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WADC TECHNICAL REPORT 58-476
VOLUME III

CATALOGED BY ASTIA
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THERMOPHYSICAL PROPERTIES OF SOLID MATERIALS

VOLUME III — CERAMICS

ALEXANDER GOLDSMITH
HARRY J. HIRSCHHORN
THOMAS E. WATERMAN

ARMOUR RESEARCH FOUNDATION

REVISED EDITION
NOVEMBER 1960

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WRIGHT AIR DEVELOPMENT DIVISION

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MATERIALS CENTRAL
CONTRACT No. AF 33(616)-5312
PROJECT No. 7381

WRIGHT AIR DEVELOPMENT DIVISION
AIR RESEARCH AND DEVELOPMENT COMMAND
UNITED STATES AIR FORCE
WRIGHT-PATTERSON AIR FORCE BASE, OHIO

McGregor & Werner, Inc., Dayton, O.
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FOREWORD

This compilation of thermophysical property data was prepared by the Heat Transfer Section of the Fluid Dynamics and Systems Research Division of the Armour Research Foundation, Chicago, Illinois, under USAF Contract No. AF 33(616)-5212. This contract was initiated under Project No. 7381, "Thermophysical Data Consolidation", Task No. 73812, "Thermophysical Data for Solid Materials". The program was administered under the direction of Materials Central, Directorate of Advanced Systems Technology, Wright Air Development Division, with Jules I. Wittebort acting as project engineer.

These volumes cover work carried out from 1 July 1957 to 31 August 1960. The Materials Index, given in the forward portion of this volume, was arranged with the advice of W. H. Colner, S. W. Bradstreet and J. S. Griffith of the Ceramics Research Division.

The literature search was conducted by the staff of the Technical Information Research Section.

The study, evaluation, and compilation phases were carried out by the following personnel of the Heat and Mass Transfer Section: W. A. Gans, A. Goldsmith, J. I. Lang, H. J. Hirschhorn, and T. E. Waterman.

Computation, reading of published graphs, and plotting of data for this publication was done by D. Brast, G. Buzyna, M. Deahl, S. Chmel, A. Karazija, T. Schmugge, and a number of others.

The bulk of the typing of reproducible copy was done by Mrs. Mary A. Scroll.

The authors are particularly grateful to Mr. I. B. Fieldhouse, Supervisor of Heat and Mass Transfer, for his guidance and encouragement and to Mr. S. W. Bradstreet, Supervisor of Inorganic Technology for his aid in the area of Ceramics.

The entire effort at the Armour Research Foundation was directed by Alexander Goldsmith, project engineer.

ABSTRACT

Thermophysical property data, and their variation with temperature, are presented for a great number of solid materials, based on literature published during the period 1940-1957. Each reported value is shown and annotated, and recommended "most probable value" curves are given.

Materials covered include Elements, Alloys, Ceramics, Cermets, Intermetallics, Polymerics, and Composite Materials. Except for materials in the last two categories, only those melting above 1000°F are included.

Properties covered include the following: Melting point, density, latent heats, specific heat, thermal conductivity, thermal diffusivity, emissivity, reflectivity, thermal expansion, vapor pressure, and electric resistivity.

Each of the four volumes is designed to be expansible, and it is expected that additional or revised data sheets for inclusion in these volumes will be forthcoming.

PUBLICATION REVIEW

This report has been reviewed and is approved.

FOR THE COMMANDER:

JULES I. WITTEBORT
Chief, Thermophysics Branch
Physics Laboratory
Materials Central

THERMOPHYSICAL PROPERTIES OF SOLID MATERIALS

I. INTRODUCTION

At the initiative of the Materials Laboratory, Wright Air Development Center, and under its sponsorship, a program was undertaken to compile, evaluate, and consolidate all original test data on thermophysical properties of solid materials published during the period 1940-1957 inclusive. This publication contains the accumulated information and represents three years of effort. The data are presented in four volumes, divided as follows:

1. Elements
2. Alloys
3. Ceramics
4. Cermets, Intermetallics, Polymerics, and Composites

Each volume is designed to be expansible so that it will lend itself to the inclusion of new data as well as to the substitution of others. Additional data sheets for inclusion in these volumes will be published when available.

The collected data were obtained from a search of the following sources: (a) Chemical Abstracts, (b) Ceramic Abstracts, (c) Metallurgical Abstracts, (d) Nuclear Science Abstracts, and (e) Armed Services Technical Information Agency (ASTIA).

A detailed description of contents and of the method of presentation of data is given in the following several pages.

II. MATERIALS

Materials included in this survey are those which may find application in the design of aircraft, missiles, space vehicles, conventional or nuclear power plants, or allied equipment. Generally, only materials melting above 1000°F are included; exceptions are limited to the categories of plastics or composite materials. A listing of materials covered in the literature search is given in the Materials Index, which is described in Section IV-A below. This index also serves as a guide to the arrangement of data, and as a page numbering system. Due to the lack of published data, some of the materials listed in the index may not be represented by data sheets.

Manuscript released by authors 30 June 1960 for publication as a WADC Technical Report.

III. PROPERTIES

Physical properties included in this survey are the following:

Property	Symbol
1. Density	ρ
2. Melting Point	M. P.
3. Latent Heat of Fusion	Δh_f
4. Latent Heat of Vaporization	Δh_v
5. Latent Heat of Sublimation	Δh_s
6. Specific Heat (constant pressure)	c_p
7. Thermal Conductivity	k
8. Thermal Diffusivity	α
9. Emissivity, Reflectivity	ϵ, R
10. Linear Thermal Expansion	$\Delta L/L$
11. Vapor Pressure	p
12. Electric Resistivity	r

The first five properties in the above list are given as single point values, in individual tables grouped on a single sheet. The others are presented graphically as functions of temperature. All data on linear thermal expansion have been reduced to a datum of 20°C; i.e. $\Delta L/L = 0$ at 528°R (293°K).

IV. CONTENTS

Each of the four volumes of data consists of four sections arranged in the following order:

1. Introductory remarks and explanatory text
2. Materials Index
3. Tables of Conversion Factors
4. Body of Data

The fifth volume, or Appendix, consists of the following sections:

1. Introductory remarks and explanatory text
2. Materials Index
3. List of References
4. Author Index (alphabetic)

A. Materials Index

The Materials Index, located in the front portion of each volume following these introductory pages, gives the order in which the body of data is arranged. It is based, with few exceptions, on the chemical composition of materials, and is arranged in outline fashion. It can have four orders of subdivision designated by Roman numerals, capital letters, common numerals and lower case letters such as:

I. A. 1. a.

Each category, even in the lowest order, represents a family of materials, rather than a specific one, so that the number of individual materials that can be accommodated is virtually unlimited. The index lends itself to future expansion.

B. Body of Data

The body of data is arranged by materials in the order of the Materials Index. Properties for a given small family of materials are given in the order listed in Section III above. Each plotted point or numerical value in the body of data is identified as to source by reference to the List of References.

C. List of References

The List of References gives complete bibliographic notations for all the references from which usable data have been extracted. These are arranged chronologically by year of publication, and in an arbitrary sequence within any given year.

D. Author Index

The Author Index is arranged in alphabetic order by author's surname. Coauthors are also included. Each entry is cross-referred to the List of References where a complete bibliographic notation is given.

V. METHOD OF PRESENTATION OF DATA

A. Format

A "unit" of information in this volume consists of a single sheet having a graph on one face and reference information on the back. The first five properties listed in Section III above are referred to as "point values" and are grouped together as a "unit" on a single sheet in the same manner as a graph.

B. Pagination

Each volume is designed to be expansible, and therefore is not compatible with conventional page numbering. The system adopted is as follows:

The body of data is arranged by materials in accordance with the Materials Index which is located in the forward portion of each volume. Furthermore, for a given small family of materials, data for the several properties are arranged in accordance with the listing given in Section III above. The Materials Index designation is given in the lower right corner of each graph or data sheet in lieu of a page number. This identification is not unique since several materials of the same family carry the same designation, but it guides the reader to the approximate location of the desired information.

Materials that do not fit into any subgroup presently listed in the Materials Index are designated by the next higher order grouping.

Example: Nickel-Silicon alloys are not specifically identified as a family grouping in the Materials Index. These therefore, are designated by the next higher order of subdivision, namely, Nickel-Base Alloys, category IV-A in the index.

Data for such materials are located at the end of the group; that is, after those materials which do fit into a currently identified subgroup. Within this framework, where necessary, data sheets are further arranged in alphabetic order by the major alloying element. It is expected that after the initial familiarization with this arrangement, the user will be able to locate the desired information (or convince himself of its absence) with a minimum of page-by-page searching.

A unique identification of each sheet is provided by the number in the lower left corner of the sheet. The initial two digits of this number give the year when the sheet was prepared; the latter digits are merely a numerical sequence for identification purposes only and serve no other purpose.

C. Graph Sheets

Data extracted from various references on the same subject (material and property) are identified on each graph by means of distinctive plotting symbols. These sysbols indicate the data of a given investigator, but do not necessarily imply actual test points. In numerous instances in the literature an author presents only smoothed data, either graphically or in tabular form, and it is frequently impossible to distinguish these from actual test values.

In presenting data on thermal expansion, an investigator sometimes gives only a coefficient of expansion for a considerable temperature range. In such instances it is assumed that a linear relationship is implied, and in plotting such data the straight line may be indicated by more than the two end-points in order that the given investigator's data not be obscured by those of others.

With regard to specific heat, some investigators present only total heat content of the material above a given datum, and make no attempt to reduce such data to specific heat. In such instances the investigator's enthalpy data were fitted with a quadratic equation of the form $\Delta H = A + BT + CT^2$ using a least-mean-square procedure to determine the coefficients. This equation was then differentiated with respect to temperature to obtain a linear variation of specific heat with temperature. Instances where this was done are so indicated.

Curves drawn through the plotted points are deemed "most probable value" curves based on the data presented. As additional information from other investigators is added in the future, it may be necessary to modify these curves.

D. Point Values

The first five properties listed in Section III above are considered point functions(at standard temperature and pressure unless indicated otherwise) and are grouped in individual tables, by property, on a single sheet. Data extracted from various references are identified by distinctive plotting symbols in the same manner as points on a graph. "Most probable values", usually based only on the data presented, are given at the top of the page. In some instances where data were not available from the current survey, density and melting point information was taken from secondary (nonoriginal) sources. These appear only at the top of the sheet and are identified as to source. Melting points of binary alloys, representing the solidus line on a phase diagram, have generally not been included. Many of these are given by Hansen and Anderko in "Constitution of Binary Alloys" (Ref. 58-11).

E. Reference Information

1. Symbol

The plotting symbols are identical with, and correspond to those used on the face of a given graph or data sheet.

2. Investigator

The investigator, or author, of each reference is identified by name. Coauthors are included.

3. Reference

References are identified by hyphenated numbers such as 00-00, which serve to locate the bibliographic entry for the given source in the List of References in the Appendix. The initial two digits indicate the year of publication. The remaining number locates the specific reference within the given year.

Example: Ref. 54-7 is found in the List of References under the year 1954; the seventh entry of that year. It is an article by R. W. Powell entitled "The Thermal Conductivity of Beryllia".

References which are not dated are identified with the letters ND in place of the year of publication, such as ND-00. Undated references are listed at the end of the List of References.

4. Range

The column marked "Range, °R" indicates the temperature range covered by the data in the given reference.

5. Material Composition

This column contains any pertinent information given in a reference that serves to describe the material investigated. Primarily this consists of the chemical composition of the material, its purity, density, and common trade name when given. Where a material was identified by trade name only, the nominal composition was added.

6. Test Method

A general indication of the test method used by the investigator is given in this column. While test methods for a given property can be reasonably grouped into several broad categories, each investigator makes his own modifications and alterations which do not lend themselves to brief description.

7. Remarks

Pertinent remarks concerning the given data are included in this column. Such remarks may describe a prior treatment of the material, the environment during the test, the author's estimate of accuracy, or similar information.

MATERIALS INDEX

MAJOR HEADINGS

I. ELEMENTS (Melting temperature above 1000°F)

II. IRON BASE ALLOYS

III. COPPER BASE ALLOYS

IV. NICKEL BASE, COBALT BASE, AND REFRACTORY METAL BASE ALLOYS

V. LIGHT METAL ALLOYS (Including Ti Alloys)

VI. OTHER METAL ALLOYS (Melting temperature above 1000° F)

VII. CERAMICS (Including Glasses)

VIII. CERMETS

IX. INTERMETALLICS

X. POLYMERIC MATERIALS (Including Plastics)

XI. COMPOSITE MATERIALS

MATERIALS INDEX

I. ELEMENTS (Melting temperature above 1000° F)

	Element	Symbol
I - A - 1	Actinium	Ac
I - A - 2	Aluminum	Al
I - A - 3	Americium	Am
I - A - 4	Antimony	Sb
I - A - 5	Arsenic	As
I - A - 6	Astatine	At
I - B - 1	Barium	Ba
I - B - 2	Berkelium	Bk
I - B - 3	Beryllium	Be
I - B - 4	Boron	B
I - C - 1	Calcium	Ca
I - C - 2	Californium	Cf
I - C - 3	Carbon	C

a. Extruded Acheson graphite, multicrystalline
b. Extruded Acheson amorphous carbon
c. Extruded Acheson graphite, impregnated
d. Molded Acheson graphite, multicrystalline
e. Molded Acheson amorphous carbon
f. Molded Acheson graphite, impregnated
g. Lampblack - base carbon or graphite
h. Pyrolytic graphite
j. Natural graphite-base graphite
k. Natural graphite-base carbon
m. Diamond
n. Single crystal graphite
p. Lampblacks

I - C - 4	Cerium	Ce
I - C - 5	Chromium	Cr
I - C - 6	Cobalt	Co
I - C - 7	Copper	Cu
I - C - 8	Curium	Cm
I - D - 1	Dysprosium	Dy
I - E - 1	Einsteinium	E
I - E - 2	Erbium	Er
I - E - 3	Europium	Eu
I - F - 1	Fermium	Fm
I - F - 2	Francium	Fr

I. ELEMENTS (Continued)

	Element	Symbol
I - G - 1	Gadolinium	Gd
I - G - 2	Germanium	Ge
I - G - 3	Gold	Au
I - H - 1	Hafnium	Hf
I - H - 2	Holmium	Ho
I - J - 1	Iridium	Ir
I - J - 2	Iron	Fe
I - L - 1	Lanthanum	La
I - L - 2	Lutetium	Lu
I - M - 1	Magnesium	Mg
I - M - 2	Manganese	Mn
I - M - 3	Mendelevium	Mv
I - M - 4	Molybdenum	Mo
I - N - 1	Neodymium	Nd
I - N - 2	Neptunium	Np
I - N - 3	Nickel	Ni
I - N - 4	Niobium (Columbium)	Nb
I - N - 5	Nobelium	No
I - O - 1	Osmium	Os
I - P - 1	Palladium	Pd
I - P - 2	Platinum	Pt
I - P - 3	Plutonium	Pu
I - P - 4	Polonium	Po
I - P - 5	Praseodymium	Pr
I - P - 6	Promethium	Pm
I - P - 7	Protactinium	Pa
I - R - 1	Radium	Ra
I - R - 2	Rhenium	Re
I - R - 3	Rhodium	Rh
I - R - 4	Ruthenium	Ru
I - S - 1	Samarium	Sm
I - S - 2	Scandium	Sc
I - S - 3	Silicon	Si
I - S - 4	Silver	Ag
I - S - 5	Strontium	Sr

I. ELEMENTS (Continued)

	Element	Symbol
I - T - 1	Tantalum	Ta
I - T - 2	Technetium	Tc
I - T - 3	Terbium	Tb
I - T - 4	Thorium	Th
I - T - 5	Thulium	Tm
I - T - 6	Titanium	Ti
I - T - 7	Tungsten	W
I - U - 1	Uranium	U
I - V - 1	Vanadium	V
I - Y - 1	Ytterbium	Yb
I - Y - 2	Yttrium	Y
I - Z - 1	Zirconium	Zr

II. IRON BASE ALLOYS

(Iron greatest weight fraction with one or more other elements.)

A. Plain Carbon Steels (Mn < 2.5%; Si < 0.36%; P, S < 0.051% each)

1. $0.02 < C \leq 0.20\%$
2. $0.20 < C \leq 0.40\%$
3. $0.40 < C \leq 0.60\%$
4. $0.60 < C \leq 0.80\%$
5. $0.80 < C \leq 1.00\%$
6. $1.00 < C \leq 1.20\%$
7. $1.20 < C \leq 1.50\%$
8. $1.50 < C \leq 2.00\%$

B. Cast Irons

1. Gray, unalloyed and low alloy (Less than 2% total alloying elements exclusive of C, Mn < 1%, Si, P, S)
2. Gray, alloyed (More than 2% total alloying elements exclusive of C, Mn < 1%, Si, P, S)
3. White, unalloyed and low alloy (Less than 2% total alloying elements exclusive of C, Mn < 1%, Si, P, S)
4. White, alloyed (More than 2% total alloying elements exclusive of C, Mn < 1%, Si, P, S)
5. Malleable, Ferritic
6. Malleable, Pearlitic
7. Nodular, Ferritic
8. Nodular, Pearlitic

II. IRON-BASE ALLOYS (Continued)

C. Low Alloy Steels (Less than 10% of any single alloying element, exclusive of C; Mn < 2.5%; Si < 0.36%; P, S < 0.051% each. Alloying elements listed in decreasing order of their weight fractions. X may be none, one, or more elements; $X = X_1 + X_2 + \ldots$)

1. Fe + Ni
2. Fe + Ni + Cr + X
3. Fe + Ni + Mo + X
4. Fe + Ni + X ($X_1 \neq$ Mo, Cr)
5. Fe + Mo + X
6. Fe + Cr + X ($X_1 \neq$ Mo)
7. Fe + Cr + Mo + X
8. Fe + W + X
9. Fe + Si + X

D. High Alloy Steels (More than 10% of any single alloying element exclusive of C; Mn < 2.5%; Si < 1.00%; P, S < 0.051% each. Alloying elements listed in decreasing order of their weight fraction. X may be none, one, or more elements; $X = X_1 + X_2 + \ldots$)

1. Fe + Cr
2. Fe + Cr + Ni
3. Fe + Cr + Ni + X ($X_1 \neq 0$)
   a. Fe + Cr + Ni + Co + X
4. Fe + Cr + X ($X_1 \neq 0$, Ni)
5. Fe + Ni
6. Fe + Ni + X ($X_1 \neq 0$)
   a. Fe + Ni + Cr + X
7. Fe + Al + X
8. Fe + W + X
9. Fe + Mn + X

III. COPPER-BASE ALLOYS

(Copper greatest weight fraction with one or more other elements. Alloying elements listed in decreasing order of their weight fractions. X may be none, one, or more elements.)

A. Copper + Zinc + X

1. Cu + Zn + Pb + X
2. Cu + Zn + Sn + X
3. Cu + Zn

B. Copper + Tin + X

1. Cu + Sn + Pb + X
2. Cu + Sn + Zn + X
3. Cu + Sn

C. Copper + Lead + X

D. Copper + Nickel + X

E. Copper + Aluminum + X

F. Copper + Silicon + X

G. Copper + Beryllium + X

H. Copper + Manganese + X

J. Copper + Tellurium + X

K. Copper + Chromium + X

L. Copper + Zirconium + X

IV. NICKEL-BASE, COBALT-BASE, AND REFRACTORY METAL-BASE ALLOYS

(Major element greatest weight fraction with one or more other elements. Alloying elements listed in decreasing order of their weight fractions. X may be none, one, or more elements.)

A. Nickel-Base Alloys

1. Ni + Cu + X
2. Ni + Mo + X
3. Ni + Co + X
   a. Ni + Co + Cr + X
4. Ni + Fe + X
   a. Ni + Fe + Cr + X
5. Ni + Cr + X
   a. Ni + Cr + Fe + X
6. Ni + Mn + X

B. Cobalt-Base Alloys

1. Co + Cr + X
2. Co + Ni + X
3. Co + Fe + X
4. Co + Pd + X

C. Tungsten-Base Alloys

D. Molybdenum-Base Alloys

E. Niobium-Base Alloys

F. Chromium-Base Alloys

1. Cr + Ni + X
2. Cr + Mo + X

G. Vanadium-Base Alloys

H. Tantalum-Base Alloys

J. Zirconium-Base Alloys

1. Zr + Sn + X
2. Zr + Nb + X
3. Zr + U + X

K. Hafnium-Base Alloys

L. Thorium-Base Alloys

V. LIGHT METAL ALLOYS (Including Ti Alloys)

(Major element greatest weight fraction with one or more other elements. Alloying elements listed in decreasing order of their weight fractions. X may be none, one, or more elements; $X = X_1 + X_2 + \ldots$)

A. Aluminum-Base Alloys

1. Al + Cu + X
2. Al + Si + X
   a. Al + Si + Cu + X
   b. Al + Si + Mg + X
3. Al + Mg + X
4. Al + Zn + X
5. Al + Mn + X
6. Al + Ag + X

B. Magnesium-Base Alloys

1. Mg + Al + Zn + X
2. Mg + Al + X ($X_1 \neq$ Zn)
3. Mg + Rare Earth + X
4. Mg + Th + X
5. Mg + Li + X
6. Mg + Zn + X

C. Titanium-Base Alloys

1. Ti + Al + X
2. Ti + Mn + X
3. Ti + Mo + X
4. Ti + V + X
5. Ti + Cr + X
6. Ti + Fe + X ($X_1 \neq$ Cr)
7. Ti + Fe + Cr + X
8. Ti + O + X

D. Beryllium-Base Alloys

VI. OTHER METAL ALLOYS, melting temperature above 1000°F

(Major element greatest weight fraction with one or more other elements. Alloying elements listed in decreasing order of their weight fractions. X may be none, one, or more elements.)

A. Gold-Base Alloys
   1. Au + Cd + X
   2. Au + Co + X
   3. Au + Pd + X
   4. Au + Ni + X
   5. Au + Mn + X

B. Silver-Base Alloys
   1. Ag + Al + X
   2. Ag + Cd + X
   3. Ag + Cu + X
   4. Ag + Pd + X

C. Platinum-Base Alloys

D. Palladium-Base Alloys
   1. Pd + Au + X
   2. Pd + Co + X
   3. Pd + Cu + X

E. Manganese-Base Alloys
   1. Mn + Cu + X
   2. Mn + Ni + X

F. Uranium-Base Alloys
   1. U + Cr + X
   2. U + Mo + X
   3. U + Zr + X

G. Silicon-Base Alloys
   1. Si + Fe + X

VII. CERAMICS

A. Oxide Ceramics (Nominal oxide; or nominal oxide greatest weight fraction with one or more other oxides. X may be none, one, or more oxides. Also see VII-B and VII-E.)

1. Aluminum Oxide + X

   a. Aluminum oxide (alumina, corundum, sapphire)
   b. Aluminum oxide + Chromium oxide + X

2. Beryllium Oxide + X

   a. Beryllium oxide (beryllia, bromellite)

3. Calcium Oxide + X

   a. Calcium oxide (calcia, lime)

4. Rare Earth Oxides (Atomic Numbers 57-71 in Alphabetic Order)

   a. Cerium oxide + X (ceria)
   b. Dysprosium oxide + X (dysprosia)
   c. Erbium oxide + X (erbia)
   d. Europium oxide + X (europia)
   e. Gadolinium oxide + X (gadolinia)
   f. Holmium oxide + X
   g. Lanthanum oxide + X (lanthana)
   h. Lutetium oxide + X
   j. Neodymium oxide + X (neodymia)
   k. Praseodymium oxide + X (praseodymia)
   m. Promethium oxide + X
   n. Samarium oxide + X (samaria)
   p. Terbium oxide + X (terbia)
   q. Thulium oxide + X (thulia)
   r. Ytterbium oxide + X (ytterbia)

5. Magnesium Oxide + X

   a. Magnesium oxide (magnesia, periclase)

6. Silicon Oxide + X (silica, crystobalite, quartz; see also VII-C-6)

7. Thorium Oxide + X (thoria, thorianite)

8. Titanium Oxide + X (anatase, brookite, rutile)

9. Hafnium Oxide + X; Zirconium Oxide + X

   a. Hafnium oxide (hafnia)
   b. Zirconium oxide (zirconia)

VII. CERAMICS (Continued)

A. Oxide Ceramics (Continued)

10. Uranium Oxide + X

11. Plutonium Oxide + X

12.

13. Other Oxide Ceramics, in Alphabetic Order: A-I

14. Other Oxide Ceramics, in Alphabetic Order : J-R

15. Other Oxide Ceramics, in Alphabetic Order: S-Z

B. Mineral Ceramics (Also see VII-A and VII-E)

1. Aluminosilicates, non-hydrous (mullite, kyanite, sillimanite)

2. Silicates of Ba, Be, Ca, Fe, Mg, Mn, Ni, Sr, and Zn in order listed.

3. Alkali and alkaline-earth aluminosilicates (feldspars)

   a. Barium-modified feldspar
   b. Beryllium-modified feldspar (beryl)
   c. Calcium-modified feldspar
   d. Cesium-modified feldspar
   e. Lithium-modified feldspar
      Magnesium aluminosilicate, see VII-E-3
   f. Potassium feldspar
   g. Rubidium feldspar
   h. Sodium feldspar
   j. Strontium-modified feldspar

4. Hafnium silicate; Zirconium silicate

   a. Hafnium silicate (hafnon)
   b. Zirconium silicate (zircon)

5. Borates (borax, colemanite); Phosphates

VII. CERAMICS (Continued)

B. Mineral Ceramics (Continued)

6. Hafnates; Niobates; Titanates; Zirconates

   a. Hafnates
   b. Niobates
   c. Zirconates
   d. Aluminum titanate
   e. Barium titanate
   f. Calcium titanate
   g. Iron titanate
   h. Lithium titanate
   j. Magnesium titanate
   k. Strontium titanate
   m. Zinc titanate
   n. Zirconium titanate

7. Aluminates

   a. Magnesium aluminate (spinel)
   b. Barium aluminate
   c. Beryllium aluminate
   d. Calcium aluminate
   e. Cesium aluminate
   f. Lithium aluminate
   g. Potassium aluminate
   h. Rubidium aluminate
   j. Sodium aluminate
   k. Strontium aluminate
   m. Zinc aluminate

8. Ferrites

   a. Magnesium ferrite
   b. Barium ferrite
   c. Beryllium ferrite
   d. Calcium ferrite
   e. Cesium ferrite
   f. Lithium ferrite
   g. Potassium ferrite
   h. Rubidium ferrite
   j. Sodium ferrite
   k. Strontium ferrite
   m. Cobalt ferrite
   n. Nickel ferrite
   p. Zinc ferrite

9. Micas (Illites)

10. Asbestos minerals

VII. CERAMICS (Continued)

C. Vitreous Structures

1. Silic glasses
   - a. Lithium silicate glass
   - b. Sodium silicate glass
   - c. Potassium silicate glass
   - d. Rubidium silicate glass
   - e. Cesium silicate glass
   - f. Beryllium silicate glass
   - g. Magnesium silicate glass
   - h. Calcium silicate glass
   - j. Strontium silicate glass
   - k. Barium silicate glass
   - m. Lead silicate glass
2. Borate glasses
3. Phosphate glasses
4. Arsenic oxide glasses
5. Borosilicate glasses (pyrex)
6. Silica glasses (fused quartz)

D. Covalent Ceramic Structures (Also see Section IX)

1. Silicon carbide + X
   - a. Silicon carbide
   - b. Silicon carbide + Boron carbide + X
2. Boron carbides
3. Alkali and alkaline earth carbides
   - a. Beryllium carbide
4. Boron nitrides
5. Halides and oxyhalides
   - a. Fluorides
6. Sulfides; Selenides

VII. CERAMICS (Continued)

E. Vitreous Bonded Crystalline Ceramics (conventional ceramics; also see VII-A and VII-B)

1. Alkaline earth silicate glass bond

2. Alkali silicate glass bond

3. Magnesium aluminosilicate glass bond (cordierite, steatit talc body)

   a. Lithium modified
   b. Sodium modified
   c. Potassium modified
   d. Rubidium modified
   e. Cesium modified
   f. Beryllium modified
   g. Calcium modified
   h. Strontium modified
   j. Barium modified
   k. Lead modified

4. Calcium aluminosilicate glass bond (porcelain)

5. Other alkaline earth aluminosilicates glass bond

6. Alkali aluminosilicate glass bond

7. Borosilicate glass bond

8. Phosphate glass bond

9. Alumina firebrick

10. Basic brick

11. Silica brick

F. Inorganic Cements and Adhesives

VIII. CERMETS

(Nominal refractory phase is that which is greatest weight fraction of total refractory phase.)

A. Cermets Containing Carbides as Major Refractory Phase

1. Tungsten carbide as major refractory phase
2. Titanium carbide as major refractory phase
3. Chromium carbide as major refractory phase
4. Hafnium carbide or Zirconium carbide as major refractory phase
5. Silicon carbide as major refractory phase

B. Cermets Containing Oxides or Suboxides as Major Refractory Phase

1. Aluminum oxide as major refractory phase
2. Magnesium oxide as major refractory phase
3. Uranium oxide as major refractory phase
4. Thorium oxide as major refractory phase
5. Beryllium oxide as major refractory phase

C. Cermets Containing Borides as Major Refractory Phase

1. Zirconium boride as major refractory phase

D. Cermets Containing Silicides as Major Refractory Phase

E. Cermets Containing Nitrides as Major Refractory Phase

F. Cermets Containing Hydrides as Major Refractory Phase

IX. INTERMETALLICS

(Nominal intermetallic, or nominal intermetallic greatest weight fraction with one or more other intermetallics. Also see section VII - D and respective alloy system.)

A. Carbide Systems

1. Tungsten carbide
2. Titanium carbide
3. Chromium carbide
4. Hafnium carbide; Zirconium carbide
5. Tantalum carbide
6. Molybdenum carbide
7. Uranium carbide

B. Silicide Systems

1. Molybdenum silicide
2. Uranium silicide

C. Boride Systems

1. Magnesium boride
2. Titanium boride
3. Zirconium boride

D. Nitride Systems

1. Titanium nitride
2. Uranium nitride
3. Zirconium nitride

E. Hydride Systems

1. Lithium hydride
2. Zirconium hydride

F. Antimonide, Arsenide, Phosphide, Telluride Systems

1. Antimonides
2. Tellurides

IX. INTERMETALLICS (Continued)

G. Intermetallics Involving a Light Metal (Al, Be, Mg, Ti)

1. Aluminides
2. Beryllides
3. Magnesium intermetallics
4. Titanium intermetallics

H. Intermetallics Involving a Rare Earth

J. Intermetallics Involving a Refractory Metal

1. Chromium intermetallics
2. Cobalt intermetallics
3. Hafnium intermetallics
4. Molybdenum intermetallics
5. Nickel intermetallics
6. Niobium intermetallics
7. Tantalum intermetallics
8. Thorium intermetallics
9. Tungsten intermetallics
10. Vanadium intermetallics
11. Zirconium intermetallics

For intermetallics not listed above, see respective alloy system.

X. POLYMERIC MATERIALS (Including plastics and filled plastics)

A. Polyesters
   1. Cellulose acetate
   2. Cellulose propionate
   3. Cellulose acetate butyrate
   4. Cellulose nitrate
   5. Ethyl cellulose
   6. Polyvinyl acetals
   7. Polyvinyl acetate
   8. Copolyvinyl chloride-acetate
   9. Isocyanates
   10. Polyurethanes
   11. Unsaturated polyesters

B. TAC Polyesters (tri-allyl cyanurate)

C. Phenolics
   1. Phenol formaldehyde
   2. Furfural formaldehyde
   3. Urea formaldehyde

D. Epoxides

E. Melamines

F. Acrylics

G. Polyethylene and halogenated polyethylenes

H. Polyamide (nylon)

J. Natural and Synthetic Rubber

XI. COMPOSITE MATERIALS

(The word "ceramic", as used below, includes any material which is inorganic and nonmetallic. Semiorganic materials, such as silicones, are included in the term "organic".)

A. Composite Organic Materials; Sandwich Structures. (Any layer may be pure, filled, or reinforced.)

1. Plastic skin, plastic foam core
2. Plastic skin, plastic honeycomb core
3. Solid plastic layers

B. Composite Metallic Materials

1. Metal skin, metal honeycomb core
2. Unbonded metal layers
3. Fusion bonded metal layers
4. Mechanically bonded metal layers
5. Clad metals
6. Plated metals

C. Composite Ceramic Materials

D. Composite Organic - Metallic Materials; Sandwich Structures. (Any organic layer may be pure, filled, or reinforced.)

1. Plastic skin, metal honeycomb core
2. Metal skin, plastic honeycomb core
3. Metal skin, plastic foam core
4. Adhesive bonded metal layers

E. Composite Metallic - Ceramic Materials

F. Composite Organic - Ceramic Materials; Sandwich Structures. (Any organic layer may be pure, filled, or reinforced.)

G. Composite Organic - Metallic - Ceramic Materials; Sandwich Structures. (Any organic layer may be pure, filled, or reinforced.)

XI. COMPOSITE MATERIALS (Continued)

H. Reinforced Organic Materials

1. Reinforced teflon
2. Reinforced melamine formaldehyde
3. Reinforced phenolics
4. Reinforced diallyl phthalate
5. Reinforced polyesters and TAC polyesters
6. Reinforced silicones
7. Reinforced epoxides

J. Reinforced Ceramic Materials

CONVERSION FACTORS FOR DENSITY

	g/cm^3	g/in^3	kg/m^3	kg/ft^3	lb/in^3	lb/ft^3
1 g/cm^3 =	1	16.38716	10^3	28.3170	0.0361275	62.4283
1 g/in^3 =	0.0610234	1	61.0234	1.728	2.20462×10^{-3}	3.80959
1 kg/m^3 =	10^{-3}	0.01638716	1	0.0283170	3.61275×10^{-5}	0.0624283
1 kg/ft^3 =	0.0351446	0.578704	35.31446	1	1.275824×10^{-3}	2.20462
1 lb/in^3 =	27.6797	453.592	27679.7	783.808	1	1728
1 lb/ft^3 =	0.01601837	0.262496	16.01837	.453592	5.78704×10^{-4}	1

These tables are based on conversion factors given in "Tables of Thermal Properties of Gases", National Bureau of Standards Circular 564, November 1, 1955.

CONVERSION FACTORS FOR SPECIFIC HEAT

	cal/g °K	$\frac{\text{joules}}{\text{g °K}}$	$\frac{\text{watt sec}}{\text{g °K}}$	Btu/lb °R
1 cal/g °K =	1.	4.184	4.184	0.999346
1 $\frac{\text{joules}}{\text{g °K}}$ =	0.239006	1	1	0.238849
1 $\frac{\text{watt sec}}{\text{g °K}}$ =	0.239006	1	1	0.238849
1 Btu/lb °R=	1.000654	4.18674	4.18674	1

CONVERSION FACTORS FOR LATENT HEAT

	cal/g	joules/g	$\frac{\text{watt sec}}{\text{g}}$	Btu/lb
1 cal/g =	1	4.184	4.184	1.798823
1 joules/g =	0.239006	1	1	0.429929
1 $\frac{\text{watt sec}}{\text{g}}$ =	0.239006	1	1	0.429929
1 Btu/lb =	0.555919	2.32597	2.32597	1

CONVERSION FACTORS FOR THERMAL CONDUCTIVITY

	$\frac{\text{Watts}}{\text{cm °K}}$	$\frac{\text{Watts}}{\text{in °R}}$	$\frac{\text{cal}}{\text{sec cm °K}}$	$\frac{\text{Btu in}}{\text{hr ft}^2\text{ °R}}$	$\frac{\text{Btu}}{\text{hr ft °R}}$	$\frac{\text{Btu}}{\text{sec in °R}}$	$\frac{\text{Btu}}{\text{hr in °R}}$	$\frac{\text{k cal}}{\text{hr m °K}}$
1 $\frac{\text{Watt}}{\text{cm °K}}$ =	1	1.4111	0.2390	693.4	57.78	1.337×10^{-3}	4.81499	86.04
1 $\frac{\text{Watt}}{\text{in °R}}$ =	0.7087	1	0.16937	491.4	40.946	9.478×10^{-4}	3.412	60.97
1 $\frac{\text{cal}}{\text{sec cm °K}}$ =	4.184	5.904	1	2901	241.8	5.596	20.15	360
1 $\frac{\text{Btu in}}{\text{hr ft}^2\text{ °R}}$ =	1.4423×10^{-3}	2.035×10^{-3}	3.447×10^{-4}	1	0.08333	1.9290×10^{-6}	6.944×10^{-3}	0.12409
1 $\frac{\text{Btu}}{\text{hr ft °R}}$ =	0.01731	0.02442	4.136×10^{-3}	12	1	2.3148×10^{-5}	0.08333	1.4891
1 $\frac{\text{Btu}}{\text{sec in °R}}$ =	747.7	1.0550	178.70	518,400	43,200	1	3600	6.433×10^{4}
1 $\frac{\text{Btu}}{\text{hr in °R}}$ =	0.2077	0.2931	0.04964	144	12	2.778×10^{-4}	1	17.87
1 $\frac{\text{k cal}}{\text{hr m °K}}$ =	0.011622	0.016400	2.778×10^{-3}	8.058	0.6715	1.55447×10^{-5}	0.05596	1

CONVERSION FACTORS FOR DIFFUSIVITY

	ft^2/hr	ft^2/sec	in^2/sec	cm^2/hr	cm^2/sec
1 ft^2/hr =	1	2.778×10^{-4}	0.04	929.0	0.2581
1 ft^2/sec =	3600	1	144	3.3445×10^{6}	929.0
1 in^2/sec =	25	6.944×10^{-3}	1	2.323×10^{4}	6.452
1 cm^2/hr =	1.0764×10^{-3}	2.990×10^{-7}	4.306×10^{-5}	1	2.778×10^{-4}
1 cm^2/sec =	3.875	1.0764×10^{-3}	0.15500	3600	1

CONVERSION FACTORS FOR VAPOR PRESSURE

	dyne/cm²	standard atmosphere	kg/cm²	mm Hg	in Hg	lb/in²	lb/ft²
1 dyne/cm² =	1	9.869×10^{-7}	1.0197×10^{-6}	7.501×10^{-4}	2.953×10^{-5}	1.4504×10^{-5}	2.089×10^{-3}
1 standard atmosphere =	1.0133×10^{6}	1	1.0332	760	29.92	14.696	2116
1 kg/cm² =	9.807×10^{5}	0.9678	1	735.6	28.96	14.223	2048
1 mm Hg =	1333.2	1.3158×10^{-3}	1.3595×10^{-3}	1	0.03937	0.019337	2.7845
1 in Hg =	3.386×10^{4}	0.03342	0.03453	25.40	1	0.4912	70.73
1 lb/in² =	6.8947×10^{4}	0.068046	0.07031	51.71	2.036	1	144
1 lb/ft² =	478.8	4.725×10^{-4}	4.882×10^{-4}	0.3591	0.014139	6.944×10^{-3}	1

PROPERTIES OF ALUMINUM OXIDE

MOST PROBABLE VALUES

Property	Brit. Engineering Units	C. G. S. Units
Density.	250 lb_m/ft^3 *	4.0 g/cm^3 *
Melting Point	4160 °R	2310 °K
Heat of Fusion		
Heat of Vaporization. . .		
Heat of Sublimation . . .	$8052_{537°R}$ Btu/lb_m	$4473_{298°K}$ cal/g

* Value for α-phase; for γ-phase, see Reported Values below

REPORTED VALUES

		lb_m/ft^3	g/cm^3	Material
Density:	O	250	4.0	α phase
	O	212	3.4	γ phase
	□	222.18 ± 0.06	3.559 ± 0.001	sinter
	▽	248.65 ± 0.06	3.983 ± 0.001	sapphire

		°R	°K
Melting Point:	△	4155 ± 18	2308 ± 10
	◇	4085 ± 2	2267 ± 1
	▽	4092 ± 18	2273 ± 10
	○	4100 ± 10	2278
	□	4182	2323
	△	4167 ± 13	2315 ± 7
	▷	4153 ± 29	2307 ± 16

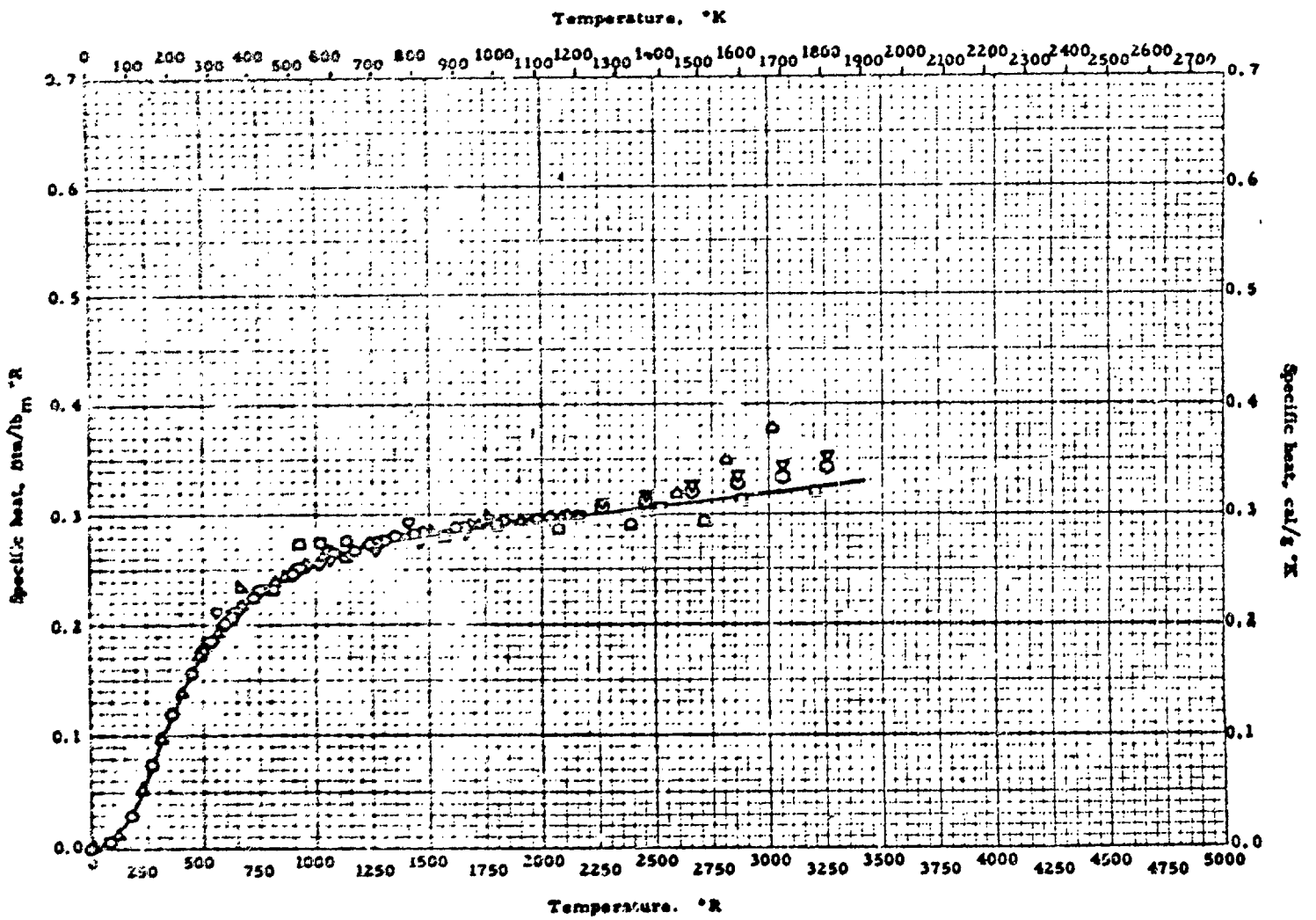
	Btu/lb_m	cal/g
Heat of Fusion:		
Heat of Vaporization:	Btu/lb_m	cal/g

		Btu/lb_m	cal/g
Heat of Sublimation:	O	$2650_{4002°R}$	$1472_{2223°K}$
	□	$8052_{537°R}$	$4473_{298°K}$

PROPERTIES OF ALUMINUM OXIDE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Wartenberg, H. V.	52-15	4002	Alumina, Al_2O_3	Δh_s: from vapor pressure data by Langmuir method.	
			Room	α and γ phases	ρ: not given	
□	Brewer, L. and Searcy, A. W.	51-10	537	Alumina, Al_2O_3	Δh_s: from vapor pressure data by Knudsen method	Vapor pressure data obtained at 4155-4690°R, assuming $Al_2O_3(s) \rightarrow 2AlO(g) + 1/2\ O_2(g)$
△	Geller, R. F. and Bonting, E. N.	43-14	4137-4173		MP: visual observation optical pyrometer	Prepared by dissolving 99.98% Al in reagent grade HNO_3 and igniting at 1100°C
◇	Geller, R. F. and Yavorsky, P. J.	45-4	4083-4087	99.99% pure α phase; 0.004% CaO; 0.003% SiO_2	MP: rounding of corners of pyramid; 3 optical pyrometers	Sample B
▽	Ibid.	45-4	4073-4092	α phase; <0.01% ea. Ag, B, Ca, Cu, Fe, Mg, Si	MP: same as above	Sample C; prepared by dissolving 99.98% Al in reagent grade HNO_3 and igniting at 1100°C
○	Ibid.	45-4	4092-4110	α phase; 0.05% C; fused and recrystallized Alumina, Al_2O_3	MP: same as above	Sample A
⌂	Trombe, F.	49-16	4182	Alumina, Al_2O_3	MP: not given	
⌂	National Bureau of Standards	54-132	4155-4180	Alumina, Al_2O_3	MP: visual observation, optical pyrometer	Auth. est. accuracy ± 2%
⌂	Oak Ridge National Lab.	57-150	537	Alumina, Al_2O_3	ρ: weight in air and in kerosene	Sintered. Measured by O. Sisman, C. D. Bopp and R. L. Towns
▽	Ibid.	57-150	537	Sapphire	ρ: same as above	
⌂	Lamberton, W. A. and Gunsel Jr., F. H.	52-131	4124-4182	99.5 + % pure Al_2O_3, Alcoa T-61 grade	MP: visual observation of material in const. temp. furnace, temp. by optical pyrometer.	

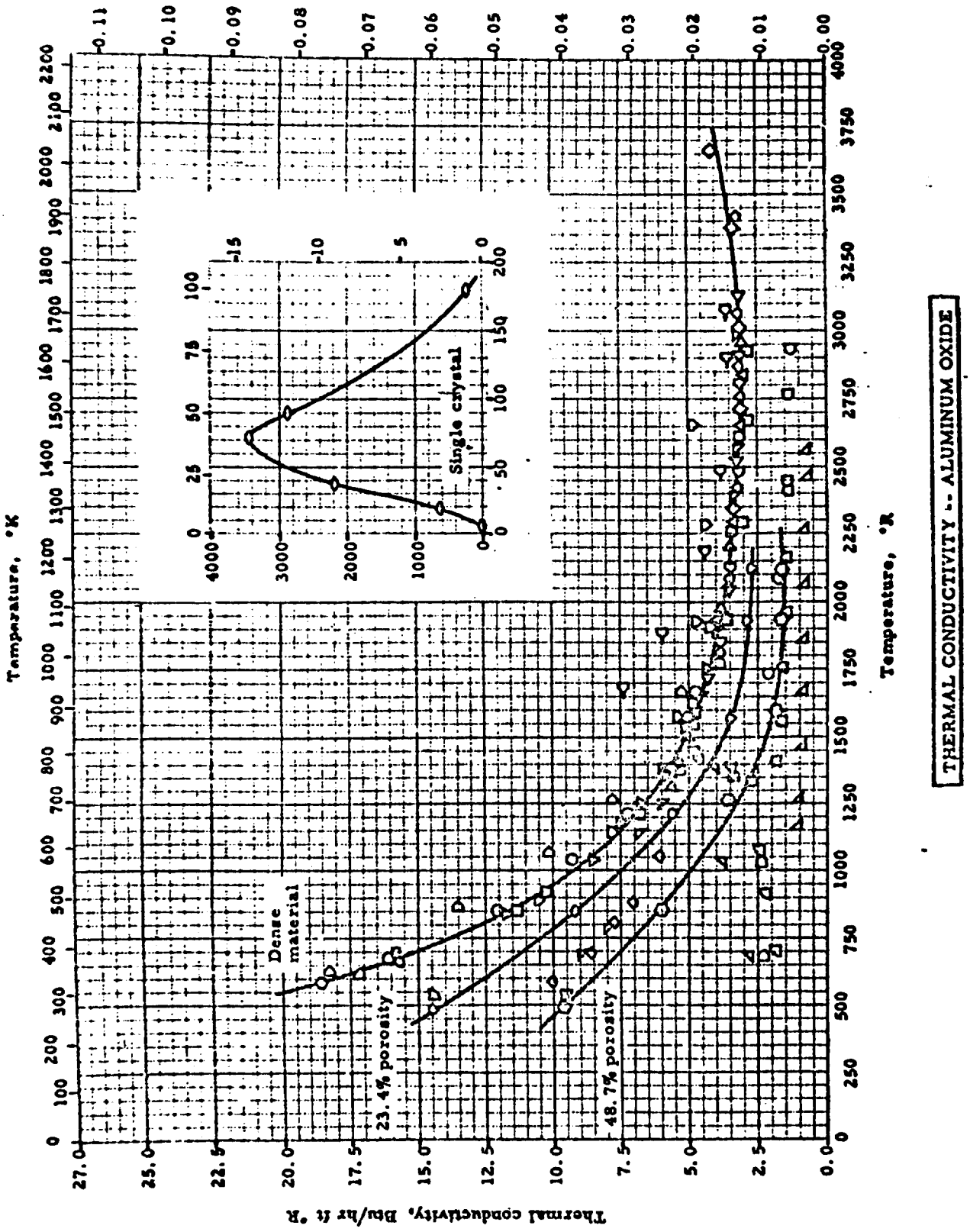


SPECIFIC HEAT -- ALUMINUM OXIDE

SPECIFIC HEAT -- ALUMINUM OXIDE

REFERENCE INFORMATION

Sym	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Ginnings, D.C. and Furukawa, G.T.	53-59	0-2160	Corundum; synthetic sapphire: 0.01-0.02% impurities	Guarded sample up to 260°F; drop method; ice calorimeter at higher temp.	Auth. est. accuracy 0.2%, (-370 to 1160°F); slightly lower accuracy at higher temp.
□	Sherrate, C.H. and Naylor, B.F.	45-3	830-3220	100% Al_2O_3; natural, almost colorless sapphires	Drop method	Auth. est. accuracy of heat content data ± 0.4% (298 to 1800°K)
△	Furukawa, G.	56-24	9-2160	α-Al_2O_3 (corundum; synthetic sapphire): 99.98% pure; 0.005% ea. Si, Fe; 0.002% Cr	Adiabatic calorimeter up to 380°K; drop method; ice calorimeter between 273-1180°K	
◇	Ginnings, D.C. and Corruccini, R.J.	47-17	492-2112	α-Al_2O_3 (corundum; synthetic sapphire): 0.02-0.03% impurities, mostly SiO_2	Drop method; ice calorimeter	Auth. est. accuracy of heat content data ± 0.2% above 100°C
▽	Fieldhouse, I.B., Hedge, J.C. and Lang, J.I.	58-2	960-3260	Polycrystalline Al_2O_3	Drop method; water calorimeter	
⬡	Ibid.	58-2	960-3260	Synthetic sapphire	Same as above	
⌂	Lucks, C.F. and Deem, H.W.	56-1	932-2715	Not given	Drop method; ice calorimeter	Enthalpy data of auth. fitted with quadratic eq. by ARF
○	Lucks, C.F. and Ding, G.F.	52-33	1021-1401	Not given	Drop method; ice calorimeter	Enthalpy data of auth. fitted with quadratic eq. by ARF
⌂	Rodigina, E.N. and Cornel'skii, K.Z.	55-71	2472-3012	α-Al_2O_3. 99.9% pure	Drop method; copper block calorimeter	Enthalpy data of auth. fitted with quadratic eq. by ARF
○	Oriani, R.A. and Murphy, W.K.	54-21	534-1415	α-Al_2O_3. High purity corundum	Drop method; ice calorimeter	Enthalpy data of auth. fitted with quadratic eq. by ARF
⌂	Ewing, C.T. and Faker, B.E.	54-65	669-1761	Al_2O_3 crystals	Drop method; copper block calorimeter	Enthalpy data of auth. fitted with quadratic eq. by ARF
◇	Oriani, R.A.	51-84	492-1415	Synthetic sapphire	Drop method, ice calorimeter Sample temp. measured by calibrated Pt-Pt Rh thermocouple	Author reports enthalpy. c_p calculated from $c_p = \frac{\Delta h}{\Delta t}$



THERMAL CONDUCTIVITY -- ALUMINUM OXIDE

THERMAL CONDUCTIVITY -- ALUMINUM OXIDE

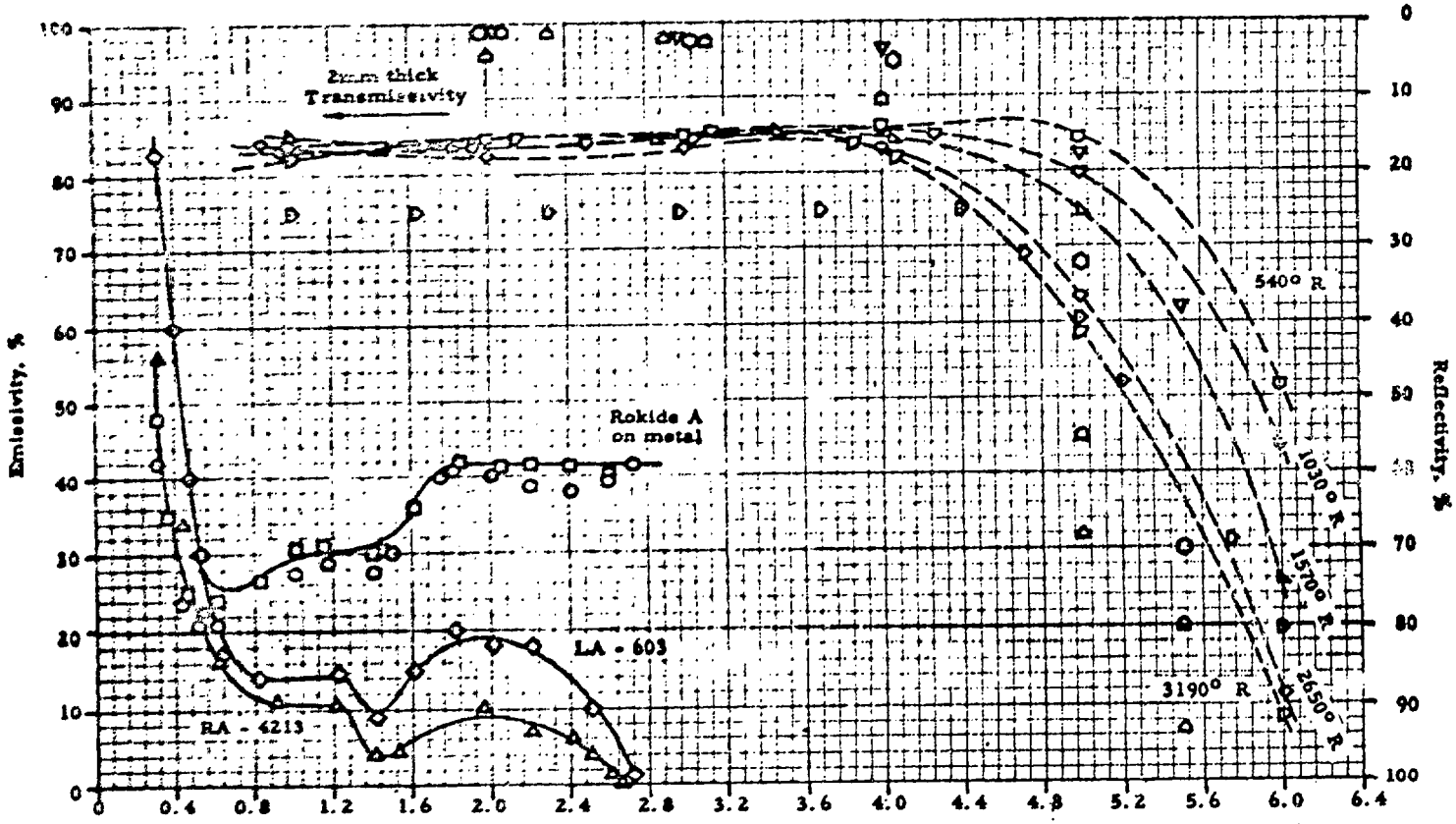
REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Francl, J. and Kingery, W. D.	54-6 53-67 52-66	564-1662	ρ = 236.5 lb_m/ft^3; apparent porosity 0%	Comparative; rods	Slip cast from suspension of finely ground material
△	Adams, Milton	54-5 53-67	1392-2832	ρ = 228.4 to 230.3 lb_m/ft^3; porosity 6.35 to 7.11%	Prolate spheroid envelope	Slip cast from suspension of finely ground material
□	Kingery, W. D.	54-4 53-67	852-2922	"High density"; Al_2O_3	Radial heat flow in sphere and in cylinder	Slip cast from suspension of finely ground material
◇	McQuarrie, Malcolm	54-3 52-65 53-67 52-67	2292-3660	Prepared from Norton Co. Alundum abrasive grain 38 x 220F; 99.44% Al_2O_3; 0.31% Fe_2O_3; 0.24% SiO_2; 0.01% TiO_2	Prolate spheroid envelope	Slip cast from suspension of finely ground material
△	Weeks, James L. and Seifert, Ralph L.	52-1 also 51-39	658-672	Synthetic sapphire	Comparative, rods (Armco Iron Standards)	Sample axis at 60° from "C" axis
▷	Whittemore Jr., O. J.	49-1	1160-2560	99+% pure; ρ = 120 lb_m/ft^3; porosity = 53%	Flat plate with liquid calorimeter	Made from 8 mesh grain or finer; fired at 3690°R; measured by G. B. Wilkes, M.I.T.
□	Ibid.	49-1	1410-2260	99+% pure; ρ = 195 lb_m/ft^3; porosity = 23%	Same as above	Made from 14 mesh grain or finer; fired at 3690°R; measured by G. B. Wilkes, M.I.T.
○	Francl, J. and Kingery, W. D.	54-2 52-58 53-65	492-2112	Prepared from Norton Co. Alundum abrasive grain 38 x 220F; porosity = 48.7%	Comparative; rods	Ground in steel mill and acid treated to remove Fe. Pores formed by casting with napthalene flakes and evaporating napthalene.
◇	Ibid.	54-2	492-2112	Prepared from Norton Co. Alundum abrasive grain 38 x 220F; porosity = 23.4%	Same as above	Same as above
○	Berman, R.	51-14	5-180	Corundum: single crystal 3 mm dia. and 60 mm long	Axial heat flow in rod, guarded heat source and sample	Tested in vacuum
▽	Francis, R. K., McNamara, E. P. and Tinklepaugh, J. R.	58-7	852-1752	97.6% Al_2O_3; ρ = 230 lb_m/ft^3; identified as Western Gold and Platinum Body Al-300	Comparative; rods alumina standard	Standard supplied by W. D. Kingery
◁	Norton, F. H. and Kingery, W. D.	51-75	690-2480	Al_2O_3	Comparative; rods below 1400°R; ellipsoidal envelope above 1400°R	

WADC TR 59-610 Pt 2 59-616

REFERENCE INFORMATION

Sym	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
▽	Charvat, F. R. and Kingery, W. D.	57-53	888-2652	Single crystal (sapphire)	Comparative; rods (Al_2O_3 polycrystalline cube standards)	
▽	Ibid.	57-53	888-2652	Polycrystalline Al_2O_3	Same as above	Samples, 9μ and 12μ average crystal size; data corrected to 0% porosity
▷	Weeks, J. L. and Siefert, R. A.	53-17	618	Sapphire (axis 60° from C axis); ρ = 249.6 lb_m/ft^3	Comparative; rods (Armco iron standard)	Tested in vacuum
○	Fieldhouse, I. B., Hedge, J. C. and Lang, J. I.	58-2	582-3377	Polycrystalline Al_2O_3	Radial heat flow in cylinder of stacked disks	In He atmos.
△	Knapp, W. J.	43-11	670-1385	Corundum (African)	Comparative; cubes, Stainless steel standard	Parallel to C axis
□	Ibid.	43-11	670-1774	Same as above	Same as above	Normal to C axis
△	Ibid.	43-11	705-1375	Sapphire (synthetic)	Same as above	Normal to C axis
▽	Oak Ridge National Laboratory	57-150	546	Al_2O_3	Not given, refers to others	Sintered; measured by O. Sisman, C. D. Bopp and R. L. Towns
▽	Ibid.	57-150	546	Sapphire	Same as above	
▷	Truesdale, R. S., Swica, J. J. and Tinklepaugh, J. R.	58-25	625-1660	Alumina, Norton 38-900, ρ is 91% of theor.	Comparative; one inch cubes; alumina standard	Grain size 5-9μ; hot pressed at 3000°F at 3000 psi
◁	Norton, F. H. et al.	50-66	1460-3079	Al_2O_3	Oblate ellipsoidal envelope	◁-first heating ◁-after repeated heatings
◁	Norton, F. H., Fellows, D. M., et al.	49-68	1385-2936	Al_2O_3 Total pores: 13.00% Bulk ρ = 217 lb_m/ft^3 Open pores: 10.65 % Closed pores: 2.35%	Cylindrical envelope with hemispherical ends. Temp. by Pt-Rh thermocouple	Sintered. Auth. consider these values low
◁	Norton, F. H. et al.	50-64	1823-3187	Al_2O_3	Prolate ellipsoid with heavy insulating cover	Sintered
▷	Norton, F. H.	51-77	1320-2832	Al_2O_3	Ellipsoidal envelope	Auth. est. max. deviation from avg. ± 20%

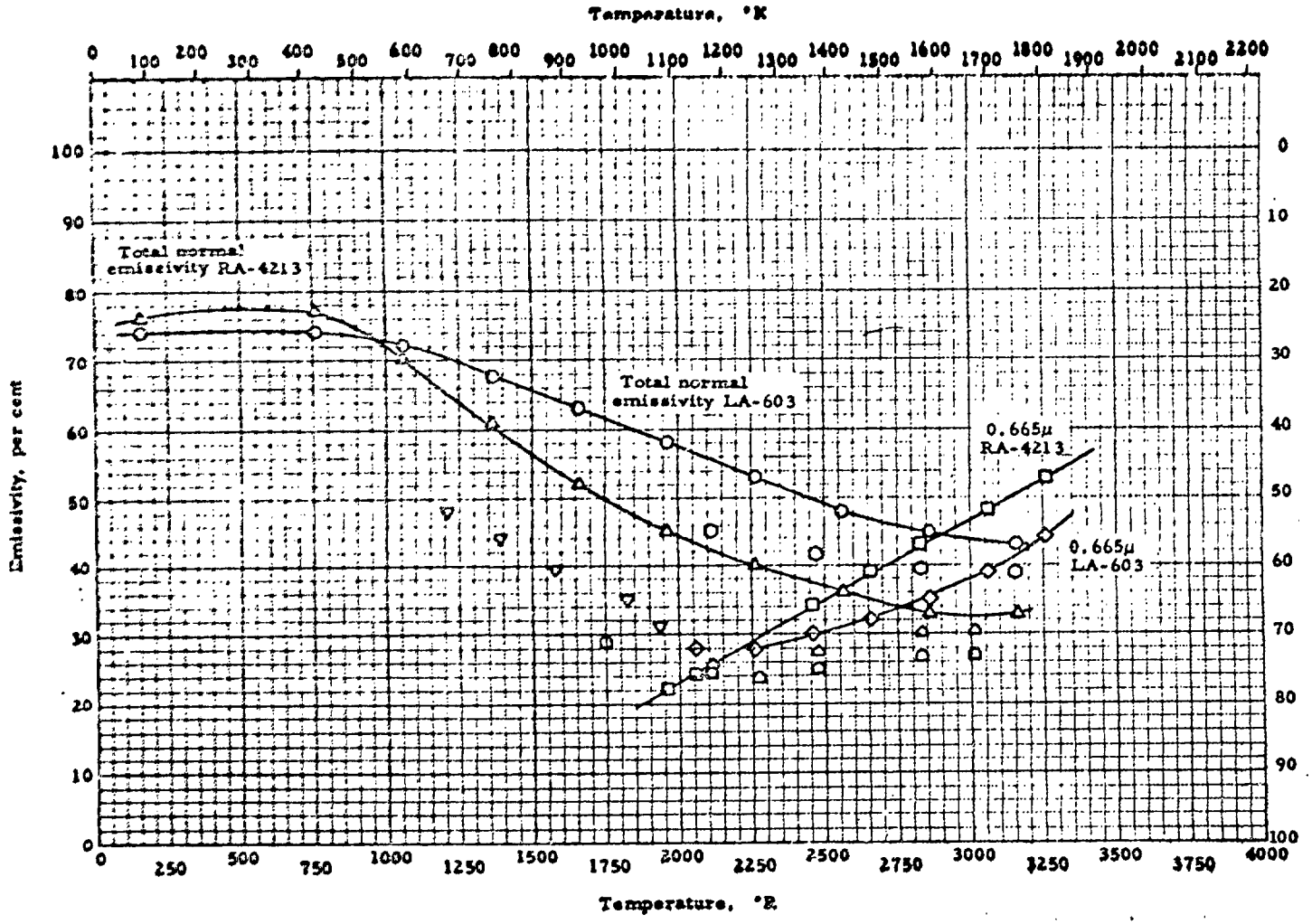


SPECTRAL EMISSIVITY -- ALUMINUM OXIDE

SPECTRAL EMISSIVITY -- ALUMINUM OXIDE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Olson, O.H. and Morris, J.	58-1	Room	Norton Rokide A on molybdenum	Spectral reflectivity at 9°; sample compared with $MgCO_3$ standard in MgO integrating sphere, quarts lens, PbS detector	
□	Olson, O.H. and Morris, J.	59-1	Room	Norton Rokide A on No. 446 stainless steel	Same as above	
△	Ibid.	59-1	Room	Norton LA 603	Same as above	
◇	Ibid.	59-1	Room	Norton RA 4213	Same as above	
▽	Kingery, W.D. and Norton, F.H.	55-47	553	Sapphire*	Transmissivity meas. by Beckman IR-3 infrared spectrometer	Sample is 2mm thick. Data are already corrected for reflectance loss by the auth.
○	Ibid.	55-47	1032	Same as above	Same as above	Same as above
□	Ibid.	55-47	1572	Same as above	Same as above	Same as above
△	Ibid.	55-47	2652	Same as above	Same as above	Same as above
□	Alfred Univ.	57-180	537	Sapphire	Transmissivity measured with Reeder infrared spectrometer double beam apparatus. Thermocouple with NaCl window. Sample temp. by optical pyrometer	Sample is 1.97 mm thick
○	Ibid.	57-180	1032	Same as above	Same as above	Same as above
△	Ibid.	57-180	1572	Same as above	Same as above	Same as above
◇	Ibid.	57-180	2652	Same as above	Same as above	Same as above
▽	Ibid.	57-180	3192	Same as above	Same as above	Same as above
▷	Gaunt, J.	51-79	Room	Synthetic sapphire	Transmissivity: not given	Sample is 3 mm thick

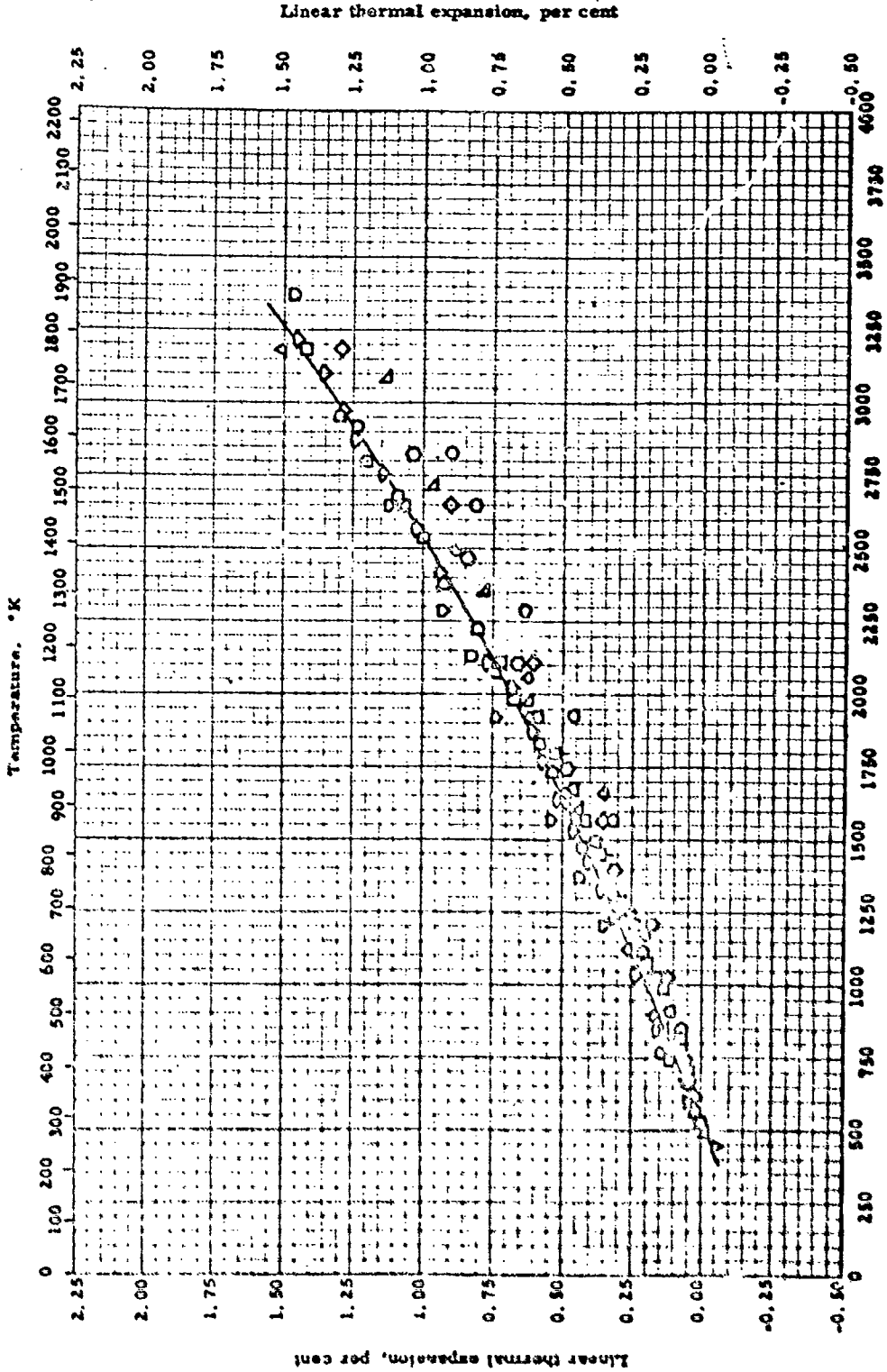


EMISSIVITY -- ALUMINUM OXIDE

EMISSIVITY -- ALUMINUM OXIDE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Olson, O.H. and Morris, J.C.	59-1	160-3160	Norton LA 603	Total normal emissivity: comparative: radiant heat flow compared with that of a black body, thermopile; sample temp. by thermocouple; in air	
□	Ibid.	59-1	1960-3260	Same as above	Spectral normal emissivity at 0.665μ: comparative; surface brightness compared with that of a black body hole, disappearing filament optical pyrometer	
△	Ibid.	59-.	160-3160	Norton RA 4213	Total normal emissivity: comparative; radiant heat flow compared with that of a black body, thermopile; sample temp. by thermocouple; in air	
◇	Ibid.	59-1	1960-3260	Same as above	Spectral normal emissivity at 0.665μ: comparative; surface brightness compared with that of a black body hole;disappearing filament optical pyrometer	
▽	Sully, A.H., Brandes, E.A. and Waterhouse, R.B.	52-81	1212-1932	"Pure"	Total normal emissivity: radiant heat meas. with thermopile; sample temp. by calibrated Pt-Rh thermocouple	
○	Parrison, J.R.	55-86	2112-3156	Not given	Total normal emissivity: radiant heat meas. with thermopile; sample temp. by optical pyrometer sighting on black body cavity	
○	Kingery, W.D. and Norton, F.H.	55-57	2112-3012	High density alumina	Spectral normal emissivity: comparative; surface brightness compared with that of a black body hole	
○	Ibid.	55-57	1752-3012	Same as above	Spectral normal emissivity: comparative; surface brightness compared with that of a black body hole; sample temp. by thermocouple	

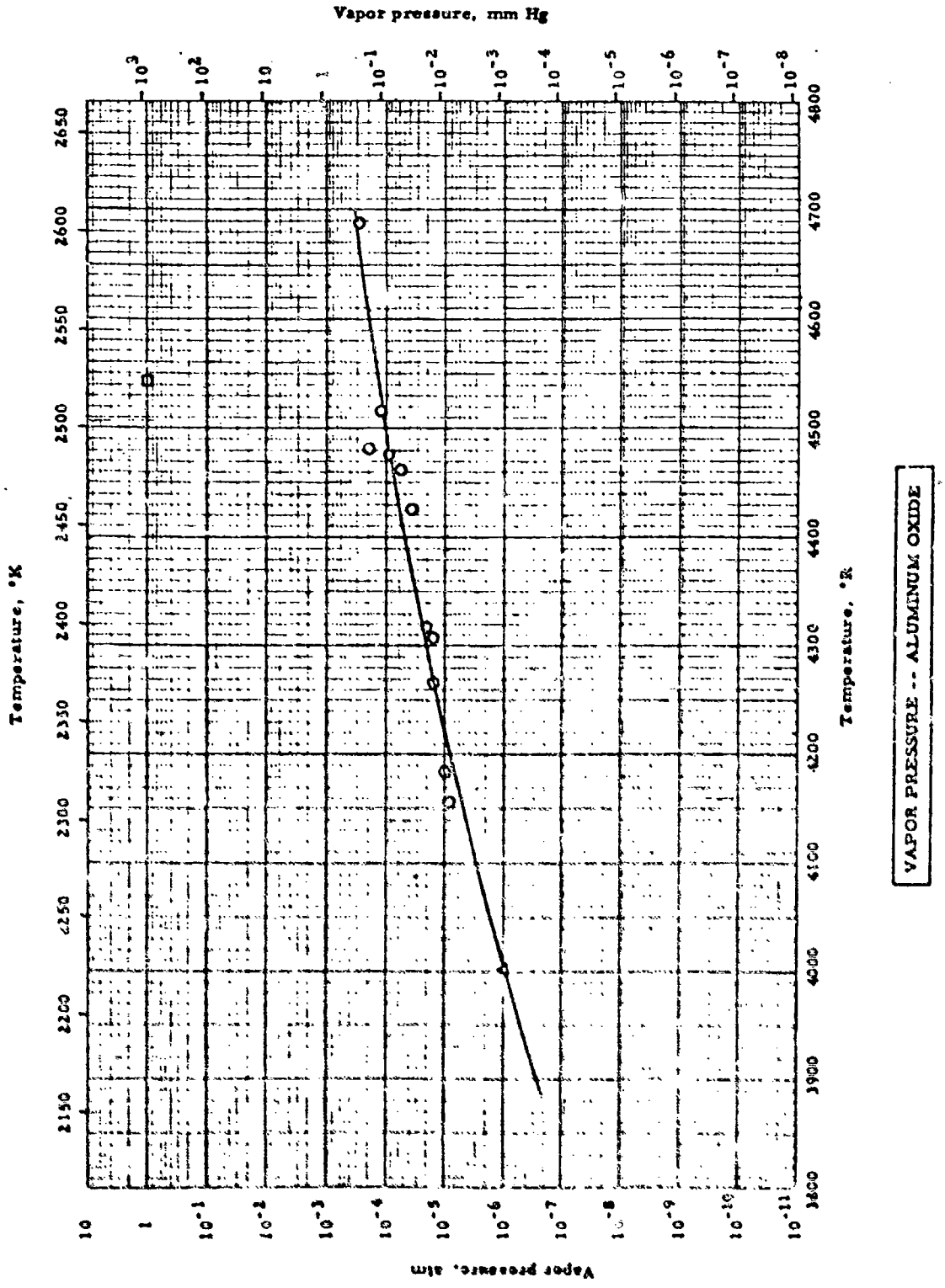


LINEAR THERMAL EXPANSION -- ALUMINUM OXIDE

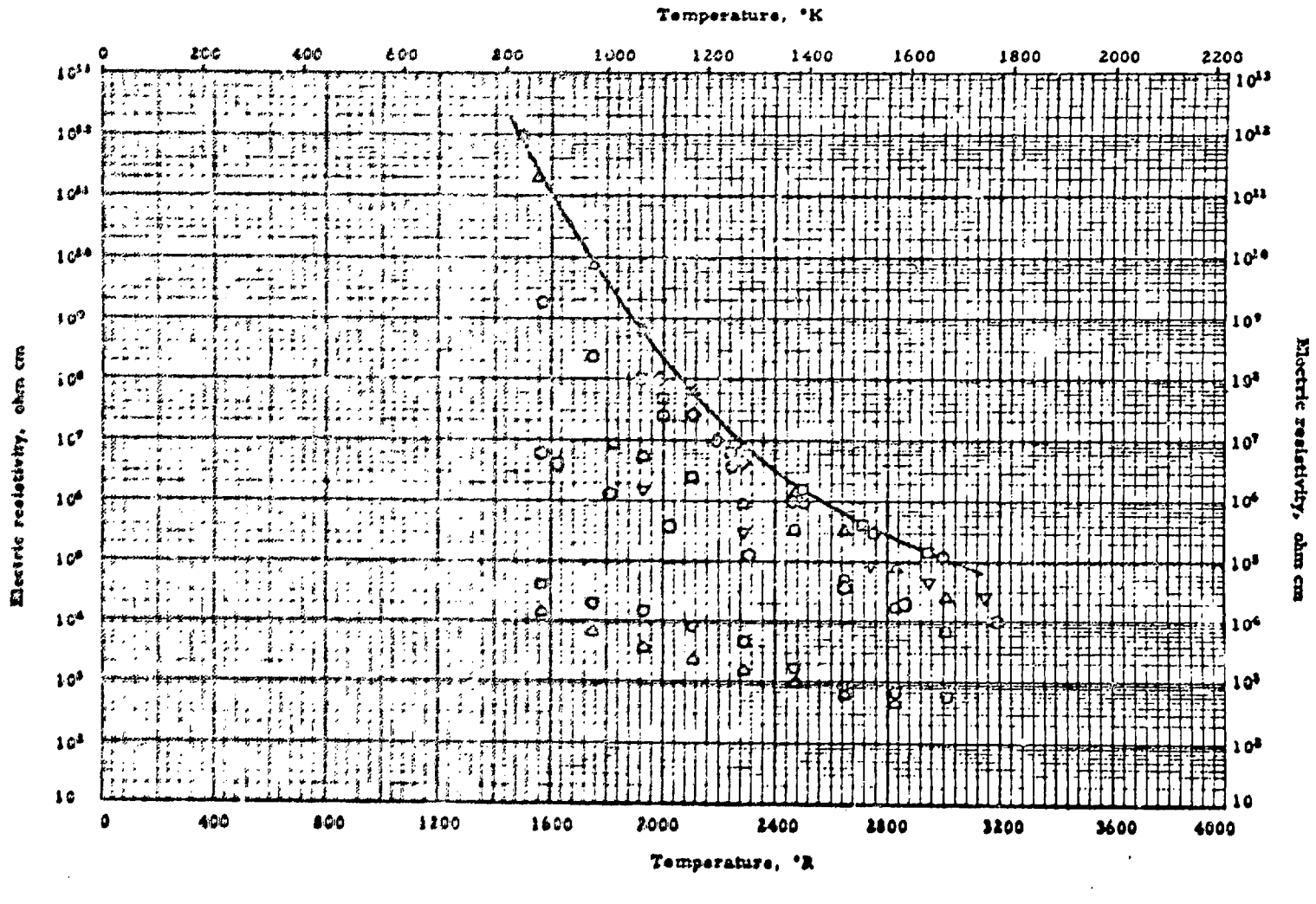
LINEAR THERMAL EXPANSION -- ALUMINUM OXIDE

REFERENCE INFORMATION

Sym.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Schwartz, B.	52-11	537-2832	Commercially pure (<1% impurities) fused refractory grains	Telemicroscopes sighting on sample	Slip cast, dried, fired at 1150°C, machined and refired at 1830°C 3 hr. Tested at 4°C/min rise
□	Whittemore, O. J. and Ault, N. M.	56-7	1032-3192	99% Al_2O_3; sintered; high density	Telemicroscopes sighting on pointed ends of sample	
△	Ibid.	56-7	1032-3192	99% Al_2O_3; coarse fused grains	Same as above	
◇	Ibid.	56-7	1032-3192	88% Al_2O_3; clay bonded fused grain	Same as above	
▽	Smoke, E. J.	49-3	room	From various manufacturers	Dilatometer; 8 in. sample	Points shown are to illustrate the slope at room temp.
○	Coble, R. L. and Kingery, W. D.	56-10	522-2832	Sintered; various porosities	Telemicroscopes	Ground and acid washed (Norton Co) Al oxide. Gas fired 3 hr. at 1790°C Auth. states that coeff. of exp. does not vary with porosity
○	Shevlin, T. S. and Hauch, C. A.	54-40 also 55-19	528-1932		Silica tube dilatometer	Sintered at 3000°F; ○ -heating, ○ -cooling
○	Beals, R. J. and Cook, [illegible]	57-20	526-2652	Reagent grade	X-ray back reflection	
□	Trombe, F.	49-16	460-3372	95.5% pure	Not given	Cast
△	Ibid.	49-16	528-1932	99% pure	Same as above	Same as above
◇	Ibid.	49-16	460-672	Pure	Same as above	Same as above
△	Mauer, F.A. and Bole, L.H.	57-62	492-3084	Commercial grade: 0.50% Na_2O; 0.025% SiO_2; 0.04% Fe_2O_3; 0.002% TiO_2; 1.2% H_2O	X-ray diffraction	Test run in He atmos.
○	Fitzhouse, I.B., Hedge, J.C. and Lang, J.I.	56-2	540-2953	Aluminum Oxide - Polycrystalline	Telemicroscopes sighting on sample	
◇	Ibid.	58-2	535-3206	Synthetic Sapphire	Same as above	
◇	Truesdale, R. S., Swica, J. J. and Tinklepaugh, J. R.	58-25	760-2460	Alumina	Dilatometer	Alumina grain size 5-9μ. Hot pressed at 3000°F and 3000 psi, density: 91% of theoretical



VAPOR PRESSURE -- ALUMINUM OXIDE

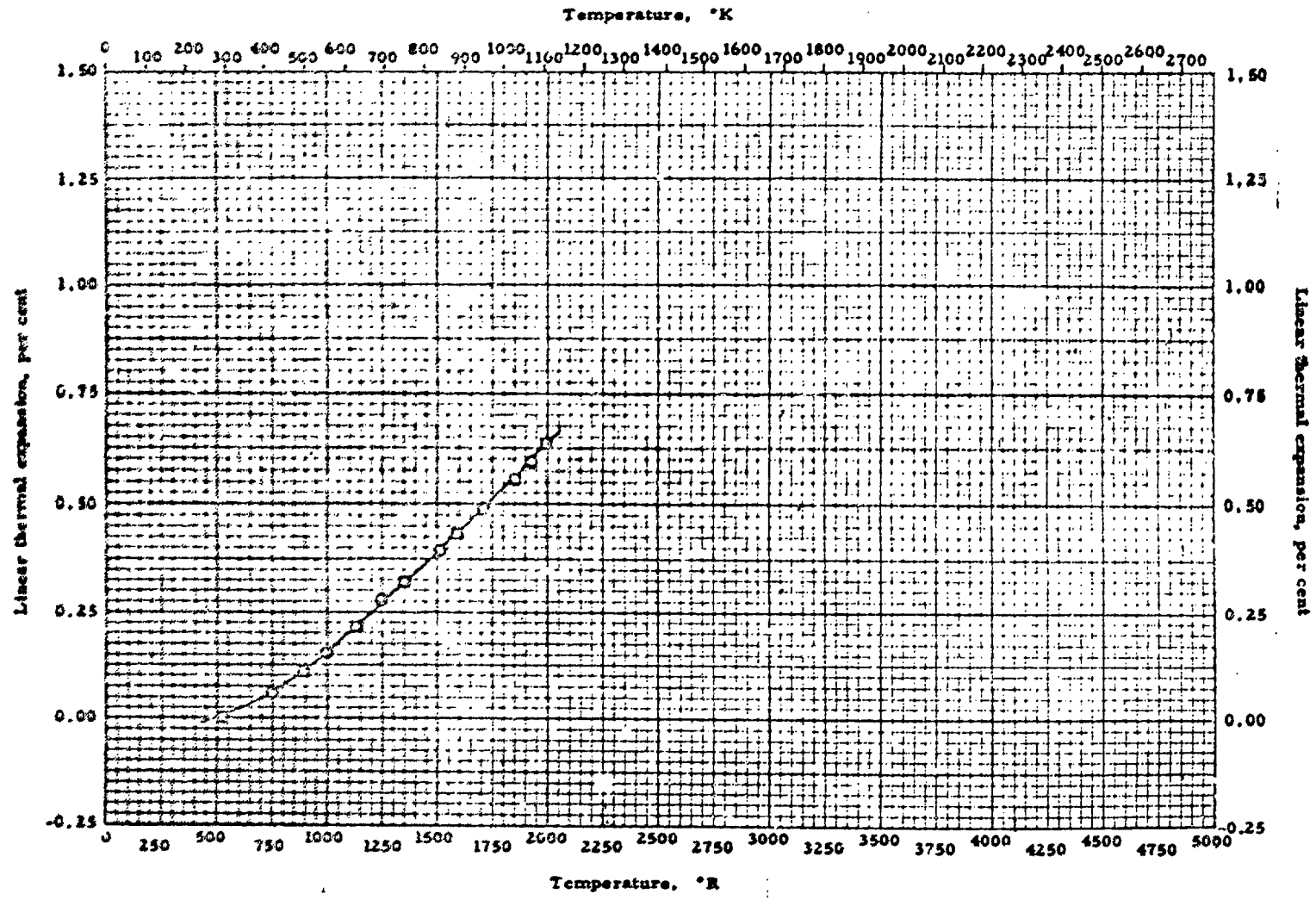


ELECTRIC RESISTIVITY -- ALUMINUM OXIDE

ELECTRIC RESISTIVITY -- ALUMINUM OXIDE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Wachtman, J. B. and Maxwell, L. H.	53-146	1572-3000	Sapphire	Meas. by winding 0.5 in. wide strips of Pt around rods at 1 in. distance, with 200 v. DC applied	Preheated to 1400°C, undeformed
□	Ibid.	53-140	1925-3000	Same as above	Same as above	Same as above, but another sample
△	Heidt, K. and Haase, C.	54-138	1499-3191	Al_2O_3, α phase. Total impurities <0.03%	For $R = 10^{14} - 10^{9}$ ohm: electrometer was used. For $R < 10^{6}$; potential drop	Sintered. 99.996% Al + triple distilled $H_2O \longrightarrow Al_2O_3$ · Bayerit Heated under $<10^{-5}$ atm. Compressed by hand; shrinkage when fired up to 35%. Electrometer accuracy ± 20%. Potential drop accuracy ± 5%. Ohm's law holds.
◇	Regener, H.	40-20	1986-2292	Al_2O_3	Potential drop. Sample temp. by Pt-Rh thermocouple	1 cm cube samples, platinized faces. Auth. est. accuracy order of magnitude only
▽	Meseler, J. R. and Henry, E. C.	53-95	1932-3156	Al_2O_3, porosity = 37%	Wheatstone bridge, with cathode-ray null indicator	Acid treated Al_2O_3, fired 10 hr. at 1500° C
○	Ibid.	53-95	1572-2192	Al_2O_3	Same as above	Calcined $Al(OH)_3$, fired 10 hr. at 1500° C
◇	Chlechetti, V. E. J. and Henry, E. C.	53-94	1824-3012	99% Al_2O_3, pyrometric cone equivalent 41-42, porosity = 24%	Wheatstone bridge at 10v and 965 cps	Meas. commercial material. Auth. est. accuracy ± 10% in megohm range, ± 4% in 51 kohm range, ± 3% in 100 ohm range
△	Ibid.	53-94	1572-2832	Alumina, apparent porosity = 3.1%	Same as above	Fused, cast at 1930°C
□	Ibid.	53-94	1572-3012	Alumina, apparent porosity = 4.2%	Same as above	Fused, cast at 1940°C



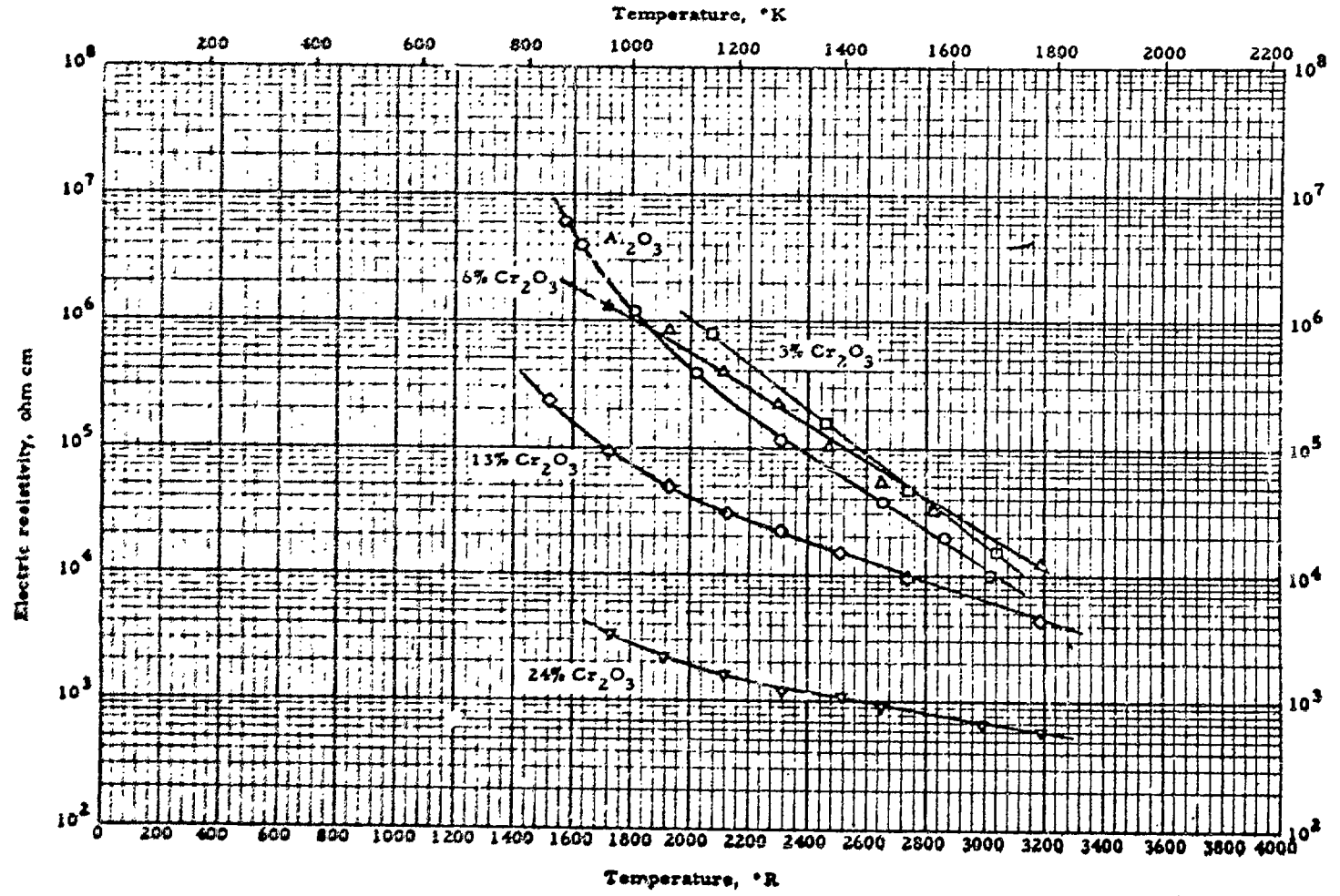
LINEAR THERMAL EXPANSION -- ALUMINUM OXIDE + CHROMIUM OXIDE

WADC TR 59-676 51
59-291

LINEAR THERMAL EXPANSION -- ALUMINUM OXIDE + CHROMIUM OXIDE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Shevlin, T. S. and Hauck, C. A.	54-40 also 55-19	528-1932	10% Cr_2O_3	Silica tube dilatometer	Sintered at 3000°F
□	Ibid.	54-40 also 55-19	528-1990	20% Cr_2O_3	Same as above	Same as above



ELECTRIC RESISTIVITY -- ALUMINUM OXIDE + CHROMIUM OXIDE

ELECTRIC RESISTIVITY -- ALUMINUM OXIDE + CHROMIUM OXIDE

REFERENCE INFORMATION

Key	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Hensler, J.R., and Henry, R.C.	53-95	1572-3192	100% Al_2O_3; 0% Cr_2O_3	Wheatstone bridge	Oxides obtained by calcining the coprecipitated hydroxides of aluminum and chromium. Fired 10 hr. to 1500°C
□	Ibid.	53-95	2076-3138	97% Al_2O_3; 3% Cr_2O_3	Same as above	Same as above
△	Ibid.	53-95	1716-3197	94% Al_2O_3; 6% Cr_2O_3	Same as above	Same as above
◇	Ibid.	53-95	1518-3192	87% Al_2O_3; 13% Cr_2O_3	Same as above	Same as above
▽	Ibid.	53-95	1736-3192	76% Al_2O_3; 24% Cr_2O_3	Same as above	Same as above

DENSITY -- ALUMINUM OXIDE + URANIUM OXIDE

MOST PROBABLE VALUES

Property	Brit. Engineering Units	C. G. S. Units
Density, 79% alumina . .	286 lb_m/ft^3	4.58 g/cm^3
Melting Point		
Heat of Fusion		
Heat of Vaporization . . .		
Heat of Sublimation . . .		

