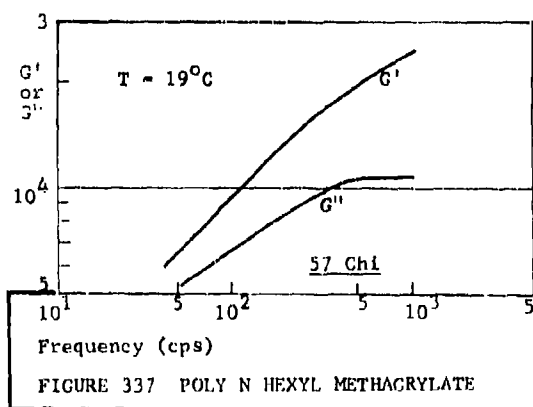
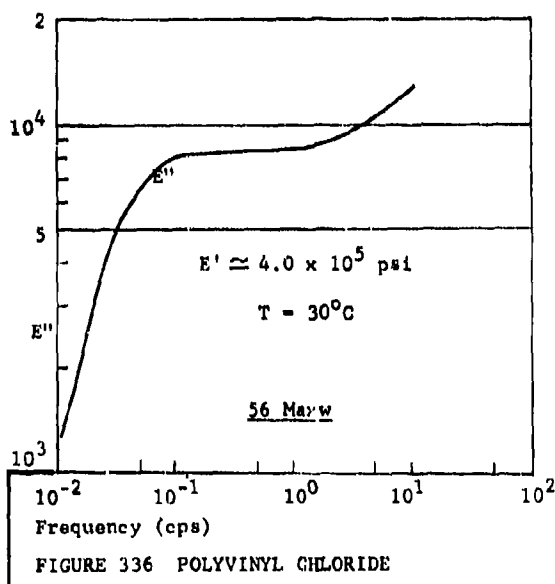
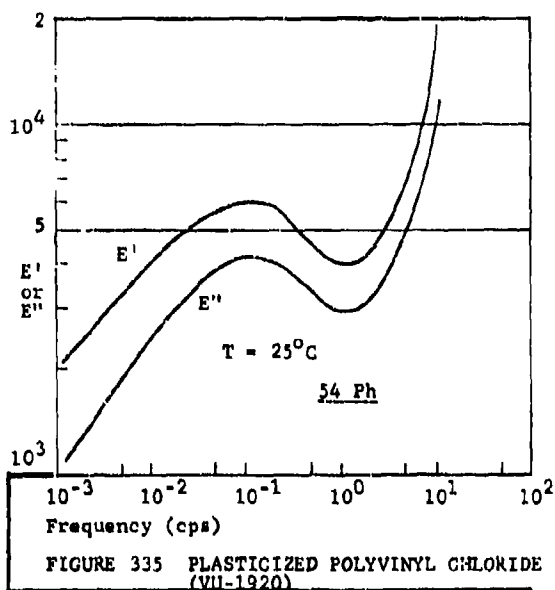


FIGURE 314 PLYWOOD (birch)









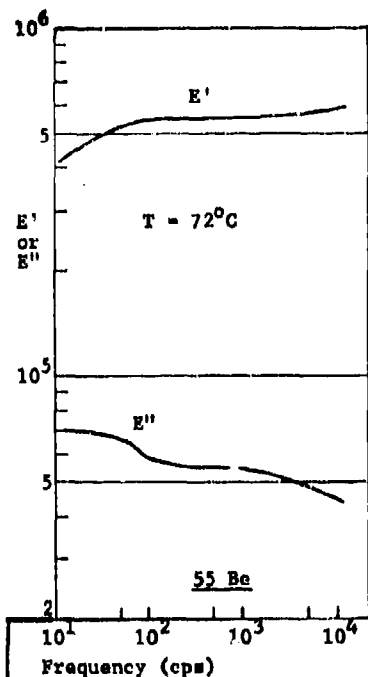


FIGURE 341 POLYESTER

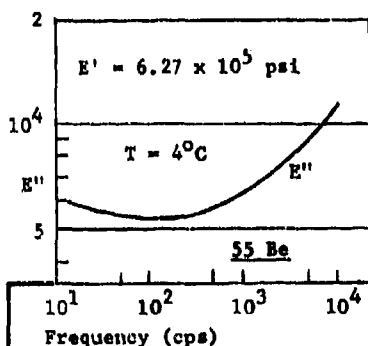


FIGURE 342 POLYESTER

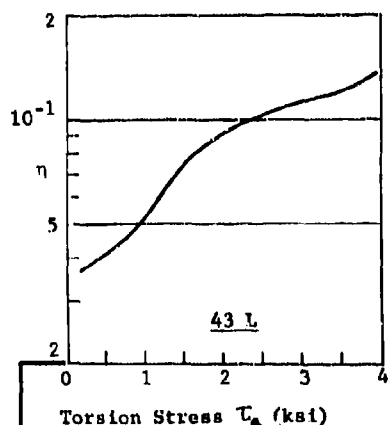


FIGURE 343 LAMINATED PLASTIC (bakelite, grade X)

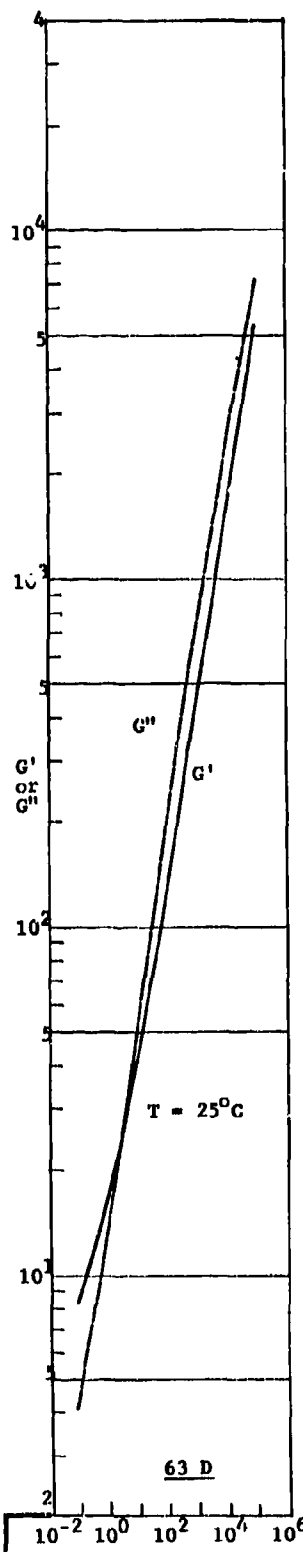


FIGURE 344 ADHESIVE (3M transfer tape #466)

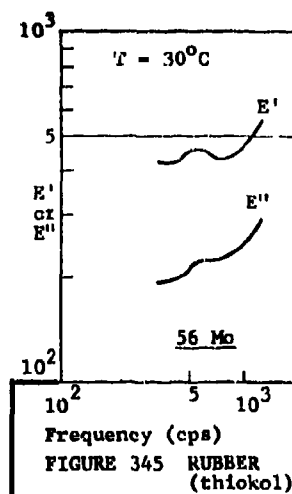


FIGURE 345 RUBBER (thiokol)

