A Computerized Fracture Mechanics Database for Oxide Glasses

S.W. Freiman, T.L. Baker, and J.B. Wachtman, Jr.
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Some divisions within the center are located at Boulder, CO 80303.

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## Contents

1. Introduction .................................................................................................................. 1
2. Design of the Fracture Mechanics Data Base ................................................................. 2
3. Design of the Computer Programs and Files ................................................................. 2
4. Results ............................................................................................................................. 4
5. Discussion of Results ...................................................................................................... 83
6. Summary ......................................................................................................................... 87
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and

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Values of critical fracture toughness ($K_{IC}$), fracture energy ($\gamma$), subcritical crack growth exponents ($n$) and Young's modulus ($E$), are compiled and tabulated for a wide variety of oxide glasses. A computerized data retrieval system has been formulated to allow for selection of data by either glass composition, investigator, or experimental technique, and year. Plotting routines allow $K_{IC}$ or $\gamma$ to be plotted versus either the mole % of a particular component or the Young's modulus of the glass. A few illustrations are given to demonstrate trends in $K_{IC}$ and $\gamma$ as a function of composition and elastic modulus.

Key words: crack growth exponents; elastic modulus; fracture database; fracture mechanics; fracture toughness; oxide glasses.

1. Introduction

The strength of glass and other brittle materials has long been known to depend on the size and character of flaws. The strength of a particular specimen of glass depends on both the severity of the most serious flaw (an extrinsic property of the glass) and the resistance of the glass to flaw propagation (thought to be an intrinsic property of the glass). The theory of linear elastic fracture mechanics predicts that for a simple crack of length $C$ the strength $S$ will be given by

$$S = K_{IC}/(Y C^{1/2})$$  \hspace{1cm} (1)$$

where $Y$ is a numerical constant that depends on flaw location and geometry and $K_{IC}$ is the critical stress intensity factor, usually taken to be an intrinsic property of the material.

An entire theory and methodology of design has been developed for brittle materials based on linear elastic fracture mechanics. It is recognized that $K_{IC}$ will change with glass composition. However, all of the aspects of composition which affect the critical stress intensity factor are not sufficiently well understood to achieve the goal of being able to predict those glasses which have optimum fracture toughness as well as possess the other properties required by the application. Accordingly, there is both scientific and technological interest in examining the whole body of fracture mechanics data for glasses to see how well critical stress intensity values can be understood in terms of the character of the glasses.

The foregoing discussion relates to cases in which no environmentally enhanced slow crack propagation occurs prior to sudden failure, i.e. in inert environments, or to rapid-fracture measurements in which any slow crack propagation has a minimal effect on the strength. The phenomenon of moisture-assisted slow crack growth occurs to some extent in every oxide glass of which we are aware, and so must be accounted for in structural design. The rate of crack propagation is a strong function of the stress intensity factor, $K_I$, at the flaw. The external factors of crack size and shape can be taken into account through eq (1). An equation widely used to fit crack growth data over large ranges of crack propagation rates is:

$$V = A K_I^n$$  \hspace{1cm} (2)$$

where $V$ is the crack velocity and $A$ and $n$ are empirical constants that depend on glass composition as well as the external environment. A methodology for safe-life design with materials that undergo slow crack propaga-
tion has been developed based on eqs (1) and (2). Again it is recognized that the constants $A$ and $n$ may vary if the composition varies within a family of glasses. As before, it is hoped that the factors affecting the above constants can be sufficiently understood, specified, and controlled to permit reliable engineering use.

The time is ripe for the development of a comprehensive compilation of the available fracture mechanics data on glasses. On one level, it is appropriate to inquire if the accumulated data are sufficiently consistent to form a useful guide in the choice of glass compositions for load-bearing applications. On another level, one can ask if the existing data show trends, such as dependence on composition, useful in developing new glasses or in further understanding fracture behavior. In addition, such a compilation is the first step in evaluating the quality of this data. The present paper describes a computerized fracture mechanics data base and associated computer programs which permit extension and modification of the data base as well as selection, plotting and curve fitting. Some preliminary results of correlations of fracture energy, $\gamma$, and critical stress intensity factor $K_{IC}$ with composition and elastic modulus are presented.

2. Design of the Fracture Mechanics Data Base

The form of the fracture mechanics data base was designed with several ideas in mind. The following information was included:

1. Primary parameters such as $K_{IC}$, $n$, etc., required for engineering design for glass structure.
2. Secondary parameters, e.g. elastic modulus.
3. Test methods and environmental factors.
4. Manufacturers and engineering designations for commercial glasses.
5. References.

The design is intended to be as open-ended as possible and the data base should be capable of expansion in the number of records it contains. The data base should be computer searchable in detail; i.e., for each record, each type of information is formatted to be available for analysis without further personal judgment being required. The data base is in a format generally accessible for computer research by other users; i.e., it is in a format and language generally available and likely to remain in use.

For this data base, fracture energy and the related quantity, critical fracture toughness, were chosen as the primary variables. The slow crack-propagation constant, $n$, and Young's modulus, $E$, were also compiled when available. A survey of published literature as well as private sources, i.e., government reports and corporate data, suggested that about 300 measurements are available on reasonably well-characterized glasses. For each measurement, the number of associated items making up a record can be as large as 25. An expansion of a factor of 2 in the number of records in the next few years seems possible, and was taken as a data base design goal. The resulting size, though substantial in terms of data bases to be manually developed and analyzed, is not very large by computer standards. Flexibility rather than efficiency in use of computer memory or speed was therefore taken as the primary goal.

3. Design of the Computer Programs and Files

In anticipation of possible future use by a variety of persons with minimal programming knowledge, all programs were written in menu-driven style and in a simple language (Basic). In anticipation of possible use in small organizations which might lack large center computers, the programs and files were subdivided into units which can be run on the current generation of stand-alone laboratory microcomputers. That is, the computer only needs Basic, a minimum of 128 kilobytes of memory, and floppy disk storage of at least 160 kilobytes per diskette. To keep within these limits, the file-creating program was kept separate from the file-analysis program.

The file creating program has been designed to ask the keyboard operation for the following information for each record:

1. The record number
2. The first previous record number for the same glass
3. A generic description of the glass (e.g., aluminosilicate)
4. A specific description of the glass (e.g., a commercial specification)

---

1The term record is taken to mean the complete set of information associated with each independent measurement of a fracture mechanics parameter.
5. Manufacturers name when appropriate
6. Indication of whether composition will be input in mole percent ($M$) or weight percent ($W$).\(^3\)
7. The percentage of each of the following in mole or weight percent:
   a. $\text{Al}_2\text{O}_3$
   b. $\text{B}_2\text{O}_3$
   c. $\text{CaO}$
   d. $\text{MgO}$
   e. $\text{Na}_2\text{O}$
   f. $\text{K}_2\text{O}$
   g. $\text{PbO}_2$
   h. $\text{SiO}_2$
8. The percentage of any two other oxides specified by the user
9. Young's modulus in units of MPa
10. The fracture mechanics data itself:
   a. the test method (see table 1 for abbreviations used for the test methods).
   b. the critical stress intensity in units of MPa $m^{1/2}$.\(^3\)
   c. the fracture energy in units of J/m\(^2\).\(^3\)
11. Same as 10 but for a second measurement method when appropriate.
12. The crack growth exponent, $n$.
13. The test environment.\(^4\)
15. Comments.

### Table 1. Abbreviations used in the computerized data base for the test methods used.

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Test method</th>
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<tr>
<td>NB</td>
<td>Notched Beam</td>
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<tr>
<td>DCB</td>
<td>Double Cantilever Beam</td>
</tr>
<tr>
<td>AMDCB</td>
<td>Applied Moment Double Cantilever Beam</td>
</tr>
<tr>
<td>DT</td>
<td>Double Torsion</td>
</tr>
<tr>
<td>Ind. Crk. Len.</td>
<td>Indentation Crack Length</td>
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<tr>
<td>Controlled Flaw</td>
<td>Controlled Flaw</td>
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<tr>
<td>Static Fat.</td>
<td>Static Fatigue</td>
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<tr>
<td>Dynamic Fat.</td>
<td>Dynamic Fatigue</td>
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<tr>
<td>Short bar</td>
<td>Short Bar</td>
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### Table 2. List of environments used by various authors

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<tr>
<th>Environment</th>
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<tr>
<td>air, x % RH (i.e. air with x % relative humidity)</td>
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<tr>
<td>$\text{H}_2\text{O}$</td>
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<tr>
<td>D.I. $\text{H}_2\text{O}$ (i.e. deionized water)</td>
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<tr>
<td>$\text{N}_2$ (l) at $-196^\circ\text{C}$ (i.e. liquid nitrogen at $-196^\circ\text{C}$)</td>
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<tr>
<td>Heptane</td>
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<tr>
<td>$\text{N}_2$ (l) (i.e. liquid nitrogen)</td>
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<tr>
<td>$\text{N}_2$ (g) (i.e. nitrogen gas)</td>
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<tr>
<td>Vacuum</td>
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<tr>
<td>Toluene</td>
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<tr>
<td>Mineral oil</td>
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<tr>
<td>1 M Cs in D.I. $\text{H}_2\text{O}$ (i.e. 1 Molar Cs in deionized water)</td>
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<tr>
<td>1 M Li in D.I. $\text{H}_2\text{O}$ (i.e. 1 Molar Li in deionized water)</td>
</tr>
<tr>
<td>6 N $\text{NaOH}$ (i.e. 6 Normal $\text{NaOH}$)</td>
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<tr>
<td>6 N $\text{HCl}$ (i.e. 6 Normal $\text{HCl}$)</td>
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</tbody>
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\(^3\)When the input is in weight percent, a subroutine in the program enables the user to convert these values to mole percent, and a C is placed in Item 6 to indicate the calculation has been done.

\(^3\)When either b or c alone is given and a value for Young's modulus is present, the program calculates the other from the identity ($K_{ic} = \frac{2E}{Y}$)\(^{1/2}\) where $E$ is Young's modulus.

\(^4\)Both the relative humidity of air, the chemical activity of water in solutions and the pH value in solutions are known to affect the slow crack propagation parameters and may affect other fracture mechanics parameters unless the test is conducted very rapidly. The various environments that have been used are listed in table 2.
To reduce effort in keyboarding, the program allows duplication of earlier data (such as the reference) by a single keystroke when appropriate. Each record is written to permanent storage on a diskette before entry of the next record.

The file-analysis program as currently written provides for a search of the file for any combination of the following keys:

1. Generic material
2. Specific material designation
3. Presence of a first specified oxide
4. Presence of a second specified oxide
5. Presence of a third specified oxide
6. Test techniques
7. Principal author
8. Year

Following the search and selection of the appropriate data, this program provides the option of plotting with the critical stress intensity factor, the fracture energy, or the crack velocity parameter as the independent variable. Any of these parameters may be plotted as a function of Young’s modulus, or the mole percentage of one of the specified oxides. Provision for fitting and plotting a straight line or a quadratic least squares fit to the data is also provided. Also, Young’s modulus may be plotted as a function of composition.

4. Results

The current data base consists of 291 separate records, some of which contain measurements of $\gamma$ or $K_{IC}$ obtained by more than one technique. In some instances, a record will contain a value of the crack growth exponent, $n$, instead of $\gamma$ or $K_{IC}$. The entire list of records is given in table 3. Because table 3 is not ordered with respect to composition, author etc., finding a specific set of data could be difficult. Therefore, we have constructed additional tables 4-7 which contain the four major compositional categories of these glasses, i.e. silicate ($\text{SiO}_2$), borate ($\text{B}_2\text{O}_3$), phosphate ($\text{P}_2\text{O}_5$), and germanate ($\text{GeO}_2$). Within each table the data is listed in order of decreasing amounts of the primary constituent of the glass. At the end of each different glass composition is the reference indicating the source of the data. Each reference, which is included in its entirety in table 3, has been abbreviated and is broken down in the following manner: “WIE74/1” refers to a paper which has Wiederhorn as the primary author and is the first of two papers written by him in 1974. If there is only one paper by a particular author in one year, no /# will be suffixed to the reference.
### Table 3. Fracture mechanics parameters for oxide glasses

**ASH82**

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<th>Specific Material</th>
<th>Manufacturer</th>
<th>% Al2O3</th>
<th>% B2O3</th>
<th>% CaO</th>
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<tr>
<td>Young's Modulus</td>
<td>5.4 E4</td>
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<tr>
<td>1st Technique</td>
<td>Ind. Crk. Len.</td>
<td></td>
<td></td>
<td>KIC = .95</td>
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<td>2nd Technique</td>
<td></td>
<td></td>
<td></td>
<td>KIC=</td>
<td>Gamma =</td>
<td></td>
<td></td>
<td></td>
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<tr>
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<td>Reference</td>
<td>ASHIZUKA,M., BRADT,R., JACTAW, Vol. 65, No. 5, 1982</td>
<td></td>
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<td>Comments</td>
<td></td>
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Specific Material =
Manufacturer =
% Al₂O₃ = % B₂O₃ = % CaO = % MgO =
% Na₂O = % K₂O = % PbO = % SiO₂ =
Other Formula = ZnO Other % = 50
Other Formula = P₂O₅ Other % = 50
Young's Modulus = 4.24 E4
1st Technique = Ind. Crk. Len. \( K_{IC} = 6 \) Gamma = 4.25
2nd Technique =
\( n = \)
Environment = air
Reference = ASHIZUKA,M.,BRADT,R., JACTAW, Vol. 65, No. 5, 1982
Comments =

Specific Material =
Manufacturer =
% Al₂O₃ = % B₂O₃ = % CaO = % MgO =
% Na₂O = % K₂O = % PbO = % SiO₂ =
Other Formula = ZnO Other % = 50
Other Formula = P₂O₅ Other % = 50
Young's Modulus = 3.45 E4
1st Technique = Ind. Crk. Len. \( K_{IC} = .35 \) Gamma = 1.78
2nd Technique =
\( n = \)
Environment = air
Reference = ASHIZUKA,M.,BRADT,R., JACTAW, Vol. 65, No. 5, 1982
Comments =

Specific Material =
Manufacturer =
% Al₂O₃ = % B₂O₃ = % CaO = % MgO =
% Na₂O = % K₂O = % PbO = % SiO₂ =
Other Formula = Li₂O Other % = 50
Other Formula = P₂O₅ Other % = 50
Young's Modulus = 4.9 E4
1st Technique = Ind. Crk. Len. \( K_{IC} = .57 \) Gamma = 3.32
2nd Technique =
\( n = \)
Environment = air
Reference = ASHIZUKA,M.,BRADT,R., JACTAW, Vol. 65, No. 5, 1982
Comments =

BRU77
Specific Material =
Manufacturer =
% Al₂O₃ = 1.16 % B₂O₃ = % CaO = 7.43 % MgO = 5.91
% Na₂O = 13.4 % K₂O = .632 % PbO = % SiO₂ = 71.3
Other Formula = Other % =
Other Formula = Other % =
Young's Modulus =
1st Technique = DT \( K_{IC} = .77 \) Gamma =
2nd Technique =
\( n = \)
Environment = Toluene
Reference = BRUCE,J.,KOEPKE,B., JACTAW, Vol. 60, No. 5-6, 1977
Comments =
### Specific Material

<table>
<thead>
<tr>
<th>Material</th>
<th>Manufacturer</th>
<th>% Al₂O₃</th>
<th>% B₂O₃</th>
<th>% CaO</th>
<th>% MgO</th>
</tr>
</thead>
<tbody>
<tr>
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<td></td>
<td>1.16</td>
<td></td>
<td>7.43</td>
<td>5.91</td>
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<td></td>
<td>13.4</td>
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Other Formula:

<table>
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Young's Modulus:

1st Technique = DT

<table>
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<tr>
<th>Technique</th>
<th>K╵IC</th>
<th>Gamma</th>
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2nd Technique =

<table>
<thead>
<tr>
<th>Technique</th>
<th>K╵IC</th>
<th>Gamma</th>
</tr>
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<tbody>
<tr>
<td>Second</td>
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</table>

n =

Environment = Mineral oil

Reference = BRUCE, J., KOEPKE, B., JACTAW, Vol. 60, No. 5-6, 1977

Comments =

---

### CHA58

Specific Material = 0080

Manufacturer = Corning Glass

<table>
<thead>
<tr>
<th>Material</th>
<th>Manufacturer</th>
<th>% Al₂O₃</th>
<th>% B₂O₃</th>
<th>% CaO</th>
<th>% MgO</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td>1.76</td>
<td></td>
<td>5.35</td>
<td>4.46</td>
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<td></td>
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<td>16.4</td>
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Other Formula:

<table>
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Young's Modulus:

1st Technique = Dynamic Fat.

<table>
<thead>
<tr>
<th>Technique</th>
<th>K╵IC</th>
<th>Gamma</th>
</tr>
</thead>
<tbody>
<tr>
<td>First</td>
<td>.62</td>
<td></td>
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</table>

2nd Technique =

<table>
<thead>
<tr>
<th>Technique</th>
<th>K╵IC</th>
<th>Gamma</th>
</tr>
</thead>
<tbody>
<tr>
<td>Second</td>
<td></td>
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</table>

n = 16

Environment = air, 50% RH


Comments = Surface condition--abraded

---

### EAG78

Specific Material =

Manufacturer =

<table>
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<tr>
<th>Material</th>
<th>Manufacturer</th>
<th>% Al₂O₃</th>
<th>% B₂O₃</th>
<th>% CaO</th>
<th>% MgO</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td>.40</td>
<td></td>
<td>6.0</td>
<td>40</td>
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<tr>
<td></td>
<td></td>
<td>1.60</td>
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Other Formula:

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Young's Modulus = 6.0 E4

1st Technique = NB

<table>
<thead>
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<th>Technique</th>
<th>K╵IC</th>
<th>Gamma</th>
</tr>
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<tbody>
<tr>
<td>First</td>
<td>.62</td>
<td></td>
</tr>
</tbody>
</table>

2nd Technique =

<table>
<thead>
<tr>
<th>Technique</th>
<th>K╵IC</th>
<th>Gamma</th>
</tr>
</thead>
<tbody>
<tr>
<td>Second</td>
<td></td>
<td></td>
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</tbody>
</table>

n =

Environment = air


Comments =
Specific Material =
Manufacturer =

\% Al₂O₃ = 8 \% B₂O₃ = \% CaO = \% MgO =
\% Na₂O = 32 \% K₂O = \% PbO = \% SiO₂ = 60
Other Formula = Other % =
Other Formula = Other % =

Young's Modulus = 6.9 \times 10^4
1st Technique = NB
2nd Technique =
\( K_{IC} = 0.64 \) Gamma = 2.97
\( n = \)
Environment = air
Comments =

Specific Material =
Manufacturer =

\% Al₂O₃ = 16.2 \% B₂O₃ = \% CaO = \% MgO =
\% Na₂O = 23.8 \% K₂O = \% PbO = \% SiO₂ = 60
Other Formula = Other % =
Other Formula = Other % =

Young's Modulus = 7.25 \times 10^4
1st Technique = NB
2nd Technique =
\( K_{IC} = 0.62 \) Gamma = 2.61
\( n = \)
Environment = air
Comments =

Specific Material =
Manufacturer =

\% Al₂O₃ = 20 \% B₂O₃ = \% CaO = \% MgO =
\% Na₂O = 20 \% K₂O = \% PbO = \% SiO₂ = 60
Other Formula = Other % =
Other Formula = Other % =

Young's Modulus = 7.3 \times 10^4
1st Technique = NB
2nd Technique =
\( K_{IC} = 0.67 \) Gamma = 3.10
\( n = \)
Environment = air
Comments =