REPORTED VALUES

		lb_m/ft^3	g/cm^3
Density:	O	275.5 ± 0.5	4.415 ± 0.015
	□	286	4.58

Melting Point: °R °K

Heat of Fusion: Btu/lb_m cal/g

Heat of Vaporization: Btu/lb_m cal/g

Heat of Sublimation: Btu/lb_m cal/g

DENSITY -- ALUMINUM OXIDE + URANIUM OXIDE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Belle, J. and Jones, L. J.	57-190	Room	79% Al_2O_3; 21% $U^{235}O_2$	ρ: not given	Mixed enriched UO_2 and Fisher Al_2O_3 powder, dry milled 16 hr., granulated with 1% PVA and water, drying 0.2% Sterotex added, pressed at 27,400 psi, sintered 14 hr. at 1750°C in H_2 atm.
□	Ibid.	57-190	Room	Same as above	ρ: computed from x-ray measurements of lattice	Same as above

Symbol	Material Composition, % by Wt Al_2O_3	Nb_2O_5	ThO_2	BeO	ZrO_2	Mole Ratio	Melting Point °R	°K
○	60.25	39.75				4:1	3210	1783
	53.20	46.80				3:1	3183	1768
□	53.68		33.36	12.96		4:1:4	3748 ± 2	2082 ± 1
△	60.70		39.30			4:1	3935 ± 5	2186 ± 3
	53.67		46.33			3:1	3938 ± 8	2188 ± 5
◇	54.07			13.26	32.67	2:2:1	3678 ± 18	2043 ± 10

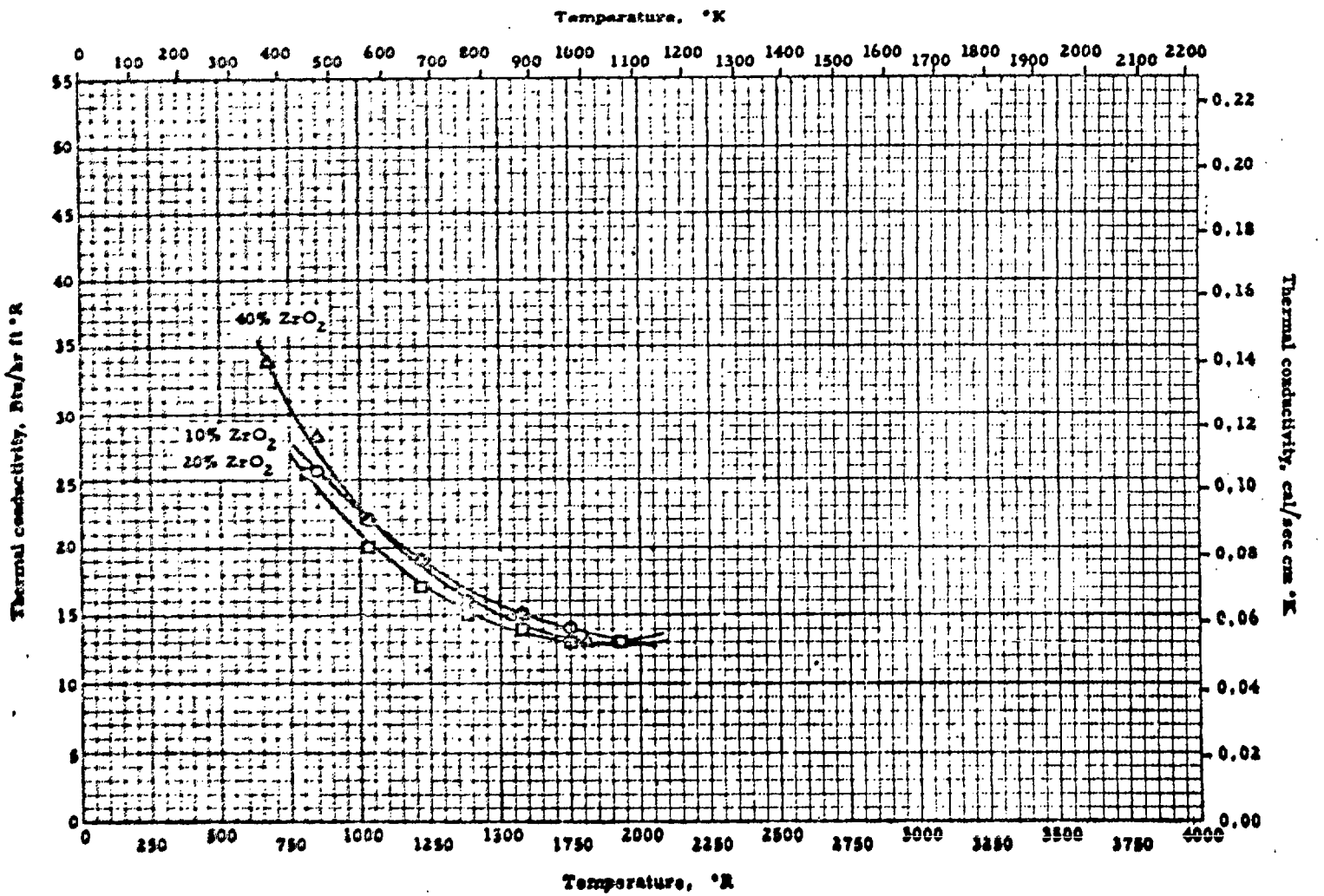
MELTING POINT -- ALUMINUM OXIDE + OTHER OXIDES

60-802
TPRC TR 66-474

MELTING POINT -- ALUMINUM OXIDE + OTHER OXIDES

REFERENCE INFORMATION

	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Durtin, E. A. and Marman, C. C.	52-31	3093-3210	$Al_2O_3 + Nb_2O_5$	Measured approximate fusion temperature during sintering	Prepared from 99.5+ % pure Al_2O_3 and 99.9% pure Nb_2O_5
□	National Bureau of Standards	54-132	3746-3750	$4Al_2O_3 + ThO_2 + 4BeO$	Visual observation, optical pyrometer	Average of 3 - 5 tests. Author states precision ± 2%
△	Ibid.	54-132	3930-3946	$4Al_2O_3 + ThO_2$	Same as above	Same as above
◇	Ibid.	54-132	3660-3697	$2Al_2O_3 + ZrO_2 + 2BeO$	Same as above	Same as above

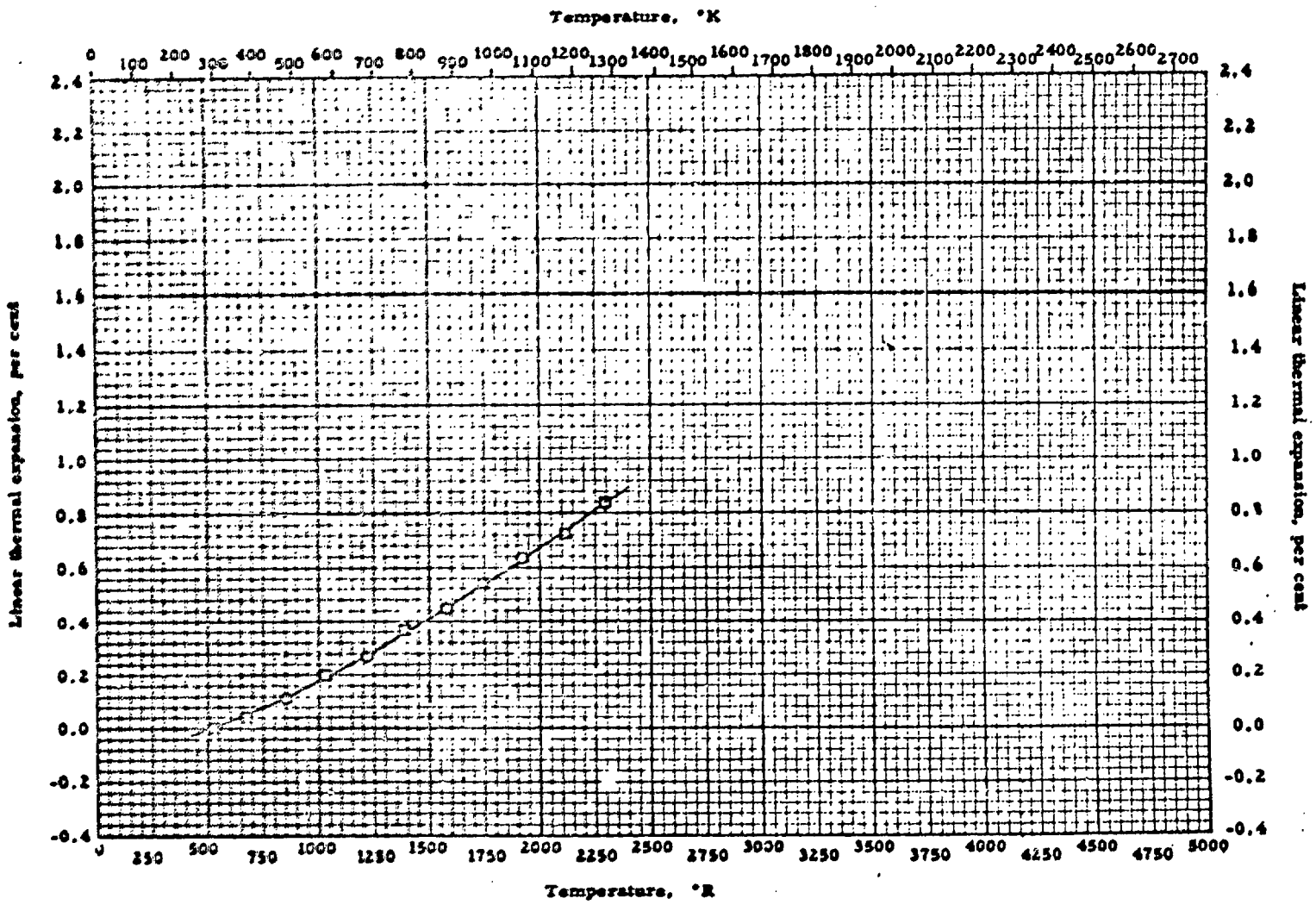


THERMAL CONDUCTIVITY -- ALUMINUM OXIDE - ZIRCONIUM OXIDE SINTER

THERMAL CONDUCTIVITY -- ALUMINUM OXIDE - ZIRCONIUM OXIDE SINTER

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Kingery, W. D., and Norton, F. H.	55-47	852-1932	90% Al_2O_3; 10% ZrO_2	Comparative rods	Sintered
□	Ibid.	55-47	807-1932	80% Al_2O_3; 20% ZrO_2	Same as above	Same as above
△	Ibid.	55-47	672-1806	60% Al_2O_3; 40% ZrO_2	Same as above	Same as above

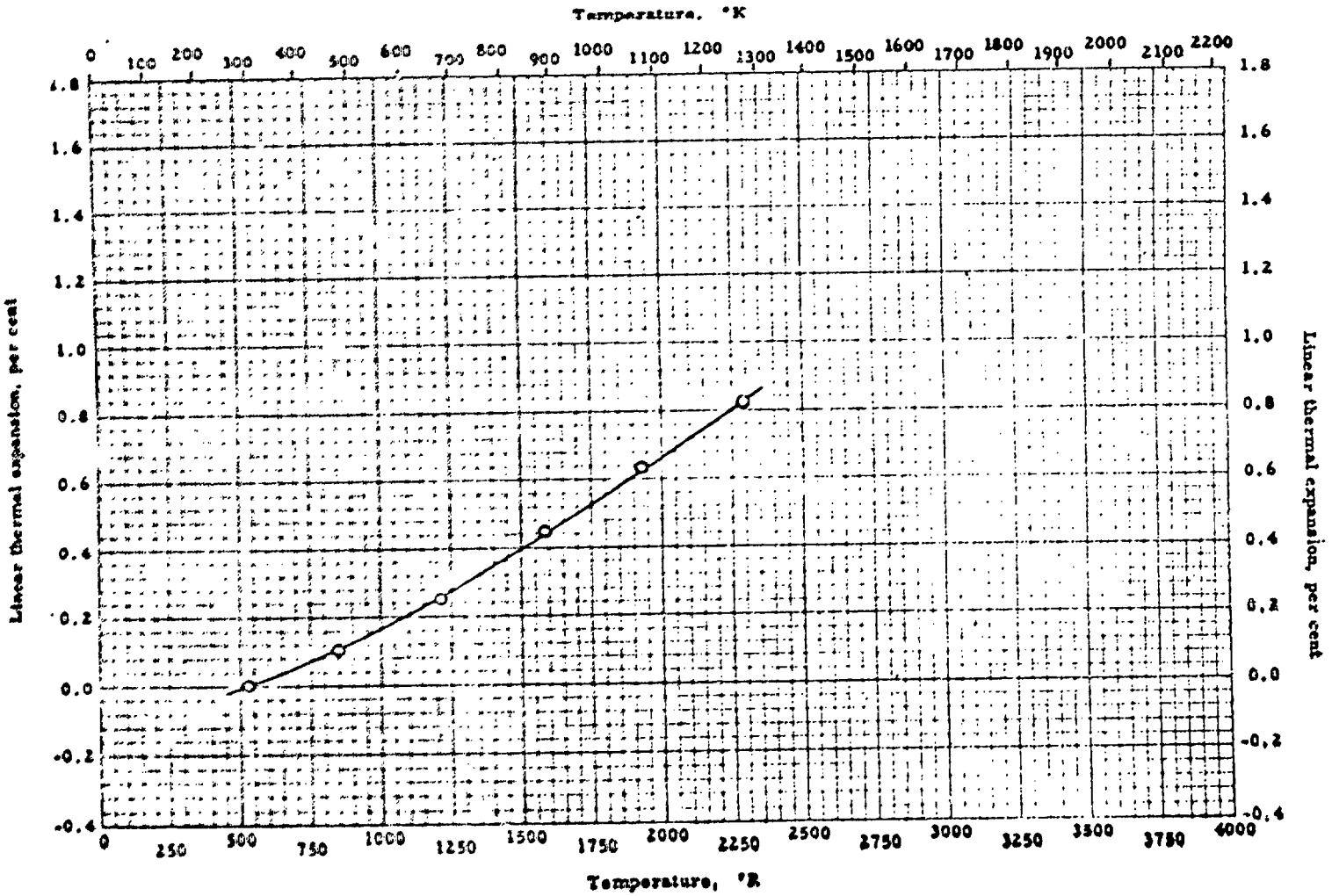


LINEAR THERMAL EXPANSION -- ALUMINUM OXIDE + MAGNESIUM OXIDE + BERYLLIUM OXIDE

LINEAR THERMAL EXPANSION -- ALUMINUM OXIDE + MAGNESIUM OXIDE + BERYLLIUM OXIDE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition *	Test Method	Remarks
O	Geller, R. F., Yavorsky, P. J. et al.	46-4	528-2292	8.52% MgO; 5.29% BeO; prepared from 97% pure MgO, 99.7% pure BeO, 99+% pure Al_2O_3	Interferometer	($MgO \cdot BeO \cdot 4Al_2O_3$)
□	Ibid.	46-4	528-2292	41.29% BeO; 16.64% MgO; prepared from 97% pure MgO, 99.7% pure BeO, 99+% pure Al_2O_3	Same as above	($MgO \cdot 4BeO \cdot Al_2O_3$)



LINEAR THERMAL EXPANSION -- ALUMINUM OXIDE + THORIUM OXIDE + BERYLLIUM OXIDE

LINEAR THERMAL EXPANSION -- ALUMINUM OXIDE + THORIUM OXIDE + BERYLLIUM OXIDE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Geller, R. F., Yaversky, P. J., Stierman, B. L. and Creamer, A. S.	46-4	528-2292	34.22% ThO_2; 12.96% BeO; prepared from 99.7% pure BeO, 99+% pure Al_2O_3, 99+% pure ThO_2 (calcined)	Interferometer	($4BeO \cdot 4Al_2O_3 \cdot ThO_2$) Sintered

PROPERTIES OF BERYLLIUM OXIDE

MOST PROBABLE VALUES

Property	Brit. Engineering Units	C. G. S. Units
Density.	189 lb_m/ft^3	3.03 g/cm^3
Melting Point	4905° R	2725°K
Heat of Fusion		
Heat of Vaporization. . .		
Heat of Sublimation . . .		

REPORTED VALUES

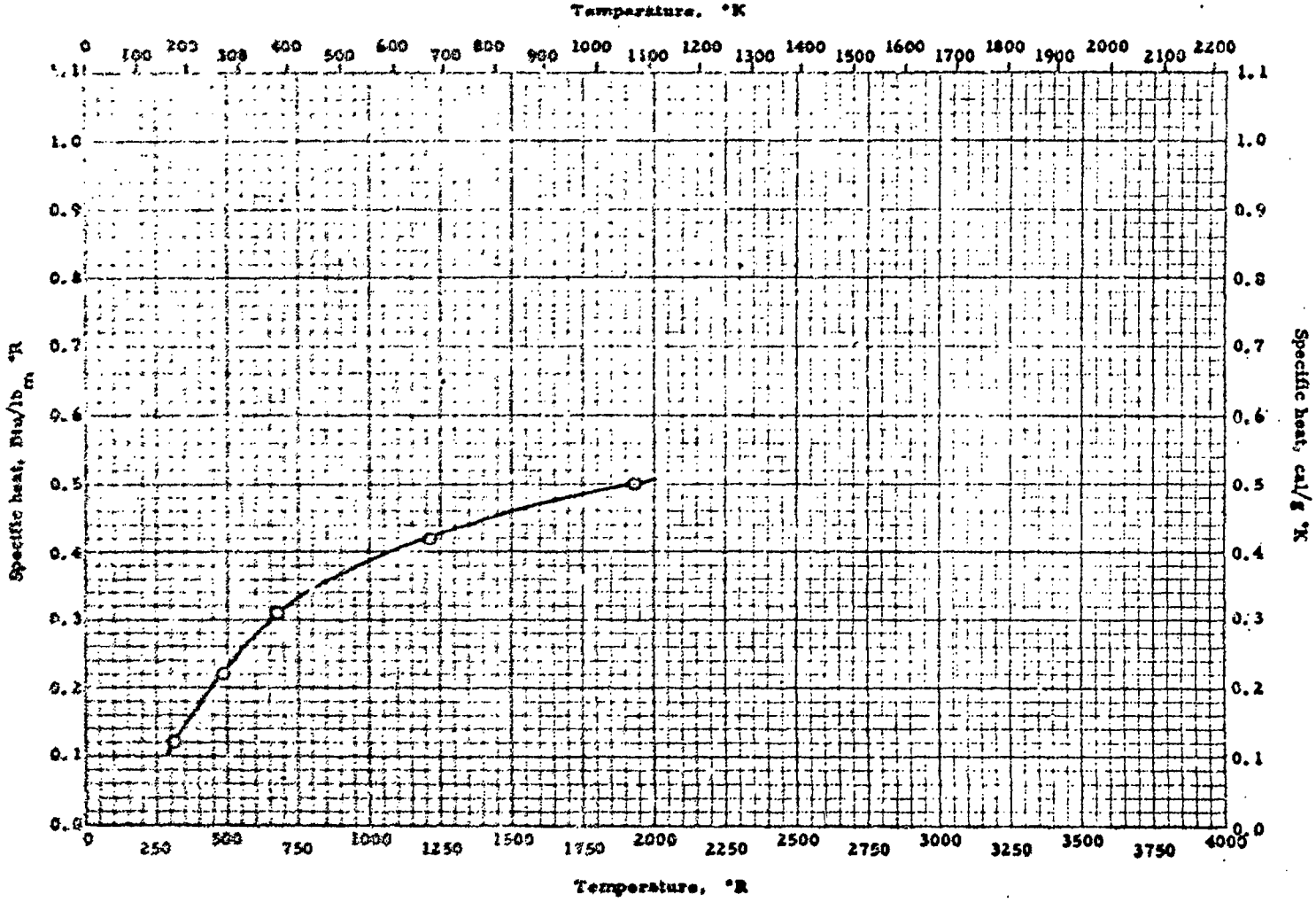
Density:		lb_m/ft^3	g/cm^3
	○	185	2.96
	□	189	3.03
	◇	92.4	1.48
	▽	192	3.08
	○	178	2.8
	⌂	177 ± 2	2.84 ± 0.03
Melting Point:		°R	°K
	△	5118	2843
	⌂	4905	2725

Heat of Fusion:	Btu/lb_m	cal/g
Heat of Vaporization:	Btu/lb_m	cal/g
Heat of Sublimation:	Btu/lb_m	cal/g

PROPERTIES OF BERYLLIUM OXIDE

REFERENCE INFORMATION

n	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Gangler, J. J.	50-10	Room	35.66% Be; 63.24% O_2; 0.08% free C	ρ: weight in air and in distilled water	Fabricated by hot pressing in graphite mold
□	Ibid.	50-10	Room	Same as above	ρ: computed from X-ray measurements of lattice	Same as above
△	Trombe, F.	49-16	5118	Not given	MP: not given	
▽	Johnson, P. D.	50-37	Room	<1.0% Ca; <0.01% ea. Mg, Na, Si	ρ: computed from x-ray measurements of lattice	From Be hydroxide; calcined 1 hr. at 1000°C, pressed at 52000 psi
◇	Ibid.	50-37	Room	Same as above	ρ: not given	Same as above
○	Ibid.	50-37	Room	Same as above	ρ: same as above	From Be hydroxide; calcined 1 hr. at 1000°C; fired at 1900-2100°C
□	Oak Ridge National Laboratory	57-150	537	BeO	ρ: weight in air and in kerosene	By O. Sisman, C. D. Bopp and R. L. Towns
△	National Bureau of Standards	54-132	4905	BeO	MP: visual observation, optical pyrometer	Average of 3 - 5 tests; auth. est. accuracy ± 2%

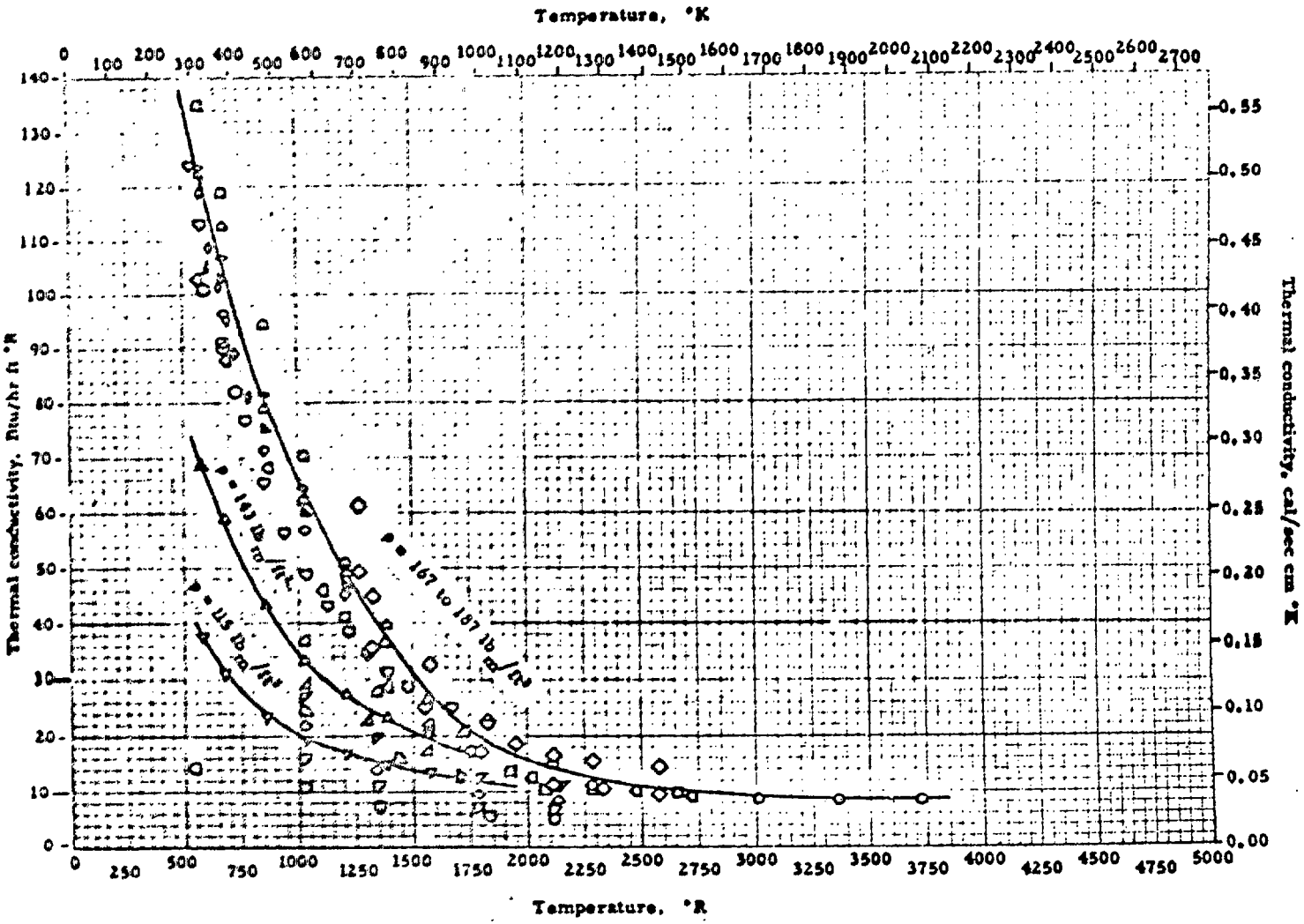


SPECIFIC HEAT -- BERYLLIUM OXIDE

SPECIFIC HEAT -- BERYLLIUM OXIDE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Reactor Handbook	55-152	512-1932	Beryllia, BeO	Not given	Not original data. Source not indicated



THERMAL CONDUCTIVITY - BERYLLIUM OXIDE

VALC TPRC 59-287

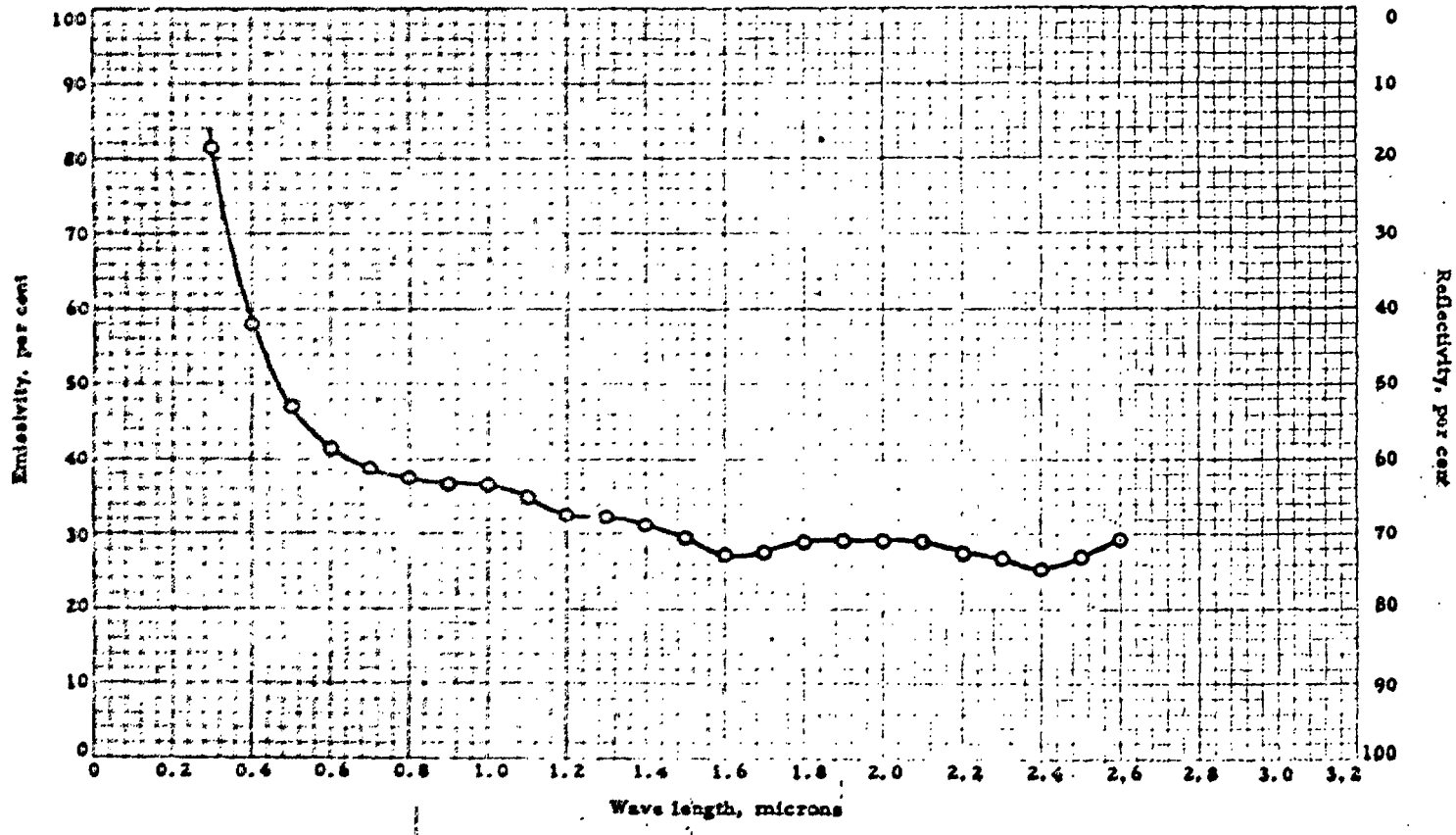
REFERENCE INFORMATION

Sym	Investigator	Ref.	Range, °K	Material Composition	Test Method	Remarks
○	McQuarrie, Malcolm	54-3 also 52-61 53-67	2292-3732	99.73% BeO; 0.18% MgO; 0.05% Al_2O_3; 0.01% Fe_2O_3; prepared from refractory grade (220 mesh) BeO	Prolate spheroid envelope	Prepared by slip casting finely ground material
□	Adams, Milton	54-5 also 53-67	1212-2652	ρ = 168 lb_m/ft^3; porosity = 9.7%	Prolate spheroid envelope	Prepared by slip casting finely ground material
◇	Kingery, W.D. and Norton, F.H.	55-57	1366-2560	Prepared by KAPL; ρ = 174 lb_m/ft^3	Comparative; rods	
△	Francl, J. and Kingery, W.D.	54-6 also 53-67 52-67 52-66	582-1572	ρ = 167 lb_m/ft^3 Zero apparent porosity	Comparative; rods	Prepared by slip casting finely ground material
◊	New Jersey Ceramic Research Station	53-5 also 53-43	579-791	ρ = 185 lb_m/ft^3	Comparative; rods (Cu standard)	Hot pressed; tested in vacuum
○	Scholes, William A.	50-4	588-735	"100% BeO"; ρ = 185.3 lb_m/ft^3	Comparative; rods (Cu standard)	Hot pressed
∤	Weeks, James L. and Seifert, Ralph A.	53-17	618	ρ = 187 lb_m/ft^3	Comparative; rods (Armco Iron standard)	Hot pressed, tested in vacuum
▷	Powell, R.W.	54-7	582-1212	ρ = 175 lb_m/ft^3	Comparative; rods (Iron standard)	Hot molded
○	Ibid.	54-7	682-1212	ρ = 170 lb_m/ft^3	Same as above	Same as above
△	Ibid.	54-7	582-1392	ρ = 176 lb_m/ft^3	Same as above	Same as above
⊙	Ibid.	54-7	582-1032	ρ = 188 lb_m/ft^3	Same as above	Same as above
△	Ibid.	54-7	582-1572	Over 99% BeO, main impurity Al_2O_3; ρ = 143 lb_m/ft^3	Same as above	Fired at 1750 °C
▽	Ibid.	54-7	582-1572	Over 99% BeO, main impurity Al_2O_3; ρ = 115 lb_m/ft^3	Same as above	Same as above
○	Ditmars, D.A. and Cezairliyan, D.C.	57-59	546-1838	Impurities <0.2%; ρ = 163 lb_m/ft^3	Axial heat flow in rod; guarded heat source and sample	Hot pressed; fired at 1700°C. Auth. est. accuracy ± 3%

THERMAL CONDUCTIVITY -- BERYLLIUM OXIDE (Cont'd)

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Nelson, H. R.	57-176	1032-2112	ρ = 118 lb_m/ft^3	Axial heat flow in rod	Prepared from 200 mesh refractory grade powder by dust pressing
○	Ibid.	57-176	1032-2112	ρ = 129 lb_m/ft^3	Same as above	Same as above
▽	Ibid.	57-176	1032-2112	ρ = 125 lb_m/ft^3	Same as above	Prepared from 200 mesh refractory grade powder by extrusion of blanks fired at 2800°F and 3100°F
▽	Ibid.	57-176	1032-2112	ρ = 136 lb_m/ft^3	Same as above	Same as above
□	Ibid.	57-176	1032-2112	ρ = 132 lb_m/ft^3	Same as above	Prepared from 200 mesh refractory grade powder by hot pressing
△	Ibid.	57-176	1032-1572	ρ = 140 lb_m/ft^3	Same as above	Same as above
△	Ibid.	57-176	1032-2112	ρ = 179 lb_m/ft^3	Same as above	Same as above
◇	Norton, F. H. and Kingery, W. D.	51-75	580-2700	99.6+% BeO; ρ = 165 lb_m/ft^3 10% total porosity	Ellipsoidal envelope, temp. by thermocouple	Slip cast Auth. est. accuracy ±8%
◇	Oak Ridge Natl. Laboratory	57-150	546	BeO	Not described here, refers to others	Auth. est. accuracy ±30% Measured by O. Sisman, C. B. Bopp and R. L. Towns

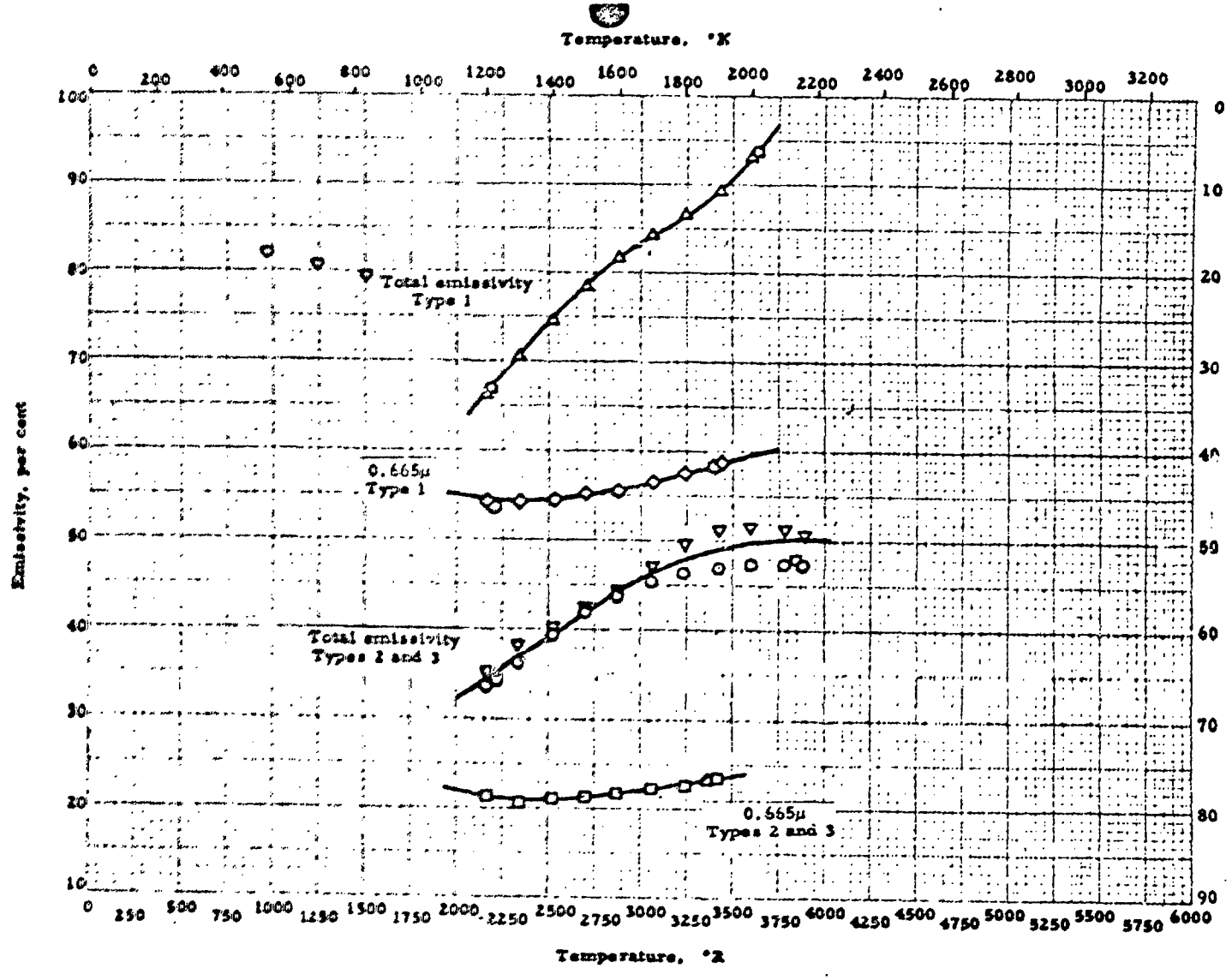


SPECTRAL EMISSIVITY -- BERYLLIUM OXIDE

SPECTRAL EMISSIVITY -- BERYLLIUM OXIDE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Beta, H.T., Olson, O.H., et al.	57-8	Room	Refractory. (Bureau of Standards)	Spectral reflectivity at 9°: sample compared with $MgCO_3$ standard in MgO integrating sphere, quarts lens, PbS detector	Surface as received



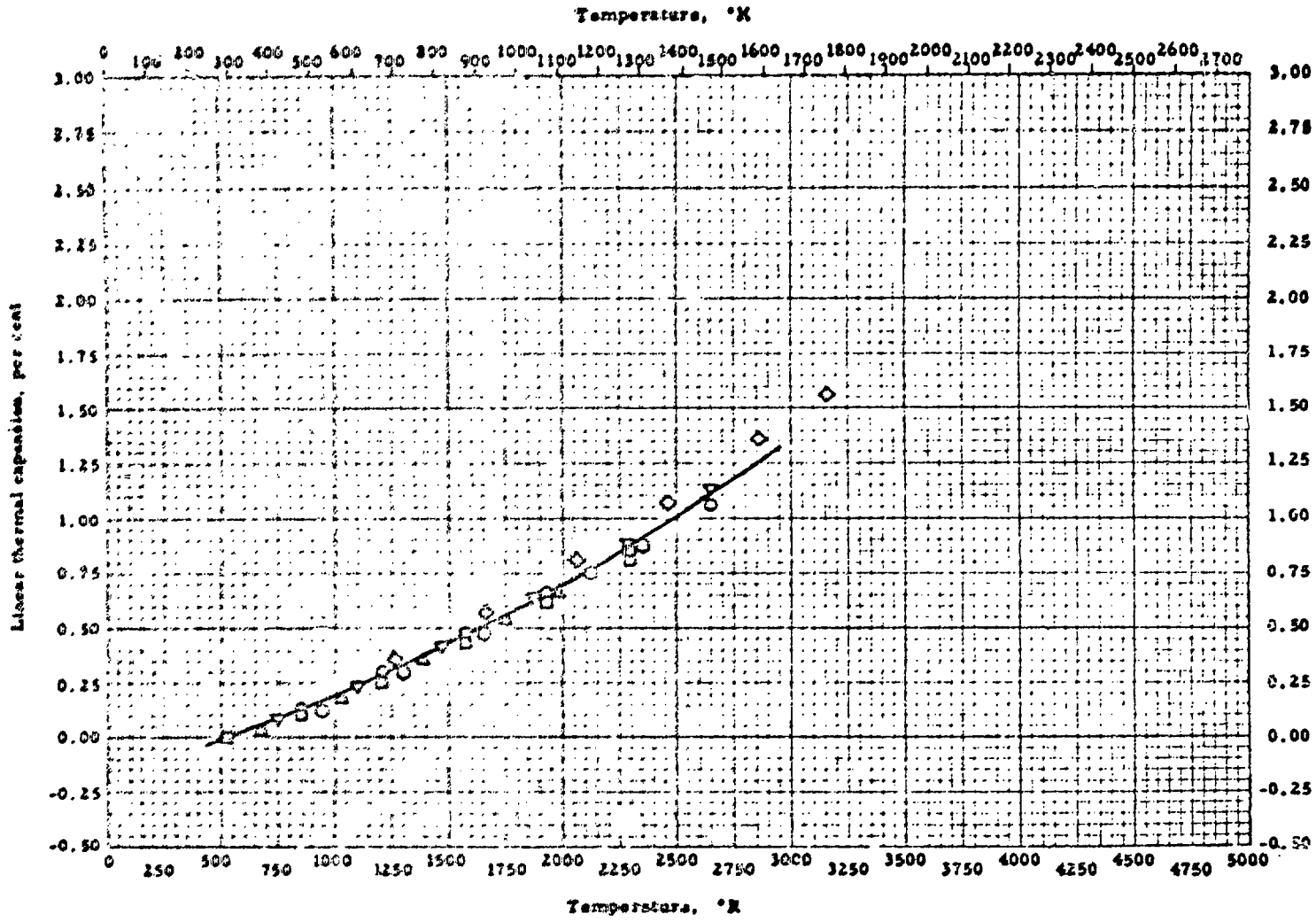
EMISSIVITY -- BERYLLIUM OXIDE

99-1026
CLASSIFIED

EMISSIVITY -- BERYLLIUM OXIDE

REFERENCE INFORMATION

Key	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Seifert, R. L.	48-15	2160-3870	Not given. Type 3 BeO, white, ρ = 173 lb_m/ft^3	Total normal emissivity; radiant heat meas. with thermopile; sample temp. by calibrated optical pyrometer	Auth. est. ± 20% accuracy. Hot pressed powder, annealed, polished, heated to 1300°C in air
□	Ibid.	48-15	2160-3420	Same as above	Spectral normal emissivity at 0.665μ; comparative; surface brightness compared with a standard, platinum, also auxiliary standards of gold and polished sulfate	Auth. est. ± 10% accuracy. Hot pressed powder, annealed, polished, heated to 1300°C in air. Auth. reports same values for Type 2
◇	Ibid.	48-15	2160-3420	Not given. Type 1 BeO, black, ρ = 178 lb_m/ft^3	Same as above	Auth. est. ± 10% accuracy. Hot pressed in graphite mold, heated to 1300°C in air
△	Ibid.	48-15	2160-3600	Same as above	Total normal emissivity: radiant heat meas. with thermopile; sample temp. by calibrated optical pyrometer	Auth. est. ± 20% accuracy. Hot pressed in graphite mold, heated to 1300°C in air
▽	Ibid.	48-15	2160-3870	Not given. Type 2 BeO, white, ρ = 177 lb_m/ft^3	Same as above	Auth. est. ± 20% accuracy. Hot pressed powder, heated to 1300°C in air
○	Argonne National Laboratory	47-23	2160-3420	BeO	Spectral normal emissivity: not given	Blackened samples direct from mold. Measured by R. L. Seifert
⌂	Ibid.	47-23	3420	Same as above	Same as above	Same as above, but sample whitened by anneal in air
□	Ibid.	47-23	2160-3600	Same as above	Total normal emissivity: total radiation pyrometer	Same as above, but blackened
□	Ibid.	47-23	2160-3870	Same as above	Same as above	Same as above, but whitened
▽	Olsen, O. H. and Morris, J. C.	99-1	975-1500	BeO	Total normal emissivity: not given	Meas. in air

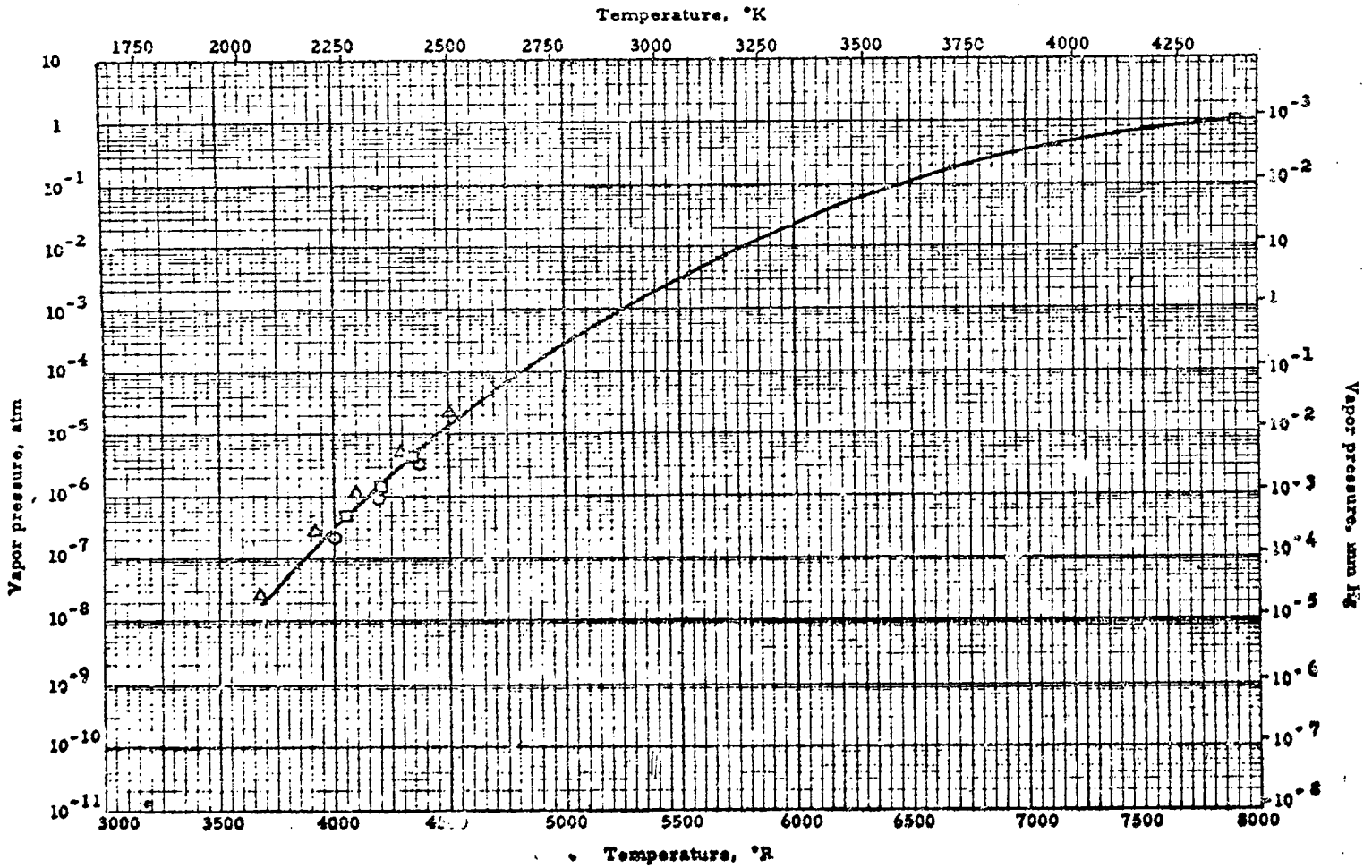


LINEAR THERMAL EXPANSION - BERYLLIUM OXIDE

LINEAR THERMAL EXPANSION -- BERYLLIUM OXIDE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Beals, R. J. and Cook, R. L.	57-20	528-2652	Reagent grade	X-ray back reflection	
□	Schwartz, Bernard	52-30	852-2292	BeO; apparent porosity = 4%	Quartz tube dilatometer	Ballmilled to 50% < 3 microns, fired at 1820°C
△	Nelson, H. R.	57-19[illegible]	530-1932	BeO. Refractory grade. ρ = 130-139 lb_m/ft^3	Not given, tested at 100°C/hr. rise	Same results for 4 samples 2 dust pressed, 2 extruded, fired at 2800°F and at 3100°F
◇	Seibel, R. D. and Mason, G. L.	57-15[illegible]	1260-3160	BeO	Alumina tube differential dilatometer	Tested at 305°F/min rise in vacuum of 10^{-6}-10^{-5} mm Hg
▽	Fulkerson, S. D.	57-15[illegible]	490-2650	BeO	Sapphire dilatometer	Hot pressed. Meas. perpendicular to direction of pressing
○	Malm, J. G. and Gilbreath, J. R.	48-36	672-2292	BeO ρ = 170-175 lb_m/ft^3	Fused quartz dilatometer with dial gauge. Temp. by thermocouple	Plotted avg. of 2 samples. Powder at 1600-2100°C pressed to 1000-2000 psi from Brush S. P. powder

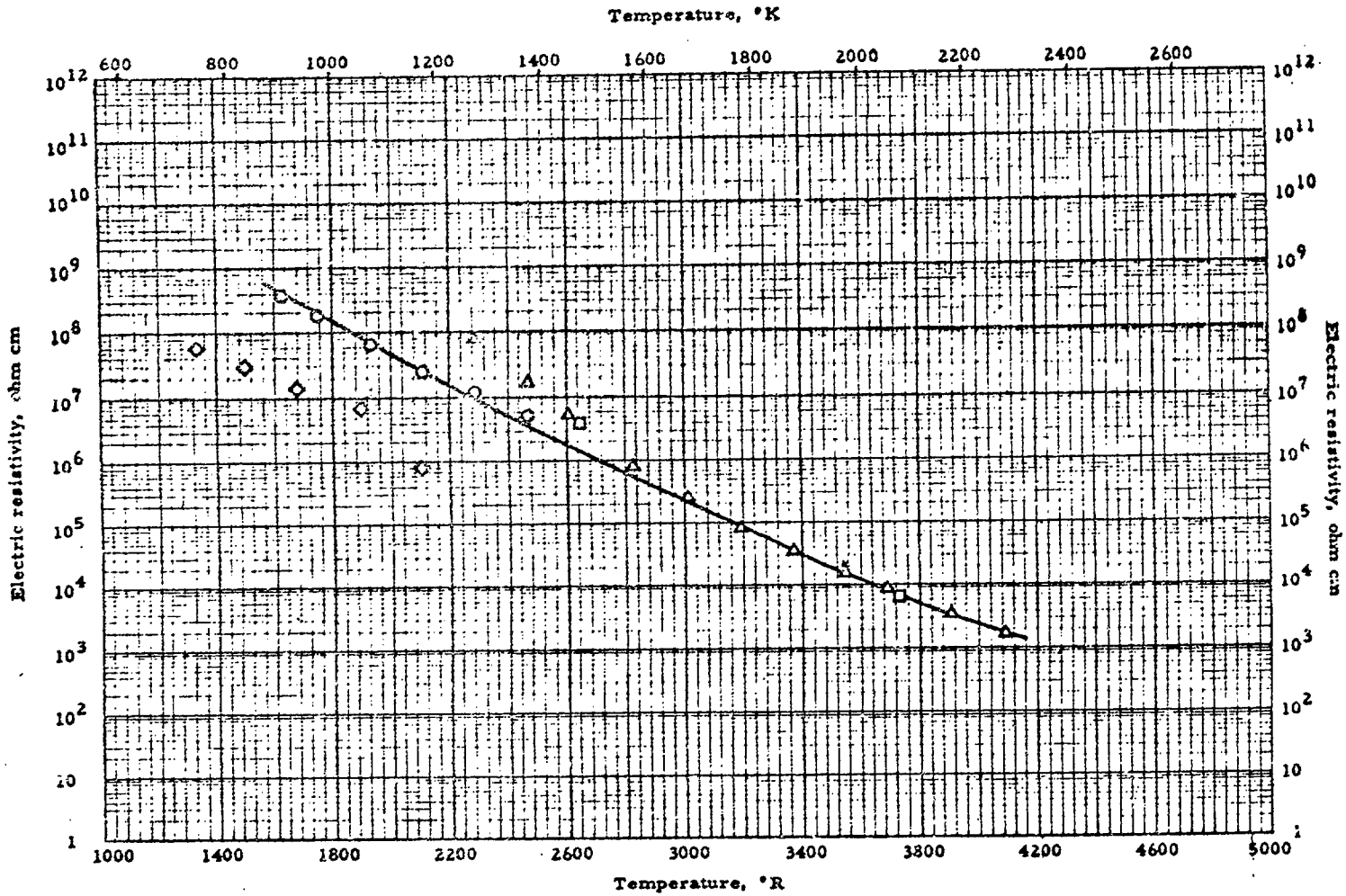


VAPOR PRESSURE -- BERYLLIUM OXIDE

VAPOR PRESSURE -- BERYLLIUM OXIDE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Argonne National Laboratories	47-23	4002-4362	BeO	Knudsen cell with radioactive counting of $_4Be^7$ tracer	Measured by N. D. Erway and R. L. Seifert. Calc. from auth. eq.: $\log_{10} P(\text{mm Hg}) = 18.32 - \frac{34,230}{T(°K)} - 2\log_{10} T(°K)$
□	Erway, N. D. and Seifert, R. L.	51-82	4050-4181	BeO, 99.2% pure crystals	Knudsen cell with radioactive counting of $_4Be^7$ contained in original material. Temperature by optical pyrometer sighting on black body hole	Calc. from auth. eq.: $\text{Log}_{10} P(\text{mm Hg}) = 18.50 \pm 0.23 - \frac{34,230 \pm 530}{T(°K)} - 2\log_{10} T(°K)$ from 1977 - 2140° C
△	Yosim, S. J. and Milne, T. A.	57-1-5	3674-4500	BeO	Knudsen effusion cell of Tungsten	Vapor pressure for reaction $2BeO \longrightarrow 2Be + O_2$

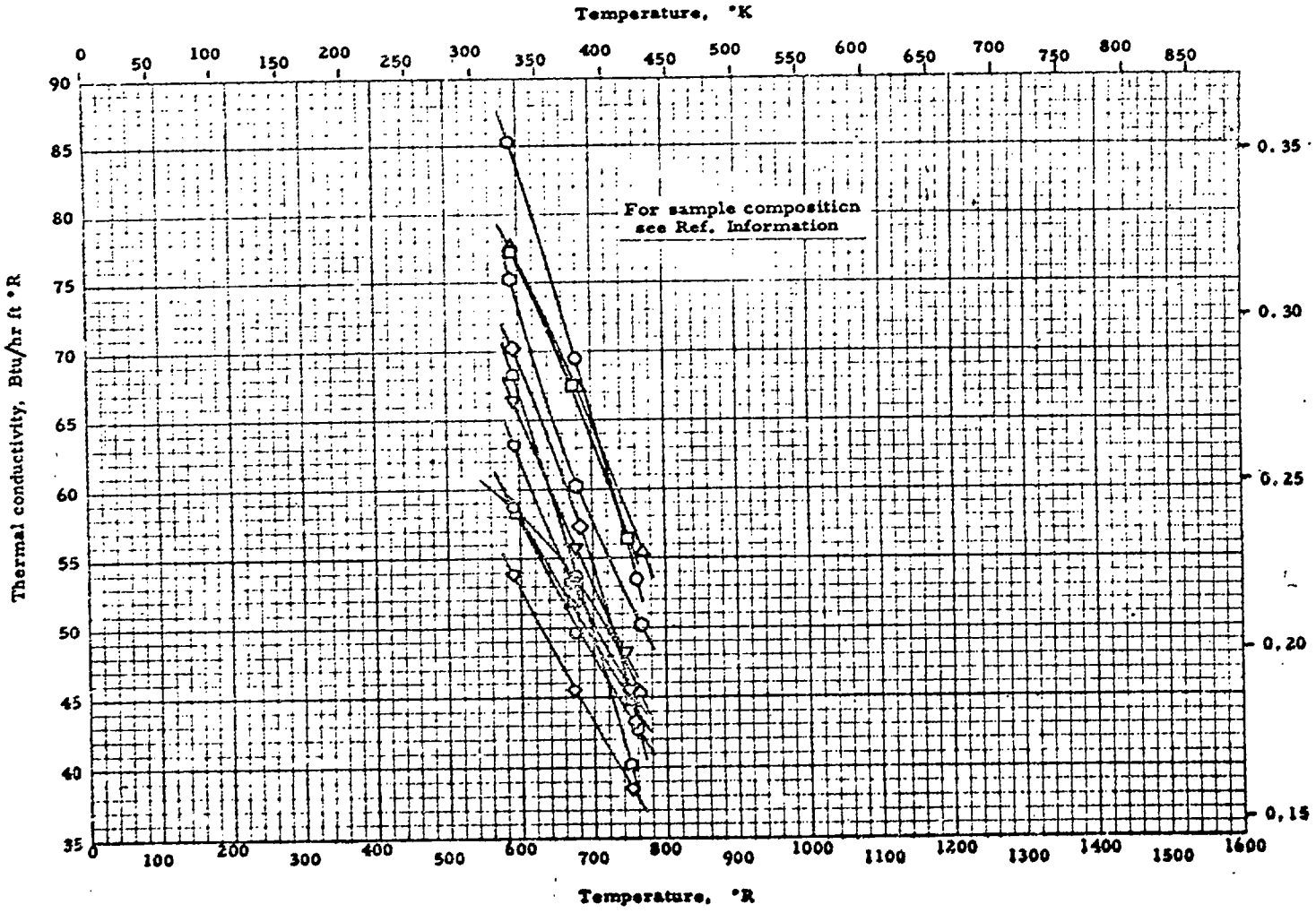


ELECTRIC RESISTIVITY -- BERYLLIUM OXIDE

ELECTRIC RESISTIVITY -- BERYLLIUM OXIDE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Rogener, H.	40-20	1626-2472	BeO	Potential drop. Sample temp. by Pt-Pt Rh thermocouple. Voltage by electrometer.	1 cm cube samples, plantinized surfaces. Auth. est. accuracy order of magnitude only
□	Trombe, F.	49-16	2652-3732	BeO	Not given	
△	Foex, M.	42-10	1752-4272	"Pure" BeO, Glucina. ρ = 140 lb_m/ft^3	Potential drop. Sample temp. by optical pyrometer	Optical pyrometer has precision of ± 7°C at 2000°C; calcined at 2100°C
◇	Nakhodnova, A. P.	56-73	1330-2100	BeO	Potential drop. Sample temp. by Mo-Ni thermocouple. In range 800-900°C, optical pyrometer was also used	Formed from chemically pure materials. Baked polycrystalline samples, calcined 2 hr. at const. temp. in furnace. Meas. under 10^{-5} mm Hg, const. current

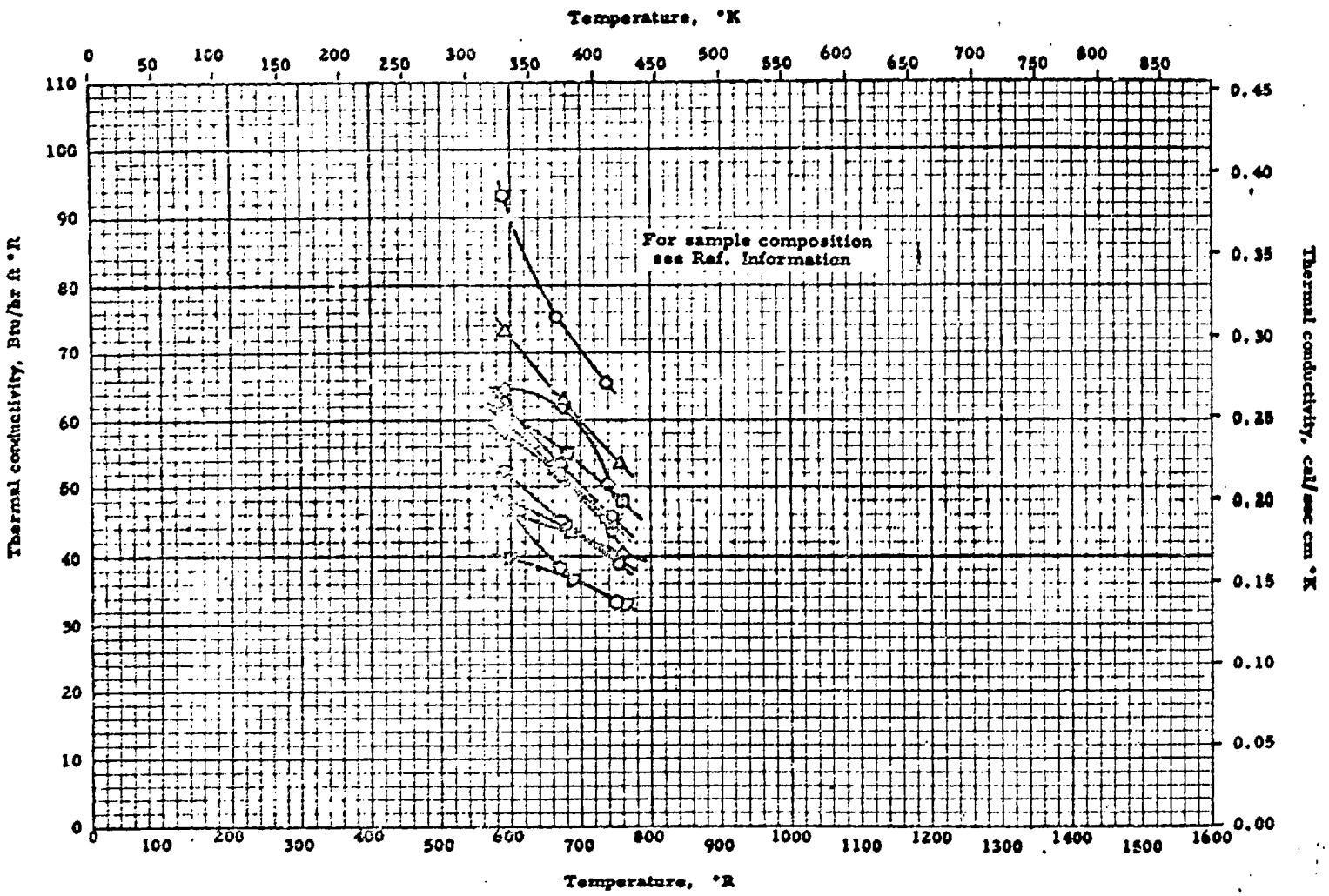


THERMAL CONDUCTIVITY -- BERYLLIA + ALUMINA + THORIA + MAGNESIA

THERMAL CONDUCTIVITY -- BERYLLIA + ALUMINA + THORIA + MAGNESIA

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Scholes, W	80-4	893-761	95% BeO; 2.5% Al_2O_3; 2.5% ThO_2	Comparative; rods	Samples formed at 10,000 psi and matured at 1600°C. All raw materials passed 325 mesh screen. Crystalline phases of BeO, ThO_2, $MgO \cdot Al_2O_3$ and MgO present
□	Ibid.	50-4	594-747	90% BeO; 5% Al_2O_3; 5% ThO_2	Same as above	Same as above
△	Ibid.	50-4	596-769	80% BeO; 10% Al_2O_3; 10% ThO_2	Same as above	Same as above
◇	Ibid.	50-4	594-755	91.3% BeO; 3.9% MgO; 2.4% Al_2O_3; 2.4% ThO_2	Same as above	Same as above
▽	Ibid.	50-4	592-748	86.5% BeO; 4.8% Al_2O_3; 4.8% ThO_2; 3.9% MgO	Same as above	Same as above
○	Ibid.	50-4	591-766	76.9% BeO; 9.6% Al_2O_3; 9.6% ThO_2; 3.9% MgO	Same as above	Same as above
◻	Ibid.	50-4	593-753	88% BeO; 7.4% MgO; 2.3% Al_2O_3; 2.3% ThO_2	Same as above	Same as above
▽	Ibid.	50-4	592-748	83.4% BeO; 7.3% MgO; 4.6% Al_2O_3; 4.6% ThO_2	Same as above	Same as above
○	Ibid.	50-4	594-759	74% BeO; 9.3% Al_2O_3; 9.3% ThO_2; 7.4% MgO	Same as above	Same as above
△	Ibid.	50-4	596-766	82.6% BeO; 13% MgO; 2.2% Al_2O_3; 2.2% ThO_2	Same as above	Same as above
▷	Ibid.	50-4	490-746	78.2% BeO; 13% MgO; 4.4% Al_2O_3; 4.4% ThO_2	Same as above	Same as above
◇	Ibid.	50-4	591-752	69.6% BeO; 8.7% Al_2O_3; 8.7% ThO_2; 13% MgO	Same as above	Same as above

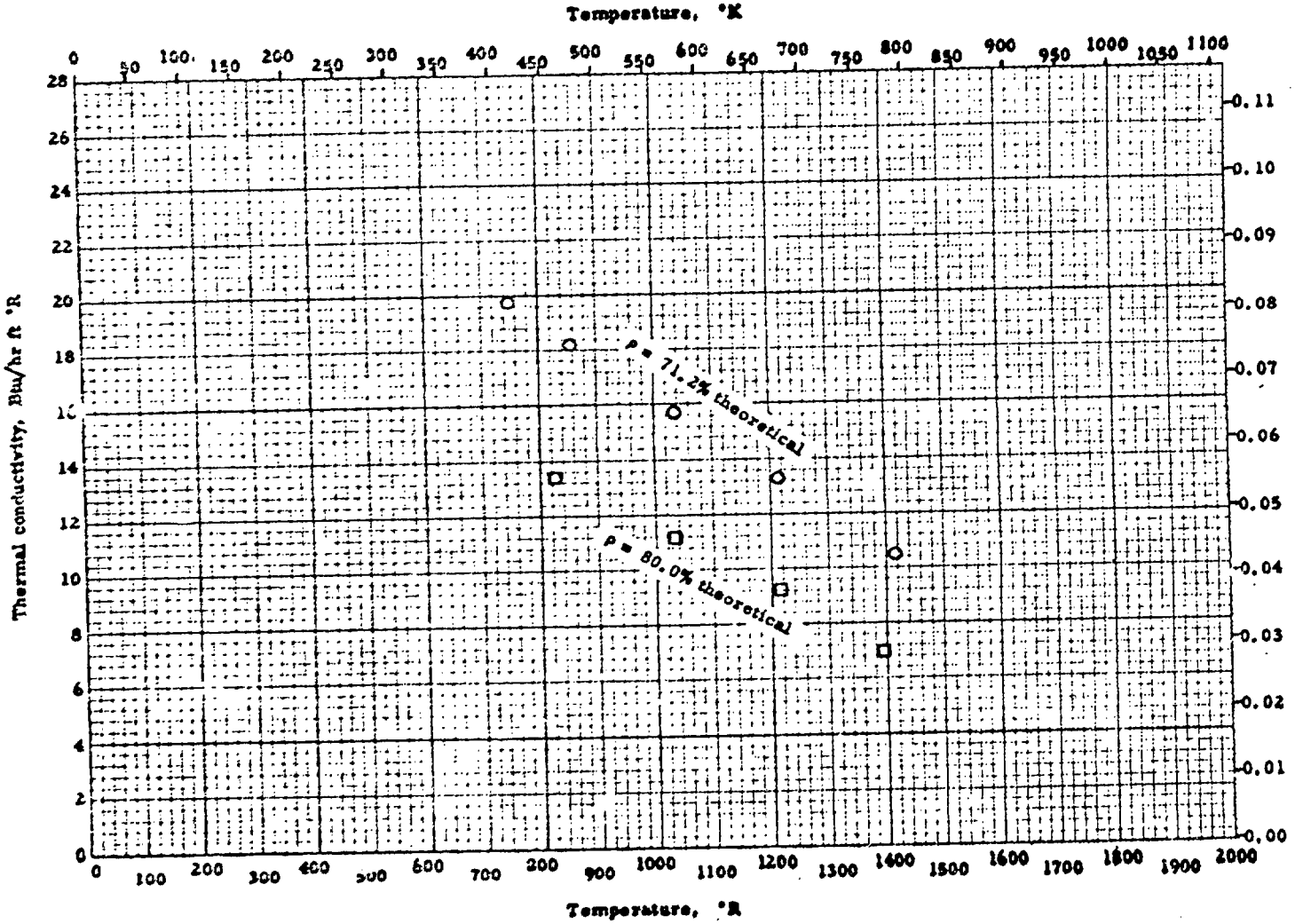


THERMAL CONDUCTIVITY -- BERYLLIA + ALUMINA + ZIRCONIA + MAGNESIA

THERMAL CONDUCTIVITY -- BERYLLIA + ALUMINA + ZIRCONIA + MAGNESIA

REFERENCE INFORMATION

	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Scholes, W.A.	50-4	589-733	95% BeO, 2.5% Al_2O_3; 2.5% ZrO_2	Comparative; rods	Samples formed at 10 [illegible] psi, and matured at 1600°C. [illegible] materials passed 325 mesh screen... Crystalline phases of BeO, ZrO_2, $BeO \cdot Al_2O_3$ and MgO present
□	Ibid.	50-4	595-758	90% BeO; 5% Al_2O_3; 5% ZrO_2	Same as above	Same as above
△	Ibid.	50-4	593-756	80% BeO; 10% Al_2O_3; 10% ZrO_2	Same as above	Same as above
◇	Ibid.	50-4	590-733	91.3% BeO; 3.9% MgO; 2.4% Al_2O_3; 2.4% ZrO_2	Same as above	Same as above
▽	Ibid.	50-4	591-745	86.5% BeO; 4.8% Al_2O_3; 4.8% ZrO_2; 3.9% MgO	Same as above	Same as above
⬡	Ibid.	50-4	591-751	76.9% BeO; 9.6% Al_2O_3; 9.6% ZrO_2; 3.9% MgO	Same as above	Same as above
⌂	Ibid.	50-4	591-745	88% BeO; 7.4% MgO; 2.3% Al_2O_3; 2.3% ZrO_2	Same as above	Same as above
▽	Ibid.	50-4	593-746	83.4% BeO; 7.4% MgO; 4.6% Al_2O_3; 4.6% ZrO_2	Same as above	Same as above
▭	Ibid.	50-4	595-758	74% BeO; 9.3% Al_2O_3; 9.3% ZrO_2; 7.4% MgO	Same as above	Same as above
△	Ibid.	50-4	599-758	78% BeO; 8% ZrO_2; 7.4% MgO; 6.6% Al_2O_3	Same as above	Same as above
▷	Ibid.	50-4	626-736	82.6% BeO; 13% MgO; 2.2% Al_2O_3; 2.2% ZrO_2	Same as above	Same as above
◇	Ibid.	50-4	592-747	78.2% BeO; 13.0% MgO; 4.4% Al_2O_3; 4.4% ZrO_2	Same as above	Same as above
▱	Ibid.	50-4	597-764	69.6% BeO; 13% MgO; 8.7% Al_2O_3; 8.7% ZrO_2	Same as above	Same as above

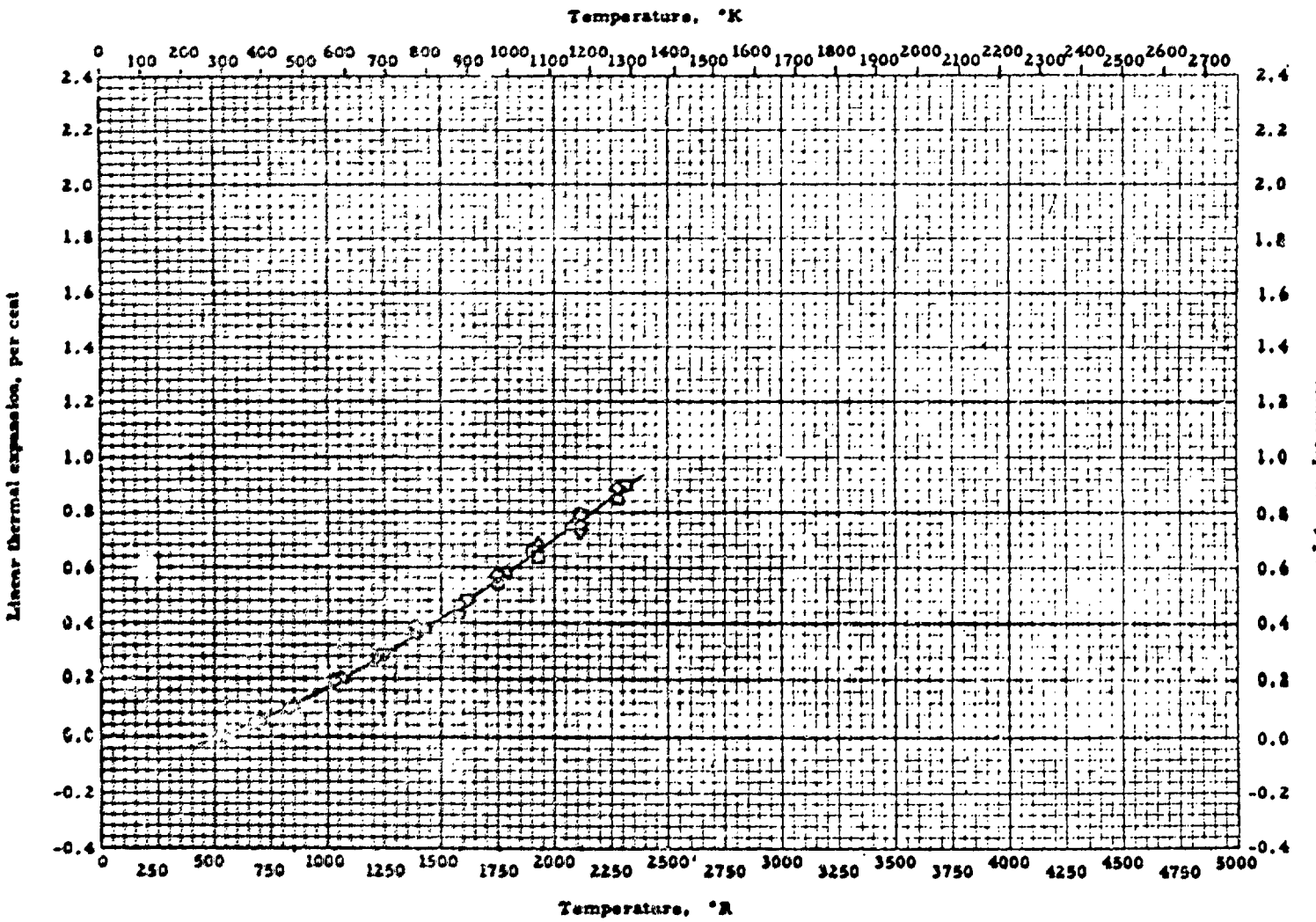


THERMAL CONDUCTIVITY -- BERYLLIUM OXIDE + URANIUM OXIDE

THERMAL CONDUCTIVITY -- BERYLLIUM OXIDE + URANIUM OXIDE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Mc Creight, L. R.	57-148	744-1410	53% BeO; 47% UO_2. ρ = 71.2% theoretical	Two methods: a) comparative, rods and b) axial heat flow in rod, calorimeter sink guarded sample	Sintered
□	Ibid.	57-148	825-1392	53% BeO; 47% UO_2 . ρ = 80.0% theoretical	Same as above.	Sintered



LINEAR THERMAL EXPANSION -- BERYLLIUM OXIDE + ALUMINUM OXIDE + X

LINEAR THERMAL EXPANSION -- BERYLLIUM OXIDE + ALUMINUM OXIDE + K

REFERENCE INFORMATION

Sym bol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Geller, R. F., Yavorsky, P. J. et al.	46-4	528-2292	89.55% BeO; 5.91% ThO_2; 4.56% Al_2O_3; prepared from 99.7% pure BeO, 99+% pure Al_2O_3, 99+% pure ThO_2 (calcined)	Interferometer	($160BeO \cdot 2Al_2O_3 \cdot ThO_2$)
□	Ibid.	46-4	528-2292	76.63% BeO; 16.86% ThO_2; 6.5% Al_2O_3; raw materials same as above	Same as above	($48\ BeO \cdot Al_2O_3 \cdot ThO_2$)
△	Ibid.	46-4	528-2292	64.17% BeO; 21.78% Al_2O_3; 14.11% ThO_2; raw materials same as above	Same as above	($48BeO \cdot 4Al_2O_3 \cdot ThO_2$)
◇	Ibid.	46-4	528-2292	56.19% BeO; 24.72% ThO_2; 19.09% Al_2O_3; raw materials same as above	Same as above	($24BeO \cdot 2Al_2O_3 \cdot ThO_2$)
▽	Ibid.	46-4	528-2292	48.33% BeO; 41.04% Al_2O_3; 10.63% ThO_2; raw materials same as above	Same as above	($48BeO \cdot 10Al_2O_3 \cdot ThO_2$)
○	Ibid.	46-4	528-2292	45.05% BeO; 39.65% ThO_2; 15.30% Al_2O_3; raw materials same as above	Same as above	($12BeO \cdot Al_2O_3 \cdot ThO_2$)
○	Ibid.	46-4	528-2292	40.12% BeO; 39.34% Al_2O_3; 23.54% ThO_2; raw materials same as above	Same as above	($18BeO \cdot 4Al_2O_3 \cdot ThO_2$)
○	Ibid.	46-4	528-2292	90.12% BeO; 6.05% MgO; 3.83% Al_2O_3; prepared from 97% pure MgO, 99.7% pure BeO, 99+% pure Al_2O_3	Same as above	($4MgO \cdot 96BeO \cdot Al_2O_3$)
○	Ibid.	46-4	528-2292	73.77% BeO; 18.80% Al_2O_3; 7.43% MgO; raw materials same as above	Same as above	($MgO \cdot 16BeO \cdot Al_2O_3$)

PROPERTIES OF CALCIUM OXIDE

MOST PROBABLE VALUES

Property	Brit. Engineering Units	C. G. S. Units
Density.	207 lb_m/ft^3 *	3.35 g/cm^3 *
Melting Point	5120°R	2840°K
Heat of Fusion		
Heat of Vaporization. . .		
Heat of Sublimation . . .		

*Handbook Chem. and Phys. (Ref. 57-60)

REPORTED VALUES

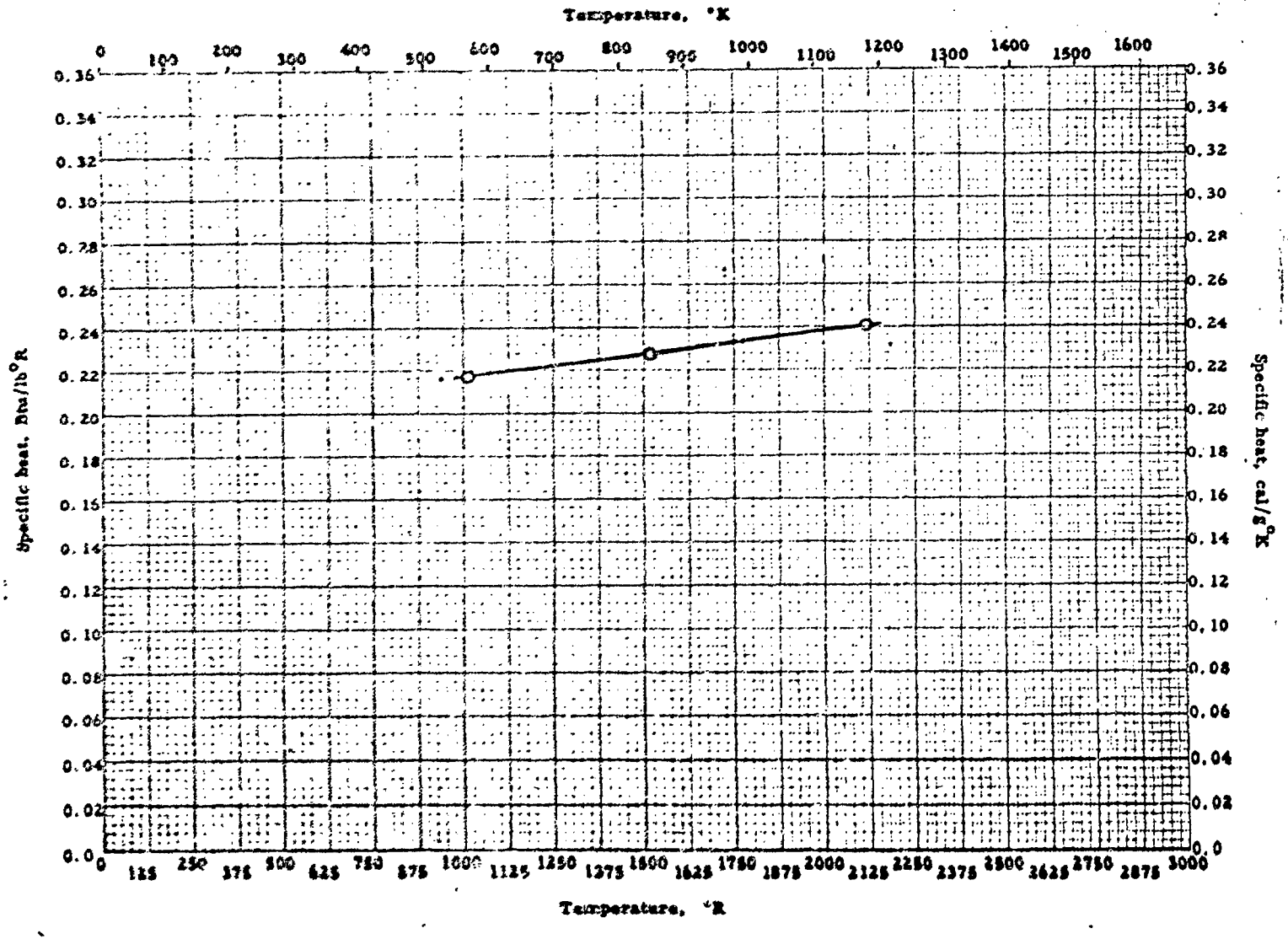
Density:		lb_m/ft^3	g/cm^3
	O	187	3.0
	□	109	1.74
Melting Point:		°R	°K
	△	5118	2843
Heat of Fusion:		Btu/lb_m	cal/g
Heat of Vaporization:		Btu/lb_m	cal/g
Heat of Sublimation:		Btu/lb_m	cal/g

NASA TR 32-976

PROPERTIES OF CALCIUM OXIDE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Fischer, H. C.	55-67	Room	Not given; made from high purity calcium carbonate	ρ: weight and volume by mercury displacement	Dense material; ρ varies with calcining temp., retention time, heating rate
□	Ibid.	55-67	Room	Same as above	ρ: same as above	Light material; ρ varies with calcining temp., retention time, heating rate
△	Trombe, F.	49-16	5118	Not given	MP: not given	

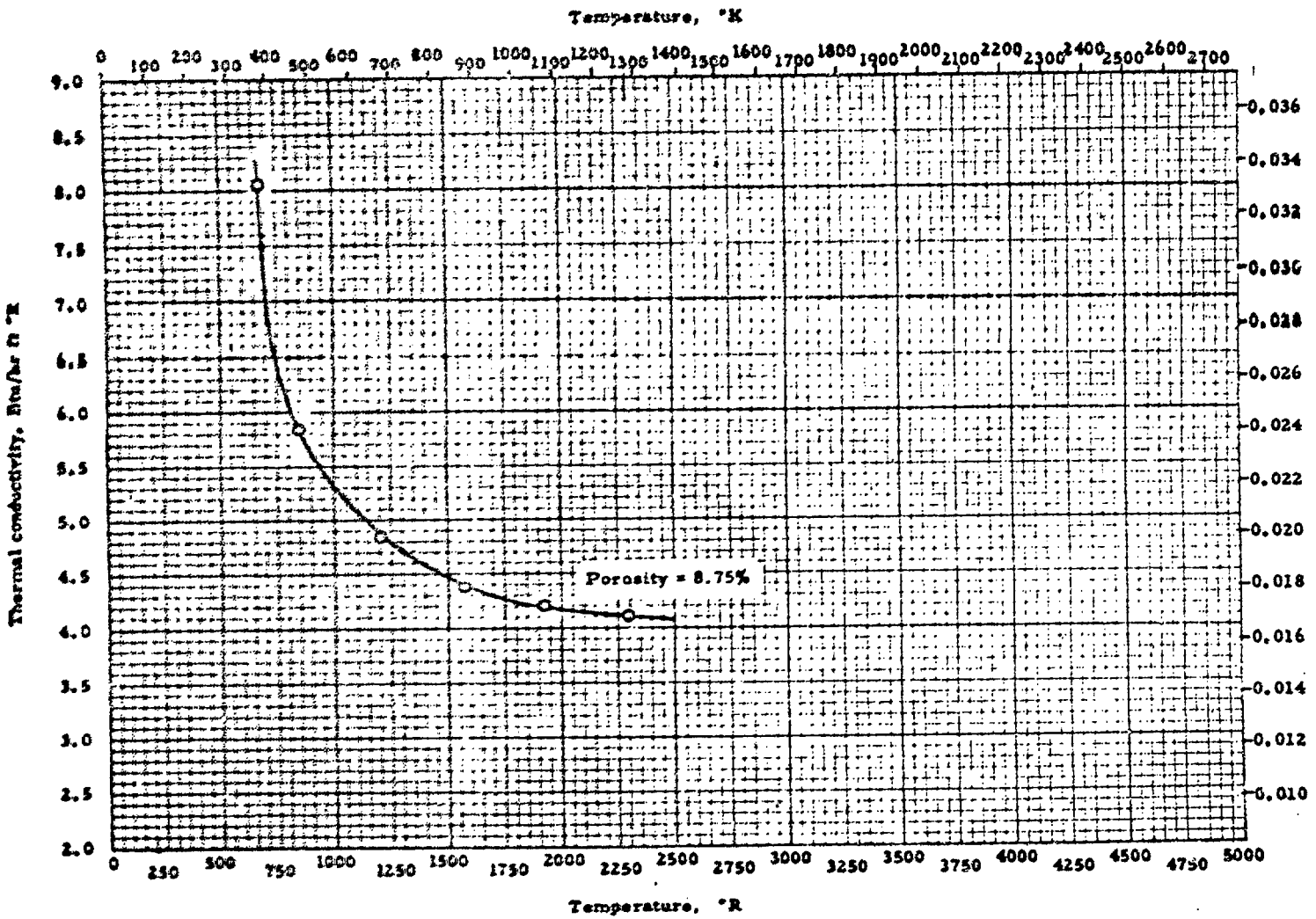


SPECIFIC HEAT -- CALCIUM OXIDE

SPECIFIC HEAT -- CALCIUM OXIDE

REFERENCE INFORMATION

Curve Ident.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Landar, J. J.	51-78	1010-2120	CaO	Drop method, calibrated by Pt sample.	Material obtained by calcining CaO_2 at 800°C in vaccum. Computed C_p from quadratic equation fitted to author's enthalpy values by least mean square routine at ARF.