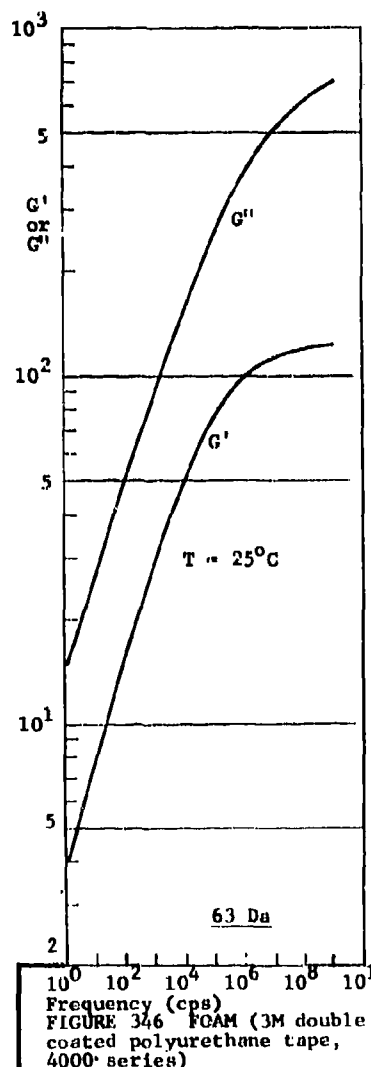
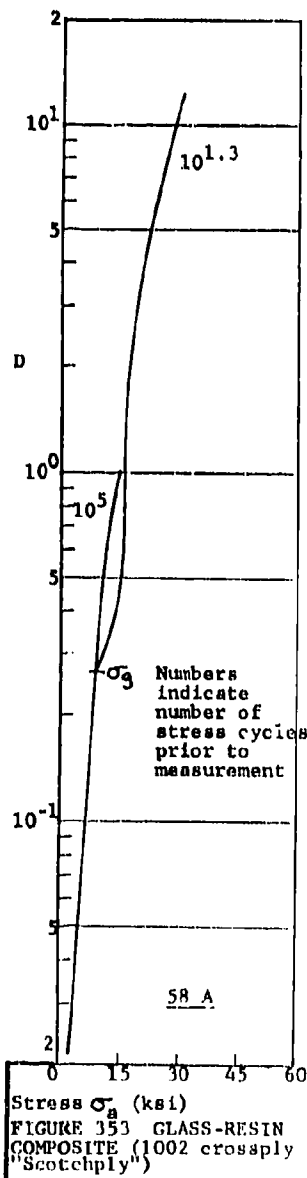
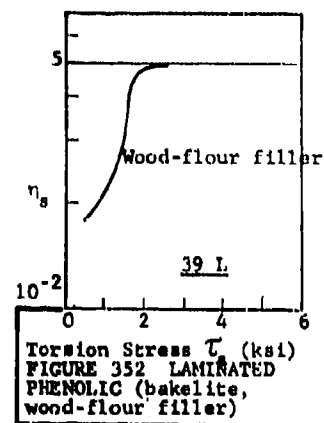
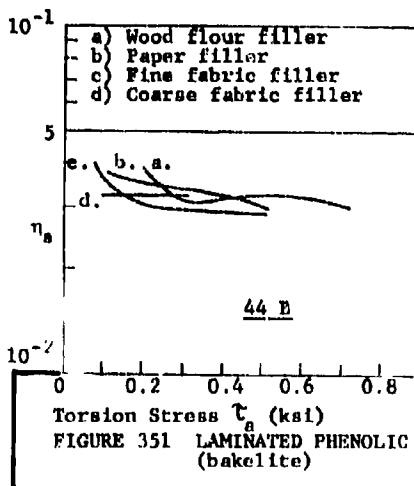
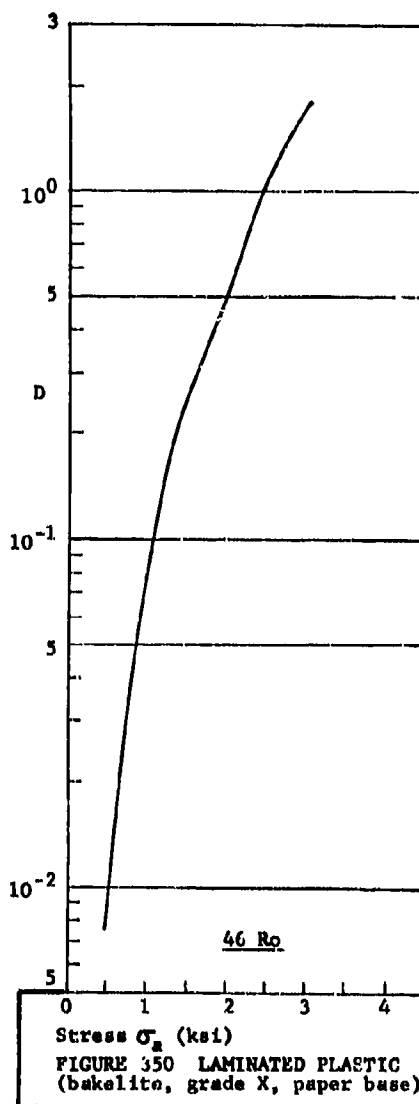
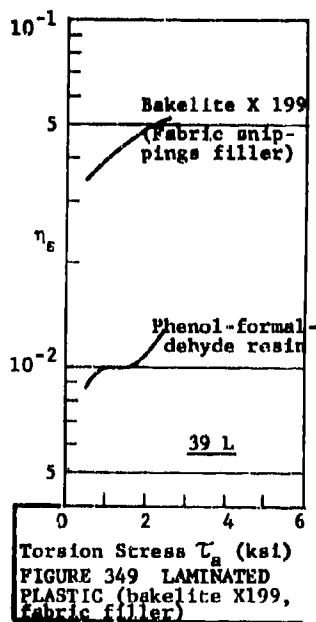
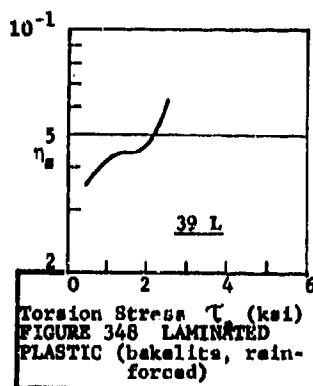
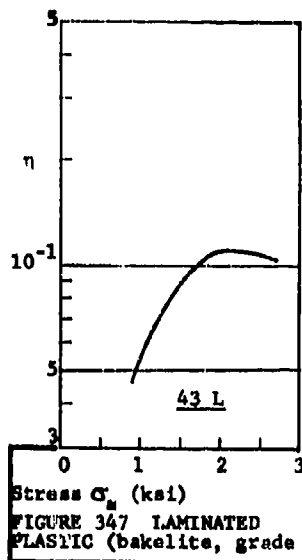
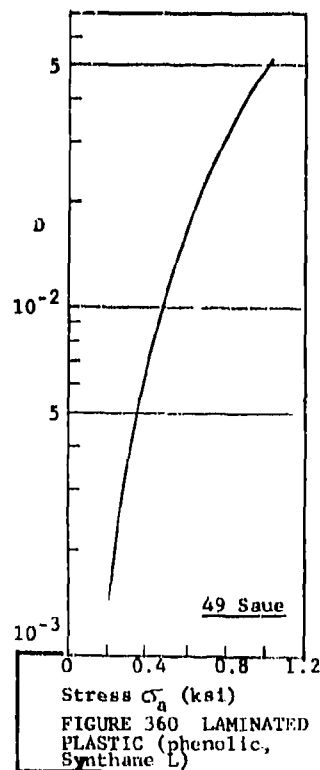
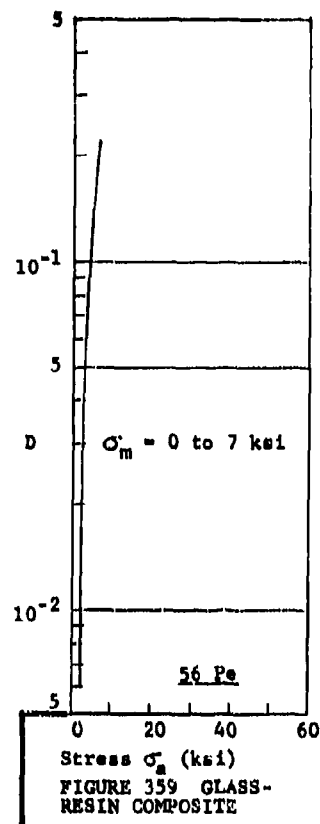
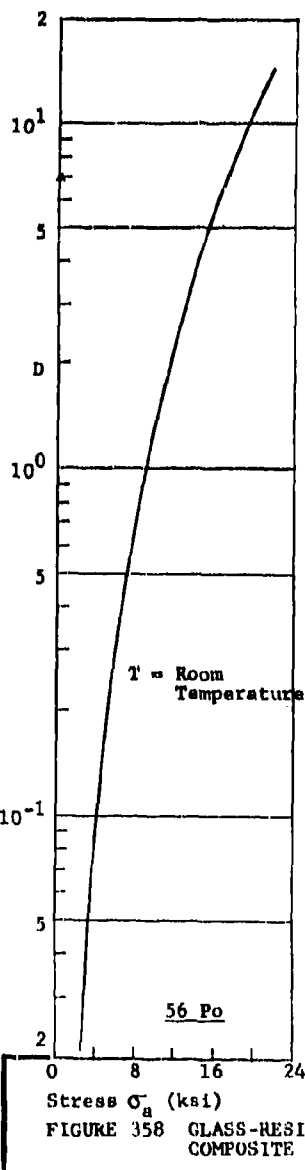
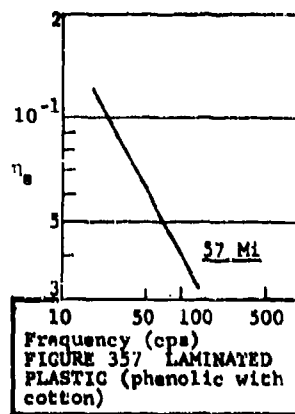
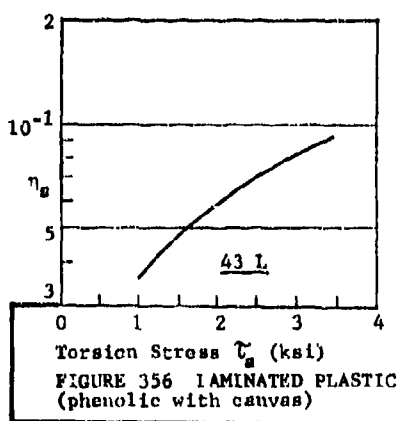
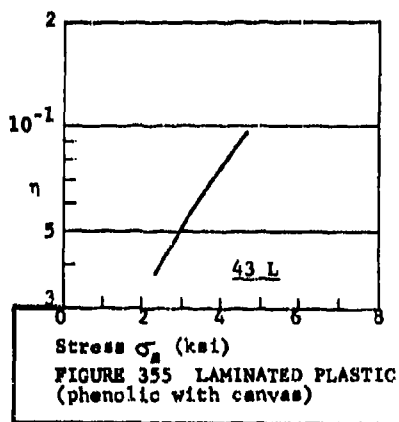
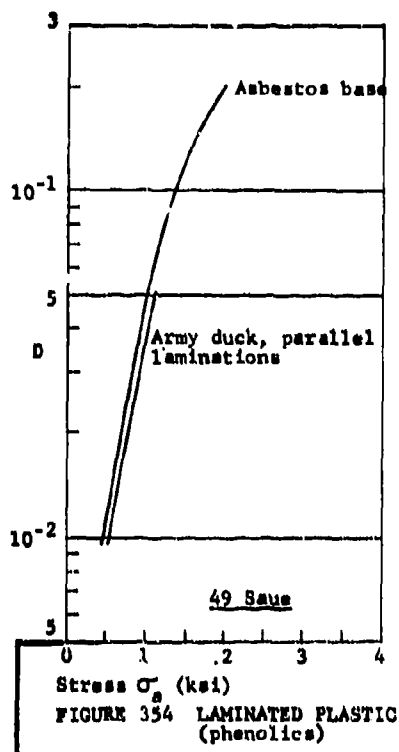
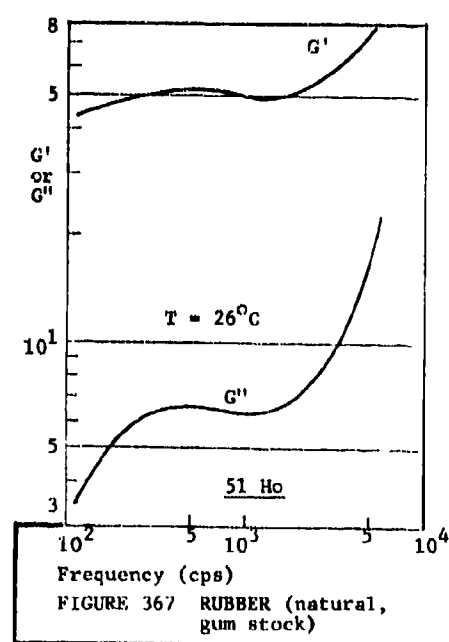
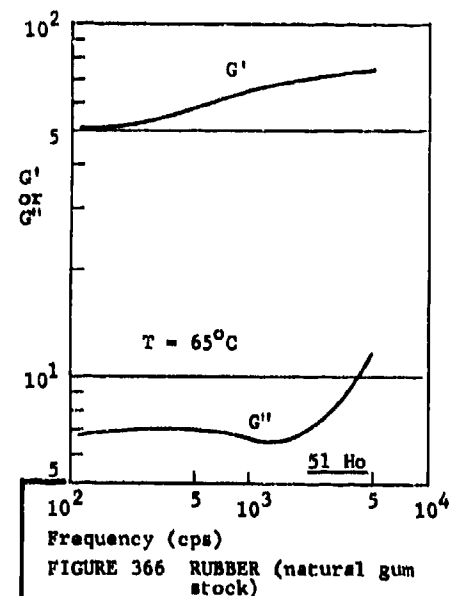
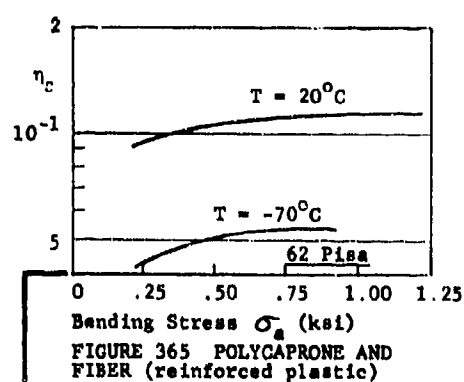
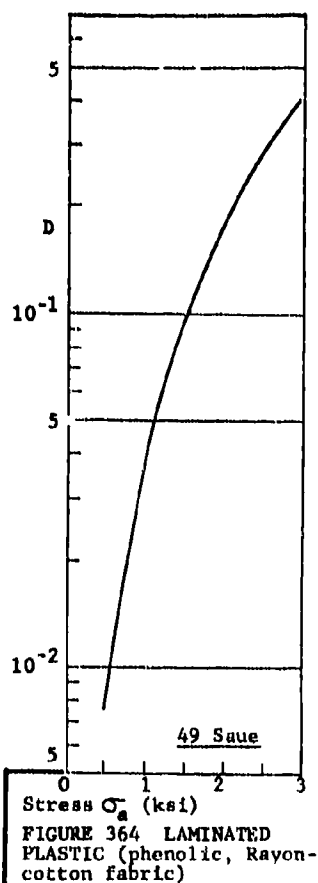
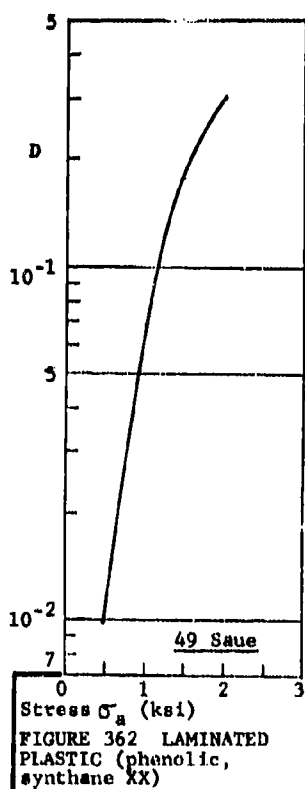
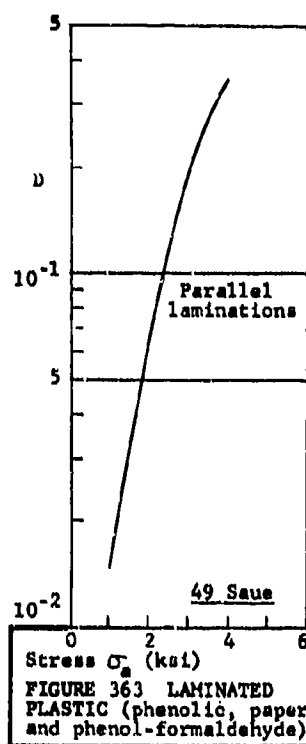
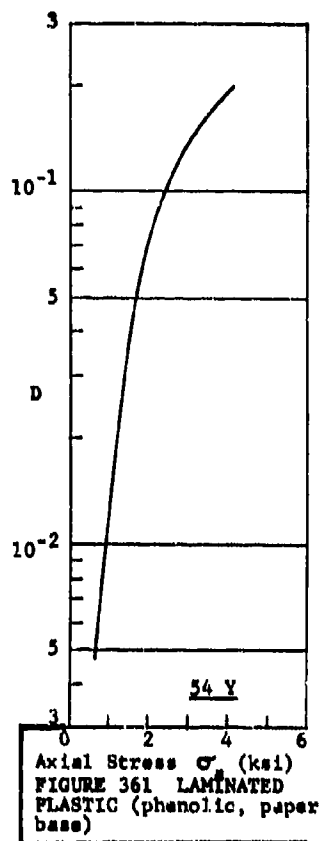
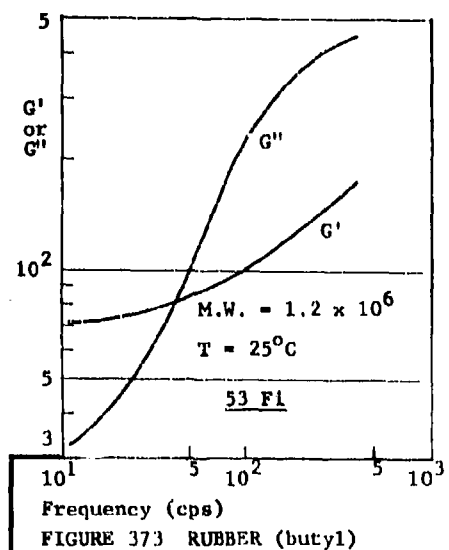
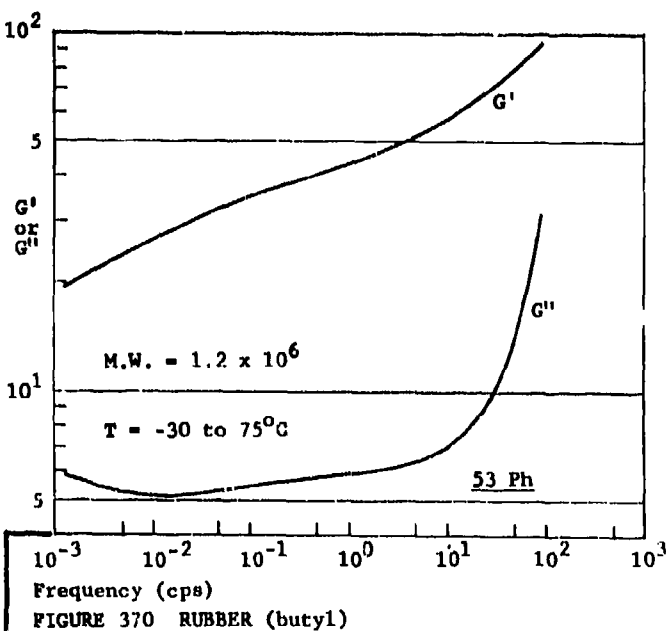
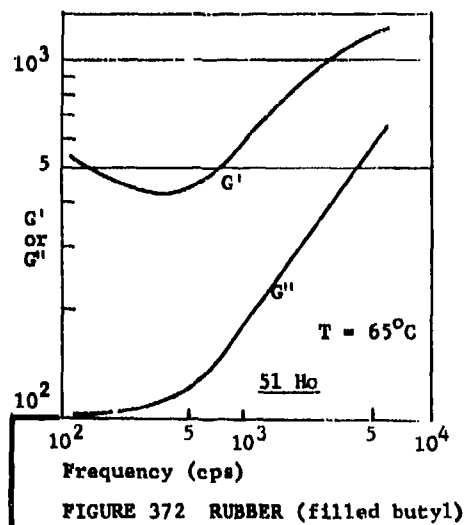
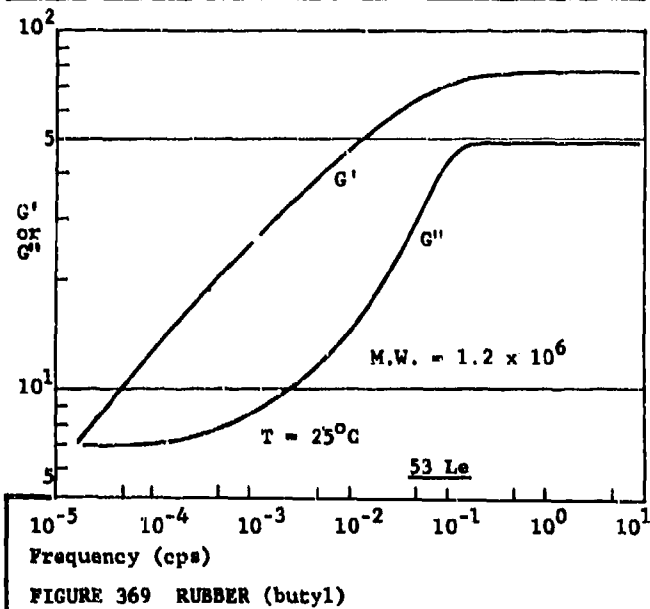
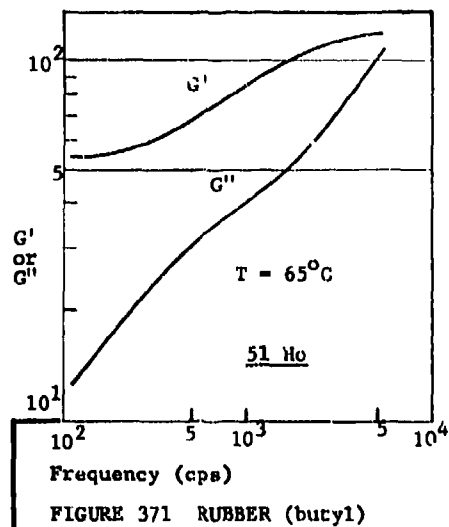
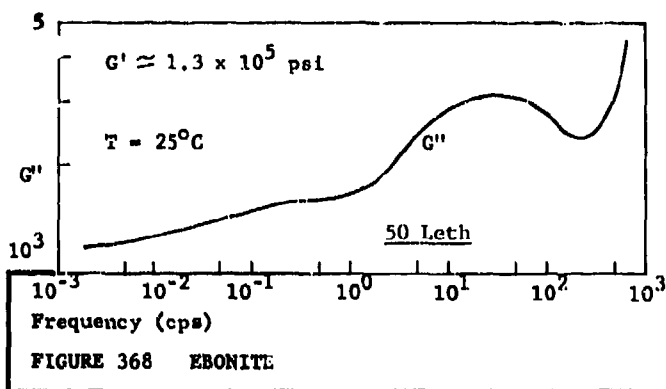