Specific Material =
Manufacturer =

\% Al₂O₃ = 22.8 \% B₂O₃ = \% CaO = \% MgO =
\% Na₂O = 17.2 \% K₂O = \% PbO = \% SiO₂ = 60
Other Formula = Other % =
Other Formula = Other % =

Young's Modulus = 7.8 \times 10^4
1st Technique = NB
2nd Technique =
\( K_{IC} = 0.70 \) Gamma = 3.10
\( n = \)
Environment = air
Comments =
Specific Material = Manufacturer =
% Al₂O₃ = % B₂O₃ = % CaO = % MgO =
% Na₂O = % K₂O = % PbO = % SiO₂ = 80
Other Formula = Other % =
Other Formula = Other % =
Young's Modulus = 6.1 \times 10⁴
1st Technique = NB
2nd Technique =
\( K_{IC} = 0.58 \) \( \Gamma = 2.76 \)
\( n = \)
Environment = air
Comments =

Specific Material = Manufacturer =
% Al₂O₃ = 5 % B₂O₃ = % CaO = % MgO =
% Na₂O = 20 % K₂O = % PbO = % SiO₂ = 75
Other Formula = Other % =
Other Formula = Other % =
Young's Modulus = 6.4 \times 10⁴
1st Technique = NB
2nd Technique =
\( K_{IC} = 0.63 \) \( \Gamma = 3.10 \)
\( n = \)
Environment = air
Comments =

Specific Material = Manufacturer =
% Al₂O₃ = 10 % B₂O₃ = % CaO = % MgO =
% Na₂O = 20 % K₂O = % PbO = % SiO₂ = 70
Other Formula = Other % =
Other Formula = Other % =
Young's Modulus = 6.9 \times 10⁴
1st Technique = NB
2nd Technique =
\( K_{IC} = 0.67 \) \( \Gamma = 3.25 \)
\( n = \)
Environment = air
Comments =

Specific Material = Manufacturer =
% Al₂O₃ = 20 % B₂O₃ = % CaO = % MgO =
% Na₂O = 20 % K₂O = % PbO = % SiO₂ = 60
Other Formula = Other % =
Other Formula = Other % =
Young's Modulus = 7.25 \times 10⁴
1st Technique = NB
2nd Technique =
\( K_{IC} = 0.67 \) \( \Gamma = 3.10 \)
\( n = \)
Environment = air
Comments =
Specific Material =
Manufacturer =
% Al₂O₃ = 24  % B₂O₃ =   % CaO =   % MgO =
% Na₂O = 20  % K₂O =   % PbO =   % SiO₂ = 56
Other Formula = Other % =
Other Formula = Other % =
Young's Modulus = 7.75 E⁴
1st Technique = NB
2nd Technique =

n =
Environment = air
Comments =

Specific Material =
Manufacturer =
% Al₂O₃ = 32  % B₂O₃ =   % CaO = 8   % MgO =
% Na₂O =     % K₂O =   % PbO =   % SiO₂ = 60
Other Formula = Other % =
Other Formula = Other % =
Young's Modulus = 9.3 E⁴
1st Technique = NB
2nd Technique =

n =
Environment = air
Comments =

Specific Material =
Manufacturer =
% Al₂O₃ = 13.3  % B₂O₃ =   % CaO = 26.7   % MgO =
% Na₂O =     % K₂O =   % PbO =   % SiO₂ = 60
Other Formula = Other % =
Other Formula = Other % =
Young's Modulus = 9.2 E⁴
1st Technique = NB
2nd Technique =

n =
Environment = air
Comments =

Specific Material =
Manufacturer =
% Al₂O₃ = 20  % B₂O₃ =   % CaO = 20   % MgO =
% Na₂O =     % K₂O =   % PbO =   % SiO₂ = 60
Other Formula = Other % =
Other Formula = Other % =
Young's Modulus = 9.35 E⁴
1st Technique = NB
2nd Technique =

n =
Environment = air
Comments =

Specific Material = Manufacturer =
% Al₂O₃ = 22.8 % B₂O₃ = % CaO = 17.2 % MgO =
% Na₂O = % K₂O = % PbO = % SiO₂ = 60
Other Formula = Other % =
Other Formula = Other % =
Young's Modulus = 9.8 E4
1st Technique = NB
2nd Technique =
\( K_{IC} = 0.66 \) Gamma = 2.19
\( n = \)
Environment = air
Comments =

Specific Material = Manufacturer =
% Al₂O₃ = % B₂O₃ = % CaO = % MgO =
% Na₂O = % K₂O = % PbO = % SiO₂ = 60
Other Formula = Other % =
Other Formula = Other % =
Young's Modulus = 6.1 E4
1st Technique = NB
2nd Technique =
\( K_{IC} = 0.63 \) Gamma = 3.20
\( n = \)
Environment = air
Comments =

Specific Material = Manufacturer =
% Al₂O₃ = % B₂O₃ = % CaO = % MgO =
% Na₂O = % K₂O = % PbO = % SiO₂ = 60
Other Formula = Other % =
Other Formula = Other % =
Young's Modulus = 6.5 E4
1st Technique = NB
2nd Technique =
\( K_{IC} = 0.75 \) Gamma = 4.33
\( n = \)
Environment = air
Comments =

Specific Material = Manufacturer =
% Al₂O₃ = % B₂O₃ = % CaO = % MgO =
% Na₂O = % K₂O = % PbO = % SiO₂ = 60
Other Formula = Other % =
Other Formula = Other % =
Young's Modulus = 8.4 E4
1st Technique = NB
2nd Technique =
\( K_{IC} = 0.94 \) Gamma = 5.26
\( n = \)
Environment = air
Comments =
Specific Material = Manufacturer =
% Al₂O₃ = % B₂O₃ = 20 % CaO = % MgO =
% Na₂O = 23 % K₂O = % PbO = % SiO₂ = 60
Other Formula = Other % =
Other Formula = Other % =
Young's Modulus = 8.2 E4
1st Technique = NB
2nd Technique =
\( K_{IC} = .88 \) \( \Gamma \) = 4.72
\( n = \) Environment = air
Comments =

Specific Material = Manufacturer =
% Al₂O₃ = % B₂O₃ = 22.8 % CaO = % MgO =
% Na₂O = 17.2 % K₂O = % PbO = % SiO₂ = 60
Other Formula = Other % =
Other Formula = Other % =
Young's Modulus = 8.6 E4
1st Technique = NB
2nd Technique =
\( K_{IC} = .92 \) \( \Gamma \) = 4.89
\( n = \) Environment = air
Comments =

\textbf{FRE83}

Specific Material = Manufacturer =
% Al₂O₃ = % B₂O₃ = % CaO = % MgO =
% Na₂O = % K₂O = % PbO = % SiO₂ = 67
Other Formula = Li₂O Other % = 33
Other Formula = Other % =
Young's Modulus =
1st Technique = DCB
2nd Technique =
\( K_{IC} = \) \( \Gamma \) =
\( n = 11 \) Environment = H₂O
Reference = FREIMAN, S.W., Private Communications, 1983
Comments =

Specific Material = Low Iron Float
Manufacturer =
% Al₂O₃ = 1.16 % B₂O₃ = % CaO = 7.43 % MgO = 5.91
% Na₂O = 13.4 % K₂O = 632 % PbO = % SiO₂ = 71.3
Other Formula = Other % =
Other Formula = Other % =
Young's Modulus =
1st Technique = DCB
2nd Technique =
\( K_{IC} = \) \( \Gamma \) =
\( n = 19.3 \) Environment = H₂O
Reference = FREIMAN, S.W., et al, Submitted to JACTAW, 1983
Comments =
Specific Material = Low Iron Float
Manufacturer =
% $\text{Al}_2\text{O}_3 = 1.16$  % $\text{B}_2\text{O}_3 = \%
% $\text{Na}_2\text{O} = 13.4$  % $\text{K}_2\text{O} = .632$
Other Formula =
Other % =
Other Formula =
Other % =
Young's Modulus =
1st Technique = Dynamic Fat.
2nd Technique =
n = 15.2
Environment = $\text{H}_2\text{O}$
Reference = FREIMAN, S.W., et al, Submitted to JACTAW, 1983
Comments =

Specific Material = 7809
Manufacturer = Corning Glass
% $\text{Al}_2\text{O}_3 = 5.72$  % $\text{B}_2\text{O}_3 = 7.45$
% $\text{Na}_2\text{O} = 9.41$  % $\text{K}_2\text{O} = 3.44$
Other Formula = TiO$_2$
Other % = .405
Other Formula = Fe$_2$O$_3$
Other % = < .1W%
% Young's Modulus =
1st Technique = DCB
2nd Technique =
n = 25.3
Environment = $\text{H}_2\text{O}$
Reference = FREIMAN, S.W., et al, Submitted to JACTAW, 1983
Comments =

Specific Material = 7809
Manufacturer = Corning Glass
% $\text{Al}_2\text{O}_3 = 5.72$  % $\text{B}_2\text{O}_3 = 7.45$
% $\text{Na}_2\text{O} = 9.41$  % $\text{K}_2\text{O} = 3.44$
Other Formula = TiO$_2$
Other % = .405
Other Formula = Fe$_2$O$_3$
Other % = < .1W%
Young's Modulus =
1st Technique = Dynamic Fat
2nd Technique =
n = 31.4
Environment = $\text{H}_2\text{O}$
Reference = FREIMAN, S.W., et al, Submitted to JACTAW, 1983
Comments =

Specific Material = 0317
Manufacturer = Corning Glass
% $\text{Al}_2\text{O}_3 = 18.8$  % $\text{B}_2\text{O}_3 = 8.08$
% $\text{Na}_2\text{O} = $  % $\text{K}_2\text{O} =$
Other Formula =
Other % =
Other Formula =
Other % =
Young's Modulus =
1st Technique = DCB
2nd Technique =
n = 25.1
Environment = $\text{H}_2\text{O}$
Reference = FREIMAN, S.W., et al, Submitted to JACTAW, 1983
Comments = % composition - 9.5% modifiers
Specific Material = 0317
Manufacturer = Corning Glass
% Al₂O₃ = 18.8 % B₂O₃ = 8.08 % CaO = % MgO =
% Na₂O = % K₂O = % PbO = % SiO₂ = 73.0
Other Formula = Other % =
Other Formula = Other % =
Young's Modulus =
1st Technique = Dynamic Fat. $K_{IC} =$ Gamma =
2nd Technique = $K_{IC} =$ Gamma =
n = 32.6
Environment = H₂O
Reference = FREIMAN, S.W., et al, Submitted to JACTAW, 1983
Comments = % composition - 9.5% modifier

FRE84
Specific Material = 8244
Manufacturer = NBS
% Al₂O₃ = % B₂O₃ = % CaO = % MgO =
% Na₂O = % K₂O = % PbO = % SiO₂ =
Other Formula = P₂O₅ Other % = 74.6
Other Formula = La₂O₃ Other % = 25
Young's Modulus = 6.05 $E4$
1st Technique = Ind. Crk. Len. $K_{IC} = .58$ Gamma = 2.78
2nd Technique = $K_{IC} =$ Gamma =
n =
Environment = Heptane
Reference = FREIMAN, S.W., Private Communications, 1984
Comments = 3rd Other Oxide- 0.5% Nd₂O₃, & Young's Modulus is estimated

Specific Material = 8245
Manufacturer = NBS
% Al₂O₃ = 25 % B₂O₃ = % CaO = % MgO =
% Na₂O = % K₂O = % PbO = % SiO₂ =
Other Formula = P₂O₅ Other % = 74.6
Other Formula = Nd₂O₃ Other % = 0.5
Young's Modulus = 8.7 $E4$
1st Technique = Ind. Crk. Len. $K_{IC} = .58$ Gamma = 1.93
2nd Technique = $K_{IC} =$ Gamma =
n =
Environment = Heptane
Reference = FREIMAN, S.W., Private Communications, 1984
Comments = Young's Modulus is estimated

Specific Material = 9023
Manufacturer = GTE
% Al₂O₃ = 25 % B₂O₃ = % CaO = % MgO =
% Na₂O = % K₂O = % PbO = % SiO₂ =
Other Formula = P₂O₅ Other % = 74.6
Other Formula = Nd₂O₃ Other % = 0.4
Young's Modulus = 8.7 $E4$
1st Technique = Ind. Crk. Len. $K_{IC} = .72$ Gamma = 2.98
2nd Technique = $K_{IC} =$ Gamma =
n =
Environment = Heptane
Reference = FREIMAN, S.W., Private Communications, 1984
Comments = Young's Modulus is estimated
Specific Material = UP63-6771
Manufacturer =
% Al₂O₃ = % B₂O₃ = % CaO = % MgO = 20
% Na₂O = % K₂O = % PbO = % SiO₂ =
Other Formula = P₂O₅ Other % = 70
Other Formula = Other % =
Young's Modulus = 4.67 E4
1st Technique = Ind. Crk. Len. $K_{IC} = .33$ Gamma = 1.17
2nd Technique = $K_{IC} =$ Gamma =
$n =$
Environment = N₂(g)
Reference = FREIMAN, S.W., Private Communications, 1984
Comments = Compo. - 10% (La₂O₃ + Nd₂O₃)

Specific Material = UP37-6830
Manufacturer =
% Al₂O₃ = % B₂O₃ = % CaO = % MgO = 12
% Na₂O = % K₂O = 12 % PbO = % SiO₂ =
Other Formula = P₂O₅ Other % = 65
Other Formula = Other % =
Young's Modulus = 5.39 E4
1st Technique = Ind. Crk. Len. $K_{IC} = .35$ Gamma = 1.14
2nd Technique = $K_{IC} =$ Gamma =
$n =$
Environment = N₂(g)
Reference = FREIMAN, S.W., Private Communications, 1984
Comments = Compo. - 12% (La₂O₃ + Nd₂O₃)

Specific Material = UP16-6766
Manufacturer =
% Al₂O₃ = % B₂O₃ = % CaO = % MgO =
% Na₂O = % K₂O = 25 % PbO = % SiO₂ =
Other Formula = P₂O₅ Other % = 62
Other Formula = Other % =
Young's Modulus = 4.42 E4
1st Technique = Ind. Crk. Len. $K_{IC} = .33$ Gamma = 1.23
2nd Technique = $K_{IC} =$ Gamma =
$n =$
Environment = N₂(g)
Reference = FREIMAN, S.W., Private Communications, 1984
Comments = Compo. - 13% (La₂O₃ + Nd₂O₃)

Specific Material = MJ-4-5288
Manufacturer =
% Al₂O₃ = 15 % B₂O₃ = % CaO = % MgO = 15
% Na₂O = % K₂O = % PbO = % SiO₂ =
Other Formula = P₂O₅ Other % = 69
Other Formula = Other % =
Young's Modulus = 6.72 E4
1st Technique = Ind. Crk. Len. $K_{IC} = .55$ Gamma = 2.25
2nd Technique = $K_{IC} =$ Gamma =
$n =$
Environment = N₂(g)
Reference = FREIMAN, S.W., Private Communications, 1984
Comments = Compo. - 2% (La₂O₃ + Nd₂O₃)
Specific Material = UP86-6961
Manufacturer =
% Al₂O₃ = 9.4  % B₂O₃ =  % CaO =  % MgO =
% Na₂O =  % K₂O = 9.4  % PbO =  % SiO₂ =
Other Formula = P₂O₅  Other % = 75.3
Other Formula = La₂O₃  Other % = 1.6
Young's Modulus = 6.37 E4
1st Technique = Ind. Crk. Len.  \( K_{IC} = .37 \)  Gamma = 1.08
2nd Technique =
\( K_{IC} = \)  Gamma =
n =
Environment = Heptane
Reference = FREIMAN, S.W., Private Communications, 1984
Comments = Compo.- 3rd Other Oxide- 4.3% Nd₂O₃

Specific Material = UP77-6945
Manufacturer =
% Al₂O₃ = 16.5  % B₂O₃ =  % CaO =  % MgO =
% Na₂O =  % K₂O = 12.5  % PbO =  % SiO₂ =
Other Formula = P₂O₅  Other % = 65.1
Other Formula = La₂O₃  Other % = 1.7
Young's Modulus = 6.55 E4
1st Technique = Ind. Crk. Len.  \( K_{IC} = .45 \)  Gamma = 1.55
2nd Technique =
\( K_{IC} = \)  Gamma =
n =
Environment = Heptane
Reference = FREIMAN, S.W., Private Communications, 1984
Comments = Compo.- 3rd Other Oxide- 4.2% Nd₂O₃

Specific Material = UP69-6897
Manufacturer =
% Al₂O₃ = 11.8  % B₂O₃ =  % CaO =  % MgO =
% Na₂O =  % K₂O = 23.6  % PbO =  % SiO₂ =
Other Formula = P₂O₅  Other % = 59
Other Formula = La₂O₃  Other % = 1.5
Young's Modulus = 5.37 E4
1st Technique = Ind. Crk. Len.  \( K_{IC} = .33 \)  Gamma = 1.01
2nd Technique =
\( K_{IC} = \)  Gamma =
n =
Environment = Heptane
Reference = FREIMAN, S.W., Private Communications, 1984
Comments = Compo.- 3rd Other Oxide- 4.1% Nd₂O₃

Specific Material = UP70-6937
Manufacturer =
% Al₂O₃ = 15.9  % B₂O₃ =  % CaO =  % MgO =
% Na₂O =  % K₂O = 15.9  % PbO =  % SiO₂ =
Other Formula = P₂O₅  Other % = 62.7
Other Formula = La₂O₃  Other % = 1.4
Young's Modulus = 6.21 E4
1st Technique = Ind. Crk. Len.  \( K_{IC} = .41 \)  Gamma = 1.35
2nd Technique =
\( K_{IC} = \)  Gamma =
n =
Environment = Heptane
Reference = FREIMAN, S.W., Private Communications, 1984
Comments = Compo.- 3rd Other Oxide- 4.1% Nd₂O₃
Specific Material = UP68-6893
Manufacturer =
% Al₂O₃ = 9.4   % B₂O₃ =   % CaO =   % MgO =
% Na₂O =   % K₂O = 28.3  % PbO =   % SiO₂ =
Other Formula = P₂O₅,  Other % = 56.7
Other Formula = La₂O₃,  Other % = 1.5
Young’s Modulus = 4.94 E4
1st Technique = Ind. Crk. Len.  \( K_{ic} = .31 \)  Gamma = .97
2nd Technique =
\( K_{ic} = \)
\( \Gamma = \)
\( n = \)
Environment = Heptane
Reference = FREIMAN, S.W., Private Communications, 1984
Comments = Compo- 3rd Other Oxide- 4.0% Nd₂O₃

Specific Material = UP84-6957
Manufacturer =
% Al₂O₃ = 9.4   % B₂O₃ =   % CaO =   % MgO =
% Na₂O =   % K₂O = 18.8  % PbO =   % SiO₂ =
Other Formula = P₂O₅,  Other % = 65.9
Other Formula = La₂O₃,  Other % = 1.7
Young’s Modulus = 5.38 E4
1st Technique = Ind. Crk. Len.  \( K_{ic} = .37 \)  Gamma = 1.27
2nd Technique =
\( K_{ic} = \)
\( \Gamma = \)
\( n = \)
Environment = Heptane
Reference = FREIMAN, S.W., Private Communications, 1984
Comments = Compo- 3rd Other Oxide- 4.2% Nd₂O₃

Specific Material = UP85-6959
Manufacturer =
% Al₂O₃ = 9.4   % B₂O₃ =   % CaO =   % MgO =
% Na₂O =   % K₂O = 14.1  % PbO =   % SiO₂ =
Other Formula = P₂O₅,  Other % = 70.6
Other Formula = La₂O₃,  Other % = 1.6
Young’s Modulus = 5.68 E4
1st Technique = Ind. Crk. Len.  \( K_{ic} = .38 \)  Gamma = 1.27
2nd Technique =
\( K_{ic} = \)
\( \Gamma = \)
\( n = \)
Environment = Heptane
Reference = FREIMAN, S.W., Private Communications, 1984
Comments = Compo- 3rd Other Oxide- 4.2% Nd₂O₃