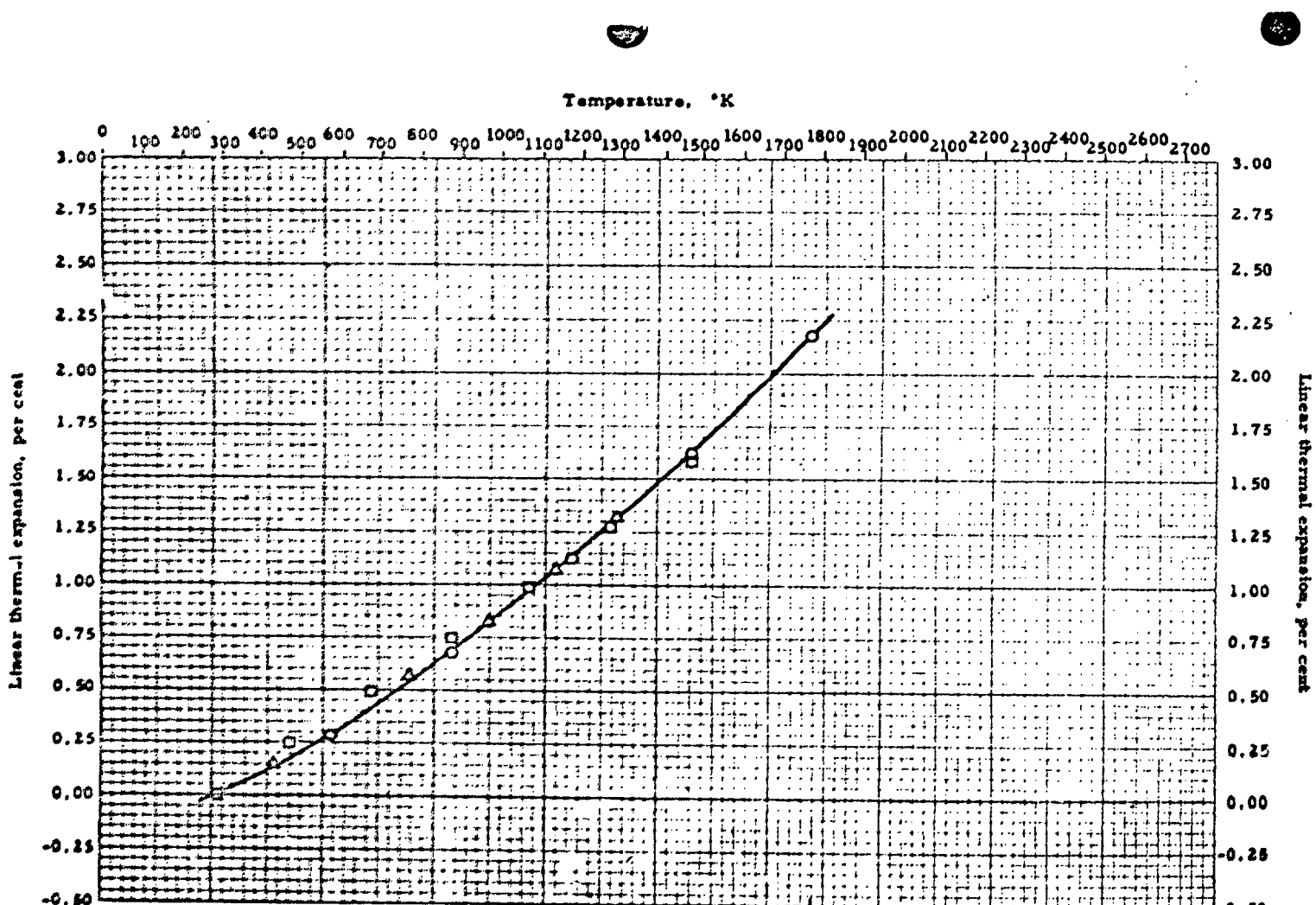


THERMAL CONDUCTIVITY - CALCIUM OXIDE

THERMAL CONDUCTIVITY -- CALCIUM OXIDE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Kingery, W.D., and Francl, J.	54-1	672-2292	ρ = 189 lb_m/ft^3; porosity = 8.75%	Comparative; rods	Prepared by calcining c.p. $CaCO_3$ at 1600°C and pressing; fired at 1900°C

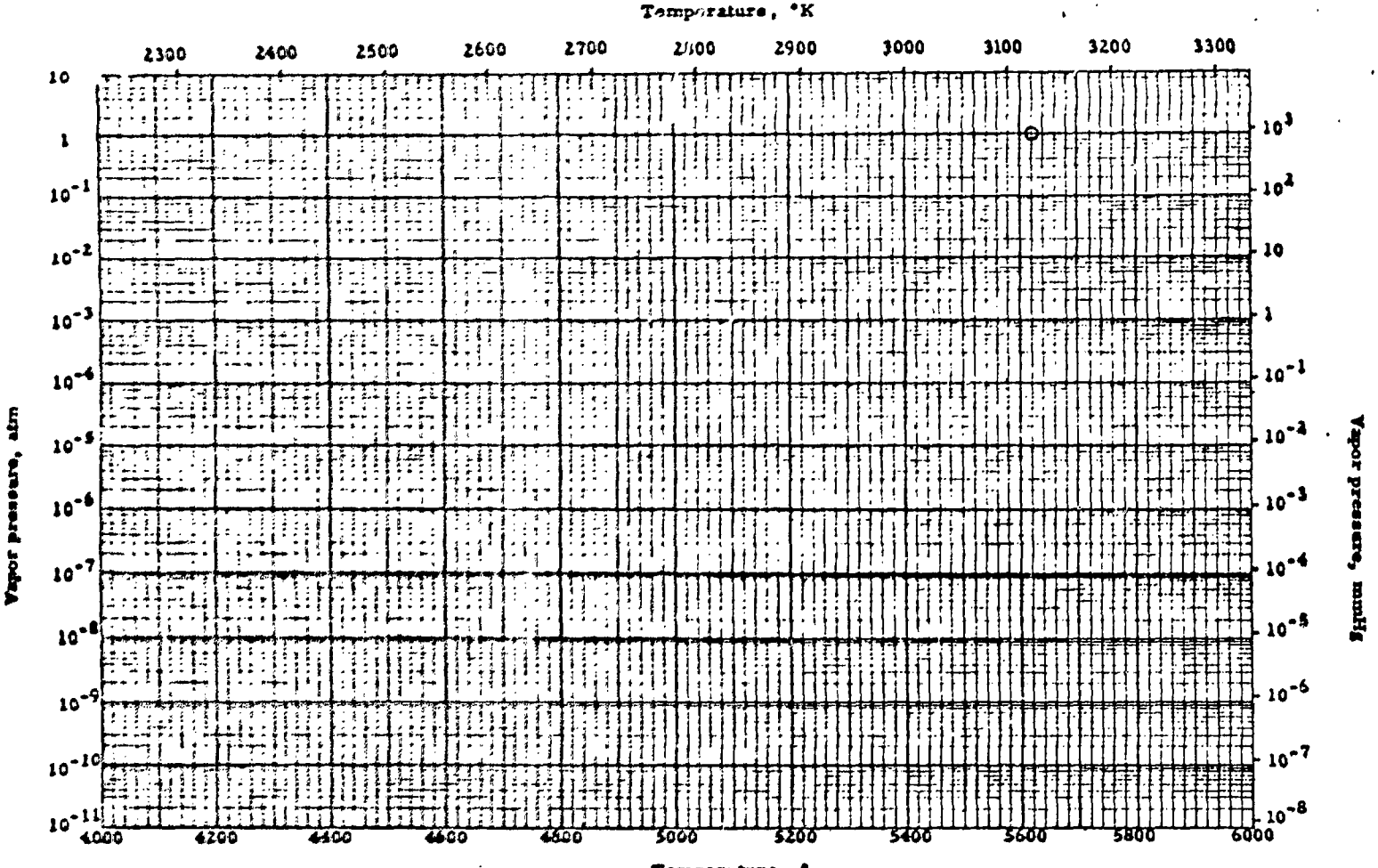


LINEAR THERMAL EXPANSION - CALCIUM OXIDE

LINEAR THERMAL EXPANSION -- CALCIUM OXIDE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Whittemore, O. J. and Ault, N. N.	56-7	1032-3192	Coarse fused grain CaO	Telemicroscopes sighting on sample	
□	Beals, R. J. and Cook, R. L.	57-20	528-2652	Reagent grade CaO	X-ray back reflection	
△	Eichelberger, R. L.	54-146	492-2300	CaO	Interferometer below 1000°C. Dilatometer above 1000° C	



VAPOR PRESSURE--CALCIUM OXIDE

WADC TR 59-676 100

VAPOR PRESSURE -- CALCIUM OXIDE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Trombe, F.	49-16	5622	CaO	Not given	

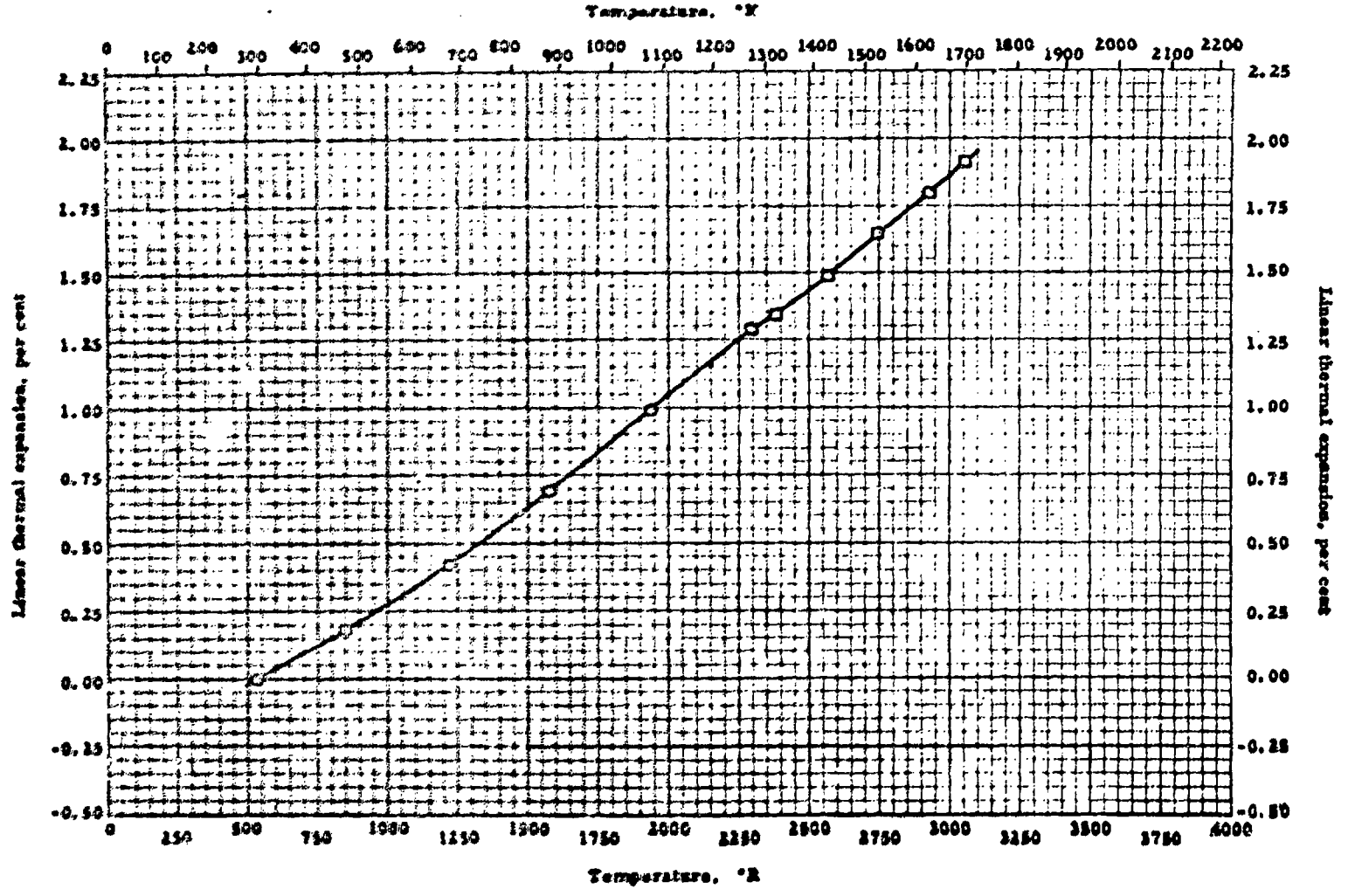
ELECTRIC RESISTIVITY -- CALCIUM OXIDE

VII - A - 3 - a

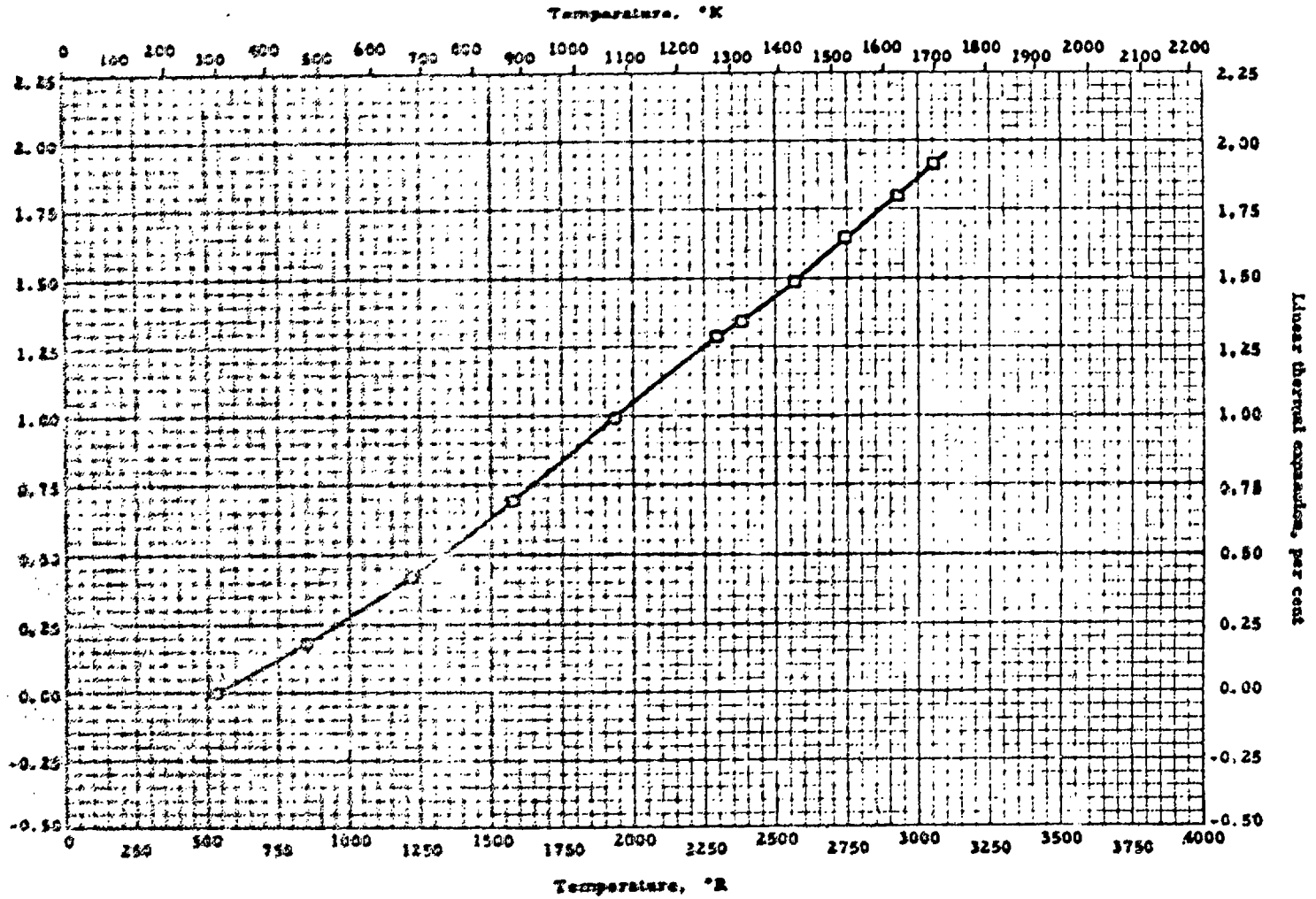
ELECTRIC RESISTIVITY -- CALCIUM OXIDE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Nakhodnova, A. P.	58-73	1160-2120	CaO; polycrystalline	Potential drop; sample temp. by thermocouple and optical pyrometer	Prepared from chemically pure materials. Calcined 2 hr. at 0.46 of MP



LINEAR THERMAL EXPANSION -- CALCIUM OXIDE + TITANIUM OXIDE



LINEAR THERMAL EXPANSION -- CALCIUM OXIDE + TITANIUM OXIDE

LINEAR THERMAL EXPANSION -- CALCIUM OXIDE + TITANIUM OXIDE

REFERENCE INFORMATION

Sym bol	Investigator	Ref.	Range, °K	Material Composition	Test Method	Remarks
○	Eichelberger, R. L.	54-146	672-2292	Stabilized calcia. 94.72% CaO; 5.28% TiO_2	Two methods: a. below 1000°C: interferometer b. above 1000°C: dilatometer	Pressed, fired to 1700°C
□	Ibid.	54-146	2292-3057	Stabilized calcia. 95.57% CaO; 4.43% TiO_2	Same as above	Same as above

PROPERTIES OF CERIUM OXIDE + URANIUM OXIDE

MOST PROBABLE VALUES

Property	Brit. Engineering Units	C. G. S. Units
Density, 43.6% UO_2 . . .	525 lb_m/ft^3	8.42 g/cm^3
Melting Point		
Heat of Fusion		
Heat of Vaporization. . .		
Heat of Sublimation . . .		

REPORTED VALUES

Density:		lb_m/ft^3	g/cm^3
	○	518	8.30
	□	525	8.42
	△	501	8.03
	◇	443	7.1

Melting Point:	°R	°K

Heat of Fusion:	Btu/lb_m	cal/g

Heat of Vaporization:	Btu/lb_m	cal/g

Heat of Sublimation:	Btu/lb_m	cal/g

PROPERTIES OF CERIUM OXIDE + URANIUM OXIDE

REFERENCE INFORMATION

	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Rudorff, W. and Valet, G.	53-85	Room	55.1% CeO_2; 44.9% $UO_{2.67}$	ρ: not given	
□	Ibid.	53-85	Room	56.4% CeO_2; 43.6% UO_2	ρ: same as above	
△	Ibid.	53-85	Room	71.1% CeO_2; 28.9% $UO_{2.67}$	ρ: same as above	
◇	Ibid.	53-85	Room	CeO_2	ρ: same as above	

PROPERTIES OF CERIUM OXIDE

MOST PROBABLE VALUES

Property	Brit. Engineering Units	C. G. S. Units
Density.	443 lb_m/ft^3	7.10 g/cm^3
Melting Point	5530°R	3070°K
Heat of Fusion		
Heat of Vaporization. . .		
Heat of Sublimation . . .		

REPORTED VALUES

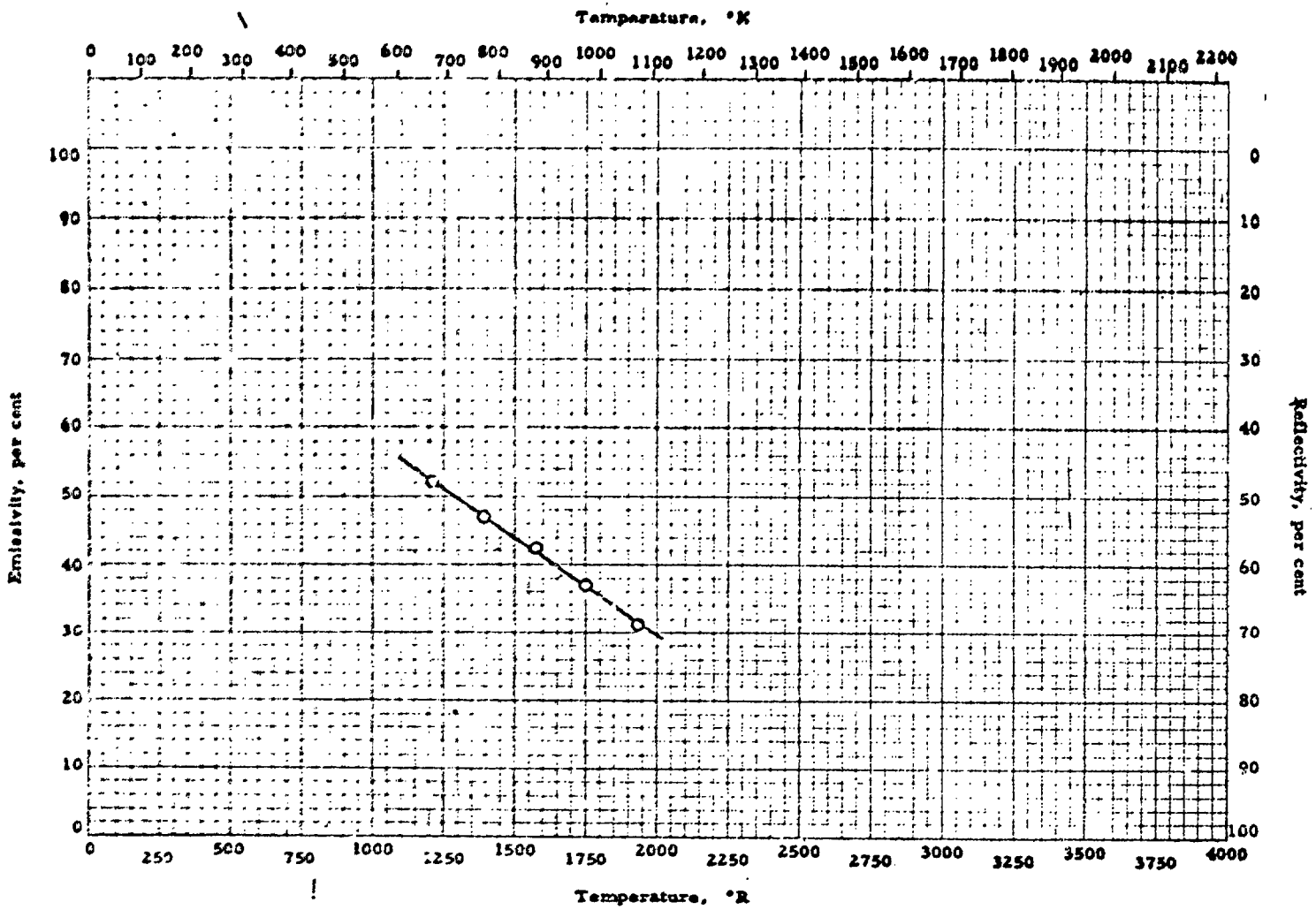
		Brit. Engineering Units	C. G. S. Units
Density:		lb_m/ft^3	g/cm^3
	O	443	7.10
Melting Point:		°R	°K
	□	5534	3073
Heat of Fusion:		Btu/lb_m	cal/g
Heat of Vaporization:		Btu/lb_m	cal/g
Heat of Sublimation:		Btu/lb_m	cal/g

594-580
WADC TR 58-476

PROPERTIES OF CERIUM OXIDE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Rudorff, W., and Valet, G.	53-65	Room	Not given	ρ: not given	
□	Trombe, F.	49-16	5532	Not given	MP: not given	

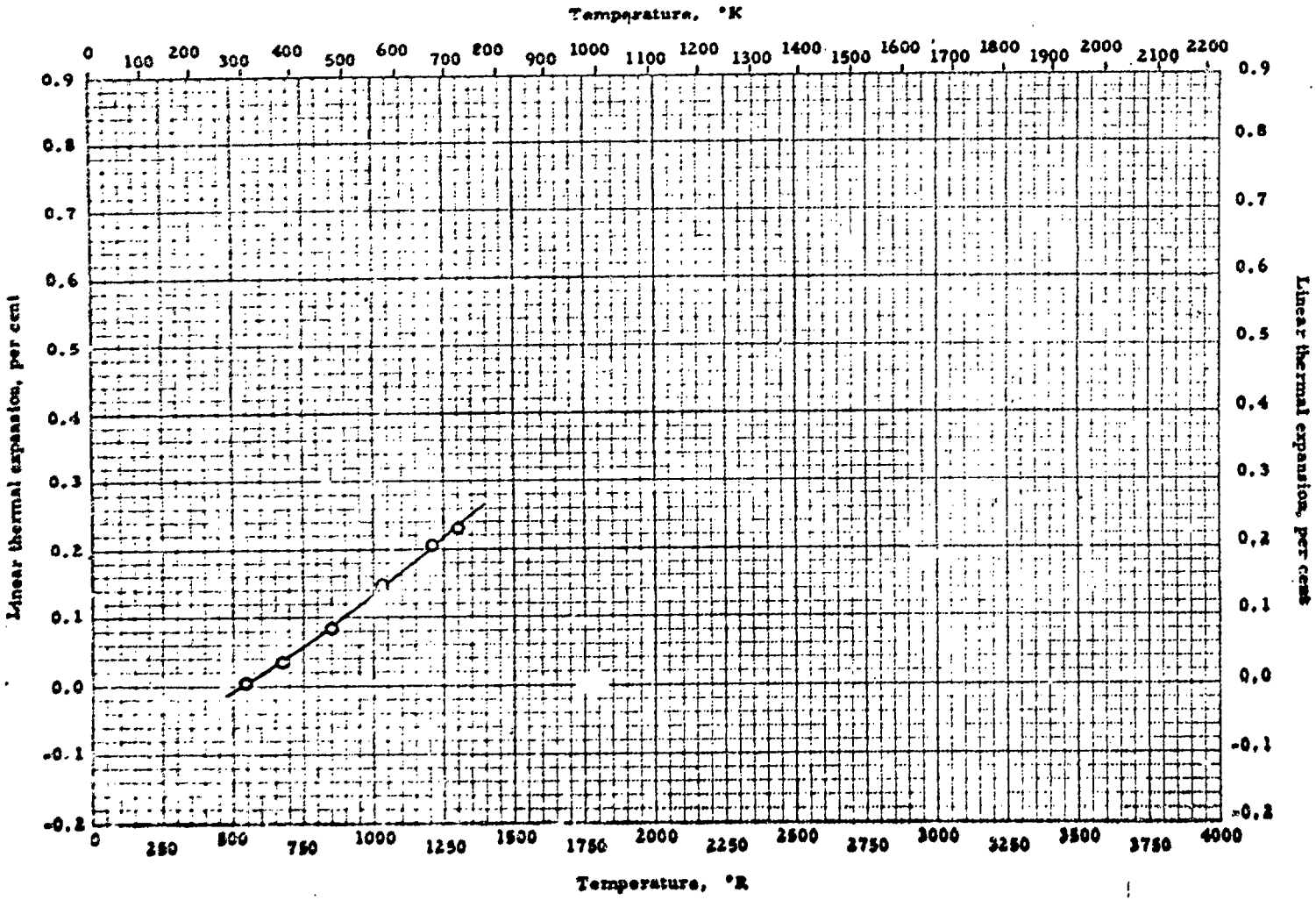


EMISSIVITY -- CERIUM OXIDE

EMISSIVITY -- CERIUM OXIDE

REFERENCE INFORMATION

Sym	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Sully, A.H., Brandes, E.A. and Waterhouse, R.B.	52-81	1212-1932	"Pure"	Total normal emissivity: radiant heat meas. with thermopile; sample temp. by calibrated Pt-Rh thermocouple	

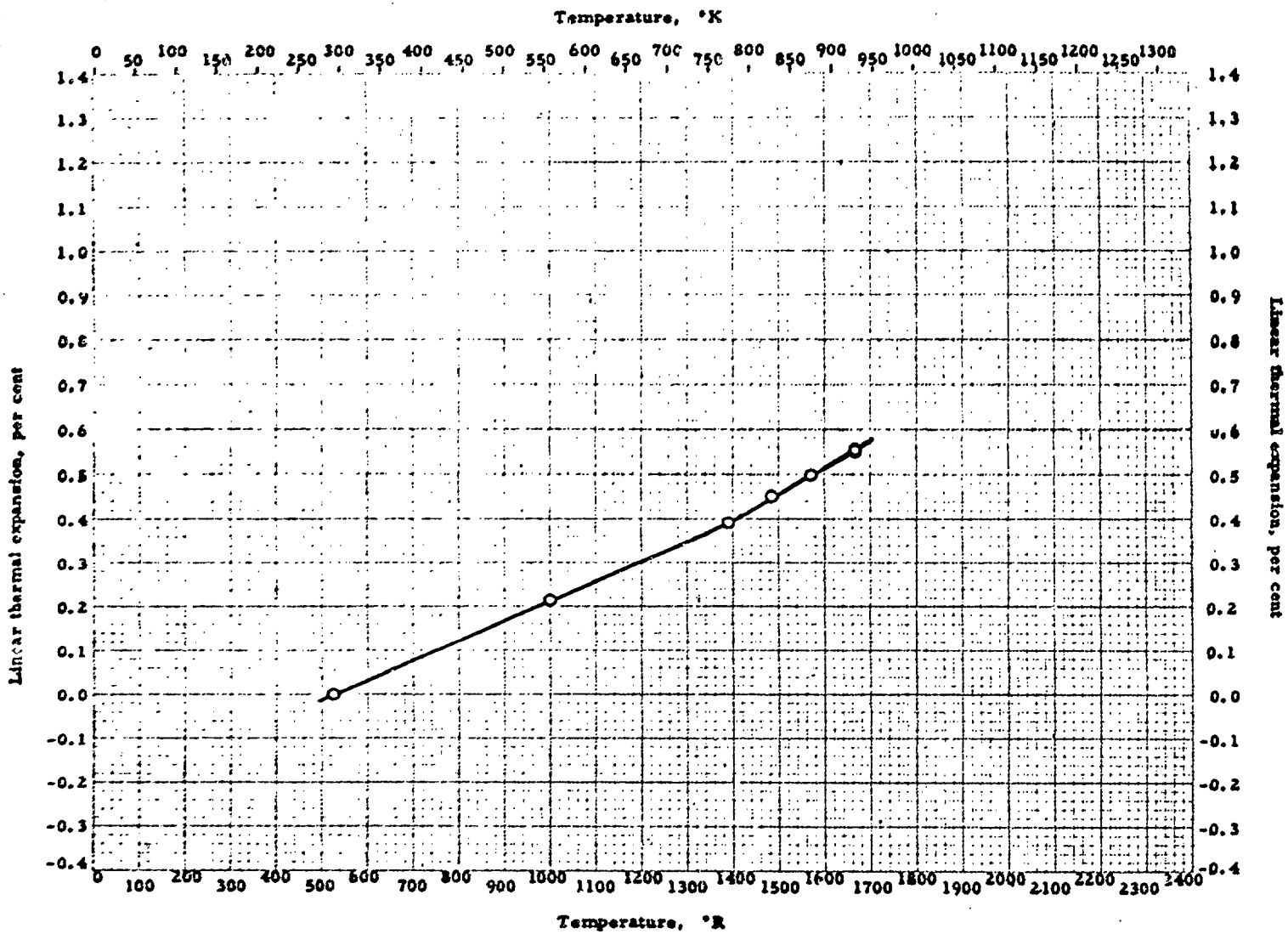


LINEAR THERMAL EXPANSION - 2 $CeO_2 \cdot V_2O_4$

LINEAR THERMAL EXPANSION -- ? $CeO_2 \cdot V_2O_4$

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	King, E. W., and Suber, L. L.	55-17	571-1302	Not given	Vitreous silica tube dilatometer	Heated to 1090° - 1200°C

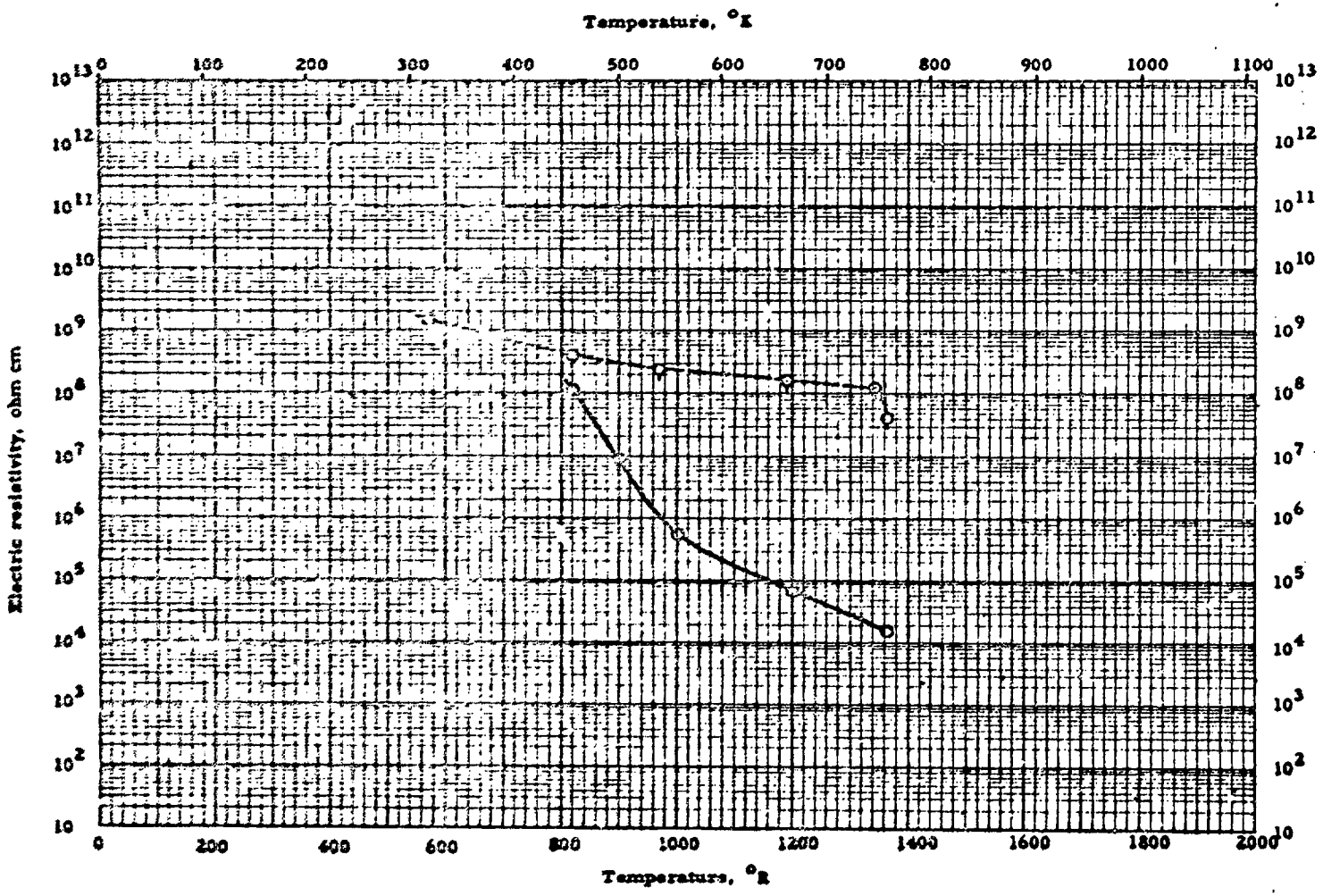


LINEAR THERMAL EXPANSION -- CERIUM OXIDE

LINEAR THERMAL EXPANSION -- CERIUM OXIDE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Hummel, F. A. and Henry, E. C.	46-13	528-1662	Cerium oxide, ceria	Fused quartz tube dilatometer	



ELECTRIC RESISTIVITY -- CERIUM OXIDE

ELECTRIC RESISTIVITY -- CERIUM OXIDE

REFERENCE INFORMATION

Key	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Saunderson, A. W. and Mennig, J. M.	57-178	570-1364	CeO_2	Temp. by thermocouples calibrated against secondary standard chromel-alumel thermocouple	Column purified powder, compacted in hand screwed apparatus. Auth. states values are inaccurate. Only interested in shape of curve. Values sensitive to partial pressure of oxygen. O-heating, Q-cooling

PROPERTIES OF DYSPROSIUM OXIDE

MOST PROBABLE VALUES

Property	Brit. Engineering Units	C. G. S. Units
Density.	488 lb_m/ft^3*	7.81 g/cm^3*
Melting Point	4706°R	2613°K
Heat of Fusion		
Heat of Vaporization. . .		
Heat of Sublimation . . .		

*Handbook of Chemistry and Physics (Ref. 59-2)

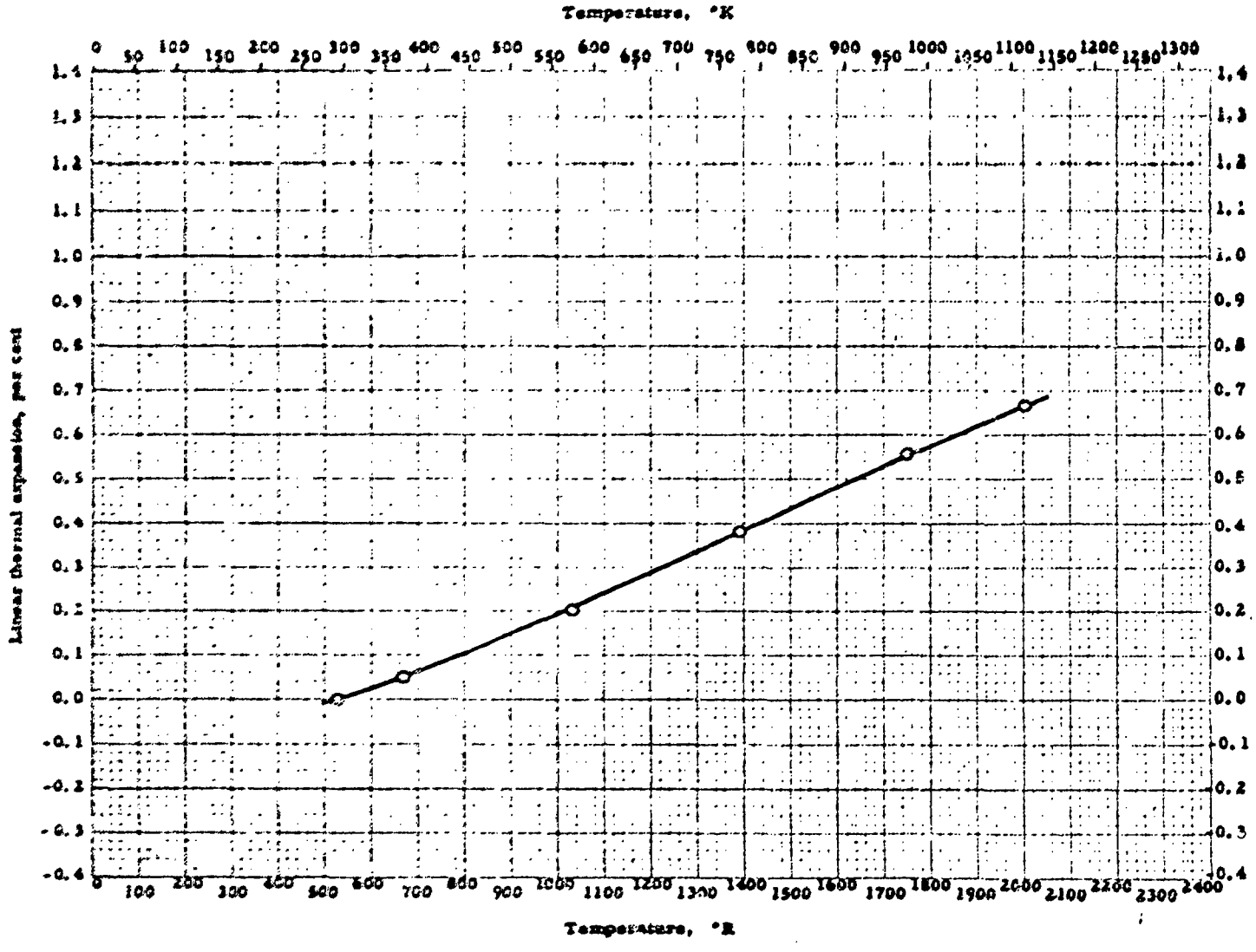
REPORTED VALUES

Density:		lb_m/ft^3	g/cm^3
Melting Point:		°R	°K
	O	4704 ± 18	2613 ± 10
Heat of Fusion:		Btu/lb_m	cal/g
Heat of Vaporization:		Btu/lb_m	cal/g
Heat of Sublimation:		Btu/lb_m	cal/g

PROPERTIES OF DYSPROSIUM OXIDE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Bruch, C. A. and Cashin, W. D.	56-109	4686-4722	Dy_2O_3	MP: observation of first liquid drop on V-shaped ribbon, temp. by calibrated optical pyrometer	



LINEAR THERMAL EXPANSION -- DYSPROSIUM OXIDE

LINEAR THERMAL EXPANSION -- DYSPROSIUM OXIDE

REFERENCE INFORMATION

Curve Ident.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Floetz, G. L., Krystynlak, C. W. and Dumas, H. E.	57-189	528-2004	Dysprosia, Dy_2O_3	Interferometer	Hot pressed at 1800°C in graphite mold to 95% of theoretical density

WADC TR 59-610 (60-697)

PROPERTIES OF EUROPIUM OXIDE

MOST PROBABLE VALUES

Property	Brit. Engineering Units	C. G. S. Units
Density.	463 lb_{mx}/ft^3*	7.42 g/cm^3*
Melting Point	4180°R	2328°K
Heat of Fusion		
Heat of Vaporization. . .		
Heat of Sublimation . . .		

*Handbook of Chemistry and Physics (Ref. 59-2)

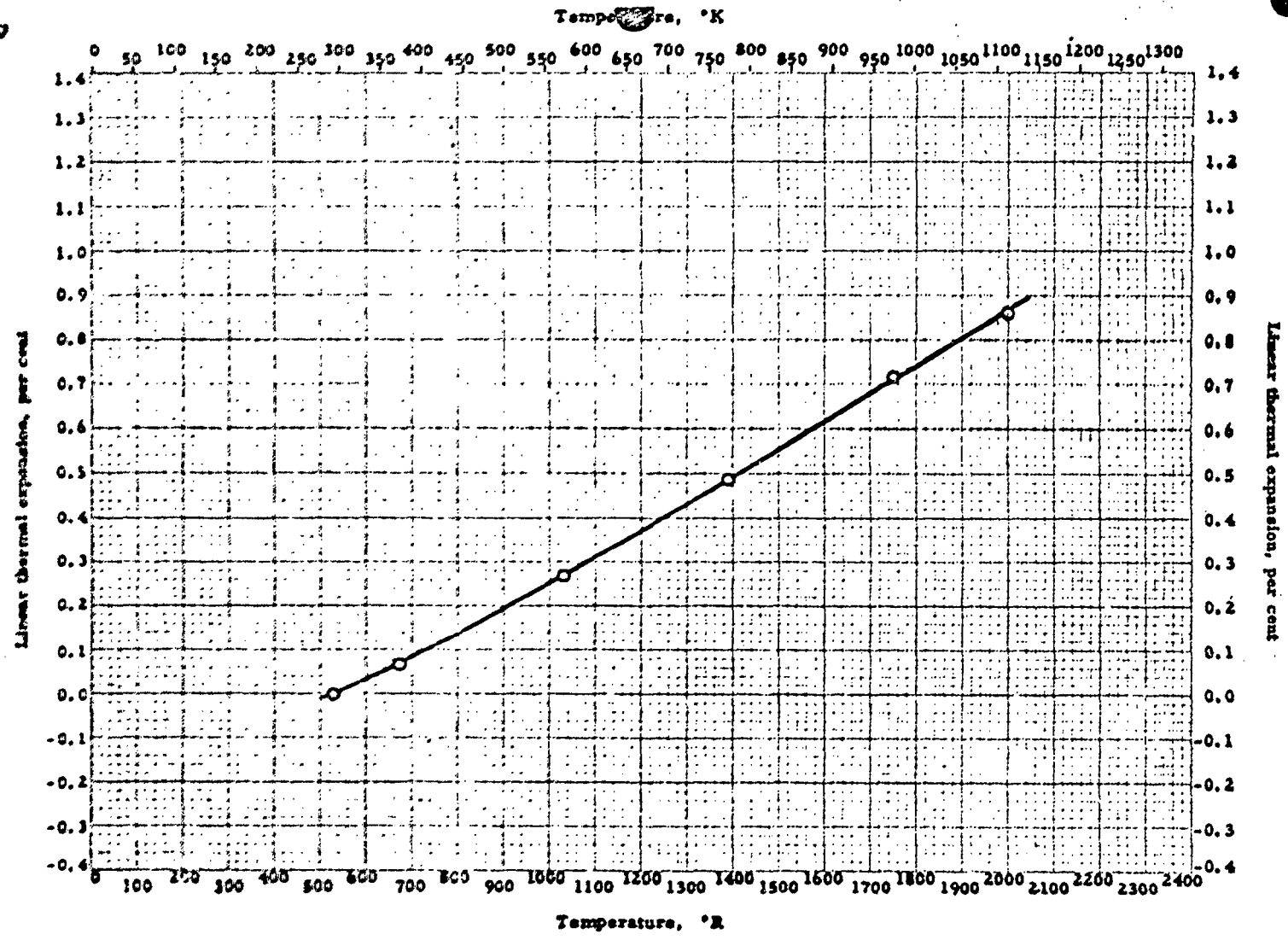
REPORTED VALUES

Density:		lb_m/ft^3	g/cm^3
Melting Point:		°R	°K
	O	4182 ± 54	2323 ± 30
Heat of Fusion:		Btu/lb_m	cal/g
Heat of Vaporization:		Btu/lb_m	cal/g
Heat of Sublimation:		Btu/lb_m	cal/g

PROPERTIES OF EUROPIUM OXIDE

REFERENCE INFORMATION

Sym bol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Bruch, C. A. and Cashin, W. M.	56-109	4128-4236	Eu_2O_3	MP: observation of first liquid drop on V-shaped ribbon; temp. by optical pyrometer	



LINEAR THERMAL EXPANSION -- EUROPIUM OXIDE

LINEAR THERMAL EXPANSION -- EUROPIUM OXIDE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Ploetz, G. L., Krystyniak, C. W. and Dumas, H. E.	57-189	528-2004	Europia. Eu_2O_3	Interferometer	Hot pressed at 1800°C in graphite mold to 95% of theoretical density

PROPERTIES OF GADOLINIUM OXIDE

MOST PROBABLE VALUES

Property	Brit. Engineering Units	C. G. S. Units
Density.	477 lb_m/ft^3	7.64 g/cm^3
Melting Point	4720°R	2620°K
Heat of Fusion		
Heat of Vaporization. . .		
Heat of Sublimation . . .		

REPORTED VALUES

Density:

	lb_m/ft^3	g/cm^3
□	435	6.97
△	477	7.64

Melting Point:

	°R	°K
○	4722 ± 90	2623 ± 50
◇	4686 ± 36	2603 ± 20

Heat of Fusion: Btu/lb_m cal/g

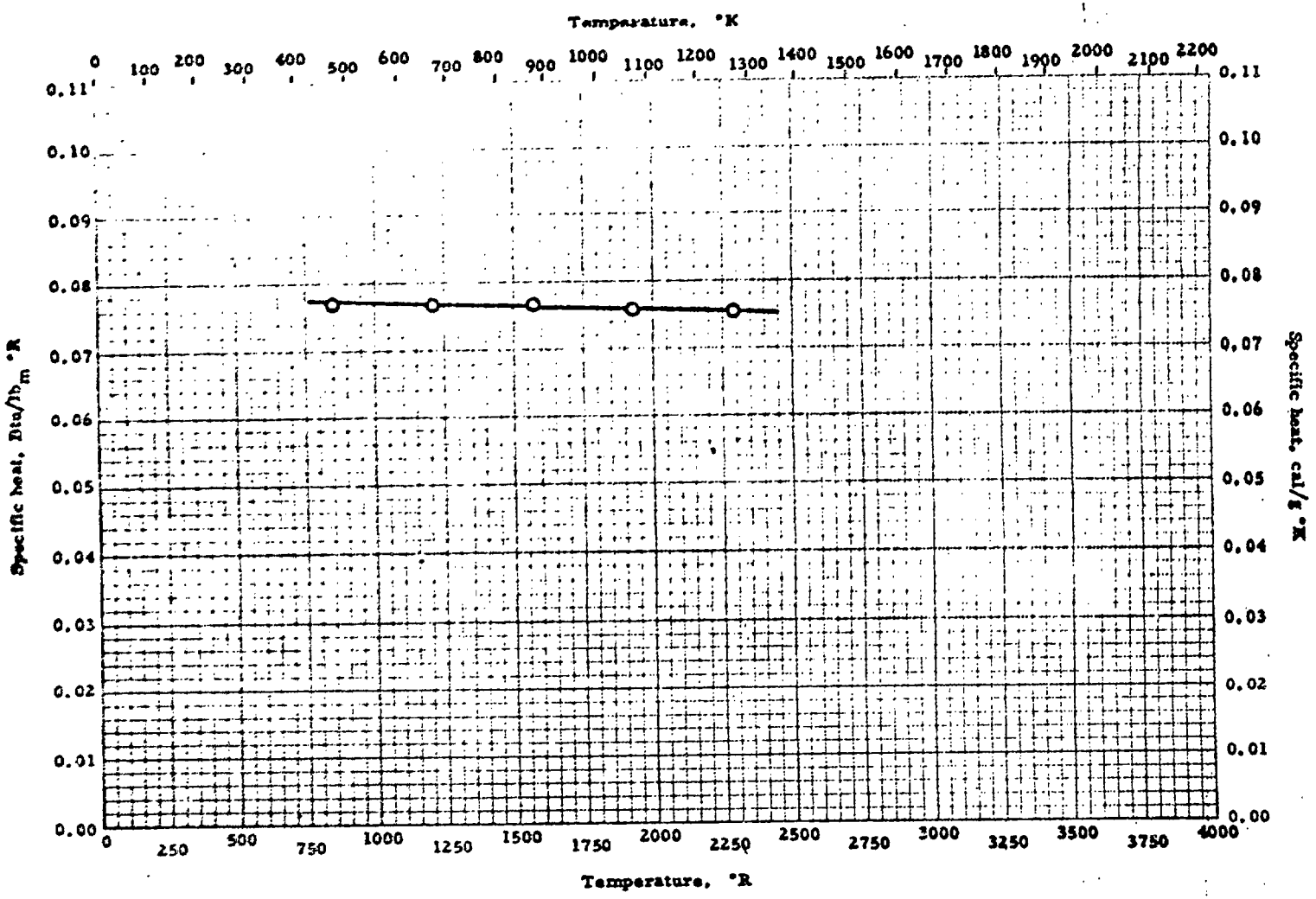
Heat of Vaporization: Btu/lb_m cal/g

Heat of Sublimation: Btu/lb_m cal/g

PROPERTIES OF GADOLINIUM OXIDE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Curtis, C. E. and Johnson, J. R.	57-24	4632-4812	Gd_2O_3; 2% Tb; 0.5% ea. Ce, Ho, Nd, Sm, Eu, Dy; 0.2% Y; < 0.05% ea. Lu, La, Er, Yb	MP: observation of first liquid drop; calibrated optical pyrometer sighting on black body cavity	
□	Ibid.	57-24	Room	Same as above	ρ: weight and volume by water displacement	Pressed at 2700 psi; fired 2 hr. at 1300°C
△	Ibid.	57-24	Room	Same as above	ρ: same as above	Pressed at 2700 psi; fired 2 hr. at 1500°C; sample sintered and cracked
◇	Brach, C. A. and Cashin, W. M.	56-10?	4650-4722	Gd_2O_3	MP: observation of first liquid drop on "V" ribbon, calibrated optical pyrometer	

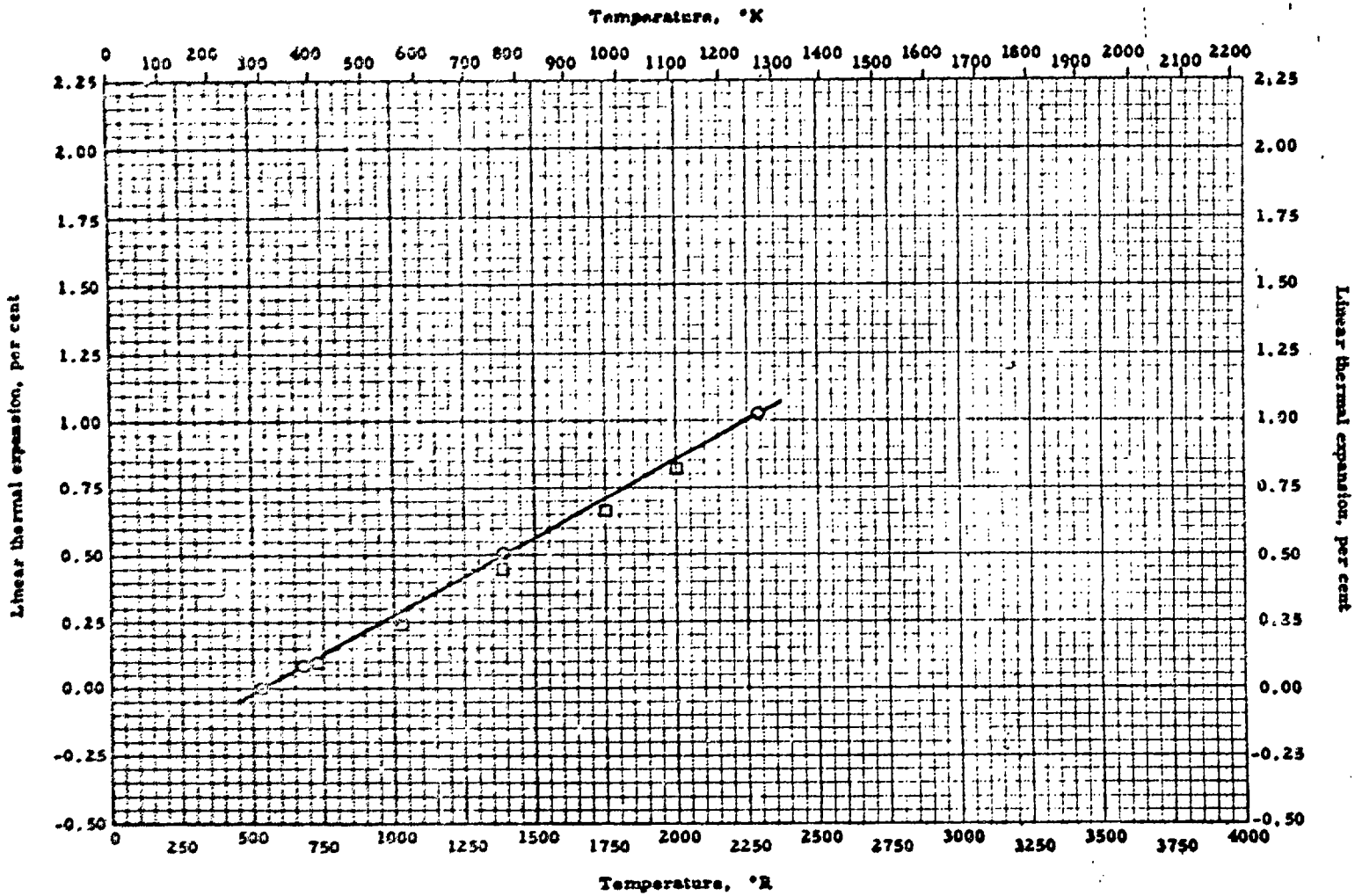


SPECIFIC HEAT -- GADOLINIUM OXIDE (Gd_2O_3)

SPECIFIC HEAT -- GADOLINIUM OXIDE (Gd_2O_3)

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Curtis, C. E., and Johnson, J. R.	57-24	852-2292	2% Tb; 0.5% ea. Ce, Nd, Sm, Eu, Dy	Drop method; ice calorimeter	Pressed at 2700 psi, fired 2 hr. at 1300°C



LINEAR THERMAL EXPANSION -- GADOLINIUM OXIDE

LINEAR THERMAL EXPANSION--GADOLINIUM OXIDE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Curtis, C. E. and Johnson, J. R.	57-24	528-2292	Gd_2O_3: 2% Tb; 0.5% each of Ce, Nd, Sm, Eu, Dy.	Not given	Pressed into bars at 2700 psi, fired 2 hrs. at 1500°C. Sintering and cracking were noted.
□	Floyd, C. L., Krystyniak, C. W. and Dumas, H. E.	57-187	528-2004	Gd_2O_3	Interferometer	Hot pressed at 1800°C in graphite mold to 95% theoretical ρ.

PROPERTIES OF LANTHANUM OXIDE

MOST PROBABLE VALUES

Property	Brit. Engineering Units	C. G. S. Units
Density.	406 lb_m/ft^3	6.51 g/cm^3
Melting Point	4470°R	2480°K
Heat of Fusion		
Heat of Vaporization. . .		
Heat of Sublimation . . .		

Handbook of Chemistry and Physics (Ref. 59-2)

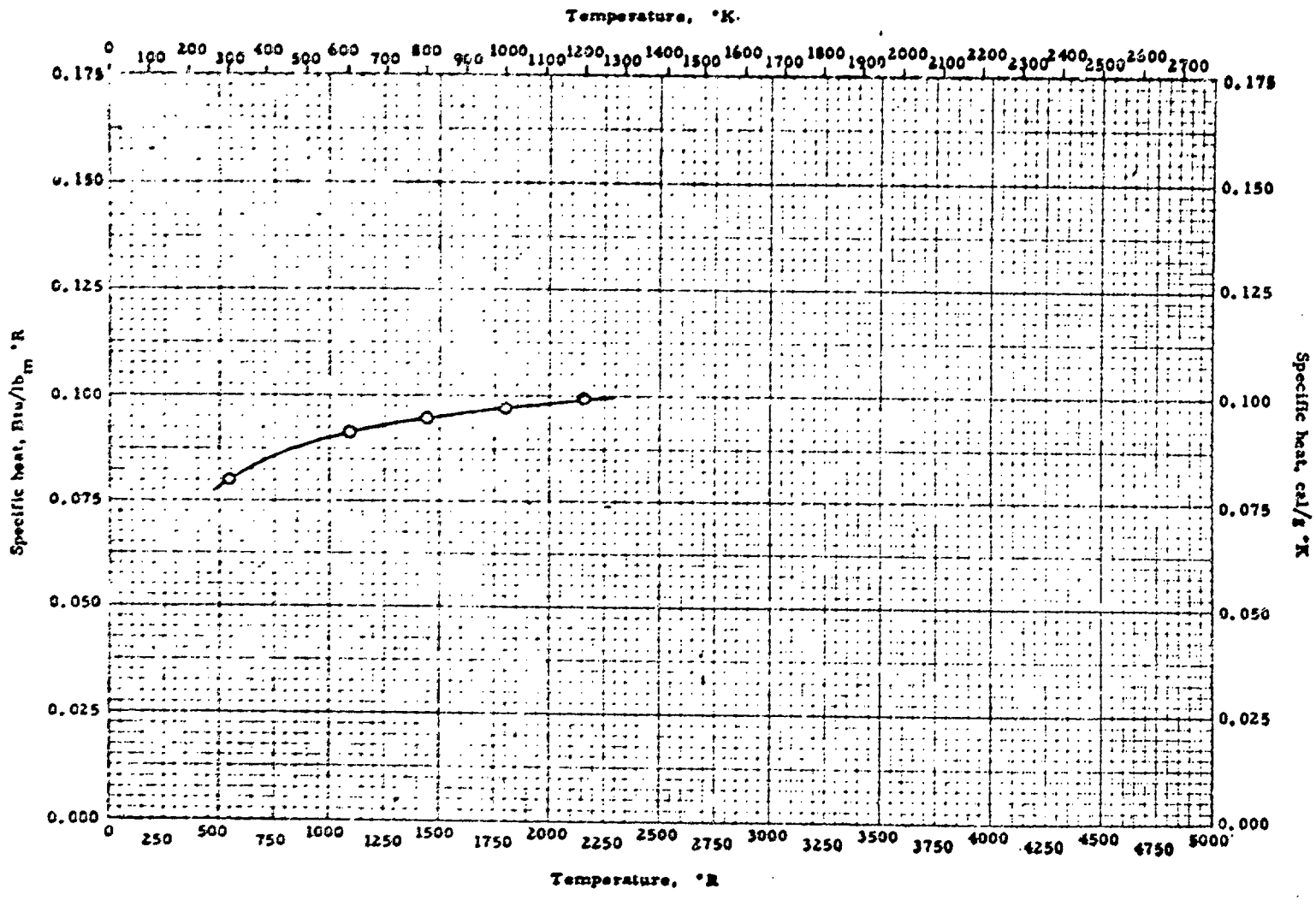
REPORTED VALUES

Density:		lb_m/ft^3	g/cm^3
Melting Point:		°R	°K
	O	4470 ± 36	2483 ± 20
Heat of Fusion:		Btu/lb_m	cal/g
Heat of Vaporization:		Btu/lb_m	cal/g
Heat of Sublimation:		Btu/lb_m	cal/g

PROPERTIES OF LANTHANUM OXIDE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Lambertson, W. A. and Gunsel, Jr., F.H.	52-131	4434-4506	99% pure lanthana, La_2O_3	MP: inspection after heating in constant temp. furnace, temp. by calibrated optical pyrometer	

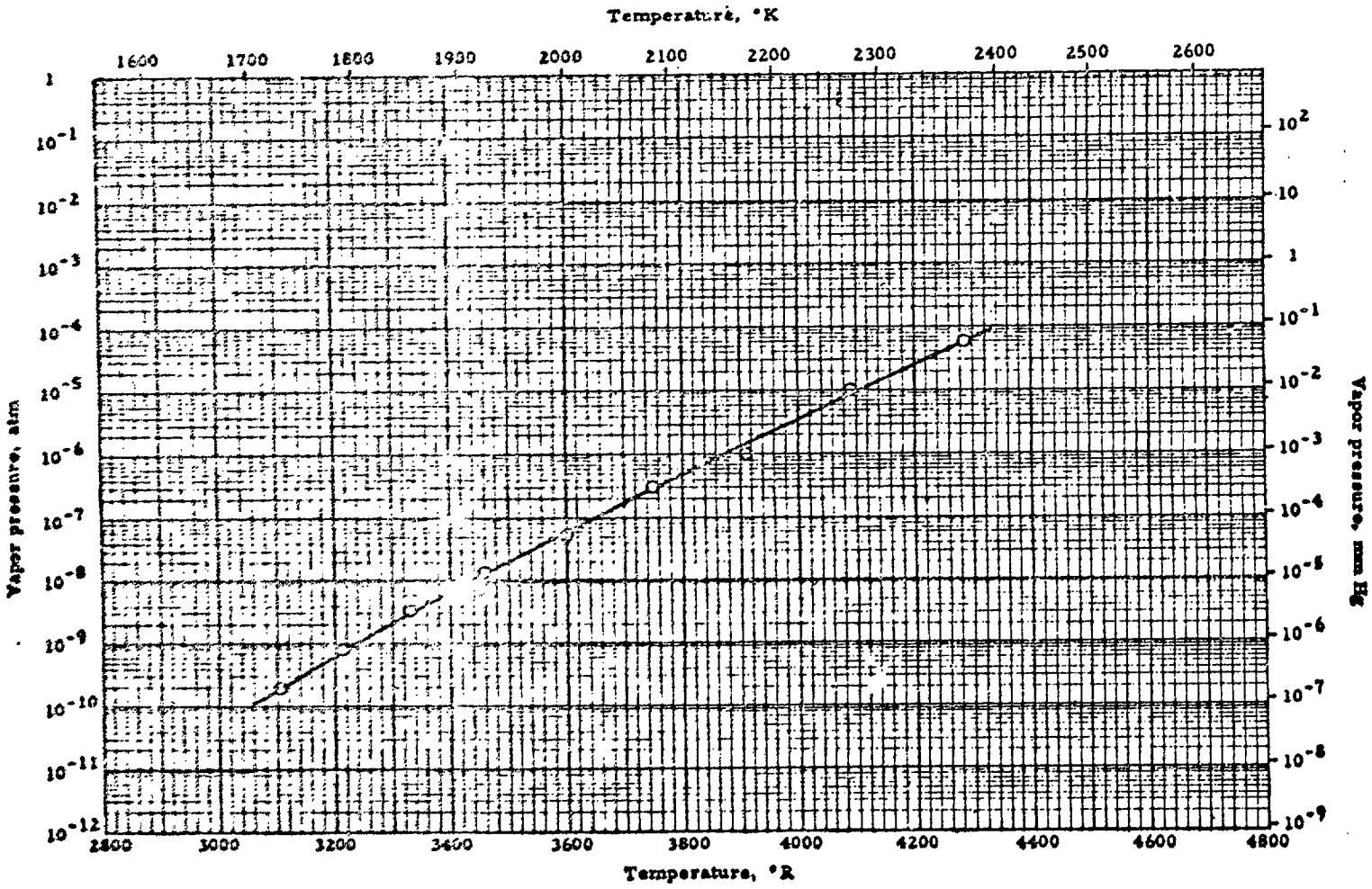


SPECIFIC HEAT -- LANTHANUM OXIDE

SPECIFIC HEAT -- LANTHANUM OXIDE

REFERENCE INFORMATION

Curve Ident.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Blomeke, J. O. and Ziegler, W. T.	51-79	690-2110	Lanthana, La_2O_3	Drop method; copper block calorimeter	Auth. est. accuracy of heat content data 0.4%



VAPOR PRESSURE -- LANTHANUM OXIDE

VAPOR PRESSURE -- LANTHANUM OXIDE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Yosim, S. J. and Milne, T. A.	57-145	3103-4286	La_2O_3	Knudsen effusion cell of tungsten	Vapor press. for reaction $La_2O_3 \rightarrow LaO + O_2$ Below 3400°R auth. quote data of others

PROPERTIES OF NEODYMIUM OXIDE

MOST PROBABLE VALUES

Property	Brit. Engineering Units	C. G. S. Units
Density.	452 lb_m/ft^3*	7.24 g/cm^3*
Melting Point	4580 °R	2545 °K
Heat of Fusion		
Heat of Vaporization. . .		
Heat of Sublimation . . .		

*Handbook of Chemistry and Physics (Ref. 59-2)

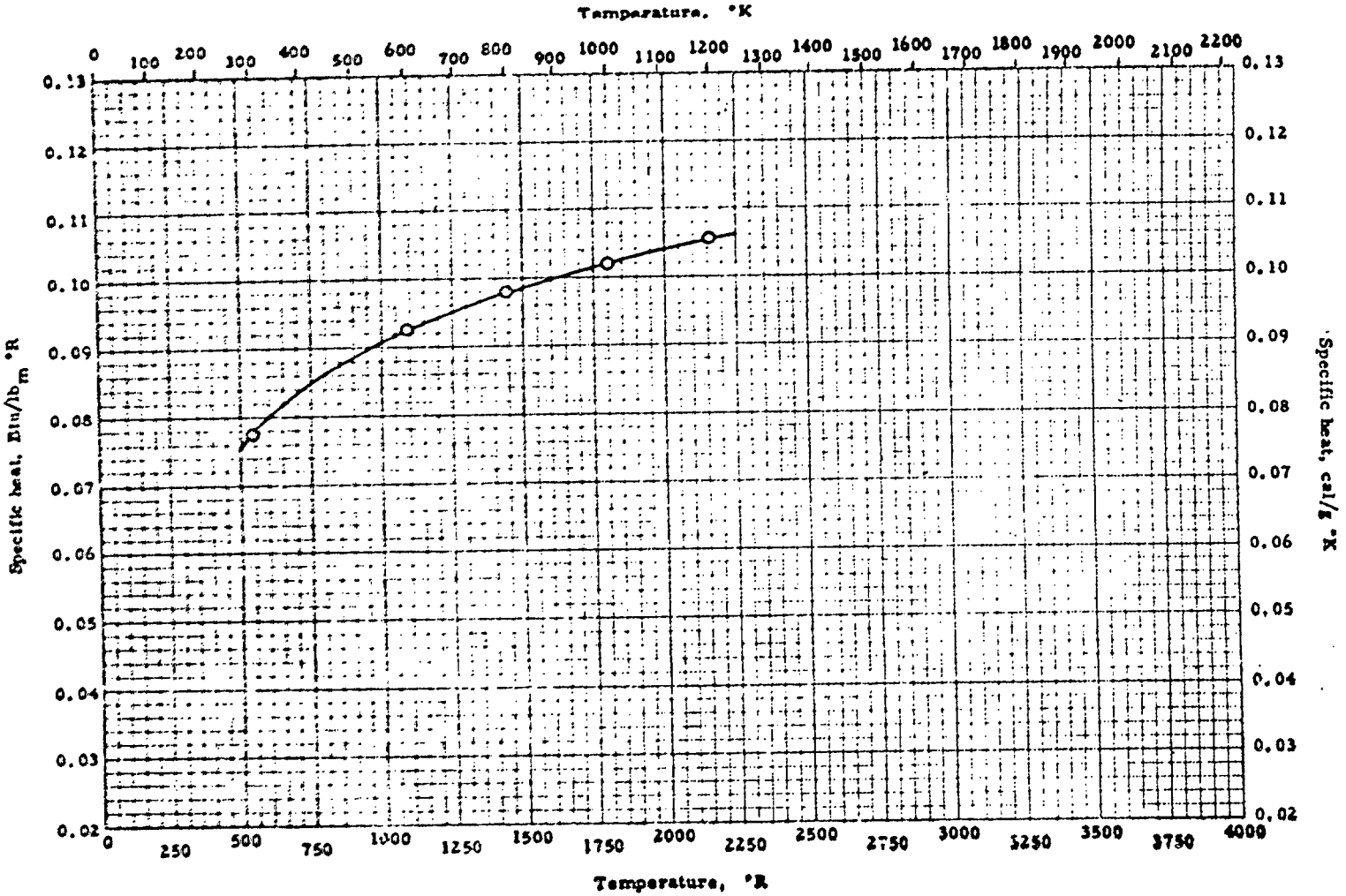
REPORTED VALUES

Density:		lb_m/ft^3	g/cm^3
Melting Point:		°R	°K
	O	4581 ± 36	2545 ± 20
Heat of Fusion:		Btu/lb_m	cal/g
Heat of Vaporization:		Btu/lb_m	cal/g
Heat of Sublimation:		Btu/lb_m	cal/g

PROPERTIES OF NEODYMIUM OXIDE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Lamberton, W. A. and Gunsel, Jr., F. H.	12-131	4545-4617	99% neodymia, Nd_2O_3	MP: by inspection after heating in constant temp. furnace, temp. by calibrated optical pyrometer	

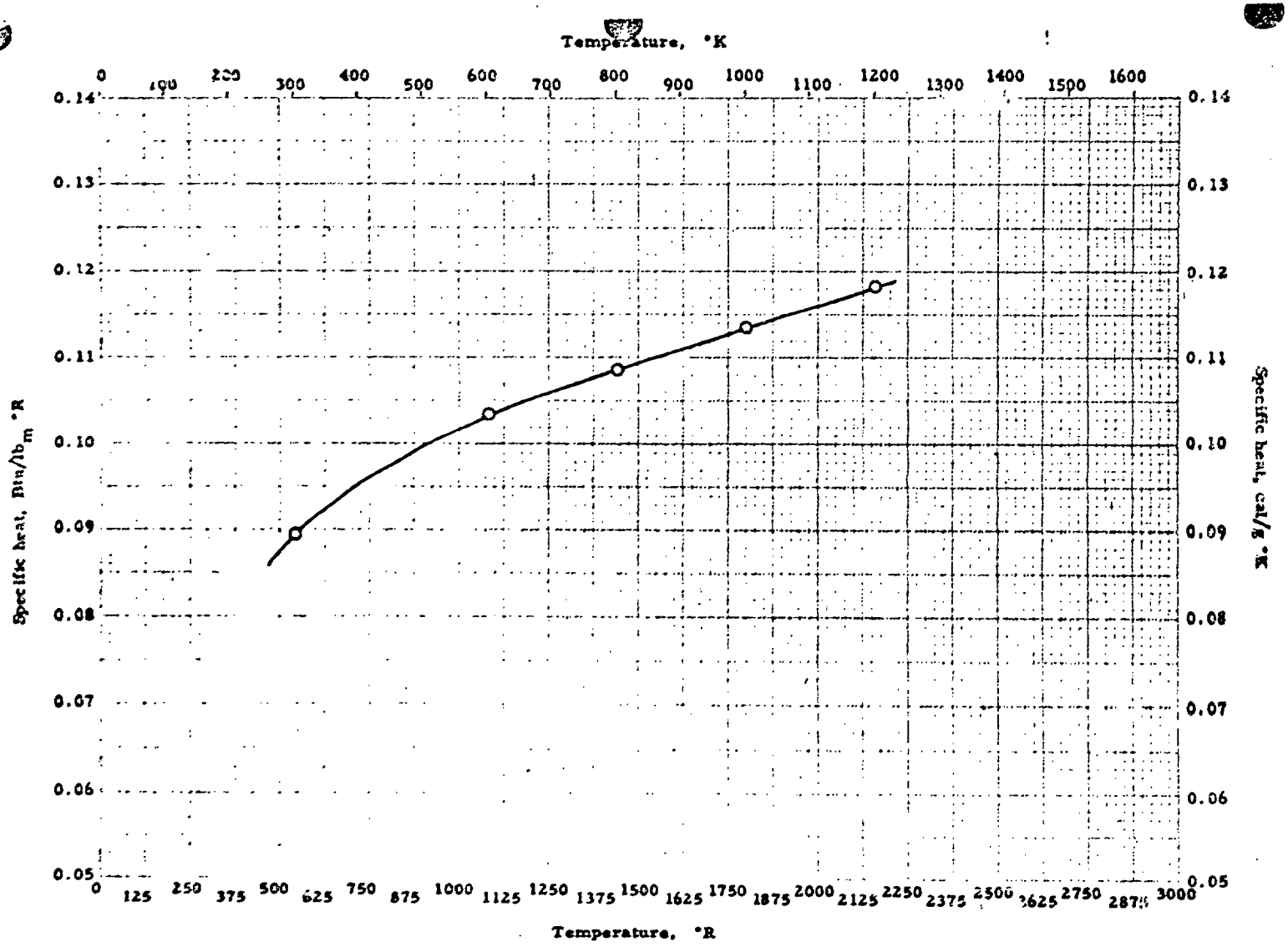


SPECIFIC HEAT -- NEODYMIUM OXIDE

SPECIFIC HEAT -- NEODYMIUM OXIDE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Blomeke, J. O. and Ziegler, W. T.	51-29	690-2110	99.5% pure Nd_2O_3	Drop method; copper block calorimeter	Auth. est. accuracy of heat content data 0.4%

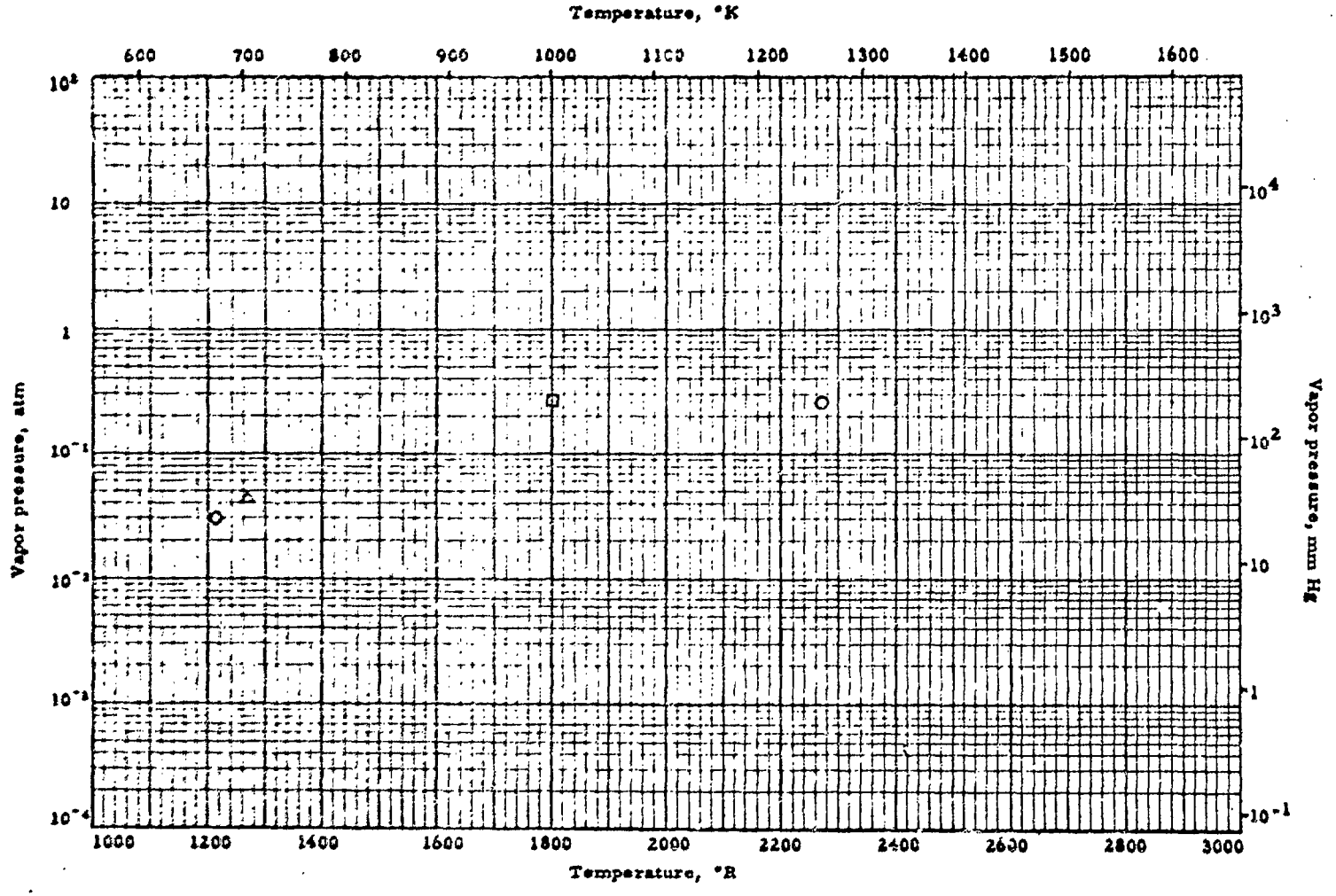


SPECIFIC HEAT -- PRASEODYMIUM OXIDE

SPECIFIC HEAT -- PRASEODYMIUM OXIDE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Blomeke, J. O. and Ziegler, W. T.	51-29	690-2110	99.5% Pr_6O_{11}	Drop method; copper block calorimeter	Auth. est. accuracy of heat content data 0.4%



VAPOR PRESSURE -- PRASEODYMIUM OXIDE

VAPOR PRESSURE -- PRASEODYMIUM OXIDE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Stubblefield, C. T.	55-151	1212-2292	$PrO_{1.795}$	Determined equilibrium temp. and pressure of O_2 over Pr during formation of oxide	Body centered cubic phase, determined by x-ray photograph
□	Ibid.	55-151	1212-2292	$PrO_{1.717}$	Same as above	Rhombohedral phase, determined by x-ray photograph
△	Ibid.	55-151	1212-2292	$PrO_{1.804}$	Same as above	Face centered cubic phase, determined by x-ray photograph
◇	Ibid.	55-151	1212-2292	$PrO_{1.833}$	Same as above	Same as above

PROPERTIES OF SAMARIUM OXIDE + X

MOST PROBABLE VALUES

Property	Brit. Engineering Units	C. G. S. Units
Density.	460 lb_m/ft^3 *	7.4 g/cm^3 *
Melting Point	4720°R *	2620°K *
Heat of Fusion		
Heat of Vaporization. . .		
Heat of Sublimation . . .		

*Value fo. Sm_2O_3.

REPORTED VALUES

Density:		lb_m/ft^3	g/cm^3
	□	375	6.0
	△	462	7.4
	▽	412	6.60
Melting Point:		°R	°K
	○	4722 ± 90	2623 ± 50
	◇	4632 ± 90	2573 ± 50

Heat of Fusion: Btu/lb_m cal/g

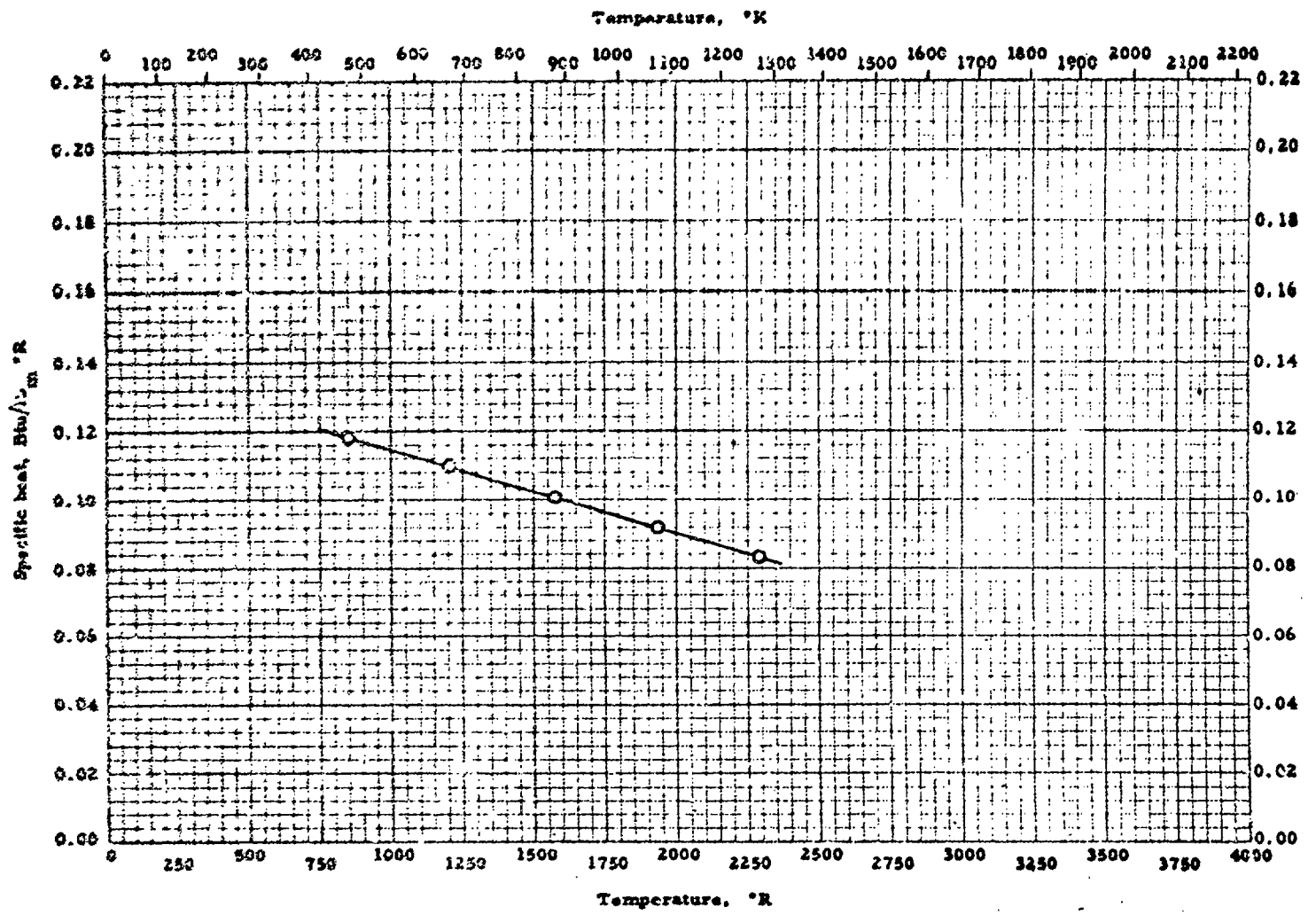
Heat of Vaporization: Btu/lb_m cal/g

Heat of Sublimation: Btu/lb_m cal/g

PROPERTIES OF SAMARIUM OXIDE + X

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Curtis, C. E. and Johnson, J. R.	57-24	4632-4812	Sm_2O_3; <0.5% Nd; 0.4% Eu; <0.3% Gd; <0.2% ea. Dy, Ho, Pr; <0.1% Tb; <0.05% ea. Y, La, Er, Yb	MP: observation of first liquid drop; calibrated optical pyrometer sighting on black body cavity	
□	Ibid.	57-24	Room	Same as above	ρ: weight and volume by water displacement	Pressed at 2700 psi; fired 2 hr. at 1300°C
△	Ibid.	57-24	Room	Same as above	ρ: same as above	Pressed at 2700 psi; fired 2 hr. at 1500°C; sintered and cracked
◇	Bruch, C. A. and Cashin, W. M.	56-109	4542-4722	Sm_2O_3	MP: observation of first liquid drop on "V" ribbon, calibrated optical pyrometer	
▽	Curtis, C. E. and Johnson, J. R.	57-24	Room	63.8% Sm_2O_3; 26.3% Gd_2O_3; 4.8% Dy_2O_3; 0.9% Nd_2O_3; 4.2% Y_2O_3 and other rare-earth oxides	ρ: weight and volume by water displacement	Lindsay commercial mixture; 1/4 of mixture precalcined at 1400°C; all dry pressed at 4000 psi; sintered at 1500°C

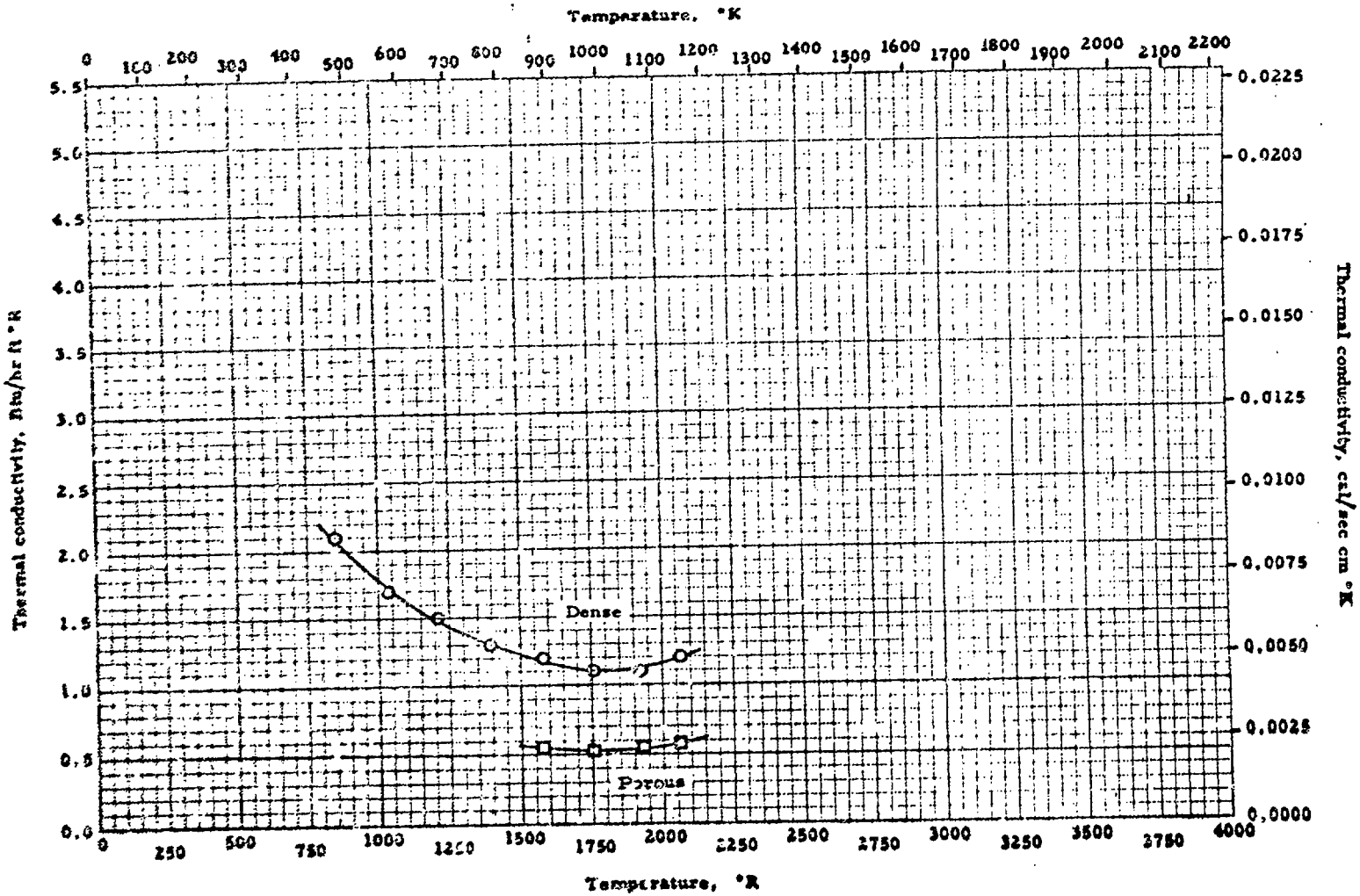


SPECIFIC HEAT -- SAMARIUM OXIDE (Sm_2O_3)

SPECIFIC HEAT -- SAMARIUM OXIDE (Sm_2O_3)

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Curtis, C. E. and Johnson, J. R.	57-24	492-2292	<0.5% Nd; <0.4% Eu; <0.3% Gd; <0.2% ea. Dy, Ho, Pr	Drop method; ice calorimeter	

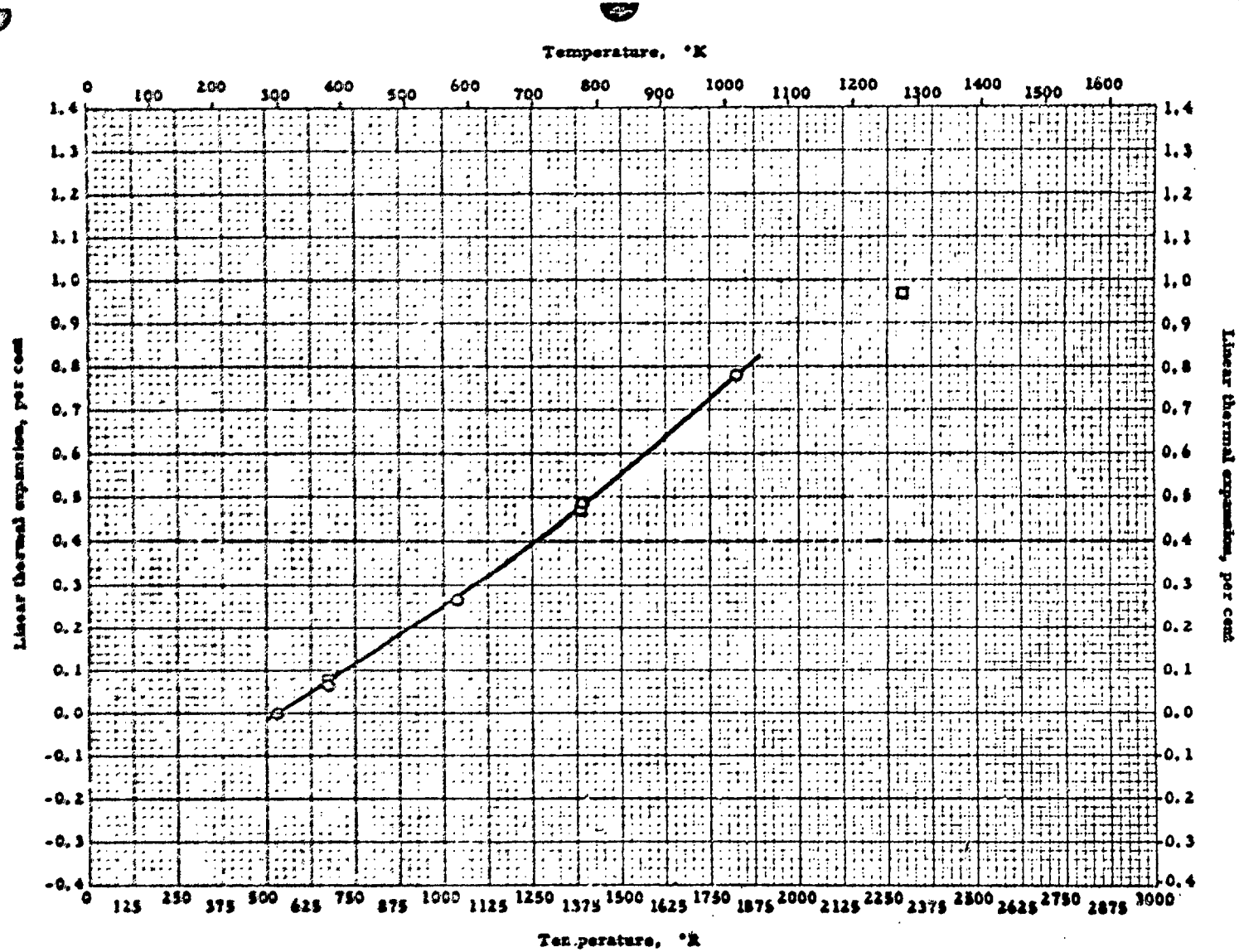


THERMAL CONDUCTIVITY -- SAMARIUM OXIDE - GADOLINIUM OXIDE SOLID SOLUTION

THERMAL CONDUCTIVITY -- SAMARIUM OXIDE - GADOLINIUM OXIDE SOLID SOLUTION

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Kingery, W. D., and Norton, F. H.	55-53	852-2067	Dense sample	Comparative; rods	Fired to dense condition
□	Ibid.	55-53	1572-2058	Porous sample	Same as above	Fired to lower temp.; quite porous

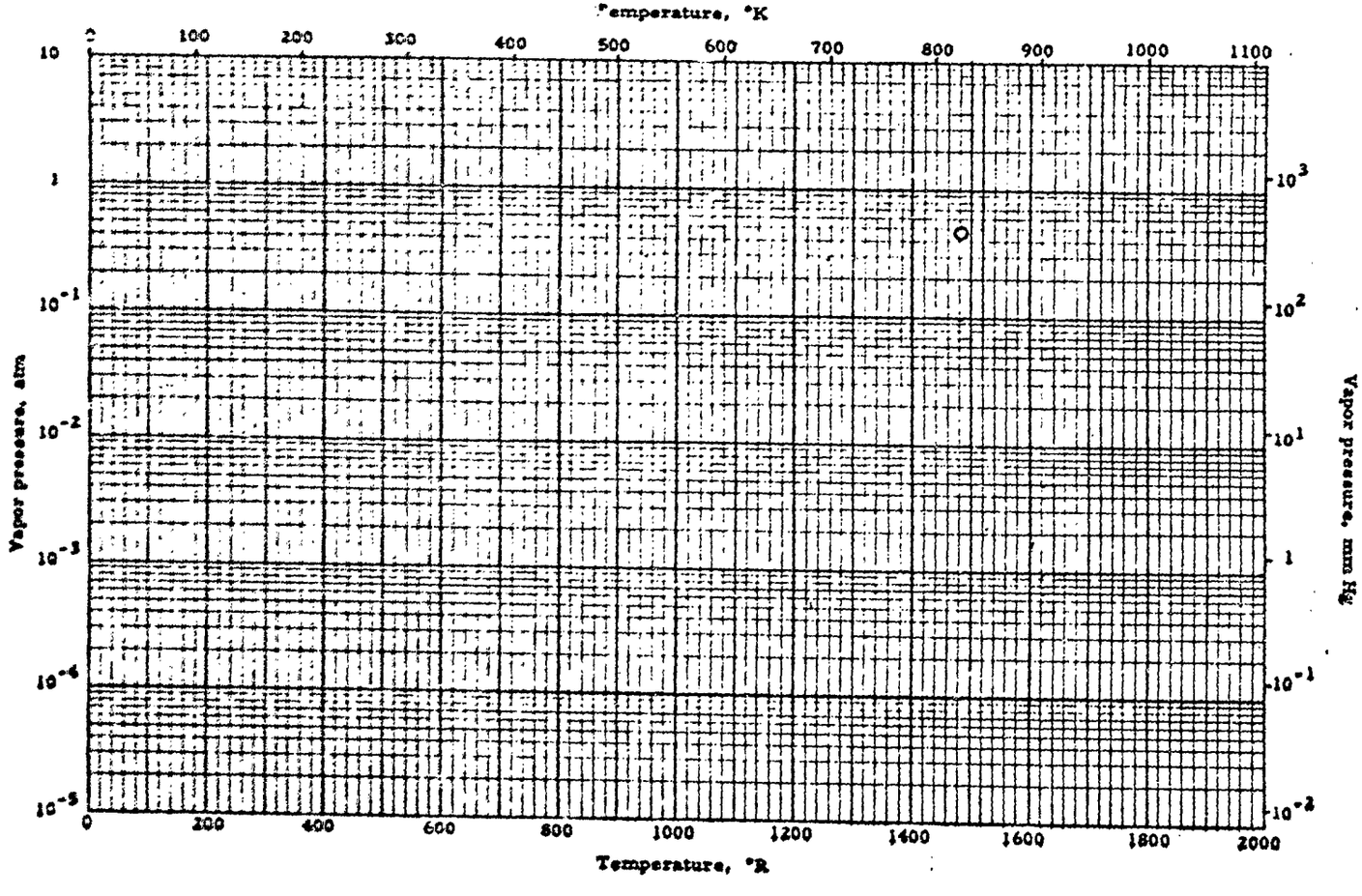


LINEAR THERMAL EXPANSION -- SAMARIUM OXIDE

LINEAR THERMAL EXPANSION -- SAMARIUM OXIDE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Ploetz, C. L., Krystyniak, C. W. and Dumes, H. E.	57-189	528-1824	Sm_2O_3	Interferometer	Hot pressed at 1800°C in graphite mold to 95% of theoretical density
□	Curtis, C. E. and Johnson, J. R.	57-24	528-2292	Sm_2O_3. <0.5% Nd; <0.4% Eu; <0.3% Gd; <0.2% ea.Dy, Ho, Pr	Not given	Pressed at 2700 psi, fired 2 hr. at 1500°C. Sintering and cracking noted at 1500°C



VAPOR PRESSURE -- TERBIUM OXIDE

VAPOR PRESSURE -- TERBIUM OXIDE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Stubblefield, C. T.	55-151	1482-1662	$TbO_{1.814}$	Determined equilibrium temp. and pressure of O_2 over Tb during preparation of oxide	Face centered cubic phase, determined by x-ray photograph

PROPERTIES OF MAGNESIUM OXIDE

MOST PROBABLE VALUES

Property	Brit. Engineering Units	C. G. S. Units
Density.	235 lb_m/ft^3	3.77 g/cm^3
Melting Point	5800°R	3220°K
Heat of Fusion		
Heat of Vaporization. . .		
Heat of Sublimation . . .		