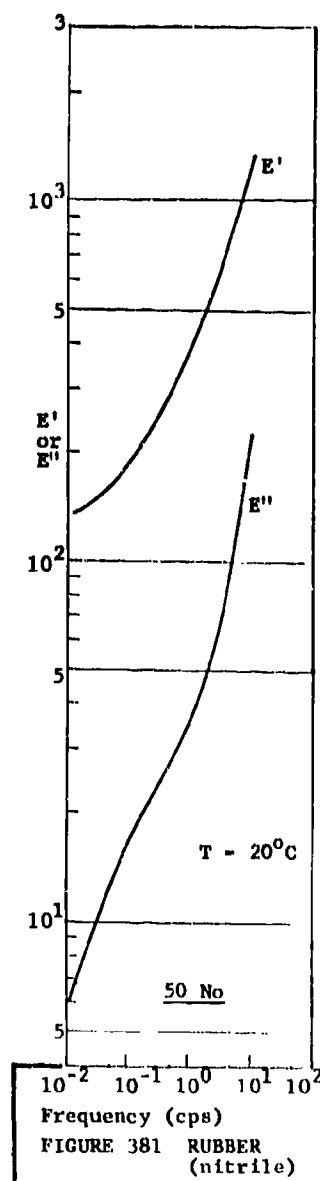
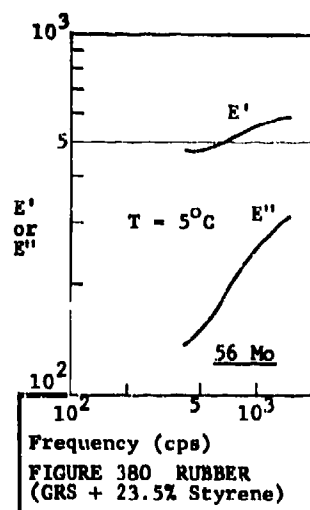
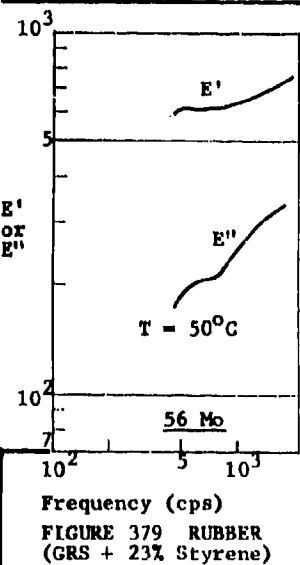
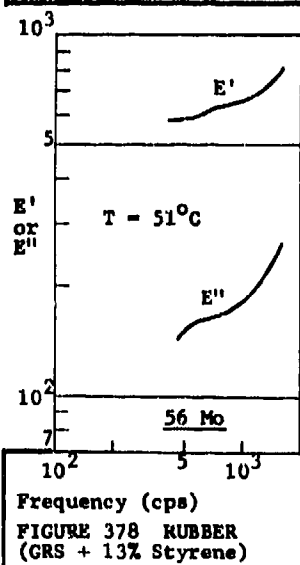
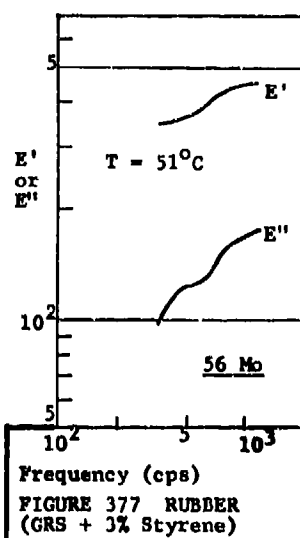
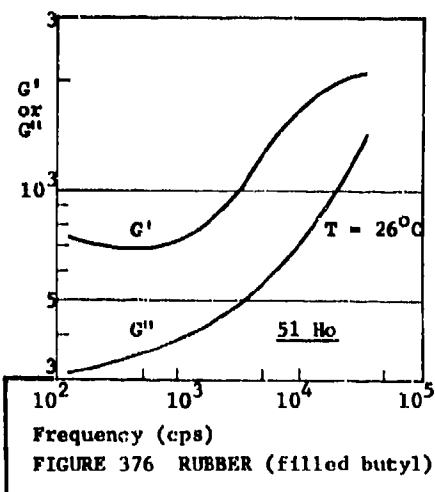
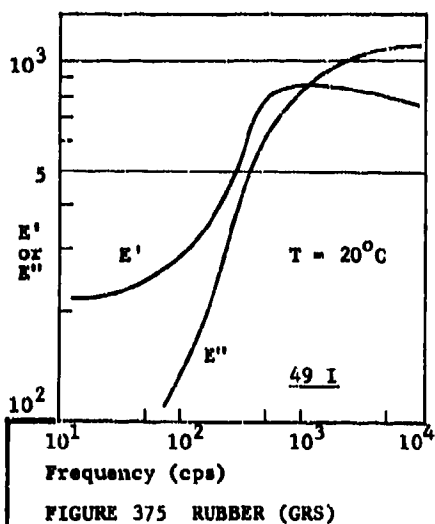
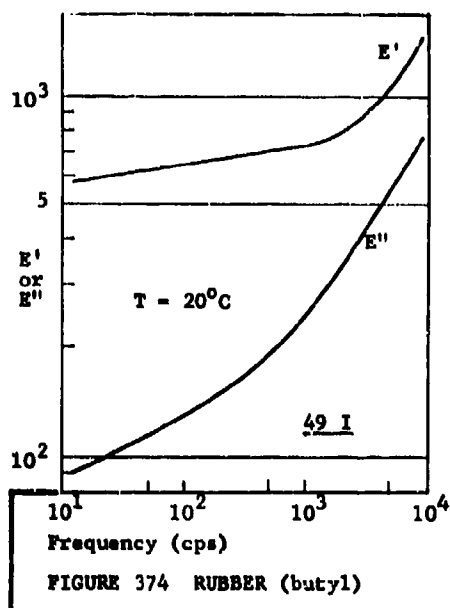
FIGURE 346 FGAM (3M double coated polyurethane tape, 4000 series)