Specific Material = UP83-6955
Manufacturer =
% Al₂O₃ = 18.8   % B₂O₃ =   % CaO =   % MgO =
% Na₂O =   % K₂O = 9.4  % PbO =   % SiO₂ =
Other Formula = P₂O₅,  Other % = 65.9
Other Formula = La₂O₃,  Other % = 1.7
Young’s Modulus = 6.48 E4
1st Technique = Ind. Crk. Len.  \( K_{ic} = .55 \)  Gamma = 2.33
2nd Technique =
\( K_{ic} = \)
\( \Gamma = \)
\( n = \)
Environment = Heptane
Reference = FREIMAN, S.W., Private Communications, 1984
Comments = Compo- 3rd Other Oxide- 4.2% Nd₂O₃
### GUP83

Specific Material = E-Glass  
Manufacturer =  
% Al₂O₃ = 13.8 % B₂O₃ = 8.07 % CaO = 17.4 % MgO = 6.66  
% Na₂O = 5.44 % K₂O = % PbO = % SiO₂ = 53.8  
Other Formula = Other % =  
Other Formula = Other % =  
Young's Modulus =  
1st Technique = Dynamic Fat.  
2nd Technique =  
\( n = 24.8 \)  
Environment = air  
Comments = Material is an E-Glass Fiber

### KEN74

Specific Material =  
Manufacturer =  
% Al₂O₃ = % B₂O₃ = % CaO = % MgO =  
% Na₂O = 33 % K₂O = % PbO = % SiO₂ = 67  
Other Formula = Other % =  
Other Formula = Other % =  
Young's Modulus = 8.9 \( E^4 \)  
1st Technique = DCB  
2nd Technique =  
\( K_{IC} = 1.12 \)  
\( K_{IC} = \) Gamma = 7.0  
\( n = \)  
Environment = \( N_2(l) \)  
Comments =

Specific Material =  
Manufacturer =  
% Al₂O₃ = % B₂O₃ = % CaO = % MgO =  
% Na₂O = 29 % K₂O = % PbO = % SiO₂ = 71  
Other Formula = Other % =  
Other Formula = Other % =  
Young's Modulus = 8.93 \( E^4 \)  
1st Technique = DCB  
2nd Technique =  
\( K_{IC} = 1.04 \)  
\( K_{IC} = \) Gamma = 6.0  
\( n = \)  
Environment = \( N_2(l) \)  
Comments =

Specific Material =  
Manufacturer =  
% Al₂O₃ = % B₂O₃ = % CaO = % MgO =  
% Na₂O = 25 % K₂O = % PbO = % SiO₂ = 75  
Other Formula = Other % =  
Other Formula = Other % =  
Young's Modulus = 9.1 \( E^4 \)  
1st Technique = DCB  
2nd Technique =  
\( K_{IC} = 1.04 \)  
\( K_{IC} = \) Gamma = 5.95  
\( n = \)  
Environment = \( N_2(l) \)  
Comments =
Specific Material =
Manufacturer =
% Al₂O₃ = % B₂O₃ = % CaO = % MgO =
% Na₂O = 20 % K₂O = % PbO = % SiO₂ = 80
Other Formula = Other % =
Other Formula = Other % =
Young's Modulus = 9.25 x 10⁴
1st Technique = DCB
2nd Technique =
KIC = .98 Gamma = 5.2
n =
Environment = N₂(l)
Comments =

Specific Material =
Manufacturer =
% Al₂O₃ = % B₂O₃ = % CaO = % MgO =
% Na₂O = 17 % K₂O = % PbO = % SiO₂ = 83
Other Formula = Other % =
Other Formula = Other % =
Young's Modulus = 9.35 x 10⁴
1st Technique = DCB
2nd Technique =
KIC = .96 Gamma = 4.95
n =
Environment = N₂(l)
Comments =

Specific Material =
Manufacturer =
% Al₂O₃ = % B₂O₃ = % CaO = % MgO =
% Na₂O = % K₂O = % PbO = % SiO₂ = 100
Other Formula = Other % =
Other Formula = Other % =
Young's Modulus = 10.1 x 10⁴
1st Technique = DCB
2nd Technique =
KIC = .87 Gamma = 3.7
n =
Environment = N₂(l)
Comments =

MEC74
Specific Material = 7940
Manufacturer = Corning Glass
% Al₂O₃ = % B₂O₃ = % CaO = % MgO =
% Na₂O = % K₂O = % PbO = % SiO₂ = 100
Other Formula = Other % =
Other Formula = Other % =
Young's Modulus = 7.21 x 10⁴
1st Technique = AMDCB
2nd Technique =
KIC = .73 Gamma = 3.7
n =
Environment = air
Reference = MECHOLSKY,J.,RICE,R., JACTAW, Vol. 57, No. 10, 1974
Comments =
Specific Material = 1723
Manufacturer = Corning Glass
% Al₂O₃ = 9.43 % B₂O₃ = 4.60 % CaO = 11.4 % MgO = 11.1
% Na₂O = % K₂O = % PbO = % SiO₂ = 60.8
Other Formula = BaO Other % = 2.51
Other Formula = Other % =
Young's Modulus = 8.91 E4

1st Technique = AMDCB

2nd Technique =

\( K_{IC} = .81 \)

\( K_{IC} = \)

\( \Gamma = 3.7 \)

\( \Gamma = \)

\( n = \)

Environment = air

Reference = MECHOLSKY, J., RICE, R., JACTAW, Vol. 57, No. 10, 1974

Comments =

Specific Material = 7740
Manufacturer = Corning Glass
% Al₂O₃ = 3.36 % B₂O₃ = 11.3 % CaO = % MgO =
% Na₂O = 3.26 % K₂O = % PbO = % SiO₂ = 82.0
Other Formula = Other % =
Other Formula = Other % =
Young's Modulus = 6.37 E4

1st Technique = AMDCB

\( K_{IC} = .71 \)

\( K_{IC} = \)

\( \Gamma = 4.0 \)

\( \Gamma = \)

\( n = \)

Environment = air

Reference = MECHOLSKY, J., RICE, R., JACTAW, Vol. 57, No. 10, 1974

Comments =

Specific Material =
Manufacturer =
% Al₂O₃ = .581 % B₂O₃ = % CaO = 5.28 % MgO = 5.88
% Na₂O = 16.2 % K₂O = % PbO = % SiO₂ = 71.9
Other Formula = Other % =
Other Formula = Other % =
Young's Modulus = 7.34 E4

1st Technique = AMDCB

\( K_{IC} = .72 \)

\( K_{IC} = \)

\( \Gamma = 3.5 \)

\( \Gamma = \)

\( n = \)

Environment = air

Reference = MECHOLSKY, J., RICE, R., JACTAW, Vol. 57, No. 10, 1974

Comments =

MEC77

Specific Material =
Manufacturer =
% Al₂O₃ = % B₂O₃ = % CaO = % MgO =
% Na₂O = % K₂O = % PbO = % SiO₂ = 67
Other Formula = Li₂O Other % = 33
Other Formula = Other % =
Young's Modulus = 5.2 E4

1st Technique = DCB

\( K_{IC} = .7 \)

\( K_{IC} = \)

\( \Gamma = 5.0 \)

\( \Gamma = \)

\( n = \)

Environment = air


Comments =
Specific Material = ENK5
Manufacturer = Owens-Corning
% Al₂O₃ = 8.55  % B₂O₃ = 8.17  % CaO = 17.6  % MgO = 6.74
% Na₂O = 2.14  % K₂O = 2.21  % PbO =  % SiO₂ = 54.4
Other Formula = Other % =
Other Formula = Other % =
Young's Modulus = 6.4 E4
1st Technique = DCB  \( K_{IC} = 0.5 \)  Gamma = 2.0
2nd Technique = \( K_{IC} = \)  Gamma =
\( n = \) 11
Environment = H₂O
Comments = Material is an E-Glass Fiber

Specific Material = EF5
Manufacturer = Owens-Corning
% Al₂O₃ = 8.94  % B₂O₃ = 8.54  % CaO = 18.4  % MgO = 7.04
% Na₂O =  % K₂O =  % PbO =  % SiO₂ = 56.9
Other Formula = Other % =
Other Formula = Other % =
Young's Modulus =
1st Technique = Dynamic Fat.  \( K_{IC} = \)  Gamma =
2nd Technique = \( K_{IC} = \)  Gamma =
\( n = 19 \)
Environment = H₂O
Comments = Material is an E-Glass Fiber

Specific Material = EBN0
Manufacturer = Owens-Corning
% Al₂O₃ = 9.83  % B₂O₃ =  % CaO = 21.3  % MgO = 7.37
% Na₂O =  % K₂O =  % PbO =  % SiO₂ = 61.4
Other Formula = Other % =
Other Formula = Other % =
Young's Modulus =
1st Technique = Dynamic Fat.  \( K_{IC} = \)  Gamma =
2nd Technique = \( K_{IC} = \)  Gamma =
\( n = 30 \)
Environment = H₂O
Comments = Material is an E-Glass Fiber
Specific Material = ES
Manufacturer = Owens-Corning
% Al₂O₃ = 8.89 % B₂O₃ = 8.53 % CaO = 18.3 % MgO = 6.97
% Na₂O = 5.04 % K₂O = % PbO = % SiO₂ = 56.7
Other Formula = Other % =
Other Formula = Other % =
Young’s Modulus =
1st Technique = Dynamic Fat.
2nd Technique =
\(n = 22\)
Environment = H₂O
Comments = Material is an E-Glass Fiber

Specific Material = EN0
Manufacturer = Owens-Corning
% Al₂O₃ = 8.88 % B₂O₃ = 8.52 % CaO = 18.3 % MgO = 6.97
% Na₂O = % K₂O = % PbO = % SiO₂ = 57.2
Other Formula = Other % =
Other Formula = Other % =
Young’s Modulus =
1st Technique = Dynamic Fat.
2nd Technique =
\(n = 22\)
Environment = H₂O
Comments = Material is an E-Glass Fiber

Specific Material = EN5
Manufacturer = Owens-Corning
% Al₂O₃ = 8.45 % B₂O₃ = 8.07 % CaO = 17.4 % MgO = 6.66
% Na₂O = 5.44 % K₂O = % PbO = % SiO₂ = 53.8
Other Formula = Other % =
Other Formula = Other % =
Young’s Modulus =
1st Technique = Dynamic Fat.
2nd Technique =
\(n = 20\)
Environment = H₂O
Comments = Material is an E-Glass Fiber

Specific Material = EK5
Manufacturer = Owens-Corning
% Al₂O₃ = 8.61 % B₂O₃ = 8.23 % CaO = 17.8 % MgO = 6.79
% Na₂O = % K₂O = 3.64 % PbO = % SiO₂ = 54.8
Other Formula = Other % =
Other Formula = Other % =
Young’s Modulus =
1st Technique = Dynamic Fat.
2nd Technique =
\(n = 17\)
Environment = H₂O
Comments = Material is an E-Glass Fiber
Specific Material =
Manufacturer =
% $\text{Al}_2\text{O}_3$ = % $\text{B}_2\text{O}_3$ = 100
% $\text{Na}_2\text{O}$ = % $\text{K}_2\text{O}$ =
Other Formula = Other % =
Other Formula = Other % =
Young's Modulus =
1st Technique = Ind. Crk. Len.
2nd Technique =
$n =$
Environment = air
Comments =

Specific Material =
Manufacturer =
% $\text{Al}_2\text{O}_3$ = % $\text{B}_2\text{O}_3$ = 96.4
% $\text{Na}_2\text{O}$ = % $\text{K}_2\text{O}$ =
Other Formula = Other % =
Other Formula = Other % =
Young's Modulus =
1st Technique = Ind. Crk. Len.
2nd Technique =
$n =$
Environment = air
Comments =

Specific Material =
Manufacturer =
% $\text{Al}_2\text{O}_3$ = % $\text{B}_2\text{O}_3$ = 95.8
% $\text{Na}_2\text{O}$ = % $\text{K}_2\text{O}$ =
Other Formula = Other % =
Other Formula = Other % =
Young's Modulus =
1st Technique = Ind. Crk. Len.
2nd Technique = NB
$n =$
Environment = air
Comments =
Specific Material =
Manufacturer =
\% Al₂O₃ = 85.7 \% B₂O₃ = 83.7 \% CaO = % MgO =
\% Na₂O = 16.2 \% K₂O = % PbO = 16.2 \% SiO₂ =
Other Formula = Other % =
Other Formula = Other % =
Young's Modulus =
1st Technique = Ind. Crk. Len. \( K_{\text{IC}} = 1.29 \) Gamma =
2nd Technique = NB \( K_{\text{IC}} = 1.33 \) Gamma =
\( n = \)
Environment = air
Comments =
Specific Material = Manufacturer =
% Al₂O₃ = % B₂O₃ = 80.7
% Na₂O = % K₂O =
Other Formula = Other % =
Other Formula = Other % =
Young's Modulus =
1st Technique = Ind. Crk. Len.
2nd Technique = NB
n =
Environment = air
Comments =

MIY81
Specific Material =
Manufacturer =
% Al₂O₃ = % B₂O₃ = 100
% Na₂O = % K₂O =
Other Formula = Other % =
Other Formula = Other % =
Young's Modulus = 1.73 E4
1st Technique = Ind. Crk. Len.
2nd Technique =
KIC = .96

Gamma = 26.64
n =
Environment = air
Reference = MIYATA,H.,JINNO,N.,Journ. of Mat. Sci. 16,2205-17,1981
Comments =

Specific Material =
Manufacturer =
% Al₂O₃ = % B₂O₃ = 98.4
% Na₂O = % K₂O =
Other Formula = Other % =
Other Formula = Other % =
Young's Modulus = 1.87 E4
1st Technique = Ind. Crk. Len.
2nd Technique =
KIC = .96

Gamma = 24.64
n =
Environment = air
Reference = MIYATA,H.,JINNO,N.,Journ. of Mat. Sci. 16,2205-17,1981
Comments =

Specific Material =
Manufacturer =
% Al₂O₃ = % B₂O₃ = 96.8
% Na₂O = % K₂O =
Other Formula = Other % =
Other Formula = Other % =
Young's Modulus = 2.02 E4
1st Technique = Ind. Crk. Len.
2nd Technique =
KIC = .88

Gamma = 19.17
n =
Environment = air
Reference = MIYATA,H.,JINNO,N.,Journ. of Mat. Sci. 16,2205-17,1981
Comments =
Specific Material =
Manufacturer =
% Al₂O₃ = % B₂O₃ = 95.8 % CaO = % MgO =
% Na₂O = % K₂O = % PbO = 4.16 % SiO₂ =
Other Formula = Other % =
Other Formula = Other % =
Young’s Modulus = 2.1E4
1st Technique = Ind. Crk. Len. K_{IC} = .87 Gamma = 18.02
2nd Technique = NB K_{IC} = .82 Gamma = 16.01
n =
Environment = air
Reference = MIYATA,H.,JINNO,N.,Journ. of Mat. Sci. 16,2205-17,1981
Comments =

Specific Material =
Manufacturer =
% Al₂O₃ = % B₂O₃ = 87.9 % CaO = % MgO =
% Na₂O = % K₂O = % PbO = 12 % SiO₂ =
Other Formula = Other % =
Other Formula = Other % =
Young’s Modulus = 3.12E4
1st Technique = Ind. Crk. Len. K_{IC} = 1.75 Gamma = 49.08
2nd Technique = NB K_{IC} = 1.6 Gamma = 41.03
n =
Environment = air
Reference = MIYATA,H.,JINNO,N.,Journ. of Mat. Sci. 16,2205-17,1981
Comments =

Specific Material =
Manufacturer =
% Al₂O₃ = % B₂O₃ = 85.9 % CaO = % MgO =
% Na₂O = % K₂O = % PbO = 14.0 % SiO₂ =
Other Formula = Other % =
Other Formula = Other % =
Young’s Modulus = 3.62E4
1st Technique = Ind. Crk. Len. K_{IC} = 1.52 Gamma = 31.91
2nd Technique = NB K_{IC} = 1.37 Gamma = 25.92
n =
Environment = air
Reference = MIYATA,H.,JINNO,N.,Journ. of Mat. Sci. 16,2205-17,1981
Comments =
Specific Material =
Manufacturer =
% $\text{Al}_2\text{O}_3$ = 83.7 % $\text{B}_2\text{O}_3$ =
% $\text{Na}_2\text{O}$ = 16.2 % $\text{MgO}$ =
Other Formula = Other % =
Other Formula = Other % =
Young's Modulus = 4.45 $E^4$
1st Technique = Ind. Crk. Len. $K_{IC} = 1.4$ Gamma = 22.02
2nd Technique = NB $K_{IC} = 1.35$ Gamma = 20.48
$n =$
Environment = air
Reference = MIYATA,H.,JINNO,N.,Journ. of Mat. Sci. 16,2205-17,1981
Comments =

Specific Material =
Manufacturer =
% $\text{Al}_2\text{O}_3$ = 80.7 % $\text{B}_2\text{O}_3$ =
% $\text{Na}_2\text{O}$ = 19.2 % $\text{MgO}$ =
$\text{Other Formula}$ = Other % =
$\text{Other Formula}$ = Other % =
Young's Modulus = 6.04 $E^4$
1st Technique = Ind. Crk. Len. $K_{IC} = 1.05$ Gamma = 9.13
2nd Technique = NB $K_{IC} = .93$ Gamma = 7.16
$n =$
Environment = air
Reference = MIYATA,H.,JINNO,N.,Journ. of Mat. Sci. 16,2205-17,1981
Comments =

MIY83
Specific Material =
Manufacturer =
% $\text{Al}_2\text{O}_3$ = 14.5 % $\text{B}_2\text{O}_3$ =
% $\text{Na}_2\text{O}$ = 5.36 % $\text{MgO}$ =
Other Formula = Other % =
Other Formula = Other % =
Young's Modulus = 6.19 $E^4$
1st Technique = NB $K_{IC} = .8$ Gamma = 5.17
2nd Technique = $K_{IC} =$
$n =$
Environment = air
Comments = Test Tech.- introduced a sharp crack at the notch

Specific Material =
Manufacturer =
% $\text{Al}_2\text{O}_3$ = 19.4 % $\text{B}_2\text{O}_3$ =
% $\text{Na}_2\text{O}$ = 5.37 % $\text{MgO}$ =
Other Formula = Other % =
Other Formula = Other % =
Young's Modulus = 6.28 $E^4$
1st Technique = NB $K_{IC} = .8$ Gamma = 5.10
2nd Technique = $K_{IC} =$
$n =$
Environment = air
Comments = Test Tech.- introduced a sharp crack at the notch
Specific Material =
Manufacturer =
% Al₂O₃ = % B₂O₃ =  % CaO = 5.37  % MgO =
% Na₂O = 24.3  % K₂O =  % PbO =  % SiO₂ = 70.2
Other Formula =  Other % =
Other Formula =  Other % =
Young's Modulus = 6.37 E4
1st Technique = NB  \( K_I = 0.8 \)
2nd Technique =  \( K_I = \)  
\( n = \)  
Environment = air
Comments = Test Tech.- introduced a sharp crack at the notch

Specific Material =
Manufacturer =
% Al₂O₃ = % B₂O₃ =  % CaO = 5.38  % MgO =
% Na₂O = 29.2  % K₂O =  % PbO =  % SiO₂ = 65.3
Other Formula =  Other % =
Other Formula =  Other % =
Young's Modulus = 6.42 E4
1st Technique = NB  \( K_I = 0.8 \)
2nd Technique =  \( K_I = \)  
\( n = \)  
Environment = air
Comments = Test Tech.- introduced a sharp crack at the notch