REPORTED VALUES

Density:		lb_m/ft^3	g/cm^3
	○	212	3.39
	◇	235	3.77
	▽	127	2.04
	○	212	3.4

Melting Point:		°R	°K
	□	5802	3223
	△	5532	3073

Heat of Fusion: Btu/lb_m cal/g

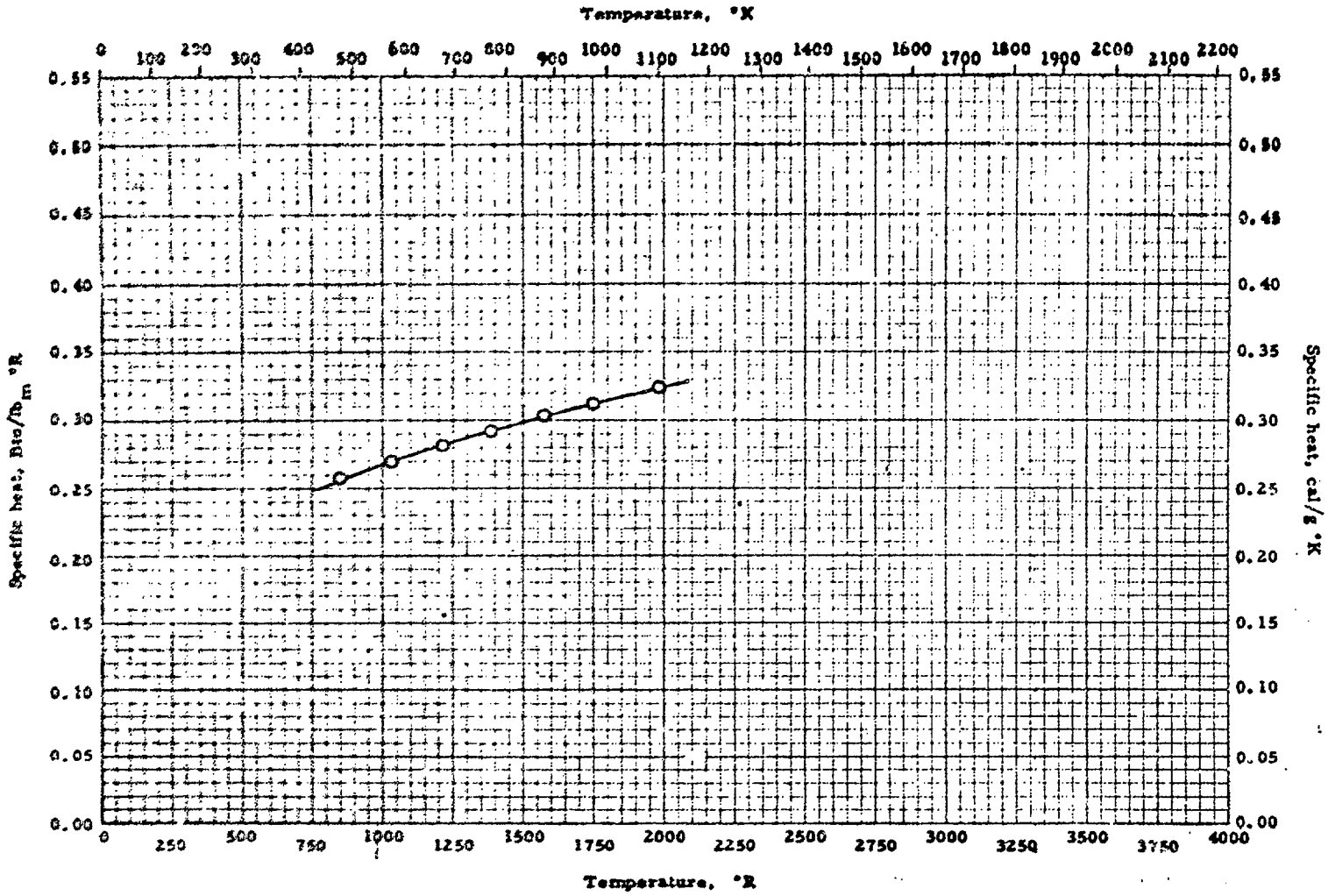
Heat of Vaporization: Btu/lb_m cal/g

Heat of Sublimation: Btu/lb_m cal/g

PROPERTIES OF MAGNESIUM OXIDE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Gangler, J. J.	50-10	Room	60.02% Mg; 39.58% O_2; 0.07% combined C; <0.01% free C	ρ: weight in air and in distilled water	Auth. quotes theor. density 3.62 g/cm^3. Samples hot pressed in graphite mold
□	O'Connor, W.F., Laszlo, T.S. et al.	51-47	5802	MgO	MP: visual observation; optical pyrometer	
△	Trombe, F.	49-16	5532	MgO	MP: not given	
◇	Johnson, P. D.	50-37	Room	MgO	ρ: computed from x-ray measurements of lattice	From $Mg(OH)_2$ containing 1% ea. Al, Ca, Na; >0.01% ea. Fe, B, K, <0.01% ea. Cu, Si. Calcined 1 hr at 1000°C, pressed at 52,000 psi
▽	Ibid.	50-37	Room	Same as above	ρ: not given	Same as above
○	Ibid.	50-37	Room	Same as above	ρ: same as above	Same as above, but also fired at 1900°C

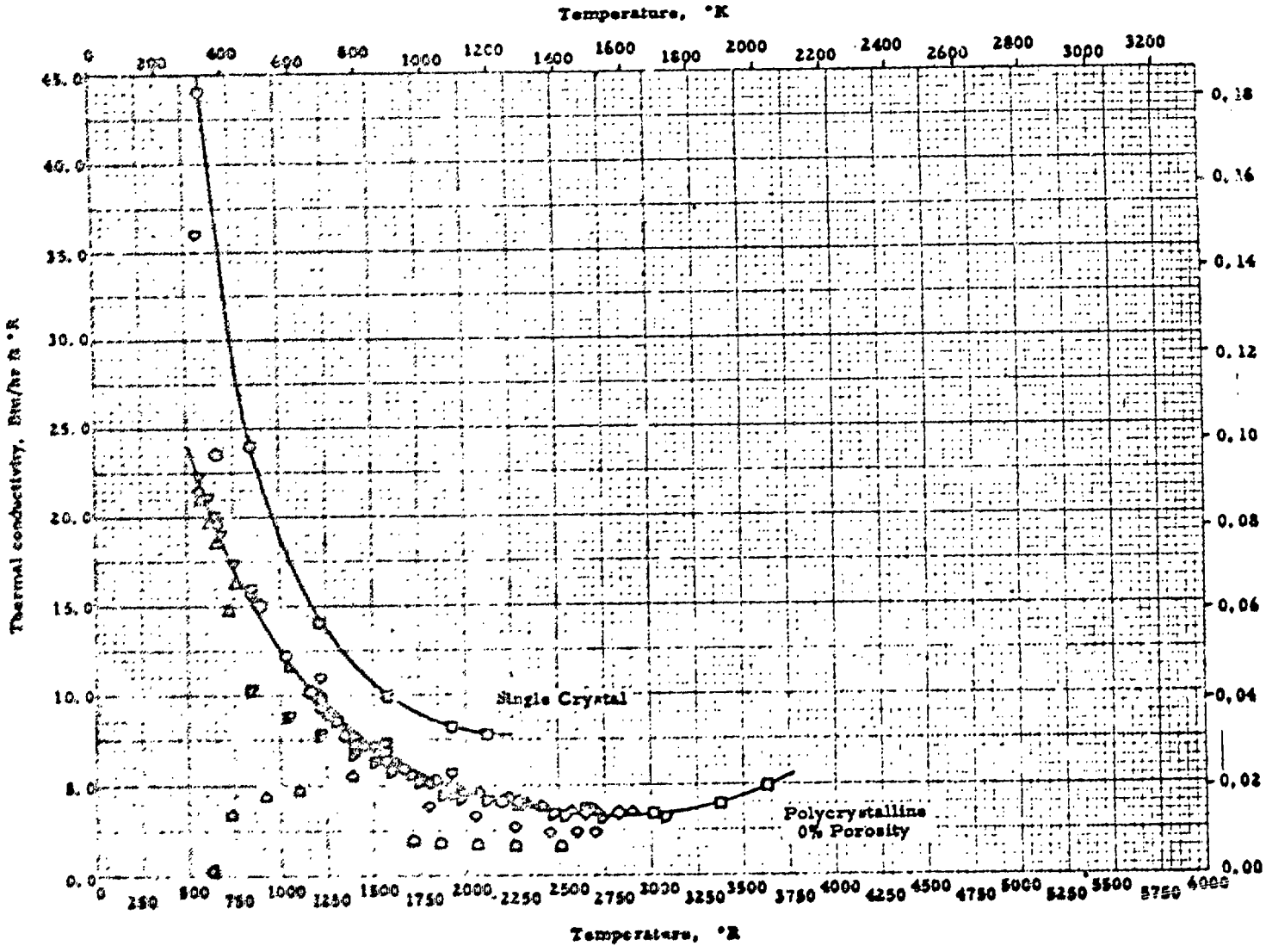


SPECIFIC HEAT -- MAGNESIUM OXIDE

SPECIFIC HEAT -- MAGNESIUM OXIDE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Arthur, J. S.	50-7	852-1936	Magnesia, MgO	Modified drop method; sample transferred manually from furnace to calorimeter	Doubtful accuracy



THERMAL CONDUCTIVITY -- MAGNESIUM OXIDE

THERMAL CONDUCTIVITY -- MAGNESIUM OXIDE

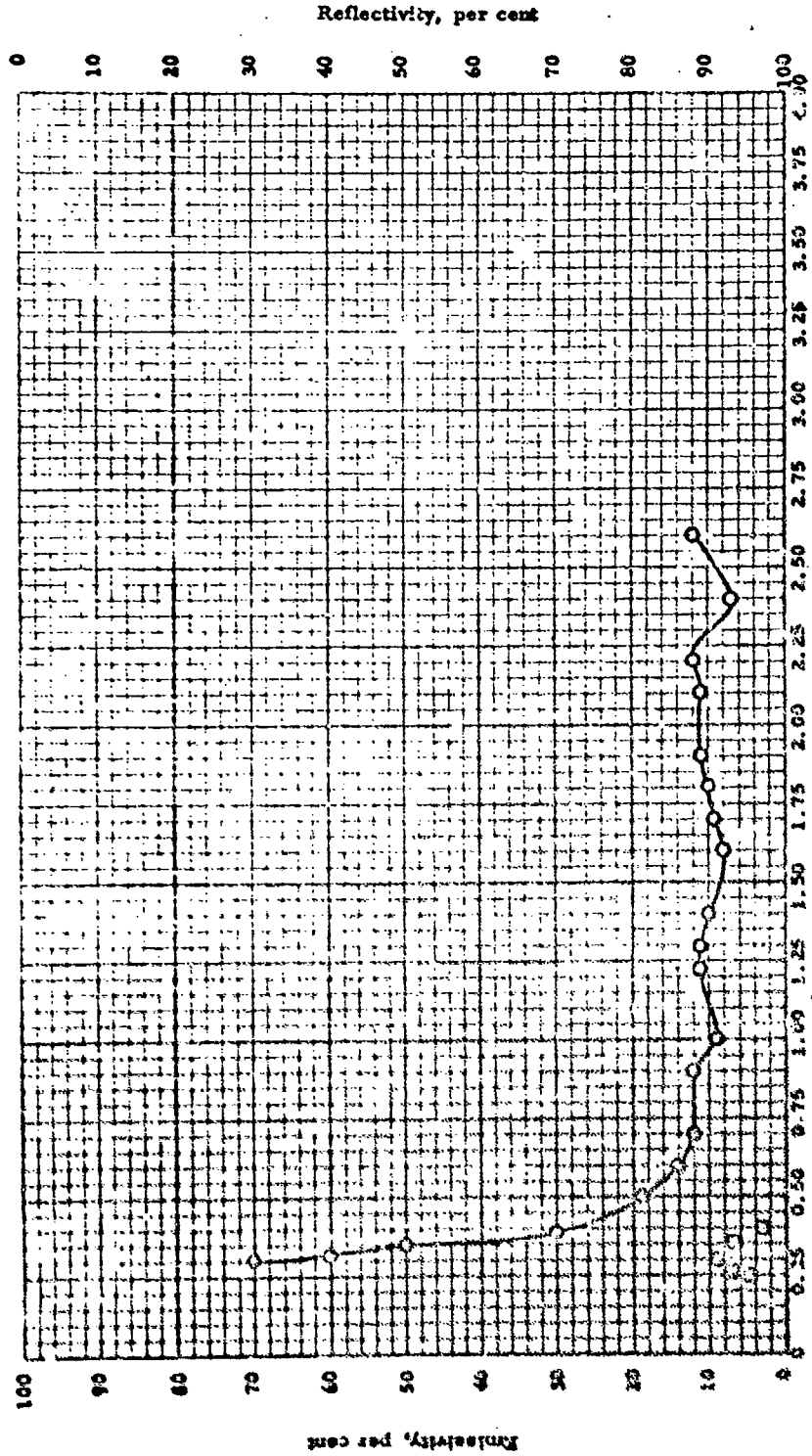
REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Francl, J. and Kingery, W. D.	54-6 also 53-67 52-66	582-1662	ρ = 217 lb_m/ft^3; zero apparent porosity	Comparative; rods	Slip cast from suspension of finely ground material
□	McQuarrie, Malcolm	54-3 also 52-55 53-67	2292-3642	Prepared from 99.16% MgO; 0.35% CaO; 0.30% SiO_2; 0.14% Al_2O_3; 0.05% Fe_2O_3	Prolate spheroidal envelope	Slip cast from ground powder
◇	Adams, Milton	54-5 also 53-67	1212-2832	ρ = 203 - 205 lb_m/ft^3; porosity 8.1 - 8.9%	Prolate spheroidal envelope	Slip cast from suspension of finely ground material
△	New Jersey Ceramic Research Station	53-3	568-754	ρ = 200 lb_m/ft^3	Comparative; rods (Cu standard)	Made from spectroscopically pure $MgCO_3$; tested in vacuum
▽	New Jersey Ceramic Research Station	53-4	567-752	97.5% MgO; 2.5% Talc. ρ = 217 lb_m/ft^3	Comparative; rods (Cu standard)	Fired 1 hr. at 2800°F; tested in vacuum
⊡	Whittemore, Jr., O. J.	49-1	1710-2510	ρ = 175 lb_m/ft^3; total porosity = 32%; apparent porosity = 19%	Flat plate; liq. calorimeter	Periclase product made from 6 mesh and finer grain; fired at 3230°F
⊙	Clarvat, F. R. and Kingery, W. D.	57-53	492-2292	Single crystal: 0.05% total MgO, CaO, K_2O; 0.02% SiO_2; 0.01% Fe_2O_3	Comparative; rods (Al_2O_3 cube standards)	
▽	Ibid.	57-53	492-2292	Polycrystalline; average crystal size 8μ porosity = 4.75%	Same as above	Data corrected to zero porosity
⊙	Ibid.	57-53	492-2292	Polycrystalline; average crystal size 12μ porosity = 13.7%	Same as above	Same as above
△	Knapp, W. J.	43-11	735-1390	Synthetic periclase, isotropic	Comparative; rods; stainless steel cube standard	
⌂	Norton, F. H., Kingery, W. D. et. al.	54-144	1032-2652	MgO	Ellipsoidal envelope	Data corrected to zero porosity
◇	Norton, F. H. et. al.	50-66	1549-2699	MgO	Oblate ellipsoidal envelope	Conductivity increased during 4 runs for 1 specimen
▽	Norton, F. H. and Kingery, W. D.	51-75	830-3010	MgO	Two methods: ▽ - comparative, rods (alumina standard) ⊡ - ellipsoidal envelope	Sample developed crack. Auth. est. accuracy ± 5% for ellipsoid.

THERMAL CONDUCTIVITY -- MAGNESIUM OXIDE (Cont'd)

REFERENCE INFORMATION

Curve	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
D	Norton, F. H. et. al.	51-76	1199-2737	0.35% Fe_2O_3; 0.30% SiO_2; 0.14% Al_2O_3; 0.03% Fe_2O_3; 0.00% ea. Cr_2O_3; TiO_2	Not given	Hydrostatically pressed at 30,000 psi
O	Norton, F. H.	51-77	1211-2813	MgO	Ellipsoidal envelope	Auth. est. accuracy ± 20% max.
C	Manowitz, B.	51-137	536	MgO pressed powder; ρ= 1.5 lb_m/ft^3	Stacked discs lucite standard	Samples pressed at 30,000 psi

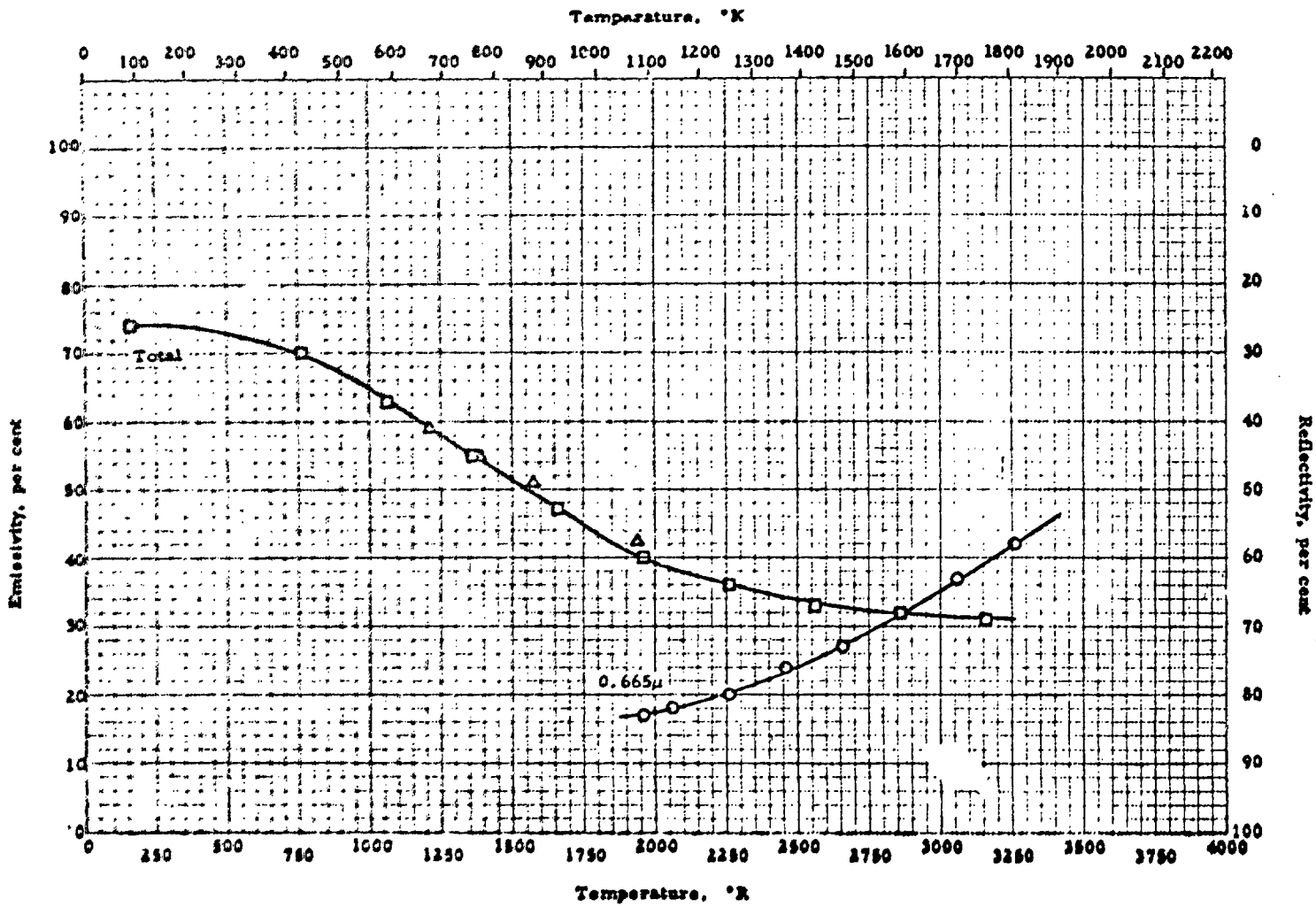


SPECTRAL EMISSIVITY -- MAGNESIUM OXIDE

SPECTRAL EMISSIVITY -- MAGNESIUM OXIDE

REFERENCE INFORMATION

Curve Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Data, K. T., Olson, O. H. et al.	57-8	Room	Bureau of Standards refractory	Spectral reflectivity at 9°: sample compared with $MgCO_3$ standard in MgO integrating sphere, quartz lens, PbS detector	
□	Benford, F., Schwarz, S. and Lloyd, G. B.	44-35	Room	Magnesia	Spectral reflectivity: Part-sphere method with 5/6 and 4/6 spheres UV arc on Rowland grating. 9 stage photomultiplier of low stability.	

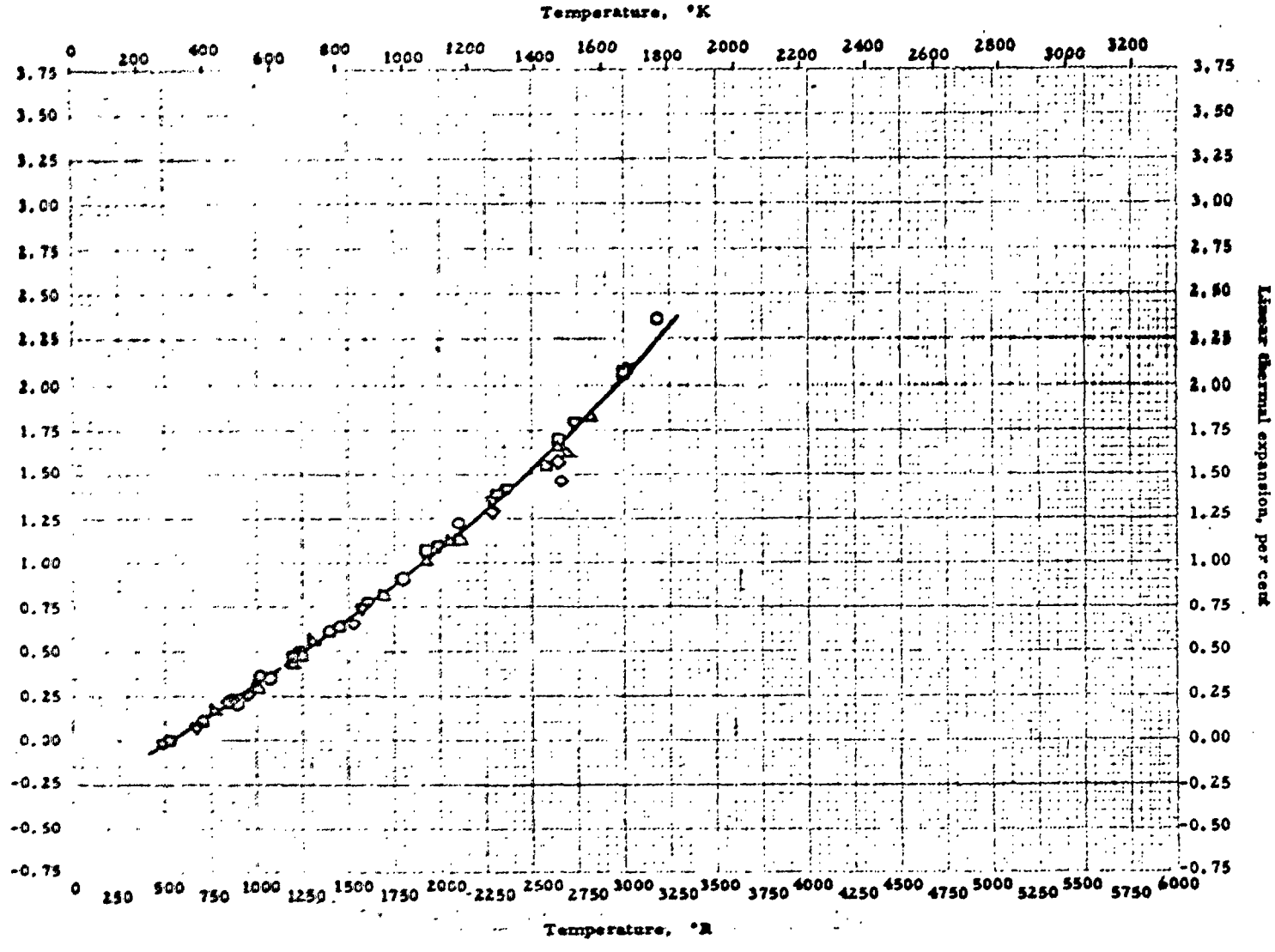


EMISSIVITY -- MAGNESIUM OXIDE

EMISSIVITY -- MAGNESIUM OXIDE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Olson, O.H. and Morris, J.C.	59-1 also 58-1	1960-3260	Fused	Spectral normal emissivity at 0.665μ:comparative: surface brightness compared with that of a black body hole, disappearing filament optical pyrometer;sample temp. by thermocouple	
□	Ibid.	59-1 also 58-1	160-3160	Same as above	Total normal emissivity: comparative;radiant heat flow compared with that of a black body, thermopile;sample temp. by thermocouple	
△	Sully, A.H., Brandes, E.A. and Waterhouse, R.B.	52-81	1212-1932	"Pure"	Total normal emissivity: radiant heat meas. with thermopile;sample temp. by Pt-Rh thermocouple	

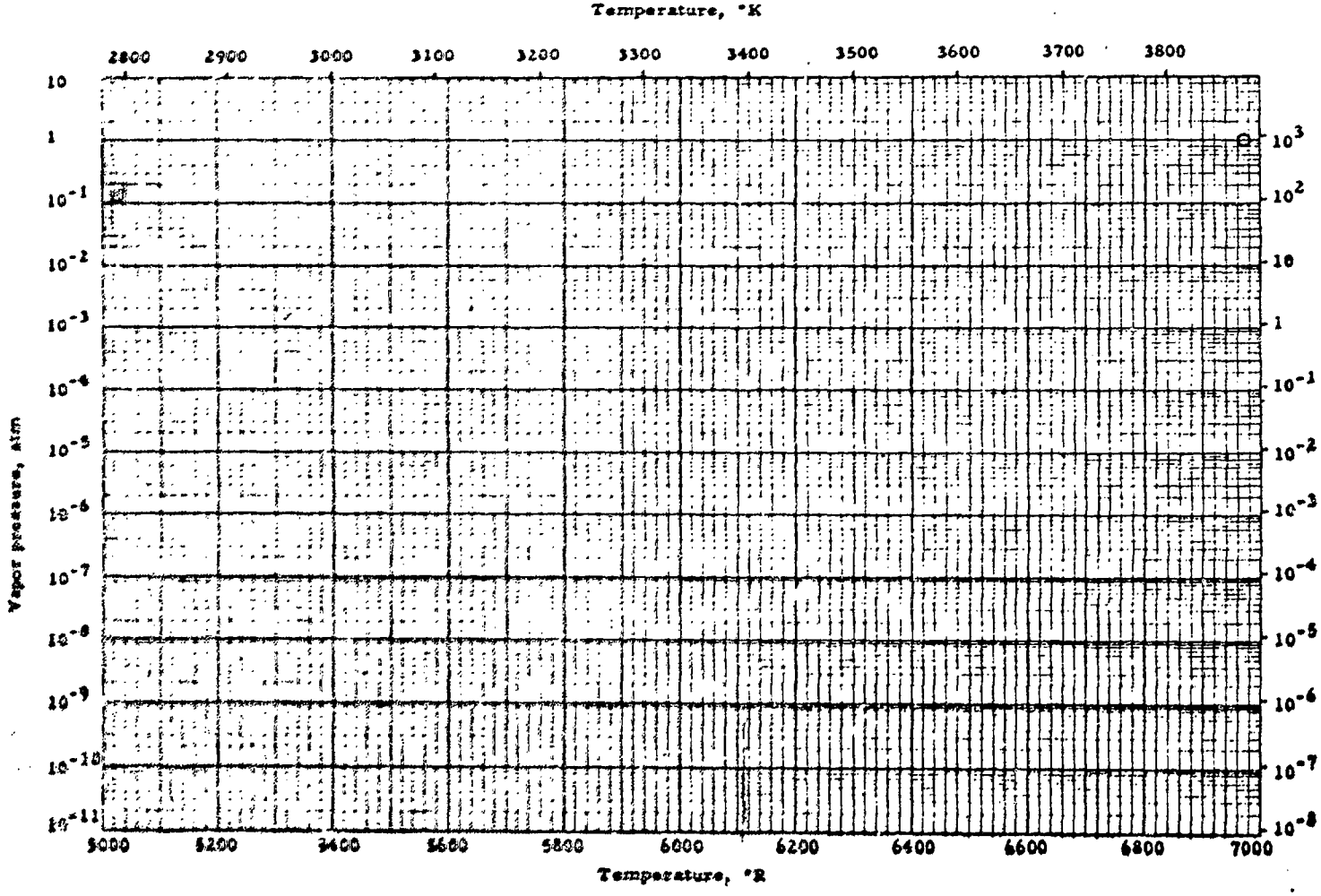


LINEAR THERMAL EXPANSION -- MAGNESIUM OXIDE

LINEAR THERMAL EXPANSION -- MAGNESIUM OXIDE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Whittemore, O. J. and Ault, N. N.	56-7	1032-3192	Coarse fused grain MgO	Telemicroscopes sighting on sample	
□	Crandall, W. B.	52-100	528-3012	Single crystal MgO	Meas. variation in light intensity through parallel line gratings due to movement of one relative to the other	
△	Schwartz, B.	52-11	537-2832	Made from fused refractory grains (<1% impurities)	Telemicroscopes sighting on sample	Slip cast, dried, fired at 1150°C, machined, matured 3 hr. at 1830°C
◇	Beals, R. J. and Cook, R. L.	57-20	528-2652	Reagent grade MgO	X-ray back reflection	
▽	Trombe, F.	49-16	528-2292	"Pure" MgO	Not given	Cast
○	Skinner, B. J.	57-21	540-1800	Synthetic periclase	X-ray diffraction	Auth. est. accuracy ±0.5%
⌂	Gangler, J. J.	50-10 also 49-20	1535-1460	60.2% Mg; 39.5% O_2; 0.07% combined carbon; < 0.01% free carbon. ρ = 211.5 lb_m/ft^3	Interferometer	
▽	Mauer, F. A. and Bole, L. H.	55-58	492-3019	99.6% MgO	X-ray diffraction	
□	Kingery, W. D.	57-33	528-2292	Not given	Not given	
⊙	Pole, G. R., Deinlich, A. W. and Gilbert, N.	46-14	528-2652	97.5% electrically fused MgO; 2.5% sea-water MgO. Fired to 1450°C: Porosity = 31%, ρ = 151 lb_m/ft^3. Fired to 2100°C: Porosity = 19%, ρ = 177 lb_m/ft^3	Not described here, refers to others	Fired. Heated at 4°C/min
▲	Zimmerman, W. F. and Allen, A. W.	56-164	528-2621	MgO	X-ray back reflection	High purity
▷	Ibid.	56-164	528-2639	MgO	Same as above	Dead burned Magnesite ($MgCO_3$)

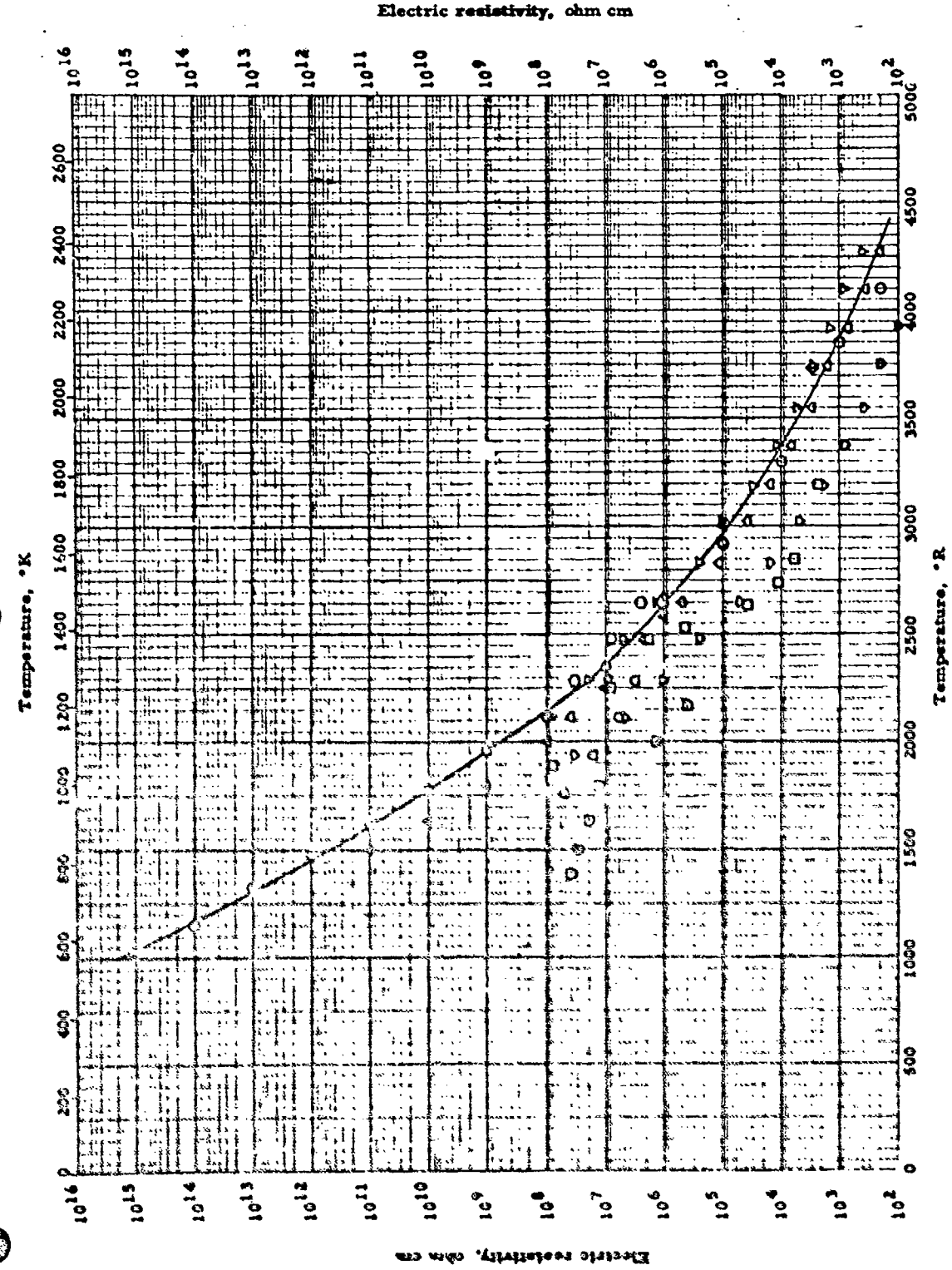


VAPOR PRESSURE--MAGNESIUM OXIDE

VAPOR PRESSURE -- MAGNESIUM OXIDE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Trombe, F.	49-16	6972	MgO	Not given	



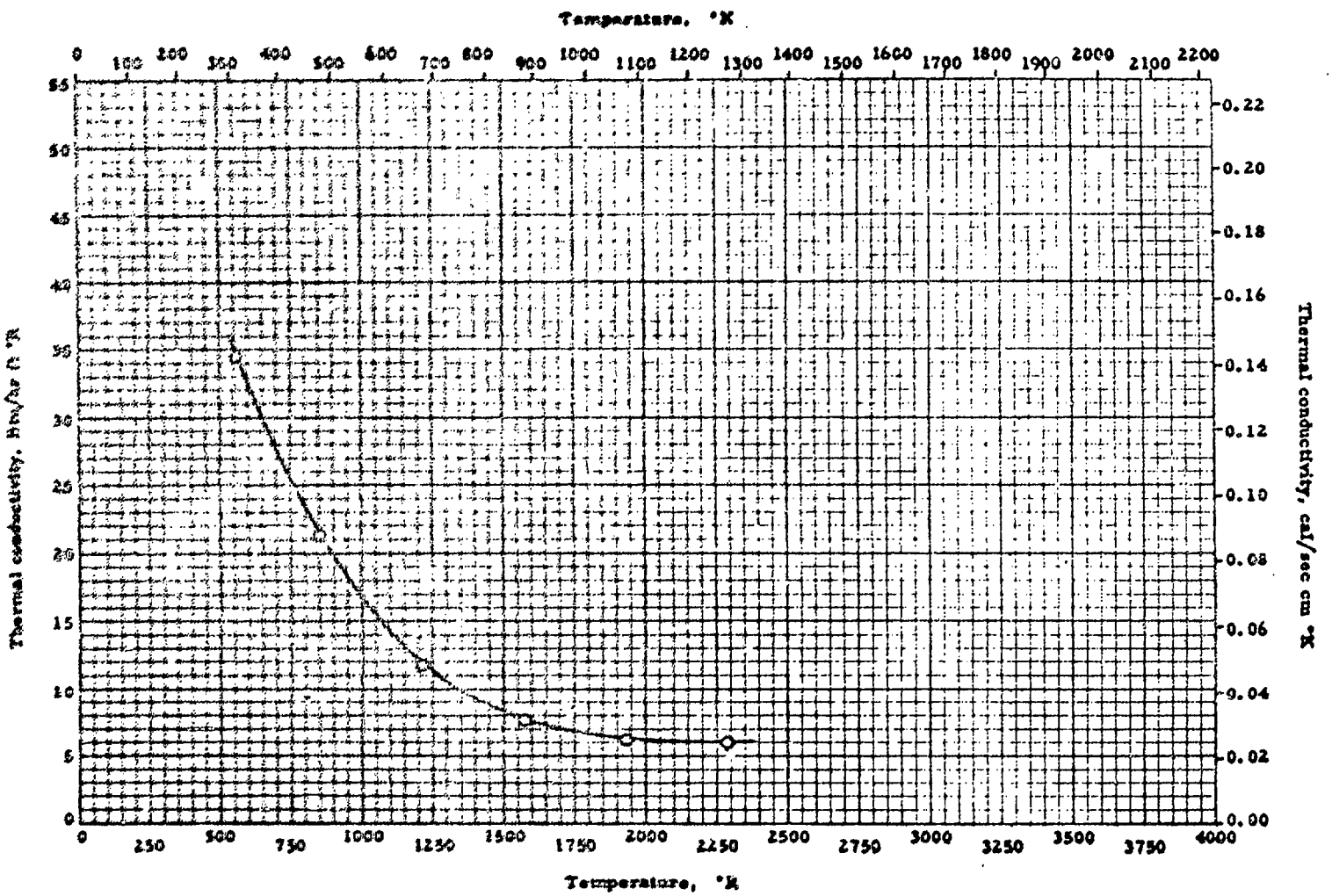
ELECTRIC RESISTIVITY -- MAGNESIUM OXIDE

WADC TR 58-476 (pt I)

ELECTRIC RESISTIVITY -- MAGNESIUM OXIDE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °K	Material Composition	Test Method	Remarks
○	Wright, W. and Hasse, G.	54-94	1032-4092	"Very pure"	Potential drop: sample temp. by calibrated Pt-Rh thermocouple	Burned 99.99% pure Mg in purified O_2, powder mixed with conductivity water and sintered in high vacuum
□	Hamaker, J.R. and Henry, E.C.	53-95	1076-1192	100% MgO; c.p. grade	Wheatstone bridge	Calcined at 1000°C fired 10 hr. to 1500°C
△	Mansfield, R.	53-102	1500-3000	MgO	Potential drop	Sintered 14 hr. at 1500°C. Density 70% greater than calculated from X-ray measurements
◇	Trombe, F.	49-14	2552-3712	MgO	Not given	
▽	Foex, M.	62-10	1752-4172	"Pure" ρ = 174 lb_m/ft^3	Potential drop; sample temp. by optical pyrometer	Compressed at 430 psi and calcined at 2100°C
○	Ibid.	62-10	1752-4172	"Pure" ρ = 62 lb_m/ft^3	Same as above	Compressed at 430 psi and calcined at 1200°C
□	Ibid.	62-10	1752-4172	"Pure" ρ = 62 lb_m/ft^3	Same as above	Hydrated, compressed at 430 psi
◇	Ibid.	62-10	1752-4172	"Pure" ρ = 234 lb_m/ft^3	Same as above	Cast
▽	Ibid.	62-10	1752-4172	97.5% MgO; 2% ZrO_2. ρ = 233 lb_m/ft^3	Same as above	Cast industrial grade
○	Nikhodnova, A. P.	56-73	1392-2170	MgO, polycrystalline	Potential drop, temp. by Mo-Ni thermocouple	Prepared from chemically pure materials. Calcined for 2 hr.

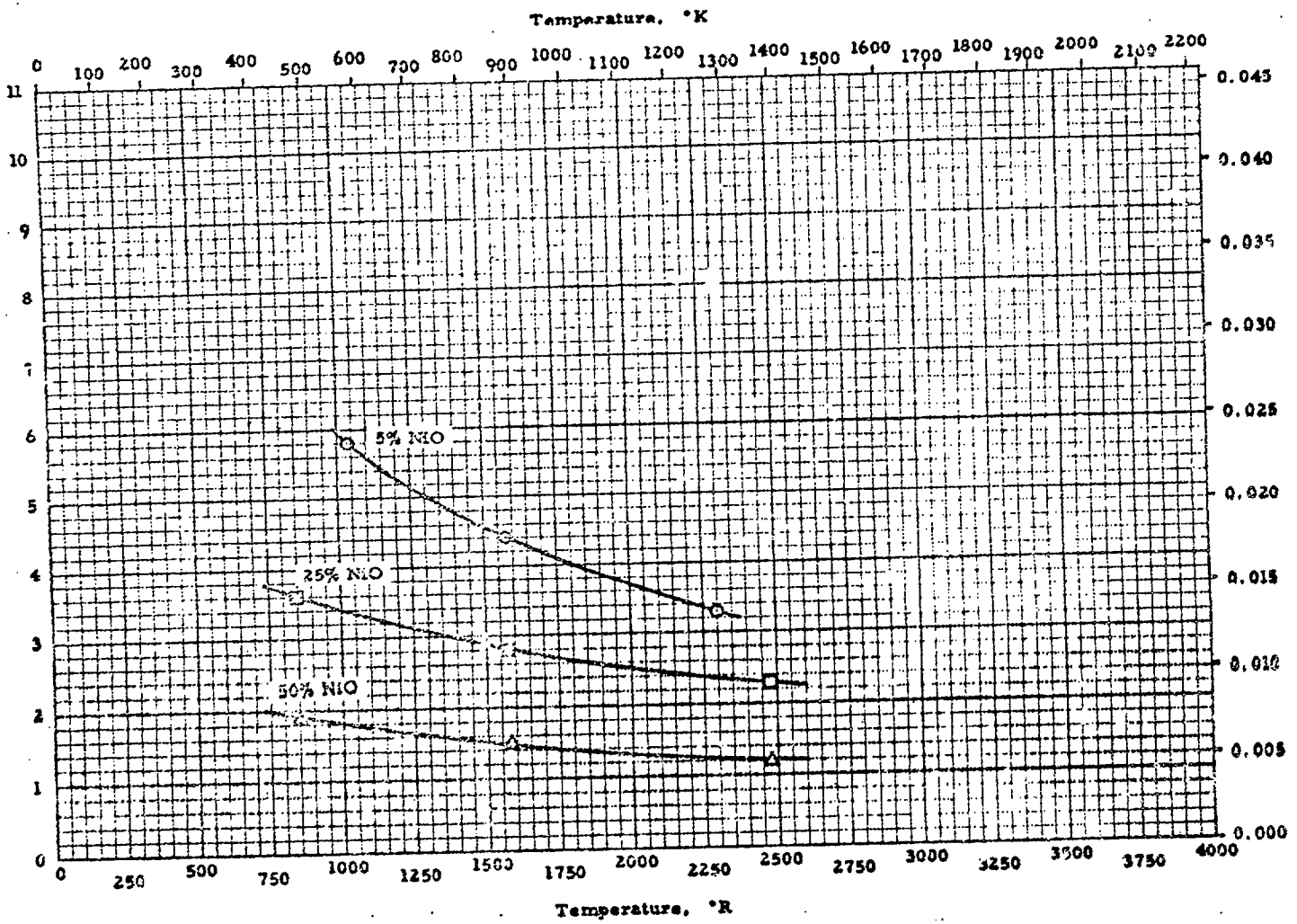


THERMAL CONDUCTIVITY -- MAGNESIUM OXIDE + BERYLLIUM OXIDE

THERMAL CONDUCTIVITY -- MAGNESIUM OXIDE + BERYLLIUM OXIDE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °K	Material Composition	Test Method	Remarks
O	Norton, F. H. and Kingery W. D.	54-142	564-2292	50% MgO; 50% BeO; bulk ρ = 152 lb$_m$/ft^3 at 25.7% porosity	Ellipsoidal envelope	Slip cast. Data corrected to zero porosity by auth.

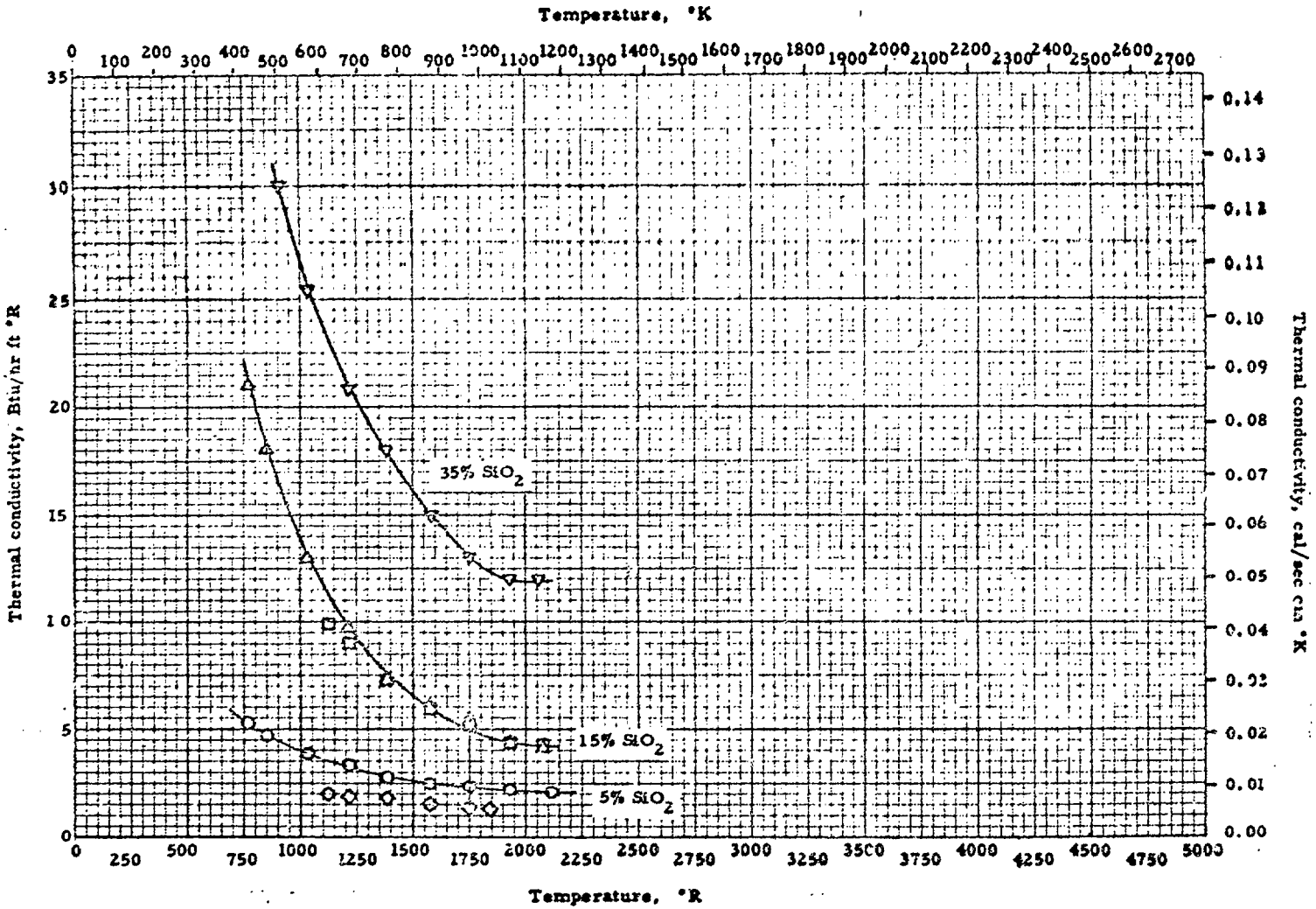


THERMAL CONDUCTIVITY -- MAGNESIUM OXIDE + NICKEL OXIDE

THERMAL CONDUCTIVITY -- MAGNESIUM OXIDE + NICKEL OXIDE

REFERENCE INFORMATION

Sym bol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Norton, F. H., Kingery, W. D. et al.	54-144	1032-2292	5% NiO	Ellipsoidal envelope	Data corrected to zero porosity by auth.
□	Ibid.	54-144	852-2472	25% NiO	Same as above	Same as above
△	Ibid.	54-144	852-2472	50% NiO	Same as above	Same as above

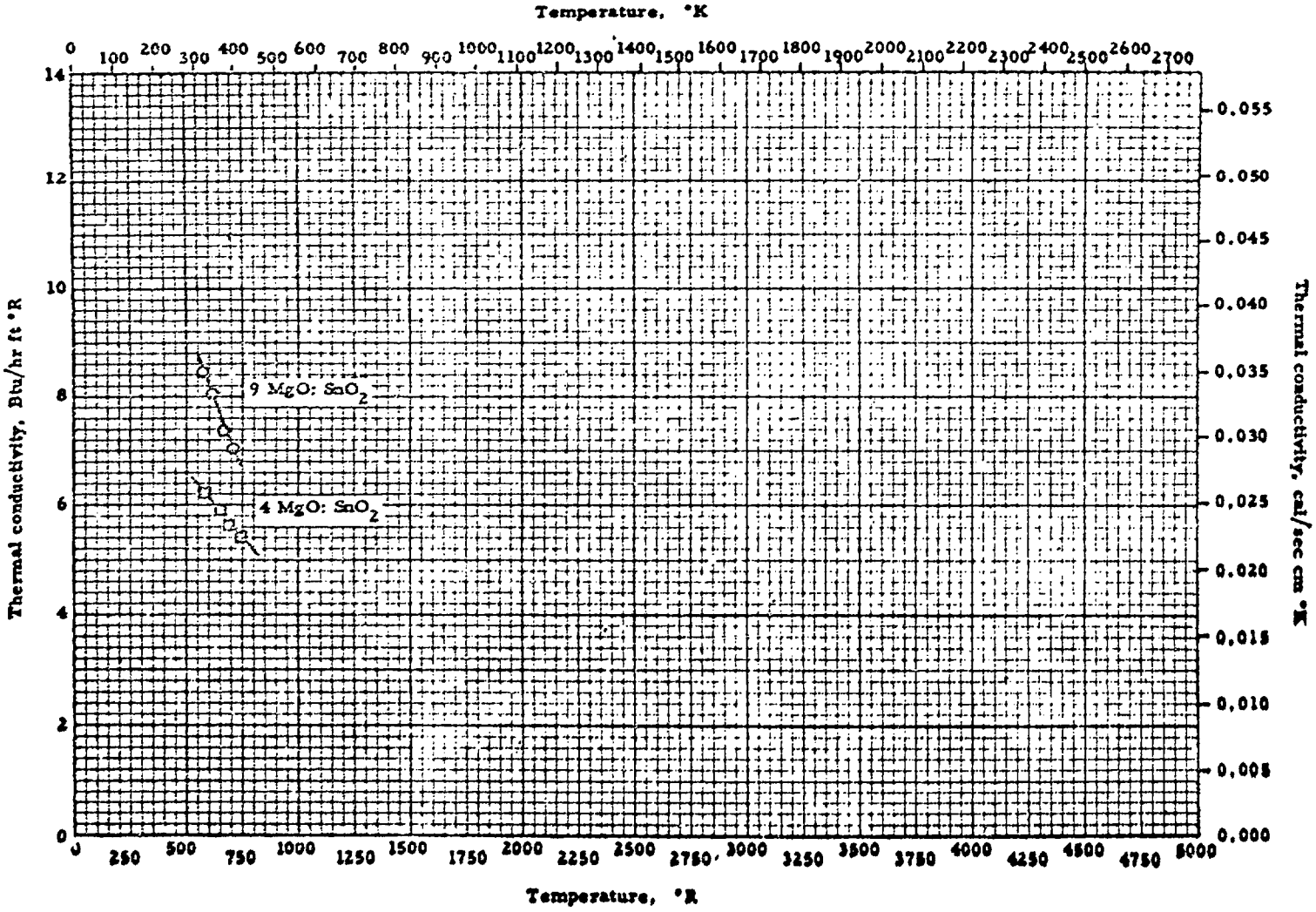


THERMAL CONDUCTIVITY -- MAGNESIUM OXIDE + SILICON OXIDE

THERMAL CONDUCTIVITY -- MAGNESIUM OXIDE + SILICON OXIDE

REFERENCE INFORMATION

Sym bol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
□	Norton, F. H., and Kingery, W. D.	55-25	1122-2076	92.7% MgO; 7.3% SiO_2	Comparative; rods	"Preliminary data"
○	Kingery, W.D., and Norton, F. H.	55-53	762-2112	95% MgO; 5% SiO_2	Comparative; rods	
△	Ibid.	55-53	762-2022	85% MgO; 15% SiO_2	Same as above	
◇	Ibid.	55-53	1122-1842	75% MgO; 25% SiO_2	Same as above	
▽	Kingery, W.D., and Norton, F.H.	55-47	852-2112	65% MgO; 35% SiO_2	Comparative; rods	

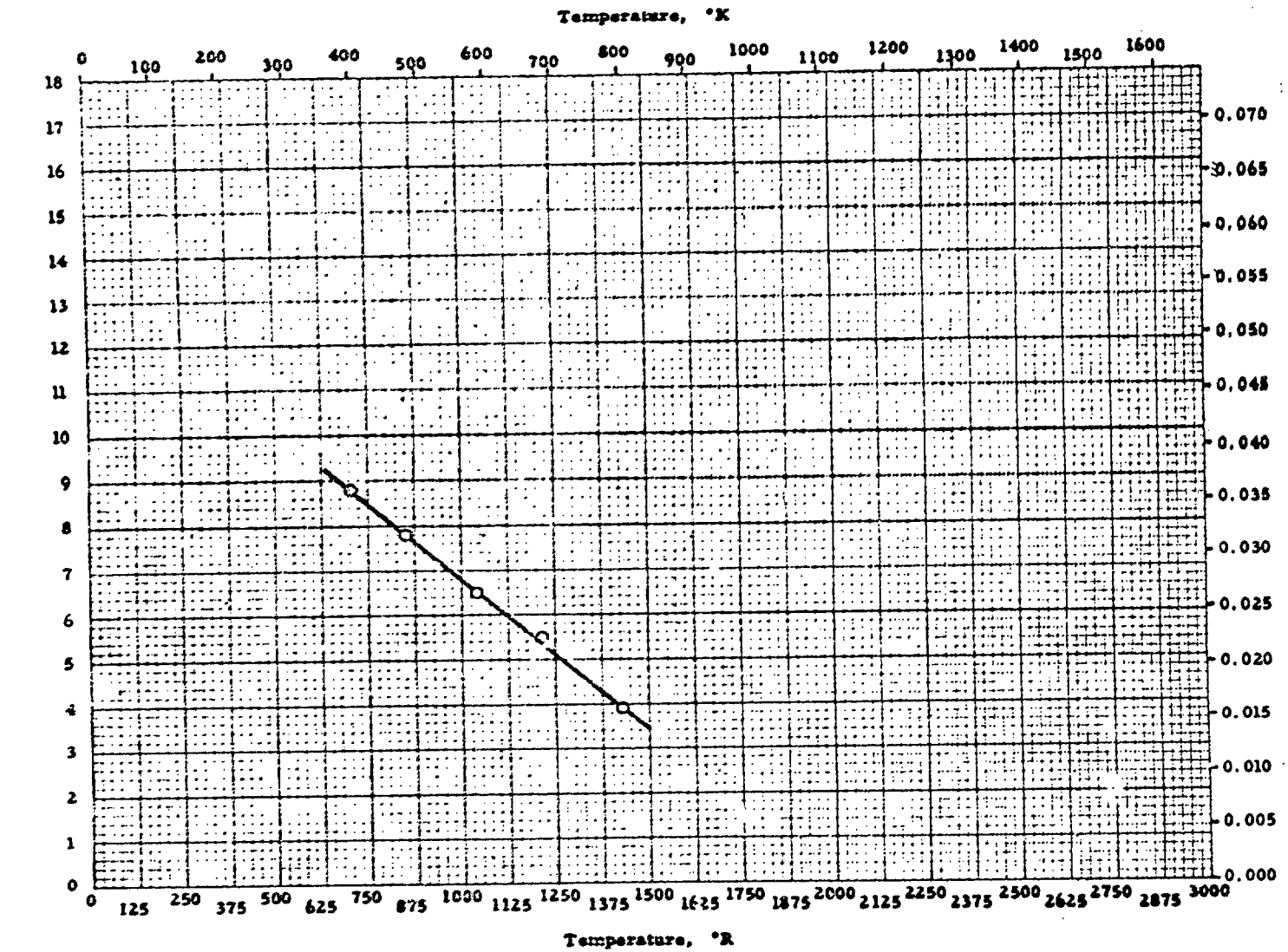


THERMAL CONDUCTIVITY -- MAGNESIUM OXIDE + TIN OXIDE

THERMAL CONDUCTIVITY -- MAGNESIUM OXIDE + TIN OXIDE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	New Jersey Ceramic Research Station	53-4	575-705	9 MgO : SnO_2; 70.7% MgO; 29.3% SnO_2 (0.17% water absorption); ρ = 240 lb_m/ft^3	Comparative	Fired 1.5 hr. at 2800°F; tested in vacuum
□	Ibid.	53-4	580-747	4 MgO : SnO_2; 51.7% MgO; 48.3% SnO_2 (0.028% water absorption); ρ = 261 lb_m/ft^3	Same as above	Fired 1.5 hr. at 2700°F; tested in vacuum

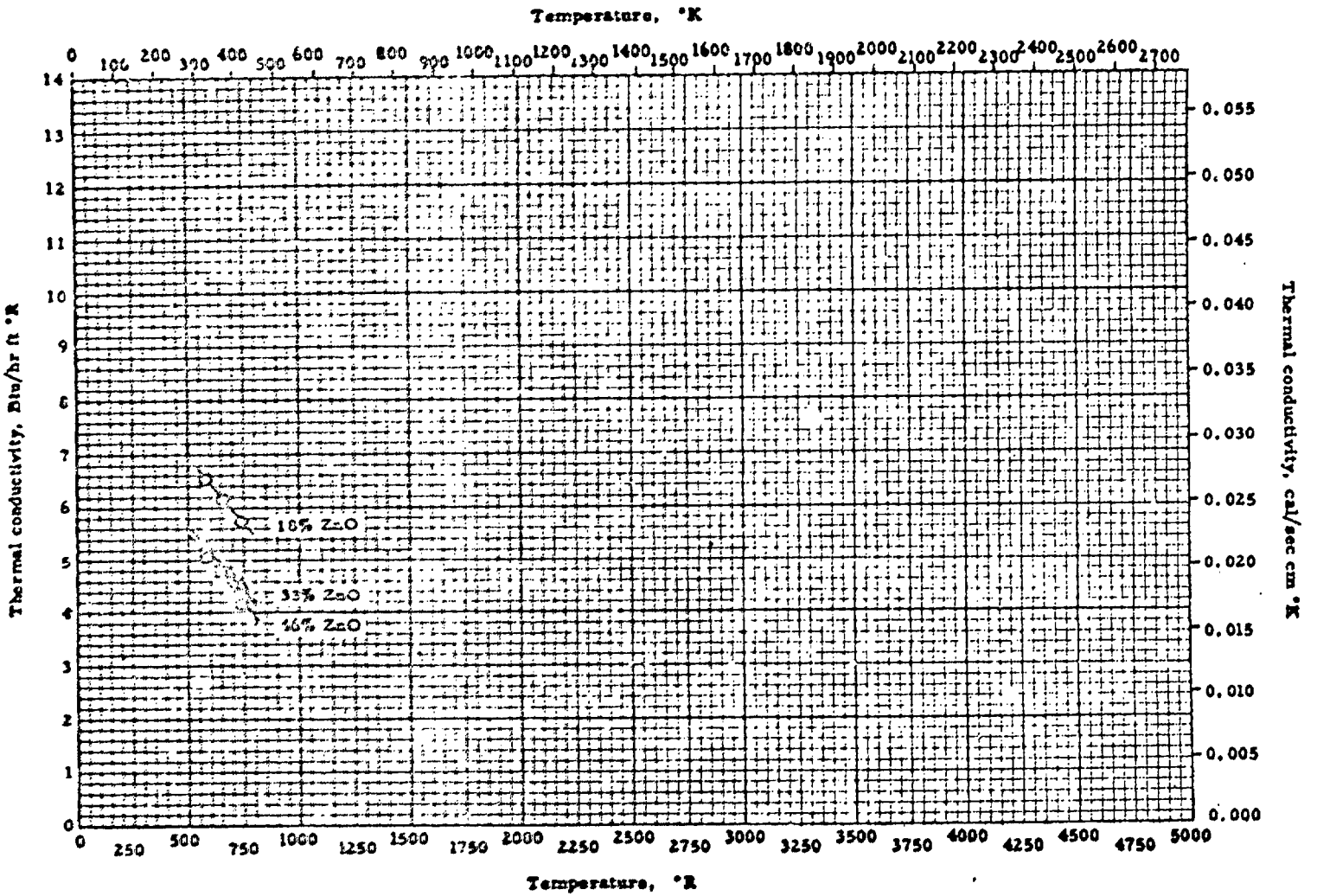


THERMAL CONDUCTIVITY -- MAGNESIUM OXIDE + URANIUM OXIDE

THERMAL CONDUCTIVITY -- MAGNESIUM OXIDE + URANIUM OXIDE

REFERENCE INFORMATION

Curve No.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	McCreight, L. R.	57-148	768-1428	53% MgO; 47% UO_2. ρ = 87% of theoretical	Two methods: a. comparative, rods b. axial heat flow in rod, calorimeter sink, guarded sample	Sintered

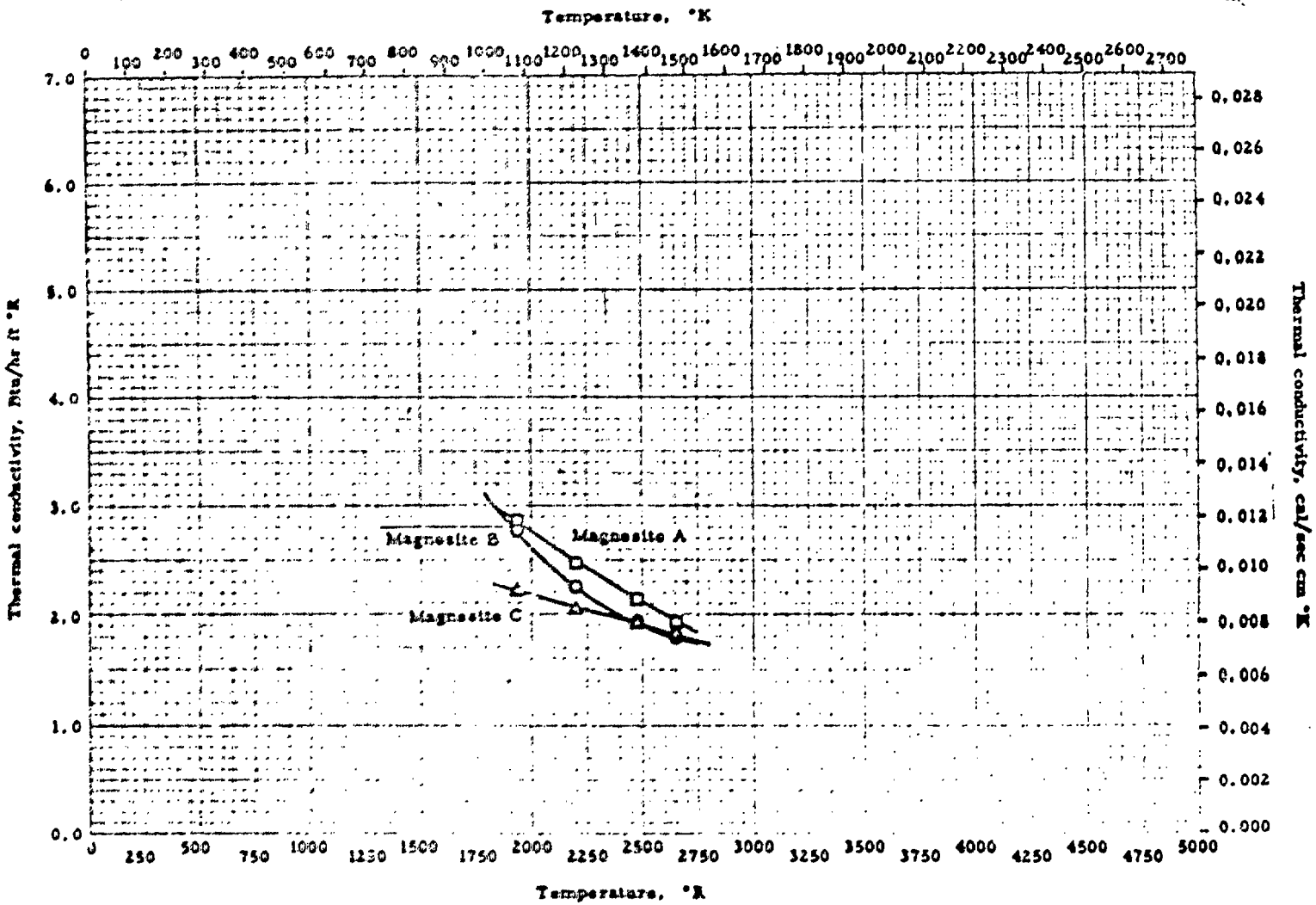


THERMAL CONDUCTIVITY -- MAGNESIUM OXIDE-ZINC OXIDE

THERMAL CONDUCTIVITY -- MAGNESIUM OXIDE + ZINC OXIDE

REFERENCE INFORMATION

Sym	Investigator	Ref.	Range, °F.	Material Composition	Test Method	Remarks
O	New Jersey Ceramic Research Station	53-5	579-740	81.7% MgO; 18.3% ZnO; ρ = 314.5 lb_m/ft^3	Comparative; rods	9 MgO: ZnO. Fired to 2700 °F. Tested in vacuum
□	Ibid.	53-5	576-741	66.5% MgO; 33.5% ZnO; ρ = 303.3 lb_m/ft^3	Same as above	4 MgO: ZnO. Fired 2 hr. at 2700°F. Tested in vacuum
△	Ibid.	53-5	574-740	53.6% MgO; 46.4% ZnO;	Same as above	7 MgO: 3 ZnO. Fired 2 hr, at 2700 °F. Tested in vacuum

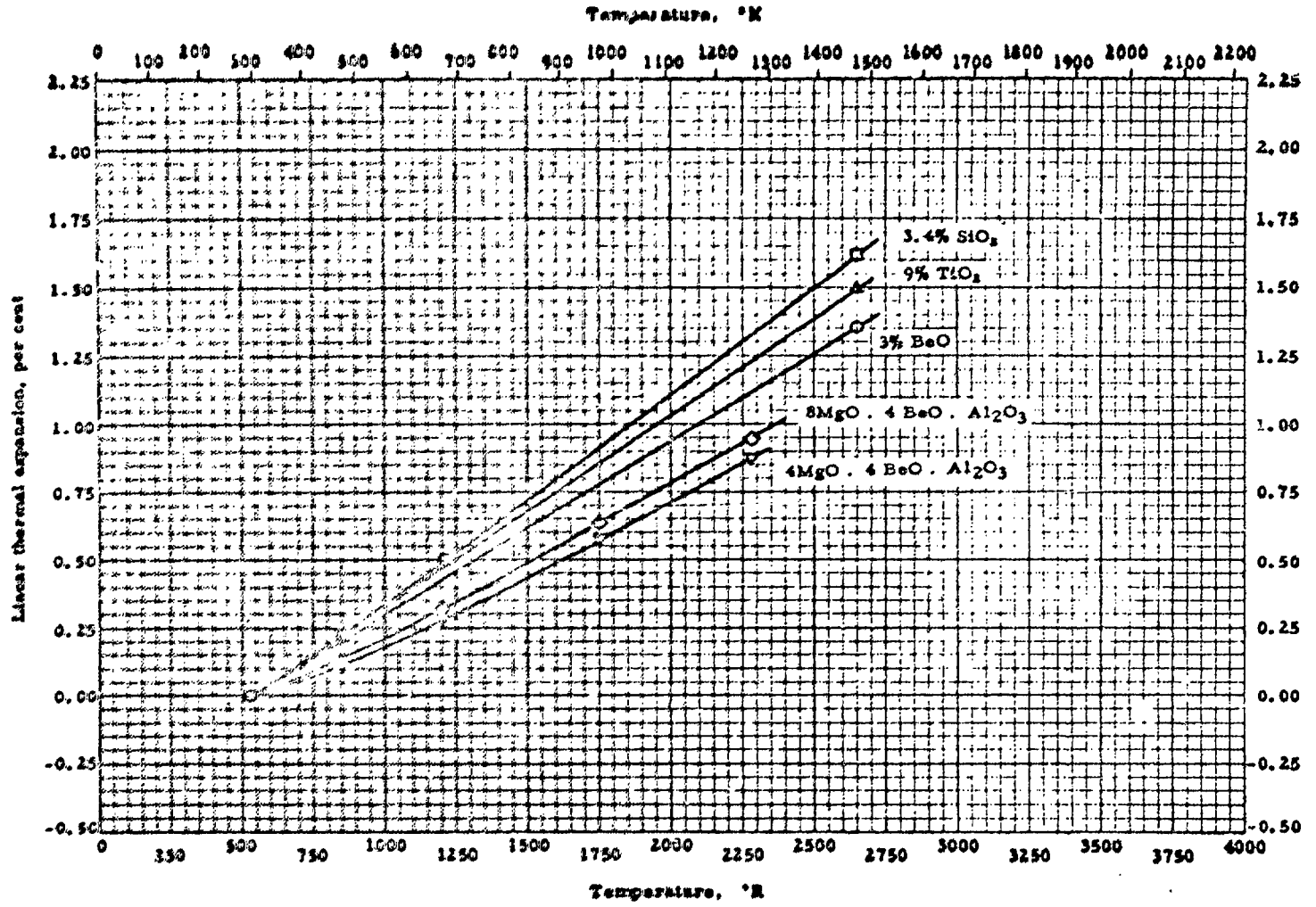


THERMAL CONDUCTIVITY -- CALCINED MAGNESITE

THERMAL CONDUCTIVITY -- CALCINED MAGNESITE

REFERENCE INFORMATION

Sym	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Clumecia, J.F., and Vyse, J.	57-26	1932-2652	Magnesite B: 93.10% MgO; 2.78% Fe_2O_3; 2.16% CaO; 1.22% SiO_2; 0.54% Al_2O_3; 0.12% TiO_2; 0.03% Na_2O; 0.01% K_2O; 0.12% loss on ignition. ρ = 172 lb_m/ft^3; apparent porosity = 22.6%	Not adequately described	Auth. est. accuracy ± 8%
□	Ibid.	57-26	1932-2652	Magnesite A: 90.08% MgO; 2.91% Fe_2O_3; 3.40% CaO; 1.64% SiO_2; 0.75% Al_2O_3; 0.14% TiO_2; 0.04% Na_2O; 0.02% K_2O; 0.10% loss on ignition. ρ = 192 lb_m/ft^3; apparent porosity = 14.5%	Same as above	Same as above
△	Ibid.	57-26	1932-2652	Magnesite C: 85.86% MgO; 4.99% Al_2O_3; 3.73% Fe_2O_3; 3.22% SiO_2; 2.06% CaO; 0.13% Na_2O; 0.06% K_2O; 0.16% loss on ignition. ρ = 182 lb_m/ft^3; apparent porosity = 17.2%	Same as above	Same as above

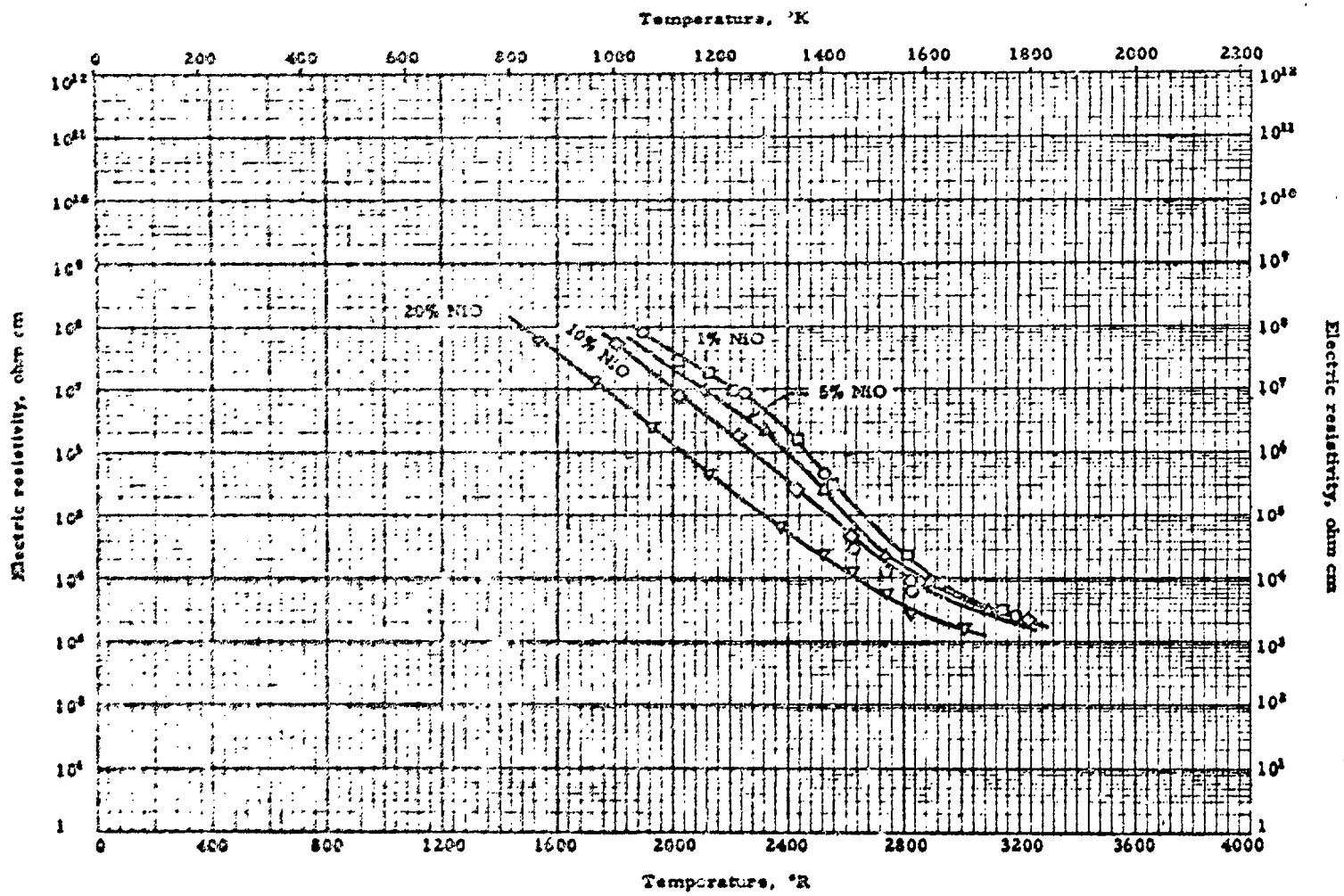


LINEAR THERMAL EXPANSION -- MAGNESIUM OXIDE + OTHER OXIDES

LINEAR THERMAL EXPANSION -- MAGNESIUM OXIDE + OTHER OXIDES

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °K	Material Composition	Test Method	Remarks
○	Pole, G. R., Deinlein Jr., A. W. and Gilbert, N.	46-14	528-2652	97% MgO; 3% BeO (ρ= 156 lb_m/ft^3 and 29% porosity for 2.5% BeO fired at 1450°C)	Not described here, refers to others	Heated at 4° C/min.
□	Ibid.	46-14	528-2652	97.5% No. 93 periclase (95% MgO, 3.5% SiO_2), 2.5% sea-water MgO. Porosity 31%, ρ = 155 lb_m/ft^3	Same as above	Same as above
△	Ibid.	46-14	528-2652	91% MgO; 9% TiO_2	Same as above	Same as above
◇	Geller, R. F., Yavorsky, P. J. et al.	46-4	528-2292	($4MgO \cdot 4BeO \cdot Al_2O_3$). 61.49% MgO; 19.44% Al_2O_3; 19.07% BeO prepared from 97% pure MgO, 99.7% pure BeO, 99+% pure Al_2O_3	Interferometer	
▽	Ibid.	46-4	528-2292	($4MgO \cdot 4BeO \cdot Al_2O_3$). 44.40% MgO; 28.06% Al_2O_3; 27.54% BeO; raw materials same as above	Same as above	



ELECTRIC RESISTIVITY -- MAGNESIUM OXIDE + NICKEL OXIDE

DO-654 VANDC TR 64-176 189

ELECTRIC RESISTIVITY -- MAGNESIUM OXIDE + NICKEL OXIDE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Messler, J. R. and Henry, E. C.	53-95	1896-3192	100% MgO	Wheatstone bridge, with cathode-ray null indicator	Calcined to 1000°C in Pt, fired 10 hr. at 1500°C
□	Ibid.	53-95	2022-3192	99% MgO; 1% NiO	Same as above	Mixed c.p. MgO and c.p. NiO wet-mixed in Mullite mortar, dried, calcined to 1000°C in Pt, fired 10 hr. at 1500°C
△	Ibid.	53-95	2112-3156	95% MgO; 5% NiO	Same as above	Same as above
◇	Ibid.	53-95	1806-3192	90% MgO; 10% NiO	Same as above	Same as above
▽	Ibid.	53-95	1536-3012	80%; 20% NiO	Same as above	Same as above

PROPERTIES OF SILICON OXIDE

MOST PROBABLE VALUES

Property	Brit. Engineering Units	C. G. S. Units
Density.	165 lb_m/ft^3	2.65 g/cm^3
Melting Point		
Heat of Fusion		
Heat of Vaporization. . .		
Heat of Sublimation . . .		