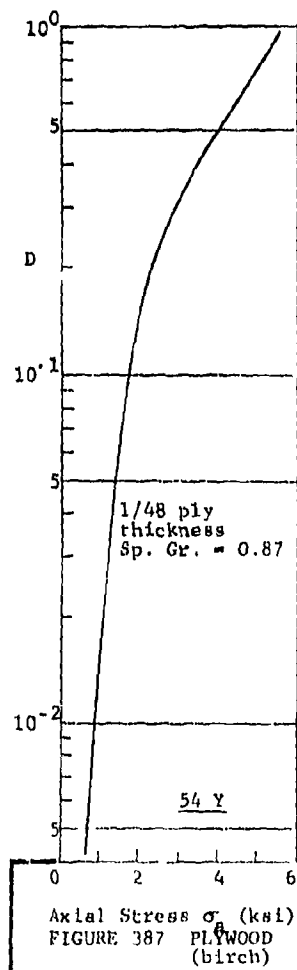
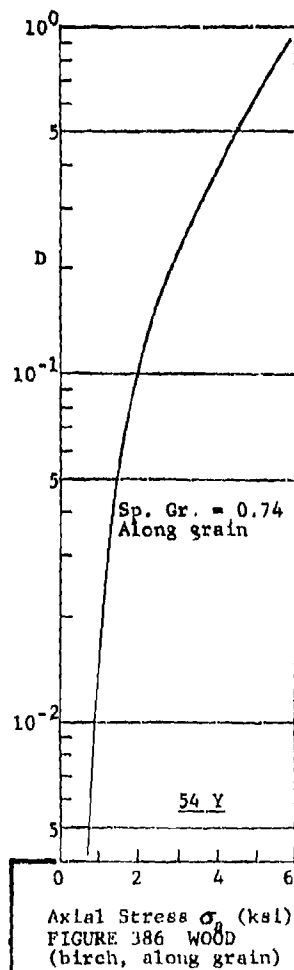
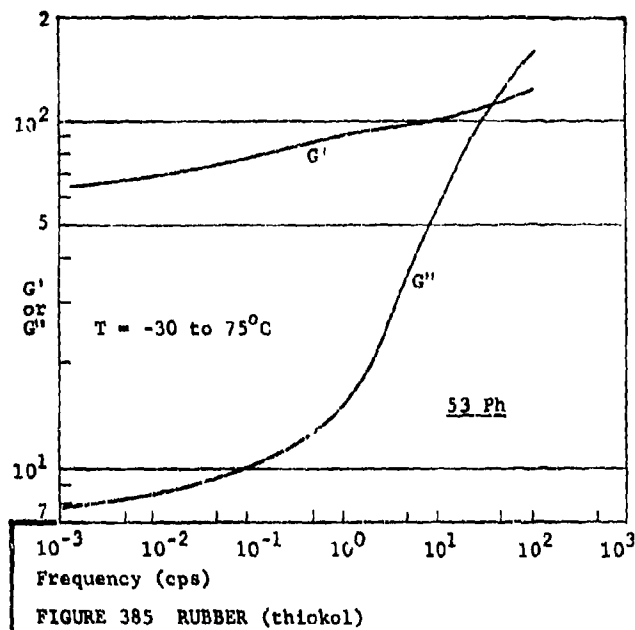
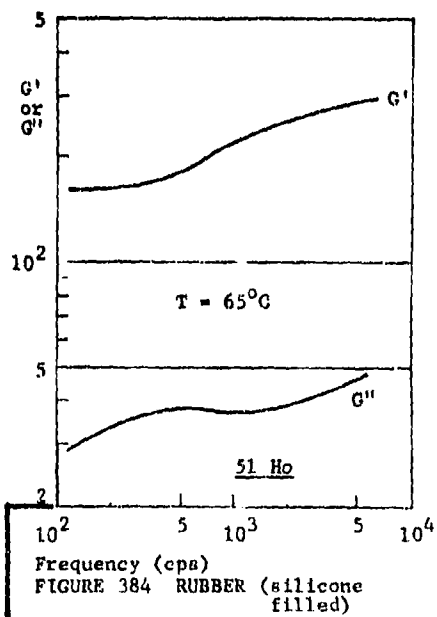
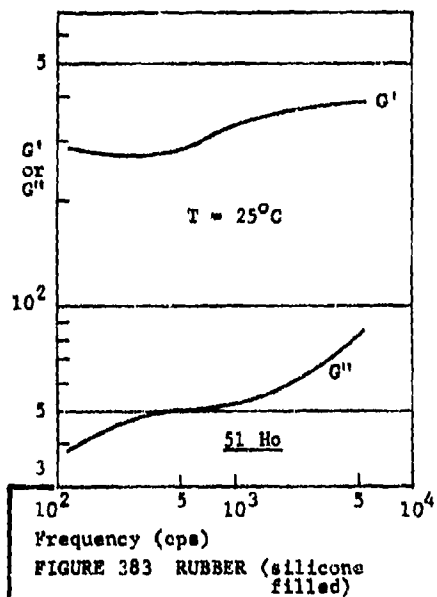
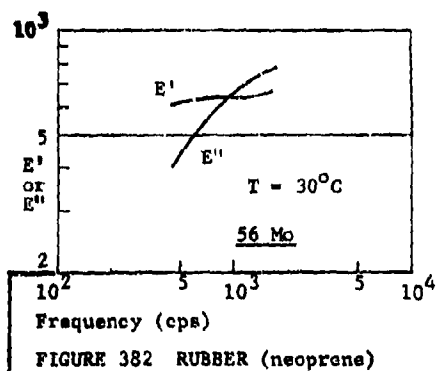