MOU59
Specific Material =
Manufacturer =
% Al₂O₃ = 1.16  % B₂O₃ =  % CaO = 7.43  % MgO = 5.91
% Na₂O = 13.4  % K₂O = .632  % PbO =  % SiO₂ = 71.3
Other Formula =  Other % =
Other Formula =  Other % =
Young's Modulus =
1st Technique = Static Fat.  \( K_I = \)  
2nd Technique =  \( K_I = \)  
\( n = 13 \)
Environment = H₂O
Reference = MOULD, R.E., SOUTHWICK, R.D., JACTAW, 42, 542-47, 582-92, 1959
Comments = Surface condition- abraded

PRO67
Specific Material =
Manufacturer =
% Al₂O₃ = % B₂O₃ =  % CaO =  % MgO =
% Na₂O =  % K₂O =  % PbO =  % SiO₂ = 100
Other Formula =  Other % =
Other Formula =  Other % =
Young's Modulus =
1st Technique = Static Fat.  \( K_I = \)  
2nd Technique =  \( K_I = \)  
\( n = 19.2 \)
Environment = air, 50% RH
Comments = Surface condition- as-drawn fiber
Specific Material =
Manufacturer =
\% Al_{2}O_{3} = \% B_{2}O_{3} = \% CaO = \% MgO =
\% Na_{2}O = \% K_{2}O = \% PbO = \% SiO_{2} = 100
Other Formula = Other % =
Other Formula = Other % =
Young's Modulus =
1st Technique = Dynamic Fat. \( K_{IC} = \) Gamma =
2nd Technique = \( K_{IC} = \) Gamma =
n = 27
Environment = air, 50% RH
Comments = Surface condition- as-drawn fiber

RIT69
Specific Material =
Manufacturer =
\% Al_{2}O_{3} = 1.16 \% B_{2}O_{3} = \% CaO = 7.43 \% MgO = 5.91
\% Na_{2}O = 13.4 \% K_{2}O = 6.32 \% PbO = \% SiO_{2} = 71.3
Other Formula = Other % =
Other Formula = Other % =
Young's Modulus =
1st Technique = Dynamic Fat. \( K_{IC} = \) Gamma =
2nd Technique = \( K_{IC} = \) Gamma =
n = 13
Environment = air, 50% RH
Reference = RITTER,J.E.,Jr.,Jour. of Appl. Phys., 40, 340-44,1969
Comments = Surface condition- acid etch and abraded

RIT71
Specific Material = 7740
Manufacturer = Corning Glass
\% Al_{2}O_{3} = 1.21 \% B_{2}O_{3} = 12.4 \% CaO = \% MgO =
\% Na_{2}O = 3.99 \% K_{2}O = \% PbO = \% SiO_{2} = 82.3
Other Formula = Other % =
Other Formula = Other % =
Young's Modulus =
1st Technique = Dynamic Fat. \( K_{IC} = \) Gamma =
2nd Technique = \( K_{IC} = \) Gamma =
n = 27.4
Environment = air, 100% RH
Reference = RITTER,J.E.,Jr.,SHERBOURNE,C.L.,JACTAW,54,601-05,1971
Comments = Surface condition- abraded

Specific Material =
Manufacturer =
\% Al_{2}O_{3} = \% B_{2}O_{3} = \% CaO = \% MgO =
\% Na_{2}O = \% K_{2}O = \% PbO = \% SiO_{2} = 100
Other Formula = Other % =
Other Formula = Other % =
Young's Modulus =
1st Technique = Dynamic Fat. \( K_{IC} = \) Gamma =
2nd Technique = \( K_{IC} = \) Gamma =
n = 37.8
Environment = air, 100% RH
Reference = RITTER,J.E.,Jr.,SHERBOURNE,C.L.,JACTAW,54,601-05,1971
Comments = Surface condition- abrade
Specific Material = R6
Manufacturer = Owens-Illinois
% Al2O3 = 1.78  % B2O3 = 1.74  % CaO = 5.42  % MgO = 6.03
% Na2O = 14.7  % K2O = .645  % PbO =  % SiO2 = 68.8
Other Formula = BaO  Other % = .793
Other Formula = Other % =
Young's Modulus =
1st Technique = Static Fat.  $K_{IC} =$  Gamma =
2nd Technique =  $K_{IC} =$  Gamma =
n = 32
Environment = air, 50% RH
Reference = RITTER,J.E.,Jr.,SHERBOURNE,C.L.,JACTAW,54,601-05,1971
Comments = Surface condition- acid etch

RIT73
Specific Material = 7740
Manufacturer = Corning Glass
% Al2O3 = 1.21  % B2O3 = 12.4  % CaO =  % MgO =
% Na2O = 3.99  % K2O =  % PbO =  % SiO2 = 82.3
Other Formula = Other % =
Other Formula = Other % =
Young's Modulus =
1st Technique = Dynamic Fat.  $K_{IC} =$  Gamma =
2nd Technique =  $K_{IC} =$  Gamma =
n = 16
Environment = air, 100% RH
Reference = RITTER,J.E.,Jr.,MANTHURUTHIL,J.,Glass Tech.,14,60-64,1973
Comments = Surface condition- abraded

Specific Material = 7740
Manufacturer = Corning Glass
% Al2O3 = 1.21  % B2O3 = 12.4  % CaO =  % MgO =
% Na2O = 3.99  % K2O =  % PbO =  % SiO2 = 82.3
Other Formula = Other % =
Other Formula = Other % =
Young's Modulus =
1st Technique = Dynamic Fat.  $K_{IC} =$  Gamma =
2nd Technique =  $K_{IC} =$  Gamma =
n = 22
Environment = air, 100% RH
Reference = RITTER,J.E.,Jr.,MANTHURUTHIL,J.,Glass Tech.,14,60-64,1973
Comments = Surface condition- abraded

RIT75
Specific Material = R6
Manufacturer = Owens-Illinois
% Al2O3 = 1.78  % B2O3 = 1.74  % CaO = 5.42  % MgO = 6.03
% Na2O = 14.7  % K2O = .645  % PbO =  % SiO2 = 68.8
Other Formula = BaO  Other % = .793
Other Formula = Other % =
Young's Modulus =
1st Technique = Dynamic Fat.  $K_{IC} =$  Gamma =
2nd Technique =  $K_{IC} =$  Gamma =
n = 19.5
Environment = 6N NaOH
Reference = RITTER,J.E.,Jr.,LAPORTE,R.P., JACTAW, 58, 265-67, 1975
Comments = Surface condition- abraded
Specific Material = R6
Manufacturer = Owens-Illinois
\% Al\textsubscript{2}O\textsubscript{3} = 1.78 \% B\textsubscript{2}O\textsubscript{3} = 1.74 \% CaO = 5.42 \% MgO = 6.03
\% Na\textsubscript{2}O = 14.7 \% K\textsubscript{2}O = .645 \% PbO = \% SiO\textsubscript{2} = 68.8
Other Formula = BaO Other \% = .793
Young's Modulus =
1st Technique = Dynamic Fat. \( K_{IC} = \) Gamma
2nd Technique = \( K_{IC} = \) Gamma
\( n = 13 \)
Environment = H\textsubscript{2}O
Reference = RITTER,J.E.,Jr.,LAPORTE,R.P., JACTAW, 58, 265-67, 1975
Comments = Surface condition- abraded

Specific Material = R6
Manufacturer = Owens-Illinois
\% Al\textsubscript{2}O\textsubscript{3} = 1.78 \% B\textsubscript{2}O\textsubscript{3} = 1.74 \% CaO = 5.42 \% MgO = 6.03
\% Na\textsubscript{2}O = 14.7 \% K\textsubscript{2}O = .645 \% PbO = \% SiO\textsubscript{2} = 68.8
Other Formula = BaO Other \% = .793
Young's Modulus =
1st Technique = Dynamic Fat. \( K_{IC} = \) Gamma
2nd Technique = \( K_{IC} = \) Gamma
\( n = 25.1 \)
Environment = 6N HCl
Reference = RITTER,J.E.,Jr.,LAPORTE,R.P., JACTAW, 58, 265-67, 1975
Comments = Surface condition- abraded

Specific Material = R6
Manufacturer = Owens-Illinois
\% Al\textsubscript{2}O\textsubscript{3} = 1.78 \% B\textsubscript{2}O\textsubscript{3} = 1.74 \% CaO = 5.42 \% MgO = 6.03
\% Na\textsubscript{2}O = 14.7 \% K\textsubscript{2}O = .645 \% PbO = \% SiO\textsubscript{2} = 68.8
Other Formula = BaO Other \% = .793
Young's Modulus =
1st Technique = Dynamic Fat. \( K_{IC} = \) Gamma
2nd Technique = \( K_{IC} = \) Gamma
\( n = 19.3 \)
Environment = 6N NaOH
Reference = RITTER,J.E.,Jr.,LAPORTE,R.P., JACTAW, 58, 265-67, 1975
Comments = Surface condition- acid polished

Specific Material = R6
Manufacturer = Owens-Illinois
\% Al\textsubscript{2}O\textsubscript{3} = 1.78 \% B\textsubscript{2}O\textsubscript{3} = 1.74 \% CaO = 5.42 \% MgO = 6.03
\% Na\textsubscript{2}O = 14.7 \% K\textsubscript{2}O = .645 \% PbO = \% SiO\textsubscript{2} = 68.8
Other Formula = BaO Other \% = .793
Young's Modulus =
1st Technique = Dynamic Fat. \( K_{IC} = \) Gamma
2nd Technique = \( K_{IC} = \) Gamma
\( n = 16.9 \)
Environment = H\textsubscript{2}O
Reference = RITTER,J.E.,Jr.,LAPORTE,R.P., JACTAW, 58, 265-67, 1975
Comments = Surface condition- acid polished
Specific Material = R6
Manufacturer = Owens-Illinois
% Al₂O₃ = 1.78  % B₂O₃ = 1.74  % CaO = 5.42  % MgO = 6.03
% Na₂O = 14.7  % K₂O = .645  % PbO =  % SiO₂ = 68.8
Other Formula = BaO  Other % = .793
Other Formula = Other % =
Young's Modulus =
1st Technique = Dynamic Fat.  \( K_{IC} = \)  Gamma =
2nd Technique =  \( K_{IC} = \)  Gamma =
\( n = 17.8 \)
Environment = 6N HCl
Reference = RITTER,J.E.,Jr.,LAPORTE,R.P., JACTAW, 58, 265-67, 1975
Comments = Surface condition- acid polished

Specific Material = 7740
Manufacturer = Corning Glass
% Al₂O₃ = 1.21  % B₂O₃ = 12.4  % CaO =  % MgO =
% Na₂O = 3.99  % K₂O =  % PbO =  % SiO₂ = 82.3
Other Formula = Other % =
Other Formula = Other % =
Young's Modulus =
1st Technique = Dynamic Fat.  \( K_{IC} = \)  Gamma =
2nd Technique =  \( K_{IC} = \)  Gamma =
\( n = 22.6 \)
Environment = 6N NaOH
Reference = RITTER,J.E.,Jr.,LAPORTE,R.P., JACTAW, 58, 265-67, 1975
Comments = Surface condition- abraded

Specific Material = 7740
Manufacturer = Corning Glass
% Al₂O₃ = 1.21  % B₂O₃ = 12.4  % CaO =  % MgO =
% Na₂O = 3.99  % K₂O =  % PbO =  % SiO₂ = 82.3
Other Formula = Other % =
Other Formula = Other % =
Young's Modulus =
1st Technique = Dynamic Fat.  \( K_{IC} = \)  Gamma =
2nd Technique =  \( K_{IC} = \)  Gamma =
\( n = 35.1 \)
Environment = H₂O
Reference = RITTER,J.E.,Jr.,LAPORTE,R.P., JACTAW, 58, 265-67, 1975
Comments = Surface condition- abraded

Specific Material = 7740
Manufacturer = Corning Glass
% Al₂O₃ = 1.21  % B₂O₃ = 12.4  % CaO =  % MgO =
% Na₂O = 3.99  % K₂O =  % PbO =  % SiO₂ = 82.3
Other Formula = Other % =
Other Formula = Other % =
Young's Modulus =
1st Technique = Dynamic Fat.  \( K_{IC} = \)  Gamma =
2nd Technique =  \( K_{IC} = \)  Gamma =
\( n = 26.9 \)
Environment = 6N HCl
Reference = RITTER,J.E.,Jr.,LAPORTE,R.P., JACTAW, 58, 265-67, 1975
Comments = Surface condition- abraded
Specific Material = 7740
Manufacturer = Corning Glass
% Al₂O₃ = 1.21 % B₂O₃ = 12.4
% Na₂O = 3.99 % K₂O =
Other Formula = Other % =
Other Formula = Other % =
Young's Modulus =
1st Technique = Dynamic Fat. $K_{1C} =$
2nd Technique = $K_{1C} =$
$n = 21.1$
Environment = 6N NaOH
Reference = RITTER, J.E., Jr., LAPORTE, R.P., JACTAW, 58, 265-67, 1975
Comments = Surface condition- acid polished

Specific Material = 7740
Manufacturer = Corning Glass
% Al₂O₃ = 1.21 % B₂O₃ = 12.4
% Na₂O = 3.99 % K₂O =
Other Formula = Other % =
Other Formula = Other % =
Young's Modulus =
1st Technique = Dynamic Fat. $K_{1C} =$
2nd Technique = $K_{1C} =$
$n = 39.8$
Environment = H₂O
Reference = RITTER, J.E., Jr., LAPORTE, R.P., JACTAW, 58, 265-67, 1975
Comments = Surface condition- acid polished

Specific Material = 7740
Manufacturer = Corning Glass
% Al₂O₃ = 1.21 % B₂O₃ = 12.4
% Na₂O = 3.99 % K₂O =
Other Formula = Other % =
Other Formula = Other % =
Young's Modulus =
1st Technique = Dynamic Fat. $K_{1C} =$
2nd Technique = $K_{1C} =$
$n = 64.9$
Environment = 6N HCl
Reference = RITTER, J.E., Jr., LAPORTE, R.P., JACTAW, 58, 265-67, 1975
Comments = Surface condition- acid polished

Specific Material = 7740
Manufacturer = Corning Glass
% Al₂O₃ = 1.21 % B₂O₃ = 12.4
% Na₂O = 3.99 % K₂O =
Other Formula = Other % =
Other Formula = Other % =
Young's Modulus =
1st Technique = DCB $K_{1C} =$
2nd Technique = $K_{1C} =$
$n = 34.1$
Environment = H₂O
Reference = RITTER, J.E., Jr., LAPORTE, R.P., JACTAW, 58, 265-67, 1975
Comments =
Specific Material = 7740
Manufacturer = Corning Glass
% Al$_2$O$_3$ = 1.21  % B$_2$O$_3$ = 12.4  % CaO =
% Na$_2$O = 3.99  % K$_2$O =  % PbO =  % SiO$_2$ = 82.3
Other Formula = Other % =
Other Formula = Other % =
Young's Modulus =
1st Technique = DCB
\[ K_{IC} = \text{Gamma} = \]
2nd Technique =
\[ K_{IC} = \text{Gamma} = \]
\[ n = 22.7 \]
Environment = 6N NaOH
Reference = RITTER, J.E., Jr., LAPORTE, R.P., JACTAW, 58, 265-67, 1975
Comments =

SHI79
Specific Material =
Manufacturer =
% Al$_2$O$_3$ =  % B$_2$O$_3$ = 30  % CaO =  % MgO =
% Na$_2$O =  % K$_2$O =  % PbO = 70  % SiO$_2$ =
Other Formula = Other % =
Other Formula = Other % =
Young's Modulus = 4.33 E4
1st Technique = Controlled Flaw
\[ K_{IC} = .32 \text{ Gamma} = 1.16 \]
2nd Technique =
\[ K_{IC} = \text{Gamma} = \]
\[ n = \]
Environment = N$_2$(l) at -196C
Reference = SHINKAI, N., Thesis by author at Penn. State Univ., 1979
Comments =

Specific Material =
Manufacturer =
% Al$_2$O$_3$ =  % B$_2$O$_3$ = 30  % CaO =  % MgO =
% Na$_2$O =  % K$_2$O =  % PbO = 70  % SiO$_2$ =
Other Formula = Other % =
Other Formula = Other % =
Young's Modulus = 4.33 E4
1st Technique = Controlled Flaw
\[ K_{IC} = .24 \text{ Gamma} = .65 \]
2nd Technique =
\[ K_{IC} = \text{Gamma} = \]
\[ n = \]
Environment = air
Reference = SHINKAI, N., Thesis by author at Penn. State Univ., 1979
Comments =
Specific Material =
Manufacturer =
% Al₂O₃ = % B₂O₃ = 30 % CaO = % MgO =
% Na₂O = % K₂O = % PbO = 52.5 % SiO₂ =
Other Formula = ZnO Other % = 17.5
Other Formula = Other % =
Young's Modulus = 5.27 E4
1st Technique = Controlled Flaw
2nd Technique =
\[ n = \]
Environment = N₂(l) at -196°C
Reference = SHINKAI,N., Thesis by author at Penn. State Univ., 1979
Comments =

Specific Material =
Manufacturer =
% Al₂O₃ = % B₂O₃ = 30 % CaO = % MgO =
% Na₂O = % K₂O = % PbO = 35 % SiO₂ =
Other Formula = ZnO Other % = 35
Other Formula = Other % =
Young's Modulus = 6.1 E4
1st Technique = Controlled Flaw
2nd Technique =
\[ n = \]
Environment = N₂(l) at -196°C
Reference = SHINKAI,N., Thesis by author at Penn. State Univ., 1979
Comments =

Specific Material =
Manufacturer =
% Al₂O₃ = % B₂O₃ = 40 % CaO = % MgO =
% Na₂O = % K₂O = % PbO = 60 % SiO₂ =
Other Formula = Other % =
Other Formula = Other % =
Young's Modulus = 5.55 E4
1st Technique = Controlled Flaw
2nd Technique =
\[ n = \]
Environment = N₂(l) at -196°C
Reference = SHINKAI,N., Thesis by author at Penn. State Univ., 1979
Comments =

Specific Material =
Manufacturer =
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% Na₂O = % K₂O = % PbO = 35 % SiO₂ =
Other Formula = ZnO Other % = 35
Other Formula = Other % =
Young's Modulus = 6.1 E4
1st Technique = Controlled Flaw
2nd Technique =
\[ n = \]
Environment = air
Reference = SHINKAI,N., Thesis by author at Penn. State Univ., 1979
Comments =

Specific Material =
Manufacturer =
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% Na₂O = % K₂O = % PbO = 60 % SiO₂ =
Other Formula = Other % =
Other Formula = Other % =
Young's Modulus = 5.55 E4
1st Technique = Controlled Flaw
2nd Technique =
\[ n = \]
Environment = N₂(l) at -196°C
Reference = SHINKAI,N., Thesis by author at Penn. State Univ., 1979
Comments =
Specific Material =
Manufacturer =
% Al₂O₃ = 40
% B₂O₃ = 30
% Na₂O =
% K₂O =
Other Formula = ZnO
Other % = 17.5
Other Formula =
Other % =
Young's Modulus = 5.55 E4
1st Technique = Controlled Flaw
Kₐ = .36
Gamma = 1.17
2nd Technique =
Kₐ =
Gamma =

n =
Environment = air
Reference = SHINKAI,N., Thesis by author at Penn. State Univ., 1979
Comments =