REPORTED VALUES

Density:		lb_m/ft^3	g/cm^3
	○	165.9	2.658
	□	146.0	2.339
	△	164.5	2.635
	◇	146.1	2.341
	▽	164.0	2.628
	○	144.9	2.321
	⌂	158.9	2.545
	△	143.4	2.298
	⊔	162.5	2.604
	▽	143.6	2.301
	⌂	162.9	2.609
	◇	145.1	2.324
	▱	163.3	2.615
	▷	143.9	2.290
	◇	165 ± 4	2.65 ± 0.06

Melting Point:	°R	°K
Heat of Fusion:	Btu/lb_m	cal/g
Heat of Vaporization:	Btu/lb_m	cal/g
Heat of Sublimation:	Btu/lb_m	cal/g

PROPERTIES OF SILICON OXIDE

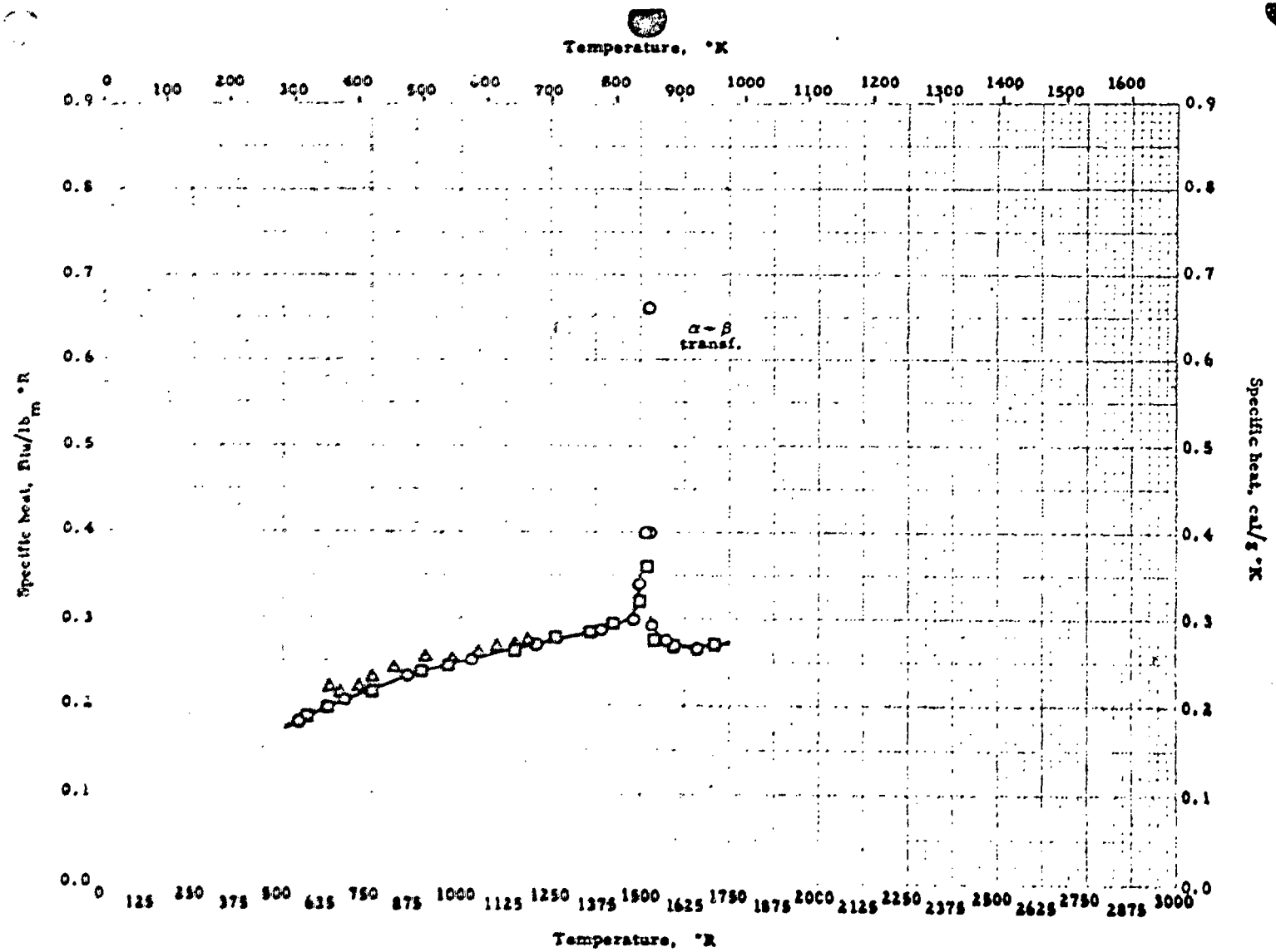
REFERENCE INFORMATION

Key	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Tokuda, T.	55-141	537	Silica rock. 95.68% SiO_2; 2.87% (Al_2O_3 + Fe_2O_3); 0.81% CaO; 0.24% MgO	ρ : pycnometer	Fired 2 hr. at 1203°C in air
□	Ibid.	55-141	537	Same as above	ρ : same as above	Fired 4 hr. at 1540°C in air. Auth. also reports values for conditions intermediate between ○ and □
△	Ibid.	55-141	537	Same as above	ρ : same as above	Fired 2 hr. at 1201°C in reducing atmos. 0.8 atm. CO; 0.2 atm. N_2
◇	Ibid.	55-141	537	Same as above	ρ : same as above	Fired 4 hr. at 1600°C in same atmos. Auth. also reports values for conditions intermediate between △ and ◇
▽	Ibid.	55-141	537	Silica rock. 97.23% SiO_2; 2.17% Fe_2O_3; 0.20% Al_2O_3; 0.18% alkalis; 0.09% CaO; 0.03% MgO	ρ : same as above	Fired 3 hr. at 1311°C in air
○	Ibid.	55-141	537	Same as above	ρ : same as above	Fired 4 hr. at 1550°C in air. Auth. also reports values for conditions intermediate between ▽ and ○
□	Ibid.	55-141	537	Silica rock. 98.35% SiO_2; 0.52% Al_2O_3; 0.43% Fe_2O_3; 0.23% MgO; 0.05% CaO	ρ : same as above	Fired 3 hr. at 1400°C in air
△	Ibid.	55-141	537	Same as above	ρ : same as above	Fired 4 hr. at 1330°C in air. Auth. also reports values for conditions intermediate between □ and △
▽	Ibid.	55-141	537	Same as above	ρ : same as above	Fired 3 hr. at 1298°C in water vapor
▷	Ibid.	55-141	537	Silica rock. 99.72% SiO_2; 0.14% Fe_2O_3; 0.10% CaO	ρ : same as above	Fired 5-1/2 hr. at 1448°C in air
◇	Ibid.	55-141	537	Silica rock. Same as above	ρ : same as above	Fired 4 hr. at 1650°C in air. Auth. also reports values for conditions intermediate between ▷ and ◇

PROPERTIES OF SILICON OXIDE (cont'd)

REFERENCE INFORMATION

Sym-bol	Investigator	Ref.	Range, °K	Material Composition	Test Method	Remarks
○	Takeda, T.	55-141	537	Silica rock. 98.35% SiO_2; 0.52% Al_2O_3; 0.43% Fe_2O_3; 0.28% MgO; p.05% CaO	ρ: pycnometer	Fired 4 hr. at 1540° C in water vapor. Auth. also reports values for conditions intermediate between ○ and ♀
○	Ibid.	55-141	537	Silica rock. 99.72% SiO_2; 0.14% Fe_2O_3; 0.10% CaO	ρ: same as above	Fired 4 hr. at 1650° C in air. Auth. also reports values for conditions intermediate between ♄ and ♀
○	Ibid.	55-141	537	Silica rock. 99.13% SiO_2; 0.63% Fe_2O_3; 0.11% alkalis; 0.09% CaO; 0.01% ea. MgO, Al_2O_3	ρ: same as above	Fired 3 5/60 hr. at 1240° C in air.
○	Ibid.	55-141	537	Same as above	ρ: same as above	Fired 4 hr. at 1537° C in air. Auth. also reports values for intermediate conditions
⊕	Oak Ridge National Lab.	57-150	537	Brazilian quartz	ρ: weight in air and in kerosene	Measured by O. Sisman, C. D. Bopp and R. L. Towns

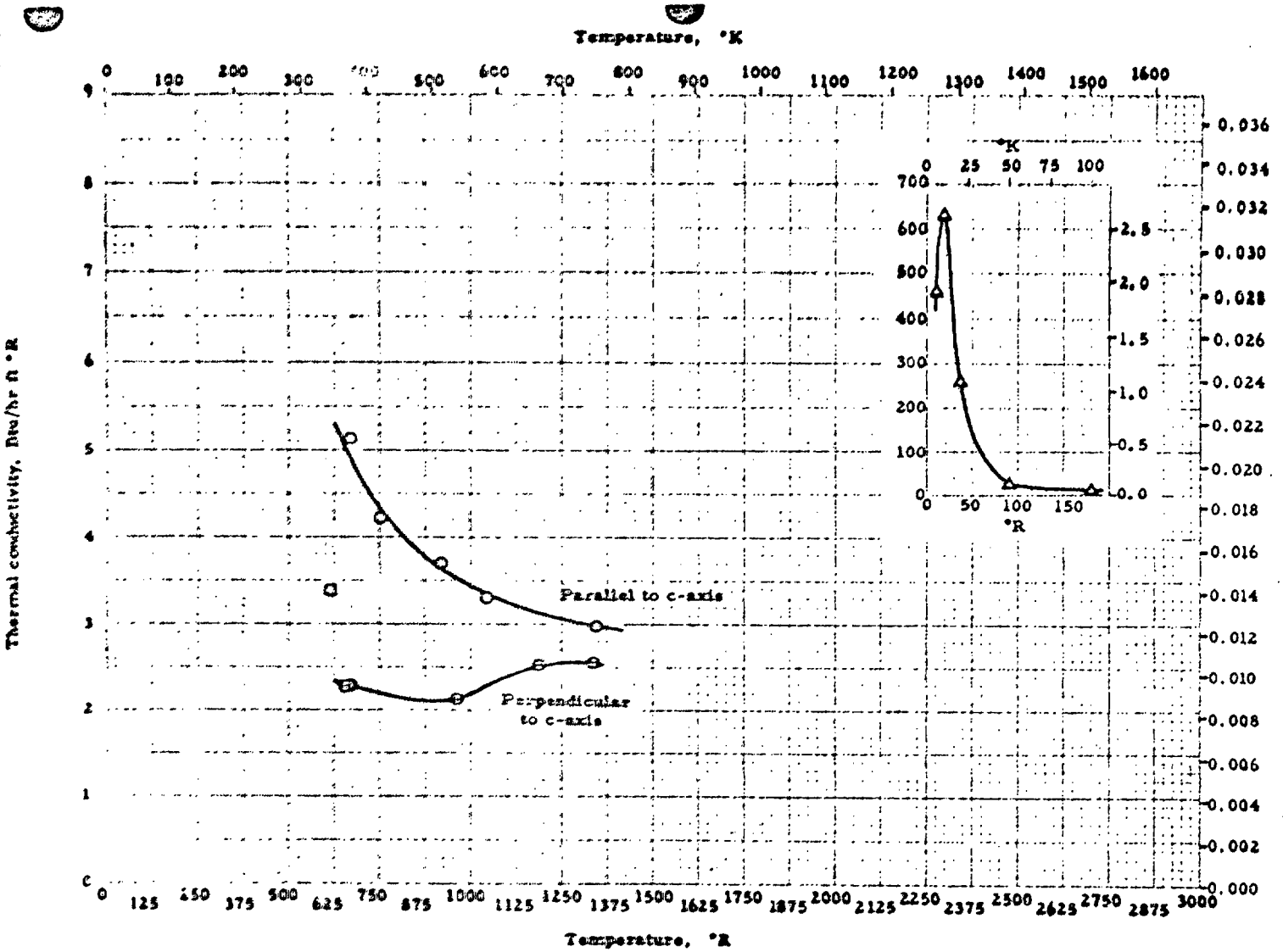


SPECIFIC HEAT -- SILICON OXIDE

SPECIFIC HEAT -- SILICON OXIDE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Sinel'nikov, N. N.	53-60	546-1660	Quartz crystal	Guarded sample	
□	Moser, H.	41-13	564-1716	Quartz crystal; transparent without blemish, from Brazil	Guarded sample	
△	Skagen, H. S.	55-39	636-1812	Special high purity North Carolina crushed vein quartz, 40 to 60 mesh powder	Guarded sample	Auth. est. error at ± 8%



THERMAL CONDUCTIVITY -- SILICON OXIDE

THERMAL CONDUCTIVITY -- SILICON OXIDE

REFERENCE INFORMATION

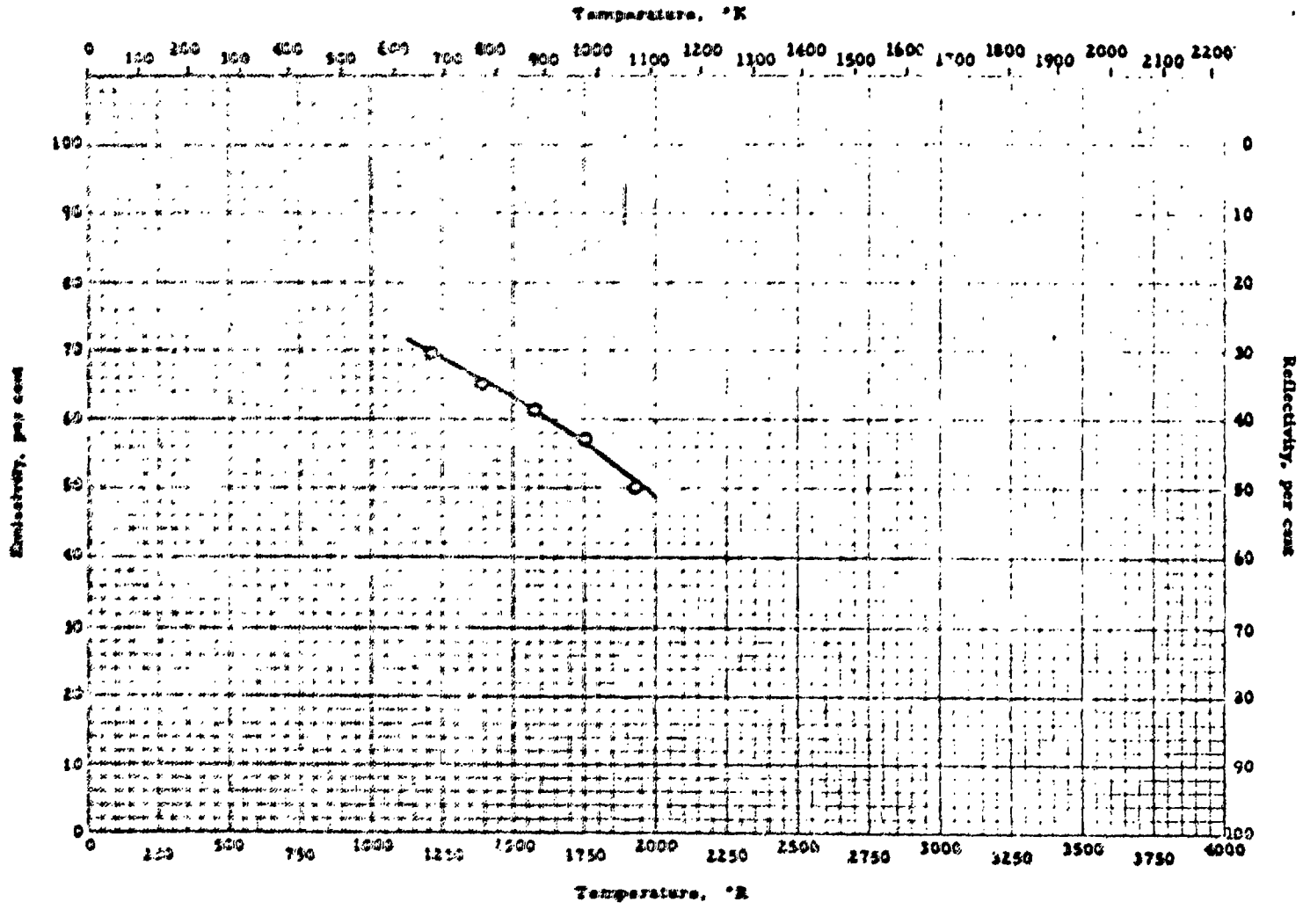
Curve Ref.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Knapp, W. J.	43-11	666-1347	Single crystal quarts	Comparative, rods. Sample 1 cm cube	○ - parallel to c axis ⊖ - perpendicular to c axis
□	Weeks, J. L. and Seifert, R. A.	53-17	618	Single crystal quarts	Comparative, rods, in vacuum with radiation shield. Armco standard	Meas. perpendicular to c axis. Auth est. accuracy ± 3%
△	Berman, R.	51-14	12-180	Single crystal quarts	Temp. distribution of sample in vacuum	

SPECTRAL EMISSIVITY -- SILICON OXIDE

SPECTRAL EMISSIVITY -- SILICON OXIDE

REFERENCE INFORMATION

Curve	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Florenskaya, V. A.	53-146	Room	Low temp. crystalline quartz, cut parallel to axis	Spectral reflectivity at 13°: compared reflection from sample with Al standard mirror by thermopile	

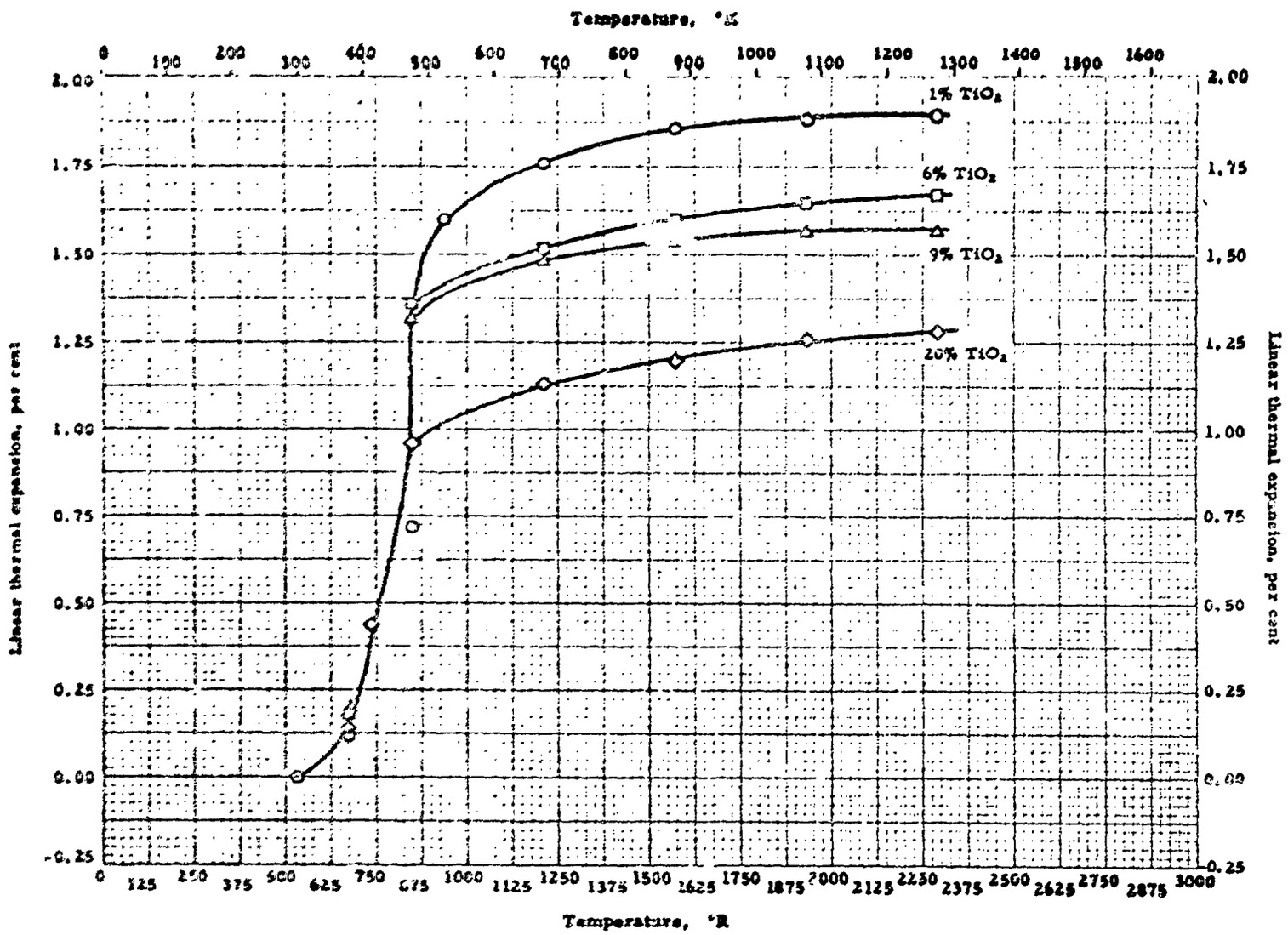


EMISSIVITY -- SILICON OXIDE

EMISSIVITY -- SILICON OXIDE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
	Silly, A.H., Brandes, E.A. and Waterhouse, R.B.	52-81	1212-1932	Pure silica	Total normal emissivity: radiant heat meas. with thermopile; sample temp. by calibrated Pt-Rh thermocouple	

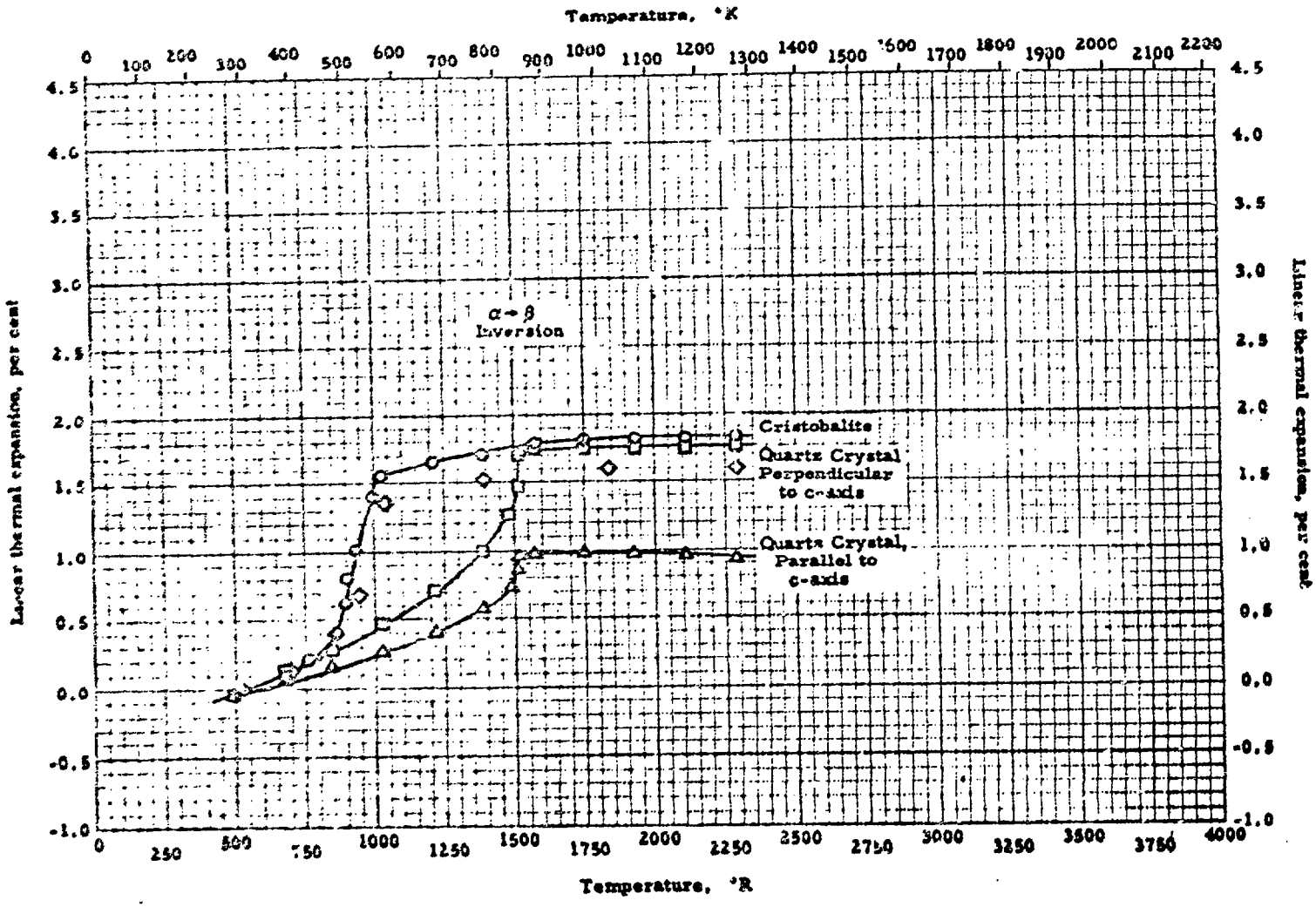


LINEAR THERMAL EXPANSION -- SILICON OXIDE + TITANIUM OXIDE

LINEAR THERMAL EXPANSION -- SILICON OXIDE + TITANIUM OXIDE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Ricker, R. W. and Hummel, F. A.	51-48	528-2292	99% SiO_2 ; 1% TiO_2	Fused silica dilatometer with dial gauge	Heated 2 hr. at 1540°C and 8 hr. at 1500°C
□	Ibid.	51-48	528-2292	94% SiO_2 ; 6% TiO_2	Same as above	Same as above
△	Ibid.	51-48	528-2292	91% SiO_2 ; 9% TiO_2	Same as above	Same as above
◇	Ibid.	51-48	528-2292	80% SiO_2 ; 20% TiO_2	Same as above	Same as above

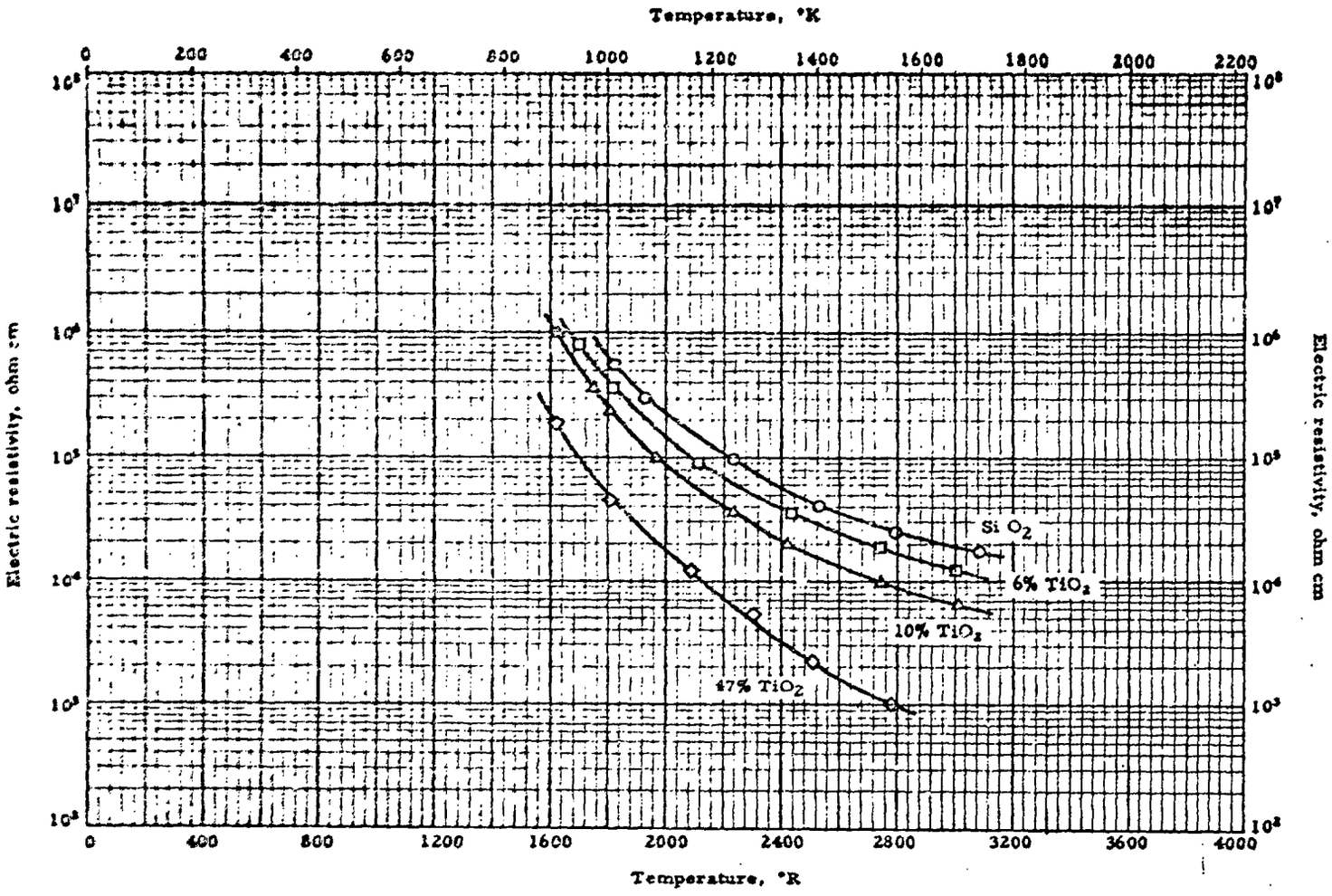


LINEAR THERMAL EXPANSION -- SILICON OXIDE

LINEAR THERMAL EXPANSION -- SILICON OXIDE

REFERENCE INFORMATION

	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Hummel, F.A.	49-14	537-2292	Cristobalite	Fused silica dilatometer	Prepared from silica gel, calcined 1 hr. at 1500 °C; refired with 6% metaphosphate bond, pressed into bars
□	Rosenholtz, J.L., and Smith, D. T.	41-8	492-2292	Quartz - clear rock crystal from Minas Geraes, Brasil; ρ = 2.649 g/cm^3	Fused quartz dilatometer	Perpendicular to c-axis
△	Ibid.	41-8	492-2292	Same as above	Same as above	Parallel to c-axis
◇	Richer, R.W., and Hummel, F.A.	51-48	528-2292	Not given	Fused silica dilatometer	Heated 2 hr. at 1540°C; 8 hr. at 1500°C

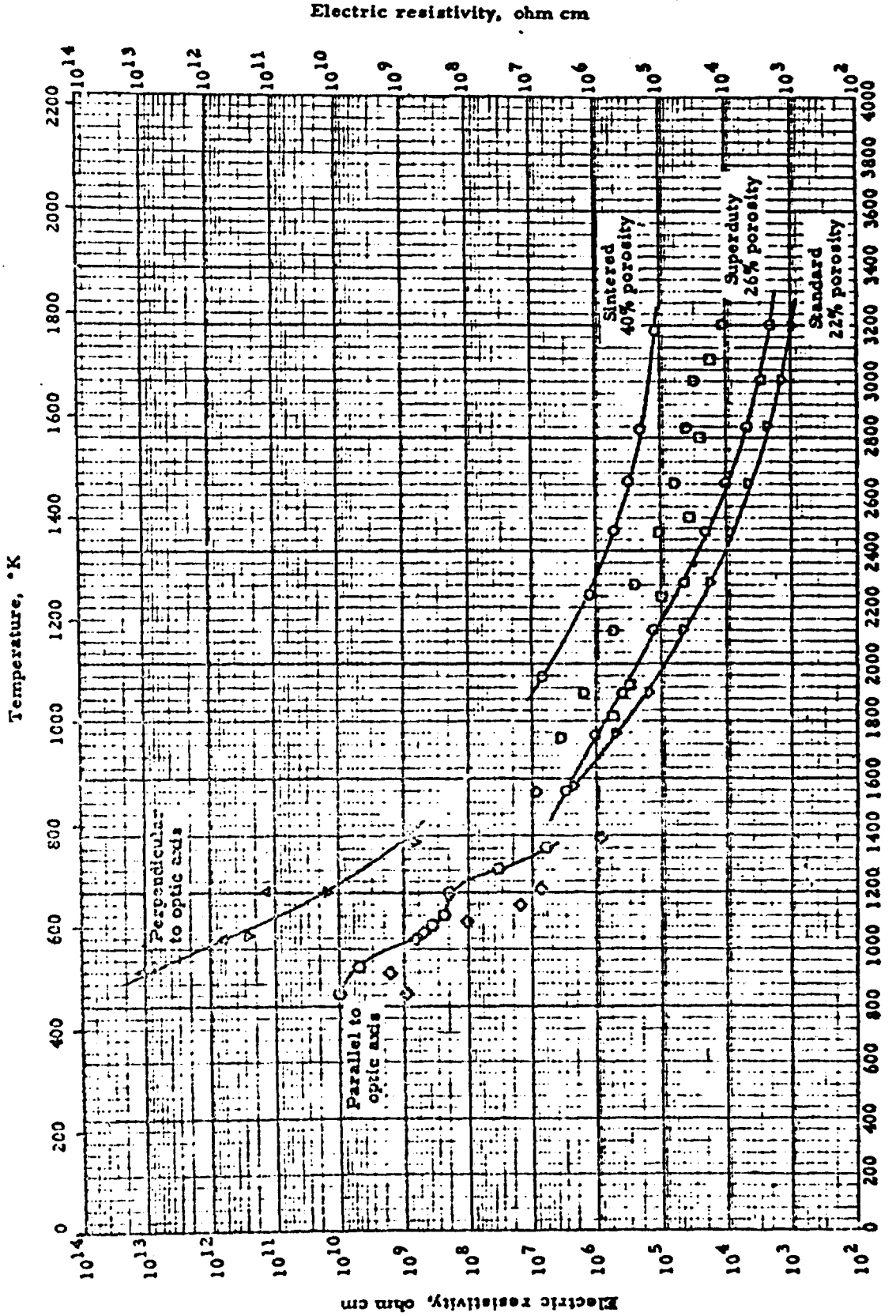


ELECTRIC RESISTIVITY -- SILICON OXIDE + TITANIUM OXIDE

ELECTRIC RESISTIVITY -- SILICON OXIDE + TITANIUM OXIDE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Hensler, J. R. and Henry, E. C.	53-95	1824-3084	100% SiO_2	Wheatstone bridge, with cathode-ray null indicator	Fired 24 hr. at 1450°C as described in "Study of the System SiO_2-TiO_2" thesis, Penn State College
□	Ibid.	53-95	1698-3102	94% SiO_2 : 6% TiO_2	Same as above	Same as above
△	Ibid.	53-95	1626-3012	90% SiO_2 : 10% TiO_2	Same as above	Same as above
◇	Ibid.	53-95	1626-2778	53% SiO_2 : 47% TiO_2	Same as above	Same as above



ELECTRIC RESISTIVITY -- SILICON OXIDE

59-1167
MADE IN U.S.A.

ELECTRIC RESISTIVITY -- SILICON OXIDE

REFERENCE INFORMATION

	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Hensler, J.R. and Henry, E.C.	53-95	1568-3174	100% SiO_2	Wheatstone bridge	40% porosity. Fired 10 hr. at 1500°C
□	Ibid.	53-95	1824-3024	Same as above	Same as above	Fired 24 hr. at 1450°C
△	National Bureau of Standards, Wash. D.C.	53-96	921-1392	Quartz crystal	Not described here, refers to others; 200 volt DC	Parallel to optic axis (?)
◇	Ibid.	53-96	852-1392	Same as above	Same as above	Perpendicular to optic axis (?)
▽	Strauss, S.W., Moore, D.G., et al.	56-69	947-1385	Impurities 0.01-0.1% Al; 0.001-0.01% ea. Fe, Mg, Na; 0.0001-0.001% ea. Cr, Ca, Cu	Potential drop, DC reversal every 20°C; sample temp. by Fe-Const thermocouple	Perpendicular to optic axis
⊂	Ibid.	56-69	857-1358	Same as above	Same as above	Parallel to optic axis
⊃	Chiocketti, V.E.J. and Henry, E.C.	53-94	1572-3192	Super duty silica, 97% SiO_2; comml. refractory	Potential drop at 965 cycles	26% porosity
▽	Ibid.	53-94	1572-3192	Standard silica, 96% SiO_2; comml. refractory	Same as above	22% porosity
□	Ibid.	53-94	1572-3192	92% SiO_2; pyrometric cone equivalent less than standard; commercial refractory	Same as above	27% porosity

Symbol	Nominal Composition	Melting Point °R	Melting Point °K
○	$ThO_2 + Al_2O_3$	3938 ± 8	2188 ± 5
□	$2\,ThO_2 + Al_2O_3 + BeO$	3741 ± 9	2078 ± 5

PROPERTIES OF THORIUM OXIDE + ALUMINUM OXIDE + X

PROPERTIES OF THORIUM OXIDE + ALUMINUM OXIDE + X

REFERENCE INFORMATION

Curve Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	National Bureau of Standards	54-132	3930-3946	$ThO_2 + Al_2O_3$ 72.1% ThO_2; 27.9% Al_2O_3	MP: visual observation, temp. by optical pyrometer	Average of 3-5 tests, auth. est. accuracy ± 2%
□	Ibid.	54-132	3732-3750	$2ThO_2 + Al_2O_3 + BeO$. 80.6% ThO_2; 15.6% Al_2O_3; 3.8% BeO	MP: same as above	Same as above

PROPERTIES OF THORIUM OXIDE

MOST PROBABLE VALUES

Property	Brit. Engineering Units	C. G. S. Units
Density.	624 lb_m/ft^3	10 g/cm^3
Melting Point	6370 °R	3540 °K
Heat of Fusion		
Heat of Vaporization. . .		
Heat of Sublimation . . .	$1165_{3870\,°R}$ Btu/lb_m	$647_{2150\,°K}$ cal/g

REPORTED VALUES

Density:		lb_m/ft^3	g/cm^3
	O	540	8.65
	Δ	596	9.55
	▽	625	10.01
	□	606	9.70
	△	609	9.75
	▷	613.0	9.820
	▽	604	9.68
	◇	520	8.3
	▷	411	6.58
	○	624	10.0
	□	556 ± 6	8.9 ± 0.1
	▷	468	7.5
	▷	468	7.5
	◁	471 ± 22	7.55 ± 0.35
	▷	537	8.6
	△	499	8.0
	▷	606.5 ± 0.5	9.715 ± 0.015
	○	613	9.82
Melting Point:		°R	°K
	△	5492	3273
	◇	6378	3543
	○	6287 ± 90	3493 ± 50
Heat of Fusion:		Btu/lb_m	cal/g
Heat of Vaporization:		Btu/lb_m	cal/g
Heat of Sublimation:		Btu/lb_m	cal/g
	O	$1161.0_{537\,°R}$	$644.8_{298\,°K}$
	□	$1165_{3870\,°R}$	$647_{2150\,°K}$
	▽	$984.8_{5090\,°R}$	$547.1_{2828\,°K}$

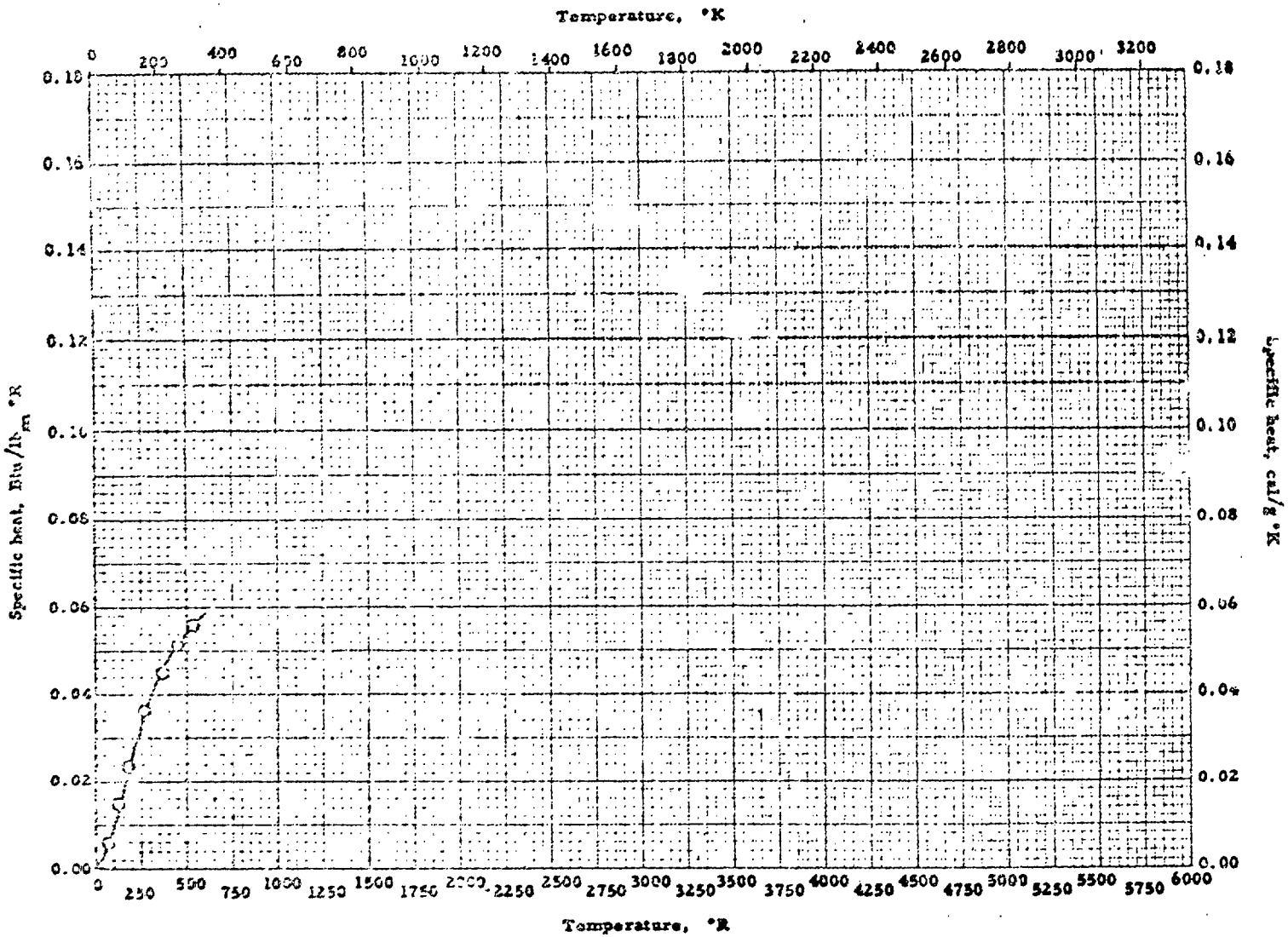
REFERENCE INFORMATION

	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Fitch, M. and Johnson, H. L.	56-10	537	"Pure" ThO_2	Δh_s: from vapor pressure data by Knudsen method	Vapor pressure data obtained at 4317-4817°R
C	Shapiro, E.	52-16	3690-4050	99% pure ThO_2	Δh_s: from vapor pressure data by Langmuir method with coated tungsten filament	Vapor pressure data obtained at 3690-4050°R
Δ	Trombe, F.	49-16	5892	ThO_2	MP: not given	
◇	Lamberton, W. A. and Sandwerk, J. H.	56-5	6378	ThO_2	MP: not given	
▽	Ackermann, R. J., Thorn, R. J. and Gilles, P. W.	56-43	5090	ThO_2	Δh_s: from vapor pressure data by Knudsen method with W cell	Short letter about preliminary results
O	Lang, S. M. and Knudsen, F. P.	56-18	Room	99.9% pure ThO_2	ρ: not given	Pressed at 10,000 psi
O	Ibid.	56-18	Room	Same as above	ρ: same as above	Pressed at 5000 psi; heated 5 hr. at 1000°C; repressed at 1000,000 psi
O	Ibid.	56-18	Room	Same as above	ρ: computed from x-ray measurements	
O	Ibid.	56-18	Room	99.5% ThO_2; 0.5% CaO	ρ: not given	Pressed at 10,000 psi
◇	Ibid.	56-18	Room	Same as above	ρ: same as above	Pressed at 5000 psi; heated 5 hr. at 1000°C; repressed at 100,000 psi
◣	Ibid.	56-18	Room	Same as above	ρ: computed from x-ray measurements	
◇	Lamberton, W. A. and Conael Jr., F. H.	52-131	6197-6177	99.7% ThO_2	MP: visual observation after heating in constant temp. furnace. Calibrated optical pyrometer	
D	Johnson, P. D.	58-37	Room	ThO_2	ρ: computed from x-ray measurements of lattice	Made from oxalate containing <0.01% Mg, Pb, Zn; <0.01% ea. Ca, Cu, Si by calcining 1 hr. at 1000°C. Heated to 1100°C in 20 min., then fired either 2 min. at 2300°C or 10 min. at 1900°C
O	Ibid.	58-37	Room	Same as above	ρ: not given	Same as above
D	Ibid.	58-37	Room	Same as above	ρ: same as above	Same as above, but also pressed at 52,000 psi

PROPERTIES OF THORIUM OXIDE (Cont'd)

REFERENCE INFORMATION

Curve	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
G	Bannick, M. D. and Parker, H. S.	55-144	Room	ThO_2	ρ: computed from x-ray measurements of lattice	Molded at 18,000 psi
G	Ibid.	55-144	Room	Same as above	ρ: weight in air and in Hg	Same as above, fused 1 hr. at 1800°C from 0-5μ particles
D	Ibid.	55-144	Room	Same as above	ρ: same as above	Same as above, but particles are 10-15μ
A	Ibid.	55-144	Room	Same as above	ρ: same as above	Same as above, but particles are 30-60μ
G	Ibid.	55-144	Room	Same as above	ρ: same as above	Same as above, but mixtures of particles
F	Ibid.	55-144	Room	1% TiO_2	ρ: same as above	Same as above, but particles are 10-15μ
G	Ibid.	55-144	Room	1% Fe_2O_3	ρ: same as above	Same as above
D	Ibid.	55-144	Room	0.1% CaO	ρ: same as above	
G	Ibid.	55-144	Room	Same as above	ρ: computed from x-ray measurements of lattice	

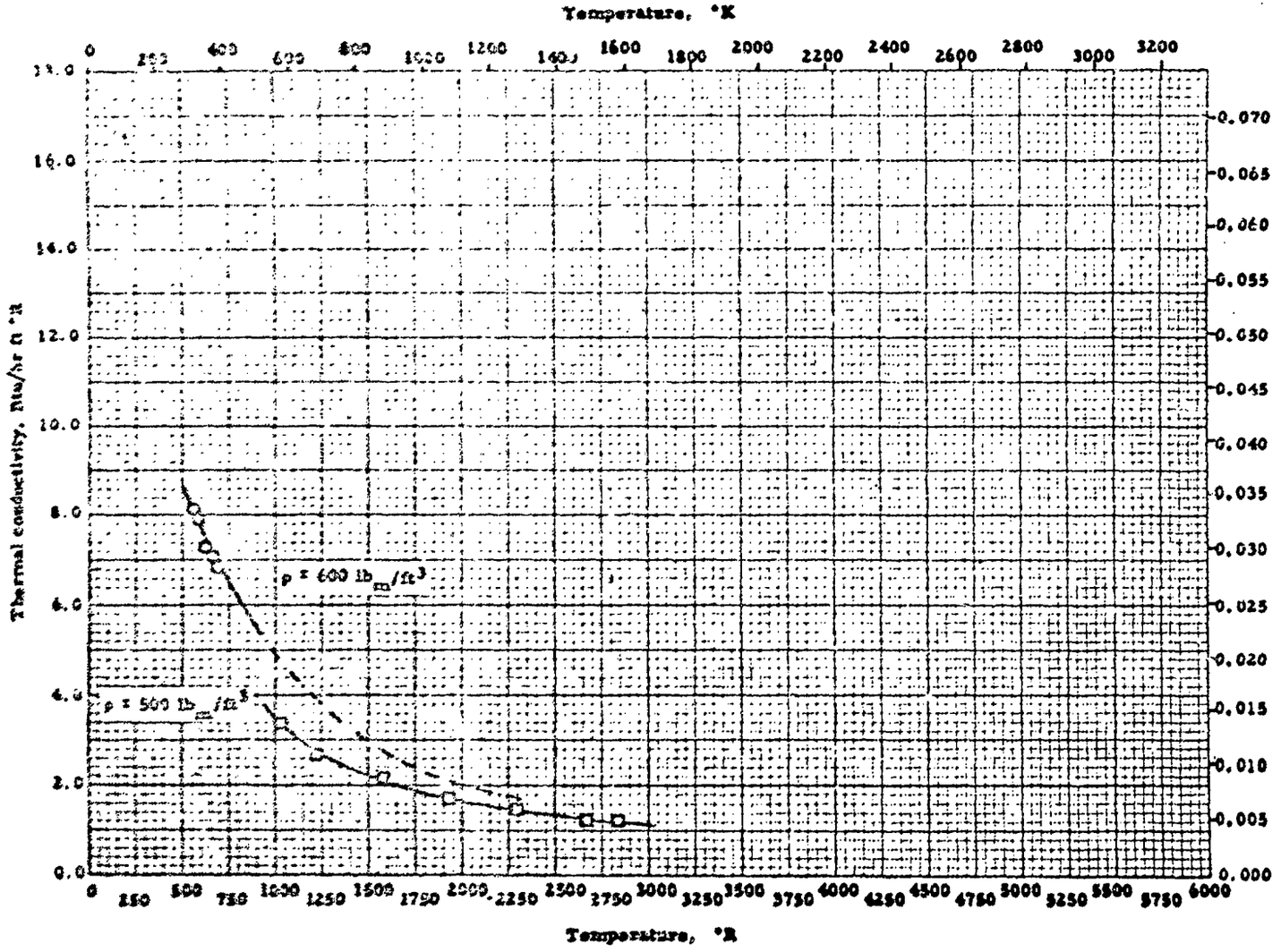


SPECIFIC HEAT -- THORIUM OXIDE

SPECIFIC HEAT -- THORIUM OXIDE

REFERENCE INFORMATION

	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Osborne, D. W., and Westrum, Jr. E. F.	53-55	18-540	Source, ThO_2 0.015% max. rare earths; 0.005% ea. Al, Si; 0.004% La; < 0.005% others	Guarded sample	

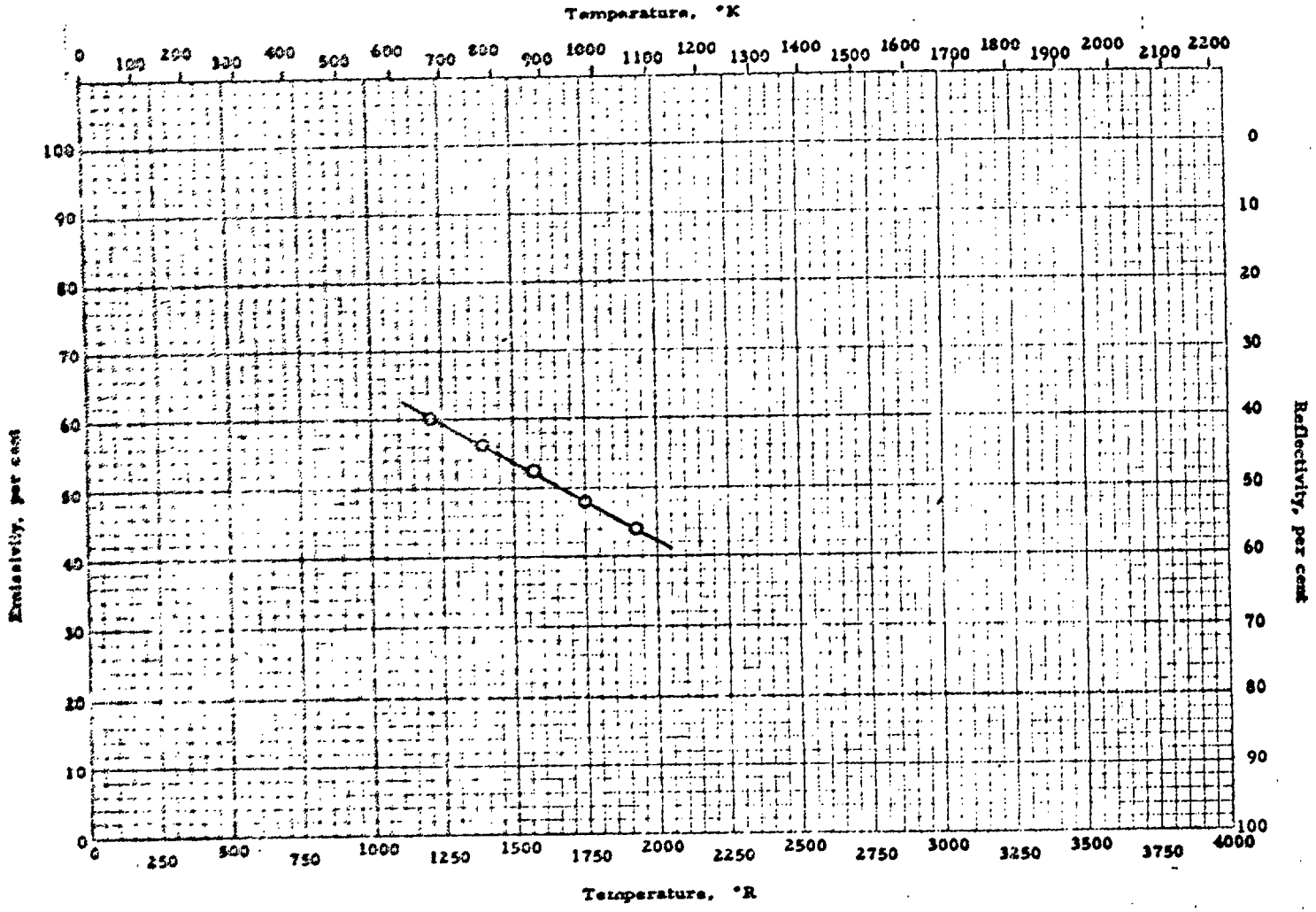


THERMAL CONDUCTIVITY -- THORIUM OXIDE

THERMAL CONDUCTIVITY -- THORIUM OXIDE

REFERENCE INFORMATION

Sym bol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	New Jersey Ceramic Research Station	53-3	551-682	Spectroscopically pure; ρ = 593 lb/ft^3	Comparative; rods (Cu standard)	Hot pressed at 1790 - 1820°C (Tested in vacuum)
□	Adams, Milton	54-5	1332-2832	ρ = 534 lb/ft^3; total porosity = 16.7%	Prolate spheroid envelope	Slip cast from suspension of finely ground material

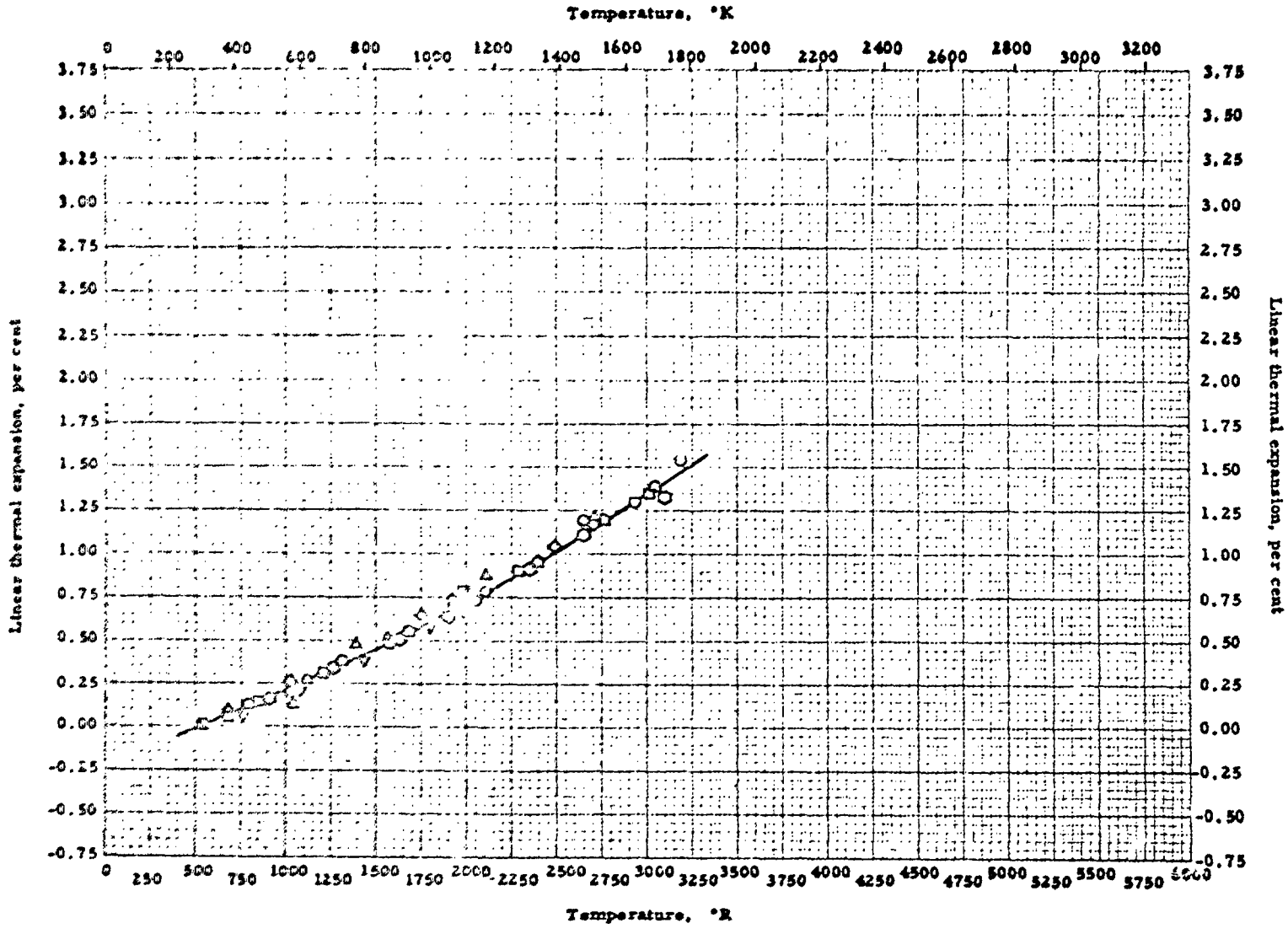


EMISSIVITY -- THORIUM OXIDE

EMISSIVITY -- THORIUM OXIDE

REFERENCE INFORMATION

Plot No.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Silby, A.H., Dziedzic, E.A. and Waterhouse, R.B.	52-81	1212-1932	"Pure"	Total normal emissivity: radiant heat meas. with thermopile; sample temp. by calibrated Pt-Rh thermocouple	

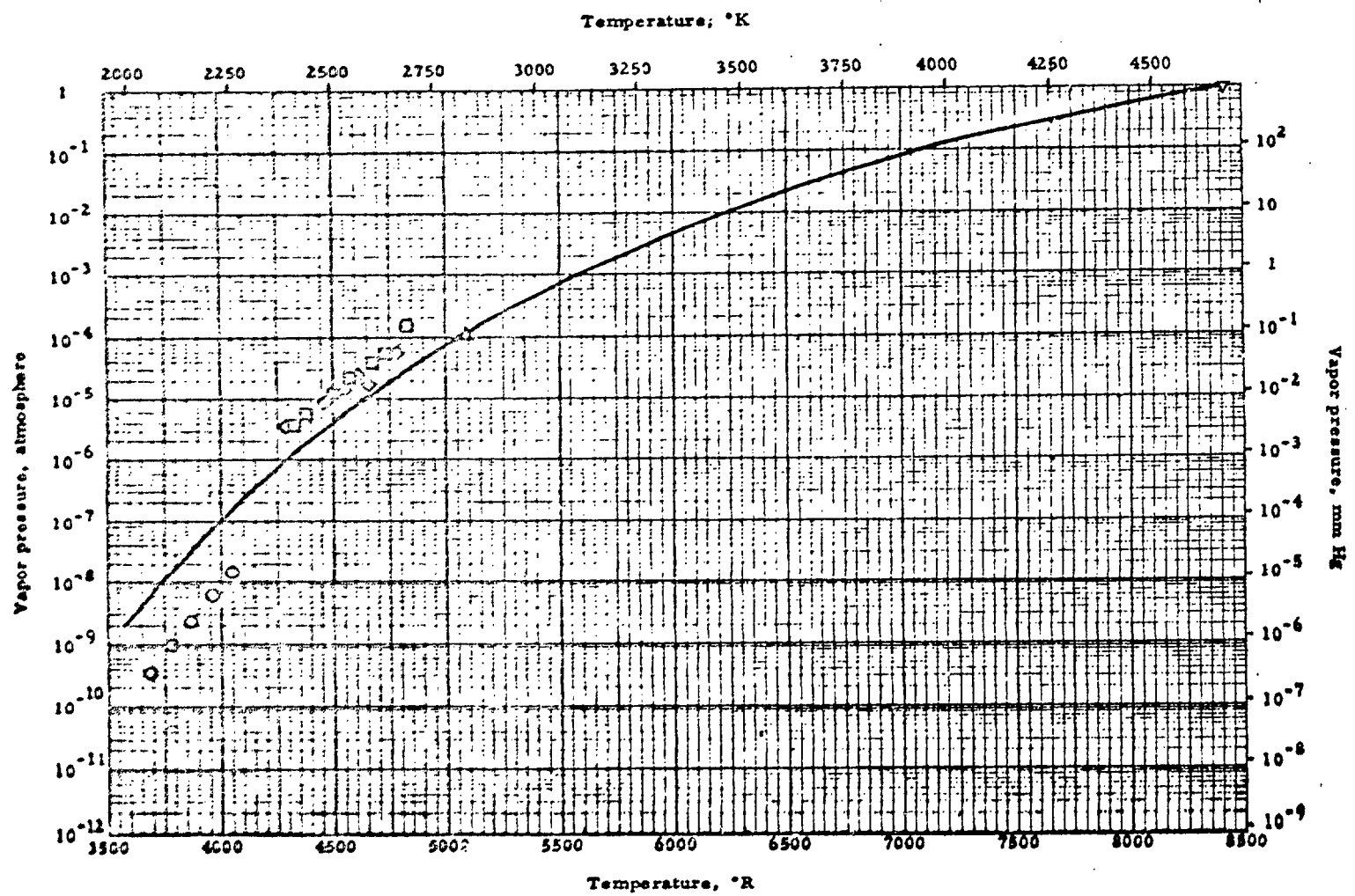


LINEAR THERMAL EXPANSION - THORIUM OXIDE

LINEAR THERMAL EXPANSION -- THORIUM OXIDE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Whittemore, O. J. and Ault, N. N.	56-7	1032-3192	Fine fused grain ThO_2	Telemicroscopes sighting on sample	
□	Lang, S. M. and Kaufman, F. P.	56-18	546-3012	ThO_2. 0.5% CaO	Dilatometer	Data to 800°C checked with interferometer
△	Curtis, C. E. and Johnson, J. R.	57-22	672-2706	ThO_2. 1% CaO	Not given	Fired at 1800°C
◇	Ibid.	57-22	672-2706	"Pure"; 75% theoretical density	Same as above	Same as above
▽	Skinner, B. J.	57-21	536-1931	0.1-0.5% ea. Si, Mg; 0.01-0.05% ea. Fe, B, Al; 0.001-0.005% ea. Sc, Cu; 0.0001-0.0005% Be	X-ray diffraction	Auth. est. accuracy ± 0.2%
○	Somiya, S., Yamauchi, T. and Suzuki, H.	57-93	528-3102	"Pure" ThO_2	Dilatometer	Dry mixed, pressed at 1000 kg/cm^2; fired to 1700°C in 5-1/2 hr; held 1 hr; cooled overnight. Plotted data are average of auth.'s heating and cooling curves
○	Mauer, F.A. and Bolz, L.H.	55-58	492-3019	ThO_2 + 0.001-0.01% Al, 0.0001-0.001% ea. Ag, Ca, Cu, Mg	X-ray diffraction	
△	National Bureau of Standards	55-147	546-1932	99.5% ThO_2; 0.5% CaO. ρ=606-607 lb m/ft^3	Interferometer	Dry pressed (no binder) at 3000 psi, pressed 1 hr. at 1800° C under 30,000 psi in oxidizing atmos.
○	Burdick, M.D. and Parker, H.S.	55-144	546-3012	99.5% ThO_2; 0.5% CaO	Dilatometer	Pressed sample heated, pressed 1 hr. at 1800° C, under 30,000 psi
▽	Ibid.	55-144	546-1932	Same as above	Interferometer	Same as above

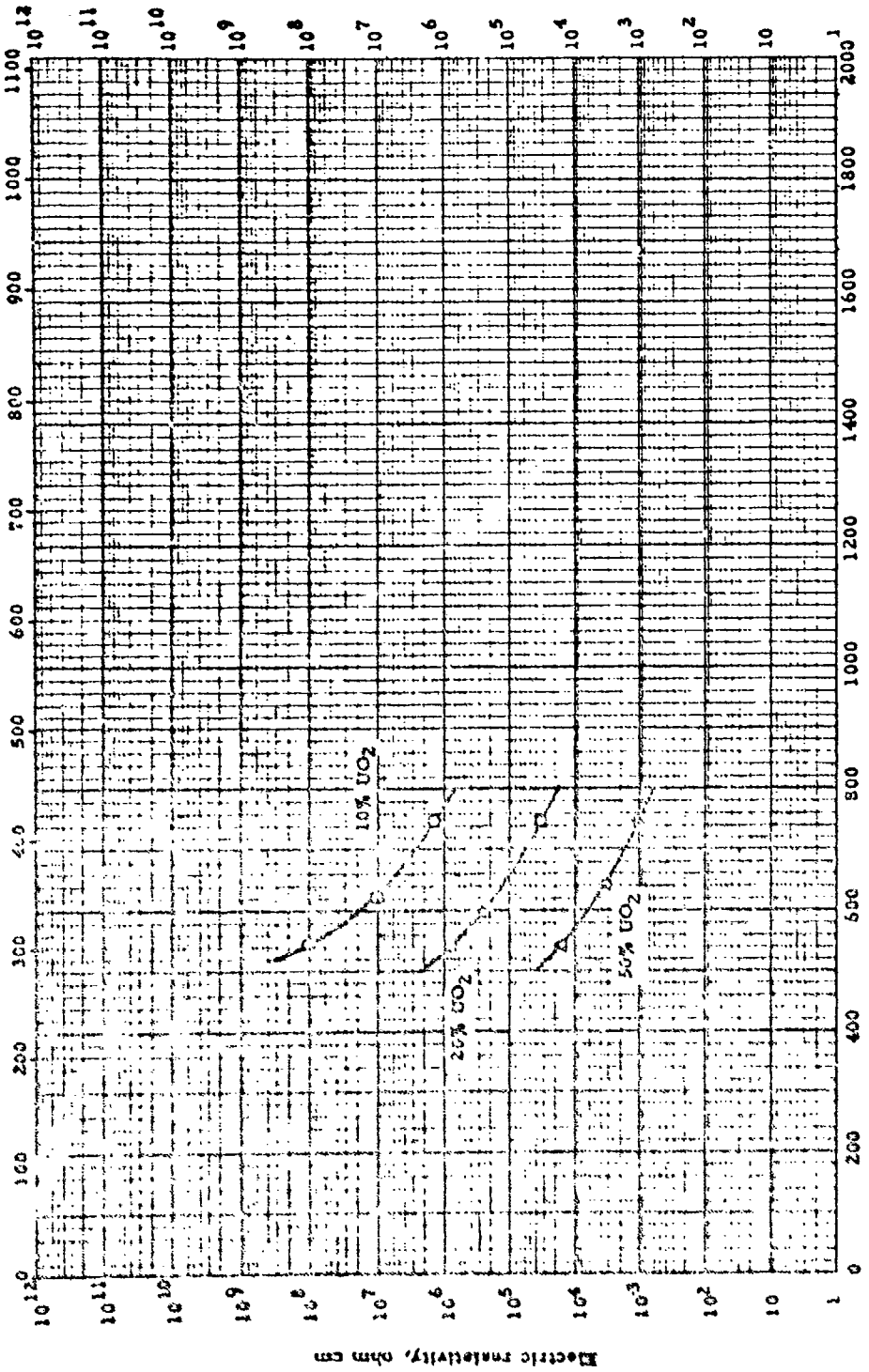


VAPOR PRESSURE -- THORIUM OXIDE

VAPOR PRESSURE -- THORIUM OXIDE

REFERENCE INFORMATION

Sym.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Shapiro, E.	52-16	3690-4050	99% pure ThO_2	Langmuir weight loss method	W wire coated with ThO_2
□	Hoch, M. and Johnston, H. L.	54-30 also 54-138	4317-4817	"Pure" ThO_2	Knudsen effusion cell	Ta cell degassed for 2 hr. before each run. Corrected for evaporation of cell (ca 10%)
△	Ackermann, R. J., Thorn, R. J. and Gilles, P. W.	56-43	5091	ThO_2	Knudsen effusion cell	W cell
▽	Trombe, F.	49-16	6412	ThO_2	Not given	
◇	Hoch, M. and Johnston, H. L.	54-30	4300-4790	ThO_2	Knudsen effusion cell	Corrected for evaporation of Ta cell material and for thermal expansion of orifice. Authors suspect major error in temp. measurement leading to high values for p

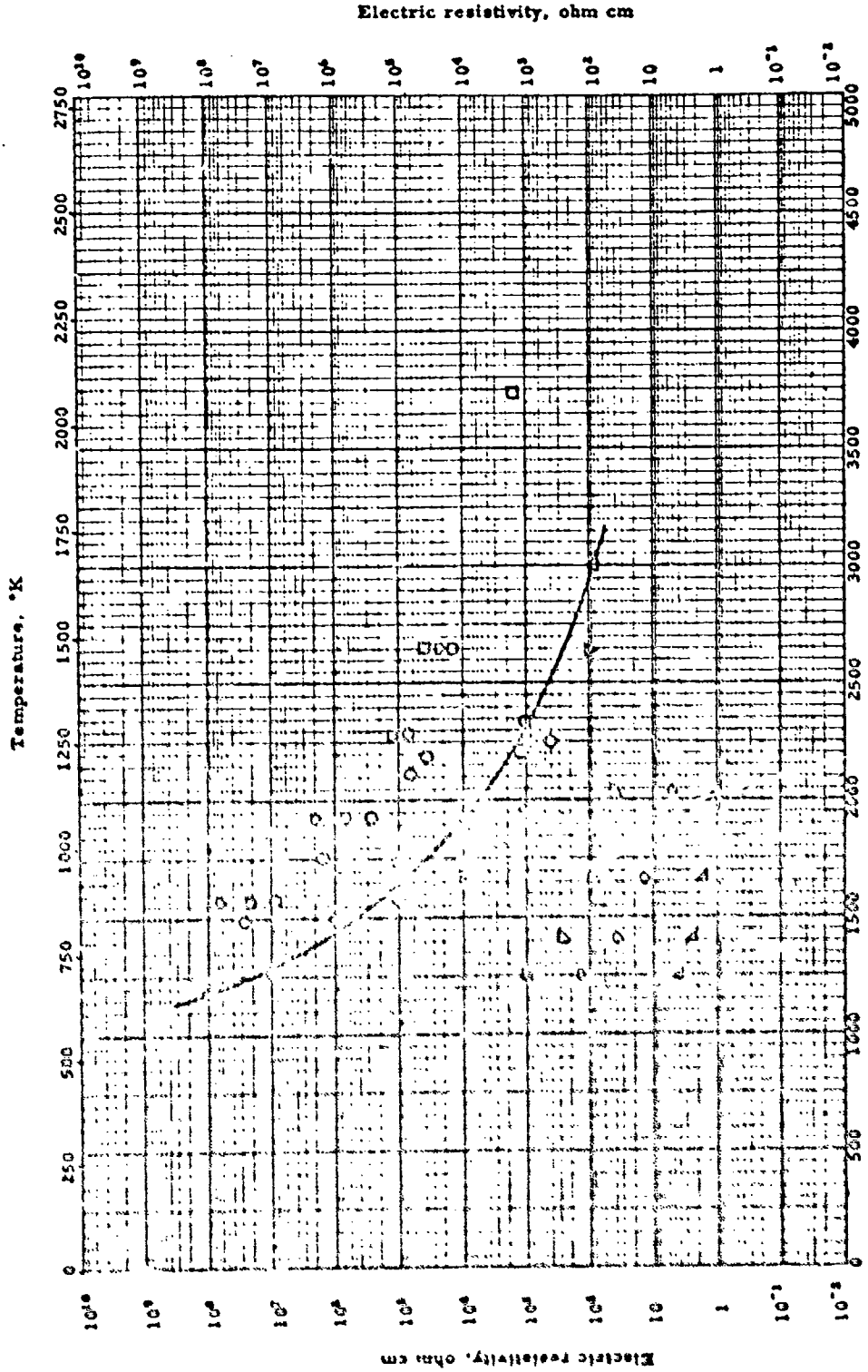


ELECTRIC RESISTIVITY -- THORIUM OXIDE + URANIUM OXIDE

ELECTRIC RESISTIVITY -- THORIUM OXIDE + URANIUM OXIDE

REFERENCE INFORMATION

	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Gruen, D. M.	54-143	545-750	90% ThO_2 : 10% UO_2	Potential drop; sample temp. by Chromel-Alumel thermocouple	Mixed from elements with <0.01% transition and rare earth metals, pressed, fired 8 hr. at 1750°C in H_2
□	Ibid.	54-143	545-750	80% ThO_2 : 20% UO_2	Same as above	Same as above
△	Ibid.	54-143	545-750	50% ThO_2 : 50% UO_2	Same as above	Same as above

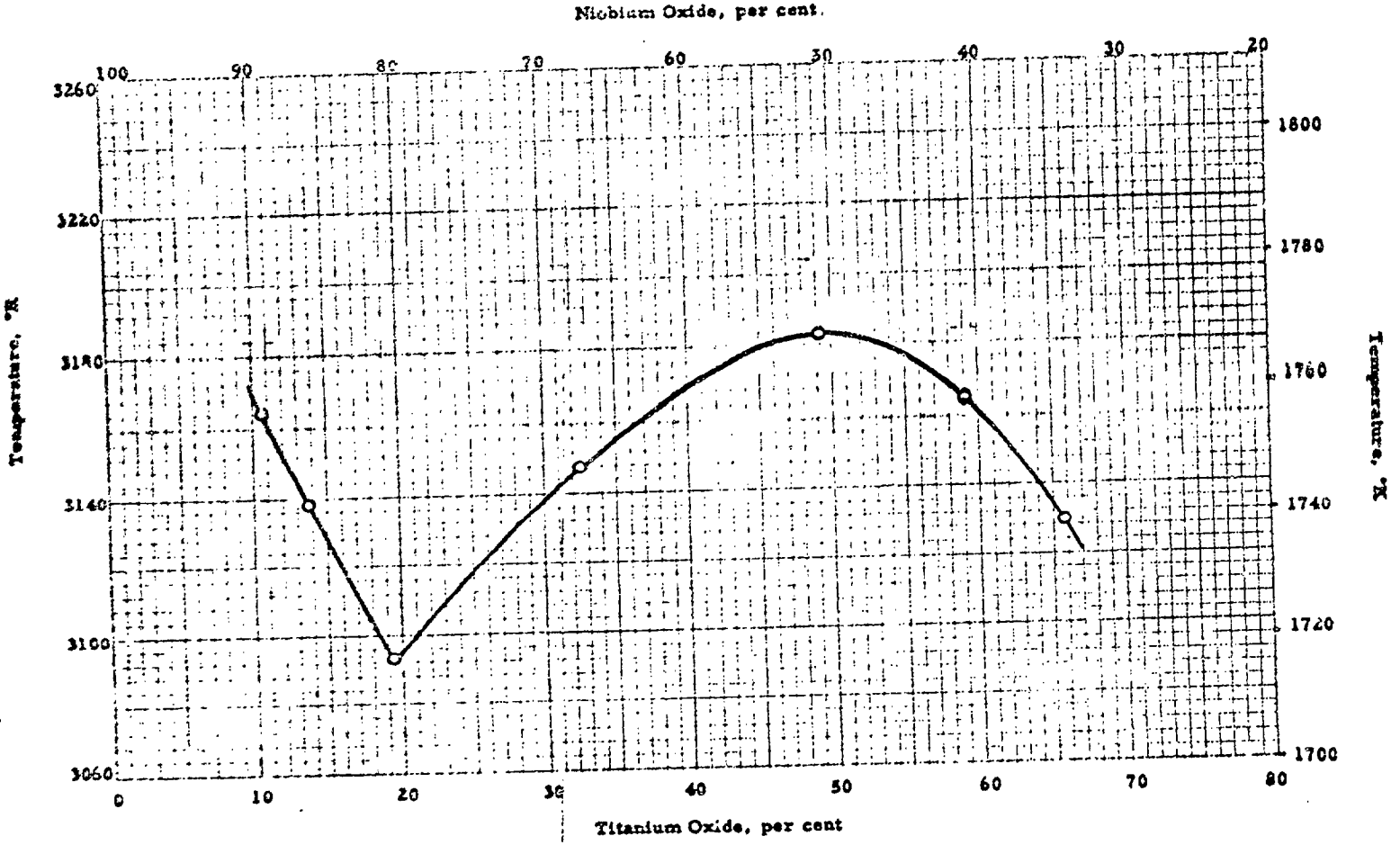


ELECTRIC RESISTIVITY -- THORIUM OXIDE

ELECTRIC RESISTIVITY -- THORIUM OXIDE

REFERENCE INFORMATION

	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Rogener, H.	40-20	1491-2193	ThO_2	Potential drop. Voltage by electrometer. Sample temp. by Pt-Pt Rh thermocouple	1 cm.cube samples, platinized end faces. Auth. est. accuracy only order of magnitude
□	Trombe, F.	49-16	2652-3732	ThO_2	Not given	
△	Danforth, W. E.	54-141	1185-2250	ThO_2. 0.01% Al, La; traces of Cr, Cu, Si, Be, Ti, Ce, Y, and Zr	Potential drop, using a pulse charge. Checked against a Wheatstone bridge	H_2 and He atmosphere
◇	Ibid.	54-141	1500-2250	Same as above	Same as above	O_2 atmosphere
▽	Ibid.	54-141	1682-2647	Same as above	Same as above	Meas. in O_2 at 760 mm Hg
○	Ibid.	54-141	1875-2250	Same as above	Same as above	Meas. in O_2 at 0.37 mm Hg
◻	Ibid.	54-141	1731-2338	Same as above	Same as above	Meas. in O_2 at 0.000002 mm Hg
△	Danforth, W. E.	56-159	1268-3001	ThO_2	Pulse charge, read on scope	Arc fused, cut into parallelepipeds. Meas. under 10^{-6} mm Hg. Resistance R by equation: $i = \frac{V}{R} e^{-\left(\frac{t}{RC}\right)}$
○	Foex, M.	42-14	1572-2652	ThO_2. Porosity = 24%, ρ = 487 lb_m/ft^3	Not given	Very pure, no ceria. Pressed at 3,000 kg/cm^2, calcined at 2100°C. $r = Ae^{\left(\frac{B}{T}\right)}$ where A, B = const., T = absolute temp. Meas. in air atmos.
▽	Ibid.	42-14	1572-2652	Same as above	Same as above	Same as above, except meas. in vacuum. Author also reports measurements in other atm.
△	Danforth, W. E. and Morgan, F. H.	50-65	1250-2041	ThO_2. ρ = 437 lb_m/ft^3	Potential drop	r varies as current density J. Meas. in vacuum. J = 7.6 amp/cm^2
◇	Ibid.	50-65	1250-2041	Same as above	Same as above	Same as above, except J = 0.76 amp/cm^2
▽	Ibid.	50-65	1250-2041	Same as above	Same as above	Same as above, except J = 0.07 amp/cm^2



MELTING POINT -- TITANIUM OXIDE + NIOBIUM OXIDE

MELTING POINT -- TITANIUM OXIDE + NIOBIUM OXIDE

REFERENCE INFORMATION

Mark	Investigator	Ref.	Range, °K	Material Composition	Test Method	Remarks
O	Barbin, E. A. and Harman, C. G.	52-51	3093-3183	59.05 - 65.79% TiO_2 ; 40.95 - 34.21% Nb_2O_5	MP: not given	Prepared from 99.5% TiO_2, 99.9% Nb_2O_5 ; sintered

PROPERTIES OF TITANIUM OXIDE

MOST PROBABLE VALUES

Property	Brit. Engineering Units	C. G. S. Units
Density.	250 lb_m/ft^3	4.0 g/cm^3
Melting Point	3800°R *	2110°K *
Heat of Fusion		
Heat of Vaporization. . .		
Heat of Sublimation . . .	$3920_{536°R}$ Btu/lb_m **	$2175_{298°K}$ cal/g **

* Value for TiO_2, rutile
** Value for TiO_2

REPORTED VALUES

Density:		lb_m/ft^3	g/cm^3
	○	243.7 ± 0.1	3.904 ± 0.002
	□	259.1 ± 0.1	4.150 ± 0.002
	▷	228	3.66
	◇	244	3.92
	▽	239	3.83
	▷	228	3.66
	◇	240	3.85
	◁	243	3.90
	◁	161	2.59
	▷	164	2.64
	◢	208	3.34
	◁	157	2.52
	▷	158	2.54
	△	250.3 ± 0.6	4.01 ± 0.01
Melting Point:		°R	°K
	△	3583	1993
	◇	3804 ± 18	2113 ± 10
Heat of Fusion:		Btu/lb_m	cal/g
Heat of Vaporization:		Btu/lb_m	cal/g
Heat of Sublimation:		Btu/lb_m	cal/g
	▽	$3129_{0°R}$ ± 11	$1738_{0°K}$ ± 6
	○	$3790_{0°R}$ ± 15	$2106_{0°K}$ ± 8
	□	$3920_{536°R}$ ± 140	$2175_{298°K}$ ± 78
	▽	$3390_{536°R}$ ± 110	$1830_{298°K}$ ± 60

PROPERTIES OF TITANIUM OXIDE

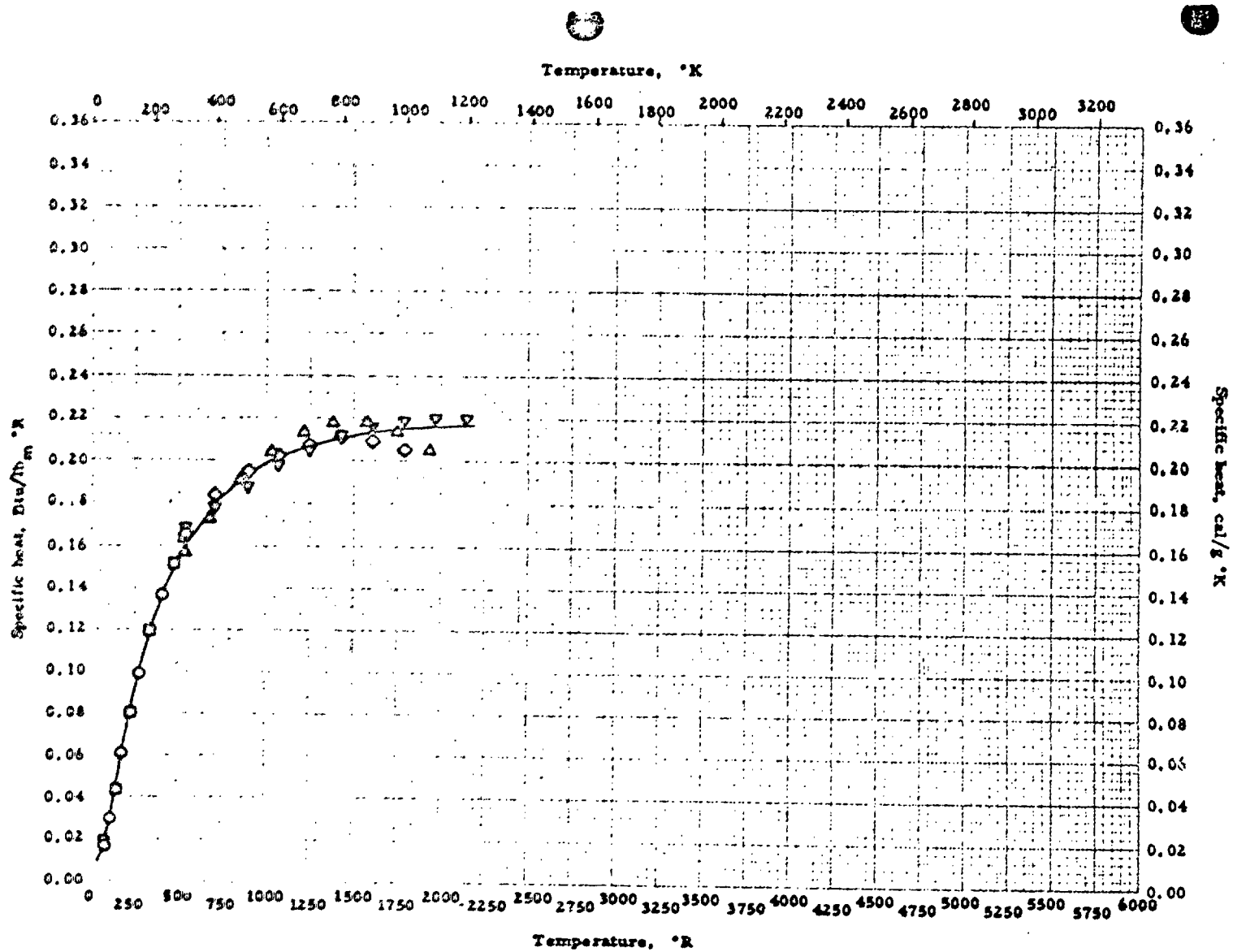
REFERENCE INFORMATION

	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Ikeda, J.	56-52	Room	TiO_2; anatase; x-rays showed only anatase lines	ρ: powdered sample in pycnometer with kerosene	Synthetically prepared from doubly distilled clear and colorless $TiCl_4$ practically free of Fe, precipitated with ammonia, washed, heated 4 hr. at 565°C
□	Ibid.	56-52	Room	TiO_2; rutile; x-rays showed no anatase lines; material was white with slight yellow cast	ρ: same as above	Synthetically prepared from doubly distilled clear and colorless $TiCl_4$ practically free of Fe, precipitated with ammonia, washed, dried, pulverized and heated 1.5 hr. at 930°C, pulverized and reheated several hr.
△	Stratton, W.O.	51-45	3588	TiO_2, very pure single crystals of rutile and anatase	MP: visual observation of sample on Mo strip; optical pyrometer	Corrected 6°C for absorption by Vycor window in furnace
◇	St. Pierre, P.D.S.	52-74	3786-3822	TiO_2; rutile with only trace of anatase. Several samples of specially pure oxide (0.04% Si; 0.02% Mg; 0.01% Ca) and c.p. reagent grade (0.04% H_2O soluble salts; 0.001% ea. Zn, Pb; 0.00001% As)	MP: observation of cone collapse; 2 optical pyrometers	In oxidizing atmos.
▽	Groves, W.O., Finch, M. and Johnston, H.L.	55-64	0	TiO_2. "Bakers Analyzed" C.P. grade; 0.04% water soluble salts; 0.01% Pb; 0.003% Fe; 0.002% Zn; 0.00000% As	Δh_s: from vapor pressure by Knudsen method	Vapor pressure measured 2868-3158°F
○	Ibid.	55-64	0	TiO; prepared from TiO_2 (see above) and iodide Ti containing 0.02% N_2, Te, Pb, Cu; 0.0082% Mn; 0.007% Si; 0.0060% Al	Δh_s: same as above	Vapor pressure measured 2865-3082°F
□	Ingram, M.G., Berkowitz, J. and Chupka, W.A.	56-44 also 57-65	536	TiO_2	Δh_s: from vapor pressure by Knudsen method with mass-spectrometer; optical pyrometer	
○	Ibid.	56-44 also 57-65	536	TiO	Δh_s: same as above	Vapor pressure measured 3649-3730°R
△	Grim, M. S. et al.	49-67	Room	98.7% TiO_2; 0.93% SiO_2; 0.40% Fe_2O_3. Porosity = 9.9%	ρ: Dry weight, water saturated weight and immersed weight	Dust pressed, partially dried, granulated, dried, pressed at 10,000 psi, fired at 1500°C. Unfired, dry bulk ρ = 161 lb_m/ft^3
◇	Ibid.	49-67	Room	Same as above, porosity = 6.1%	ρ: Same as above	Same as above

PROPERTIES OF TITANIUM OXIDE (Cont'd)

REFERENCE INFORMATION

Curve Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
□	Grim, M. S. et al.	49-67	Room	98.7% TiO_2; 0.93% SiO_2; 0.40% Fe_2O_3. Porosity = 6.5%	ρ: dry weight, water saturated weight and immersed weight	Dust pressed, partially dried, granulated, dried, pressed at 10,000 psi, fired at 1500°C. Unfired, dry bulk ρ = 160 lb_m/ft^3
○	Ibid.	49-67	Room	Same as above, porosity = 9.5%	ρ: same as above	Same as above, but unfired dry bulk ρ = 166 lb_m/ft^3
○	Ibid.	49-67	Room	Same as above, porosity = 6.0%	ρ: same as above	Same as above, but unfired, dry bulk ρ = 162 lb_m/ft^3
◇	Ibid.	49-67	Room	Same as above, porosity = 10.6%	ρ: same as above	Same as above
◇	Ibid.	49-67	Room	Same as above, porosity = 37.9%	ρ: same as above	Dust press, partially dried, granulated, dried, pressed at 10,000 psi, fired at 1500°C, partially reduced to sub-oxides in graphite-resistor load-test furnace, held 3 hr. at 1500°C. Unfired, dry bulk ρ = 152 lb_m/ft^3
□	Ibid.	49-67	Room	Same as above, porosity = 37.6%	ρ: same as above	Same as above
△	Ibid.	49-67	Room	Same as above, porosity = 31.0%	ρ: same as above	Same as above, but unfired, dry bulk ρ = 161 lb_m/ft^3
▽	Ibid.	49-67	Room	Same as above, porosity = 39.4%	ρ: same as above	Same as above, but unfired, dry bulk ρ = 154 lb_m/ft^3
▷	Ibid.	49-67	Room	Same as above, porosity = 40.9%	ρ: same as above	Same as above, but unfired, dry bulk ρ = 155 lb_m/ft^3
◁	Oak Ridge National Lab.	57-150	537	TiO_2	ρ: weight in water and in kerosene	Measured by O. Sisman, C. D. Bopp and R. L. Towns

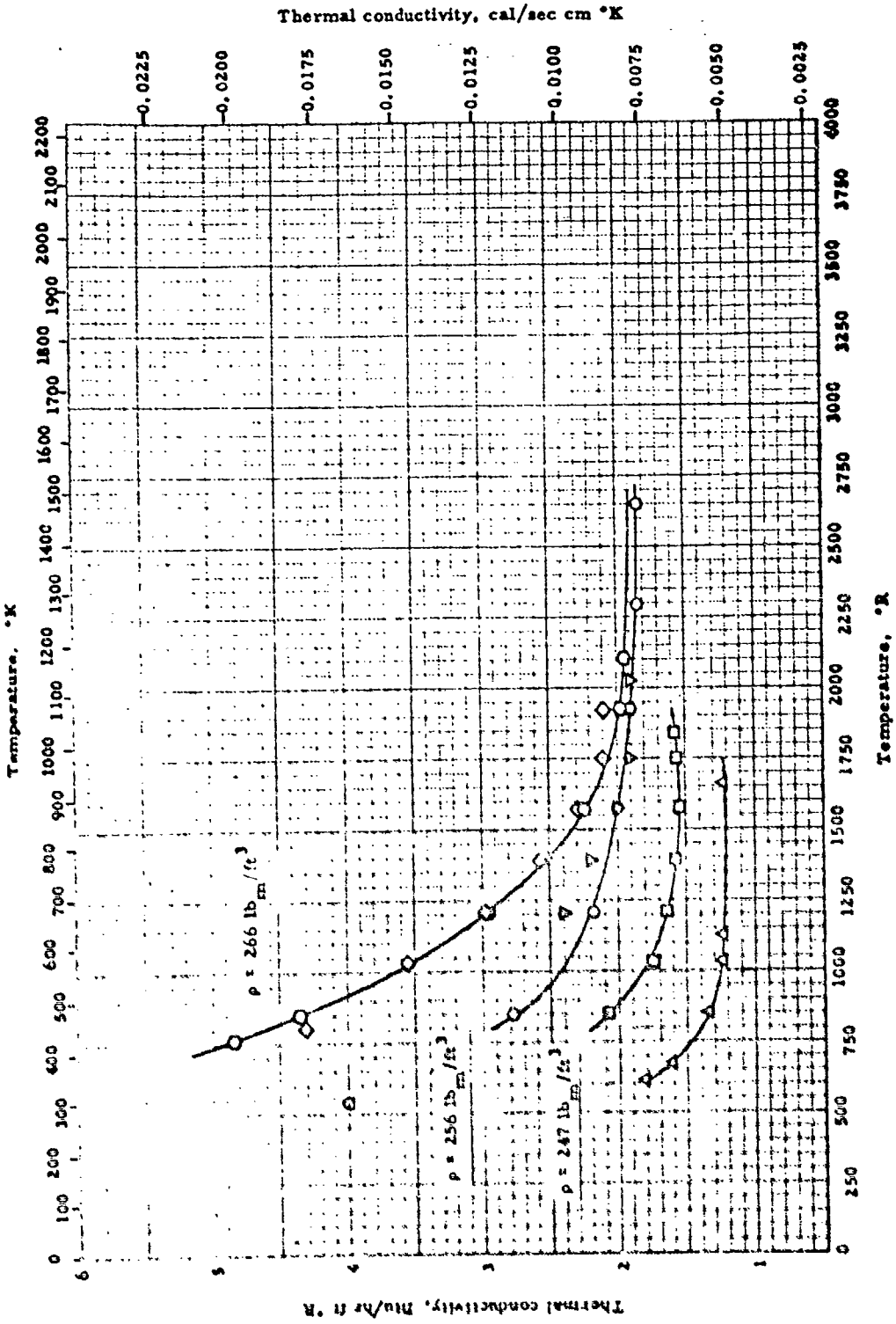


SPECIFIC HEAT -- TITANIUM OXIDE

SPECIFIC HEAT -- TITANIUM OXIDE

REFERENCE INFORMATION

Sym.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Shomate, C. H.	47-16	95-537	99.3% TiO_2; 0.3% H_2O (Anatase) ρ = 242 lb_m/ft^3	Guarded sample	Corrected for H_2O. Auth. est. accuracy ± 0.3%
□	Ibid.	47-16	95-537	99.7% TiO_2 (Rutile) ρ = 265 lb_m/ft^3	Same as above	Same as above
△	Arthur, J. S.	50-7	531-1932	Not given	Modified drop method; sample transferred manually from furnace to calorimeter	Doubtful accuracy
◇	Lieta, J.	56-52	708-1788	TiO_2. X-ray showed only lines of Anatase. ρ = 243.7 lb_m/ft^3	Drop method; copper block calorimeter	Synthetically prepared from doubly distilled $TiCl_4$. Heated 4 hr. at 565°C
▽	Ibid.	56-52	708-2148	TiO_2 (Rutile); x-ray showed no lines of Anatase; ρ = 259.1 lb_m/ft^3	Same as above	Same as above except heated 1.5 hr. at 930°C. Material was white with slight yellow cast