IV. REFRACTORIES, GLASS, MASONRY, MINERALS,
STONE, NATURAL CRYSTALS, AND OXIDES

4.1 Data Tabulation

ALUMINA. $\eta = 1 - 3 \times 10^{-5}$. (64 Ast)

ALUMINA (Lucalax). $\eta < 10^{-5}$. (64 Ast)

ALUMINUM OXIDE (Single crystals, undeformed and deformed 20% at 1,300°C). Axial stress. $T = 0$ to 1,200°C. $\eta_s = 10^{-5}$ to 10^{-3} . (61 Hube, Figures 395 and 396)

Al_2O_3 (Polycrystalline, refractory material). At $T = 200$ to 1,000°C, $\eta = 3 \times 10^{-3}$. At $T = 1,100^\circ C$, $\eta = 4 \times 10^{-2}$, peak value. η decreases above $T = 1,100^\circ C$. (61 Cha)

Al_2O_3 (Polycrystalline containing 0.25% by weight of La_2O_3 , refractory material). At $T = 0$ to 800°C, $\eta = 0.3 \times 10^{-2}$. At $T = 900^\circ C$, $\eta = 2.4 \times 10^{-2}$. At $T = 1,000^\circ C$, $\eta = 1.4 \times 10^{-2}$. At $T = 1,200^\circ C$, $\eta = 3.0 \times 10^{-2}$. At $T = 1,250^\circ C$, $\eta = 6.0 \times 10^{-2}$. (61 Cha)

$Ba_{0.92}Ca_{0.08}TiO_3$ AND ALSO $BaTiO_3$. Thin ring tested in extensional mode. $f = 40,000$ and 50,000. $\sigma_a = 0$ to 2 ksi. $\eta = 3 \times 10^{-3}$ to 10^{-2} . (60 Ger, Figures 397 and 398)

BeO (Polycrystalline, refractory material). At $T = 200$ to 1,100°C, $\eta = 10^{-3}$. At $T = 1,300^\circ C$, $\eta = 2 \times 10^{-2}$. At $T = 1,450^\circ C$, $\eta = 6.8 \times 10^{-2}$, peak value. η decreases above $T = 1,450^\circ C$.

Temperature required to produce peak value of η reduced from 1,450°C to 1,380°C as frequency of cyclic stress reduced from $f = 30$ to $f = 5$. (61 Cha)

Be O (Polycrystalline, containing 1% by weight of MgO, refractory material). At $f = 42$, $\eta = 0.004, 0.014, 0.025, 0.045, 0.067$ at $T = 930, 1,100, 1,300$, and 1,400°C respectively, with small peaks at 1,140 and 1,230°C. At $f = 31$, $\eta = 0.01, 0.024, 0.04, 0.053, 0.067$ at $T = 930, 1,100, 1,200, 1,300$ and 1,350°C with small peaks at 1,100 and 1,200°C. (61 Cha)

BARIUM TITANITE (84% BaTiO₃, 8% PbTiO₃, 8% CaTiO₃ and 80% BaTiO₃, 12% PbTiO₃, 8% CaTiO₃; aged). $\eta_s = 2 \times 10^{-3}$ to 5×10^{-4} . (58 Mas, Figure 400)

CABBRO (French Creek). Under axial stress, $\eta_s = 5.9 \times 10^{-3}$. Under torsion: at 200 atm, $\eta_s = 2.5 \times 10^{-3}$ and at 4,000 atm, $\eta_s = 0.7 \times 10^{-3}$. (42 Bi*)

CHINA (Bone). $\eta = 0.25 \times 10^{-3}$. (64 Ast)

CHROMIC SESQUIOXIDE (Cr₂O₃). Axial stress. $f = 85,000$. $T = 0$ to 60°C. $\eta_s = 6 \times 10^{-4}$ to 2×10^{-4} . (61 Ye)

CLAY-LIKE MATERIALS. Cyclic torsion. Strains of 1 to 3%. Earthenware, $\eta_s = 0.38$. Ball clay, $\eta_s = 0.61$ to 0.65. China Clay, $\eta_s = 0.53$ to 0.60. Etruria Marl, $\eta_s = 0.42$ to 0.48. Bentomite, $\eta_s = 0.27$ to 0.46. Brick Clay, $\eta_s = 0.48$. Plastincine, $\eta_s = 0.40$. (64 Ast)

CONCRETE. Low stress. Vibration of a 5 ft. fork of concrete.

$$\eta_s = 2.4 \times 10^{-2}. \quad (41 \text{ Ki}^*)$$

DIABASE (Vinal haven). Under axial stress, $\eta_s = 1.7 \times 10^{-3}$. Under torsion: at 200 atm, $\eta_s = 4.2 \times 10^{-3}$ and at 4,000 atm,

$$\eta_s = 2.8 \times 10^{-3}. \quad (42 \text{ Bi}^*)$$

DOLERITE (Clee Hill). At $f = 2$ to 40, $\eta = 0.0055 \pm 10\%$. At $f = 16,000$ to 96,000, $\eta = 0.005 \pm 8\%$. (62 Do)

DOLOMITE (Pennsylvania). Axial stress. $\eta_s = 2.6 \times 10^{-3}$. (42 Bi*)

DUNITE (Balsam gap, N.C.). Torsion. At 200 atm, $\eta_s = 2.5 \times 10^{-3}$. At 4,000 atm, $\eta_s = 2.0 \times 10^{-3}$. (42 Bi*)

EARTHENWARE (Porous). $\eta = 10^{-3}$ to 2.5×10^{-3} . (64 Ast)

EARTHENWARE (Vitreous). $\eta = 0.8 \times 10^{-3}$ to 1.5×10^{-3} . (64 Ast)

FIRECLAY. $T = 950$ to $1,300^\circ\text{C}$. $f = 25,000$ to $1,250,000$. $\eta = 0.6$ to 4×10^{-3} . (64 Ast)

GLASS. Bending. $f = 10$ to 100 . $\eta_s = 2 \times 10^{-3}$ to 6×10^{-3} . 2x peak at $f = 20$. (49 K, Figure 409)

GLASS. Strains of about 5×10^{-3} . Rotating bending. $\eta_s = 2.0 \times 10^{-3}$. (41 Ki*)

GLASS. Low strain. Torsion. $f = 0.25$. $\eta_s = 2 \times 10^{-6}$. (41 Ki*)

GLASS. In torsion, $\eta_s = 4.5 \times 10^{-3}$. In bending, $\eta_s = 2.9 \times 10^{-3}$. (41 Ki*)

GLASS. Small strain. Axial stress. $f = 45,000$. $\eta_s = 6.4 \times 10^{-4}$. (41 Ki*)

GLASS (Diabase). $T = 0$ to 500°C . $f = 50,000$ to $90,000$. $\eta_s = 29$ to 155 . (42 Bi*)

GLASS (Organical). Bending. $\sigma_a = 0.2$ to 1.7 ksi. At $T = -55^\circ\text{C}$, $\eta_s = 1.5 \times 10^{-2}$ to 2.5×10^{-2} . At $T = 20^\circ\text{C}$, $\eta_s = 5.5 \times 10^{-2}$ to 7.5×10^{-2} . (62 Pisa, Figure 404)

GLASS (Pyrex, 80.6% SiO_2 , 11.9% Be_2O_3 , 2.0% Al_2O_3 , 4.4% Na_2O , and 1.1% other; annealed at 500°C for 3 hrs.). Axial stress. $T = -200$ to 800°C . $f = 37,000$. $\eta_s = 5 \times 10^{-4}$ to 3×10^{-3} . $\eta_s = 5 \times 10^{-4}$ minimum at $T = 0^\circ\text{C}$. (58 Mas, Figure 388)

GLASS (Pyrex). $f = 8,000$ to $10,000$. $\eta_s = 4.6 \times 10^{-4}$ to 5.5×10^{-4} . (42 Bi*)

GLASS (Silica). $f = 1$ to 10 . $\eta_s = 80$ to 10^{-5} . (42 Bi*)

GLASS (Soft). At $f = 5$, $\eta_s = 50 \times 10^{-4}$. At $f = 10,000$, $\eta_s = 8 \times 10^{-4}$. At $f = 40,000$, $\eta_s = 8 \times 10^{-4}$. (42 Bi*)

GLASS (Soft, 69% SiO_2 , 14% Na_2O , 5% K_2O , 8% CaO , 3% Be_2O_3 , 3% Al_2O_3 , annealed at 500°C for 3 hrs.). Axial stress. $T = -50$ to 600°C . $f = 37,000$. $\eta_s = 6 \times 10^{-4}$ to 3×10^{-3} . (55 Mas, Figure 403)

GLASS FIBER (B₂T-C). Bending. $\sigma_a = 0.2$ to 0.7 ksi. $\eta_s = 2.5 \times 10^{-2}$ to 3.5×10^{-2} . (62 Pisa, Figure 404)

GLASS FIBERS (Silica, 0.06 mm diameter). $T = 500$ to $1,000^{\circ}\text{C}$.

$$f = 0.1. \quad \eta_s = 10^{-4} \text{ to } 160 \times 10^{-4}. \quad (42 \text{ Bi}^*)$$

GLASS FIBERS (Silica, 1.3 mm diameter). $T = 600$ to $1,100^{\circ}\text{C}$. $f =$

$$14. \quad \eta_s = 10^{-4} \text{ to } 57 \times 10^{-4}. \quad (42 \text{ Bi}^*)$$

GNEISS (Pelham, Mass.). Under axial stress, $\eta_s = 1.8 \times 10^{-2}$.

Under torsion: at 200 atm, $\eta_s = 10^{-2}$ and at 4,000 atm,

$$\eta_s = 1.9 \times 10^{-3}. \quad (42 \text{ Bi}^*)$$

GRAPHITE (Commercial ECA). $f = 3$. At $T = 0^{\circ}\text{C}$, $\eta = 9.7 \times 10^{-3}$.