Specific Material =
Manufacturer =
% Al₂O₃ = 30
% B₂O₃ = 40
% Na₂O =
% K₂O = 45
Other Formula = ZnO
Other % = 15
Other Formula =
Other % =
Young's Modulus = 5.27 E4
1st Technique = Controlled Flaw
Kₐ = .29
Gamma = .78
2nd Technique =
Kₐ =
Gamma =

n =
Environment = air
Reference = SHINKAI,N., Thesis by author at Penn. State Univ., 1979
Comments =

Specific Material =
Manufacturer =
% Al₂O₃ = 40
% B₂O₃ = 40
% Na₂O =
% K₂O = 52.5
Other Formula = ZnO
Other % = 15
Other Formula =
Other % =
Young's Modulus = 6.98 E4
1st Technique = Controlled Flaw
Kₐ = .48
Gamma = 1.66
2nd Technique =
Kₐ =
Gamma =

n =
Environment = N₂(l) at -196C
Reference = SHINKAI,N., Thesis by author at Penn. State Univ., 1979
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% Al₂O₃ = % B₂O₃ = 40
% Na₂O = % K₂O =
Other Formula = ZnO Other % = 30
Other Formula = Other % =
Young's Modulus = 7.47 E4
1st Technique = Controlled Flaw
2nd Technique =
\( K_{IC} = 0.61 \)
\( \Gamma = 2.47 \)
\( n = \)
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Reference = SHINKAI, N., Thesis by author at Penn. State Univ., 1979
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Specific Material =
Manufacturer =
% Al₂O₃ = % B₂O₃ = 40
% Na₂O = % K₂O =
Other Formula = ZnO Other % = 30
Other Formula = Other % =
Young's Modulus = 7.9 E4
1st Technique = Controlled Flaw
2nd Technique =
\( K_{IC} = 0.56 \)
\( \Gamma = 2.11 \)
\( n = \)
Environment = air
Reference = SHINKAI, N., Thesis by author at Penn. State Univ., 1979
Comments =

Specific Material =
Manufacturer =
% Al₂O₃ = % B₂O₃ = 40
% Na₂O = % K₂O =
Other Formula = ZnO Other % = 45
Other Formula = Other % =
Young's Modulus = 7.9 E4
1st Technique = Controlled Flaw
2nd Technique =
\( K_{IC} = 0.75 \)
\( \Gamma = 3.57 \)
\( n = \)
Environment = \( \text{N}_2\) at -196°C
Reference = SHINKAI, N., Thesis by author at Penn. State Univ., 1979
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Specific Material =
Manufacturer =
% Al₂O₃ =   % B₂O₃ = 40  % CaO =  % MgO =
% Na₂O =   % K₂O =  % PbO =  % SiO₂ =
Other Formula = ZnO  Other % = 60
Other Formula =  Other % =
Young’s Modulus = 8.88 E4
1st Technique = Controlled Flaw  \( K_{IC} = .89 \)  Gamma = 4.45
2nd Technique =  \( K_{IC} \) =  Gamma =
\( n = \)  
Environment = \( \text{N}_2(l) \) at -196°C
Reference = SHINKAI,N., Thesis by author at Penn. State Univ., 1979
Comments =

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Manufacturer =
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% Na₂O = % K₂O =
Other Formula = ZnO Other % = 12.5
Young's Modulus = 7.13 E4
1st Technique = Controlled Flaw
2nd Technique =

n =

Environment = N₂(l) at -196C
Reference = SHINKAI,N., Thesis by author at Penn. State Univ., 1979
Comments =

Specific Material =
Manufacturer =
% Al₂O₃ = % B₂O₃ = 50
% Na₂O = % K₂O =
Other Formula = ZnO Other % = 25
Other Formula =
Young's Modulus = 8.08 E4
1st Technique = Controlled Flaw
2nd Technique =

n =

Environment = N₂(l) at -196C
Reference = SHINKAI,N., Thesis by author at Penn. State Univ., 1979
Comments =

Specific Material =
Manufacturer =
% Al₂O₃ = % B₂O₃ = 50
% Na₂O = % K₂O =
Other Formula = ZnO Other % = 25
Other Formula =
Young's Modulus = 8.08 E4
1st Technique = Controlled Flaw
2nd Technique =

n =

Environment = air
Reference = SHINKAI,N., Thesis by author at Penn. State Univ., 1979
Comments =
Specific Material =
Manufacturer =
% Al₂O₃ = % B₂O₃ = 50  % CaO = % MgO =
% Na₂O = % K₂O =
Other Formula = ZnO  Other % = 37.5
Other Formula =  Other % =
Young's Modulus = 8.26 E4
1st Technique = Controlled Flaw
  K₁c = .89  Gamma = 4.80
2nd Technique =
  K₁c =
  Gamma =
n =
Environment = N₂(l) at -196C
Reference = SHINKAI,N., Thesis by author at Penn. State Univ., 1979
Comments =

Specific Material =
Manufacturer =
% Al₂O₃ = % B₂O₃ = 50  % CaO = % MgO =
% Na₂O = % K₂O =
Other Formula = ZnO  Other % = 37.5
Other Formula =  Other % =
Young's Modulus = 8.26 E4
1st Technique = Controlled Flaw
  K₁c = .71  Gamma = 3.09
2nd Technique =
  K₁c =
  Gamma =
n =
Environment = air
Reference = SHINKAI,N., Thesis by author at Penn. State Univ., 1979
Comments =

Specific Material =
Manufacturer =
% Al₂O₃ = % B₂O₃ = 50  % CaO = % MgO =
% Na₂O = % K₂O =
Other Formula = ZnO  Other % = 50
Other Formula =  Other % =
Young's Modulus = 9.73 E4
1st Technique = Controlled Flaw
  K₁c = .83  Gamma = 3.57
2nd Technique =
  K₁c =
  Gamma =
n =
Environment = N₂(l) at -196C
Reference = SHINKAI,N., Thesis by author at Penn. State Univ., 1979
Comments =
Specific Material =
Manufacturer =
% $\text{Al}_2\text{O}_3$ = % $\text{B}_2\text{O}_3$ = 60 % CaO = % MgO =
% $\text{Na}_2\text{O}$ = % $\text{K}_2\text{O}$ = % PbO = 40 % SiO$_2$ =
Other Formula = Other % =
Other Formula = Other % =
Young's Modulus = 6.37 $E4$
1st Technique = Controlled Flaw $K_{IC} = .80$ Gamma = 4.99
2nd Technique =
$n =$
Environment = $\text{N}_2(l)$ at -196°C
Reference = SHINKAI, N., Thesis by author at Penn. State Univ., 1979
Comments =

Specific Material =
Manufacturer =
% $\text{Al}_2\text{O}_3$ = % $\text{B}_2\text{O}_3$ = 60 % CaO = % MgO =
% $\text{Na}_2\text{O}$ = % $\text{K}_2\text{O}$ = % PbO = 30 % SiO$_2$ =
Other Formula = ZnO Other % = 10
Other Formula = Other % =
Young's Modulus = 8.35 $E4$
1st Technique = Controlled Flaw $K_{IC} = .90$ Gamma = 4.89
2nd Technique =
$n =$
Environment = $\text{N}_2(l)$ at -196°C
Reference = SHINKAI, N., Thesis by author at Penn. State Univ., 1979
Comments =

Specific Material =
Manufacturer =
% $\text{Al}_2\text{O}_3$ = % $\text{B}_2\text{O}_3$ = 60 % CaO = % MgO =
% $\text{Na}_2\text{O}$ = % $\text{K}_2\text{O}$ = % PbO = 30 % SiO$_2$ =
Other Formula = ZnO Other % = 10
Other Formula = Other % =
Young's Modulus = 8.35 $E4$
1st Technique = Controlled Flaw $K_{IC} = .55$ Gamma = 1.79
2nd Technique =
$n =$
Environment = air
Reference = SHINKAI, N., Thesis by author at Penn. State Univ., 1979
Comments =
Specific Material =  
Manufacturer =
% Al₂O₃ = % B₂O₃ = 60
% Na₂O = % K₂O =
Other Formula = ZnO Other % = 20
Other Formula = Other % =
Young's Modulus = 8.75 E4
1st Technique = Controlled Flaw
2nd Technique = $K_{IC} = .96$
$n =$
Environment = N₂(l) at -196C
Reference = SHINKAI, N., Thesis by author at Penn. State Univ., 1979
Comments =

Specific Material =
Manufacturer =
% Al₂O₃ = % B₂O₃ = 60
% Na₂O = % K₂O =
Other Formula = ZnO Other % = 20
Other Formula = Other % =
Young's Modulus = 8.75 E4
1st Technique = Controlled Flaw
2nd Technique = $K_{IC} = .79$
$n =$
Environment = air
Reference = SHINKAI, N., Thesis by author at Penn. State Univ., 1979
Comments =

Specific Material =
Manufacturer =
% Al₂O₃ = % B₂O₃ = 60
% Na₂O = % K₂O =
Other Formula = ZnO Other % = 30
Other Formula = Other % =
Young's Modulus = 8.91 E4
1st Technique = Controlled Flaw
2nd Technique = $K_{IC} = 1.0$
$n =$
Environment = N₂(l) at -196C
Reference = SHINKAI, N., Thesis by author at Penn. State Univ., 1979
Comments =
Specific Material = Manufacturer =
% Al₂O₃ = % B₂O₃ = 70 % CaO = % MgO =
% Na₂O = % K₂O = % PbO = 30 % SiO₂ =
Other Formula = Other % =
Other Formula = Other % =
Young’s Modulus = 5.47 E4
1st Technique = Controlled Flaw $K_{IC} = 1.36$ Gamma = 16.91
2nd Technique = $K_{IC} = \gamma$

$n =$
Environment = N₂(l) at -196°C
Reference = SHINKAI, N., Thesis by author at Penn. State Univ., 1979
Comments =

Specific Material = Manufacturer =
% Al₂O₃ = % B₂O₃ = 70 % CaO = % MgO =
% Na₂O = % K₂O = % PbO = 22.5 % SiO₂ =
Other Formula = ZnO Other % = 7.5
Other Formula = Other % =
Young’s Modulus = 6.4 E4
1st Technique = Controlled Flaw $K_{IC} = 1.23$ Gamma = 11.82
2nd Technique = $K_{IC} = \gamma$

$n =$
Environment = N₂(l) at -196°C
Reference = SHINKAI, N., Thesis by author at Penn. State Univ., 1979
Comments =

Specific Material = Manufacturer =
% Al₂O₃ = % B₂O₃ = 70 % CaO = % MgO =
% Na₂O = % K₂O = % PbO = 22.5 % SiO₂ =
Other Formula = ZnO Other % = 7.5
Other Formula = Other % =
Young’s Modulus = 6.4 E4
1st Technique = Controlled Flaw $K_{IC} = .77$ Gamma = 4.61
2nd Technique = $K_{IC} = \gamma$

$n =$
Environment = air
Reference = SHINKAI, N., Thesis by author at Penn. State Univ., 1979
Comments =
Specific Material =
Manufacturer =
% Al$_2$O$_3$ = % B$_2$O$_3$ = 70 % CaO = % MgO =
% Na$_2$O = % K$_2$O = % PbO = 15 % SiO$_2$ =
Other Formula = ZnO Other % = 15
Other Formula = Other % =
Young's Modulus = 6.97 E4
1st Technique = Controlled Flaw $K_{IC} = 1.24$ Gamma = 11.03
2nd Technique = $K_{IC} =$

$n =$
Environment = N$_2$(l) at -196C
Reference = SHINKAI, N., Thesis by author at Penn. State Univ., 1979
Comments =

Specific Material =
Manufacturer =
% Al$_2$O$_3$ = % B$_2$O$_3$ = 70 % CaO = % MgO =
% Na$_2$O = % K$_2$O = % PbO = 15 % SiO$_2$ =
Other Formula = ZnO Other % = 15
Other Formula = Other % =
Young's Modulus = 6.97 E4
1st Technique = Controlled Flaw $K_{IC} = .85$ Gamma = 5.20
2nd Technique = $K_{IC} =$

$n =$
Environment = air
Reference = SHINKAI, N., Thesis by author at Penn. State Univ., 1979
Comments =

SIM81
Specific Material =
Manufacturer =
% Al$_2$O$_3$ = % B$_2$O$_3$ = % CaO = % MgO =
% Na$_2$O = 33 % K$_2$O = % PbO = % SiO$_2$ = 67
Other Formula = Other % =
Other Formula = Other % =
Young's Modulus =
1st Technique = DCB $K_{IC} =$
2nd Technique = $K_{IC} =$

$n = 21$
Environment = D.I. H$_2$O
Reference = SIMMONS, C.J., FREIMAN, S.W., JACTAW, 64, 683-86, 1981
Comments =

Specific Material =
Manufacturer =
% Al$_2$O$_3$ = % B$_2$O$_3$ = % CaO = % MgO =
% Na$_2$O = 33 % K$_2$O = % PbO = % SiO$_2$ = 67
Other Formula = Other % =
Other Formula = Other % =
Young's Modulus =
1st Technique = DCB $K_{IC} =$
2nd Technique = $K_{IC} =$

$n = 21$
Environment = 1M Cs in D.I. H$_2$O
Reference = SIMMONS, C.J., FREIMAN, S.W., JACTAW, 64, 683-86, 1981
Comments =
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<th>Specific Material =</th>
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<th>% Al₂O₃ =</th>
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<th>% MgO =</th>
<th>% Na₂O = 25</th>
<th>% K₂O =</th>
<th>% PbO =</th>
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$n = 19$

Environment = D.I. H₂O

Reference = SIMMONS, C.J., FREIMAN, S.W., JACTAW, 64, 683-86, 1981

Comments =
Specific Material = 
Manufacturer = 
% Al₂O₃ = % B₂O₃ = % CaO = % MgO = 
% Na₂O = 25 % K₂O = % PbO = % SiO₂ = 75 
Other Formula = Other % = 
Other Formula = Other % = 
Young's Modulus = 
1st Technique = DCB 
2nd Technique =  

\[ K_{IC} = \text{Gamma} \] 
\[ n = 27 \] 
Environment = 1 M Li in D.I. H₂O 
Reference = SIMMONS, C.J., FREIMAN, S.W., JACTAW, 64, 683-86, 1981 
Comments = 

Specific Material = 
Manufacturer = 
% Al₂O₃ = % B₂O₃ = % CaO = 7.44 % MgO = 5.91 
% Na₂O = 13.4 % K₂O = % PbO = % SiO₂ = 71.4 
Other Formula = Other % = 
Other Formula = Other % = 
Young's Modulus = 
1st Technique = DCB 
2nd Technique =  

\[ K_{IC} = \text{Gamma} \] 
\[ \gamma = 28.3 \] 
Environment = air, 30% RH 
Reference = SIMMONS, C.J., FREIMAN, S.W., JACTAW, 64, 683-86, 1981 
Comments = 

Specific Material = 
Manufacturer = 
% Al₂O₃ = 1.75 % B₂O₃ = % CaO = % MgO = 
% Na₂O = 7 % K₂O = % PbO = % SiO₂ = 70 
Other Formula = Other % = 
Other Formula = Other % = 
Young's Modulus = 
1st Technique = DCB 
2nd Technique =  

\[ K_{IC} = \text{Gamma} \] 
\[ \gamma = 18.1 \] 
Environment = H₂O 
Reference = SIMMONS, C.J., FREIMAN, S.W., JACTAW, 64, 683-86, 1981 
Comments = 

Specific Material = 
Manufacturer = 
% Al₂O₃ = % B₂O₃ = 23 % CaO = % MgO = 
% Na₂O = 7 % K₂O = % PbO = % SiO₂ = 70 
Other Formula = Other % = 
Other Formula = Other % = 
Young's Modulus = 
1st Technique = DCB 
2nd Technique =  

\[ K_{IC} = \text{Gamma} \] 
\[ \gamma = 28.3 \] 
Environment = H₂O 
Reference = SIMMONS, C.J., FREIMAN, S.W., JACTAW, 64, 683-86, 1981 
Comments =
Specific Material =
Manufacturer =
% $\text{Al}_2\text{O}_3$ = % $\text{B}_2\text{O}_3$ =
% $\text{Na}_2\text{O}$ = % $\text{K}_2\text{O}$ =
Other Formula = Other % =
Other Formula = Other % =
Young's Modulus =
1st Technique = DCB
2nd Technique =

$n = 31.1$

Environment = air, 50% RH
Reference = SIMMONS, C.J., FREIMAN, S.W., JACTAW, 64, 683-86, 1981

Comments

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Manufacturer =
% $\text{Al}_2\text{O}_3$ = % $\text{B}_2\text{O}_3$ =
% $\text{Na}_2\text{O}$ = % $\text{K}_2\text{O}$ =
Other Formula = GeO$_2$ Other % = 100
Other Formula = Other % =
Young's Modulus = 4.65 $E4$
1st Technique = NB
2nd Technique =

$K_{ic} = .61$
Gamma = 3.8

$n =$

Environment = $N_2$(g)
Reference = SMETS, B.M.J., Private Communications, 1983
Comments = Precracked samples, crosshead speed 4.3 10-6 m/s, dew point 50C

| Specific Material =
Manufacturer =
% $\text{Al}_2\text{O}_3$ = % $\text{B}_2\text{O}_3$ =
% $\text{Na}_2\text{O}$ = % $\text{K}_2\text{O}$ =
Other Formula = GeO$_2$ Other % = 97.5
Other Formula = Other % =
Young's Modulus = 5.258 $E4$
1st Technique = NB
2nd Technique =

$K_{ic} = .69$
Gamma = 4.3

$n =$

Environment = $N_2$(g)
Reference = SMETS, B.M.J., Private Communications, 1983
Comments = Precracked samples, crosshead speed 4.3 10-6 m/s, dew point 50C

| Specific Material =
Manufacturer =
% $\text{Al}_2\text{O}_3$ = % $\text{B}_2\text{O}_3$ =
% $\text{Na}_2\text{O}$ = % $\text{K}_2\text{O}$ =
Other Formula = GeO$_2$ Other % = 95
Other Formula = Other % =
Young's Modulus = 5.84 $E4$
1st Technique = NB
2nd Technique =

$K_{ic} = .83$
Gamma = 5.6

$n =$

Environment = $N_2$(g)
Reference = SMETS, B.M.J., Private Communications, 1983
Comments = Precracked samples, crosshead speed 4.3 10-6 m/s, dew point 50C
Specific Material =
Manufacturer =
% Al₂O₃ = % B₂O₃ = % CaO = % MgO =
% Na₂O = 7.5 % K₂O = % PbO = % SiO₂ =
Other Formula = GeO₂ Other % = 92.5
Young's Modulus = 6.196 E4
1st Technique = NB
\[ K_{IC} = .82 \]
2nd Technique =
\[ K_{IC} = \] Gamma =
\[ n = \] Environment = N₃(g)
Reference = SMETS,B.M.J., Private Communications, 1983
Comments = Precracked samples, crosshead speed 4.3 10-6 m/s, dew point 50C

Specific Material =
Manufacturer =
% Al₂O₃ = % B₂O₃ = % CaO = % MgO =
% Na₂O = 10 % K₂O = % PbO = % SiO₂ =
Other Formula = GeO₂ Other % = 90
Young's Modulus = 6.12 E4
1st Technique = NB
\[ K_{IC} = .93 \]
2nd Technique =
\[ K_{IC} = \] Gamma =
\[ n = \] Environment = N₃(g)
Reference = SMETS,B.M.J., Private Communications, 1983
Comments = Precracked samples, crosshead speed 4.3 10-6 m/s, dew point 50C

Specific Material =
Manufacturer =
% Al₂O₃ = % B₂O₃ = % CaO = % MgO =
% Na₂O = 9.9 % K₂O = % PbO = % SiO₂ =
Other Formula = GeO₂ Other % = 90.1
Young's Modulus = 6.903 E4
1st Technique = NB
\[ K_{IC} = .84 \]
2nd Technique =
\[ K_{IC} = \] Gamma =
\[ n = \] Environment = N₃(g)
Reference = SMETS,B.M.J., Private Communications, 1983
Comments = Precracked samples, crosshead speed 4.3 10-6 m/s, dew point 50C