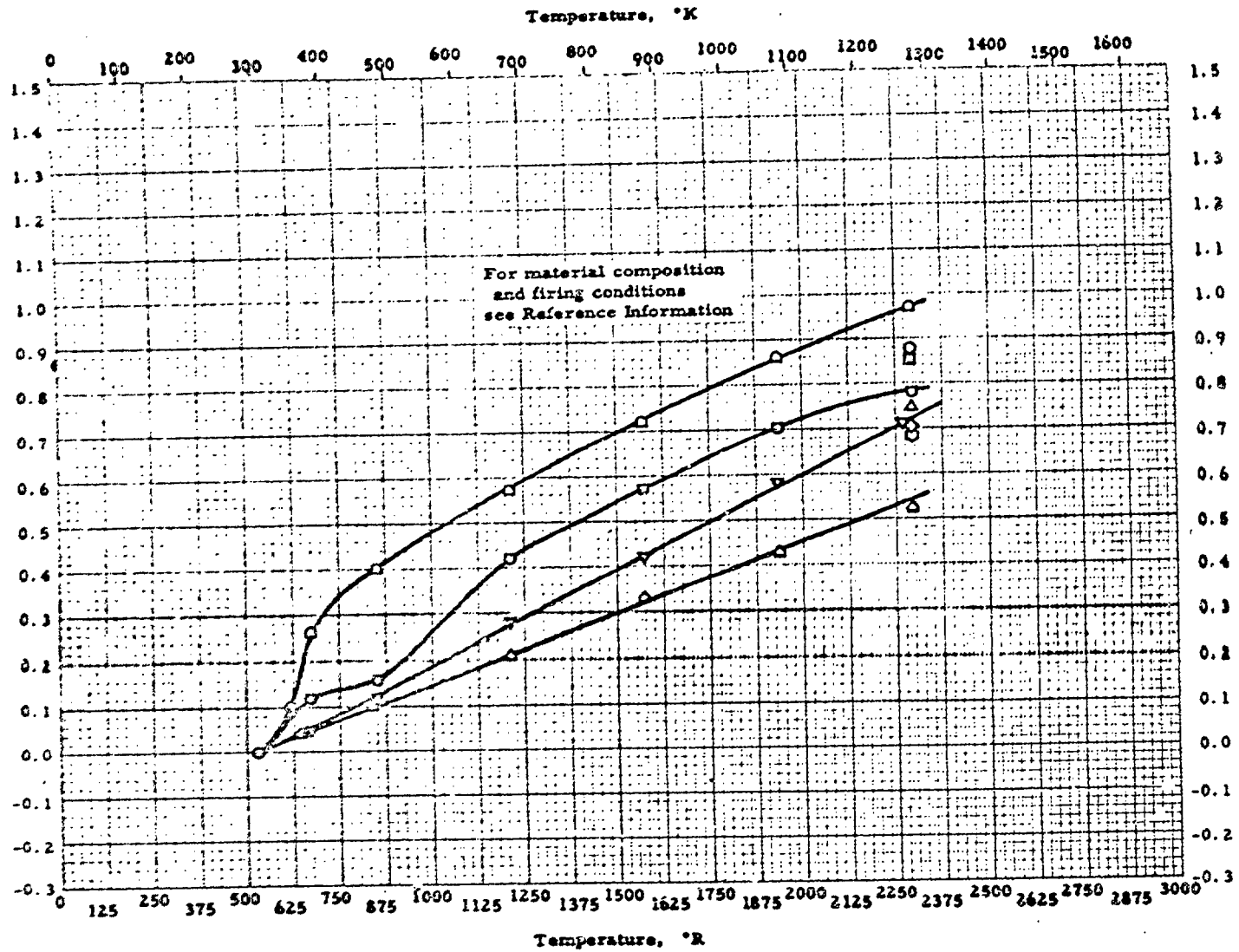


THERMAL CONDUCTIVITY -- TITANIUM OXIDE

THERMAL CONDUCTIVITY -- TITANIUM OXIDE

REFERENCE INFORMATION

	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Kingery, W. D. and Francl, J.	54-1 also 52-65 53-65	852-2652	Chemically pure TiO_2. ρ =257 lb_m/ft^3 (cf. theor. ρ = 266) Porosity = 3.5%	Ellipsoidal envelope	Calcined at 1000°C, acid leached, slip cast and fired at 1700°C in oxidizing atmos.
□	Bessem, W. R. and Bush, E. A.	55-10	852-1842	Dense TiO_2; made from 100% heavy grade TiO_2; binder consists of 500 g Carbowax, 10 g methocel and 7% water. ρ = 247 lb_m/ft^3. Apparent Porosity = 0.1%	Radial heat flow in cylinder	Samples pressed at 4400 psi and fired 20 min. at 1390° C
△	Ibid.	55-10	618-1662	Porous TiO_2; made from 70% titanox calcined 1 hr. at 1500°C and 30% RA-10-MO. Binder consisted of 500 g carbowax, 10 g methocel and 7% water. ρ = 207 lb_m/ft^3. Porosity = 17.1%	Same as above	Samples fired for 1 hr. at 1390°C
◇	Kingery, W. D. and Morton, F. H.	55-47	672-1932	TiO_2. Porosity = 2.1%. Average crystal size = 15 microns	Comparative; rods	Sintered 2 hr. at 1250°C
▽	Ibid.	55-47	1212-2022	TiO_2. Porosity = 3.0%. Average crystal size = 28 microns	Same as above	Sintered 8 hr. at 1450°C
○	Charvat, F. R. and Kingery, W. D.	57-53	762-2112	Polycrystalline TiO_2 Porosity = 2.1%. Average crystal size = 15 microns	Comparative; cubes	Data corrected to zero porosity
□	Oak Ridge National Laboratory	57-150	546	TiO_2	Not described here; refers to others	Measured by O. Sieman, C. D. Bobb and R. L. Towns, Auth. es.. accuracy ± 12%

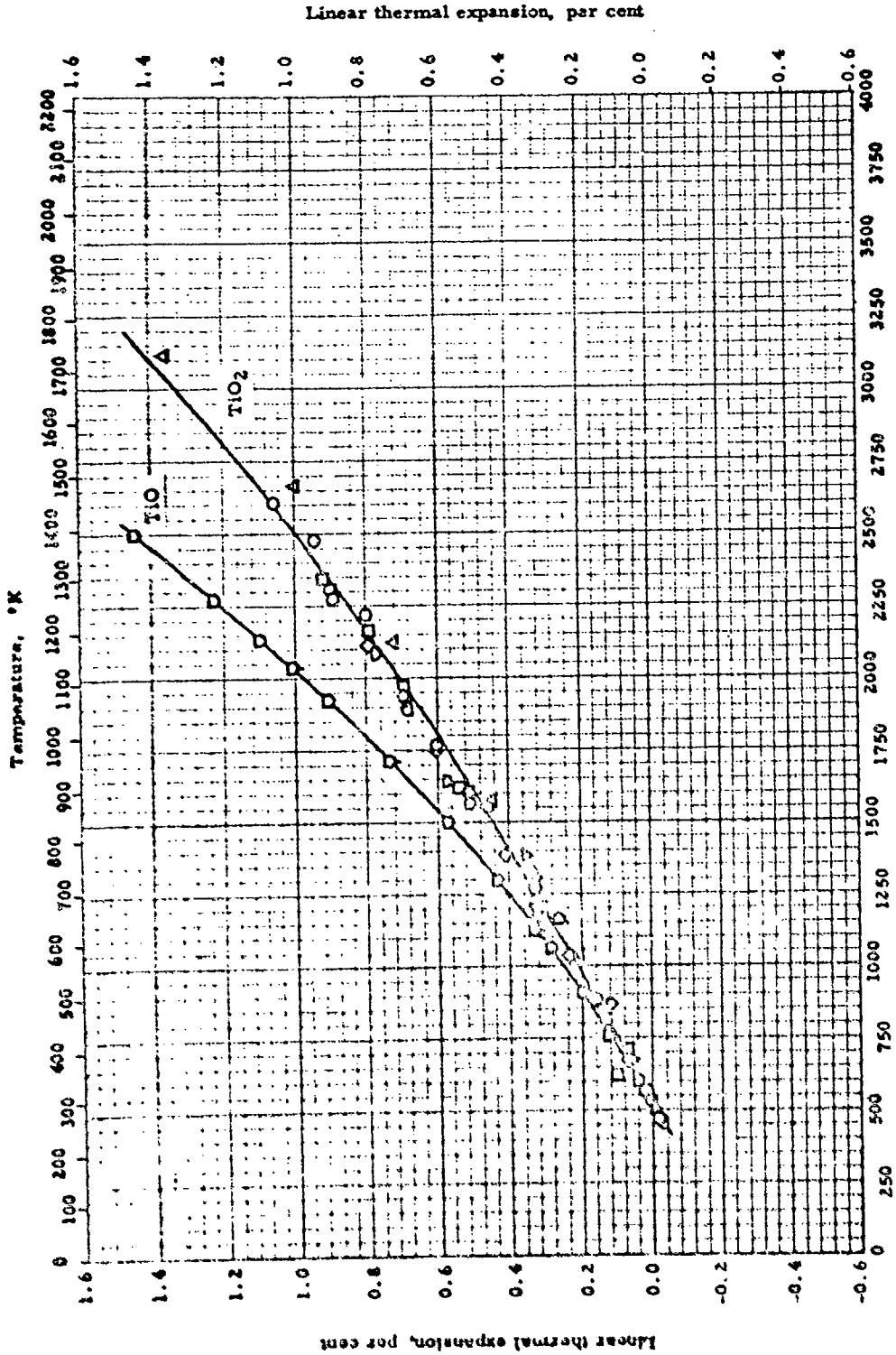


LINEAR THERMAL EXPANSION -- TITANIUM OXIDE + SILICON OXIDE

LINEAR THERMAL EXPANSION -- TITANIUM OXIDE + SILICON OXIDE

REFERENCE INFORMATION

	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Fisher, R. W. and Hummel, F. A.	51-48	528-2292	97% TiO_2 ; 3% SiO_2	Quartz tube dilatometer using dial guages calibrated to 10^{-4} in.	Heated 2 hr. at 1540°C and 8 hr. at 1500°C
□	Fisher, R. W. and Hummel, F. A.	51-48	528-2292	92% TiO_2 ; 8% SiO_2	Same as above	Same as above
△	Fisher, R. W. and Hummel, F. A.	51-48	528-2292	84% TiO_2 ; 16% SiO_2	Same as above	Same as above
◇	Fisher, R. W. and Hummel, F. A.	51-48	528-2292	76% TiO_2 ; 24% SiO_2 , Sample 1	Same as above	Same as above
▽	Fisher, R. W. and Hummel, F. A.	51-48	672-2292	Same as above, Sample 2	Same as above	Same as above
⬡	Fisher, R. W. and Hummel, F. A.	51-48	528-2292	67% TiO_2 ; 33% SiO_2	Same as above	Same as above
⌂	Fisher, R. W. and Hummel, F. A.	51-48	618-2292	57% TiO_2 ; 43% SiO_2	Same as above	Same as above
⌂	Fisher, R. W. and Hummel, F. A.	51-48	672-2292	Same as above	Same as above	Same as above, fired 1 hr. at 1670°C
⬭	Fisher, R. W. and Hummel, F. A.	51-48	672-2292	56% TiO_2 ; 42% SiO_2 ; 2% GeO_2	Same as above	Same as above, but fired at 1540°C

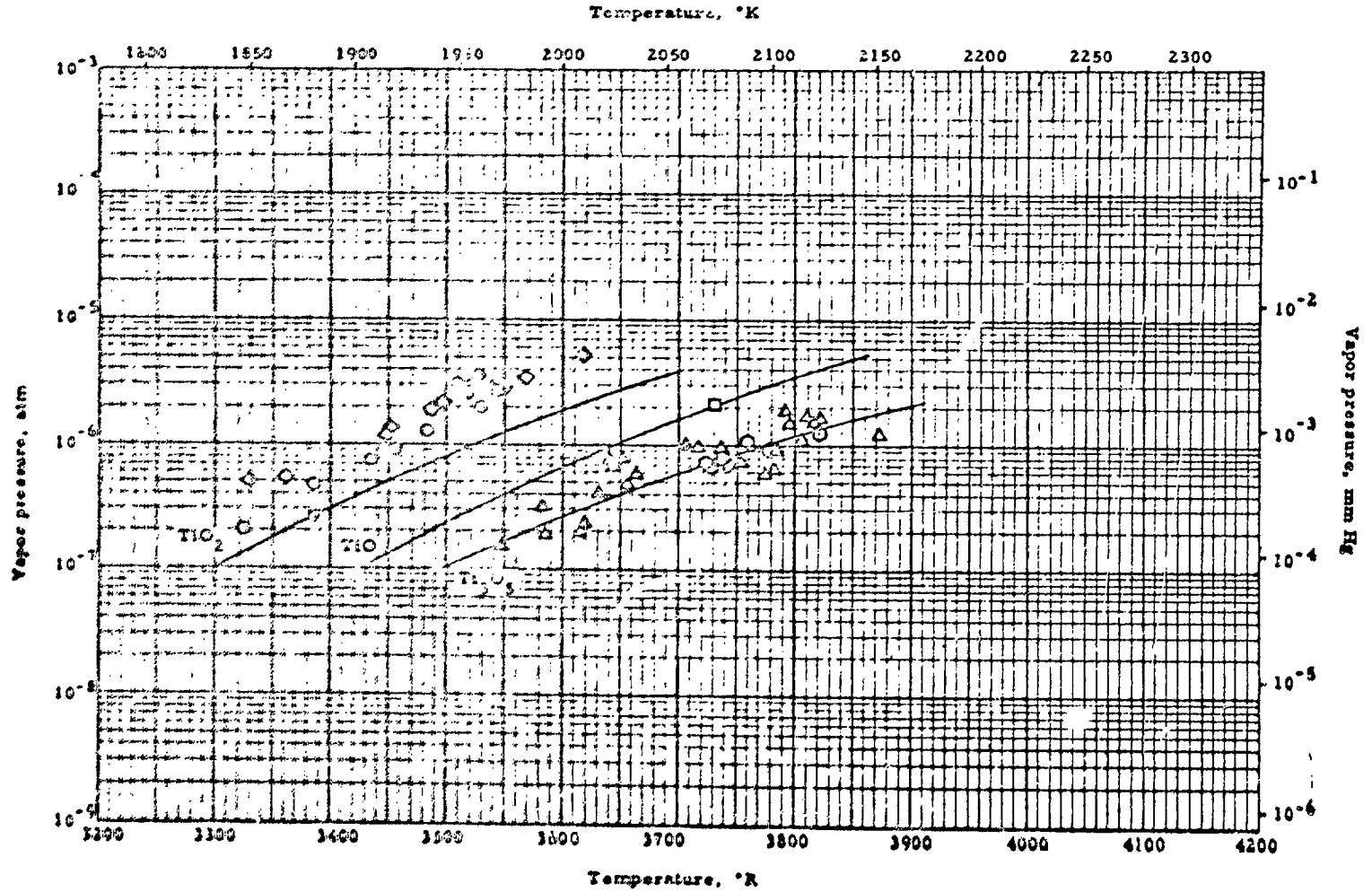


LINEAR THERMAL EXPANSION -- TITANIUM OXIDE

LINEAR THERMAL EXPANSION -- TITANIUM OXIDE

REFERENCE INFORMATION

	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Manier, F.A. and Bole, L.H.	56-8	492-2607	TiO_2	Dilatometer	Air atmos.
□	Ibid.	56-8 also 54-19 54-51 57-62 55-58	492-2351	Same as above	X-ray diffraction; averaged expansion along "a" and "c" axes to represent polycrystalline solid	Fired at 1700°C in oxidizing atmos. then ground to 325 mesh and presintered at 1200°C in air; tested in He atmos.
△	Whitemore, O.J. and Ault, N.N.	56-7	2032-3102	Coarse fused grain TiO_2	Telemicroscopes sighting on pointed ends of sample	
◇	Harding, E.N., Skelton, C.R. and Creamer, A.E.	47-9	528-2112	C.P. grade TiO_2	Interferometer	Heated 12 hr. at 1100°C, matured 6 hr. at 1250-1430°C
▽	Navias, L.	41-9	528-1392	90% TiO_2; 3.4% ea. $CaTiSiO_5$, MgO, BeO	Comparison with standard (not identified) of similar length	
○	Manier, F.A. and Bole, L.H.	55-58	492-1235	$TiO_{1.97}$; oxygen deficient rutile; "Black Rutile" prepared by heating TiO_2 to 1538°C in vacuum	X-ray diffraction	
□	Ricker, R.W. and Hummel, F.A.	51-48	528-2292	100% TiO_2	Fused silica dilatometer	Fired 2 hr. at 1540°C and 8 hr. at 1500°C
△	Ibid.	51-48	528-2292	Same as above	Same as above	Fired 18 hr. at 1080°C
▽	Manier, F.A. and Bole, L. H.	56-8 also 57-62	492-2503	TiO	Dilatometer	In vacuum. ▽ - heating; ▽ - cooling
○	Ibid.	56-8	492-1604	TiO	X-ray	He atmos. Above 600° C x-ray patterns were poor; after heating sample above 600°C, room temp. patterns also were poor

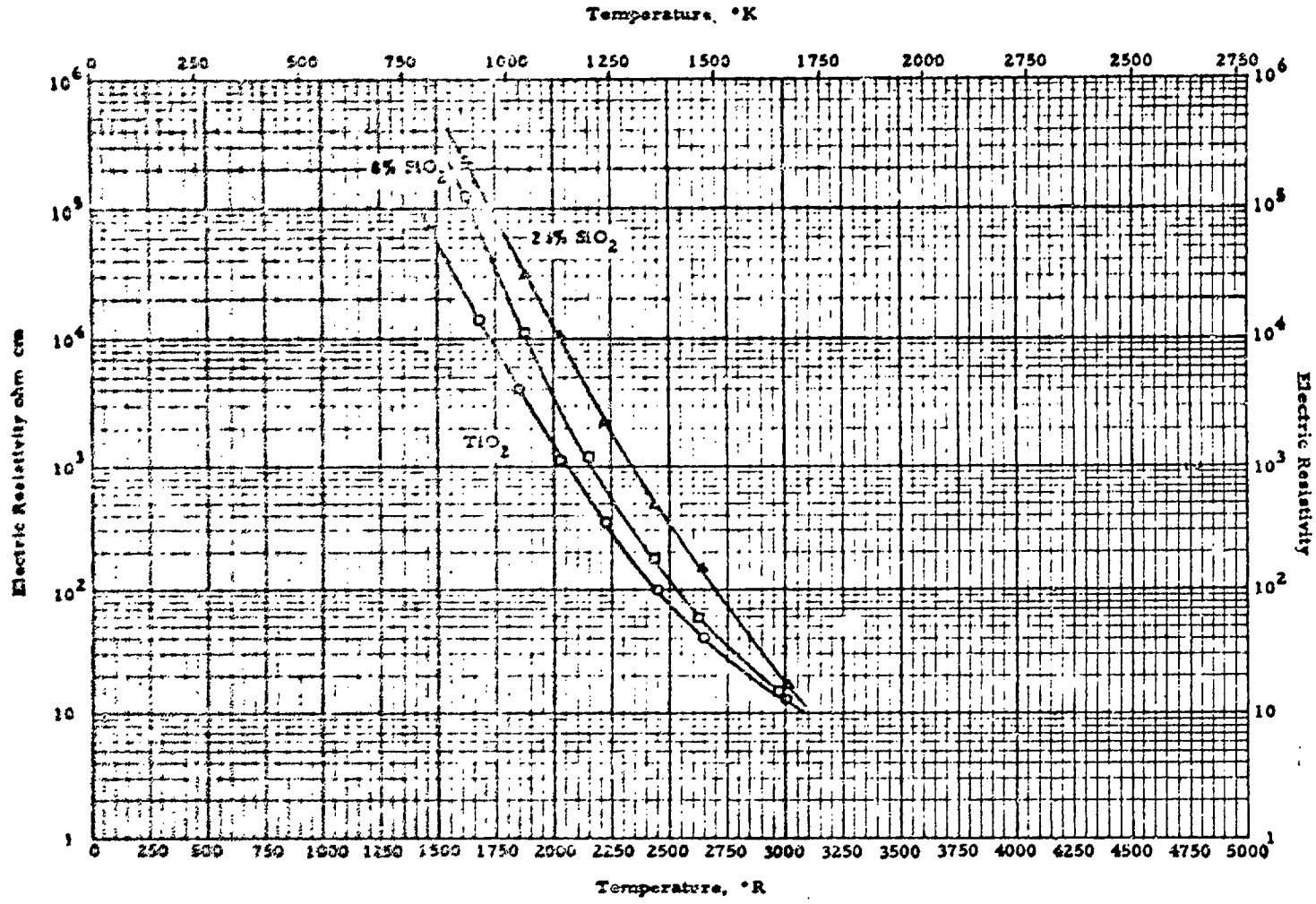


VAPOR PRESSURE -- TITANIUM OXIDE

VAPOR PRESSURE -- TITANIUM OXIDE

REFERENCE INFORMATION

	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Groves, W. O., Hock, M. and Johnston, H. L.	55-64	3325-3542	TiO; actually $TiO_{1.075}$ for two points; $TiO_{1.029}$ for others; prepared from "Baker's Analyzed" cp TiO_2 and iodide process Ti	Knudsen effusion cell; with x-ray diffraction camera	Ta cell, degassed, corrected for weight loss. Additional oxygen in solid to inhibit $TiO(s) \rightarrow TiO_2(s) + Ti(g)$
△	Ibid.	55-64	3548-3872	Ti_2O_3; raw materials same as above	Same as above	Mo lined Ta cell, degassed, corrected for weight loss, $Ti_2O_3(s) \rightarrow TiO(g) + TiO_2(g)$. Auth.'s state that the assumption: $p_{TiO} = p_{TiO_2}$ introduces error of only 0.47% therefore report results as $\sqrt{p_{TiO} \cdot p_{TiO_2}}$
◇	Ibid.	55-64	3328-3618	TiO_2; actually $TiO_{1.9}$; raw materials same as above	Same as above	Mo lined Ta cell, degassed, corrected for weight loss. $TiO_{1.9}$ used to inhibit effusion of O_2, for detailed explanation. See p. 129 of article
○	Ibid.	55-64	3723-3820	Ti_3O_5; raw materials same as above	Same as above	Data treated as $Ti_3O_5(s) \rightarrow Ti_2O_3(s) + TiO_2(g)$; results reported as p_{TiO_2}
□	Berkowitz, J., Chupka, W. A. and Inghram, M. G.	57-65 also 56-44	3736	TiO	Knudsen effusion cell and mass spectrometer	Mo lined Ta cell and Thoria cell. Auth.'s state $p_{Ti} \approx p_{TiO}$ in spite of small amount of additional oxygen
	Ibid.	57-65 also 56-44	3730	Ti_2O_3	Same as above	No p results given, however auths. state that $p_{Ti}:p_{TiO}:p_{TiO_2} \simeq 600:1400:17$ in contradiction to Groves et al.
▽	Ibid.	57-65 also 56-44	3386	TiO_2	Same as above	Mo lined Ta cell and Thoria cell. Results with first cell affected by evolution of large amounts of Mo oxides

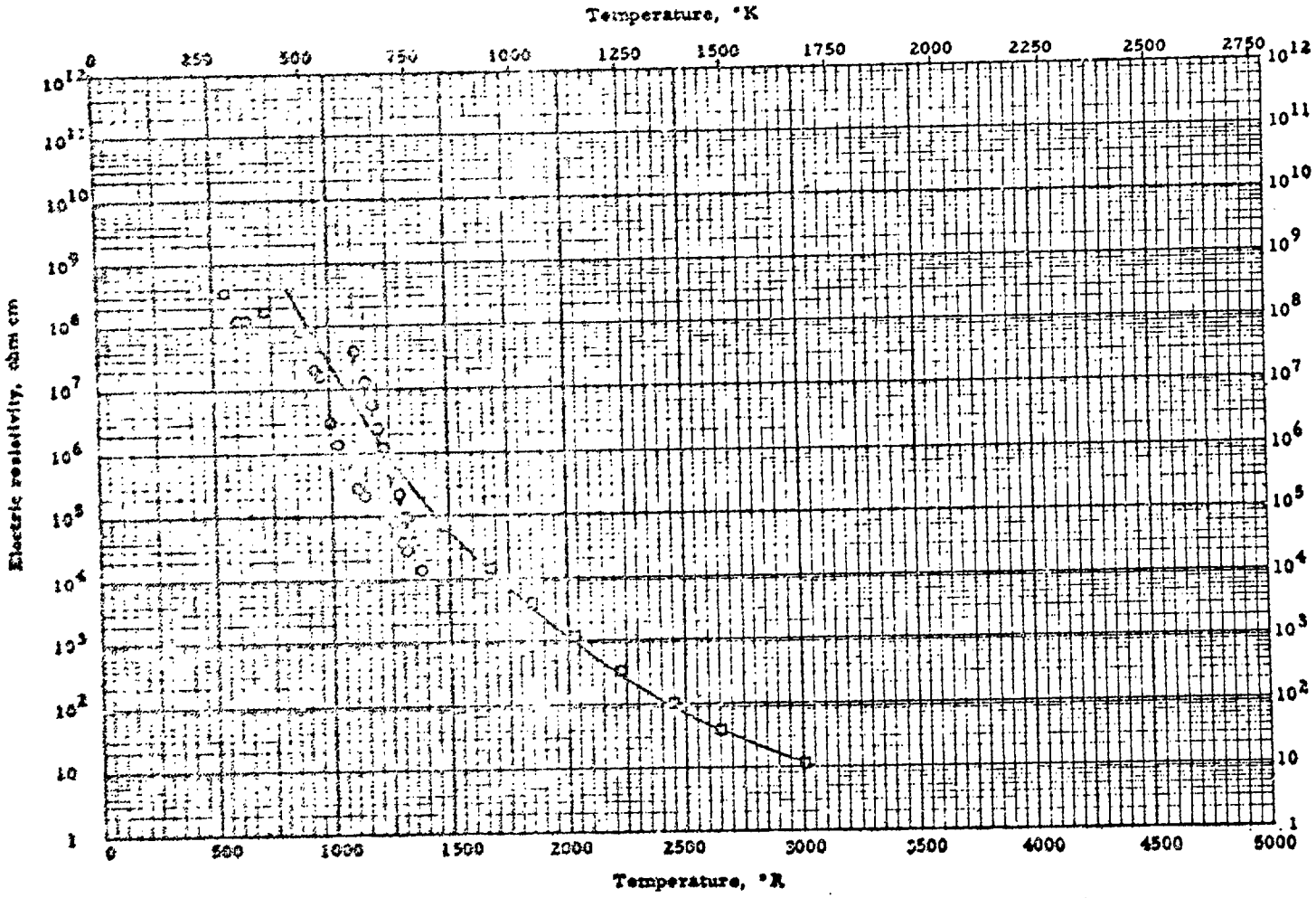


ELECTRIC RESISTIVITY -- TITANIUM OXIDE + SILICON OXIDE

ELECTRIC RESISTIVITY -- TITANIUM OXIDE + SILICON OXIDE

REFERENCE INFORMATION

	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Moesler, J.R. and Henry, R.C.	53-95	1482-3012	100% TiO_2	Wheatstone bridge	Fired 24 hr. to 1450°C
□	Ibid.	53-95	1626-3012	92% TiO_2; 8% SiO_2	Same as above	Same as above
△	Ibid.	53-95	1626-3012	76% TiO_2; 24% SiO_2	Same as above	Same as above



ELECTRIC RESISTIVITY -- TITANIUM OXIDE

ELECTRIC RESISTIVITY -- TITANIUM OXIDE

REFERENCE INFORMATION

Curve Ident.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Johnson, G.R.	53-104	546-1959	Chemically pure TiO_2; rutile	Wheatstone bridge	○ - heating ○ - cooling
□	Kessler, J.R. and Henry, E.C.	53-95	1482-3012	TiO_2	Wheatstone bridge	Fired 24 hr. to 1450°C

PROPERTIES OF HAFNIUM OXIDE

MOST PROBABLE VALUES

Property	Brit. Engineering Units	C. G. S. Units
Density.	604 lb_m/ft^3 *	9.68 g/cm^3 *
Melting Point	5720°R	3170°K
Heat of Fusion		
Heat of Vaporization. . .		
Heat of Sublimation . . .		

* Handbook of Chem. and Phys. (Ref. 57-60)

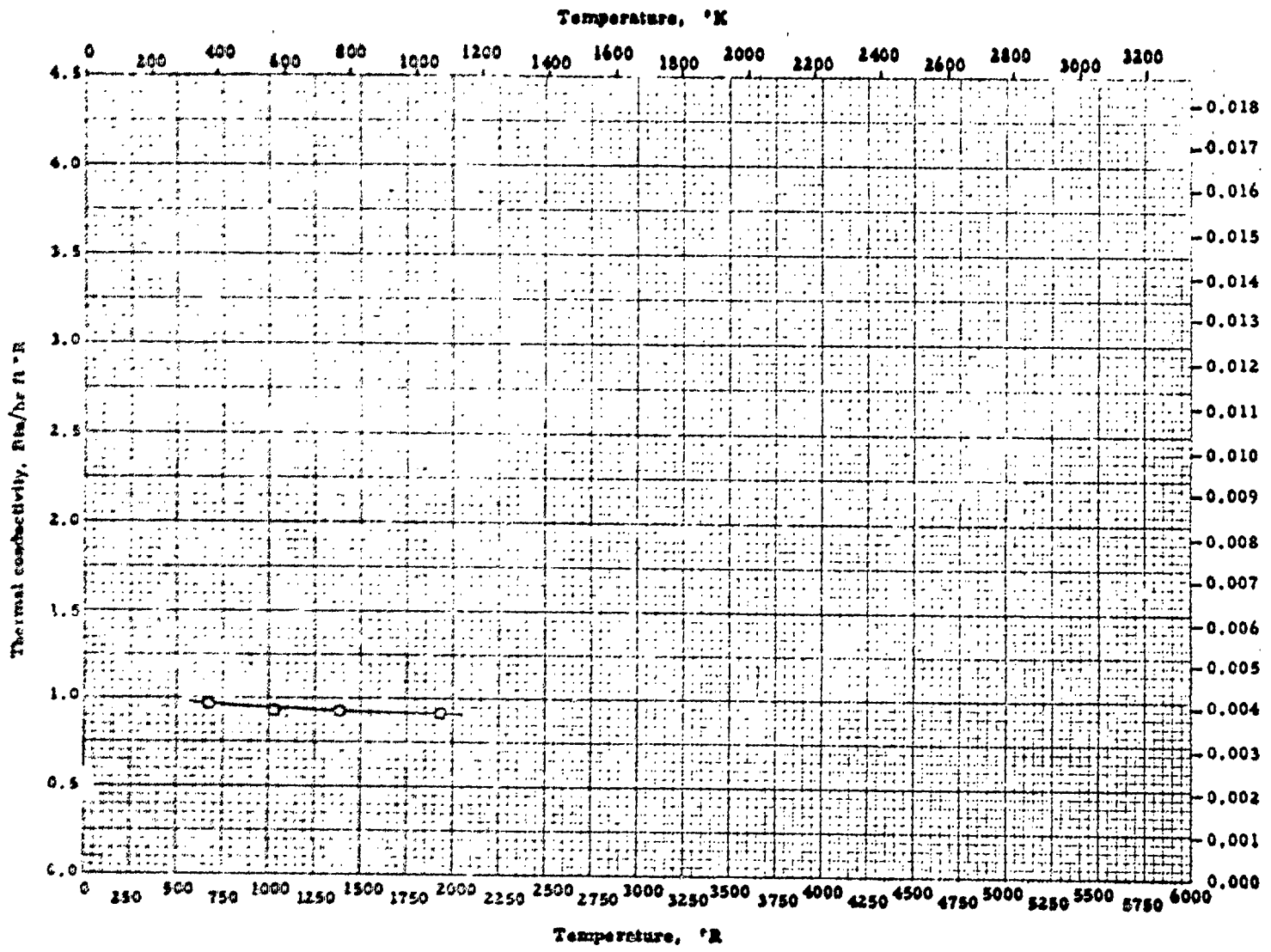
REPORTED VALUES

Density:		lb_m/ft^3	g/cm^3
Melting Point:		°R	°K
	O	5721 ± 45	3173 ± 25
	□	5553	3085
Heat of Fusion:		Btu/lb_m	cal/g
Heat of Vaporization:		Btu/lb_m	cal/g
Heat of Sublimation:		Btu/lb_m	cal/g

PROPERTIES OF HAFNIUM OXIDE

REFERENCE INFORMATION

Form 151	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Curtis, C. E., Doney, L. M., and Johnson, J. R.	54-46 also 54-45	5721	0.1+% Ti; 0.06% Al; 0.01% ea. Fe, Si; 0.0002% Zr	MP: sample heated with oxyacetylene flame: optical pyrometer	Ground to 325 mesh; pressed at 20,000 psi; fired 2 hr. at 1600°C
□	Trombe, F.	49-16	5554	Not given	MP: not given	

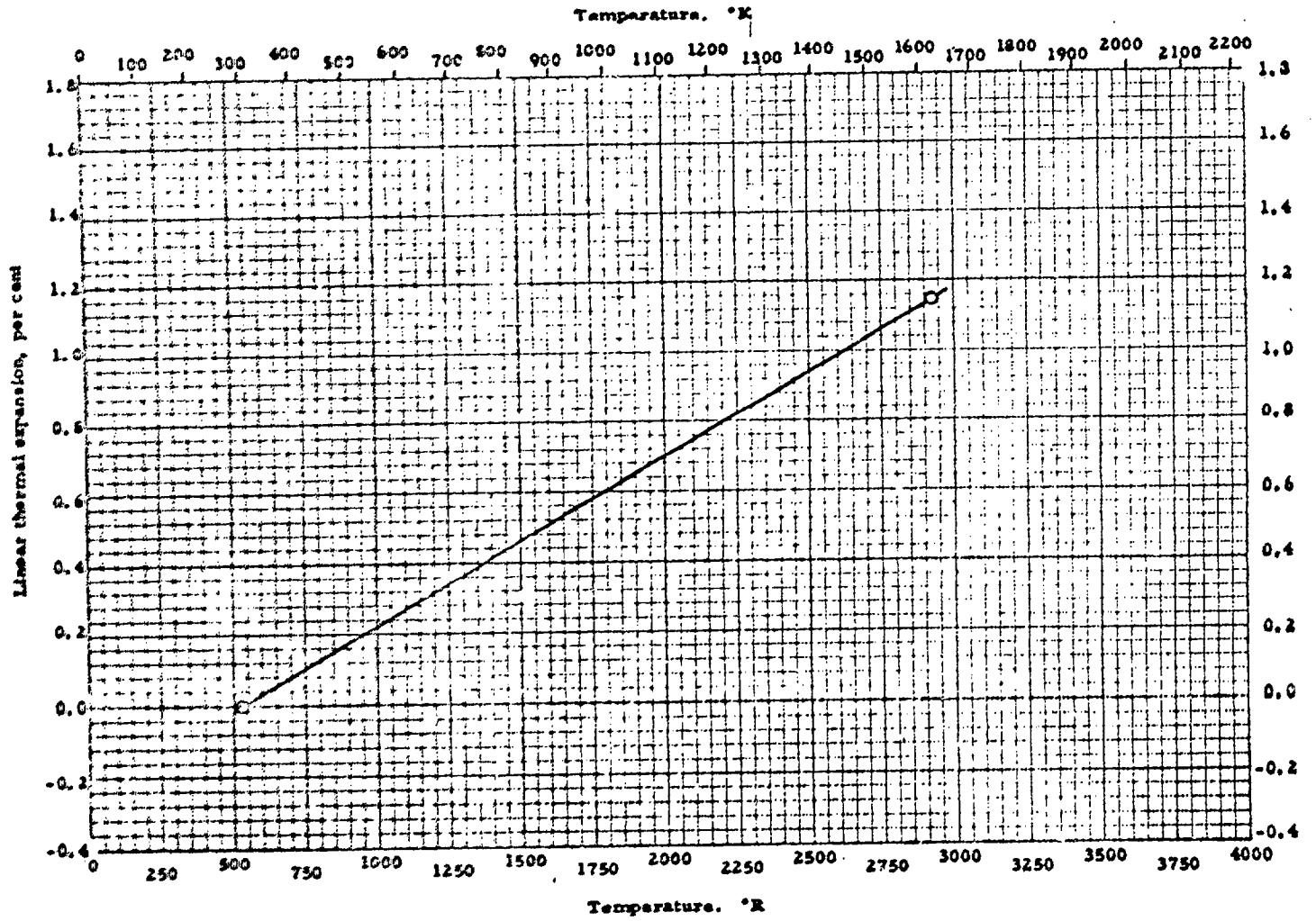


THERMAL CONDUCTIVITY -- HAFNIUM OXIDE

THERMAL CONDUCTIVITY -- HAFNIUM OXIDE

REFERENCE INFORMATION

[illegible]	Ref.	Range, °F.	Material Composition	Test Method	Remarks
[illegible], F. H., and [illegible]ery, W. D.	55-25	672-1932	Not given	Comparative; rods	

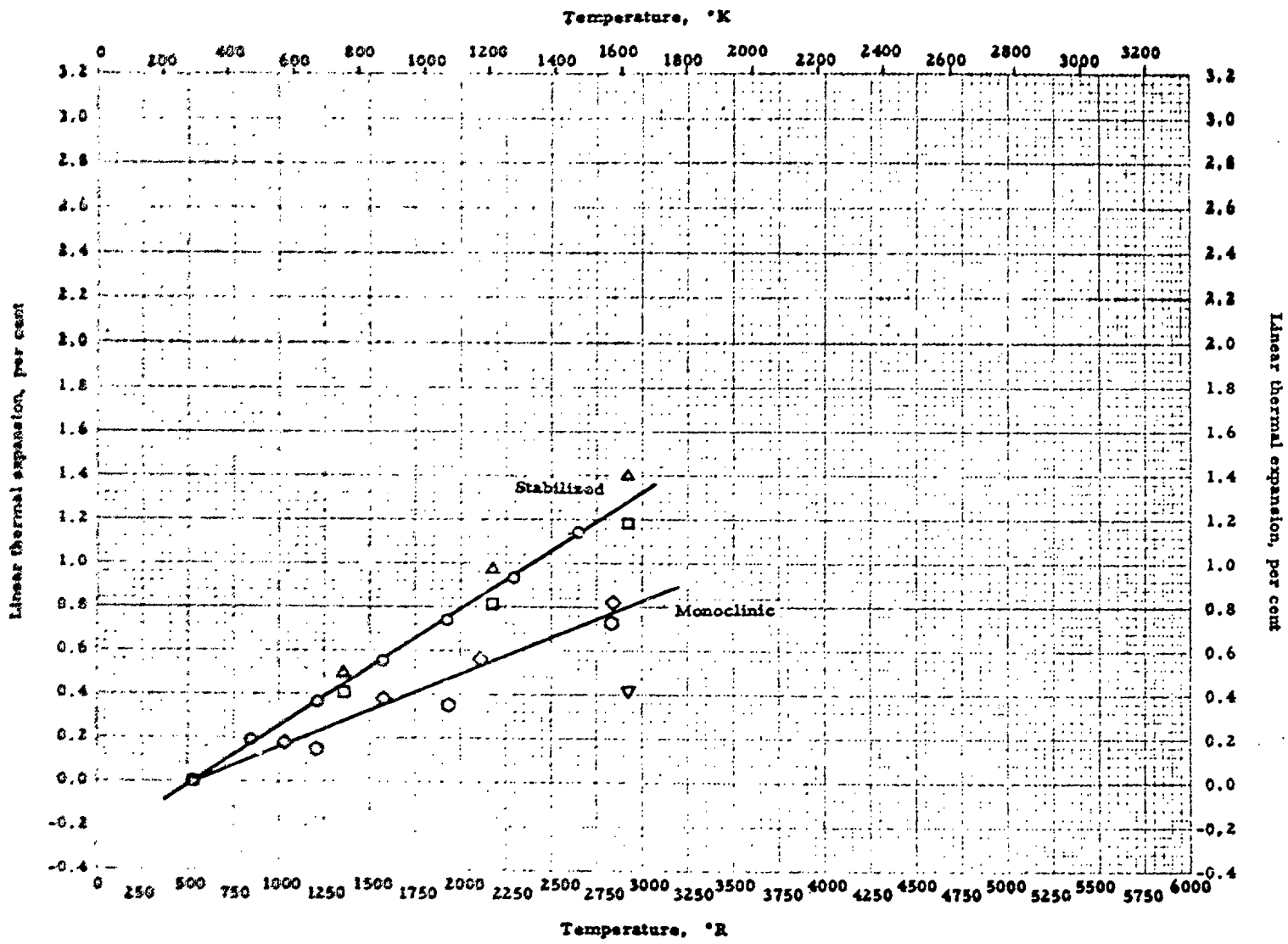


- LINEAR THERMAL EXPANSION -- HAFNIUM OXIDE + TANTALUM OXIDE

LINEAR THERMAL EXPANSION -- HAFNIUM OXIDE + TANTALUM OXIDE

REFERENCE INFORMATION

	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Cline, C. F. and Lewis, C.	57-23	528-2922	$6HfO_2 \cdot Ta_2O_5$	Not given	Ta_2O_5 impurities: 1% ea. Ta, Si; 0.05 - 0.1% F, Ti. HfO_2 impurities: 1% Th; 0.05-1% V; 0.1-0.5% Na; 0.01-0.05% ea. Al, Ti

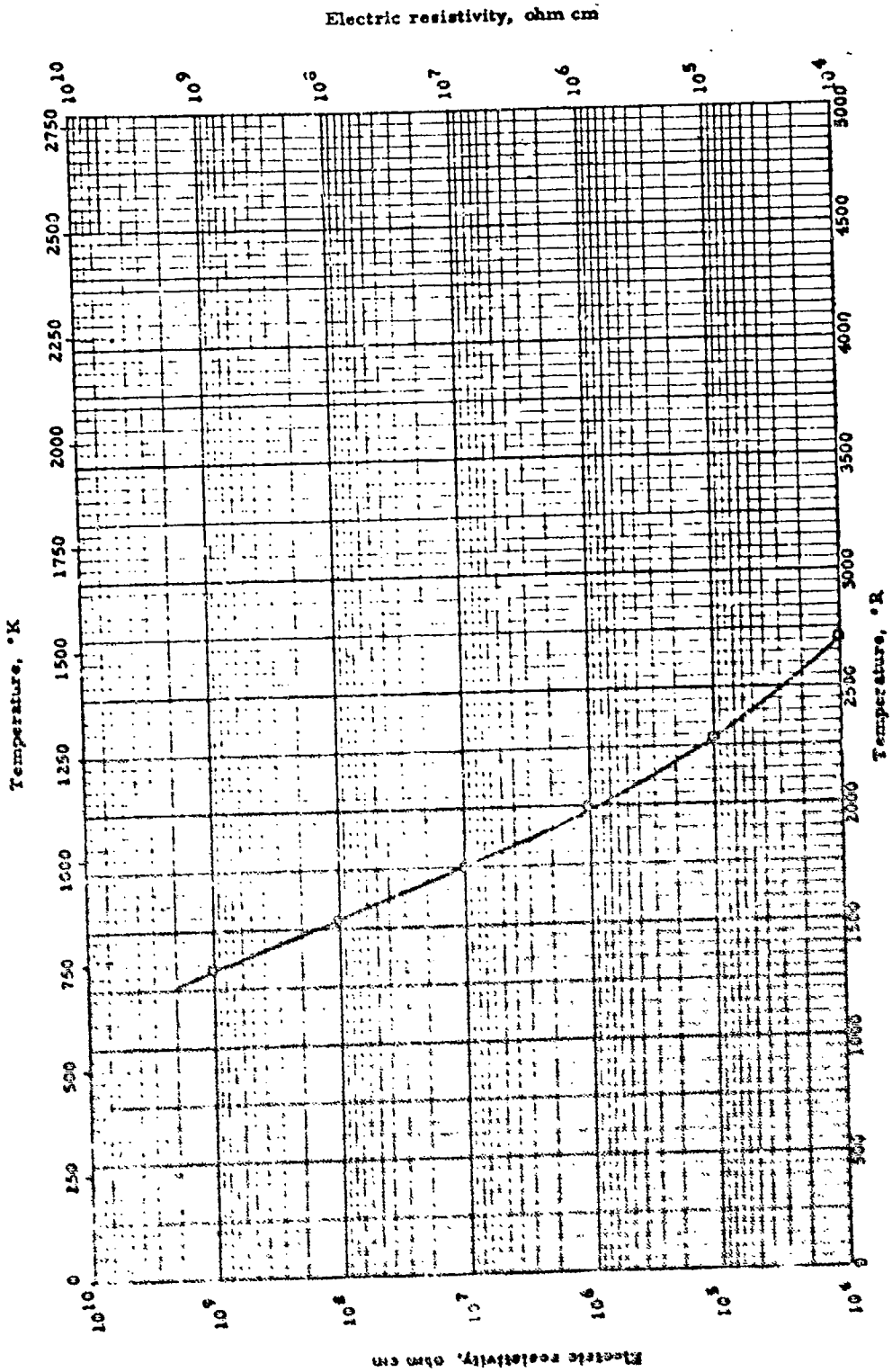


LINEAR THERMAL EXPANSION -- HAFNIUM OXIDE

LINEAR THERMAL EXPANSION -- HAFNIUM OXIDE

REFERENCE INFORMATION

	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Curtis, C. E., Doney, L. M. and Johnson, J. R.	54-45 also 54-46	528-2832	97.7% HfO_2; 2.3% CaO; ρ = 524 lb_m/ft^3; porosity = 10%; (92 mol % HfO_2; 8 mole % CaO)	Sapphire dilatometer	Mixed, pressed at 20,000 psi. Soaked 2 hr. at 1650 °C
◇	Ibid.	54-45 also 54-46	528-2832	Unstabilized hafnia. Monoclinic; 0.14% Ti; 0.1% ea. Fe, Si; 0.06% Al; 0.0002% Zr	Same as above	Ground to 325 mesh, pressed at 20,000 psi, fired 2 hr. at 1600 °C; tested at 3°C/min. rise
□	Cline, C. F. and Lewis, G.	57-23	528-2292	97.9% HfO_2; 2.1% MgO; (90 mol % HfO_2; 10 mol % MgO)	Not given	Auth. report mean expansion coeff. over range
△	Ibid.	57-23	528-2292	95.4% HfO_2; 4.6% MgO; (80 mol % HfO_2; 20 mol % MgO)	Same as above	Same as above
▽	Ibid.	57-23	528-2292	Unstabilized hafnia. 1% excess Hf; 1% Zr; 0.5-1.0% ea. Fe, Si; 0.1-0.5% Mg; 0.05-0.10% ea. Ti, Ca; 0.005-0.010% Al; 0.001-0.005% ea. Mn, Cu	Same as above	Auth. report mean coeff. of exp. = 3.18×10^{-6}/°C for range 20-1350 °C
⬡	Fulkerson, S. D.	57-159	550-2830	Unstabilized hafnia. HfO_2, Zr free	Sapphire dilatometer	Monoclinic form of crystal



ELECTRIC RESISTIVITY -- HAFNIUM OXIDE

ELECTRIC RESISTIVITY -- HAFNIUM OXIDE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Curtis, C.E., Doney, L.M. and Johnson, J.R.	54-45	1212-3192	Hafnium oxide; 0.1+% Ti; 0.1% ea. Fe, Si; 0.06% Al;0.0002% Zr	Not given	Work done at NBS. Material ground to pass 325 mesh, pressed at 20,000 psi with 5% water and 2% dextrin; fired 2 hr. at 1600°C

Symbol	Material Composition, % ZrO_2	Material Composition, % UO_2	Density lb_m/ft^3	Density g/cm^3
○	90	10	323	5.18
□	85	15	340	5.45

DENSITY -- ZIRCONIUM OXIDE + URANIUM OXIDE

60-769
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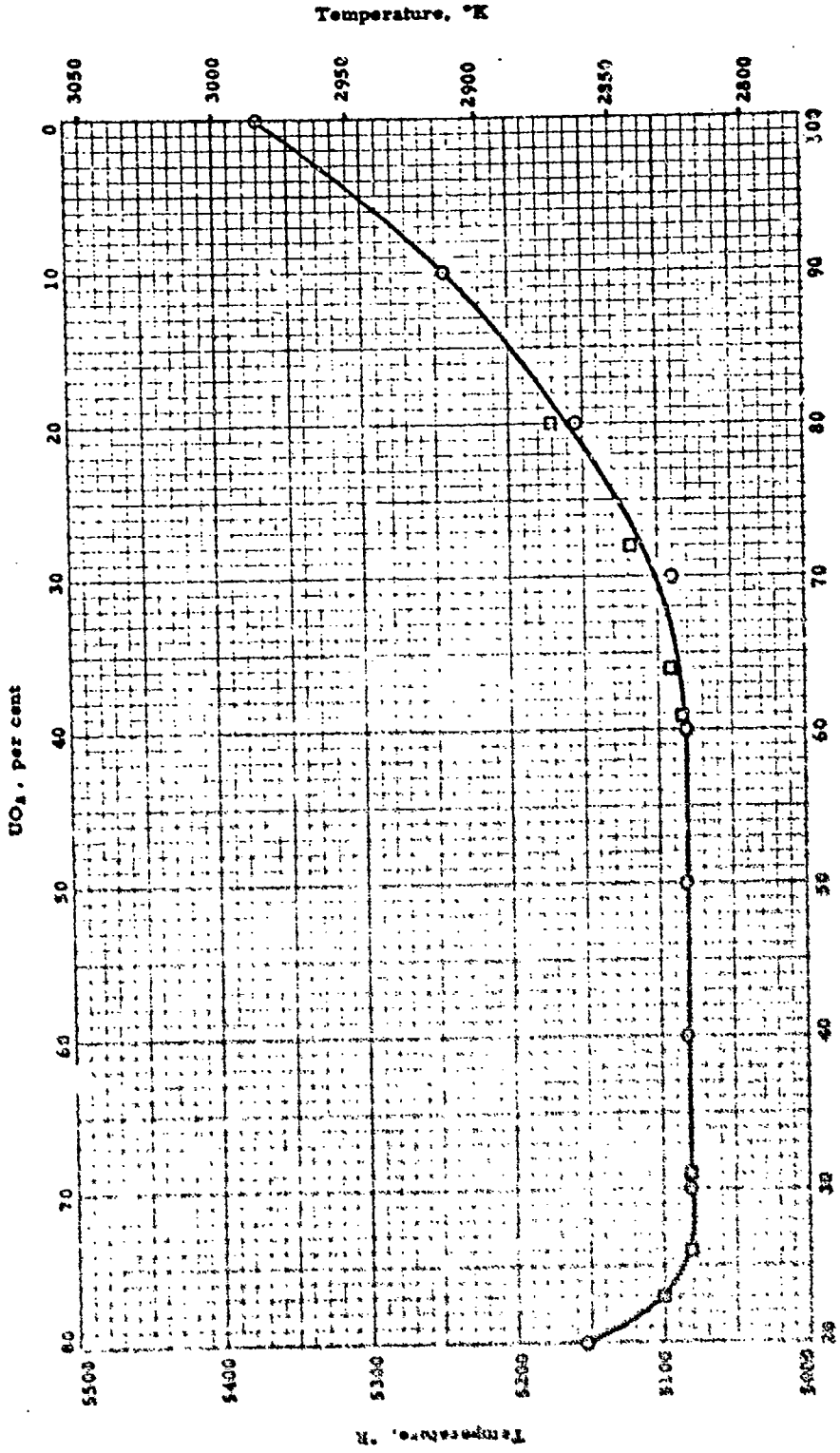
Pt 2

DENSITY -- ZIRCONIUM OXIDE + URANIUM OXIDE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Belle, J. and Jones, L. J.	56-156	Room	90% ZrO_2 ; 10% UO_2	Not given	Pressed at 80,000 psi, sintered 16 hr. at 1700°C
□	Ibid.	56-156	Room	85% ZrO_2 ; 15% UO_2	Same as above	Pressed at 80,000 psi, sintered 16 hr. at 1750°C



MELTING POINT -- ZIRCONIUM OXIDE + URANIUM OXIDE

MELTING POINT -- ZIRCONIUM OXIDE + URANIUM OXIDE

REFERENCE INFORMATION

Curve No.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Lamberton, W. A. and Mueller, M. H.	53-138	5082-5372	Binary series ZrO_2 - UO_2	Not given	Made from approx. 98% pure ZrO with 2% HfO_2 and 0.035% other impurities and probably pure UO_2
□	Ibid.	53-138	5082-5172	Same as above	Same as above	Same as above

Symbol	Nominal Composition	Melting Point °R	Melting Point °K
○	$3\ ZrO_2 + 5\ BeO + 4\ MgO$	3540 ± 8	1966 ± 5
□	$ZrO_2 + Nb_2O_5$	3111	1728
	$2\ ZrO_2 + Nb_2O_5$	3228	1784
	$3\ ZrO_2 + Nb_2O_5$	3228	1784
	$4\ ZrO_2 + Nb_2O_5$	3147	1748

MELTING POINT -- ZIRCONIUM OXIDE + OTHER OXIDES

MELTING POINT -- ZIRCONIUM OXIDE + OTHER OXIDES

REFERENCE INFORMATION

Item Ref.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	National Bureau of Standards	54-132	3532-3548	$3ZrO_2$ + 5BeO + 4MgO	MP: visual observation; temp. by optical pyrometer	Average of 3-5 tests; auth. est. accuracy ± 2%
□	Durbin, E. A. and Harman, C. G.	52-31	3111-3228	ZrO_2 + Nb_2O_5 series	MP: meas. fusion temp. during sintering	Prepared from 99.5+% ZrO_2 and 99.9% Nb_2O_5; sintered

PROPERTIES OF ZIRCONIUM OXIDE

MOST PROBABLE VALUES

Property	Brit. Engineering Units	C. G. S. Units
Density.	360 lb_m/ft^3	5.7 g/cm^3
Melting Point	5370°R	2980°K
Heat of Fusion		
Heat of Vaporization. . .		
Heat of Sublimation . . .	3700 $_{0°R}$ Btu/lb_m	1500 $_{0°K}$ cal/g

REPORTED VALUES

Density:		lb_m/ft^3	g/cm^3
	△	362	5.80
	◇	356	5.70
	▱	182	2.92
	▷	337	5.4

Melting Point:		°R	°K
	□	5080	2822
	◇	5532 ± 45	3123 ± 25
	○	5352	2973
	⌂	5370 ± 27	2983 ± 15
	△	5369 ± 18	2983 ± 10
	▽	5612 ± 233	3118 ± 130
	◺	4452	2473

Heat of Fusion:	Btu/lb_m	cal/g
Heat of Vaporization:	Btu/lb_m	cal/g

Heat of Sublimation:		Btu/lb_m	cal/g
	○	2050 $_{3870°R}$ ± 22	1139 $_{2150°K}$ ± 12
	▽	2717 $_{0°R}$	1509 $_{0°K}$
	▱	2295 $_{0°R}$	1277 $_{0°K}$ ± 8

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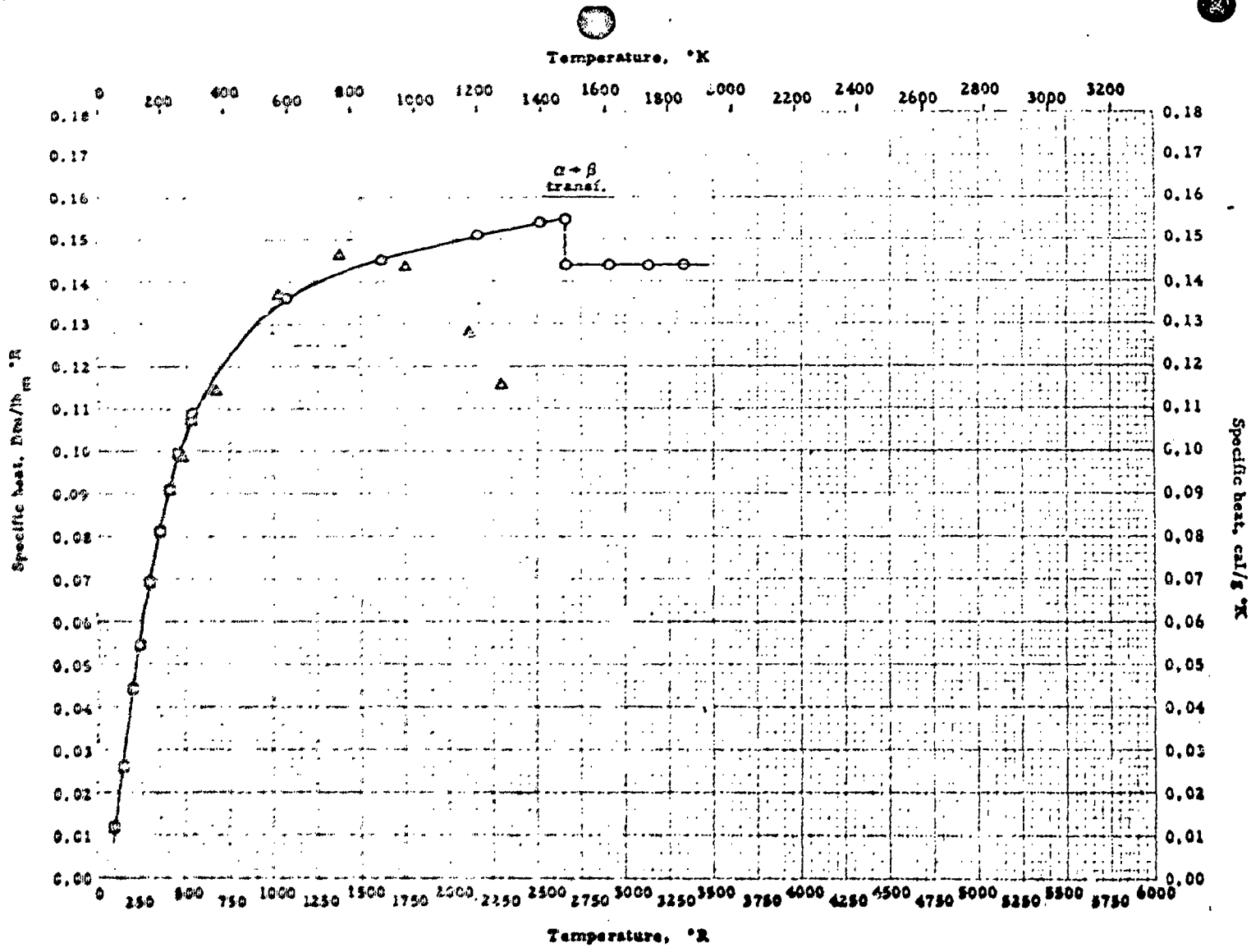
PROPERTIES OF ZIRCONIUM OXIDE

REFERENCE INFORMATION

	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
C	Hoch, M., Nakata, M. and Johnston, H. L.	53-24	5870	ZrO_2. Metal content 99.54% Zr; < 0.025% Hf	Δh_s: from vapor pressure data by Knudsen method with optical pyrometer ± 5°C	B.P. given as 3735°K. Vapor pressure measured 3625-4122°R
□	Whitemore, C. J.	51-6	5080	Stabilized zirconia	MP: not given	General comment in trade journal; no other information given
△	Caugier, J. J.	50-10 also 49-20	Room	Stabilized zirconia; 73.44% Zr; 25.43% O_2; 0.16% combined C; < 0.01% free C	ρ: weight in air and in distilled water	Hot pressed in graphite mold. Auth. quotes theoretical ρ = 6.1 g/cm³
◇	Curtis, C. E., Doney, L. M. and Johnson, J. R.	54-65 also 54-66	5532	0.06% Fe; 0.02% Si; 0.015% Al; 0.008% Hf; 0.006% Ti	MP: heated with oxyacetylene flame; optical pyrometer	Ground to 325 mesh; pressed at 20,000 psi; fired 2 hr. at 1600°C
▽	Ciereka, W. A., Berkowitz, J. and Inghram, M. G.	ND-2	0	ZrO_2	Δh_s: from vapor pressure data by Knudsen method with mass spectrometer; optical pyrometer	Vapor pressure measured 4196 - 4464°R
○	Trombe, F.	49-16	5352	ZrO_2	MP: not given	
⊡	Lamberton, W. A. and Cunsel Jr., F. H.	52-131	2[illegible]-2[illegible]	ZrO_2 2.03% HfO_2; 0.03% other	MP: visual observation after heating in constant temp. furnace; optical pyrometer	
⊙	Lamberton, W. A. and Mueller, M. H.	53-136	2[illegible]-2[illegible]	Zirconia. 2.0% HfO_2; 0.02% SiO_2; 0.005% ea. CaO, Fe_2O_3; 0.002% MgO; 0.001% ea. Al_2O_3, Na_2O; 0.0005% BaO; 0.0002% Cr_2O_3; 0.0001% Ba_2O_3	MP: not given	
⊕	Hoch, M., Nakata, M. and Johnston, H. L.	54-134	0	Zirconia. 0.025% Hf.	Δh_s: not given	$ZrO_2(s) \rightarrow ZrO_2(g)$. Auth. also tested mixture of ZrO_2 + Zr to check on undissociated gas phase. Auth. recommend ΔH (k cal/mole) = 157, 300-7.80T-400,000T^{-1} (T in °K). Also ΔH dissociation $ZrO_2(g) \rightarrow Zr(g) + O_2(g)$ = 368 ± 5 k cal/mole
⊖	Cubicciotti, D.	50-36	5[illegible]-2[illegible]	ZrO_2	MP: visual observation. Temp. by optical pyrometer	
b	O'Connor, W. F., Leasle, T. E. et al.	51-47	4452	ZrO_2	Temp. by optical pyrometer	
◇	Johnson, P. D.	50-37	Room	ZrO_2	ρ: computed from x-ray measurements of lattice	
⊡	Ibid.	50-37	Room	ZrO_2	ρ: not given	Pressed at 52,000 psi
D	Ibid.	50-37	Room	ZrO_2	ρ: not given	Fired at 2100-2300°C



SPECIFIC HEAT - ZIRCONIUM OXIDE

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SPECIFIC HEAT -- ZIRCONIUM OXIDE

REFERENCE INFORMATION

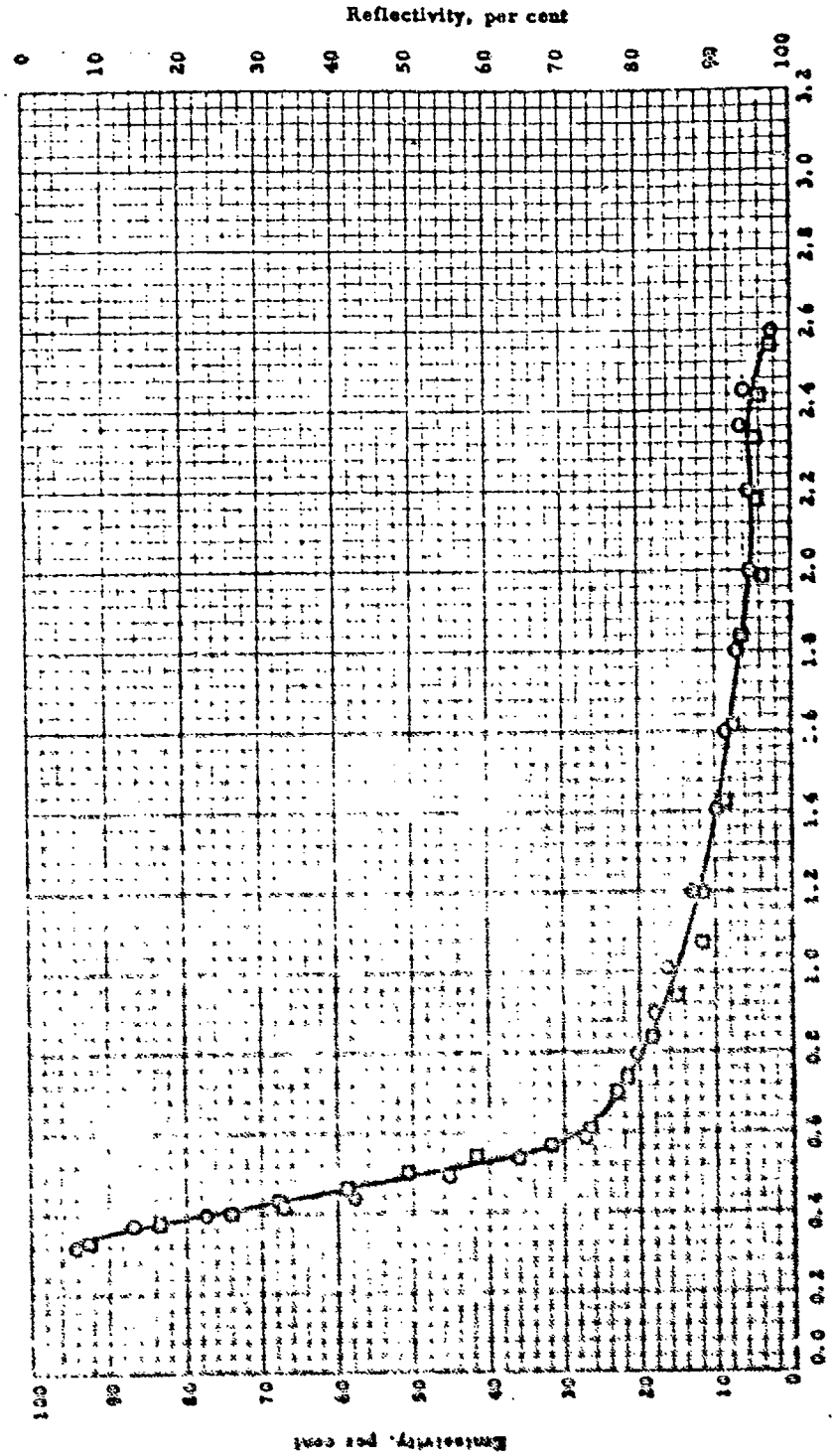
Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Coughlin, J. P. and King, E. G.	50-2	714-3315	ZrO_2. 1.25% Hf; x-ray diffraction showed only monoclinic oxide	Drop method; copper block calorimeter	Auth. est. enthalpy data accurate within 0.2%
△	Arthur, J. L.	50-7	533-2278	ZrO_2. Analysis not given	Drop method; sample transferred manually from furnace to calorimeter	
□	Kelley, K. K.	44-2	98-532	99.1% ZrO_2; 0.30% SiO_2; 0.20% TiO_2; 0.07% CaO; no other oxides > 0.05%	Guarded sample	Correction made for principal impurities (do not exceed 0.54%) Auth. est. accuracy ± 0.3%

Thermal conductivity, cal/sec cm °K
Temperature, °K
Temperature, °R
ρ = 126 to 154 lb_m/ft³
ρ = 250 lb_m/ft³
ρ = 175 lb_m/ft³
ρ = 112 lb_m/ft³

THERMAL CONDUCTIVITY -- ZIRCONIUM OXIDE + X

REFERENCE INFORMATION

Curve	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
□	Adams, M.	54-5	672-2534	ρ = 326 - 334 lb_m/ft^3; porosity = 7.76 - 10.0%	Prolate spheroid envelope	Slip cast from suspension of finely ground material
△	Jones, M. C.	52-9	1660-2460	Stabilized; 94 - 95% ZrO_2; 4 - 5% CaO; 0.14 - 0.75% SiO_2; 0.2 - 0.7% Fe_2O_3; 0.22 - 1.0% TiO_2; porosity = 25%	Not given	
▽	Ibid.	52-9	1660-2460	Same as above; porosity = 51%	Same as above	
◇	Ibid.	52-9	1660-2460	Same as above; porosity = 68%	Same as above	
○	Whittemore Jr., O. J.	49-1	1160-2360	93% ZrO_2 + CaO; stabilized zirconia mix No. 144-A-decine; ρ = 250 lb_m/ft^3. Total porosity = 23%; apparent porosity = 16%	Single flat plate; liquid calorimeter	Made from 14 mesh grain or finer. Fired at 3230°F
□	Whittemore Jr., O. J.	49-1	1160-2360	93+% ZrO_2 + CaO; stabilized zirconia mix No. 187. ρ = 175 lb_m/ft^3. Total porosity = 50%; apparent porosity = 44%	Single flat plate; liquid calorimeter	Made from 8 mesh grain or finer. Fired at 3230°F
◇	Norton, F. H. et al.	51-76	700-2103	Stabilized; ρ = 336 lb_m/ft^3; total porosity = 2.37%	Not given	
○	Ibid.	51-76	700-2103	Stabilized; ρ = 324 lb_m/ft^3; total porosity = 4.74%	Not given	
⌂	Norton, F. H.	51-77	620-2300	Stabilized ZrO_2	Ellipsoidal envelope	Plotted values are auth. average with in ± 20%

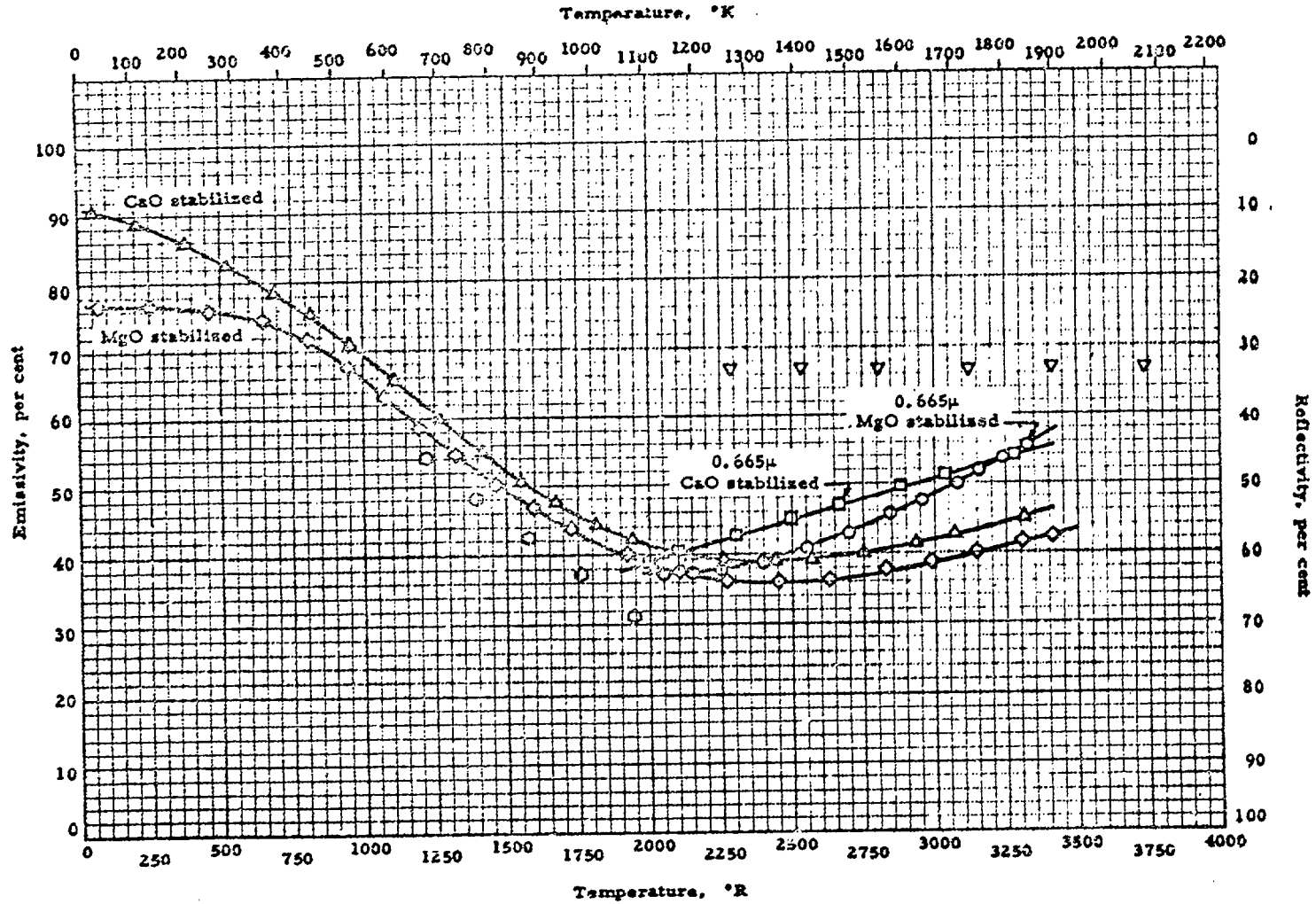


SPECTRAL EMISSIVITY -- ZIRCONIUM OXIDE, STABILIZED

SPECTRAL EMISSIVITY -- ZIRCONIUM OXIDE, STABILIZED

REFERENCE INFORMATION

	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Olson, O. H. and Morris, J. C.	59-1	Room	Zirconium oxide, calcium stabilized	Spectral reflectivity at 9°: sample compared with $MgCO_3$ standard in MgO integrating sphere, quartz lens, PbS detector	
□	Ibid.	59-1	Room	Zirconium oxide, magnesium stabilized	Same as above	



EMISSIVITY -- ZIRCONIUM OXIDE + X

EMISSIVITY -- ZIRCONIUM OXIDE + X

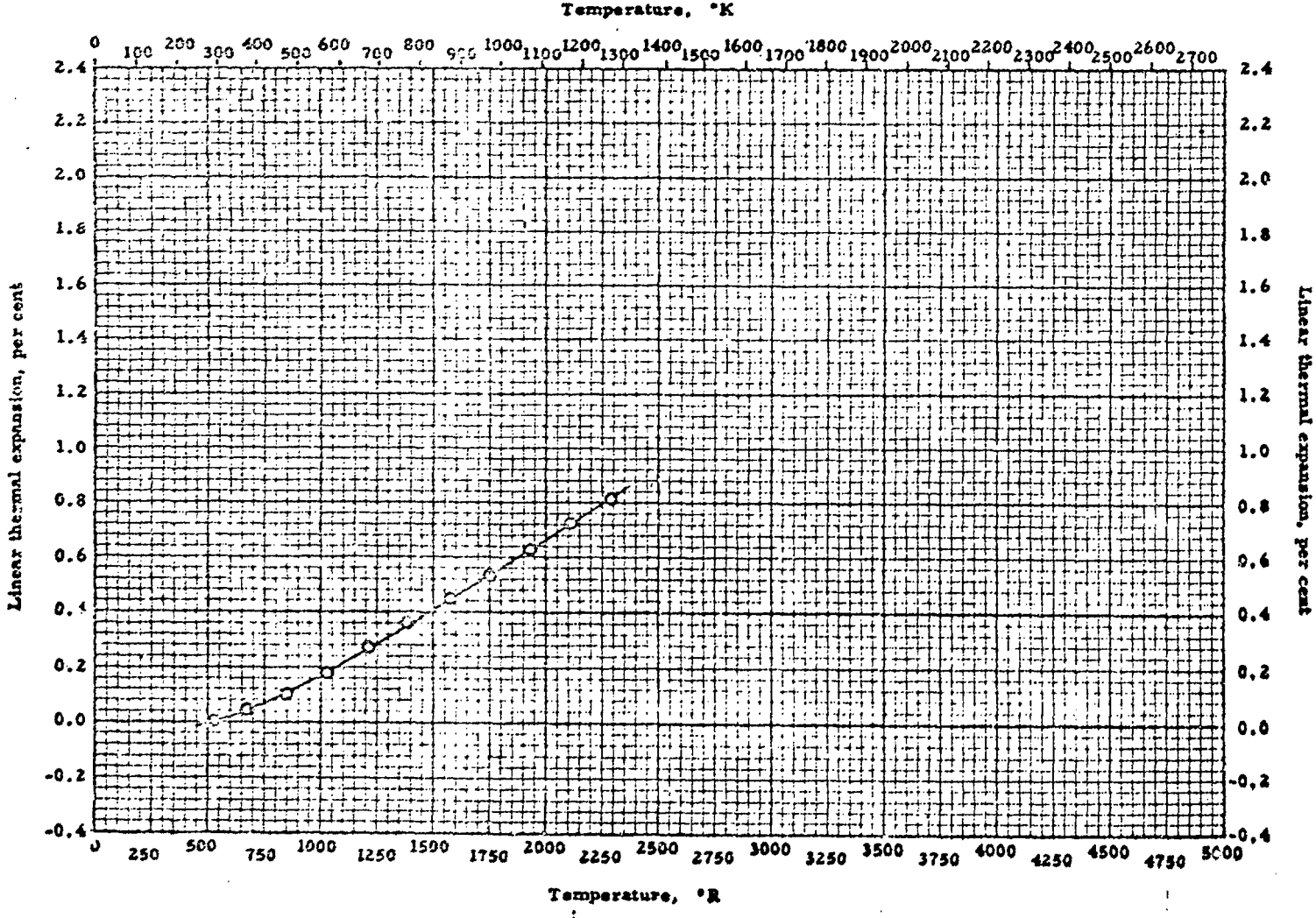
REFERENCE INFORMATION

Plot No.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Olson, O. H. and Morris, J. C.	59-1	1960-3260	Zirconium Oxide, magnesium stabilized	Normal spectral emissivity at 0.665μ : meas. apparent transmissivity through sample from black body at same temp sample temp. by thermocouple, disappearing filament optical pyrometer	
□	Ibid.	59-1	1960-3260	Zirconium oxide, calcium stabilized	Same as above	
△	Ibid.	59-1	160-3160	Same as above	Total normal emissivity: comparative, surface brightness compared with that of a black body hole, using thermopile. Temp. by thermocouple	Sample in furnace, in air. Auth. est. accuracy ± 3%
◇	Ibid.	59-1	160-3160	Zirconium oxide, magnesium stabilized	Same as above	Same as above
▽	Lemmon Jr., A. W. Wood, W. D. et al.	57-164	2292-3732	Zirconia	Total normal emissivity: comparative, surface brightness compared with that of a standard (graphite). Temp, by brightness temp. of graphite in vacuum	
○	Sully, A. H., Brandes, E. A. and Waterhouse, R. B.	52-81	1212-1932	"Pure" zirconia	Total normal emissivity: radiant heat meas. with thermopile; sample temp. by calibrated Pt-Pt Rh thermocouple	Calibrated Pt-Pt Rh thermocouple calibrated at MP of Sn, Sb, Al, Ag to within± 0.5°C

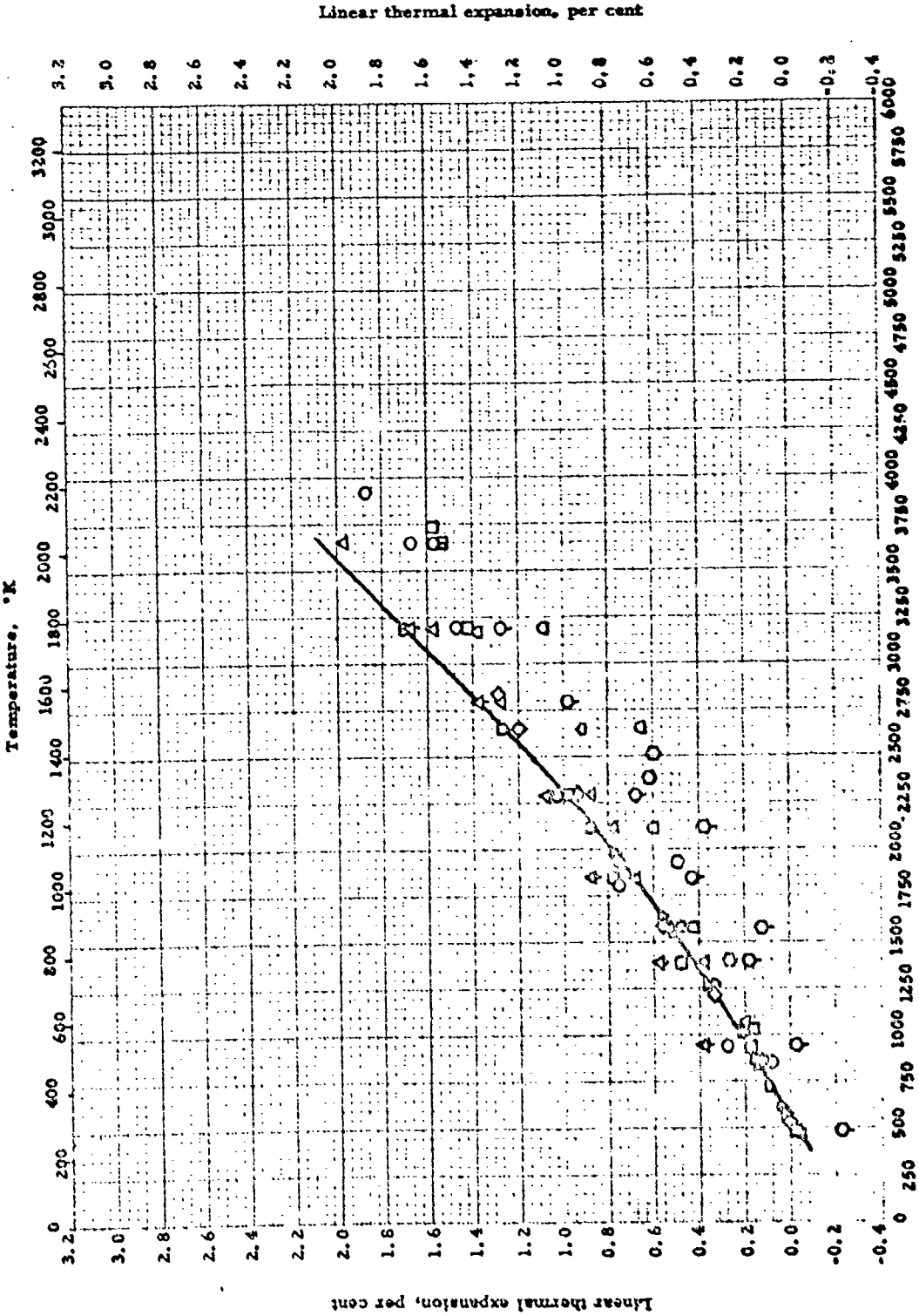
LINEAR THERMAL EXPANSION -- ZIRCONIUM OXIDE + BERYLLIUM OXIDE + ALUMINUM OXIDE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Geller, R. F., Yavorsky, P. J. et al.	46-4	528-2292	44.92% ZrO_2; 36.48% BeO; 18.59% Al_2O_3; prepared from 99.7% pure BeO, 99+% pure Al_2O_3, C.P. ZrO_2 (calcined)	Interferometer	$8BeO \cdot Al_2O_3 \cdot 2ZrO_2$



LINEAR THERMAL EXPANSION -- ZIRCONIUM OXIDE + BERYLLIUM OXIDE + ALUMINUM OXIDE

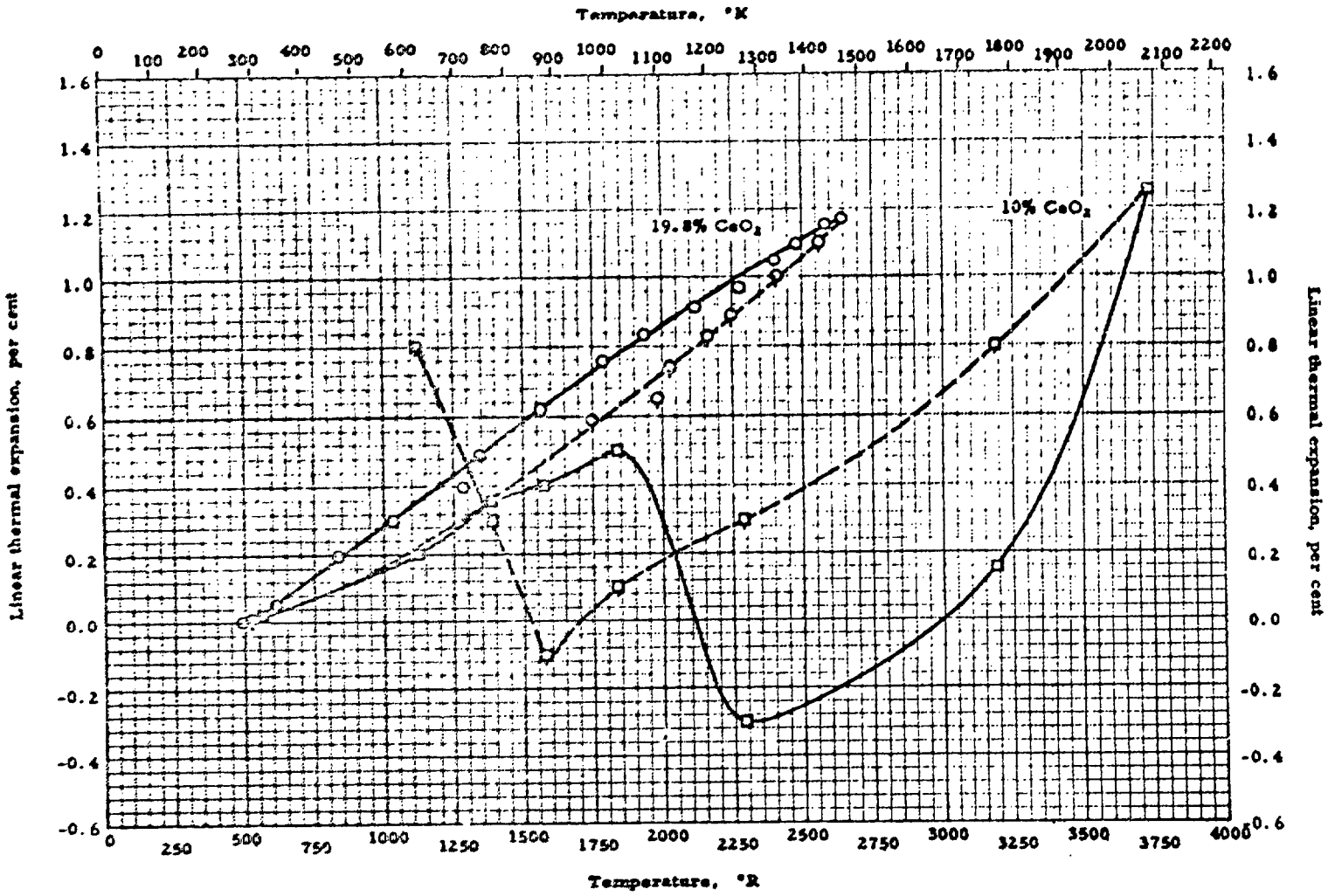


LINEAR THERMAL EXPANSION -- ZIRCONIUM OXIDE + CALCIUM OXIDE

LINEAR THERMAL EXPANSION -- ZIRCONIUM OXIDE + CALCIUM OXIDE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Pierrey, J.	49-17	492-3912	97% ZrO_2; 3% CaO	Optical comparator sighting on pointed ends of sampl	Melted in solar furnace ○ -heating; ♀ -cooling
□	Ibid.	49-17	492-3732	97% ZrO_2; 3% CaO	Same as above	Melted in electric arc, broken up, consolidated and baked at 2200°C
△	Ibid.	49-17	492-3642	69% ZrO_2; 31% CaO	Same as above	△ -heating; ♃ -cooling
◇	Schwartz, B.	52-11	531-2832	ZrO_2 with < 1% impurities; stabilized with 4% CaO	Telemicroscopes sighting on 6 in. sample	Slip cast, dried, fired at 1150°C, machined, matured 3 hr. at 1830°C. Tested at 4°C/min. rise
▽	Mauer, F.A. and Bols, L. H.	55-58	492-1975	92.29% ZrO_2; 7.71% CaO; cubic phase only, prepared from e.p. raw materials	X-ray diffraction	Tested in He atmos.
⬡	Uei, I. et al	56-64	528-2510	85.28% ZrO_2; 10% CaO; 3.11% SiO_2; 1.15% (Al_2O_3 + Fe_2O_3 + TiO_2)	Silica glass dilatometer	Calcined ZrO_2 (250 mesh) with 10% CaO at 1600°C for 2 hrs., dry pressed at 12,000 psi and fired 2 hrs. at 1600°C. Auth. also report data for 2-10% CaO; 3+% SiO_2; 1.2+% other oxides
⌂ ⌂	Whittemore, O.J., and Ault, N.N.	56-7	1032-3192	Coarse fused, stabilized	Telemicroscopes sighting on ends of sample	Two samples. Probably calcia stabilized
⌂	Ibid.	56-7	1032-3192	100% cubic, fused	Same as above	Same as above
▽	Gangler, J.J.	50-10	540-1560	Stabilized; 0.16% combined C; <0.01% free C; apparent ρ = 362 lb_m/ft^3	Interferometer	Probably calcia stabilized. Hot pressed in graphite mold; tested at 4°C/min. rise