At $T = 200^{\circ}\text{C}$, $\eta = 1.05 \times 10^{-2}$. At $T = 500^{\circ}\text{C}$, $\eta = 8 \times 10^{-3}$.

(61 Cha)

GRANITE (Rockport). Under axial stress, $\eta_s = 7.7 \times 10^{-3}$. Under

torsion: at 200 atm, $\eta_s = 5.5 \times 10^{-3}$ and at 4,000 atm,

$$\eta_s = 0.6 \times 10^{-3}. \quad (42 \text{ Bi}^*)$$

GRANITE (Quincy). $f = 140$ to $1,600$. $\eta_s = 5 \times 10^{-3}$ to 10^{-2} .

(42 Bi*)

GRANITE (Quincy). Under axial stress, $\eta_s = 10^{-2}$. Under torsion:

at 200 atm, $\eta_s = 5.5 \times 10^{-3}$ and at 4,000 atm, $\eta_s = 0.8 \times$

$$10^{-3}. \quad (42 \text{ Bi}^*)$$

HARD CHALK (Flamborough Head Pebble). At $f = 2$ to 40 , $\eta = 0.009$

$\pm 10\%$. At $f = 11,000$ to $66,000$, $\eta = 0.14 \pm 11\%$. (62 Do)

IRON OXIDE (Fe_3O_4). Thin rod specimens. $T = 70$ to 300°K . $f =$

$$50,000 \text{ to } 130,000. \quad \eta_s = 10^{-4} \text{ to } 3 \times 10^{-2}. \quad \eta_s \approx 1.5 \times 10^{-2}$$

peak at $T = 110^{\circ}\text{K}$. $\eta_s \approx 2 \times 10^{-4}$ minimum at $T = 140^{\circ}\text{K}$. (55 Mas, Figure 389)

LIMESTONE (Portland). At $f = 2$ to 40 . $\eta = 0.0055 \pm 10\%$. At $f = 10,000$ to $80,000$, $\eta = 0.0032 \pm 5\%$. (62 Do)

LIMESTONE (Pennsylvania). Under axial stress, $\eta_s = 6.7 \times 10^{-3}$. Under torsion: at 200 atm, $\eta_s = 3.7 \times 10^{-3}$ and at $4,000$ atm, $\eta_s = 1.6 \times 10^{-3}$. (42 Bi*)

LITHIUM FLUORIDE (Single crystal, slightly deformed). Axial stress. $T = 0$ to 240°K . $f = 40,000$. $\eta_s = 3 \times 10^{-6}$ to 2×10^{-5} . $\eta_s = 2 \times 10^{-5}$ peak at $T = 60^{\circ}\text{K}$. (61 T, Figure 399)

MAGNESITE REFRACTORIES. $\eta = 1.2 \times 10^{-3}$ to 3.3×10^{-3} . (64 Ast)

MgO (Polycrystalline, refractory material). At $T = 200$ to 900°C , $\eta = 3 \times 10^{-3}$. At $T = 1,050^{\circ}\text{C}$, $\eta = 6 \times 10^{-3}$, peak value. η decreases for $T > 1,050^{\circ}\text{C}$. (61 Cha)

MANGANOSITE (MnO , polycrystalline). Low axial stress. $T = -200$ to 0°C . $f = 85,000$. $\eta_s = 5 \times 10^{-3}$ to 2×10^{-4} . $\eta_s = 5 \times 10^{-3}$ peak at $T = -160^{\circ}\text{C}$. $\eta_s = 2 \times 10^{-4}$ minimum at $T = -150$ to -70°C . (61 Ye, Figure 390)

MARBLE (Vermont). Under axial stress, $\eta_s = 50 \times 10^{-3}$. Under torsion: at 200 atm, $\eta_s = 7.1 \times 10^{-3}$ and at $4,000$ atm, $\eta_s = 10^{-3}$. (42 Bi*)

NORITE (Sudbury). Under axial stress, $\eta_s = 3.4 \times 10^{-3}$. Under

torsion: at 200 atm, $\eta_s = 4.2 \times 10^{-3}$ and at 4,000 atm,
 $\eta_s = 3.0 \times 10^{-3}$. (42 Bi*)

$\text{PbZr}_{0.52} \text{Ti}_{0.48} \text{O}_3$ PLUS 1% Nb_2O_5 . Thin ring test specimen in extensional mode. $\sigma_a = 0$ to 2 ksi. $\eta = 10^{-2}$ to 5×10^{-2} .
(60 Ger, Figure 401)

$\text{Pb}_{0.94} \text{Sr}_{0.06} \text{Zr}_{0.53} \text{Ti}_{0.47} \text{O}_3$. Thin ring test specimen in extensional mode. $\sigma_a = 0$ to 2 ksi. $\eta = 2 \times 10^{-3}$ to 6×10^{-3} .
(60 Ger, Figure 402)

PORCELAIN (Electric). $\eta = 3 \times 10^{-4}$ to 1×10^{-3} . (64 Ast)

POTTERY GLAZES. $\eta = 2.5 \times 10^{-4}$ to 2×10^{-3} . (64 Ast)

QUARTZ (Single crystal). For plain quartz at $f = 40,000$, $\eta = 10^{-6}$.
For etched and polished quartz at $f = 70,000$, $\eta = 1.7 \times 10^{-6}$.
For ground quartz at $f = 70,000$, $\eta = 2.2 \times 10^{-5}$. For ground quartz at $f = 650,000$, $\eta = 1.7 \times 10^{-5}$ to 4.5×10^{-5} . For ground quartz at $f = 830,000$, $\eta = 1.3 \times 10^{-4}$ to 2.3×10^{-4} .
(52 Bi*)

QUARTZ (Single crystal). Shear. $f = 10^5$ to 10^8 . $\eta_s = 10^{-7}$ to 7×10^{-6} . (58 Mas, Figure 391)

QUARTZ (Natural clear virgin monocrystal). Flat plate specimens 1 mm thick and with a surface area of 1 to 2 sq. cm. $T = 20$ to 120°K . $\eta_s = 4 \times 10^{-5}$ to 6×10^{-5} . 1.5x peak at $T = 60^\circ\text{K}$.
(55 Vol, Figure 392)

QUARTZ (Single crystal). $T = 10$ to 120°K . $\eta_s = 2 \times 10^{-7}$ to 1.6×10^{-6} . $\eta_s = 1.6 \times 10^{-6}$ peak at $T = 55^{\circ}\text{K}$. (55 Mas, Figure 393)

QUARTZ (Fused). Low strain. Torsion. $f = 0.25$. $\eta_s = 4 \times 10^{-7}$. (41 Ki*)

QUARTZ (Ground and etched). Small strain. Piezoelectric vibration. $f = 65,000$. For ground quartz, $\eta_s = 10^{-5}$. For etched quartz, $\eta_s = 2.0 \times 10^{-6}$. (41 Ki*)

QUARTZ CRYSTALS. $\eta < 10^{-6}$. (64 Ast)

QUARTZITIC SANDSTONE. Axial stress. $\eta_s = 7.7 \times 10^{-3}$. (42 Bi*)

SAPPHIRE CRYSTAL. At $T = 400$ to $1,300^{\circ}\text{C}$, $\eta = 1.3 \times 10^{-3}$. At $T = 1,600^{\circ}\text{C}$, $\eta = 3 \times 10^{-3}$. At $T = 1,720^{\circ}\text{C}$, $\eta = 5 \times 10^{-3}$. (61 Cha)

SLATE (Pennsylvania). Axial stress. $\eta_s = 3.8 \times 10^{-3}$. (42 Bi*)

SODIUM CHLORIDE (Single crystal, annealed at 650°C , furnace cooled). Axial stress. $T = 20$ to 240°K . $f = 40,000$. For original crystal, $\eta_s = 4 \times 10^{-6}$ to 9×10^{-6} . After slight deformation, $\eta_s = 5 \times 10^{-6}$ to 2.2×10^{-5} . (61 T, Figure 394)

SILICA (Fused). Shear waves. $T = 10$ to 170°K . $f = 6.6 \times 10^4$, 2.01×10^5 , and 10^6 . $\eta_s = 2 \times 10^{-4}$ to 2×10^{-3} . Peak values occur at $T \approx 60^{\circ}\text{K}$. (58 Mas, Figure 405)

SILICA (Fused, 99.9% SiO_2 , annealed at $1,000^{\circ}\text{C}$ for 2 hrs. in air).

$T = -200$ to 800°C . $\eta_s = 10^{-6}$ to 10^{-4} . $\eta_s = 10^{-6}$ minimum at $T = 0^{\circ}\text{C}$. (58 Mas, Figure 406)

SILICA (Fused, 99.9% SiO_2). $\epsilon_a = 5$ to 40×10^{-5} . At $T = 940^{\circ}\text{C}$, $\eta_s = 8 \times 10^{-5}$. At $T = 28^{\circ}\text{C}$, $\eta_s = 1.8 \times 10^6$. (58 Mas)

SILICA (Fused, 99.9% SiO_2 , annealed at $1,000^{\circ}\text{C}$ for 2 hrs. in air). Axial stress. $T = 4$ to 35°K . $f = 37,000$. $\eta_s = 4 \times 10^{-4}$ to 2×10^{-3} . 2x increase with T . 2.5x increase with f . (58 Mas, Figure 407)

SILICA (Fused). $\eta < 0.05$. (64 Ast)

SILICA (Fused, clear, strain free). $T = 46^{\circ}\text{K}$. $f = 5 \times 10^4$ to 5×10^9 . $\eta_s = 2 \times 10^{-5}$ to 8×10^{-4} . Peak at $f \approx 10^6$ and 5×10^8 . (55 An, Figure 408)

SILICA REFRACTORIES. $\eta = 2.5$ to 10×10^{-3} . (64 Ast)

SILICEOUS REFRACTORIES. $\eta = 6$ to 12×10^{-3} . (64 Ast)