Specific Material =
Manufacturer =
% Al₂O₃ = % B₂O₃ = % CaO = % MgO =
% Na₂O = 12.5 % K₂O = % PbO = % SiO₂ =
Other Formula = GeO₂ Other % = 87.5
Young's Modulus = 6.752 E4
1st Technique = NB
\[ K_{IC} = .87 \]
2nd Technique =
\[ K_{IC} = \] Gamma =
\[ n = \] Environment = N₃(g)
Reference = SMETS,B.M.J., Private Communications, 1983
Comments = Precracked samples, crosshead speed 4.3 10-6 m/s, dew point 50C
Specific Material =
Manufacturer =
% Al₂O₃ = % B₂O₃ = % CaO = % MgO =
% Na₂O = % K₂O = % PbO = % SiO₂ =
Other Formula = GeO₂ Other % = 86
Other Formula = Other % =
Young's Modulus = 7.275 E4
1st Technique = NB
2nd Technique =
K₁c = .78
n =
Environment = N₂(g)
Reference = SMETS, B.M.J., Private Communications, 1983
Comments = Precracked samples, crosshead speed 4.3 10-6 m/s, dew point 50°C

Specific Material =
Manufacturer =
% Al₂O₃ = % B₂O₃ = % CaO = % MgO =
% Na₂O = % K₂O = 2.5 % PbO = % SiO₂ =
Other Formula = GeO₂ Other % = 97.5
Other Formula = Other % =
Young's Modulus = 5.238 E4
1st Technique = NB
2nd Technique =
K₁c = .71
n =
Environment = N₂(g)
Reference = SMETS, B.M.J., Private Communications, 1983
Comments = Precracked samples, crosshead speed 4.3 10-6 m/s, dew point 50°C

Specific Material =
Manufacturer =
% Al₂O₃ = % B₂O₃ = % CaO = % MgO =
% Na₂O = % K₂O = 5 % PbO = % SiO₂ =
Other Formula = GeO₂ Other % = 95
Other Formula = Other % =
Young's Modulus = 5.593 E4
1st Technique = NB
2nd Technique =
K₁c = .86
n =
Environment = N₂(g)
Reference = SMETS, B.M.J., Private Communications, 1983
Comments = Precracked samples, crosshead speed 4.3 10-6 m/s, dew point 50°C

Specific Material =
Manufacturer =
% Al₂O₃ = % B₂O₃ = % CaO = % MgO =
% Na₂O = % K₂O = 7.5 % PbO = % SiO₂ =
Other Formula = GeO₂ Other % = 92.5
Other Formula = Other % =
Young's Modulus = 5.8 E4
1st Technique = NB
2nd Technique =
K₁c = .79
n =
Environment = N₂(g)
Reference = SMETS, B.M.J., Private Communications, 1983
Comments = Precracked samples, crosshead speed 4.3 10-6 m/s, dew point 50°C
Specific Material =
Manufacturer =

\% Al$_2$O$_3$ = \% B$_2$O$_3$ = \% CaO = \% MgO =
\% Na$_2$O = \% K$_2$O = 10 \% PbO = \% SiO$_2$ =

Other Formula = GeO$_2$ Other \% = 90
Other Formula = Other \% =

Young's Modulus = 6.031 \times 10^4

1st Technique = NB
2nd Technique =

$K_{IC} = .75$
Gamma = 4.4

$n =

Environment = N_2(g)
Reference = SMETS,B.M.J., Private Communications, 1983
Comments = Precracked samples, crosshead speed 4.3 \times 10^{-6} m/s, dew point 50C

Specific Material =
Manufacturer =

\% Al$_2$O$_3$ = \% B$_2$O$_3$ = \% CaO = \% MgO =
\% Na$_2$O = \% K$_2$O = 12.5 \% PbO = \% SiO$_2$ =

Other Formula = GeO$_2$ Other \% = 87.5
Other Formula = Other \% =

Young's Modulus = 6.13 \times 10^4

1st Technique = NB
2nd Technique =

$K_{IC} = .72$
Gamma = 3.9

$n =

Environment = N_2(g)
Reference = SMETS,B.M.J., Private Communications, 1983
Comments = Precracked samples, crosshead speed 4.3 \times 10^{-6} m/s, dew point 50C

Specific Material =
Manufacturer =

\% Al$_2$O$_3$ = \% B$_2$O$_3$ = \% CaO = \% MgO =
\% Na$_2$O = \% K$_2$O = 15 \% PbO = \% SiO$_2$ =

Other Formula = GeO$_2$ Other \% = 85
Other Formula = Other \% =

Young's Modulus = 6.184 \times 10^4

1st Technique = NB
2nd Technique =

$K_{IC} = .67$
Gamma = 3.4

$n =

Environment = N_2(g)
Reference = SMETS,B.M.J., Private Communications, 1983
Comments = Precracked samples, crosshead speed 4.3 \times 10^{-6} m/s, dew point 50C

Specific Material =
Manufacturer =

\% Al$_2$O$_3$ = \% B$_2$O$_3$ = \% CaO = \% MgO =
\% Na$_2$O = \% K$_2$O = 16.5 \% PbO = \% SiO$_2$ =

Other Formula = GeO$_2$ Other \% = 83.5
Other Formula = Other \% =

Young's Modulus = 6.157 \times 10^4

1st Technique = NB
2nd Technique =

$K_{IC} = .62$
Gamma = 2.9

$n =

Environment = N_2(g)
Reference = SMETS,B.M.J., Private Communications, 1983
Comments = Precracked samples, crosshead speed 4.3 \times 10^{-6} m/s, dew point 50C
Specific Material = Manufacturer =
% Al₂O₃ = % B₂O₃ = % CaO = % MgO =
% Na₂O = % K₂O = 17.5 % PbO = % SiO₂ =
Other Formula = GeO₂ Other % = 82.5
Other Formula = Other % =
Young's Modulus = 6.054 E4
1st Technique = NB
2nd Technique =
K<sub>IC</sub> = .62 Gamma = 3.0
n =
Environment = N₂(g)
Reference = SMETS.B.M.J., Private Communications, 1983
Comments = Precracked samples, crosshead speed 4.3 10-6 m/s, dew point 50°C

Specific Material = Manufacturer =
% Al₂O₃ = % B₂O₃ = % CaO = % MgO =
% Na₂O = % K₂O = 20 % PbO = % SiO₂ =
Other Formula = GeO₂ Other % = 80
Other Formula = Other % =
Young's Modulus = 5.781 E4
1st Technique = NB
2nd Technique =
K<sub>IC</sub> = .65 Gamma = 3.4
n =
Environment = N₂(g)
Reference = SMETS.B.M.J., Private Communications, 1983
Comments = Precracked samples, crosshead speed 4.3 10-6 m/s, dew point 50°C

Specific Material = Manufacturer =
% Al₂O₃ = % B₂O₃ = % CaO = % MgO =
% Na₂O = % K₂O = % PbO = 5 % SiO₂ =
Other Formula = GeO₂ Other % = 95
Other Formula = Other % =
Young's Modulus = 4.866 E4
1st Technique = NB
2nd Technique =
K<sub>IC</sub> = .6 Gamma = 3.5
n =
Environment = N₂(g)
Reference = SMETS.B.M.J., Private Communications, 1983
Comments = Precracked samples, crosshead speed 4.3 10-6 m/s, dew point 50°C

Specific Material = Manufacturer =
% Al₂O₃ = % B₂O₃ = % CaO = % MgO =
% Na₂O = % K₂O = % PbO = 15 % SiO₂ =
Other Formula = GeO₂ Other % = 85
Other Formula = Other % =
Young's Modulus = 5.414 E4
1st Technique = NB
2nd Technique =
K<sub>IC</sub> = .6 Gamma = 3.5
n =
Environment = N₂(g)
Reference = SMETS.B.M.J., Private Communications, 1983
Comments = Precracked samples, crosshead speed 4.3 10-6 m/s, dew point 50°C
Specific Material =
Manufacturer =
% Al₂O₃ = 4.2 % B₂O₃ = 10 % CaO = % MgO =
% Na₂O = 20.8 % K₂O = % PbO = % SiO₂ = 75
Other Formula = Other % =
Other Formula = Other % =
Young’s Modulus = 6.8 E4
1st Technique = NB KIC = .84 Gamma = 5.19
2nd Technique = KIC = Gamma =
n =
Environment = air
Comments =

Specific Material =
Manufacturer =
% Al₂O₃ = % B₂O₃ = 14.2 % CaO = % MgO =
% Na₂O = 10.8 % K₂O = % PbO = % SiO₂ = 75
Other Formula = Other % =
Other Formula = Other % =
Young’s Modulus = 7.735 E4
1st Technique = NB KIC = .88 Gamma = 5.01
2nd Technique = KIC = Gamma =
n =
Environment = air
Comments =

Specific Material =
Manufacturer =
% Al₂O₃ = % B₂O₃ = 18.8 % CaO = % MgO =
% Na₂O = 6.2 % K₂O = % PbO = % SiO₂ = 75
Other Formula = Other % =
Other Formula = Other % =
Young’s Modulus = 8.02 E4
1st Technique = NB KIC = .83 Gamma = 4.30
2nd Technique = KIC = Gamma =
n =
Environment = air
Comments =

Specific Material =
Manufacturer =
% Al₂O₃ = % B₂O₃ = 4.2 % CaO = % MgO =
% Na₂O = 20.8 % K₂O = % PbO = % SiO₂ = 75
Other Formula = Other % =
Other Formula = Other % =
Young’s Modulus = 6.89 E4
1st Technique = NB KIC = .83 Gamma = 5.0
2nd Technique = KIC = Gamma =
n =
Environment = air
Comments =
Specific Material =
Manufacturer =
% $\text{Al}_2\text{O}_3$ =  $\% \text{B}_2\text{O}_3$ =  $\% \text{CaO} =$  $\% \text{MgO} =$
% $\text{Na}_2\text{O}$ =  $\% \text{K}_2\text{O} =$  $\% \text{PbO} =$  $\% \text{SiO}_2 =$  100
Other Formula =  Other % =
Other Formula =  Other % =
Young's Modulus =
1st Technique = Dynamic Fat.  $K_{IC} =$  Gamma =
2nd Technique =  $K_{IC} =$  Gamma =
n = 29.2
Environment = air, 2% RH
Comments = Surface condition-plastic-clad fiber (EVA-single coating)

Specific Material =
Manufacturer =
% $\text{Al}_2\text{O}_3$ =  $\% \text{B}_2\text{O}_3$ =  $\% \text{CaO} =$  $\% \text{MgO} =$
% $\text{Na}_2\text{O}$ =  $\% \text{K}_2\text{O} =$  $\% \text{PbO} =$  $\% \text{SiO}_2 =$  100
Other Formula =  Other % =
Other Formula =  Other % =
Young's Modulus =
1st Technique = Dynamic Fat.  $K_{IC} =$  Gamma =
2nd Technique =  $K_{IC} =$  Gamma =
n = 21.8
Environment = air, 45% RH
Comments = Surface condition-plastic-clad fiber (EVA-single coating)

Specific Material =
Manufacturer =
% $\text{Al}_2\text{O}_3$ =  $\% \text{B}_2\text{O}_3$ =  $\% \text{CaO} =$  $\% \text{MgO} =$
% $\text{Na}_2\text{O}$ =  $\% \text{K}_2\text{O} =$  $\% \text{PbO} =$  $\% \text{SiO}_2 =$  100
Other Formula =  Other % =
Other Formula =  Other % =
Young's Modulus =
1st Technique = Dynamic Fat.  $K_{IC} =$  Gamma =
2nd Technique =  $K_{IC} =$  Gamma =
n = 16.2
Environment = air, 71% RH
Comments = Surface condition-plastic-clad fiber (EVA-single coating)

Specific Material =
Manufacturer =
% $\text{Al}_2\text{O}_3$ =  $\% \text{B}_2\text{O}_3$ =  $\% \text{CaO} =$  $\% \text{MgO} =$
% $\text{Na}_2\text{O}$ =  $\% \text{K}_2\text{O} =$  $\% \text{PbO} =$  $\% \text{SiO}_2 =$  100
Other Formula =  Other % =
Other Formula =  Other % =
Young's Modulus =
1st Technique = Dynamic Fat.  $K_{IC} =$  Gamma =
2nd Technique =  $K_{IC} =$  Gamma =
n = 15.3
Environment = air, 97% RH
Comments = Surface condition-plastic-clad fiber (EVA-single coating)
Specific Material =
Manufacturer =
\[
\begin{align*}
\% \text{Al}_2\text{O}_3 &= \% \text{B}_2\text{O}_3 \quad \% \text{CaO} \quad \% \text{MgO} \\
\% \text{Na}_2\text{O} &= \% \text{K}_2\text{O} \quad \% \text{PbO} \quad \% \text{SiO}_2 = 100 \\
\text{Other Formula} &= \text{Other \%} \\
\text{Other Formula} &= \text{Other \%} \\
\end{align*}
\]
Young's Modulus =
1st Technique = Dynamic Fat. \(K_{IC} = \) Gamma =
2nd Technique = \(K_{IC} = \) Gamma =
\(n = 29.9\)
Environment = air, 45% RH
Comments = Surface cond.-plastic-clad fiber (silane and EVA-dual coating)

Specific Material =
Manufacturer =
\[
\begin{align*}
\% \text{Al}_2\text{O}_3 &= \% \text{B}_2\text{O}_3 \quad \% \text{CaO} \quad \% \text{MgO} \\
\% \text{Na}_2\text{O} &= \% \text{K}_2\text{O} \quad \% \text{PbO} \quad \% \text{SiO}_2 = 100 \\
\text{Other Formula} &= \text{Other \%} \\
\text{Other Formula} &= \text{Other \%} \\
\end{align*}
\]
Young's Modulus =
1st Technique = Dynamic Fat. \(K_{IC} = \) Gamma =
2nd Technique = \(K_{IC} = \) Gamma =
\(n = 16.8\)
Environment = air, 97% RH
Comments = Surface cond.-plastic-clad fiber (single coating)

Specific Material =
Manufacturer =
\[
\begin{align*}
\% \text{Al}_2\text{O}_3 &= \% \text{B}_2\text{O}_3 \quad \% \text{CaO} \quad \% \text{MgO} \\
\% \text{Na}_2\text{O} &= \% \text{K}_2\text{O} \quad \% \text{PbO} \quad \% \text{SiO}_2 = 100 \\
\text{Other Formula} &= \text{Other \%} \\
\text{Other Formula} &= \text{Other \%} \\
\end{align*}
\]
Young's Modulus =
1st Technique = Dynamic Fat. \(K_{IC} = \) Gamma =
2nd Technique = \(K_{IC} = \) Gamma =
\(n = 27.6\)
Environment = air, 45% RH
Comments = Surface condition-plastic-clad fiber (single coating)
Specific Material =
Manufacturer =
% Al₂O₃ = % B₂O₃ = % CaO = % MgO =
% Na₂O = % K₂O = % PbO = % SiO₂ = 100
Other Formula = Other % =
Other Formula = Other % =
Young’s Modulus =
1st Technique = Static Fat.
2nd Technique =
\( K_{IC} = \) Gamma =
\( n = 14.7 \)
Environment = air, 97% RH
Comments = Surface condition-plastic-clad fiber

VER80
Specific Material =
Manufacturer =
% Al₂O₃ = % B₂O₃ = 100 % CaO = % MgO =
% Na₂O = % K₂O = % PbO = % SiO₂ =
Other Formula = Other % =
Other Formula = Other % =
Young’s Modulus = \( 5.7 \times E^4 \)
1st Technique = NB
2nd Technique =
\( K_{IC} = 1.45 \) Gamma = 18.44
\( n = \)
Environment = air
Comments = Young’s Modulus is extrapolated

Specific Material =
Manufacturer =
% Al₂O₃ = % B₂O₃ = 99 % CaO = % MgO =
% Na₂O = 1 % K₂O = % PbO = % SiO₂ =
Other Formula = Other % =
Other Formula = Other % =
Young’s Modulus = \( 5.6 \times E^4 \)
1st Technique = NB
2nd Technique =
\( K_{IC} = 1.4 \) Gamma = 17.5
\( n = \)
Environment = air
Comments = Young’s Modulus is extrapolated

Specific Material =
Manufacturer =
% Al₂O₃ = % B₂O₃ = 98 % CaO = % MgO =
% Na₂O = 2 % K₂O = % PbO = % SiO₂ =
Other Formula = Other % =
Other Formula = Other % =
Young’s Modulus = \( 4.9 \times E^4 \)
1st Technique = NB
2nd Technique =
\( K_{IC} = 1.25 \) Gamma = 15.94
\( n = \)
Environment = air
Comments = Young’s Modulus is extrapolated
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<th>% Al₂O₃</th>
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<th>% Na₂O</th>
<th>% K₂O</th>
<th>% PbO</th>
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Specific Material =
Manufacturer =
% Al₂O₃ = % B₂O₃ = 90
% Na₂O = 10 % K₂O =
Other Formula = Other % =
Other Formula = Other % =
Young's Modulus = 3.9 E4
1st Technique = DT
2nd Technique =

n =
Environment = air
Comments = Young's Modulus is extrapolated

Specific Material =
Manufacturer =
% Al₂O₃ = % B₂O₃ = 80
% Na₂O = 20 % K₂O =
Other Formula = Other % =
Other Formula = Other % =
Young's Modulus = 3.3 E4
1st Technique = DT
2nd Technique =

n =
Environment = air
Comments = Young's Modulus is extrapolated

Specific Material =
Manufacturer =
% Al₂O₃ = % B₂O₃ = 75
% Na₂O = 25 % K₂O =
Other Formula = Other % =
Other Formula = Other % =
Young's Modulus = 3.0 E4
1st Technique = DT
2nd Technique =

n =
Environment = air
Comments = Young's Modulus is extrapolated

Specific Material =
Manufacturer =
% Al₂O₃ = % B₂O₃ = 66
% Na₂O = 34 % K₂O =
Other Formula = Other % =
Other Formula = Other % =
Young's Modulus = 2.6 E4
1st Technique = DT
2nd Technique =

n =
Environment = air
Comments = Young's Modulus is extrapolated
Specific Material = 
Manufacturer =
% Al2O3 = % B2O3 = 65 
% Na2O = 35 % K2O = 
Other Formula = Other % =
Other Formula = Other % =
Young's Modulus = 2.2 E4
1st Technique = DT
\[ K_{IC} = 0.57 \] \[ \gamma = 7.38 \]
2nd Technique =
\[ K_{IC} = Gamma = \]
n =
Environment = air
Comments = Young's Modulus is extrapolated

Specific Material = 
Manufacturer =
% Al2O3 = % B2O3 =
% Na2O = 7.5 % K2O = 
Other Formula = Other % =
Other Formula = Other % =
Young's Modulus = 6.225 E4
1st Technique = NB
\[ K_{IC} = 1.1 \] \[ \gamma = 9.72 \]
2nd Technique =
\[ K_{IC} = Gamma = \]
n =
Environment = air
Comments = Young's Modulus is extrapolated

Specific Material = 
Manufacturer =
% Al2O3 = % B2O3 =
% Na2O = 12.5 % K2O = 
Other Formula = Other % =
Other Formula = Other % =
Young's Modulus = 6.2 E4
1st Technique = NB
\[ K_{IC} = 1.09 \] \[ \gamma = 9.58 \]
2nd Technique =
\[ K_{IC} = Gamma = \]
n =
Environment = air
Comments = Young's Modulus is extrapolated