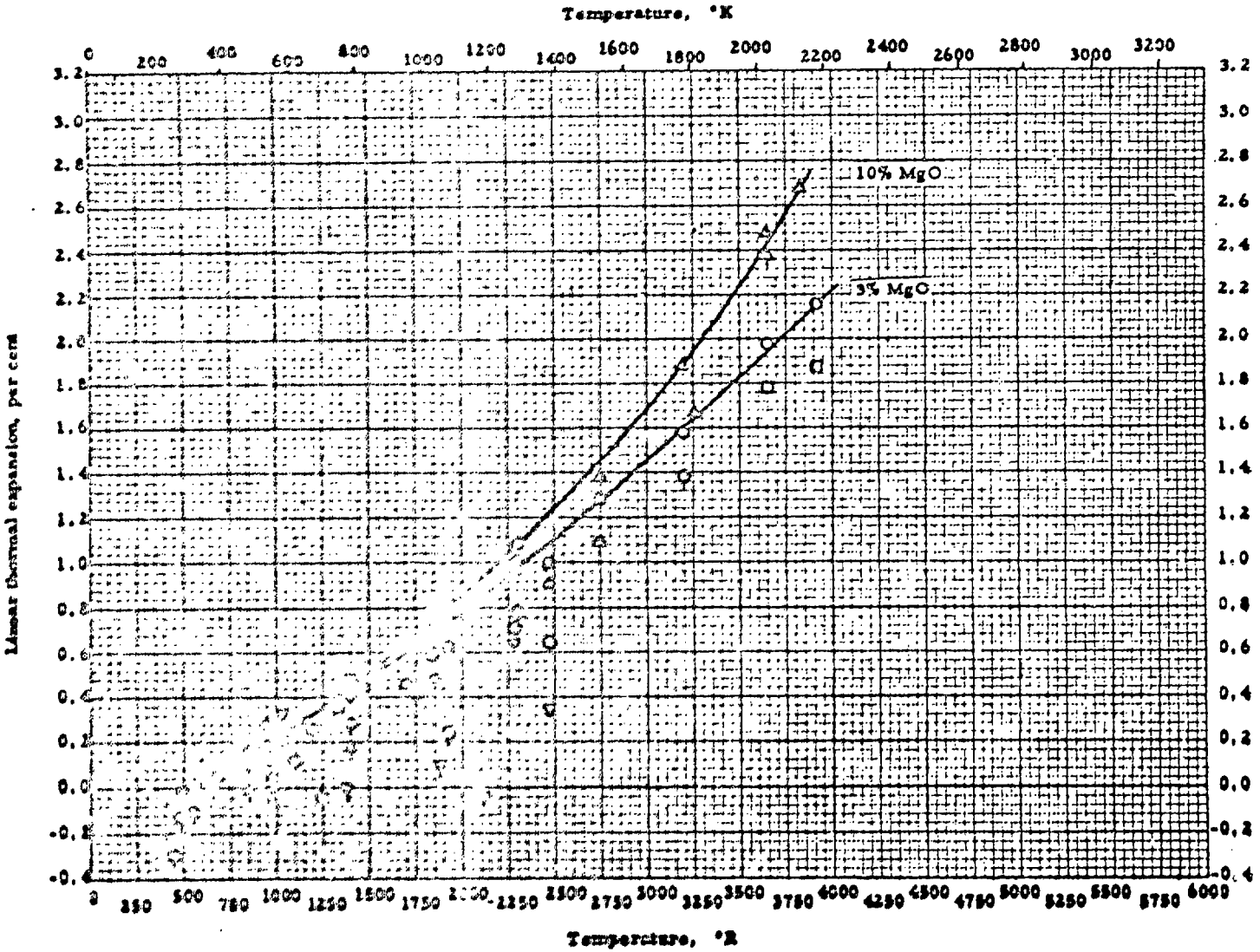


LINEAR THERMAL EXPANSION -- ZIRCONIUM OXIDE + CERIUM OXIDE

LINEAR THERMAL EXPANSION -- ZIRCONIUM OXIDE + CERIUM OXIDE

REFERENCE INFORMATION

Ref. No.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Mauer, F. A. and Bolz, L. H.	56-8	492-2647	80.2% ZrO_2 ; 19.8% CeO_2	Dilatometer	X-ray analysis showed 75% tetragonal (soln. of CeO_2 in ZrO_2) and 20% monoclinic (not enough CeO_2 to suppress transf.); the rest unmodified cubic CeO_2 ○ -heating ○ -cooling
□	Pierrey, J.	49-17	492-3732	90% zirconia; 10% ceria. ρ = 301 lb_m/ft^3	Observation of ends of bar with optical comparator. Temp. by two methods: a. <1000°C: Chromel-Alumel thermocouple b. >1000°C: optical pyrometer	Baked at 2100°C □ -heating □ -cooling

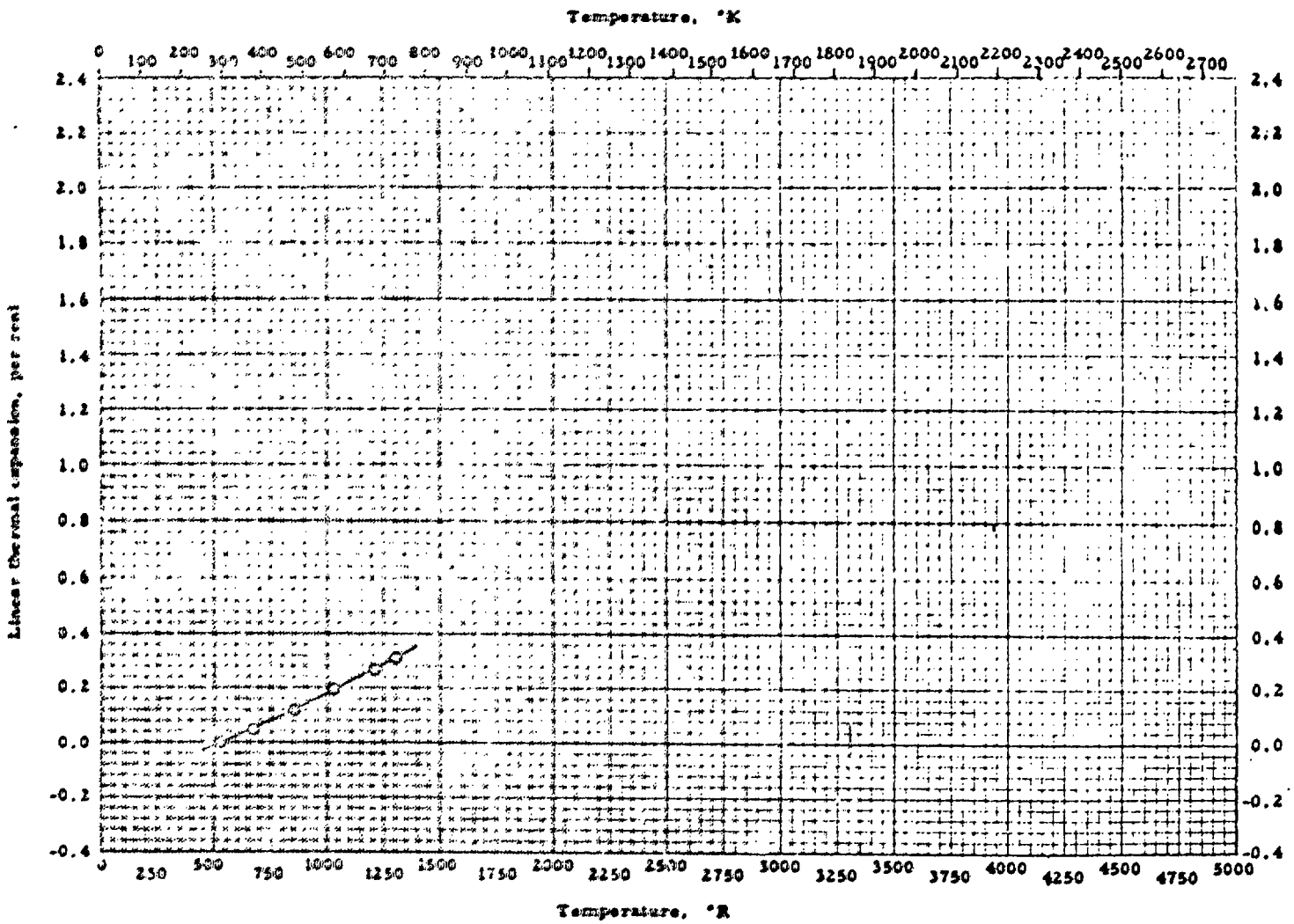


LINEAR THERMAL EXPANSION -- ZIRCONIUM OXIDE + MAGNESIUM OXIDE

LINEAR THERMAL EXPANSION -- ZIRCONIUM OXIDE + MAGNESIUM OXIDE

REFERENCE INFORMATION

Curve Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Pierrey, J.	49-17	492-3912	97% ZrO_2; 3% MgO; prepared from 99+% pure ZrO_2 and precipitated MgO	Optical comparator sighting on pointed ends of sample	Melted in solar furnace ○ - heating; ♀ - cooling
□	Ibid.	49-17	492-3912	Same as above	Same as above	Mixed; sintered at 2200°C
△	Ibid.	49-17	492-3822	90% ZrO_2; 10% MgO; raw materials same as above	Same as above	Mixed; sintered at 2200°C △ - heating; ♃ - cooling
◇	Mauer, F. A. and Bole, L. H.	54-37	672-2292	94.34% ZrO_2; 5.66% MgO; cubic	X-ray diffraction	Measured rapidly in high temp. region to reduce reversion to monoclinic type
▽	Uei, I. et al.	56-64	528-2472	97.61% ZrO_2; 2% MgO; 0.20% SiO_2	Silica glass dilatometer	Calcined 250-mesh ZrO_2 powder with MgO at 1600° C for 2 hr.; dry pressed at 1 ton/cm²; fired 2 hr. at 1600°C. ▽ - heating, ▽ - cooling
○	Ibid.	56-64	528-2472	95.62% ZrO_2; 4% MgO; 0.19% SiO_2	Same as above	Same as above ○ - heating, ♀ - cooling
⌂	Ibid.	56-64	528-2472	93.62% ZrO_2; 6% MgO; 0.19% SiO_2	Same as above	Same as above ⌂ - heating, ♀ - cooling
⌂	Ibid.	56-64	528-2472	91.62% ZrO_2; 8% MgO; 0.18% SiO_2	Same as above	Same as above ⌂ - heating, ♀ - cooling. Auth. also reports data for mat. 2-12% MgO; 3+% SiO_2; 1.1+% other oxides



LINEAR THERMAL EXPANSION -- ZIRCONIUM OXIDE + NIOBIUM OXIDE

LINEAR THERMAL EXPANSION -- ZIRCONIUM OXIDE + NIOBIUM OXIDE

REFERENCE INFORMATION

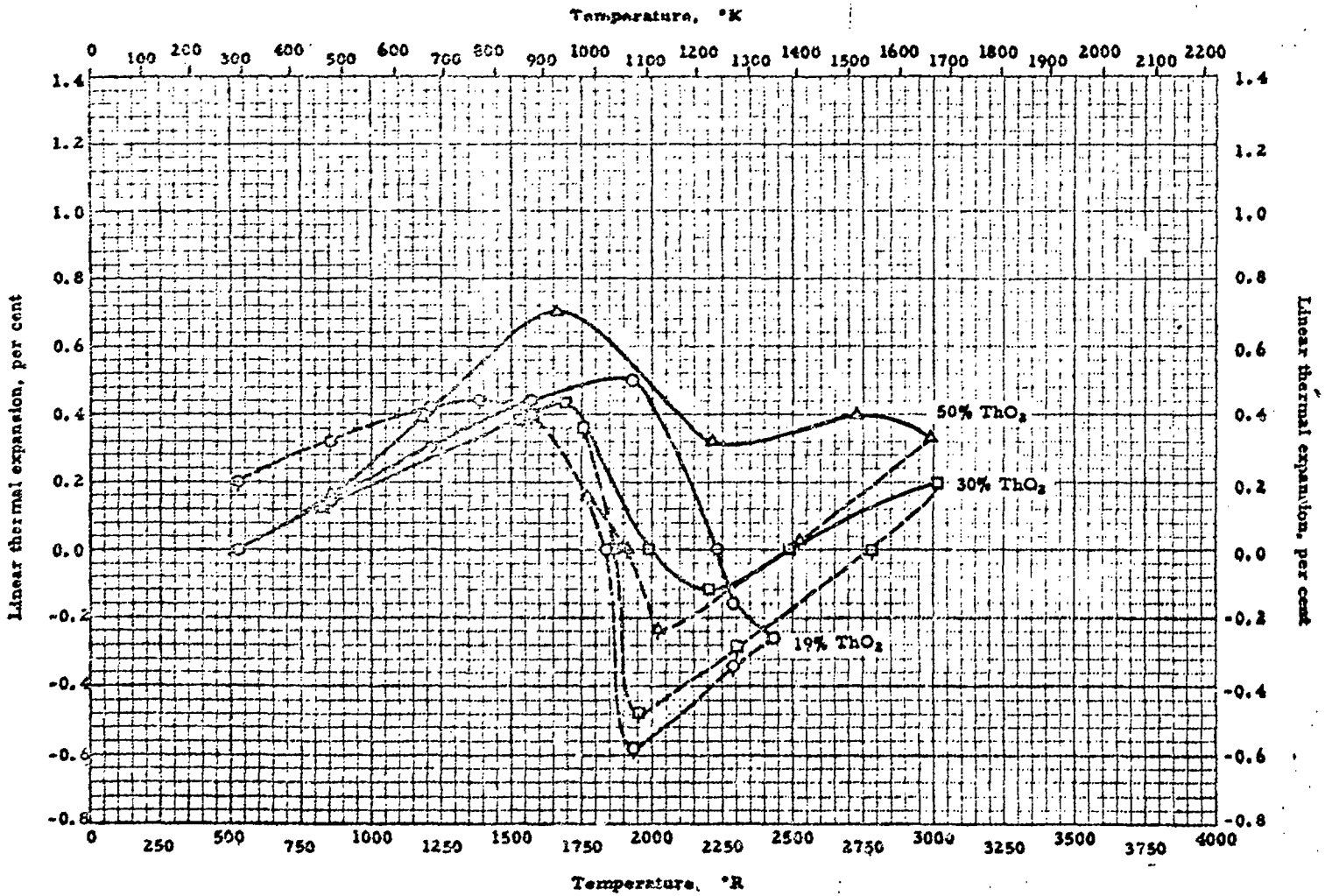
	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Curtis, E. A., and Kerman, C. G.	32-31	528-1392	70.8% ZrO_2; 29.2% Nb_2O_5 Solid solution ($3ZrO_2 + Nb_2O_5$).	Interferometer	Fired 2 hr. at 1485°C; cooled over 24 hr. period

LINEAR THERMAL EXPANSION -- ZIRCONIUM OXIDE + SILICON OXIDE

LINEAR THERMAL EXPANSION -- ZIRCONIUM OXIDE + SILICON OXIDE

REFERENCE INFORMATION

	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
□	Thessem, W. R., Eckhart, W. R. et al	52-133	519-2652	ZrO_2	Not given	Heated 3 hr. at 1000° C
△	Ibid.	52-133	519-2868	Same as above	Same as above	Heated 3 hr. at 1150°C
◇	Ibid.	52-133	519-2652	99 mole % ZrO_2 ; 1 mole % SiO_2	Same as above	Heated 3 hr. at 1000°C
▽	Ibid.	52-133	519-2868	Same as above	Same as above	Heated 3 hr. at 1150°C
○	Ibid.	52-133	519-2652	90 mole % ZrO_2 ; 10 mole % SiO_2	Same as above	Heated 3 hr. at 1000°C
▭	Ibid.	52-133	519-2886	Same as above	Same as above	Heated 3 hr. at 1150°C
▲	Ibid.	52-133	519-2886	Same as above	Same as above	Heated 3 hr. at 1350°C
⬡	Ibid.	52-133	519-2652	80 mole % ZrO_2 ; 20 mole % SiO_2	Same as above	Heated 3 hr. at 1000°C
▼	Ibid.	52-133	519-2796	Same as above	Same as above	Heated 3 hr. at 1150°C
●	Ibid.	52-133	519-2832	Same as above	Same as above	Heated 3 hr. at 1350°C

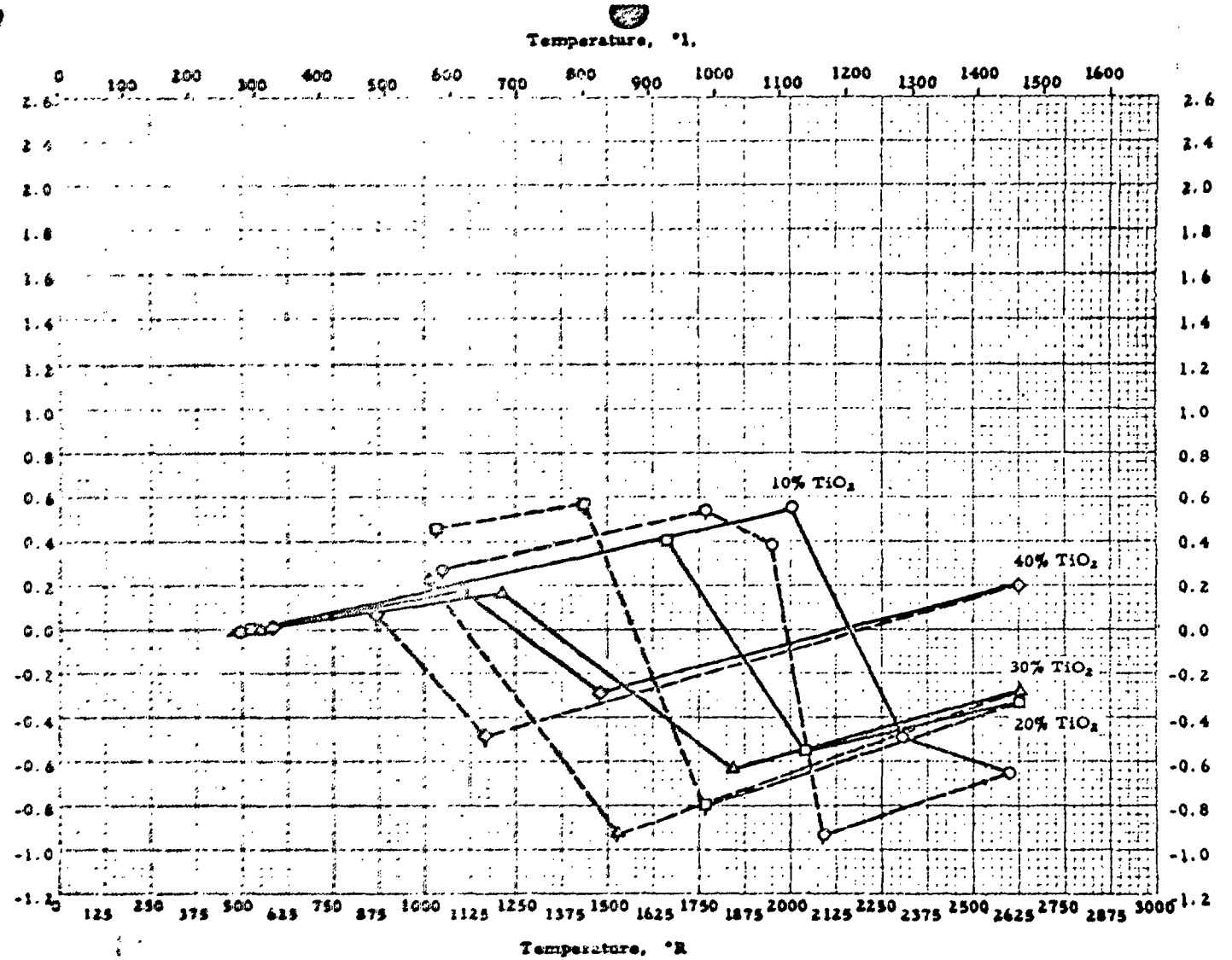


LINEAR THERMAL EXPANSION -- ZIRCONIUM OXIDE + THORIUM OXIDE

LINEAR THERMAL EXPANSION -- ZIRCONIUM OXIDE + THORIUM OXIDE

REFERENCE INFORMATION

	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Duwez, P. and Loh, E.	57-193	528-2436	81.76% ZrO_2 ; 19.24% ThO_2	Dial gauge	ZrO_2 99.7% pure and ThO_2 99+% pure were sintered at 1350°C ○ -heating ● -cooling
□	Somiya, E., Yamauchi, T. and Suzuki, H.	57-93	852-3012	70% ZrO_2 ; 30% ThO_2	Dial gauge. Temp. by Pt, Pt-Rh thermocouple	ZrO_2 analysis: 97.8% ZrO_2 ; 0.57% SiO_2 ; 0.40% H_2O; 0.23% TiO_2 ; 0.16% Fe_2O_3 ; 1.61% ignition loss, trace MgO and CaO. Component dry mixed in agate mortar, 5% dextrolyne added as binder, pressed at 1000 kg/cm², fired to 1700°C in 5-1/2 hr., soaked 1 hr., cooled overnight. Heated to 1000°C at 10°C/min, 1000-1400°C at 7° C/min. Cooled to 800°C at 10° C/min., then to room temp. naturally □ -heating ■ -cooling
△	Ibid.	57-93	852-2994	50% ZrO_2 ; 50% ThO_2	Same as above	Same as above, △ -heating ▲ -cooling

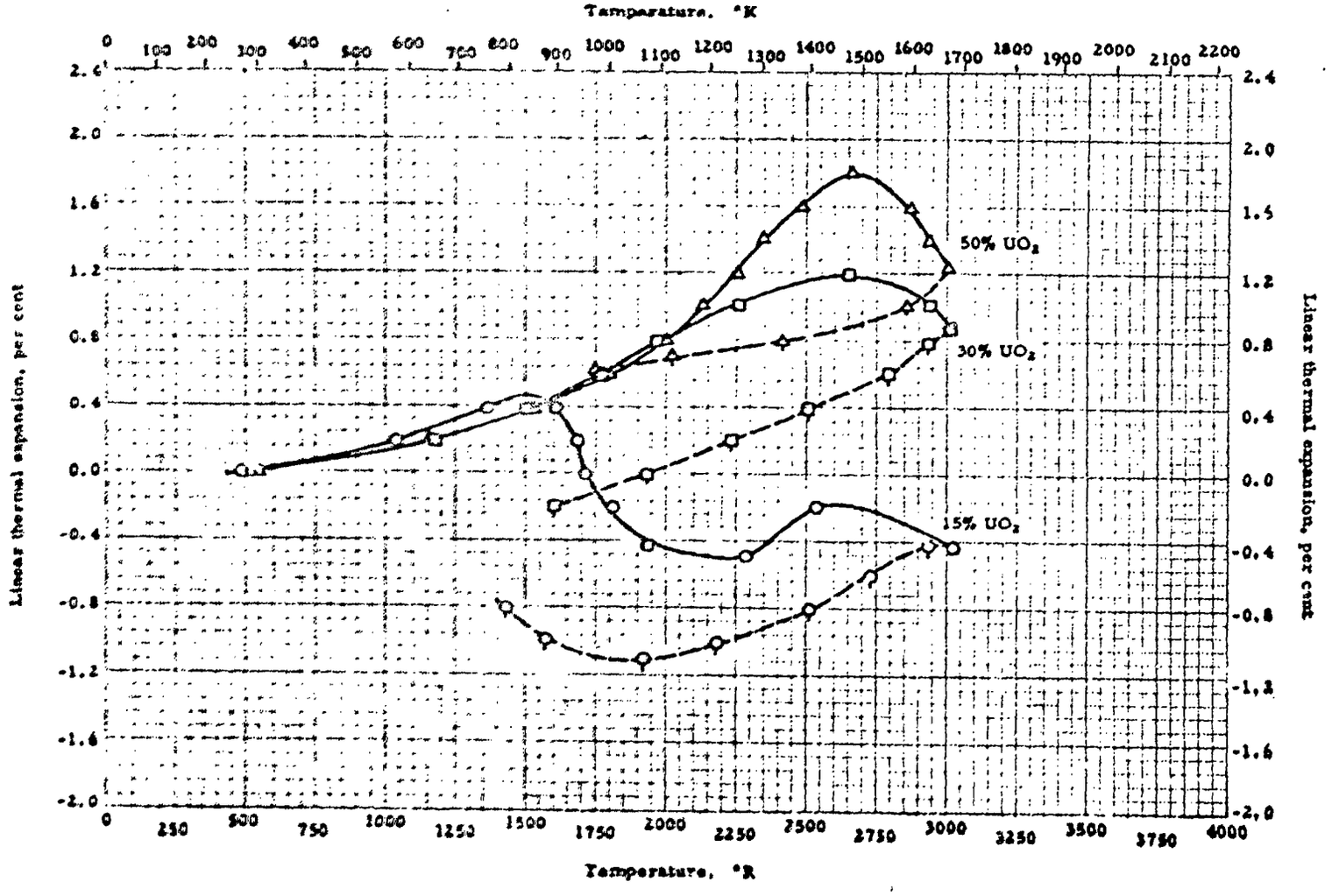


LINEAR THERMAL EXPANSION -- ZIRCONIUM OXIDE + TITANIUM OXIDE

LINEAR THERMAL EXPANSION -- ZIRCONIUM OXIDE + TITANIUM OXIDE

REFERENCE INFORMATION

Sym.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Brown Jr., F. H. and Duwez, P.	54-147	492-2598	90% ZrO_2 ; 10% TiO_2	Automatic recording dilatometer. Heating rate 220°C/hr; cooling rate 315° C/hr.	Mixed from 99% pure ZrO_2 and c.p. anatase, pressed at 15,000 psi, fired 2 hr. at 1760°C in oxidizing atm., 336 hr. at 1370°C, and 1465 hr. at 980°C, both in air ○ - heating ○ - cooling
□	Ibid.	54-147	492-2652	80% ZrO_2 ; 20% TiO_2	Same as above	Same as above □ -heating □ -cooling
△	Ibid.	54-147	492-2652	70% ZrO_2 ; 30% TiO_2	Same as above	△ -heating △ -cooling
◇	Ibid.	54-147	492-2652	60% ZrO_2 ; 40% TiO_2	Same as above	◇ -heating ◇ -cooling

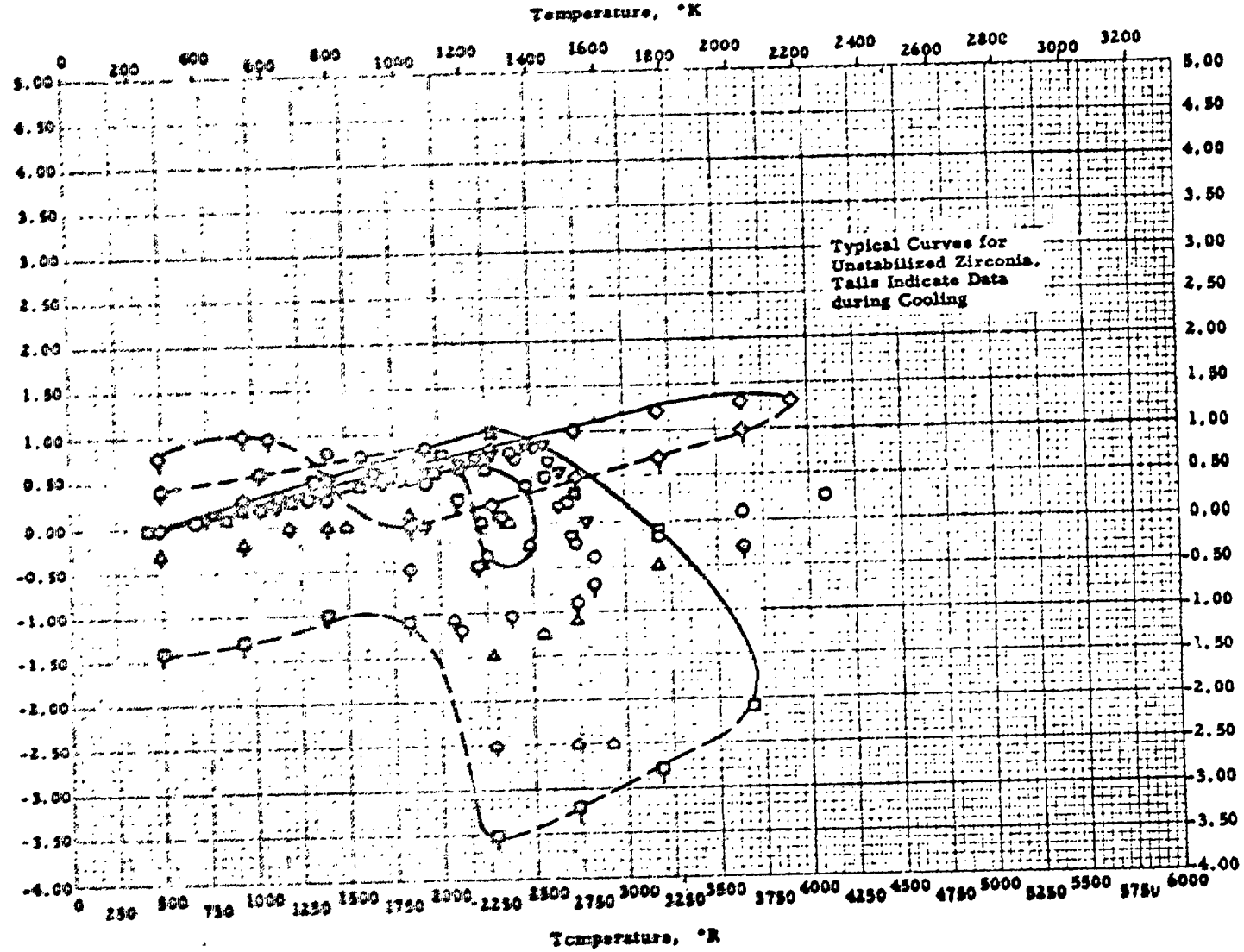


LINEAR THERMAL EXPANSION -- ZIRCONIUM OXIDE + URANIUM OXIDE

LINEAR THERMAL EXPANSION -- ZIRCONIUM OXIDE + URANIUM OXIDE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Somiya, S., Yamauchi, T. and Suzuki, H.	57-93	492-3012	85% ZrO_2 ; 15% UO_2	Dial gauge; temp. by Pt, Pt-Rh thermocouple	ZrO_2 analysis: 97.0% ZrO_2 0.57% SiO_2 , 0.40% H_2O; 0.23% TiO_2 ; 0.16% Fe_2O_3 ; 1.61% ignition loss, trace MgO and CaO. UO_2 from heating U_3O_8 1 hr. at 650°C in H_2 atm. Components dry mixed in agate mortar, 5% dextrolyne added as binder, pressed at 1000 kg/cm², fired to 1700°C in 5-1/2 hr. soaked 1 hr., cooled overnight. Heated to 1000°C at 10° C/min, 1000-1400° C at 7° C/min. Cooled to 800° C at 10° C/min. then to room temp. naturally. ○ -heating ⚲ -cooling
□	Ibid.	57-93	492-3012	70% ZrO_2 ; 30% UO_2	Same as above	Same as above, □ -heating ⚲ -cooling
△	Ibid.	57-93	492-3012	50% ZrO_2 ; 50% UO_2	Same as above	Same as above, △ -heating ⏃ -cooling

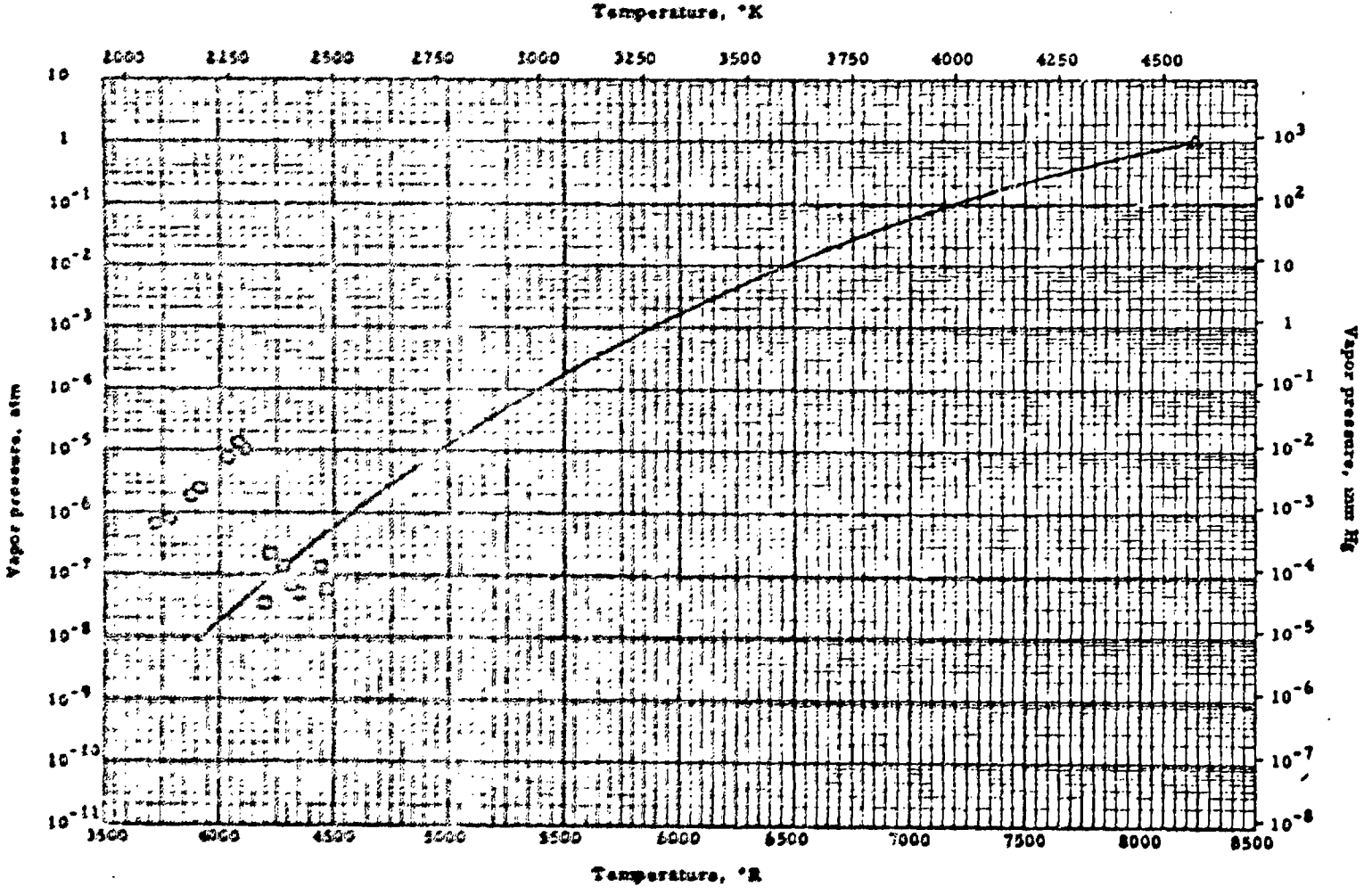


LINEAR THERMAL EXPANSION -- ZIRCONIUM OXIDE

LINEAR THERMAL EXPANSION -- ZIRCONIUM OXIDE

REFERENCE INFORMATION

Curve No.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Pierrey, J.	49-17	492-4092	Approx. 1% HfO_2; ρ = 337 lb_m/ft^3	Optical comparator sighting on pointed ends of sample	Fired at 1400°C, molded under pressure, and heated 15 min. at 2200°C in air stream
□ △	Ibid.	49-17	492-3687	99% ZrO_2; 1% BeO of 99% purity; ρ = 305 lb_m/ft^3	Same as above	Precipitated from solution, washed, dried, compression molded and baked at 2200°C. 2 samples
◇	Ibid.	49-17	492-3912	"Pure"; ρ = 341 lb_m/ft^3	Same as above	Melted in arc furnace, cast, finely broken, molded under pressure and heated 15 min. at 2100°C in air
▽	Curtis, C. E., Doney, L. M. and Johnson, J. R.	54-45 also 54-46	672-2832	0.06% Fe; 0.02% Si; 0.015% Al; 0.003% Hf; 0.006% Ti	Calibrated differential dilatometer; sapphire push rod	Ground to pass 325 mesh screen, pressed at 20,000 psi with 5% water and 2% dextrin, fired in oxyacetylene furnace 2 hr. at 1600 °C
○	Trombe, F.	49-16	528-1932	97.7% pure	Not given	Cast
△	Uei, I. et al.	56-64	528-2490	99.6% ZrO_2; 0.2% SiO_2; trace of Al_2O_3, Fe_2O_3, TiO_2; ρ = 362 lb_m/ft^3	Silica glass dilatometer	Calcined 2 hr. at 1600°C; ground to 250 mesh, dry pressed (1 ton/cm^2); fired 2 hr. at 1600°C. Auth. also reports data for ZrO_2 with 3 - 7% SiO_2 and up to 1.64% other oxides
△	Kumatsov, A. K.	57-193	492-2292	ZrO_2	Not described here, refers to others	△ - heating, ○ - cooling
○	Brown, Jr., F. H. and Dewes, P.	54-147	528-2688	ZrO_2; 99% pure	Automatic recording dilatometer	Grade A Zirox of Nat'l Lead Co. ○ - heating, ○ - cooling



VAPOR PRESSURE -- ZIRCONIUM OXIDE

VAPOR PRESSURE -- ZIRCONIUM OXIDE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Hoch, M., Nakata, M., and Johnston, H. L.	49-14 also 56-13	3715-4158	ZrO_2 <0.025% Hf	Knudsen effusion cell	Ta cell
□	Chupka, W. A., Berkowitz, J., and Inghram, M. G.	JCP-2	4196-4464	Zirconia, ZrO_2	Knudsen effusion cell with mass spectrometer	Ta cell
△	Trombe, F.	49-14	4232	ZrO_2	Not given	

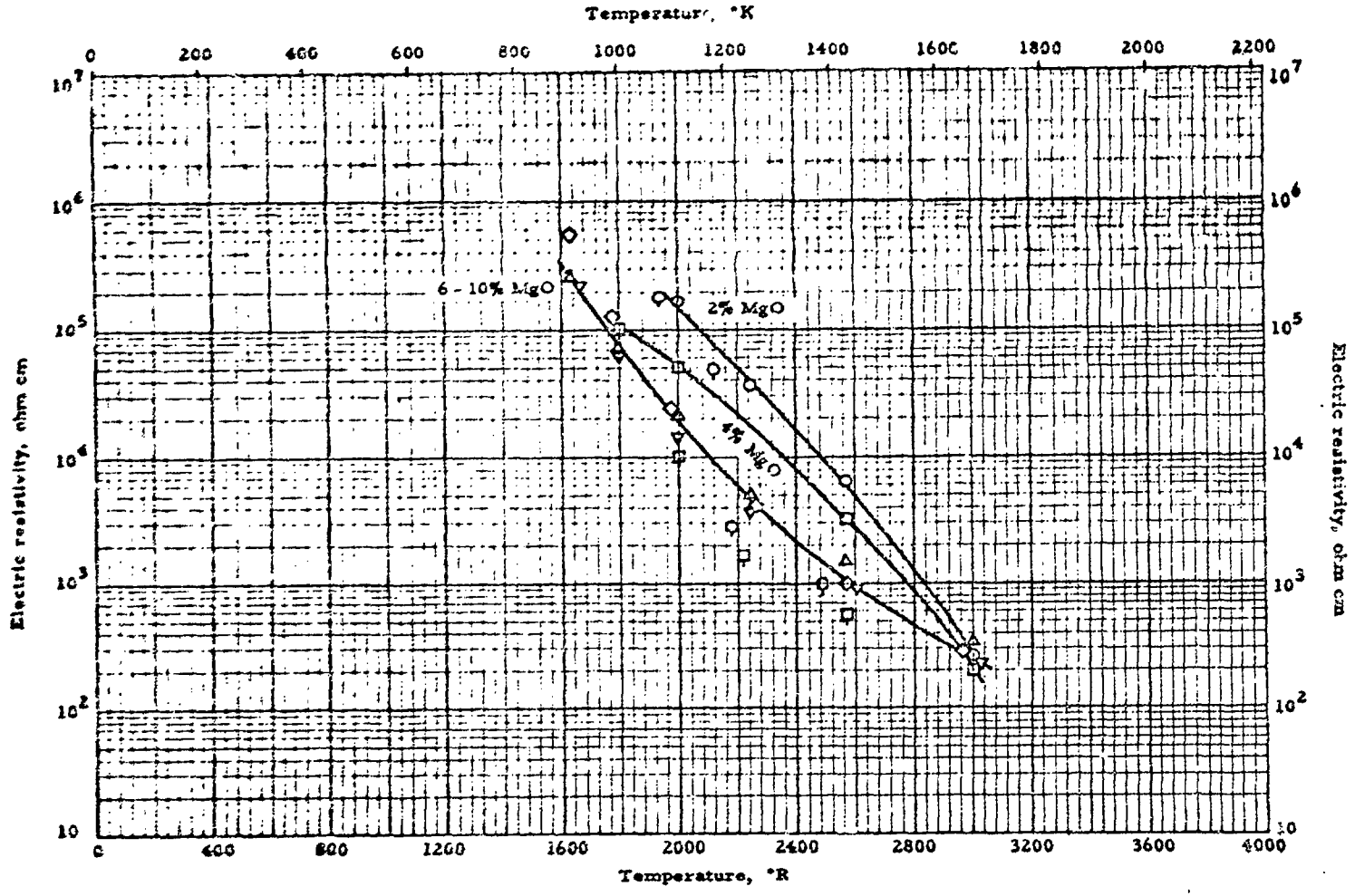
ELECTRICAL RESISTIVITY -- ZIRCONIUM OXIDE + CALCIUM OXIDE

WADC TR 58-476 304

ELECTRIC RESISTIVITY -- ZIRCONIUM OXIDE + CALCIUM OXIDE

REFERENCE INFORMATION

	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Ueki, I., Nakazawa, Y. and Uetsuki, T.	56-64	2057-2951	97.61% ZrO_2 ; 2% CaO; 0.20% SiO_2	Not given	Made from ZrO_2 with 0.20% SiO_2, trace Al_2O_3, Fe_2O_3, TiO_2 $\rho = 362\ lb_m/ft^3$ ○-heating ♀-cooling
□	Ibid.	56-64	2093-3000	95.62% ZrO_2 ; 4% CaO; 0.19% SiO_2	Same as above	Same as above, □-heating ♀-cooling
△	Ibid.	56-64	1698-3000	93.62% ZrO_2 ; 6% CaO; 0.19% SiO_2	Same as above	Same as above, but average of heating and cooling data
◇	Ibid.	56-64	1636-3000	91.63% ZrO_2 ; 8% CaO; 0.18% SiO_2	Same as above	Same as above
▽	Ibid.	56-64	1682-3000	89.64% ZrO_2 ; 10% CaO; 0.18% SiO_2	Same as above	Same as above
○	Zegener, H.	40-20	1104-1752	Not given	Potential drop; sample temp. by Pt-Rh thermocouple; voltage by electrometer	1 cm cube samples, platinized end faces. Auth. est accuracy order of magnitude only
⌂	Ueki, I., Nakazawa, Y. and Uetsuki, T.	56-64	2156-2951	99.60% ZrO_2 ; 0.20% SiO_2 ; trace Al_2O_3; Fe_2O_3, Ti_2O_3	Not given	Calcined 2 hr. at 1600°C. ZrO_2 No. 250 mesh powder dry pressed 1 ton/cm², fired 2 hr. at 1600°C ⌂ - heating ♀ - cooling
⌂	Jones, M.C.	52-9	1290-3990	94-95% ZrO_2 ; 4-5% CaO; 0.22-1.0% TiO_2 ; 0.14-0.75% SiO_2 ; 0.2-0.7% Fe_2O_3	Not given	



ELECTRIC RESISTIVITY--ZIRCONIUM OXIDE + MAGNESIUM OXIDE

ELECTRIC RESISTIVITY -- ZIRCONIUM OXIDE + MAGNESIUM OXIDE

REFERENCE INFORMATION

Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○ [illegible], I., [illegible], Kitawa, Y. and Uchiaki, T.	56-64	1935-3000	97.61% ZrO_2 ; 2% MgO; 0.20% SiO_2 $\rho = 362\ lb_m/ft^3$	Not given	From ZrO_2 : 99.60% ZrO_2 ; 0.20% SiO_2 ; trace Al_2O_3, Fe_2O_3, TiO_2 ○-heating ♀-cooling
□	Ibid.	56-64	1800-3000	95.62% ZrO_2 ; 4% MgO; 0.19% SiO_2	Same as above	□-heating □-cooling
△	Ibid.	56-64	1636-3000	93.62% ZrO_2 ; 6% MgO; 0.19% SiO_2	Same as above	Same as above, but average of heating and cooling data
◇	Ibid.	56-64	1636-3000	91.63% ZrO_2 ; 8% MgO; 0.18% SiO_2	Same as above	Same as above
▽	Ibid.	56-64	1636-3000	89.64% ZrO_2 ; 10% MgO; 0.18% SiO_2	Same as above	Same as above

Symbol	Material Composition, % UO_2	CaF_2	ZrH_2	Density lb_m/ft^3	g/cm^3
O	99.9	0.1		537.6	8.611
	99.8	0.2		528.7	8.469
	99.5	0.5		519.1	8.315
	99.9	1.0		506.1	8.107
	98.0	2.0		465.0	7.449
□	99.9		0.1	481.4	7.712
	99.8		0.2	499.2	7.997
	99.5		0.5	472.5	7.569
	99.0		1.0	424.6	6.801

DENSITY -- URANIUM OXIDE + HALIDES

DENSITY -- URANIUM OXIDE + HALIDES

REFERENCE INFORMATION

System No.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Belle, J. and Jones, L. J.	56-156	Room	UO_2 + CaF_2 system	Not given	Normal MCW UO_2 powder mixed with metal oxide, pressed at 126,000 psi, fired 2 hr at 1400°C in steam
□	Ibid.	56-156	Room	UO_2 + ZrH_2 system	Same as above	Same as above

Symbol	Material Composition, %					Density	
	UO_2	Al_2O_3	MnO_2	TiO_2	ZrO_2	lb_m/ft^3	g/cm^3
○	99.8	0.2				520.5	8.337
	99.5	0.5				515.7	8.260
	99.0	1.0				465.0	7.449
	98.0	2.0				444.5	7.120
□	99.9		0.1			497.9	7.975
	99.8		0.2			475.3	7.613
	99.5		0.5			496.5	7.953
	99.0		1.0			495.8	7.942
△	99.8			0.2		528.0	8.458
	99.7			0.3		525.3	8.414
◇	99.9				0.1	501.3	8.030
	99.8				0.2	533.5	8.546
	99.5				0.5	524.6	8.403

DENSITY -- URANIUM OXIDE + OTHER OXIDES

DENSITY -- URANIUM OXIDE + OTHER OXIDES

REFERENCE INFORMATION

	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Belle, J. and James, L. J.	56-156	Room	UO_2 + Al_2O_3 system	No. given	Normal MCW UO_2 powder mixed with metal oxides, pressed at 126,000 psi, fired 3 hr at 1400°C in steam
□	Ibid.	56-156	Room	UO_2 + MnO_2 system	Same as above	Same as above
△	Ibid.	56-156	Room	UO_2 + TiO_2 system	Same as above	Same as above
◇	Ibid.	56-156	Room	UO_2 + ZrO_2 system	Same as above	Same as above

Symbol	Material Composition	Density lb_m/ft^3	Density g/cm^3
○	U_2O_5	521	8.35
□	U_3O_8	526	8.42
△	U_3O_8	521	8.34
◇	UO_3	121	1.94
▽	UO_3	225	3.60
⬡	UO_3	98.6	1.58

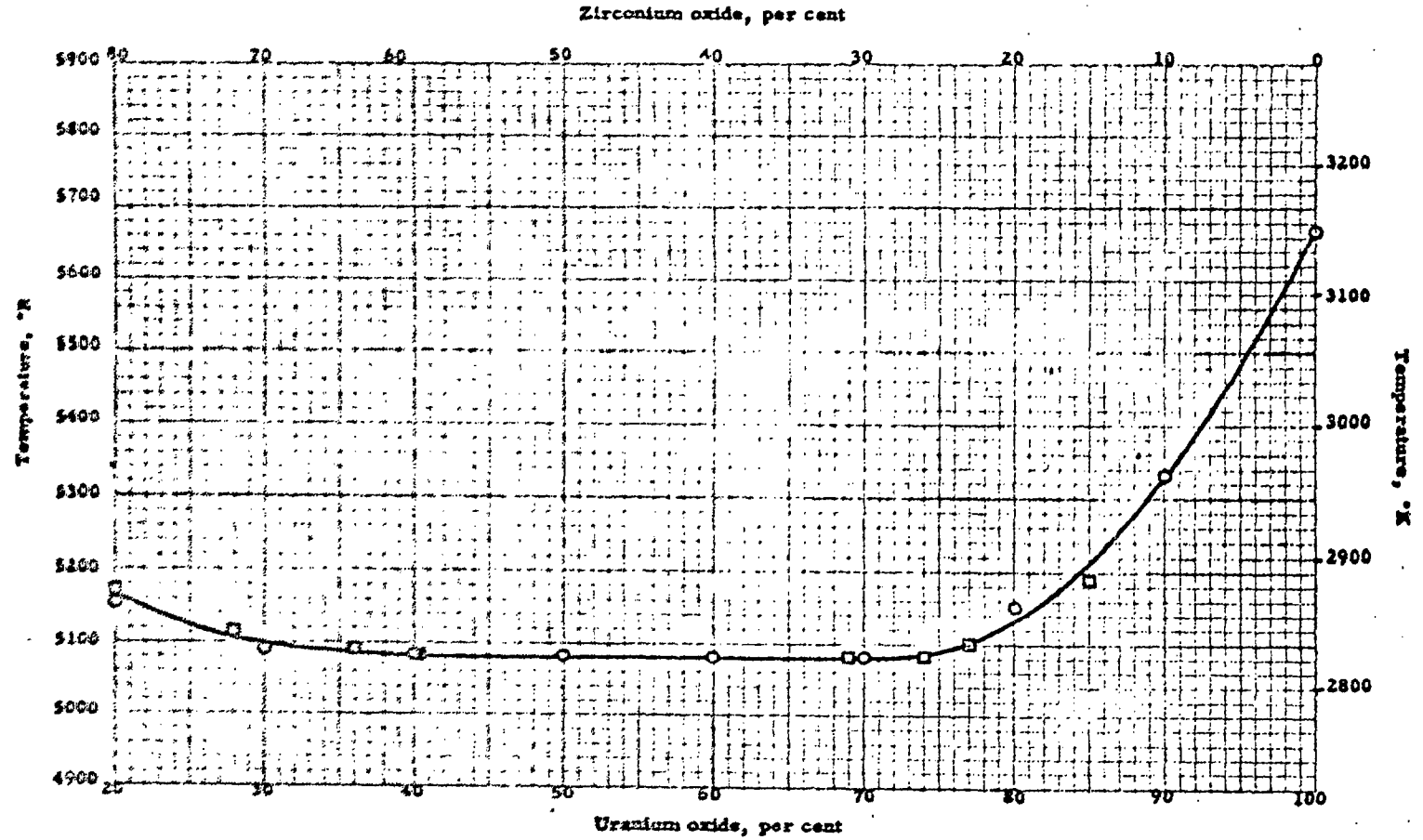
Note: For values for uranium dioxide see separate unit.

DENSITY -- URANIUM OXIDE

DENSITY -- URANIUM OXIDE

REFERENCE INFORMATION

	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Zaenziger, M. C.	44-25	Room	U_2O_5	ρ: computed from x-ray measurements of lattice	Auth. also quotes Biltz and Miller (1927) as 8.78 g/cm^3 and Rundle (1943) as 8.78 g/cm^3
□	Gronvold, F.	48-32	Room	U_3O_8	ρ: computed from x-ray measurements of lattice	
△	Ibid.	48-32	Room	Same as above	ρ: pycnometer	
◇	Belle, J. and James, J. J.	56-156	Room	UO_3	ρ: not given	Type II
▽	Ibid.	56-156	Room	Same as above	ρ: same as above	Type III
○	Ibid.	56-156	Room	Same as above	ρ: same as above	Type III. Made by very slow denitration of uranyl nitrate hexahydrate (UNH)
				For UO_2 see separate unit.		



MELTING POINT -- URANIUM OXIDE + ZIRCONIUM OXIDE

MELTING POINT -- URANIUM OXIDE + ZIRCONIUM OXIDE

REFERENCE INFORMATION

	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
C	Lamberton, W. A. and Mueller, M. H.	53-135	5082-5667	UO_2 - ZrO_2 series (0-80% ZrO_2)	MP; not given	Made from approx. 98% pure ZrO with 2% HfO_2, 0.035% other impurities and probably pure UO_2
D	Ibid.	53-135	5082-5190	Same as above	Same as above	Same as above

PROPERTIES OF URANIUM DIOXIDE

MOST PROBABLE VALUES

Property	Brit. Engineering Units	C. G. S. Units
Density.	684.8 lb_m/ft^3	10.97 g/cm^3
Melting Point	5670°R	3150°K
Heat of Fusion		
Heat of Vaporisation. . .		
Heat of Sublimation . . .		

REPORTED VALUES .

		lb_m/ft^3	g/cm^3
Density:	○	639.9	10.25
	□	661.7	10.60
	△	647.4	10.37
	◇	683.6	10.95
	▽	680.5	10.90
	○	625.5 ± 6	10.02 ± 0.1
	⌂	693.6 ± 13	11.11 ± 0.2
	▽	684.8	10.97
		°R	°K
Melting Point:	○	5676 ± 36	3153 ± 20
	⌂	5665 ± 27	3148 ± 15
	▽	5460 ± 54	3033 ± 30
Heat of Fusion:		Btu/lb_m	cal/g
Heat of Vaporisation:		Btu/lb_m	cal/g
Heat of Sublimation:		Btu/lb_m	cal/g

PROPERTIES OF URANIUM DIOXIDE

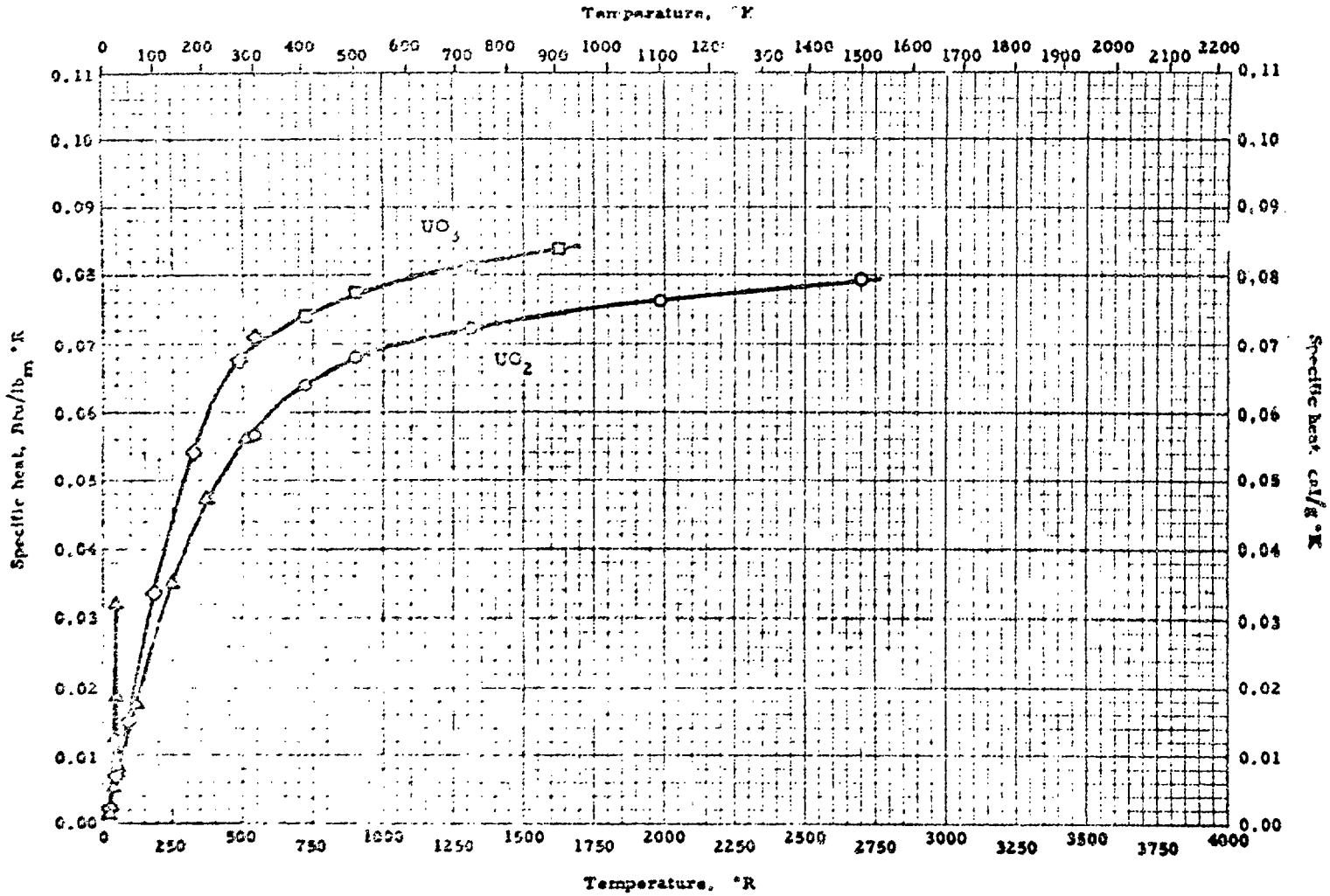
REFERENCE INFORMATION

	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Lambertson, W. A. and Handwerk, J. H.	56-5 also 54-151 52-131	Room 5676	Typical analysis before fabrication: 0.083% MgO; 0.002% Al_2O_3; 0.001% ea. copper oxide, Fe_2O_3, SiO_2. Supplied by Mallinckrodt as -325 mesh	ρ: not given MP: inspected as powdered sample with grain size below 74μ after heating it in W crucible in He atmos. at const. temp. Temp. meas. by optical pyrometer	Pressed at 70,000 psi; fired at 1750°C in H_2 atmos.
□	Ibid.	56-5 54-151	Room	Same as above	Pycnometer with water	Pebble-milled 56 hr. then same as above
△	Ibid.	56-5 54-151	Room	Same as above	ρ: not given	Calcined at 1750°C; pebble-milled 16 hr. then same as ⊖
◇	Ibid.	56-5 54-151	Room	Same as above	ρ: not given	Pebble-milled 140 hr. then same as ⊖
▽	Ibid.	56-5	Room	Same as above	ρ: not given	Pressed at 800 psi, fired at 1750°C in H_2 atmos.
⊖	Ibid.	56-5	Room	"Pure" manufactured by Norton Co.	ρ: x-ray meas. of lattice parameter	Electrically fused
⊡	Lambertson, W. A. and Mueller, M. H.	53-138	Room	UO_2	ρ: not given	
⊟	Rudorff, W. and Valet, G.	53-85	Room	UO_2	ρ: not given	
⊠	Bruch, C. A. and Cashin, W. M.	56-109	5442	UO_2	MP: visual observation of sample resting in apex of "V"-shaped ribbon heater element. Temp. by optical pyrometer sighting on apex	
⊽	Wisnyi, L. G. and Pijanowski, S. W.	57-399	5460	UO_2 (atomic ratio U:O=1:1.98) Mfr. by Mallinckrodt	MP: visual observation of sample resting in apex of "V"-shaped ribbon heater element. Temp. by optical pyrometer sighting on apex. Also observation of break in time-temp. curve.	

PROPERTIES OF URANIUM DIOXIDE (cont.)

REFERENCE INFORMATION

Curve	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
h	Burdick, M. D. and Parker, H. S.	55-106	Room	UO_2; 0.01-0.001% ea. Al, Fe; 0.001-0.0001% ea. Ca, Mg; <0.0001% Cu; 0% spectroscopically of all others. Supplied as arcfused material by Norton Co.	p; bulk density by Hg displacement	

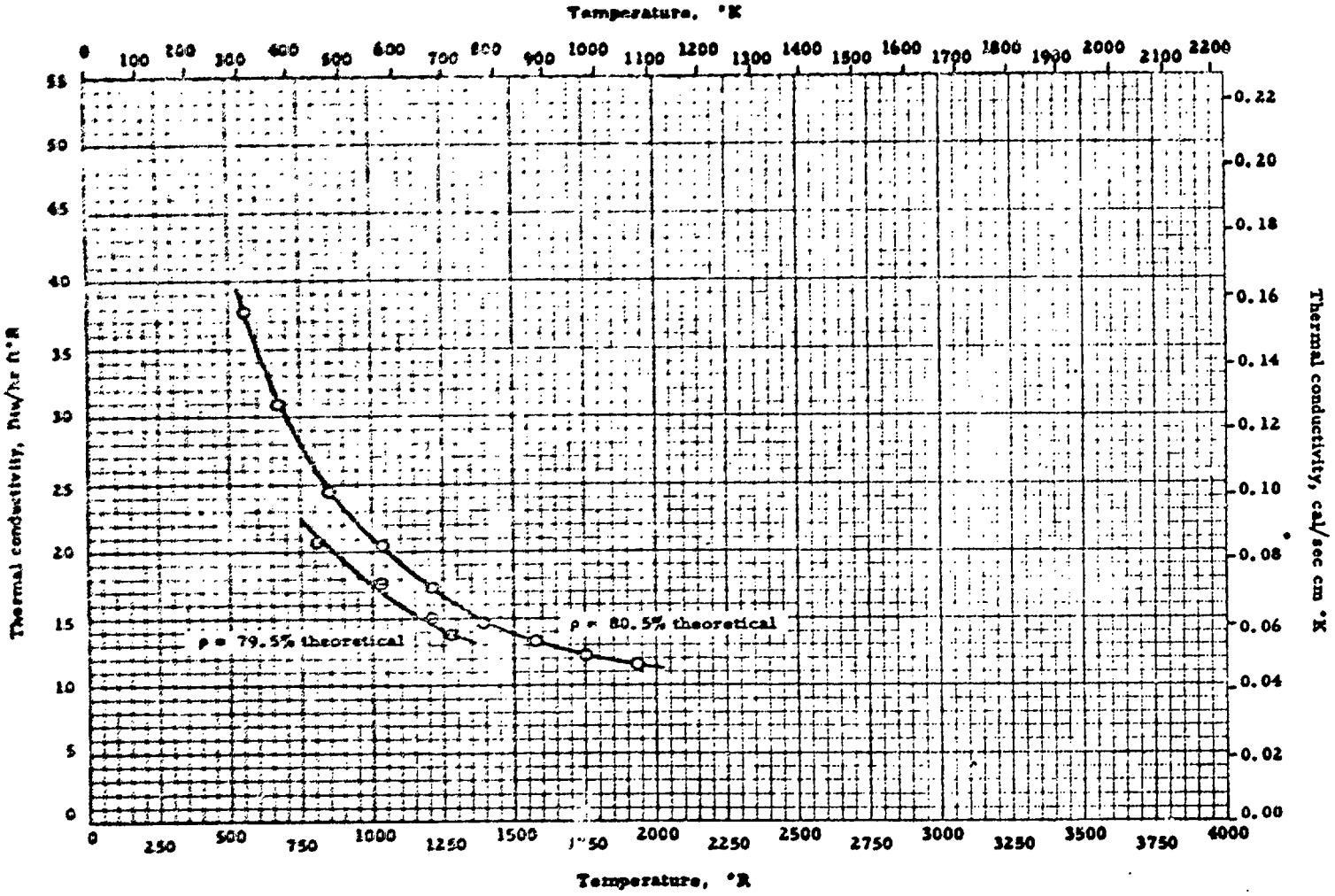


SPECIFIC HEAT -- URANIUM OXIDE

SPECIFIC HEAT -- URANIUM OXIDE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Moore, G. E. and Kelley, K. K.	47-18 also 42-11	540-2700	UO_2; 88.26% U (theor. 88.15%)	Drop method; copper block calorimeter	Mean enthalpy deviation 0.1%
□	Ibid.	47-18 also 42-11	540-1620	UO_3; 83.02% U (theor. 83.22%)	Same as above	Same as above
△	Jones, W. M., Gordon, J. and Long, E. A.	52-111	27-540	99.3% UO_2; 0.7% UO_3; traces of other metal oxides. 88.26% U	Not described here, refers to others. Temp. by calibrated gold resistance thermometer	Powder of well crystallized particles. Auth. est. accuracy ± 0.2% above 35°K
◇	Ibid.	52-111	27-540	UO_3; 0.003% H_2O	Same as above	Made by decomposing uranyl nitrate 8 hr at 300°C, ground dried 3 hr at 100°C. Auth. est. accuracy ± 0.2% above 35°K

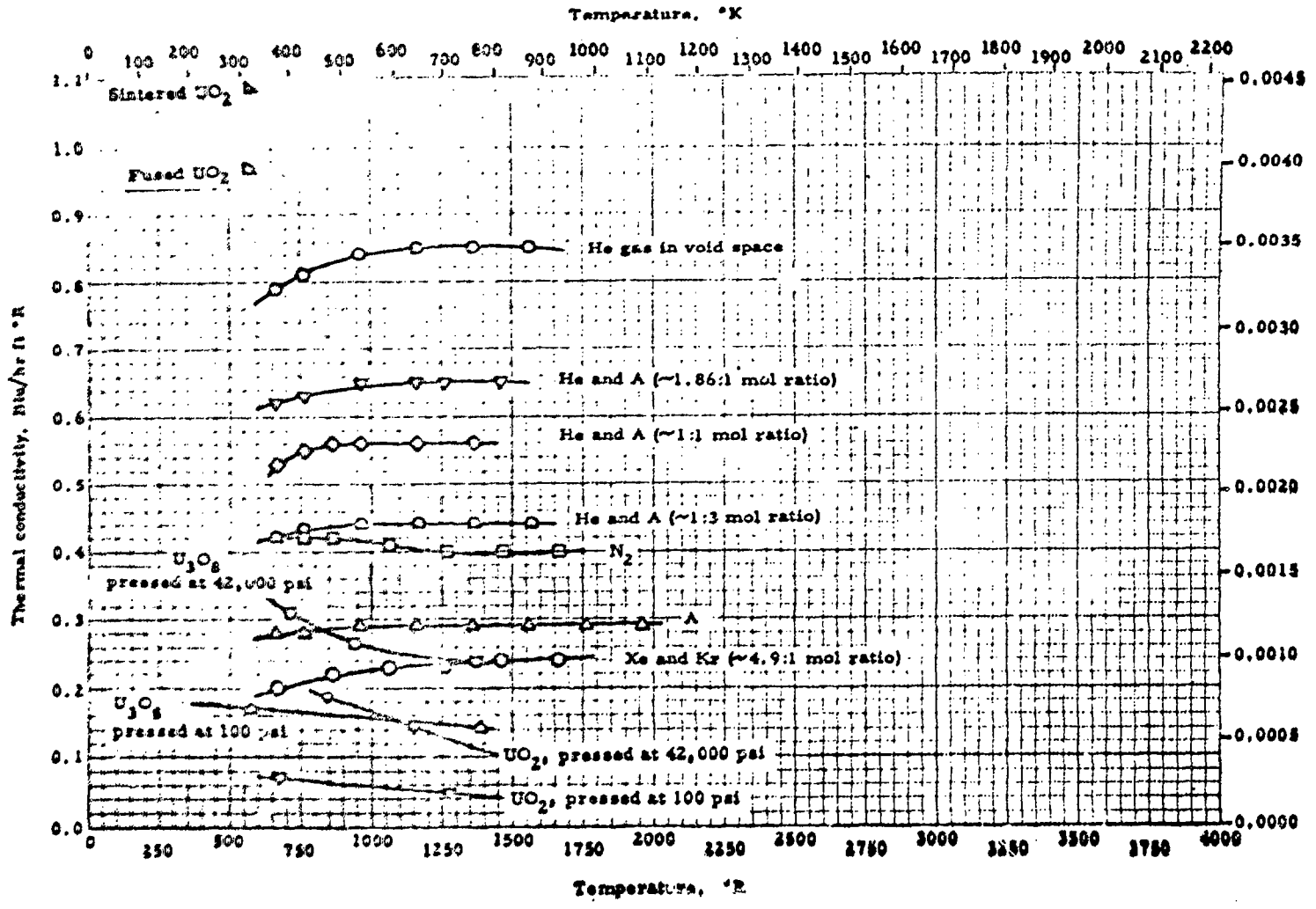


THERMAL CONDUCTIVITY -- URANIUM OXIDE + BERYLLIUM OXIDE

THERMAL CONDUCTIVITY -- URANIUM OXIDE + BERYLLIUM OXIDE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	McCreight, L. R.	57-148	555-1935	70.9% UO_2 ; 29.1% BeO ρ = 80.5% of theor.	Two methods: a. comparative, rods b. axial heat flow in rod	Sintered
●	Ibid.	57-148	810-1275	Same as above ρ = 79.5% of theor.	Same as above	Same as above

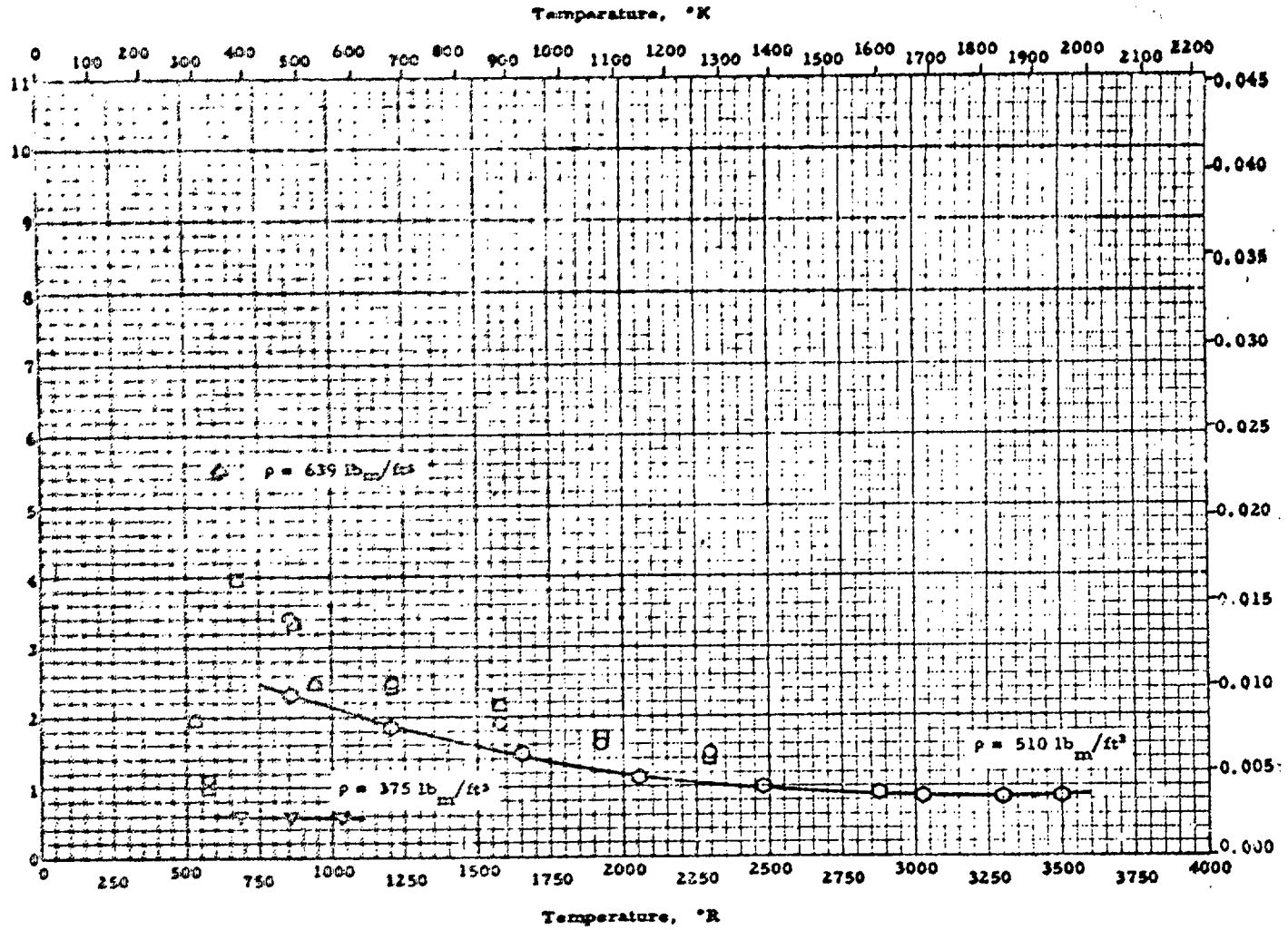


THERMAL CONDUCTIVITY -- URANIUM OXIDE POWDER

THERMAL CONDUCTIVITY -- URANIUM OXIDE POWDER

REFERENCE INFORMATION

	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
				Uranium Oxide Powder.		
○	Doegli, J. S. and Deissler, R. G.	55-54	560-1560	Void fraction = 0.405; ρ = 398 lb_m/ft^3; 0% retained on 0.0059 in. mesh; 59% on 0.0041 in. mesh; 41% on 0.000748 in. mesh	Radial heat flow in cylinder	Gas contained in void space was He at 59.3-136.9 psia
□	Ibid.	55-54	760-1660	Same as above	Same as above	Gas contained in void space was N_2 at 49.3-83.3 psia
△	Ibid.	55-54	660-1960	Same as above	Same as above	Gas contained in void space was A at 44.3-94.4 psia
◇	Ibid.	55-54	660-1360	Same as above	Same as above	Gas contained in void space was a mixture of He and A; vol. ratio 0.953 to 1; pressure level 39.4-96.3 psia
▽	Ibid.	55-54	660-1460	Same as above	Same as above	Gas contained in void space was a mixture of He and A; vol. ratio 1.857 to 1; pressure level 47.3-84.3 psia
○	Ibid.	55-54	660-1660	Same as above	Same as above	Gas contained in void space was a mixture of Xe and Kr; vol. ratio 4.898 to 1; pressure level 18.8-74.3 psia
□	Ibid.	55-54	660-1560	Same as above	Same as above	Gas contained in void space was a mixture of He and A; vol. ratio 0.333 to 1; pressure level 46.3-84.3 psia
△	Snyder, T. M. and Kamm, R. L.	55-95	582-1392	U_3O_8 powder	Single flat [illegible] guard heater	Pressed at 100 psi
□	Ibid.	55-95	710-1380	U_3O_8 powder	Same as above	Pressed at 42,000 psi
▽	Ibid.	55-95	670-1290	UO_2 powder	Same as above	Pressed at 100 psi
◇	Ibid.	55-95	840-1150	UO_2 powder	Same as above	Pressed at 42,000 psi
▷	Ibid.	55-95	582	UO_2, fused powder	Same as above	
▷	Ibid.	55-95	582	UO_2, sintered powder	Same as above	



THERMAL CONDUCTIVITY -- URANIUM OXIDE

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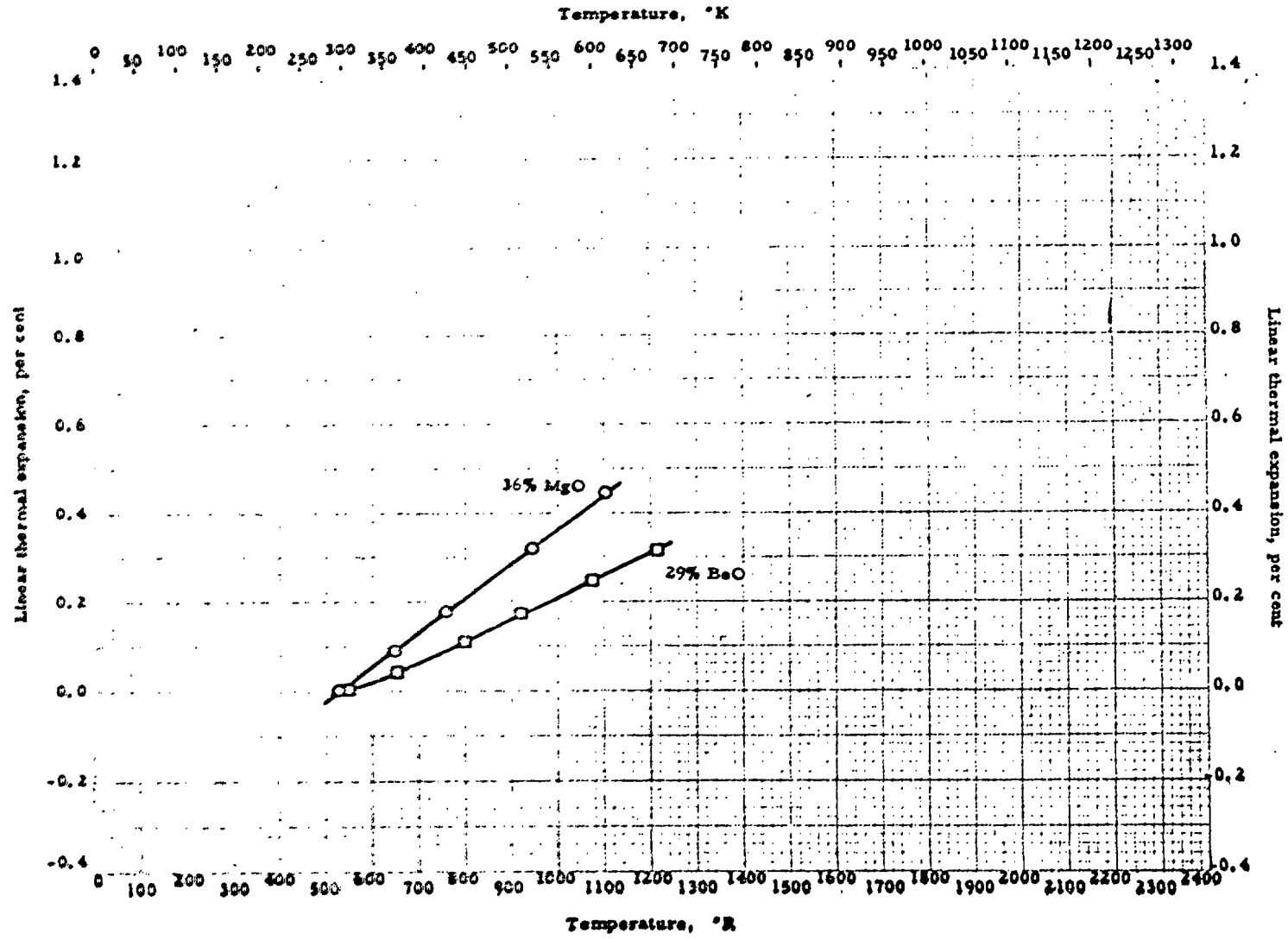
THERMAL CONDUCTIVITY -- URANIUM OXIDE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Gingery, W. D. and Francl, J.	54-1 also 53-68 & 53-65	852-2292	UO_2. Bulk ρ = 499 lb_m/ft^3; porosity = 26.7%	Comparative; rods	Cast from suspension; fired at 1980°C in vacuum
□	Lambertson, W. A. and Handwerk, J. H.	56-5 also 53-65	672-2292	UO_2. ρ = 504 lb_m/ft^3	Not given	
△	Weeks, James L. and Seifert, R. A.	53-17	618	UO_2. ρ = 637 lb_m/ft^3	Comparative; rods	
◇	Rauch, W. G.	54-68	618	UO_2. ρ = 639 lb_m/ft^3	Comparative; rods	
▽	Norton, F. H. and Gingery, W. D.	53-69	672-1032	UO_2. Bulk ρ = 375 lb_m/ft^3; porosity = 45%	Ellipsoidal envelope	
○	Hedge, J. C. and Fleischman, L. B.	56-110	856-3494	UO_2. ρ = 510 lb_m/ft^3 (74.95% of theo.)	Powell stacked disks	Ground; cold pressed at 40,000 psi; dried; fired to 1400°C in dry H_2, to 1500°C in steam; held two hr; furnace cooled in H_2
○	Englander, M.	51-85	528-942	UO_2	Twin plate without guards	Sintered. Auth. est. accuracy ± 10%
◇	Snyder, T. M. and Kamm, R.	55-95	582	UO_2, fused	Single flat plate with guard heater	
▽	Ibid.	55-95	582	UO_2, sintered	Same as above	

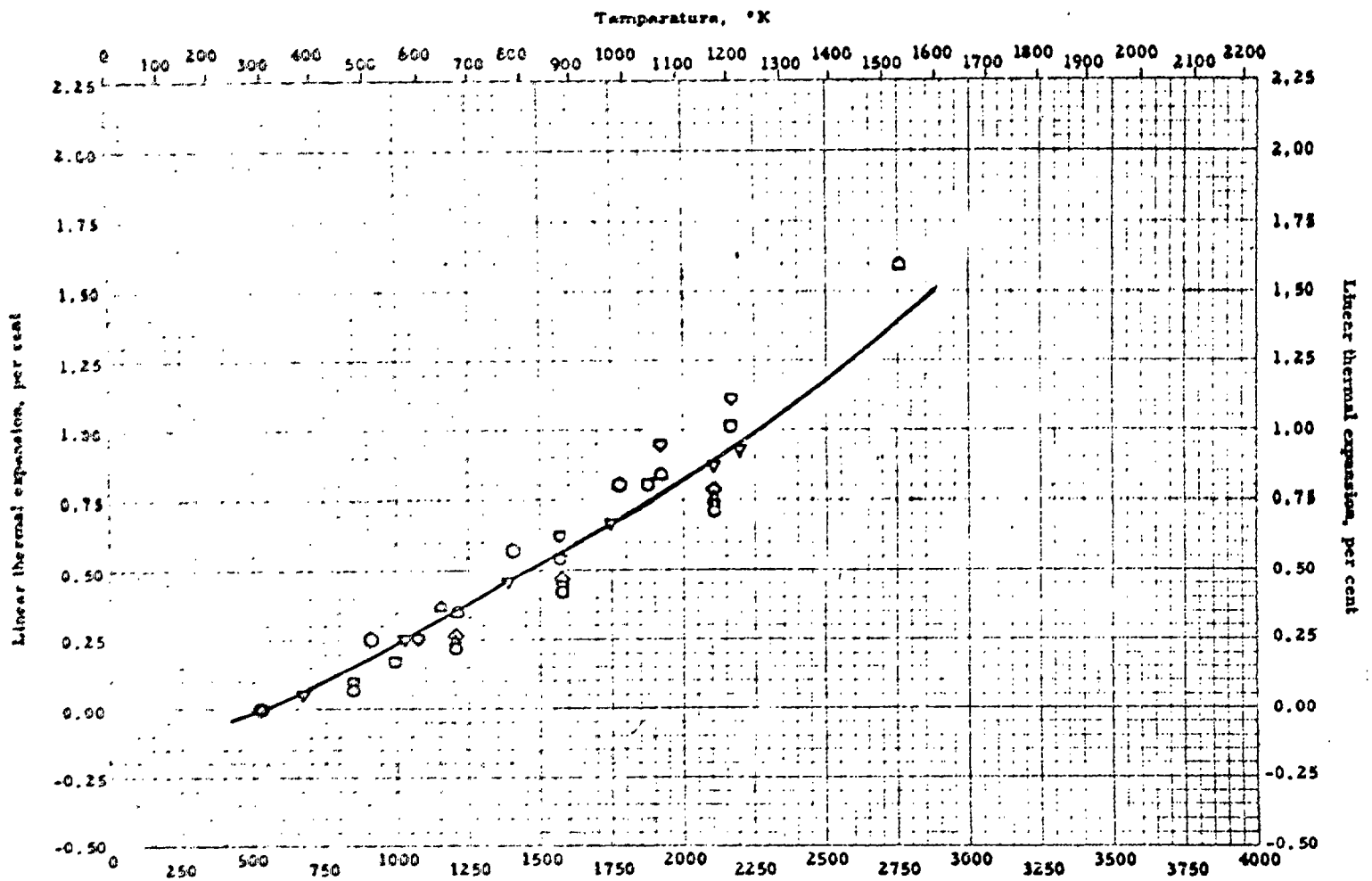


LINEAR THERMAL EXPANSION -- URANIUM OXIDE + OTHER OXIDES

LINEAR THERMAL EXPANSION -- URANIUM OXIDE + OTHER OXIDES

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Mc Creight, L. R.	52-119	528-1104	63.8% UO_2; 36.2% MgO	Gaertner interferometer in argon atmos.	Pressed from powder, sintered, 80% of theoretical density
□	Ibid.	52-119	528-1212	70.9% UO_2; 29.1% BeO	Same as above	Pressed from powder, sintered at 1850°C, 80% of theoretical density



LINEAR THERMAL EXPANSION -- URANIUM OXIDE

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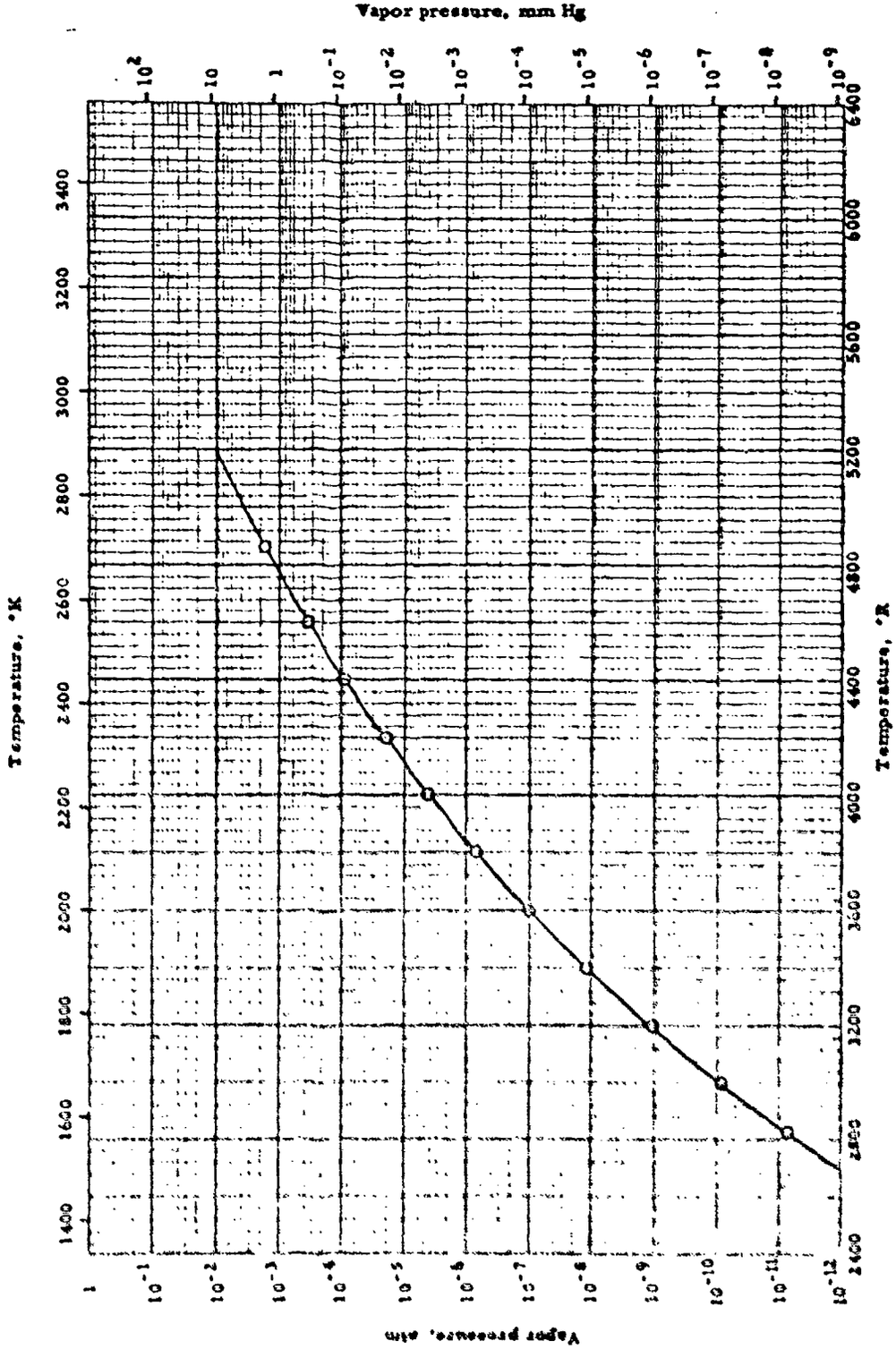
LINEAR THERMAL EXPANSION -- URANIUM OXIDE

REFERENCE INFORMATION

Sym	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Murray, P. and Thackray, R. W.	ND-1	528-2112	UO_2; ρ = 450 lb_m/ft^3	Dilatometer	Sintered; tested at 10°C/min. rise in argon atmos.
□	Ibid.	ND-1	528-2112	Same as above	Same as above	Sintered; tested at 3.5°C/min. rise in argon atmos.
△	Ibid.	ND-1	528-2112	$UO_{2.13}$; ρ = 533 lb_m/ft^3	Same as above	Sintered; tested at 10°C/min. rise in argon atmos.
◇	Ibid.	ND-1	528-2112	$UO_{2.13}$; ρ = 631 lb_m/ft^3	Same as above	Sintered; tested at 3.5°C/min. rise in argon atmos.
▽	Lambertson, W. A. and Mandewerk, J. H.	56-5	528-2202	99.8% UO_2; 0.083% MgO; 0.002% Al_2O_3; 0.001% ea. CuO, Fe_2O_3, SiO_2 ρ = 574 lb_m/ft^3	Interferometer	Slip cast; fired to 1750°C in H_2 atmos.; tested at 205°C/hr. rise
○	Thewlis, J.	52-19	528-1788	UO_2	X-ray diffraction	
◇	Burdick, M. D. and Parker, H. S.	55-144	528-2760	UO_2; 0.001 - 0.01% ea. Al, Fe; 0.0001 - 0.001% ea. Ca, Mg; 0.0001% Cu	Not given	Arc fused, milled 20 hr., 1% carbowax added, pressed at 10,000 psi in mold, at 45,000 psi hydrostatically, matured in A atm. for 30 min. at 2000°C. Plotted avg. of 2 heating and cooling runs within 3%
△	McCreight, L. R.	52-119	528-1158	UO_2, ρ = 85% theoretical	Gaertner interferometer	Pressed from powder; sintered at 1950°C in H_2 atm.
○	Bell, L. P. and Makin, S. M.	54-103	492-2170	UO_2, ρ = 624 lb_m/ft^3	Dilatometer	Prepared from Springfields UO_2 powder, pressed at 20,000 psi, sintered 3 hr. at 1400°C in argon. Sample 1
▽	Ibid.	54-103	492-2112	Same as above	Same as above	Same as above, Sample 2