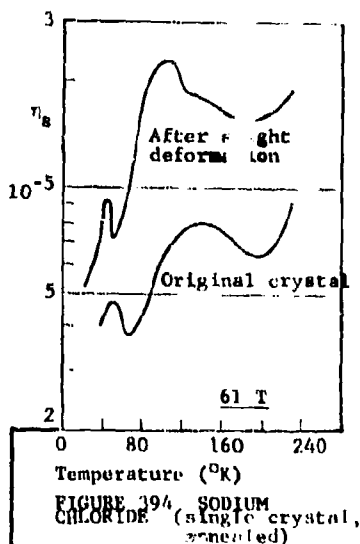
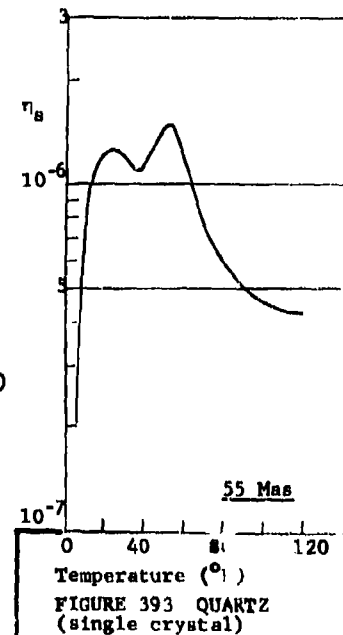
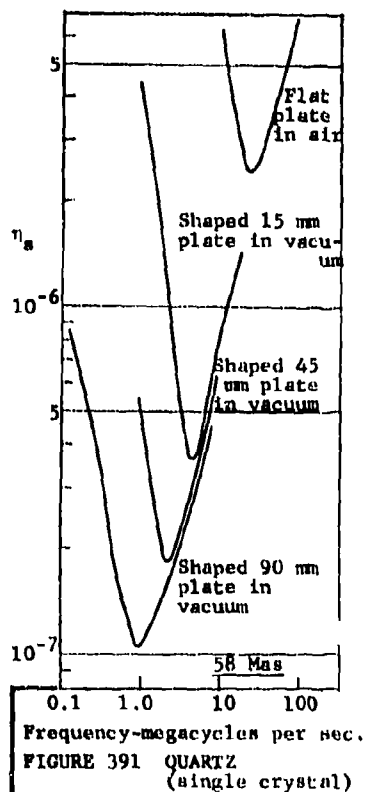
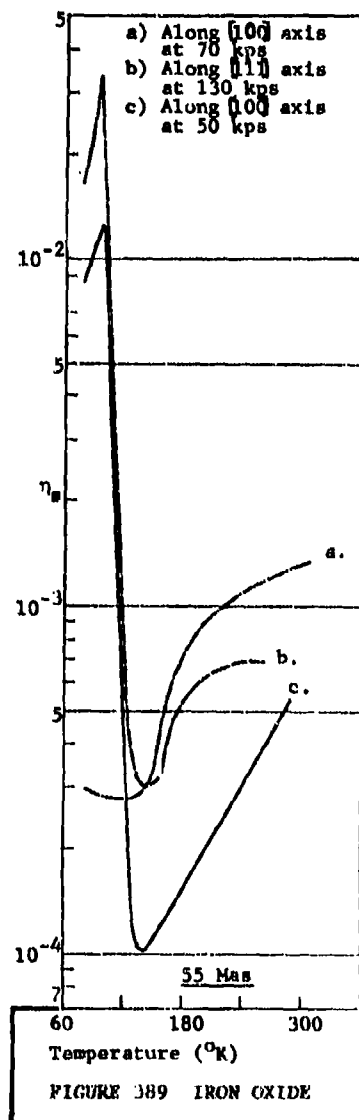
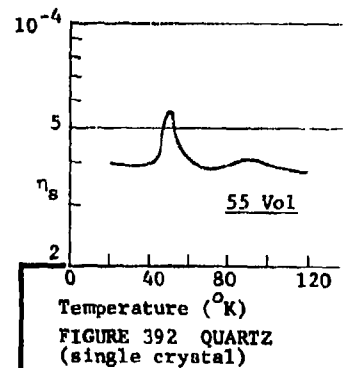
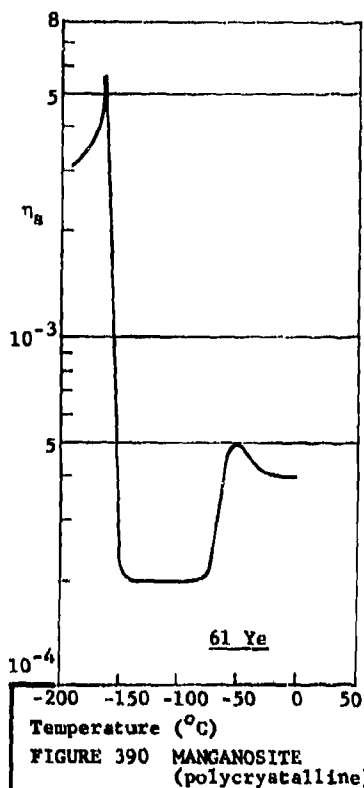
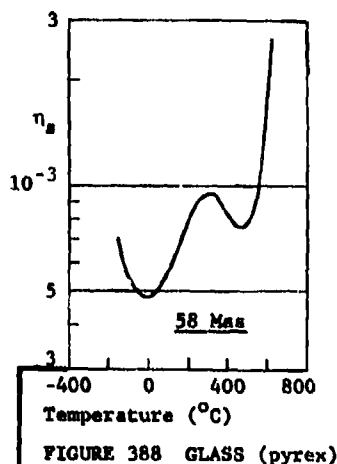
SILICON NITRIDE. $\eta \approx 0.025 \times 10^{-3}$. (64 Ast)

SYENITE (Ontario). Torsion at 4,000 atm. $\eta_s = 5 \times 10^{-4}$. (42 Bi*)

ZrH_2 (Refractory material). $f = 413$. At $T = 20^{\circ}\text{C}$, $\eta = 5 \times 10^{-3}$. At $T = 60^{\circ}\text{C}$, $\eta = 10^{-2}$. At $T = 90^{\circ}\text{C}$, $\eta = 1.8 \times 10^{-2}$ peak value. At $T = 140^{\circ}\text{C}$, $\eta = 9 \times 10^{-3}$. And at $T = 180^{\circ}\text{C}$, $\eta = 6 \times 10^{-3}$. Peak value shifted from 90°C to 110°C as frequency increased from 413 to 1,106. (61 Cha)

ZrO_2 (Refractory material). $f = 4$. At $T = 0^\circ\text{C}$, $\eta = 2 \times 10^{-3}$.

At $T = 230^\circ\text{C}$, $\eta = 1.05 \times 10^{-2}$, peak value. At $T = 400$ to 730°C , $\eta = 8 \times 10^{-3}$. Peak value shifted from 230°C to 300°C and increased to $\eta = 1.4 \times 10^{-2}$ as frequency increased from 4 to 11.6. (61 Cha)



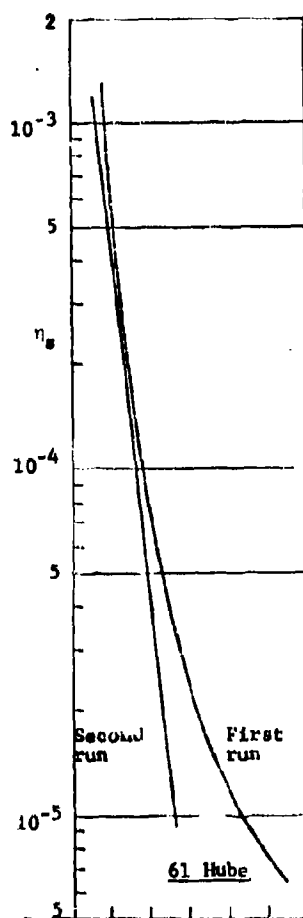


FIGURE 395 ALUMINUM OXIDE (single crystals)

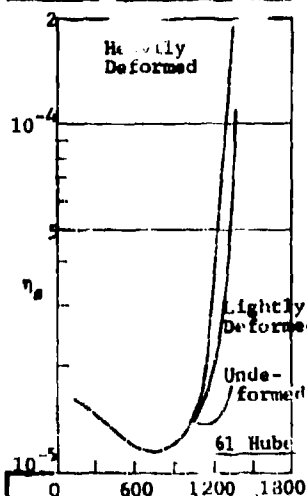


FIGURE 396 ALUMINUM OXIDE (single crystals)

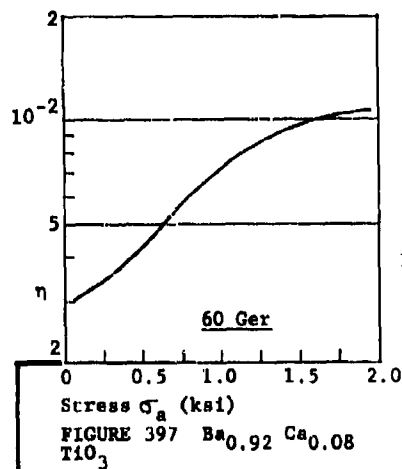


FIGURE 397 Ba_{0.92}Ca_{0.08}TiO₃

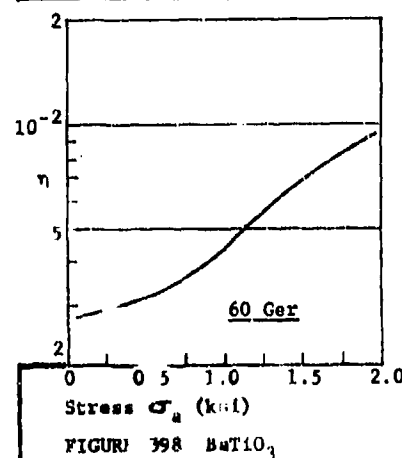


FIGURE 398 BaTiO₃

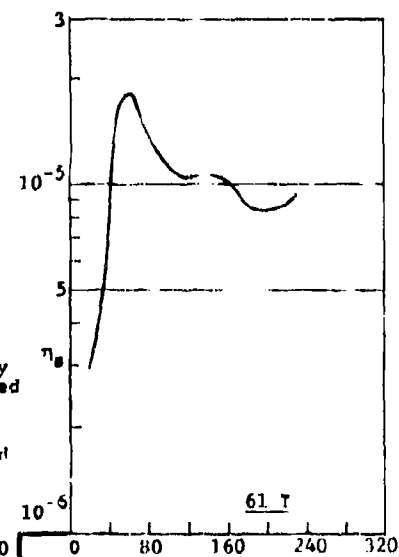


FIGURE 399 LITHIUM FLUORIDE (single crystal)