Specific Material = 
Manufacturer =
% Al2O3 = % B2O3 =
% Na2O = 20 % K2O = 
Other Formula = Other % =
Other Formula = Other % =
Young's Modulus = 5.7 E4
1st Technique = NB
\[ K_{IC} = 0.87 \] \[ \gamma = 6.64 \]
2nd Technique =
\[ K_{IC} = Gamma = \]
n =
Environment = air
Comments = Young's Modulus is extrapolated
Specific Material =
Manufacturer =
% Al₂O₃ = % B₂O₃ = % CaO = % MgO =
% Na₂O = 30 % K₂O = % PbO = % SiO₂ = 70
Other Formula = Other % =
Other Formula = Other % =
Young's Modulus = 5.8 E4
1st Technique = NB
2nd Technique =
\( \gamma = \) 
Environment = air
Comments = Young's Modulus is extrapolated

Specific Material =
Manufacturer =
% Al₂O₃ = % B₂O₃ = % CaO = % MgO =
% Na₂O = 38 % K₂O = % PbO = % SiO₂ = 62
Other Formula = Other % =
Other Formula = Other % =
Young's Modulus = 6.0 E4
1st Technique = NB
2nd Technique =
\( \gamma = \) 
Environment = air
Comments = Young's Modulus is extrapolated

Specific Material =
Manufacturer =
% Al₂O₃ = % B₂O₃ = % CaO = % MgO =
% Na₂O = 45 % K₂O = % PbO = % SiO₂ = 55
Other Formula = Other % =
Other Formula = Other % =
Young's Modulus = 5.775 E4
1st Technique = NB
2nd Technique =
\( \gamma = \) 
Environment = air
Comments = Young's Modulus is extrapolated

Specific Material =
Manufacturer =
% Al₂O₃ = % B₂O₃ = % CaO = % MgO =
% Na₂O = % K₂O = % PbO = 24 % SiO₂ = 76
Other Formula = Other % =
Other Formula = Other % =
Young's Modulus = 13.8 E4
1st Technique = NB
2nd Technique =
\( \gamma = \) 
Environment = air
Comments = Young's Modulus is extrapolated
Specific Material =
Manufacturer =
% Al₂O₃ = % B₂O₃ = % CaO = % MgO =
% Na₂O = % K₂O = % PbO = 27 % SiO₂ = 73
Other Formula = Other % =
Other Formula = Other % =
Young’s Modulus = 12.8 E4
1st Technique = NB
2nd Technique =

n =
Environment = air
Comments = Young’s Modulus is extrapolated

Specific Material =
Manufacturer =
% Al₂O₃ = % B₂O₃ = % CaO = % MgO =
% Na₂O = % K₂O = % PbO = 40 % SiO₂ = 60
Other Formula = Other % =
Other Formula = Other % =
Young’s Modulus = 11.7 E4
1st Technique = NB
2nd Technique =

n =
Environment = air
Comments = Young’s Modulus is extrapolated

Specific Material =
Manufacturer =
% Al₂O₃ = % B₂O₃ = % CaO = % MgO =
% Na₂O = % K₂O = % PbO = 60 % SiO₂ = 40
Other Formula = Other % =
Other Formula = Other % =
Young’s Modulus = 7.7 E4
1st Technique = NB
2nd Technique =

n =
Environment = air
Comments = Young’s Modulus is extrapolated

Specific Material =
Manufacturer =
% Al₂O₃ = % B₂O₃ = 82 % CaO = % MgO =
% Na₂O = % K₂O = % PbO = 18 % SiO₂ =
Other Formula = Other % =
Other Formula = Other % =
Young’s Modulus = 5.1 E4
1st Technique = NB
2nd Technique =

n =
Environment = air
Comments = Young’s Modulus is extrapolated
Specific Material =
Manufacturer =
% Al₂O₃ = % B₂O₃ = 72
% Na₂O = % K₂O =
Other Formula = Other % =
Other Formula = Other % =
Young's Modulus = 4.4 \times 10^4
1st Technique = NB 
K_{IC} = .85 \quad \text{Gamma} = 8.21
2nd Technique = 
K_{IC} = \quad \text{Gamma} =
\eta =
Environment = air
Comments = Young's Modulus is extrapolated

Specific Material =
Manufacturer =
% Al₂O₃ = % B₂O₃ = 65.5
% Na₂O = % K₂O =
Other Formula = Other % =
Other Formula = Other % =
Young's Modulus = 3.9 \times 10^4
1st Technique = NB 
K_{IC} = .65 \quad \text{Gamma} = 5.42
2nd Technique = 
K_{IC} = \quad \text{Gamma} =
\eta =
Environment = air
Comments = Young's Modulus is extrapolated

Specific Material =
Manufacturer =
% Al₂O₃ = % B₂O₃ = 50
% Na₂O = % K₂O =
Other Formula = Other % =
Other Formula = Other % =
Young's Modulus = 3.15 \times 10^4
1st Technique = NB 
K_{IC} = .38 \quad \text{Gamma} = 2.29
2nd Technique = 
K_{IC} = \quad \text{Gamma} =
\eta =
Environment = air
Comments = Young's Modulus is extrapolated

Specific Material =
Manufacturer =
% Al₂O₃ = % B₂O₃ = 40
% Na₂O = % K₂O =
Other Formula = Other % =
Other Formula = Other % =
Young's Modulus = 3.7 \times 10^4
1st Technique = NB 
K_{IC} = .58 \quad \text{Gamma} = 4.55
2nd Technique = 
K_{IC} = \quad \text{Gamma} =
\eta =
Environment = air
Comments = Young's Modulus is extrapolated
Specific Material =
Manufacturer =
% Al₂O₃ =  % B₂O₃ = 50 % CaO =  % MgO =
% Na₂O =  % K₂O =  % PbO =  % SiO₂ =
Other Formula = ZnO Other % = 50
Other Formula = Other % =
Young's Modulus = 4.0 E₄
1st Technique = NB $K_{IC} = .7$ Gamma = 6.13
2nd Technique = $K_{IC} =$ Gamma =
$n =$ Environment = air
Comments = Young's Modulus is extrapolated

Specific Material =
Manufacturer =
% Al₂O₃ =  % B₂O₃ = 45 % CaO =  % MgO =
% Na₂O =  % K₂O =  % PbO =  % SiO₂ =
Other Formula = ZnO Other % = 55
Other Formula = Other % =
Young's Modulus = 4.2 E₄
1st Technique = NB $K_{IC} = .78$ Gamma = 7.24
2nd Technique = $K_{IC} =$ Gamma =
$n =$ Environment = air
Comments = Young's Modulus is extrapolated

Specific Material =
Manufacturer =
% Al₂O₃ =  % B₂O₃ = 40 % CaO =  % MgO =
% Na₂O =  % K₂O =  % PbO =  % SiO₂ =
Other Formula = ZnO Other % = 60
Other Formula = Other % =
Young's Modulus = 4.25 E₄
1st Technique = NB $K_{IC} = .80$ Gamma = 7.44
2nd Technique = $K_{IC} =$ Gamma =
$n =$ Environment = air
Comments = Young's Modulus is extrapolated

Specific Material =
Manufacturer =
% Al₂O₃ =  % B₂O₃ =  % CaO =  % MgO =
% Na₂O =  % K₂O =  % PbO =  % SiO₂ =
Other Formula = GeO₂ Other % = 100
Other Formula = Other % =
Young's Modulus = 2.65 E₄
1st Technique = NB $K_{IC} = .67$ Gamma = 8.47
2nd Technique = $K_{IC} =$ Gamma =
$n =$ Environment = air
Comments = Young's Modulus is extrapolated
Specific Material =
Manufacturer =
% Al₂O₃ = % B₂O₃ = % CaO = % MgO =
% Na₂O = % K₂O = % PbO = % SiO₂ =
Other Formula = GeO₂ Other % = 96
Other Formula = Other % =
Young's Modulus = 4.2 \times 10^4
1st Technique = NB
K_{IC} = 1.06 \quad \Gamma =
2nd Technique =
K_{IC} = \quad \Gamma =
n =
Environment = air
Comments = Young's Modulus is extrapolated

Specific Material =
Manufacturer =
% Al₂O₃ = % B₂O₃ = % CaO = % MgO =
% Na₂O = % K₂O = % PbO = % SiO₂ =
Other Formula = GeO₂ Other % = 91
Other Formula = Other % =
Young's Modulus = 4.9 \times 10^4
1st Technique = NB
K_{IC} = 1.27 \quad \Gamma =
2nd Technique =
K_{IC} = \quad \Gamma =
n =
Environment = air
Comments = Young's Modulus is extrapolated

Specific Material =
Manufacturer =
% Al₂O₃ = % B₂O₃ = % CaO = % MgO =
% Na₂O = % K₂O = % PbO = % SiO₂ =
Other Formula = GeO₂ Other % = 90
Other Formula = Other % =
Young's Modulus = 5.2 \times 10^4
1st Technique = NB
K_{IC} = 1.34 \quad \Gamma =
2nd Technique =
K_{IC} = \quad \Gamma =
n =
Environment = air
Comments = Young's Modulus is extrapolated

Specific Material =
Manufacturer =
% Al₂O₃ = % B₂O₃ = % CaO = % MgO =
% Na₂O = % K₂O = % PbO = % SiO₂ =
Other Formula = GeO₂ Other % = 88
Other Formula = Other % =
Young's Modulus = 4.7 \times 10^4
1st Technique = NB
K_{IC} = 1.2 \quad \Gamma =
2nd Technique =
K_{IC} = \quad \Gamma =
n =
Environment = air
Comments = Young's Modulus is extrapolated
Specific Material =
Manufacturer =
% Al₂O₃ =       % B₂O₃ =       % CaO =       % MgO =
% Na₂O = 37  % K₂O =       % PbO =       % SiO₂ =
Other Formula = GeO₂ Other % = 63
Other Formula = Other % =
Young’s Modulus = 2.45 E4
1st Technique = NB
2nd Technique =
\( K_{IC} = 0.58 \)
\( \Gamma = 6.87 \)
\( n = \)
Environment = air
Comments = Young’s Modulus is extrapolated

Specific Material =
Manufacturer =
% Al₂O₃ =       % B₂O₃ =
% Na₂O = 20    % K₂O =
Other Formula = Other % =
Other Formula = Other % =
Young’s Modulus = 6.0 E4
1st Technique = NB
2nd Technique =
\( K_{IC} = 0.93 \)
\( \Gamma = 7.21 \)
\( n = \)
Environment = air
Comments = Young’s Modulus is extrapolated

Specific Material =
Manufacturer =
% Al₂O₃ =       % B₂O₃ = 80
% Na₂O = 20    % K₂O =
Other Formula = Other % =
Other Formula = Other % =
Young’s Modulus = 6.0 E4
1st Technique = NB
2nd Technique =
\( K_{IC} = 0.84 \)
\( \Gamma = 5.88 \)
\( n = \)
Environment = air
Comments = Young’s Modulus is extrapolated

Specific Material =
Manufacturer =
% Al₂O₃ =       % B₂O₃ = 60
% Na₂O = 20    % K₂O =
Other Formula = Other % =
Other Formula = Other % =
Young’s Modulus = 6.0 E4
1st Technique = NB
2nd Technique =
\( K_{IC} = 0.83 \)
\( \Gamma = 5.74 \)
\( n = \)
Environment = air
Comments = Young’s Modulus is extrapolated
Specific Material =
Manufacturer =
% Al₂O₃ = % B₂O₃ = 50
% Na₂O = 20 % K₂O =
Other Formula = Other % =
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Young’s Modulus = 6.0 \(E4\)
1st Technique = NB
2nd Technique =
\(n = \)
Environment = air
Comments = Young’s Modulus is extrapolated

Specific Material =
Manufacturer =
% Al₂O₃ = % B₂O₃ = 40
% Na₂O = 20 % K₂O =
Other Formula = Other % =
Other Formula = Other % =
Young’s Modulus = 6.0 \(E4\)
1st Technique = NB
2nd Technique =
\(n = \)
Environment = air
Comments = Young’s Modulus is extrapolated

Specific Material =
Manufacturer =
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% Na₂O = 20 % K₂O =
Other Formula = Other % =
Other Formula = Other % =
Young’s Modulus = 6.0 \(E4\)
1st Technique = NB
2nd Technique =
\(n = \)
Environment = air
Comments = Young’s Modulus is extrapolated

Specific Material =
Manufacturer =
% Al₂O₃ = % B₂O₃ = 20
% Na₂O = 20 % K₂O =
Other Formula = Other % =
Other Formula = Other % =
Young’s Modulus = 6.0 \(E4\)
1st Technique = NB
2nd Technique =
\(n = \)
Environment = air
Comments = Young’s Modulus is extrapolated
Specific Material =
Manufacturer =
% Al₂O₃ = % B₂O₃ = % CaO = % MgO =
% Na₂O = 20 % K₂O = % PbO = % SiO₂ = 70
Other Formula = Other % =
Other Formula = Other % =
Young's Modulus = 6.0 E4
1st Technique = NB
  Kₜc = .91 Gamma = 6.90
2nd Technique =
  Kₜc =
  Gamma =

n =
Environment = air
Comments = Young's Modulus is extrapolated

WIE69

Specific Material = 7944
Manufacturer = Corning Glass
% Al₂O₃ = % B₂O₃ = % CaO = % MgO =
% Na₂O = % K₂O = % PbO = % SiO₂ = 99.9
Other Formula = Other % =
Other Formula = Other % =
Young's Modulus = 7.21 E4
1st Technique = DCB
  Kₜc = .79 Gamma = 4.37
2nd Technique =
  Kₜc =
  Gamma =

n =
Environment = N₂(g)
Comments =

Specific Material = 7900
Manufacturer = Corning Glass
% Al₂O₃ = .594 % B₂O₃ = 2.61 % CaO = % MgO =
% Na₂O = % K₂O = % PbO = % SiO₂ = 96.7
Other Formula = Other % =
Other Formula = Other % =
Young's Modulus = 6.59 E4
1st Technique = DCB
  Kₜc = .72 Gamma = 3.96
2nd Technique =
  Kₜc =
  Gamma =

n =
Environment = N₂(g)
Comments =
Specific Material = 1720
Manufacturer = Corning Glass
% Al₂O₃ = 12.0 % B₂O₃ = 3.54 % CaO = 6.59 % MgO = 18.3
% Na₂O = .994 % K₂O = % PbO = % SiO₂ = 58.4
Other Formula = Other % =
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Young's Modulus = 8.91 E4
1st Technique = DCB
2nd Technique =
\( K_{IC} = .91 \)
\( \Gamma = \)
Environment = \( N_2(g) \)
Comments =

Specific Material = 7740
Manufacturer = Corning Glass
% Al₂O₃ = 1.21 % B₂O₃ = % CaO = % MgO =
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Other Formula = Other % =
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Young's Modulus = 6.37 E4
1st Technique = DCB
2nd Technique =
\( K_{IC} = .77 \)
\( \Gamma = \)
Environment = \( N_2(g) \)
Comments =

Specific Material =
Manufacturer = Corning Glass
% Al₂O₃ = 1.16 % B₂O₃ =
% Na₂O = 13.4 % K₂O = .632 % CaO = 7.43 % MgO = 5.91
% PbO = % SiO₂ = 71.3
Other Formula = Other % =
Other Formula = Other % =
Young's Modulus = 7.34 E4
1st Technique = DCB
2nd Technique =
\( K_{IC} = .75 \)
\( \Gamma = \)
Environment = \( N_2(g) \)
Comments =

Specific Material = 0041
Manufacturer = Corning Glass
% Al₂O₃ = 2.97 % B₂O₃ =
% Na₂O = 12.2 % K₂O = 1.6 % CaO = % MgO =
% PbO = 7.59 % SiO₂ = 75.6
Other Formula = Other % =
Other Formula = Other % =
Young's Modulus = 6.53 E4
1st Technique = DCB
2nd Technique =
\( K_{IC} = .68 \)
\( \Gamma = \)
Environment = \( N_2(g) \)
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<td>% CaO</td>
<td>% MgO</td>
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<tr>
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Young's Modulus =
1st Technique = DCB
2nd Technique =

n = 40.8

Environment = H₂O
Comments =

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<td>% Al₂O₃</td>
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<td>% MgO</td>
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<td>% K₂O</td>
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Young's Modulus =
1st Technique = DCB
2nd Technique =

n = 26.5

Environment = H₂O
Comments =

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<td>% Al₂O₃</td>
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<td>% CaO</td>
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<td>% Na₂O</td>
<td>% K₂O</td>
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Young's Modulus =
1st Technique = DCB
2nd Technique =

n = 28.7

Environment = H₂O
Comments =

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<td>% Al₂O₃</td>
<td>% B₂O₃</td>
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<td>% Na₂O</td>
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Young's Modulus =
1st Technique = DCB
2nd Technique =

n = 35.5

Environment = H₂O
Comments =
Specific Material = 0041
Manufacturer = Corning Glass
% Al₂O₃ = 2.97 % B₂O₃ = % CaO = % MgO =
% Na₂O = 12.2 % K₂O = 1.60 % PbO = 7.59 % SiO₂ = 75.6
Other Formula = Other % =
Other Formula = Other % =
Young's Modulus =
1st Technique = DCB
2nd Technique =
n = 25.2
Environment = H₂O
Comments =

Specific Material =
Manufacturer = Corning Glass
% Al₂O₃ = 1.16 % B₂O₃ = % CaO = 7.43 % MgO = 5.91
% Na₂O = 13.4 % K₂O = .632 % PbO = % SiO₂ = 71.3
Other Formula = Other % =
Other Formula = Other % =
Young's Modulus =
1st Technique = DCB
2nd Technique =
n = 18.5
Environment = H₂O
Comments =

WIE73

Specific Material =
Manufacturer =
% Al₂O₃ = 1.16 % B₂O₃ = % CaO = 7.43 % MgO = 5.91
% Na₂O = 13.4 % K₂O = .632 % PbO = % SiO₂ = 71.3
Other Formula = Other % =
Other Formula = Other % =
Young's Modulus =
1st Technique = DCB
2nd Technique =
n = 19.4
Environment = 6N NaOH
Reference = WIEDERHORN,S.M.,JOHNSON,H., JACTAW, 56, 192-97, 1973
Comments =

Specific Material =
Manufacturer =
% Al₂O₃ = 1.16 % B₂O₃ = % CaO = 7.43 % MgO = 5.91
% Na₂O = 13.4 % K₂O = .632 % PbO = % SiO₂ = 71.3
Other Formula = Other % =
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Young's Modulus =
1st Technique = DCB
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Environment = 6N HCl
Reference = WIEDERHORN,S.M.,JOHNSON,H., JACTAW, 56, 192-97, 1973
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<th>% $\text{MgO}$</th>
<th>% $\text{Na}_2\text{O}$</th>
<th>% $\text{K}_2\text{O}$</th>
<th>% $\text{PbO}$</th>
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<td>1723</td>
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<td>2.51</td>
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**Young's Modulus**

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<th>1st Technique</th>
<th>$K_{IC}$</th>
<th>Gamma</th>
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<td>DCB</td>
<td>.74</td>
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<td>Gamma</td>
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**Environment** = Vacuum


Comments =

11.4 % MgO

Comments =
Specific Material = 7740
Manufacturer = Corning Glass
% Al₂O₃ = 1.21  % B₂O₃ = 11.5  % CaO =  % MgO =
% Na₂O = 3.98  % K₂O =
Other Formula = Other % =
Young's Modulus =
1st Technique = DCB
2nd Technique = NB
K₁c = .76  Gamma =
K₁c = .78  Gamma =

Environment = Vacuum
Comments =

Specific Material = BK-7
Manufacturer = Schott
% Al₂O₃ =  % B₂O₃ = 10.0  % CaO = .227  % MgO =
% Na₂O = 10.3  % K₂O = 4.74  % PbO =  % SiO₂ = 73.3
Other Formula = BaO  Other % = .833
Other Formula = CeO  Other % = < .1W%
Young's Modulus =
1st Technique = DCB
2nd Technique = NB
K₁c = .86  Gamma =
K₁c = .84  Gamma =

Environment = Vacuum
Comments =

Specific Material = UBK-7
Manufacturer = Schott
% Al₂O₃ =  % B₂O₃ = 10.0  % CaO = .226  % MgO =
% Na₂O = 10.2  % K₂O = 4.71  % PbO =  % SiO₂ = 73.9
Other Formula = BaO  Other % = .828
Other Formula =
Young's Modulus =
1st Technique = DCB
2nd Technique = NB
K₁c = .89  Gamma =
K₁c = .90  Gamma =

Environment = Vacuum
Comments =

Specific Material = SF-1
Manufacturer = Schott
% Al₂O₃ =  % B₂O₃ =
% Na₂O = 7.15  % K₂O =
Other Formula = Other % =
Other Formula =
Young's Modulus =
1st Technique = DCB
2nd Technique = NB
K₁c = .62  Gamma =
K₁c = .64  Gamma =

Environment = Vacuum
Comments =
Specific Material = 7900  
Manufacturer = Corning Glass  
% Al$_2$O$_3$ = .179  \% B$_2$O$_3$ = 2.62  \% CaO = \% MgO =  
% Na$_2$O = \% K$_2$O = \% PbO = \% SiO$_2$ = 97.1  
Other Formula = Other % =  
Other Formula = Other % =  
Young's Modulus =  
1st Technique = DCB  $K_{IC} =$  Gamma =  
2nd Technique =  $K_{IC} =$  Gamma =  
n = 50.5  
Environment = air, 100% RH  
Comments =

| Specific Material | 1723 | Manufacturer = Corning Glass  
% Al$_2$O$_3$ = 9.43  \% B$_2$O$_3$ = 4.60  \% CaO = 11.4  \% MgO = 11.1  
% Na$_2$O = \% K$_2$O = \% PbO = 28.2  \% SiO$_2$ = 60.8  
Other Formula = BaO Other % = 2.51  
Other Formula = Other % =  
Young's Modulus =  
1st Technique = DCB  $K_{IC} =$  Gamma =  
2nd Technique =  $K_{IC} =$  Gamma =  
n = 46  
Environment = air, 100% RH  
Comments =

| Specific Material | SF-1 | Manufacturer = Schott  
% Al$_2$O$_3$ = \% B$_2$O$_3$ = \% CaO = \% MgO =  
% Na$_2$O = 7.15  \% K$_2$O = \% PbO = 30.8  \% SiO$_2$ = 64.5  
Other Formula = Other % =  
Other Formula = Other % =  
Young's Modulus =  
1st Technique = DCB  $K_{IC} =$  Gamma =  
2nd Technique =  $K_{IC} =$  Gamma =  
n = 38  
Environment = air, 100% RH  
Comments =

| Specific Material | NBP-3 | Manufacturer =  
% Al$_2$O$_3$ = \% B$_2$O$_3$ = \% CaO = \% MgO =  
% Na$_2$O = 30  \% K$_2$O = \% PbO = \% SiO$_2$ =  
Other Formula = BaO Other % = 20  
Other Formula = P$_2$O$_5$ Other % = 50  
Young's Modulus =  
1st Technique = Short bar  $K_{IC} = .47$  Gamma =  
2nd Technique =  $K_{IC} =$  Gamma =  
n =  
Environment = air  
Reference = WILDER, J., Private Communications, 1983  
Comments =
Specific Material = NBP-4
Manufacturer =
% Al₂O₃ =  % B₂O₃ =  % CaO =  % MgO =
% Na₂O = 25  % K₂O =  % PbO =  % SiO₂ =
Other Formula = BaO  Other % = 25
Other Formula = P₂O₅  Other % = 50
Young's Modulus = 4.3 E4
1st Technique = Short bar
2nd Technique =
\( n = \)
Environment = air
Reference = WILDER, J., Private Communications, 1983
Comments = Poisson's Ratio = .2929

Specific Material = NBP-5
Manufacturer =
% Al₂O₃ =  % B₂O₃ =  % CaO =  % MgO =
% Na₂O = 20  % K₂O =  % PbO =  % SiO₂ =
Other Formula = BaO  Other % = 30
Other Formula = P₂O₅  Other % = 50
Young's Modulus = 4.4 E4
1st Technique = Short bar
2nd Technique =
\( n = \)
Environment = air
Reference = WILDER, J., Private Communications, 1983
Comments = Poisson's Ratio = .2930

Specific Material = NBP-6
Manufacturer =
% Al₂O₃ =  % B₂O₃ =  % CaO =  % MgO =
% Na₂O = 15  % K₂O =  % PbO =  % SiO₂ =
Other Formula = BaO  Other % = 35
Other Formula = P₂O₅  Other % = 50
Young's Modulus = 4.5 E4
1st Technique = Short bar
2nd Technique =
\( n = \)
Environment = air
Reference = WILDER, J., Private Communications, 1983
Comments = Poisson's Ratio = .2958

Specific Material = NBP-7
Manufacturer =
% Al₂O₃ =  % B₂O₃ =  % CaO =  % MgO =
% Na₂O = 10  % K₂O =  % PbO =  % SiO₂ =
Other Formula = BaO  Other % = 40
Other Formula = P₂O₅  Other % = 50
Young's Modulus = 4.5 E4
1st Technique = Short bar
2nd Technique =
\( n = \)
Environment = air
Reference = WILDER, J., Private Communications, 1983
Comments = Poisson's Ratio = .2975
Specific Material = NBP-10

| Manufacturer = | % Al₂O₃ = | % B₂O₃ = | % CaO = | % MgO = |
| % Na₂O = 30 | % K₂O = | % PbO = | % SiO₂ = |
| Other Formula = BaO | Other % = 16 |
| Other Formula = P₂O₅ | Other % = 50 |

Young's Modulus = 4.3 $E^4$

1st Technique = Short bar

2nd Technique =

$n =$

Environment = air

Reference = WILDER, J., Private Communications, 1983

Comments = 3rd Other Oxide- 4% ZnO, Poisson's Ratio = .2890

---

Specific Material = NBP-11

| Manufacturer = | % Al₂O₃ = | % B₂O₃ = | % CaO = | % MgO = |
| % Na₂O = 30 | % K₂O = | % PbO = | % SiO₂ = |
| Other Formula = BaO | Other % = 12 |
| Other Formula = P₂O₅ | Other % = 50 |

Young's Modulus = 4.4 $E^4$

1st Technique = Short bar

2nd Technique =

$n =$

Environment = air

Reference = WILDER, J., Private Communications, 1983

Comments = 3rd Other Oxide- 8% ZnO, Poisson's Ratio = .2867

---

Specific Material = NBP-13

| Manufacturer = | % Al₂O₃ = | % B₂O₃ = | % CaO = | % MgO = |
| % Na₂O = 30 | % K₂O = | % PbO = | % SiO₂ = |
| Other Formula = BaO | Other % = 8 |
| Other Formula = P₂O₅ | Other % = 50 |

Young's Modulus = 4.4 $E^4$

1st Technique = Short bar

2nd Technique =

$n =$

Environment = air

Reference = WILDER, J., Private Communications, 1983

Comments = 3rd Other Oxide- 12% ZnO, Poisson's Ratio = .2839

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Specific Material = NBP-14

| Manufacturer = | % Al₂O₃ = | % B₂O₃ = | % CaO = | % MgO = |
| % Na₂O = 30 | % K₂O = | % PbO = | % SiO₂ = |
| Other Formula = BaO | Other % = 4 |
| Other Formula = P₂O₅ | Other % = 50 |

Young's Modulus = 4.4 $E^4$

1st Technique = Short bar

2nd Technique =

$n =$

Environment = air

Reference = WILDER, J., Private Communications, 1983

Comments = 3rd Other Oxide- 16% ZnO, Poisson's Ratio = .2815
Specific Material = NZP-1
Manufacturer =
% Al₂O₃ = % B₂O₃ = % CaO = % MgO =
% Na₂O = 30 % K₂O = % PbO = % SiO₂ =
Other Formula = ZnO Other % = 20
Other Formula = P₂O₅ Other % = 50
Young's Modulus = 4.4 E4
1st Technique = Short bar
2nd Technique =

n =
Environment = air
Reference = WILDER, J., Private Communications, 1983
Comments = Poisson's Ratio = .2803

Specific Material = NBP-20
Manufacturer =
% Al₂O₃ = % B₂O₃ = % CaO = 4 % MgO =
% Na₂O = 30 % K₂O = % PbO = % SiO₂ =
Other Formula = BaO Other % = 16
Other Formula = P₂O₅ Other % = 50
Young's Modulus = 4.3 E4
1st Technique = Short bar
2nd Technique =

KIC = .52
Gamma = 3.18

n =
Environment = air
Reference = WILDER, J., Private Communications, 1983
Comments = Poisson's Ratio = .2886

Specific Material = NBP-21
Manufacturer =
% Al₂O₃ = % B₂O₃ = % CaO = 8 % MgO =
% Na₂O = 30 % K₂O = % PbO = % SiO₂ =
Other Formula = BaO Other % = 12
Other Formula = P₂O₅ Other % = 50
Young's Modulus = 4.4 E4
1st Technique = Short bar
2nd Technique =

KIC = .54
Gamma = 3.29

n =
Environment = air
Reference = WILDER, J., Private Communications, 1983
Comments = Poisson's Ratio = .2855

Specific Material = NBP-23
Manufacturer =
% Al₂O₃ = % B₂O₃ = % CaO = 12 % MgO =
% Na₂O = 30 % K₂O = % PbO = % SiO₂ =
Other Formula = BaO Other % = 8
Other Formula = P₂O₅ Other % = 50
Young's Modulus = 4.5 E4
1st Technique = Short bar
2nd Technique =

KIC = .52
Gamma = 3.04

n =
Environment = air
Reference = WILDER, J., Private Communications, 1983
Comments = Poisson's Ratio = .2829
Specific Material = NBP-24
Manufacturer =
% Al₂O₃ = % B₂O₃ = % CaO = 16 % MgO =
% Na₂O = 30 % K₂O = % PbO = % SiO₂ =
Other Formula = BaO Other % = 4
Other Formula = P₂O₅ Other % = 50
Young's Modulus = 4.6 $E4$
1st Technique = Short bar
2nd Technique =

\[ K_{IC} = .53 \quad \text{Gamma} = 3.01 \]
\[ n = \]

Environment = air
Reference = WILDER, J., Private Communications, 1983
Comments = Poisson's Ratio = .2801

Specific Material = NCP-6
Manufacturer =
% Al₂O₃ = % B₂O₃ = % CaO = 20 % MgO =
% Na₂O = 30 % K₂O = % PbO = % SiO₂ =
Other Formula = P₂O₅ Other % = 50
Young's Modulus = 4.7 $E4$
1st Technique = Short bar
2nd Technique =

\[ K_{IC} = .46 \quad \text{Gamma} = 2.23 \]
\[ n = \]

Environment = air
Reference = WILDER, J., Private Communications, 1983
Comments = Poisson's Ratio = .2757

Specific Material = NCP-9
Manufacturer =
% Al₂O₃ = % B₂O₃ = % CaO = 16 % MgO =
% Na₂O = 30 % K₂O = % PbO = % SiO₂ =
Other Formula = ZnO Other % = 4
Other Formula = P₂O₅ Other % = 50
Young's Modulus = 4.6 $E4$
1st Technique = Short bar
2nd Technique =

\[ K_{IC} = .46 \quad \text{Gamma} = 2.27 \]
\[ n = \]

Environment = air
Reference = WILDER, J., Private Communications, 1983
Comments = Poisson's Ratio = .2768

Specific Material = NCP-10
Manufacturer =
% Al₂O₃ = % B₂O₃ = % CaO = 12 % MgO =
% Na₂O = 30 % K₂O = % PbO = % SiO₂ =
Other Formula = ZnO Other % = 8
Other Formula = P₂O₅ Other % = 50
Young's Modulus = 4.6 $E4$
1st Technique = Short bar
2nd Technique =

\[ K_{IC} = .45 \quad \text{Gamma} = 2.18 \]
\[ n = \]

Environment = air
Reference = WILDER, J., Private Communications, 1983
Comments = Poisson's Ratio = .2768
Specific Material = NCP-12
Manufacturer =
% Al₂O₃ = % B₂O₃ = % CaO = 4 % MgO =
% Na₂O = 30 % K₂O = % PbO = % SiO₂ =
Other Formula = ZnO Other % = 16
Other Formula = P₂O₅ Other % = 50
Young's Modulus = 4.5 E4
1st Technique = Short bar
2nd Technique =
γ =
Environment = air
Reference = WILDER, J., Private Communications, 1983
Comments = Poisson’s Ratio = .2788

Specific Material = NBP-1
Manufacturer =
% Al₂O₃ = % B₂O₃ = % CaO = % MgO =
% Na₂O = 40 % K₂O = % PbO = % SiO₂ =
Other Formula = BaO Other % = 10
Other Formula = P₂O₅ Other % = 50
Young’s Modulus = 4.0 E4
1st Technique = Short bar
2nd Technique =
γ =
Environment = air
Reference = WILDER, J., Private Communications, 1983
Comments = Poisson’s Ratio = .2909

Specific Material = NBP-2
Manufacturer =
% Al₂O₃ = % B₂O₃ = % CaO = % MgO =
% Na₂O = 35 % K₂O = % PbO = % SiO₂ =
Other Formula = BaO Other % = 15
Other Formula = P₂O₅ Other % = 50
Young’s Modulus = 4.1 E4
1st Technique = Short bar
2nd Technique =
γ =
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Reference = WILDER, J., Private Communications, 1983
Comments = Poisson’s Ratio = .2916
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Table 7. Compositions of germanate base glasses

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5. Discussion of Results

One of the primary decisions in collecting this data was what tests represented valid measurements of $K_{IC}$ or $\gamma$. Generally almost all published data, regardless of the test procedure, was included. It must be noted, however, that there will not necessarily be a correspondence in $K_{IC}$ (or $\gamma$) values between different techniques. $K_{IC}$ is at present an experimentally defined parameter, and historically has been taken as the stress intensity value at which a crack is moving at some rapid, though not precisely defined, rate. It can be expected that in all of these oxide glasses, cracks will grow at $K_1$'s below $K_{IC}$ because of the interaction of water with the crack tip bonds under stress in the test environment. $K_{IC}$ is actually just one point on a $V-K_1$ curve. For this reason, the measured value of $K_{IC}$ will be sensitive to loading rate, test environments, and the crack length dependence of $K_1$ in the test specimen. Given these considerations, it is understandable why there is a large scatter in the $K_{IC}$ and $\gamma$ data for similar glass compositions. In addition, data obtained by the notched beam technique in which the specimens were not precracked is questionable. Experience has shown that the fracture toughness data for glasses obtained in this way will lie at $K_1$ or $\gamma$ values higher than would be obtained if a crack had been present. Nevertheless, we have included data obtained in this way because it did provide trends otherwise unobtainable.

Despite the problems associated with the wide variability in the fracture toughness data, it is still useful to consider the correlations that have this large body of data makes possible. As noted earlier, $K_{IC}$ or $\gamma$ can be plotted as a function of the mole percent of a particular oxide for a given family of glass or as a function of Young's modulus. The examples presented indicate a number of interesting observations.

Figure 1 shows a plot of $K_{IC}$ as a function of the mole percent Na$_2$O in all glasses containing both Na$_2$O and SiO$_2$; other constituents are present in most of these glasses in smaller quantities. It can be seen that there is no dependence of $K_{IC}$ on Na$_2$O content. Using this same data set, but plotting $\gamma$ versus Young's modulus (fig. 2) provides an entirely different picture. Here we see that there is a distinct minimum in $\gamma$ at an $E \approx 72$ GPa. If we plot $K_{IC}$ ($= 2E\gamma$) versus $E$ (fig. 3), we see that there is a trend to increasing $K_{IC}$ with increasing Young's modulus. This latter trend might be expected if Young's modulus is considered to be in part a measure of the strength as well as the stiffness of the Si-O bond in silicate glasses.

Figure 4 shows a trend of $K_{IC}$ for Al$_2$O$_3$-P$_2$O$_5$ glasses as a function of Young's modulus similar to that seen in the Na$_2$O-SiO$_2$ series. The plot of $K_{IC}$ versus the mole % P$_2$O$_5$ (fig. 5) indicates that $K_{IC}$ rises with an increase in the amount of glass former.

Figure 6 shows a plot in which $K_{IC}$ increases with the mole % of B$_2$O$_3$ for all B$_2$O$_3$ glasses. However, one must be cautious in analyzing this data since many of the investigators reporting this data discuss the fact that phase separation was observed in their glass systems especially at high B$_2$O$_3$ contents. The existence of two phases in the glass will likely contribute to increases in $K_{IC}$ above those for single phase glasses. These microstructural effects may, in fact, explain the relatively large values of $K_{IC}$ observed in figure 7 at low values of Young's modulus.
Figure 1. Critical fracture toughness, $K_{IC}$, plotted as a function of the mole % Na$_2$O for all glasses containing both Na$_2$O and SiO$_2$. The line is the best fit curve to a quadratic equation for $K_{IC}$ in terms of the mole % Na$_2$O.

Figure 2. The same data as in figure 1, plotted as $\gamma$ versus the Young's modulus of each glass. The curve is the best fit to a quadratic equation for $\gamma$ in terms of Young's modulus.
Figure 3. The same data as in figures 1 and 2, plotted as $K_{IC}$ as function of Young's modulus. The curve is the best fit to a quadratic equation for $K_{IC}$ in terms of Young's modulus.

Figure 4. $K_{IC}$ plotted versus the Young's modulus of Al$_2$O$_3$-P$_2$O$_5$ glasses.
Figure 5. The same data shown in figure 4 plotted as $K_{IC}$ versus the mole % $P_2O_5$.

Figure 6. $K_{IC}$ plotted against the mole % $B_2O_3$ for all $B_2O_3$ containing glasses.
6. Summary

This paper presents details of a computerized data base of experimentally determined fracture mechanics parameters for oxide glasses. The philosophy behind the format of the system is described. The utility of this system in enabling a designer to choose a glass composition or for understanding fracture behavior is demonstrated through the presentation of plots of $K_{IC}$ or $\gamma$ as a function of glass composition or elastic modulus.

Finally, the system is capable of providing plots of $n$ versus composition or Young's modulus. However, the values of $n$ are quite sensitive to test environment as well, so this variable must be accounted for in any analysis.
A Computerized Fracture Mechanics Database for Oxide Glasses

S. W. Freiman, T. L. Baker, and J. B. Wachtman, Jr.

NATIONAL BUREAU OF STANDARDS
U.S. DEPARTMENT OF COMMERCE
GAIERTHSBURG, MD 20899

Values of critical fracture toughness ($K_{IC}$), fracture energy ($\gamma$), subcritical crack growth exponents ($\Pi$) and Young's modulus ($E$), are compiled and tabulated for a wide variety of oxide glasses. A computerized data retrieval system has been formulated to allow for selection of data by either glass composition, investigator, or experimental technique, and year. Plotting routines allow $K_{IC}$ or $\gamma$ to be plotted versus the mole % of a particular component or the Young's modulus of the glass. A few illustrations are given to demonstrate trends in $K_{IC}$ and $\gamma$ as a function of composition and elastic modulus.

crack growth exponents; elastic modulus; fracture database; fracture mechanics; fracture toughness; oxide glasses

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