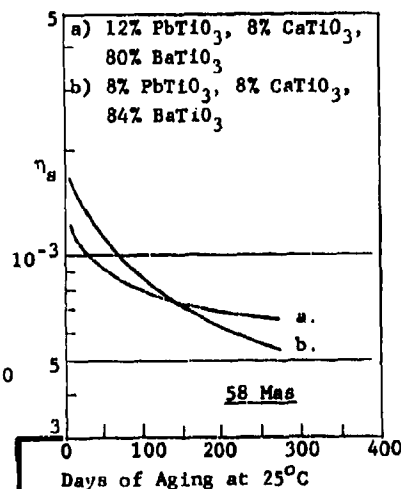


FIGURE 400 BARIUM TITANITE

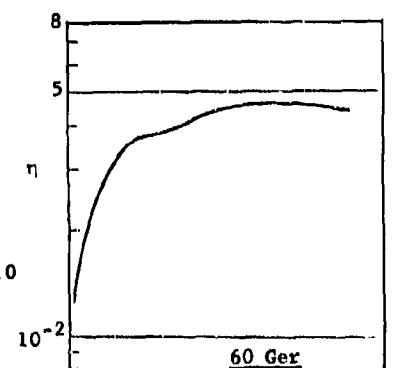


FIGURE 401 PbZr_{0.52}Ti_{0.48}O₃ PLUS 1% Nb₂O₅

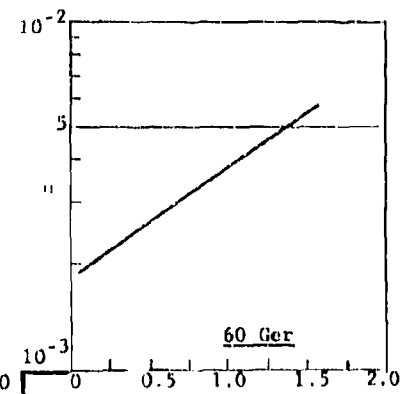
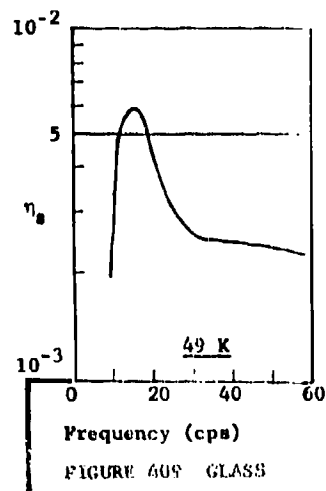
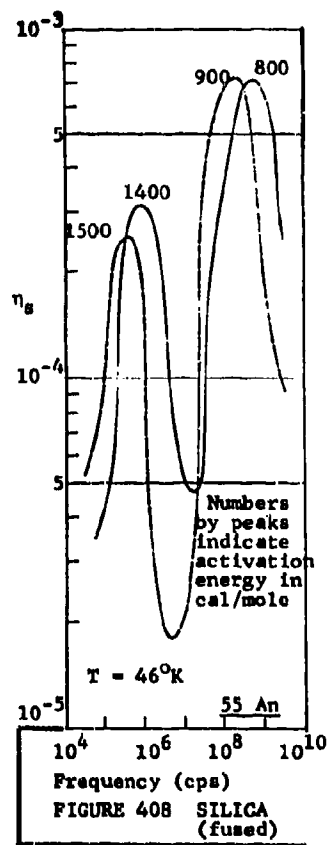
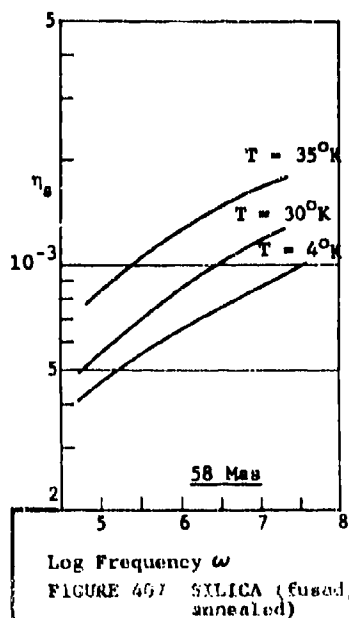
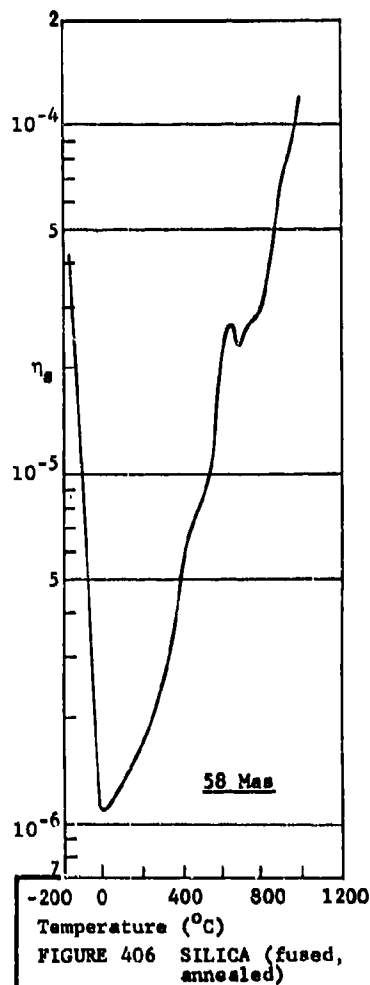
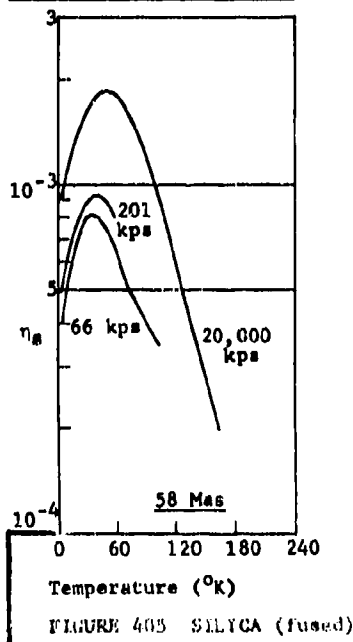
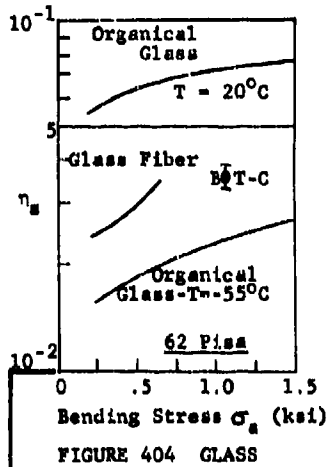
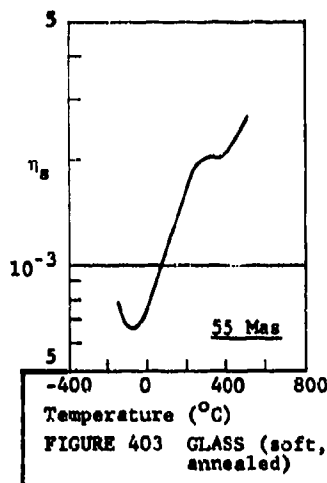


FIGURE 402 Pb_{0.94}Sr_{0.06}Zr_{0.53}Ti_{0.47}O₃



V. PARTICLE-TYPE MATERIALS, AGGREGATES, SOILS, SANDS, AND EARTH'S CRUST

Particle-like materials can dissipate energy either as loose materials or as a confined medium under stress. In the former case large relative motion between particles (such as observed in loose sand applied to surface of vibrating plate) provides mechanisms for energy dissipation. In this case the damping is associated with the cyclic displacement, velocity, or acceleration of the contact surfaces. As a confined medium (soil under triaxial stress, for example), the energy dissipation is associated with the state and magnitude of stress applied.

EARTH'S CRUST. Surface wave measurements. $\eta = 0.0022$ to 0.0074 .

(42 Bi*)

EARTH (As a planet). In shear, $\eta_s = 0.0028$. In compression,

$\eta_s = 0.001$. (61 Mac)

GRANULAR MEDIA in the form of beam in which the grains are laminated together with synthetic sheets. Loss coefficient decreases with increasing thickness of the layer of the granular media. Increasing humidity causes higher E and lower η .

BRICK PARTICLES. Grain size 0 to 10 mm. $\eta = 0.12$ to 0.21 .

COAL CINDERS. Grain size 0 to 15 mm. $\eta = 0.17$ to 0.25 .

DRY SAND. Grain size 0.3 to 1 mm. $\eta = 0.06$ to 0.12 .

GLASS PARTICLES. Grain size 1 mm. $\eta = 0.09$ to 0.15 .

IRON PARTICLES. Grain size 3 to 15 mm. $\eta = 0.09$ to 0.14 .

WET SAND. Grain size 0.3 to 1 mm. $\eta = 0.05$ to 0.17 . (64

Ku)

SAND. (As loose material on aluminum beam under flexural vibra-

tions). For beam alone, $\eta = 0.002$ for $f = 1,000$ to $4,000$.
For beam with 50% weight layer of sand, $\eta = 0.08$ to 0.2 .
For beam with 100% weight of layer of sand $\eta = 0.2$ to 0.9 .
(64 Ku)

SOIL (Granular, 30% gravel, 40% sand, 30% silt). Soil samples enclosed in a membrane under a static triaxial pressure P_o with a uniaxial cyclic stress applied. At $P_o = 2.78$ psi, $\sigma_a = 0.5$ to 2 psi, $D = 1.5 \times 10^{-5}$ to 3.5×10^{-4} . At $P_o = 6.94$ psi, $\sigma_a = 0.5$ to 10 psi, $D = 1.2 \times 10^{-5}$ to 2.7×10^{-3} . At $P_o = 12.5$ psi, $\sigma_a = 2.5$ to 10 psi, $D = 8 \times 10^{-5}$ to 1.4×10^{-3} . (60 We)

SOIL (Miscellaneous). $f = 6$ to 30 . $\eta = 0.1$. (42 B1*)

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13. ABSTRACT This report is a compilation of data on the damping properties of uniform materials and test specimens that has been collected from a wide range of publications. There are 420 entries on metals and alloys of which 300 are also illustrated with figures. There are 250 entries on polymers, elastomers, wood products, composites and similar synthetic and natural nonmetallic materials of which 85 are illustrated with figures. There are 80 entries on refrac- tories, glass, masonry, minerals, stone, natural crystals, and oxides of which 20 are illustrated with figures. In addition there are 7 entries on particle-type materials, aggregates, soils, and Earth's crust. The earliest data included comes from a 1931 publication while the latest data comes from 1964 publications. If possible the data for metals, alloys, and some nonmetals is given in either unit damping energy D or loss coefficient η , otherwise the data is presented in either total damping energy D_s or loss coefficient η_s of the specimen. The data for the polymers and elastomers is usually given in complex notation (G' , G'' or E' , E''). The primary purpose of this report is to present conveniently and concisely a compilation of published test data in a consistent set of units and to provide a useful reference for engineers and de- signers.			

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