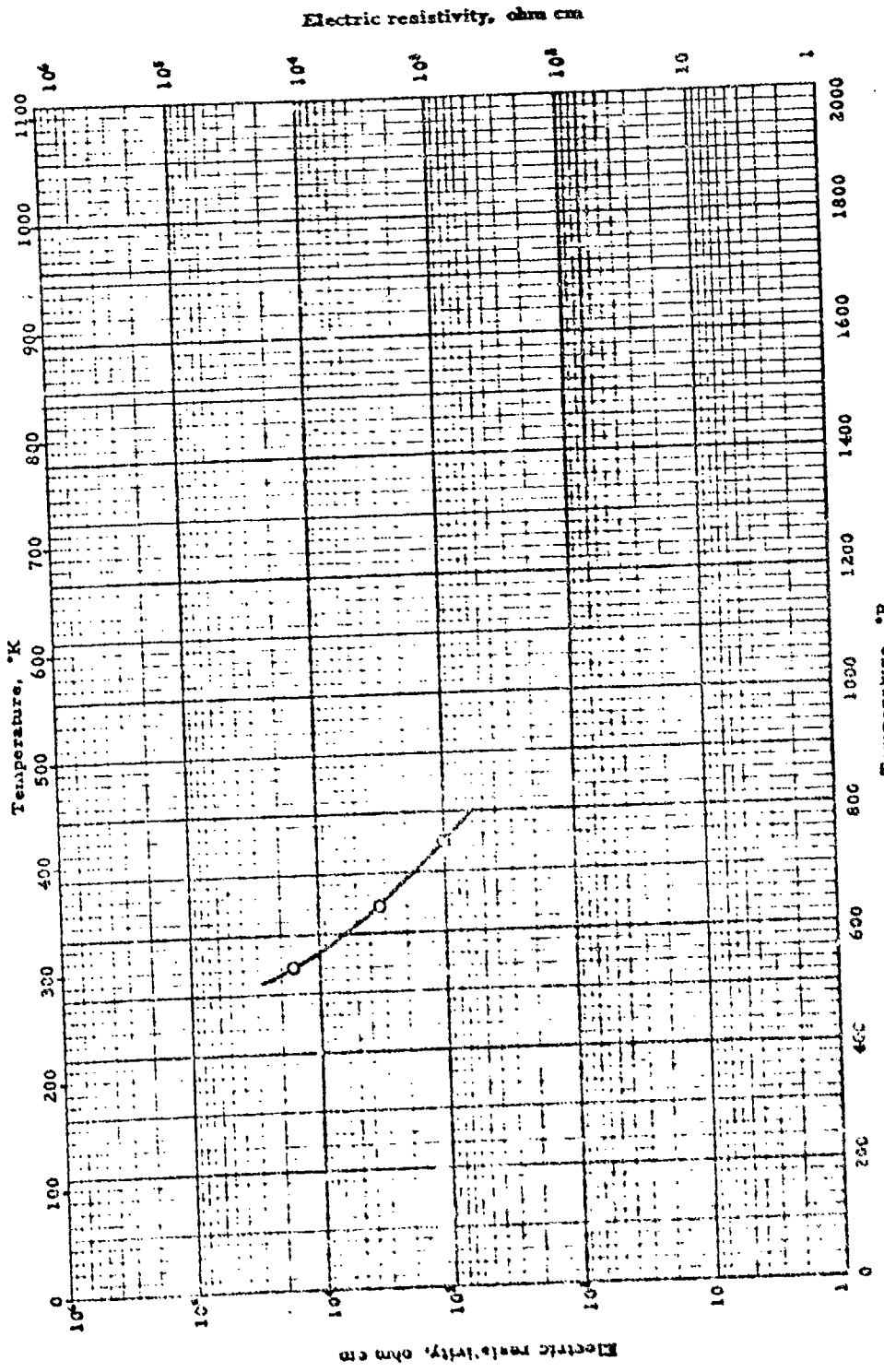


VAPOR PRESSURE -- URANIUM OXIDE

VAPOR PRESSURE -- URANIUM OXIDE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Ackerman, R. J., Gilles, P. W. and Thorn, R. J.	56-62	2831-4860	UO_2	Knudsen effusion cell; (alpha particle counting)	W cell

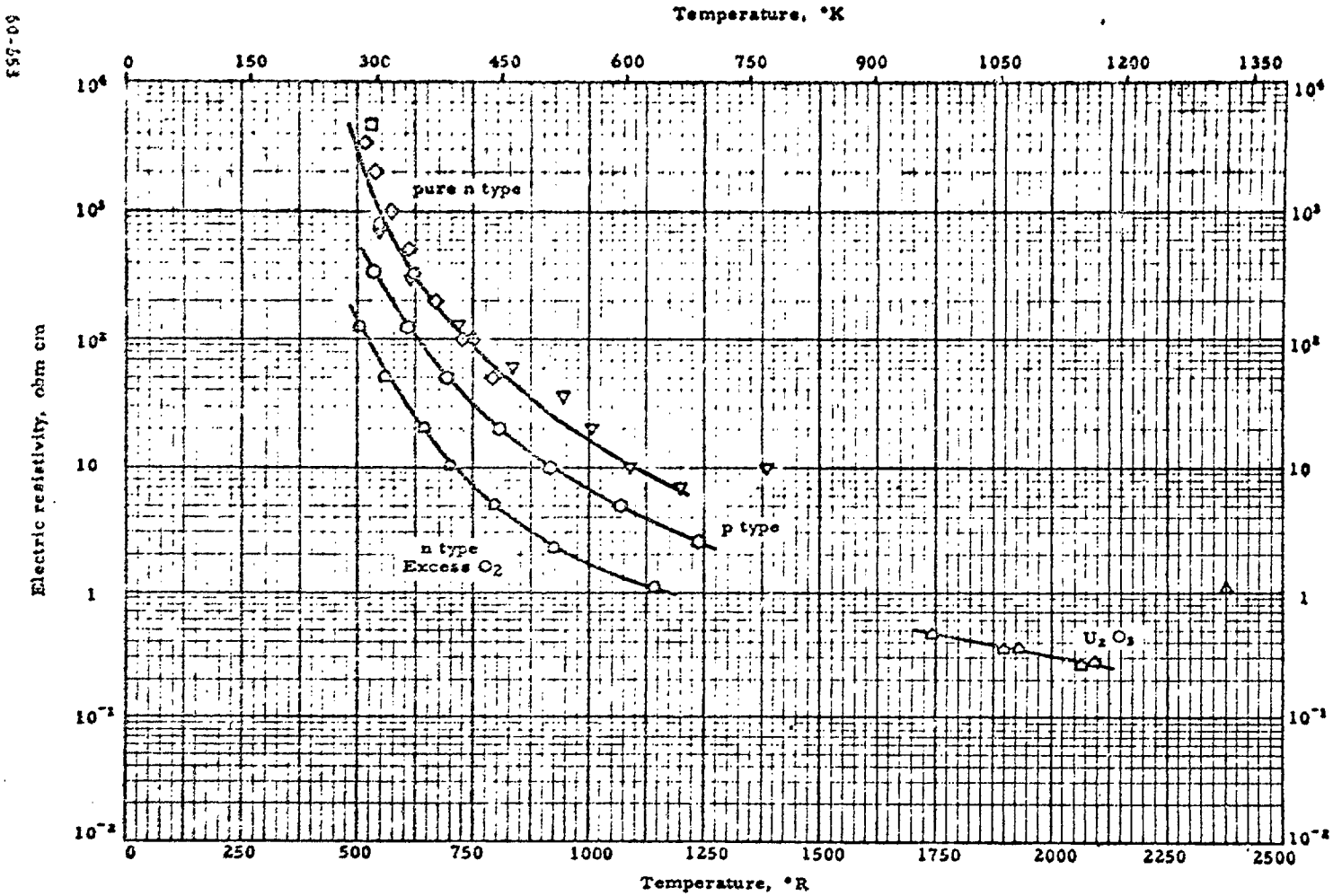


ELECTRIC RESISTIVITY -- URANIUM OXIDE + THORIUM OXIDE

ELECTRIC RESISTIVITY -- URANIUM OXIDE + THORIUM OXIDE

REFERENCE INFORMATION

	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
C	Gruen, D. M.	54-163	545-750	50% UO_2 ; 50% ThO_2	Potential drop. Sample temp. by Chromel-Alumel thermocouple	Mixed from elements with <0.01% transition and rare earth metals, pressed, fired 8 hr. at 1750°C in H_2



ELECTRIC RESISTIVITY -- URANIUM OXIDE

ELECTRIC RESISTIVITY -- URANIUM OXIDE

REFERENCE INFORMATION

	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Gruen, D. M.	54-143	545-750	UO_2	Potential drop; Chromel-Alumel thermocouple	Mixed from elements with < 0.01% transition and rare earth metals, pressed, fired 8 hr. at 1750°C in H_2
□	Rudorff, W. and Valet, G.	53-85	Room	UO_2	Not given	Powders pressed at 500 g/cm² pressure, roasted in a high vacuum until resistivity became constant. Auth. est. accuracy ± 2%
△	Hauffe, K.	41-26	2375	UO_2	Potential drop	Sintered at 1600-1800°C
◇	Willardson, R. K., Moody, J. W. and Goering, H. L.	56-161	515-789	UO_2. <0.0003% metallic impurities; n-type	Potential drop, sample temp. by Chromel-Alumel thermocouple	Pressed from Mallingkrodt UO_2 powder at 100,000 psi (no binder), sintered 1 hr. at 2050°C; corrected to zero porosity. ρ = 86% theoretical
▽	Ibid.	56-161	542-1720	Same as above	Same as above	Same as above, except sintered 1 hr. at 1600°C, and ρ = 79-95% theoretical (two samples)
○	Ibid.	56-161	534-1240	Three samples ranging $UO_{2.032}$ - 2.160 p-type	Same as above	Mallingkrodt UO_2 powder oxidized, pressed at 100,000 psi (without binder), not sintered, annealed at 400°C, quenched. ρ = 60% theoretical
□	Ibid.	56-161	503-1215	Three samples ranging $UO_{2.206}$ - 2.353 n-type	Same as above	Same as above
△	Hauffe, K.	41-26	1742-2093	U_3O_8	Potential drop	At 1 atm. O_2

PROPERTIES OF PLUTONIUM OXIDE

MOST PROBABLE VALUES

Property	Brit. Engineering Units	C. G. S. Units
Density.		
Melting Point		
Heat of Fusion		
Heat of Vaporization. . .		
Heat of Sublimation . . .	$590_{3400°R}$ Btu/lb$_m$	$330_{1900°K}$ cal/g

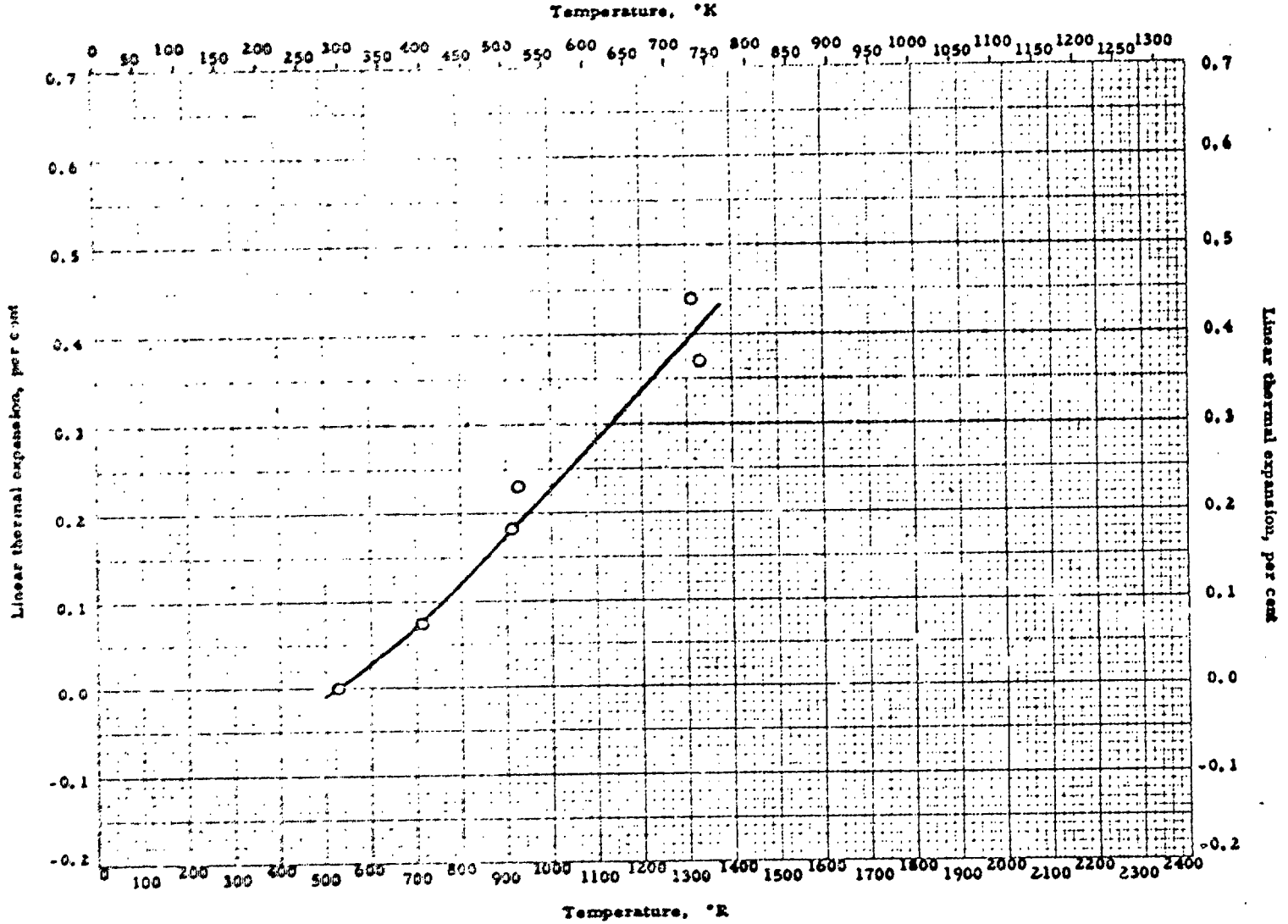
REPORTED VALUES

Density:	lb$_m$/ft^3	g/cm^3
Melting Point:	°R	°K
Heat of Fusion:	Btu/lb$_m$	cal/g
Heat of Vaporization:	Btu/lb$_m$	cal/g
Heat of Sublimation:	Btu/lb$_m$	cal/g
	O $590_{3400°R}$	$330_{1900°K}$

PROPERTIES OF PLUTONIUM OXIDE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Compton, A. H. and Allison, S. A.	43-20	3011-3731	PuO	Δh_s: from vapor pressure measurements	Authors estimate that "this value is probably too high, but of reasonable order of magnitude".

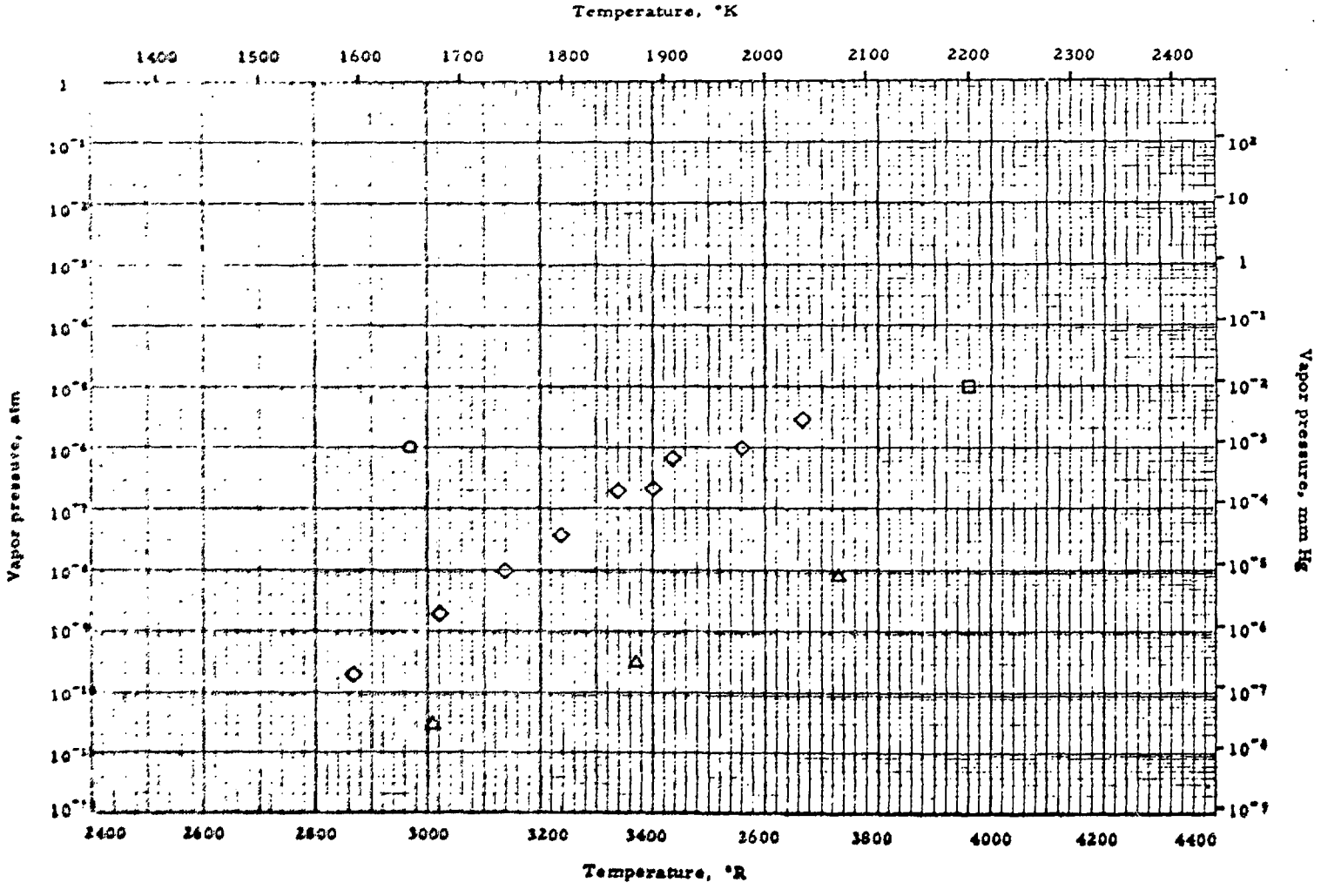


LINEAR THERMAL EXPANSION -- PLUTONIUM OXIDE

LINEAR THERMAL EXPANSION -- PLUTONIUM OXIDE

REFERENCE INFORMATION

Plot Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Mardon, P. G. and Waldron, M. B.	57-192	528-1330	PuO_2	X-ray meas. of lattice	Authors consider values of limited accuracy



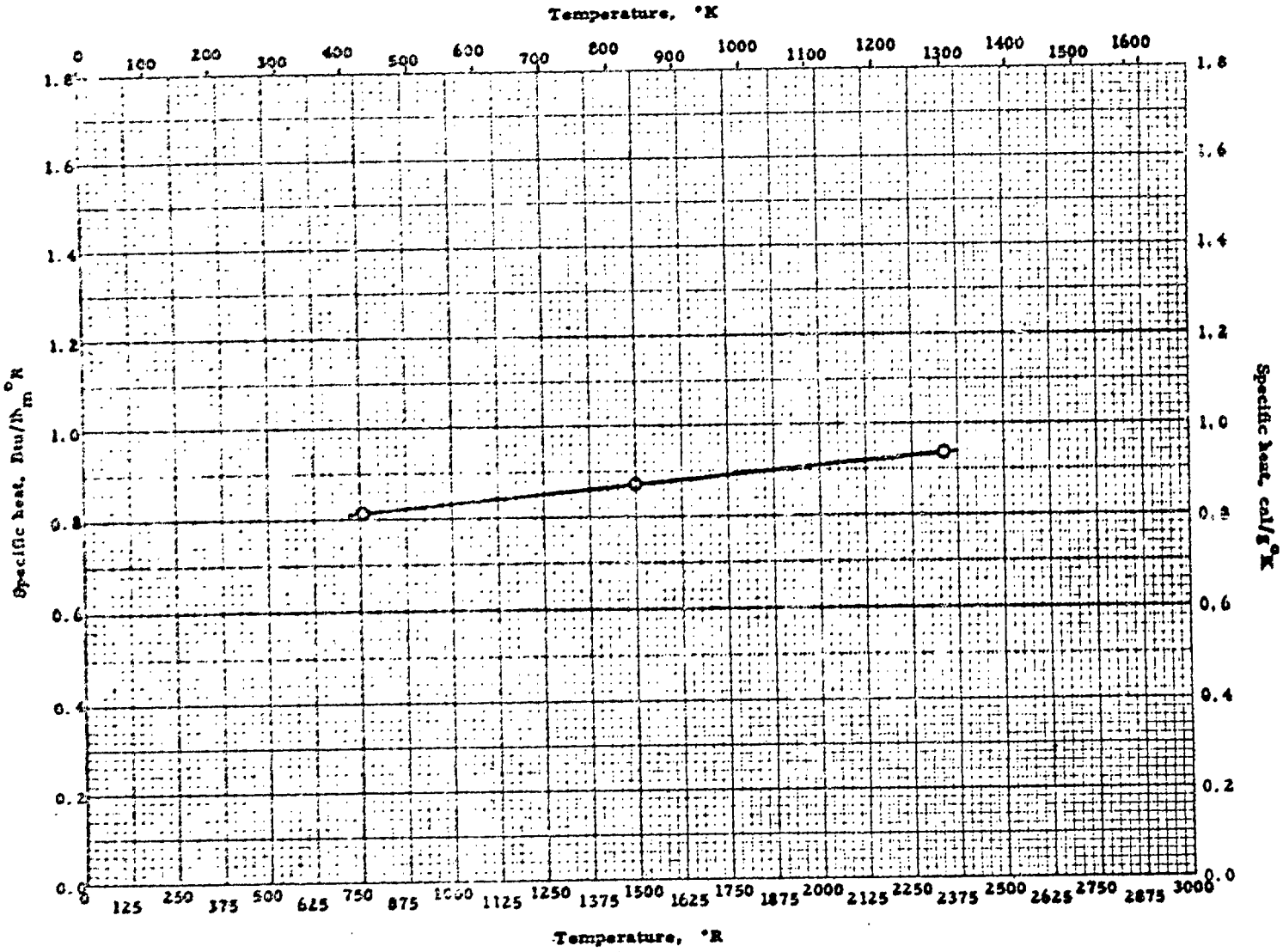
VAPOR PRESSURE -- PLUTONIUM OXIDE

WADC TR 59-416 (Pt V)

VAPOR PRESSURE -- PLUTONIUM OXIDE

REFERENCE INFORMATION

	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Brewer, L., Bromley, L. et al.	49-65	2970	PuO	Not described here, refers to others	
□	Ibid.	49-65	3960	PuO_2	Same as above	Estimate from corresponding uranium compound
△	Compton, A. H. and Allison, S. A.	43-20	3011-3731	Pu Oxide	Knudsen type test, but not an effusion vessel, only an orifice. Temp. by optical pyrometer	Auth. est. only order of magnitude
◇	Phipps, T. E. et al.	50-63	2861-3708	PuO_2 + unknown reduced Pu Oxide	Knudsen cell with radioactive counting. Temp. by optical pyrometer	

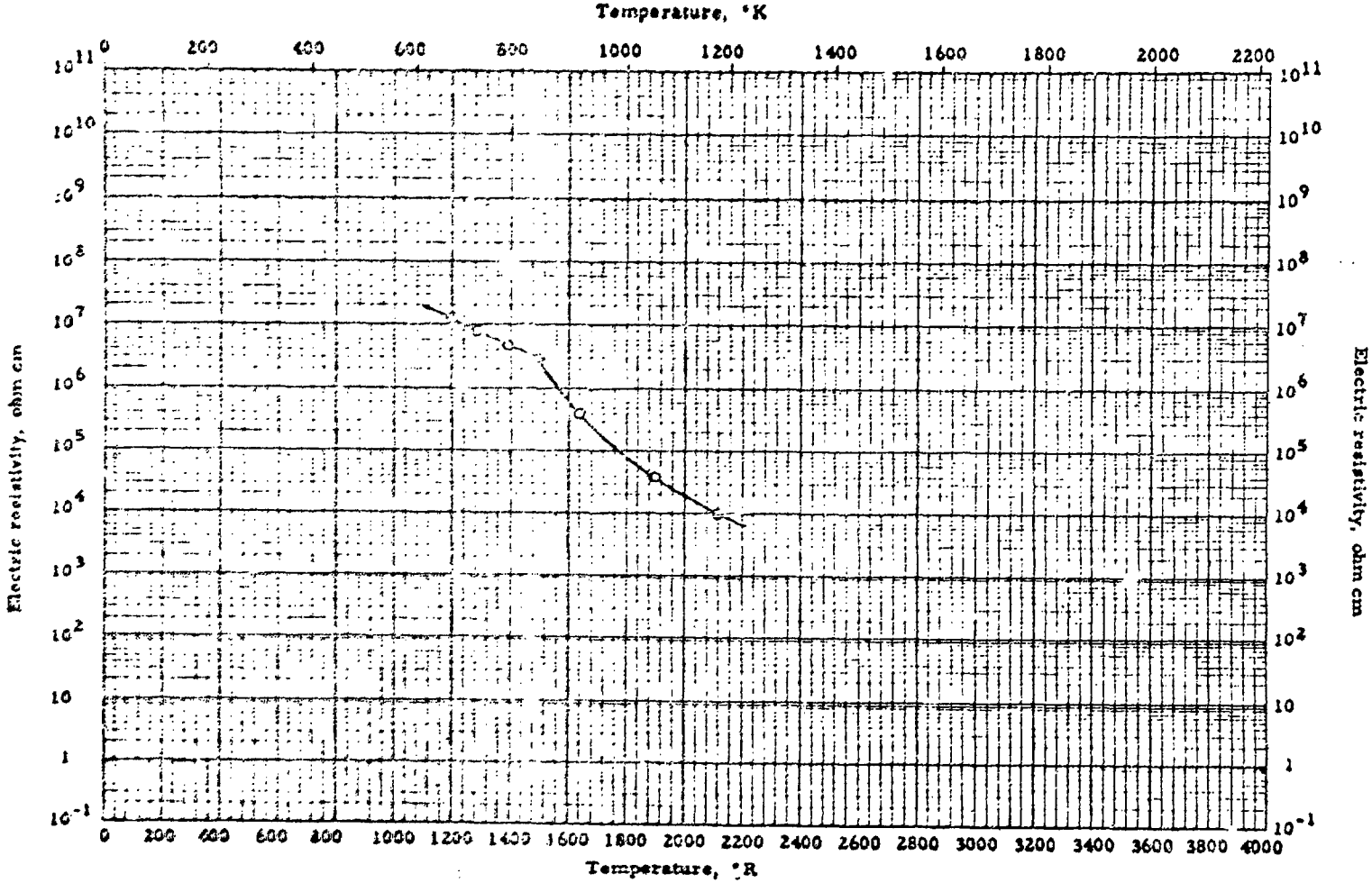


SPECIFIC HEAT -- BARIUM OXIDE

SPECIFIC HEAT -- BARIUM OXIDE

REFERENCE INFORMATION

Sym.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Lander, J.J.	51-78	750-2340	99% BaO, ~1% SiO_2	Drop method, calibrated with Pt sample.	Material prepared by decomposing BaO_2. Computed C_p from quadratic equation fitted to author's enthalpy values by least square routine at ARF.



ELECTRIC RESISTIVITY -- BARIUM OXIDE

ELECTRIC RESISTIVITY -- BARIUM OXIDE

REFERENCE INFORMATION

	Investigator	Ref.	Range, °K	Material Composition	Test Method	Remarks
C	Lakhodskaya, A. P.	56-73	1200-2120	BaO	Potential drop: sample temp. by thermocouple and optical pyrometer	Prepared from chemically pure polycrystalline materials. Sintered at 0.46 MP for 2 hr. in vacuum

PROPERTIES OF CADMIUM OXIDE

MOST PROBABLE VALUES

Property	Brit. Engineering Units	C. G. S. Units
Density.	434 lb_m/ft^3 *	6.95 g/cm^3 *
Melting Point	2930°R *	1630°K *
Heat of Fusion		
Heat of Vaporization. . .		
Heat of Sublimation . . .	$861_{1850°R}$ Btu/lb_m	$478_{1028°K}$ cal/g

* Handbook Chem. and Phys. (Ref. 57-60)

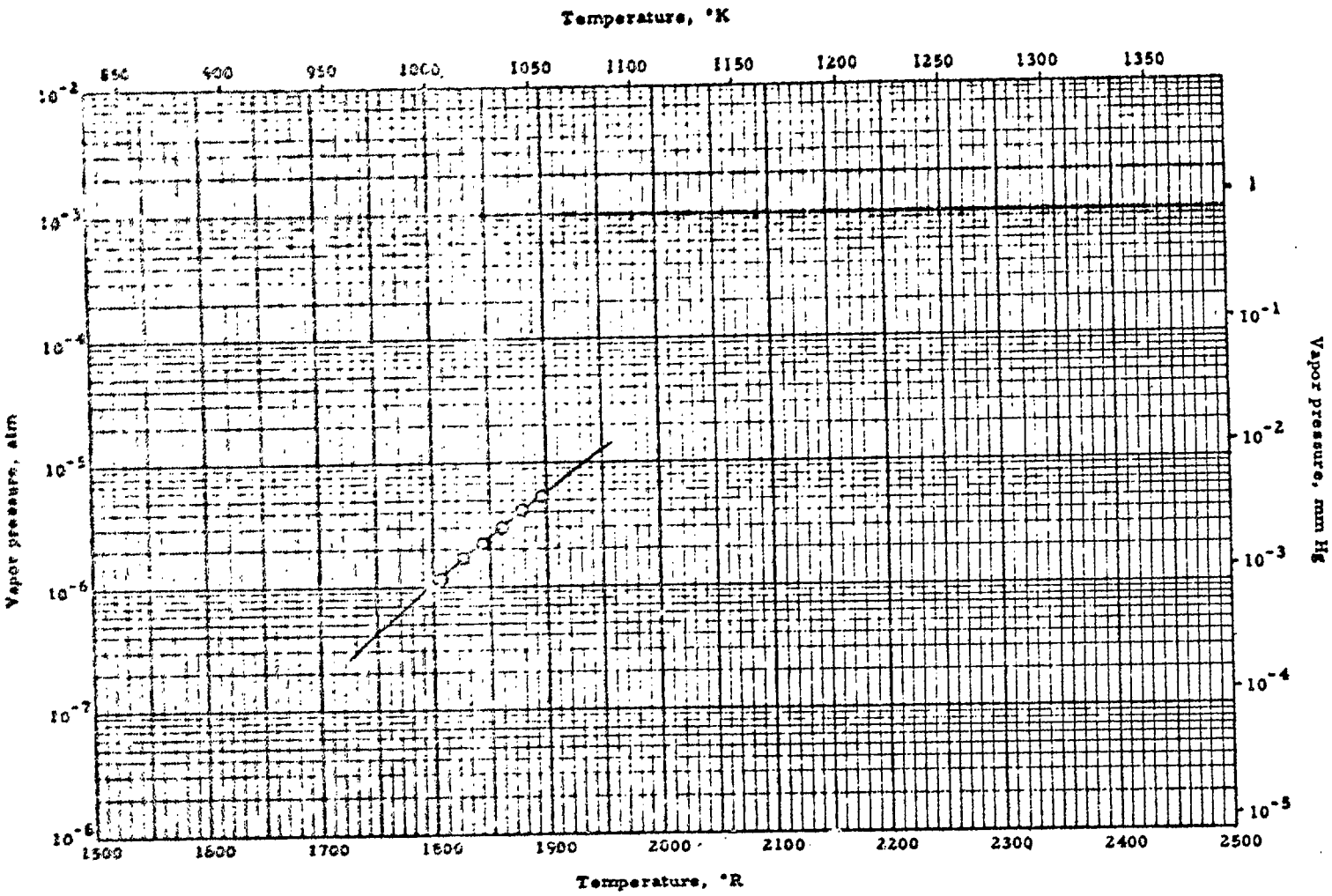
REPORTED VALUES

Density:	lb_m/ft^3	g/cm^3
Melting Point:	°R	°K
Heat of Fusion:	Btu/lb_m	cal/g
Heat of Vaporization:	Btu/lb_m	cal/g
Heat of Sublimation:	Btu/lb_m	cal/g
	$861_{1850°R}$	$478_{1028°K}$

PROPERTIES OF CADMIUM OXIDE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Lyons, K.	G-5	1851	CdO	Δh_s from vapor pressure measured by Knudsen effusion cell	

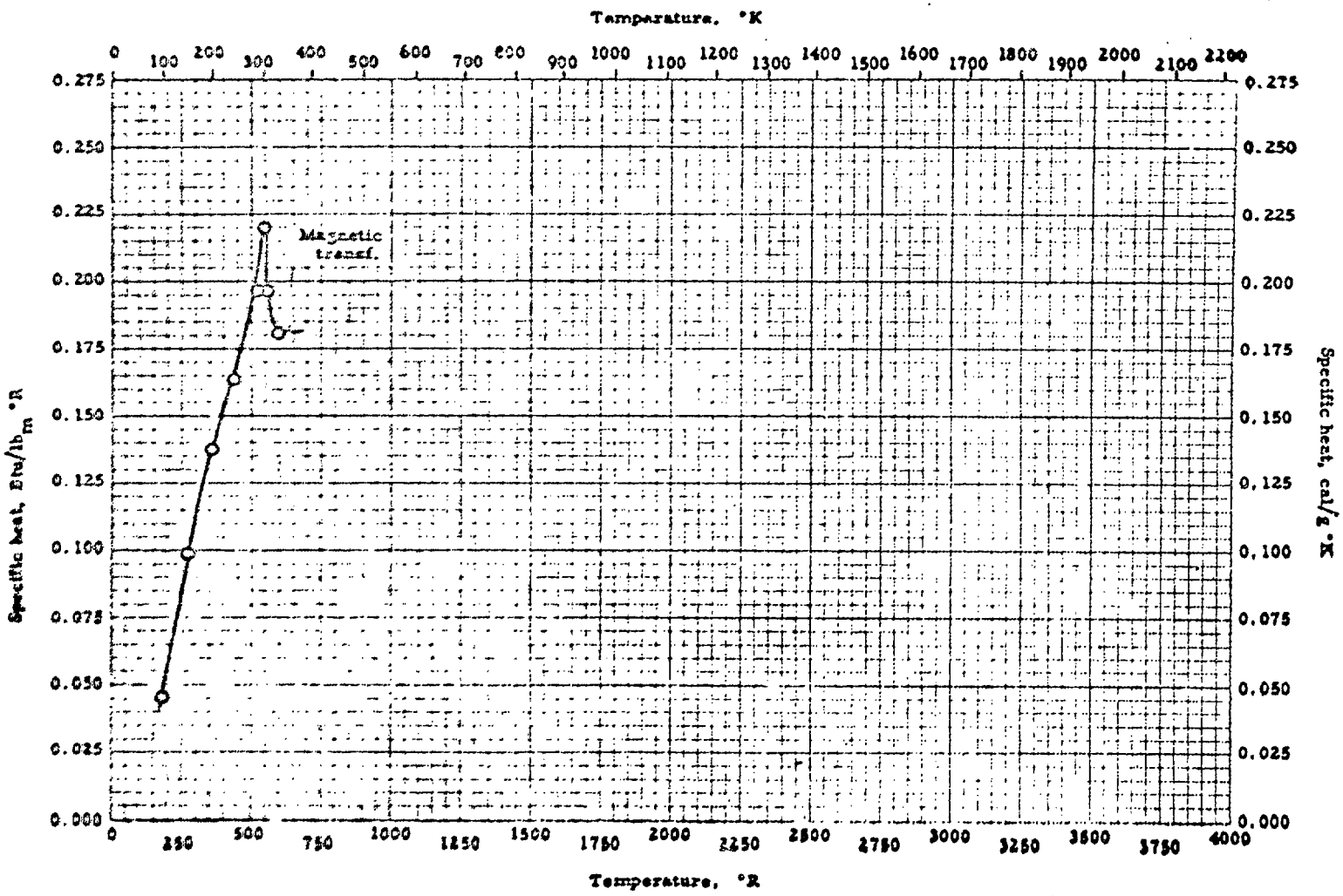


VAPOR PRESSURE -- CADMIUM OXIDE

VAPOR PRESSURE -- CADMIUM OXIDE

REFERENCE INFORMATION

Curve Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Uyeno, K.	41-5	1806-1896	CdO	Not described here; refers to others	

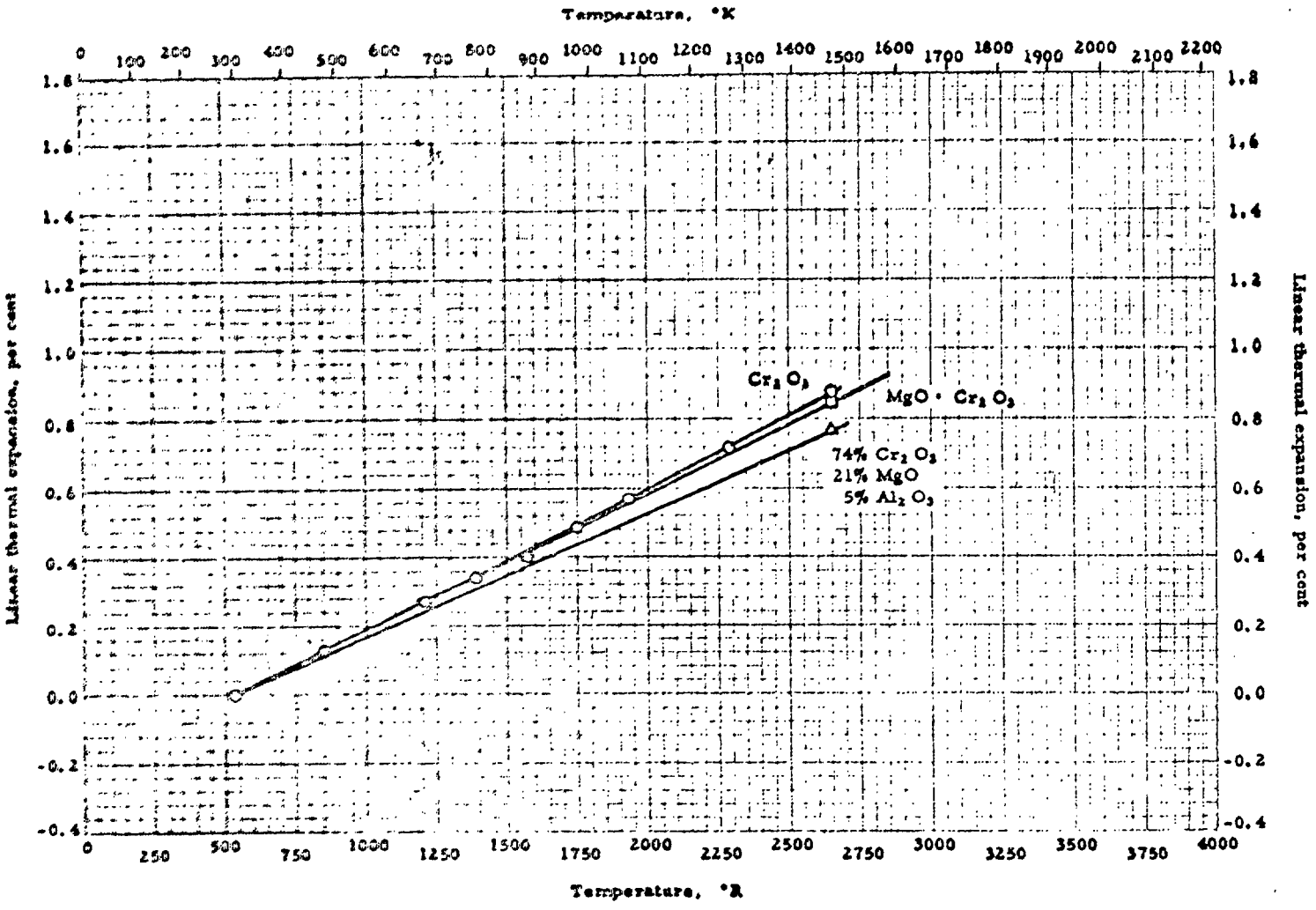


SPECIFIC HEAT -- CHROMIUM OXIDE

SPECIFIC HEAT -- CHROMIUM OXIDE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Volger, J.	52-54	180-630	Cr_2O_3	Guarded sample	Prepared by firing ammonium dichromate in air at 1000° C, formed solid piece

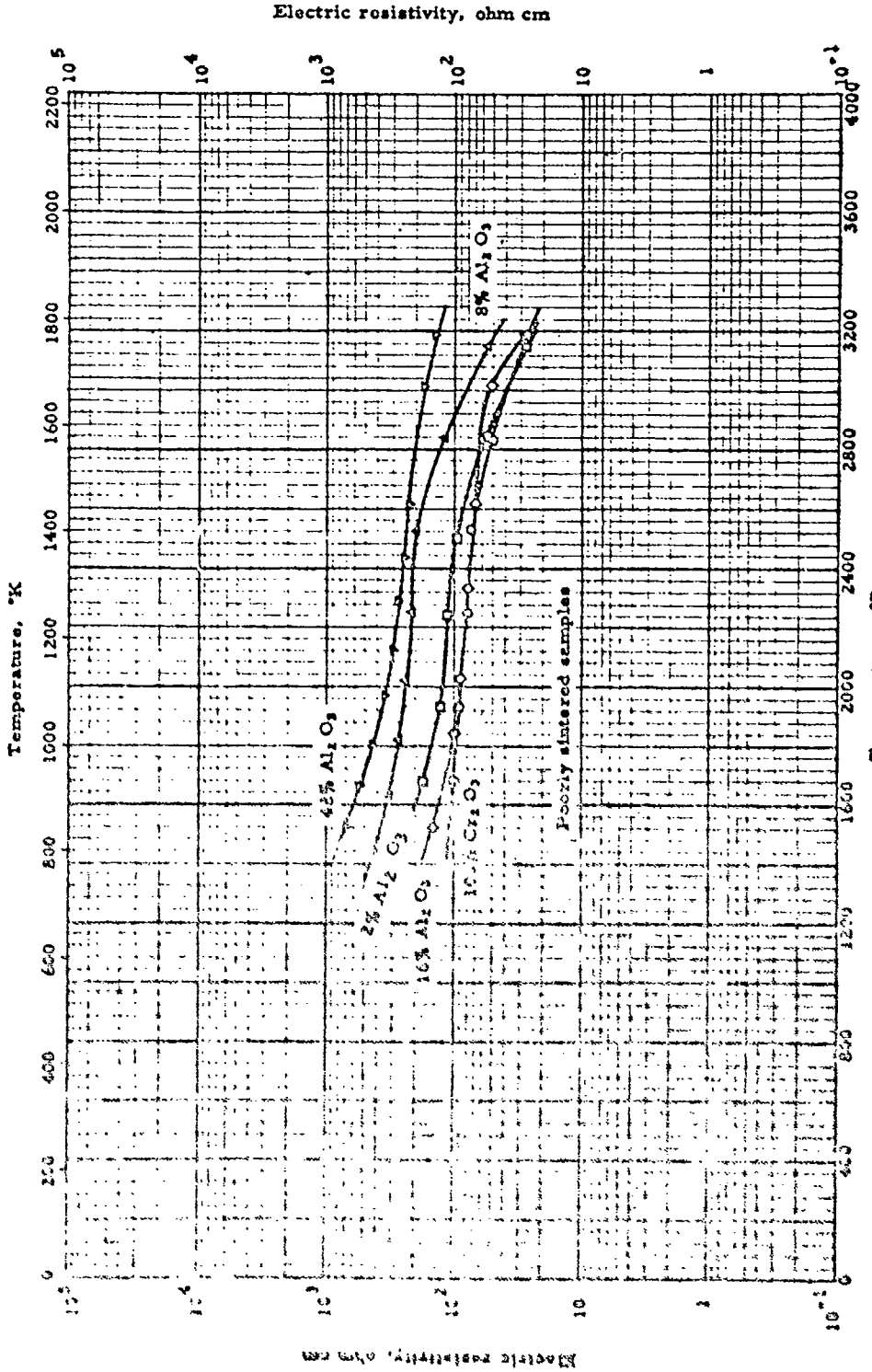


LINEAR THERMAL EXPANSION -- CHROMIUM OXIDE + X

LINEAR THERMAL EXPANSION -- CHROMIUM OXIDE + X

REFERENCE INFORMATION

	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Bl[illegible]y, G. E., Lorentt, G. H. B. and Grosse, A. V.	43-8	678-2652	Cr_2O_3 , ρ = 326 lb_m/ft^3	Not given	
□	Pole, O. R., Beckish Jr., A. W. and Gilbert, N.	46-14	528-2652	MgO · Cr_2O_3; 79% Cr_2O_3; 21% MgO	Not described here, refers to others	Heated at 4° C/min.
△	Ibid.	46-14	528-2652	74% Cr_2O_3; 21% MgO; 5% Al_2O_3	Same as above	Same as above

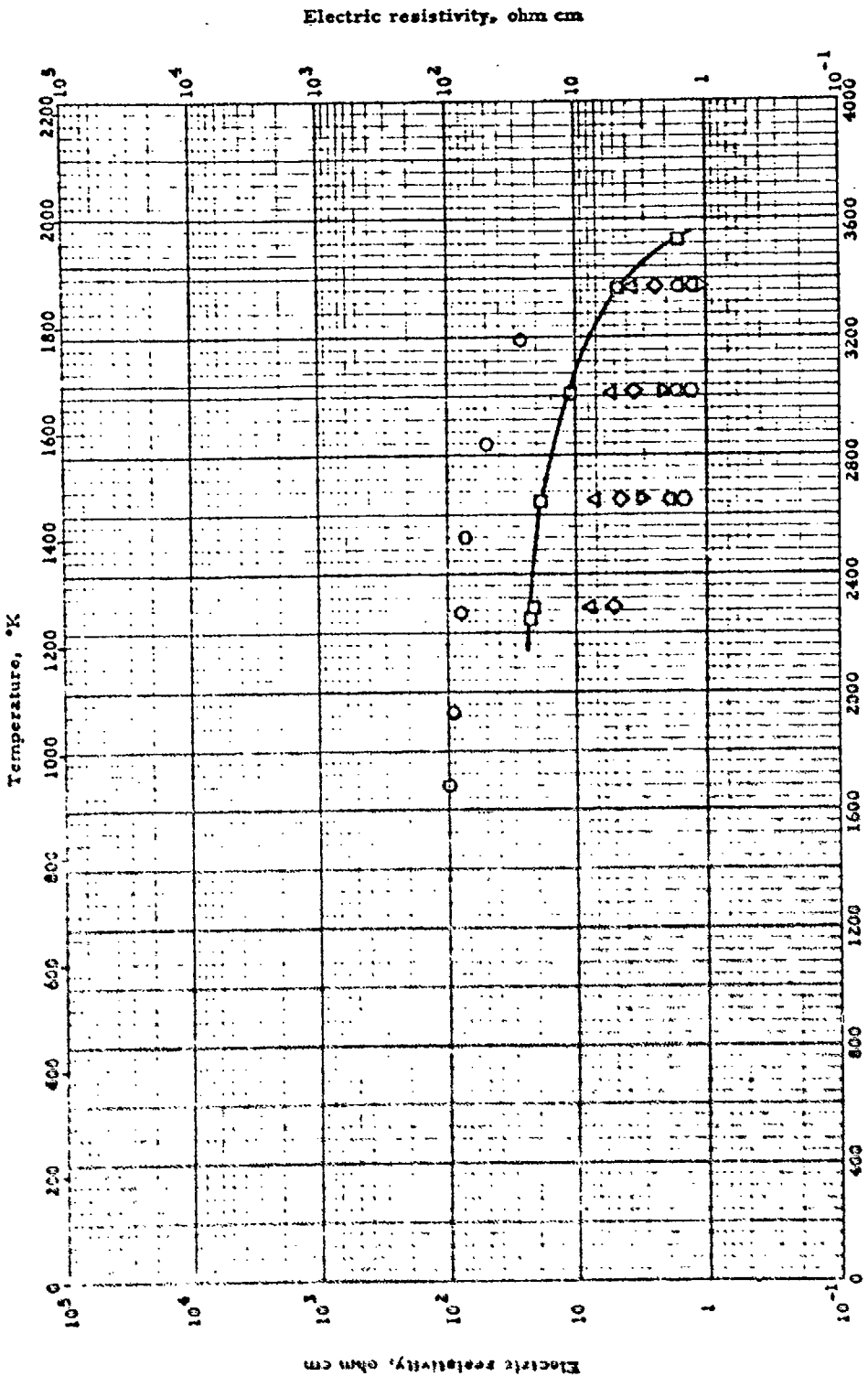


ELECTRIC RESISTIVITY -- CHROMIUM OXIDE + ALUMINA

ELECTRIC RESISTIVITY -- CHROMIUM OXIDE + ALUMINA

REFERENCE INFORMATION

Sym.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Kessler, J. E. and Henry, E. C.	53-95	1620-3192	100% Cr_2O_3	Wheatstone bridge	Fired 10 hr. to 1500°C. Poorly sintered
□	Ibid.	53-95	1680-3156	98% Cr_2O_3; 2% Al_2O_3	Same as above	Same as above
△	Ibid.	53-95	1646-3156	92% Cr_2O_3; 8% Al_2O_3	Same as above	Same as above
◇	Ibid.	53-95	1518-3192	84% Cr_2O_3; 16% Al_2O_3	Same as above	Same as above
▽	Ibid.	53-95	1518-3192	52% Cr_2O_3; 48% Al_2O_3	Same as above	Same as above

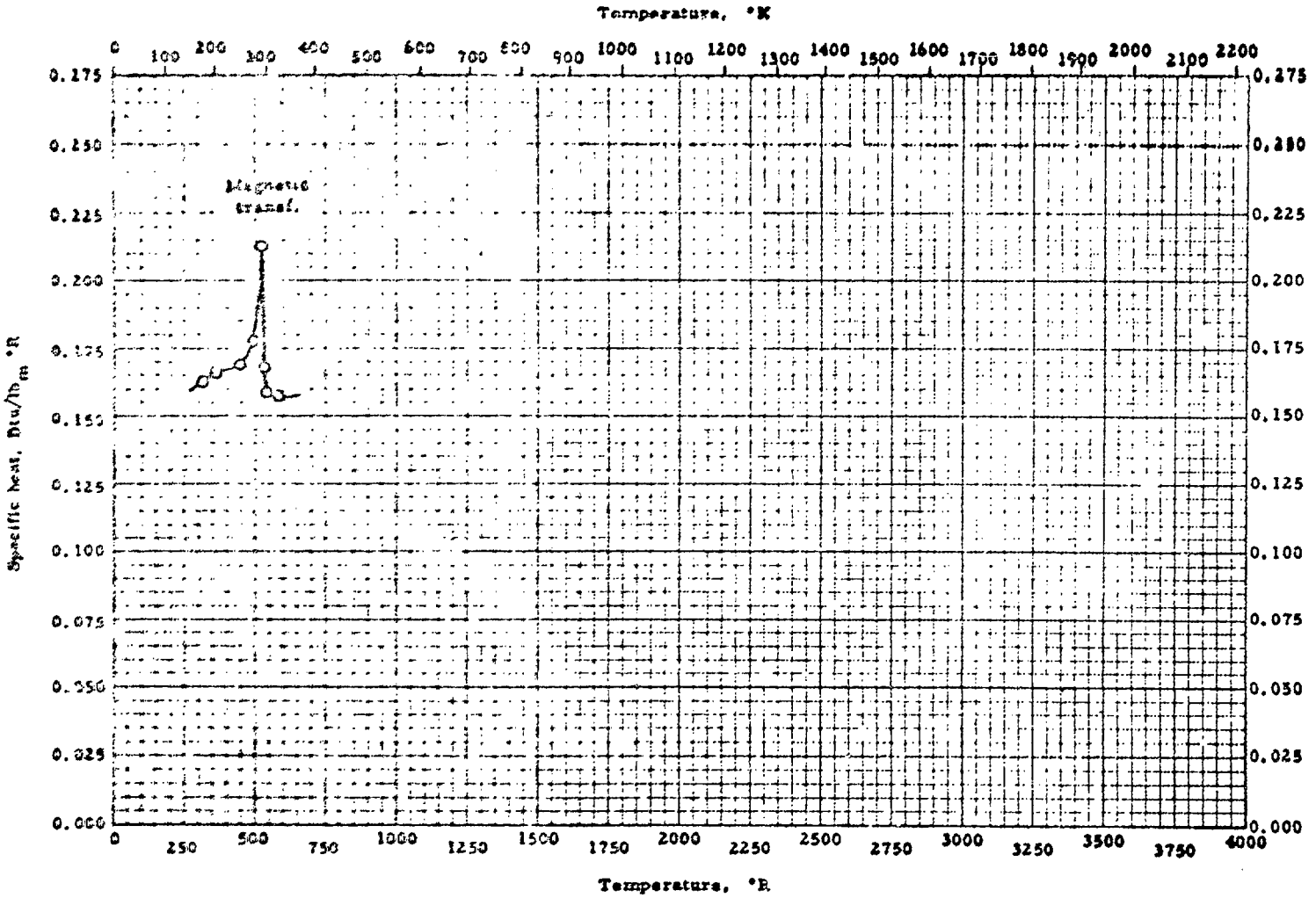


ELECTRIC RESISTIVITY -- CHROMIUM OXIDE

ELECTRIC RESISTIVITY -- CHROMIUM OXIDE

REFERENCE INFORMATION

	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
□	Hartley, J. R. and Lowry, E. C.	53-55	1680-3192	"100% Cr_2O_3"	Wheatstone bridge	Fired at 1450°C for 10 hrs. "poorly sintered"
○	Fischer, W. A. and Uebens, G.	57-177	2250-3530	Water free; 0.5% alkalies; 0.055% Fe; 0.037% Ca; 0.023% Mg; 0.010% Si; no trace Al	A. C. bridge (50 and 1000 cycles)	Presintered 1 hr. at 1500°C in argon atmos. Results independent of frequency
△	Ibid.	57-177	2292-3372	Same as above + 0.9% Cu_2O	Same as above	Same as above
◇	Ibid.	57-177	2292-3372	Same as □ + 2.6% Nb_2O_5	Same as above	Same as above
▽	Ibid.	57-177	2652-3372	Same as □ + 0.3% TiC_2	Same as above	Same as above
○	Ibid.	57-177	2652-3372	Same as □ + 0.7% TiO_2	Same as above	Same as above
◻	Ibid.	57-177	2652-3372	Same as □ + 2.4% NiO	Same as above	Same as above



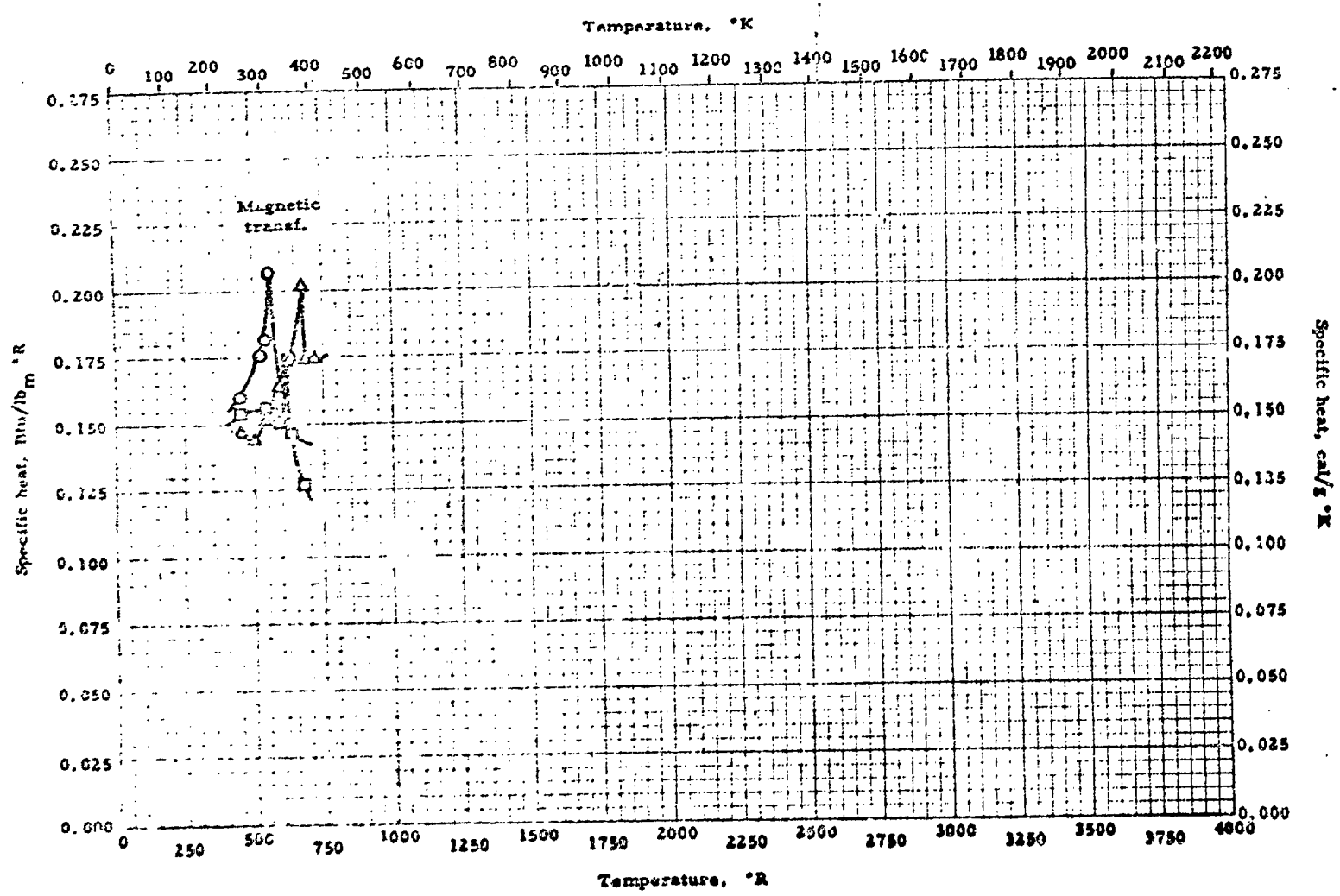
SPECIFIC HEAT -- CoO - CuO INVERSE SPINEL

SPECIFIC HEAT -- CoO-CuO INVERSE SPINEL

WADC TR 58-476 356 60-607

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Assayag, G. and Bizette, H.	54-58	315-585	91.24% CoO; 8.76% CuO	Comparative, rate of temp. rise in sample compared with standards (Al_2O_3 and benzoic acid) under same heating conditions	91.7 mol % CoO; 8.3 mol % CuO. Main purpose of article is to show the anomaly due to magnetic susceptibility (289.7°K)

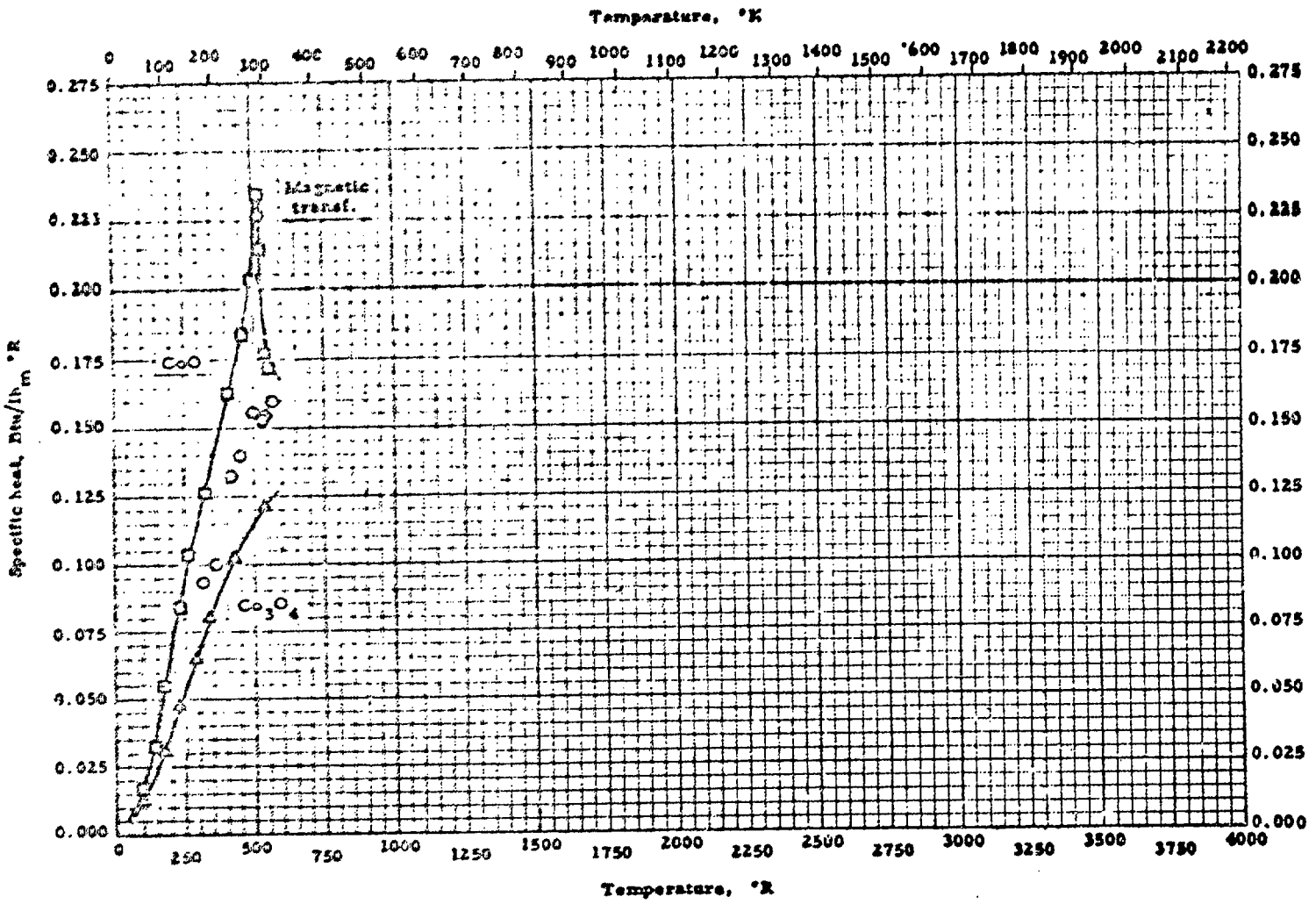


SPECIFIC HEAT -- CoO - NiO INVERSE SPINEL

SPECIFIC HEAT -- CoO-NiO INVERSE SPINEL

REFERENCE INFORMATION

Curve No.	Investigator	Ref.	Range, °K	Material Composition	Test Method	Remarks
○	Assayag, G. and Dixette, H.	54-58	450-630	90.03% CoO; 9.97% NiO	Comparative, rate of temp. rise in sample compared with standards (Al_2O_3 and benzoic acid) under same heating conditions	90 mol % CoO; 10 mol % NiO. Main purpose of article is to show the anomaly due to magnetic susceptibility (311 °K)
□	Ibid.	54-58	450-678	75.06% CoO; 24.94% NiO	Same as above	75 mol % CoO - 25 mol % NiO. Purpose same as above (345 °K)
△	Ibid.	54-58	450-720	59.98% CoO; 40.02% NiO	Same as above	59.9 mol % CoO; 40.1 mol % NiO. Purpose same as above (376.7 °K)



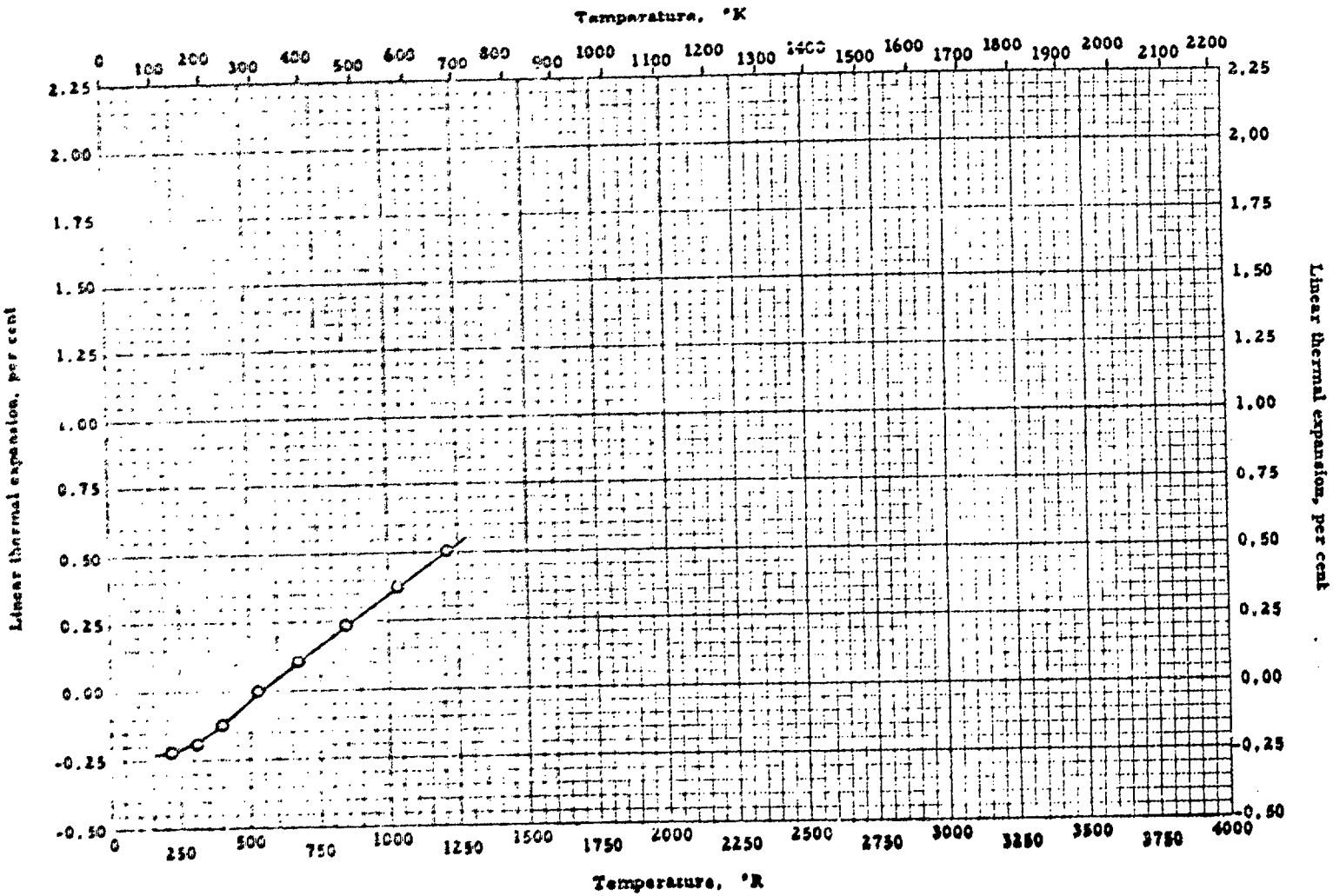
SPECIFIC HEAT -- COBALT OXIDE

WADC TR 58-476 359 59-600

SPECIFIC HEAT -- COBALT OXIDE

REFERENCE INFORMATION

No.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Assayag, G. and Sicarte, H.	54-58	315-555	CoO	Comparative; rate of temp. rise in sample compared with standard under same heating conditions	
□	King, E. G.	57-41	97-554	CoO; 78.61% Co	Guarded sample	Prepared from recrystallized reagent grade cobaltous sulfate heptahydrate
△	Ibid.	57-41	97-554	Co_3O_4	Same as above	Prepared from recrystallized reagent grade cobalt sulfate heptahydrate

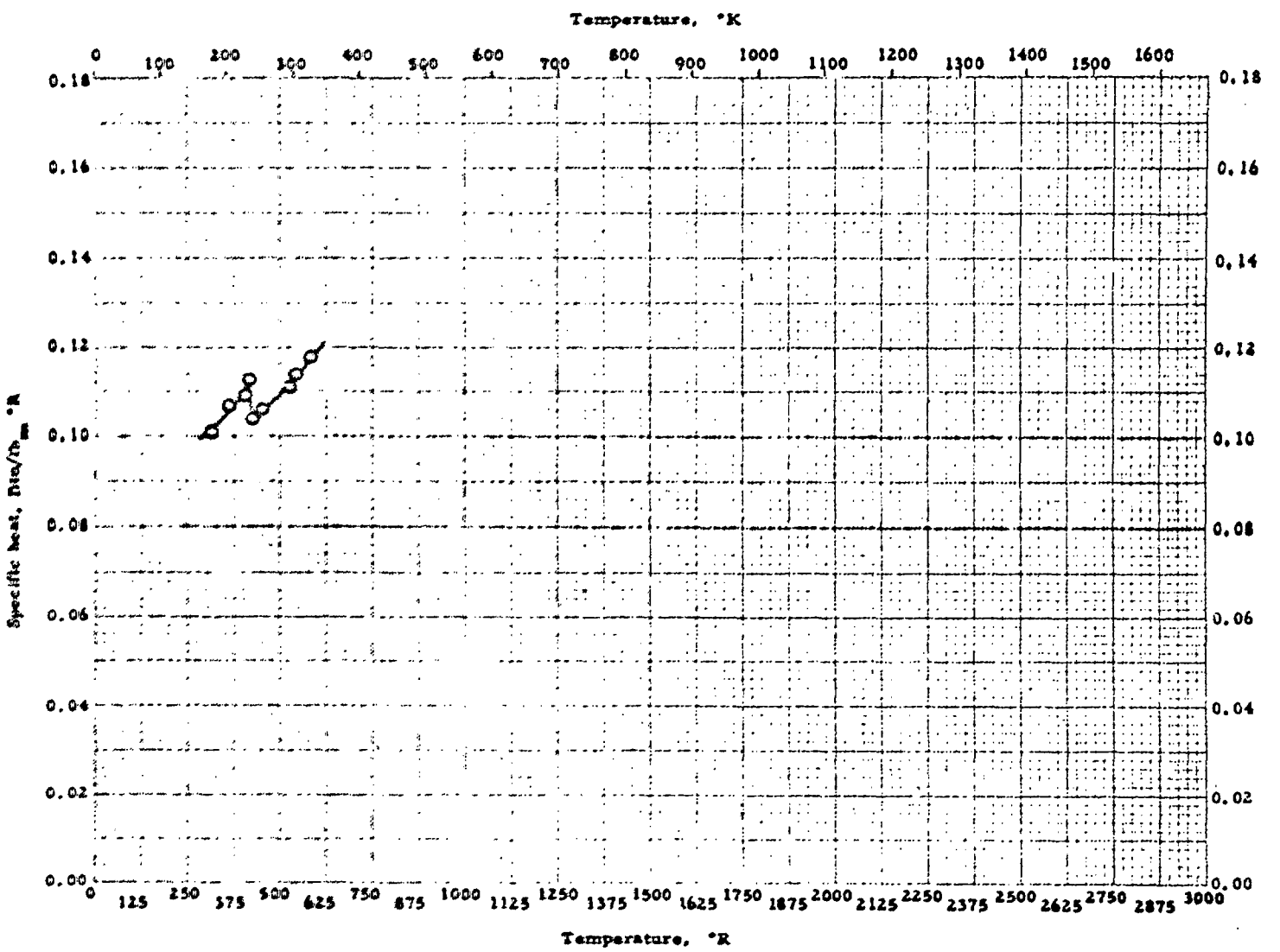


LINEAR THERMAL EXPANSION -- COBALT OXIDE

LINEAR THERMAL EXPANSION -- COBALT OXIDE

REFERENCE INFORMATION

No.	Investigator	Ref.	Range, °F	Material Composition	Test Method	Remarks
O	Foex, M.	48-5	222-1212	CoO	Dilatometer	N_2 atmos.

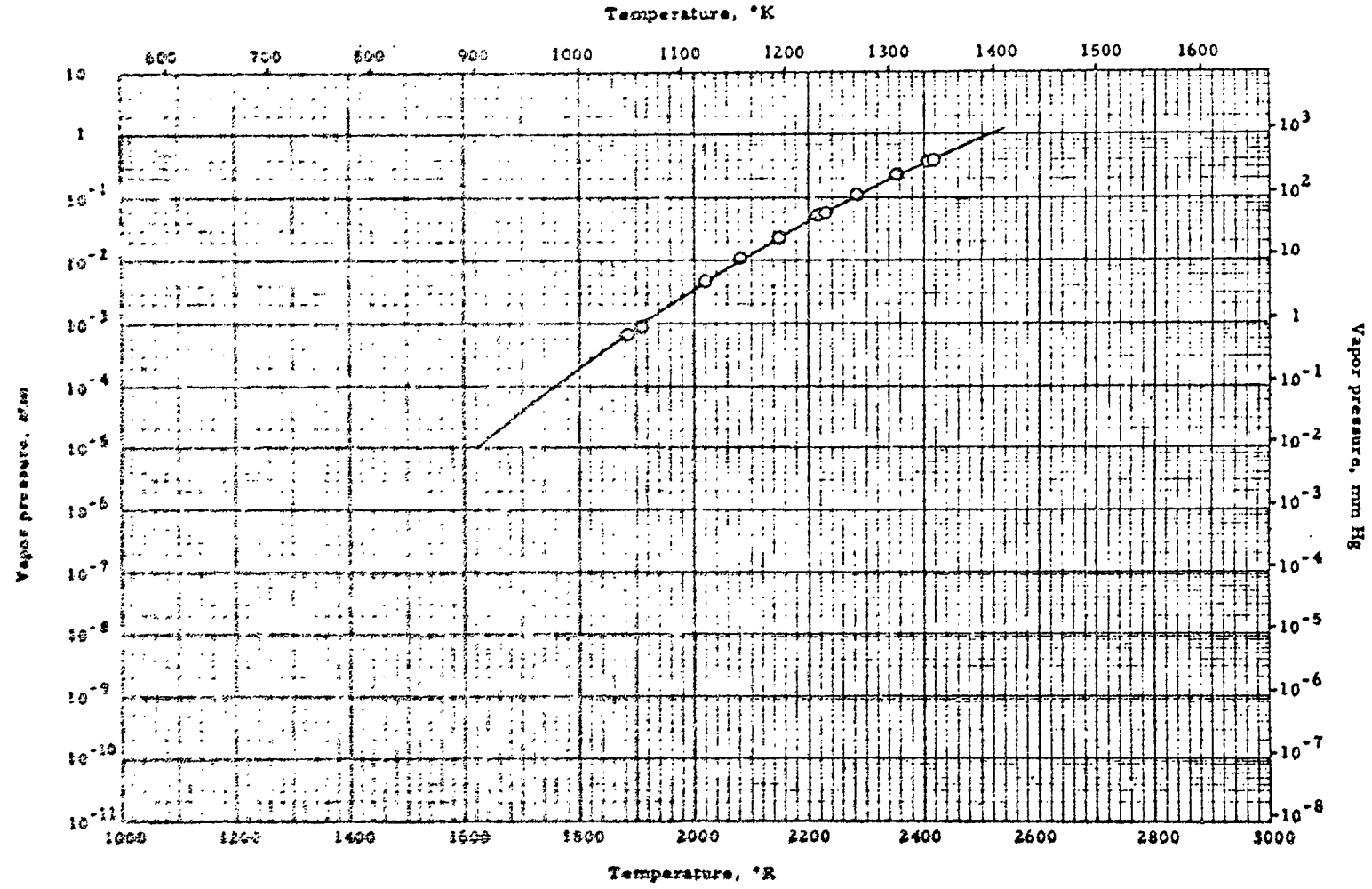


SPECIFIC HEAT -- COPPER OXIDE

SPECIFIC HEAT -- COPPER OXIDE

REFERENCE INFORMATION

	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Aronoyag, C. and Dinette, H.	54-58	325-585	CuO	Comparative; rate of temp. rise in sample compared with standard under same heating conditions	



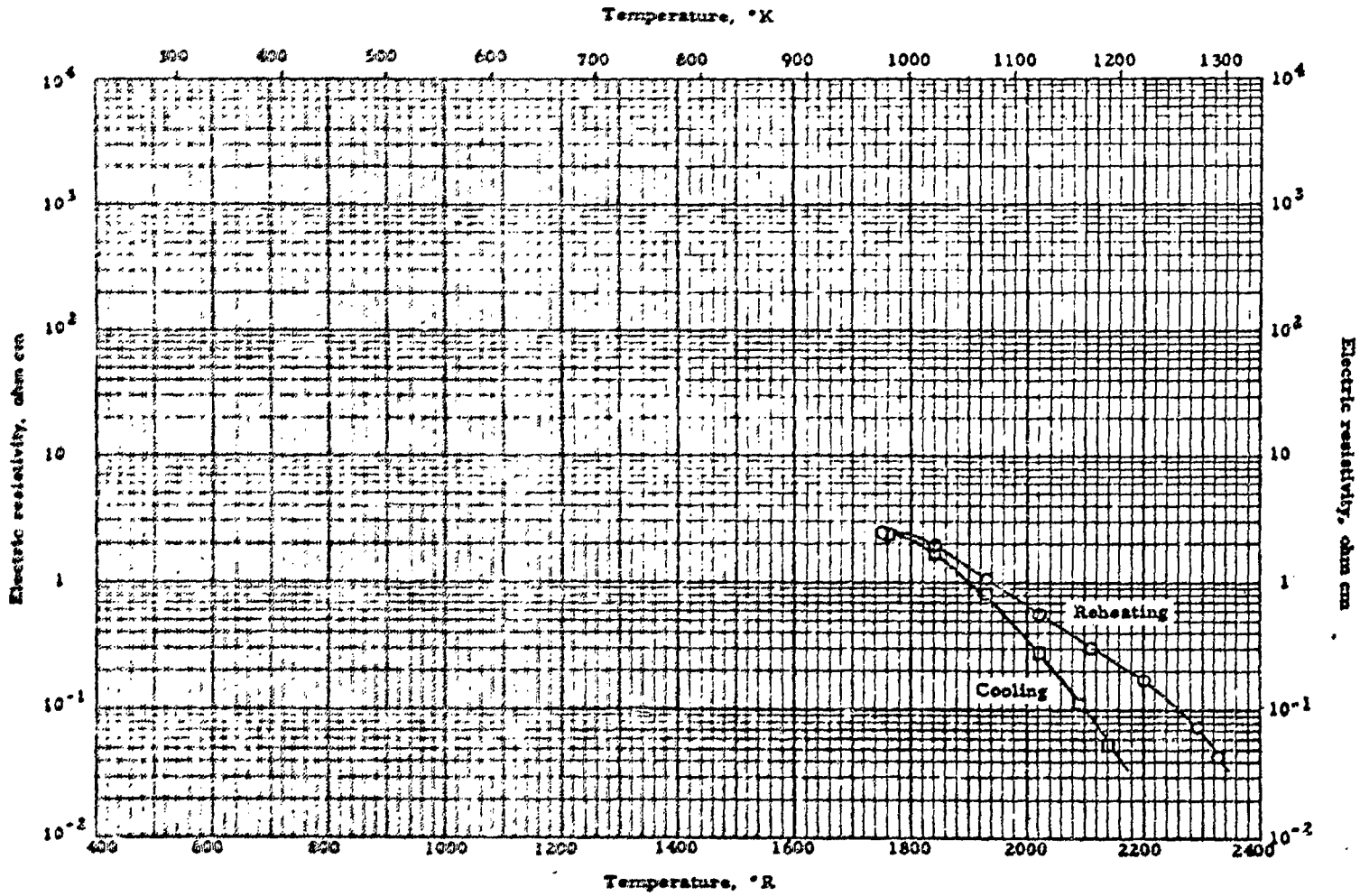
VAPOR PRESSURE -- COPPER OXIDE

VAPOR PRESSURE -- COPPER OXIDE

REFERENCE INFORMATION

	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Assayag, P.	55-63	1825-2416	CuO	McLeod Gauge up to 20mm Hg; Hg manometer above 20mm Hg	

99-1006
VALC TR 64-416 367

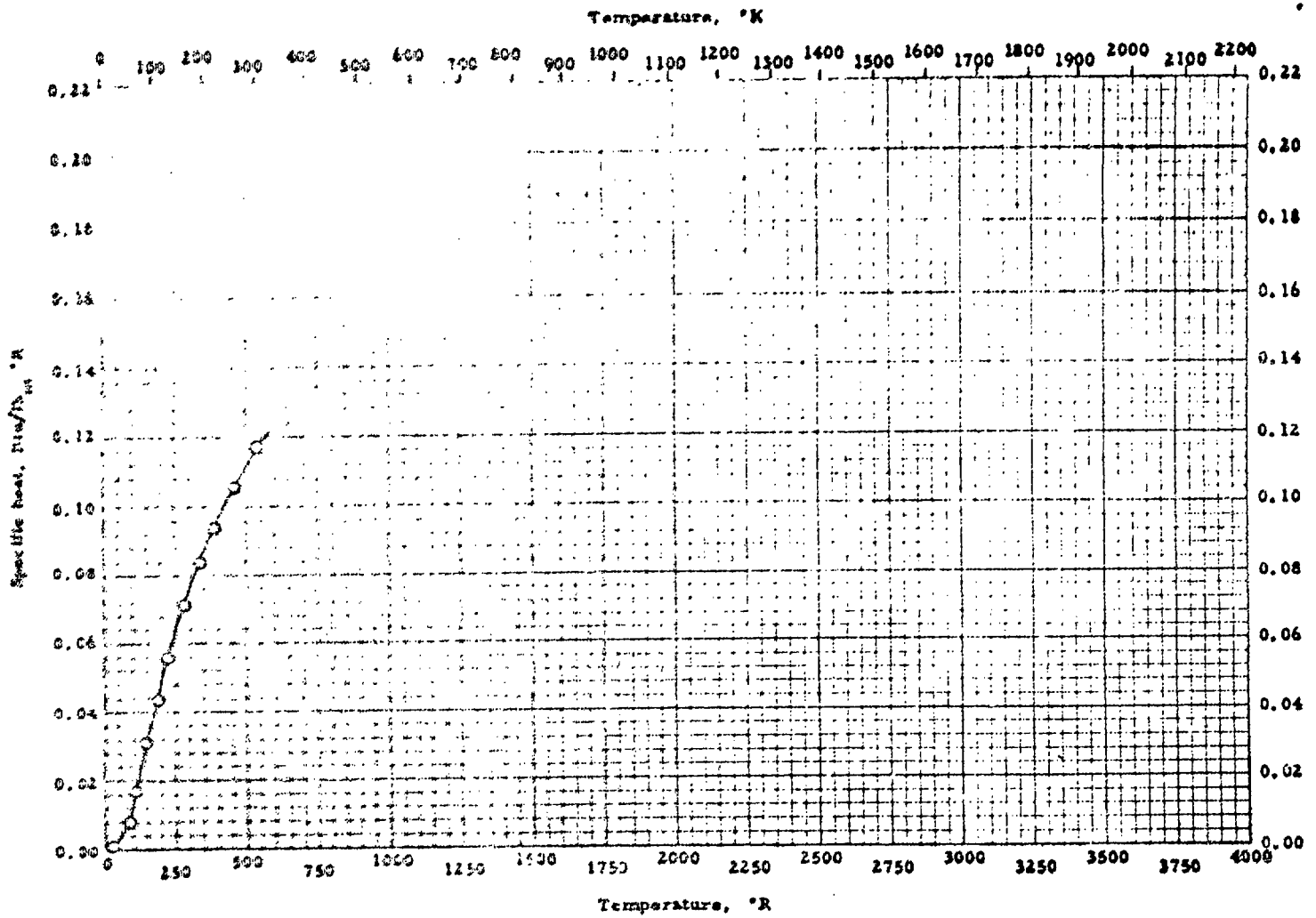


ELECTRIC RESISTIVITY -- COPPER OXIDE

ELECTRIC RESISTIVITY -- COPPER OXIDE

REFERENCE INFORMATION

	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Kats, O. A. and Zyazev, V. L.	57-108	1752-2292	CuO; Russian brand Ch. D. A.	1000 cycles resistance bridge	Reheating
⊡	Ibid.	57-108	1752-2292	Same as above	Same as above	Cooling

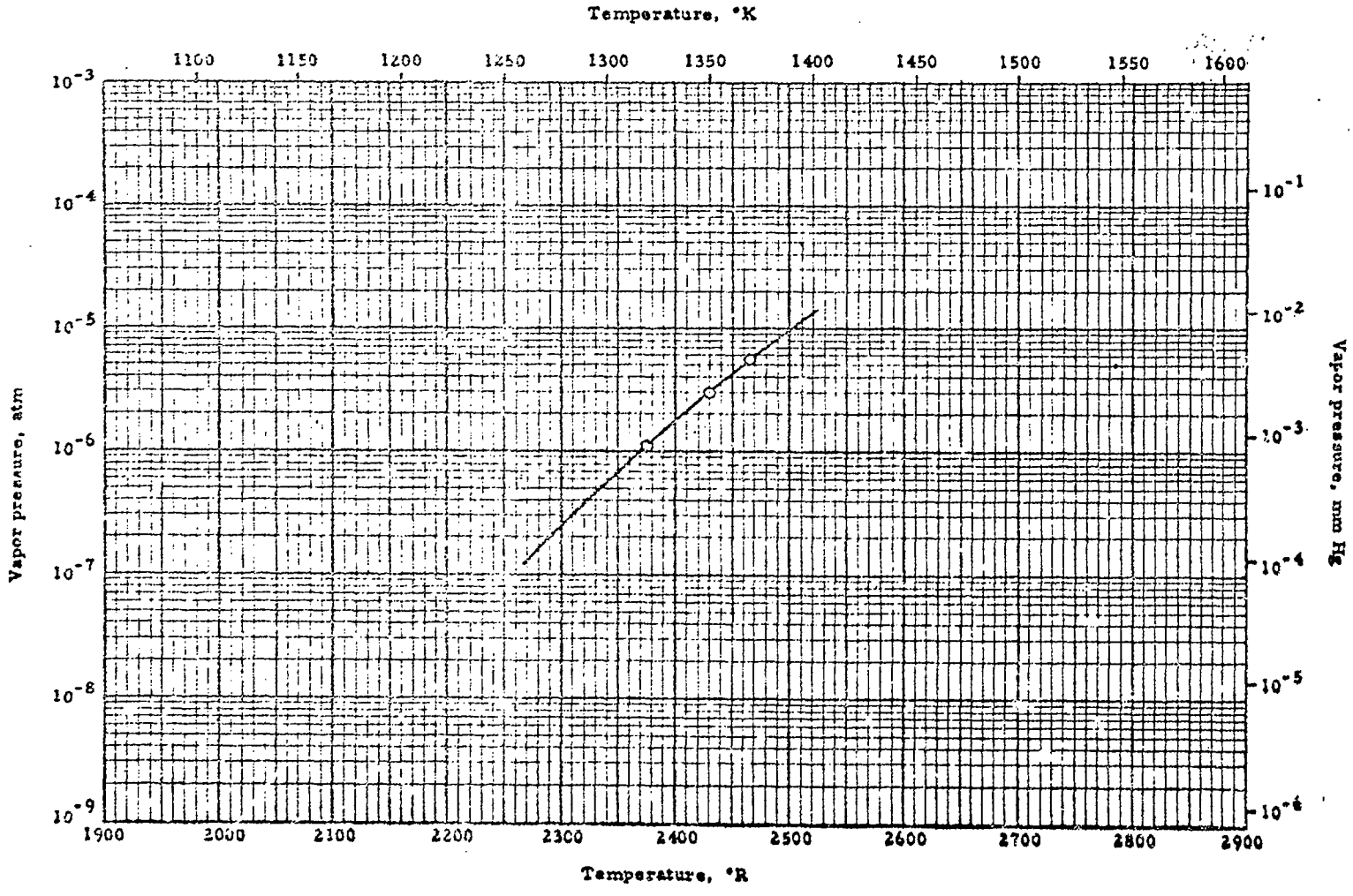


SPECIFIC HEAT -- GALLIUM OXIDE

SPECIFIC HEAT -- GALLIUM OXIDE

REFERENCE INFORMATION

	Investigator	Ref.	Range, °K	Material Composition	Test Method	Remarks
O	Adams Jr., C. C. and Johnston, H. L.	52-57	28-540	92.67% β-Ga_2O_3; 1.16% SiO_2; 0.1% ZnO; 0.05% ea. Fe_2O_3, Al_2O_3; 0.02% SnO_2; 0.01% MgO; 0.008% CuO; 0.001% ea. V_2O_5, MoO_3, PbO, MnO	Guarded sample	Corrected for impurities



VAPOR PRESSURE -- GERMANIUM OXIDE

59-555
WADD TR 59-555
572

VAPOR PRESSURE -- GERMANIUM OXIDE

REFERENCE INFORMATION

	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Shimazaki, E., Matsumoto, N. and Niwa, K.	57-64	2376-2466	99.99% pure GeO_2	Knudsen effusion cell	Auth. notes dissociation of GeO_2 into $GeO + 1/2\ O_2$ in gas phase

PROPERTIES OF IRON OXIDE

MOST PROBABLE VALUES

Property	Brit. Engineering Units	C. G. S. Units
Density, Magnetite . . .	314 lb_m/ft^3	5.03 g/cm^3
Melting Point, Magnetite	3260°R*	1811°K*
Heat of Fusion		
Heat of Vaporization . . .		
Heat of Sublimation . . .		

*Handbook of Chemistry and Physics (Ref. 59-2)

REPORTED VALUES

		lb_m/ft^3	g/cm^3
Density:	○	314	5.03
	□	313	5.01
	△	316	5.06

	°R	°K
Melting Point:		

	Btu/lb_m	cal/g
Heat of Fusion:		

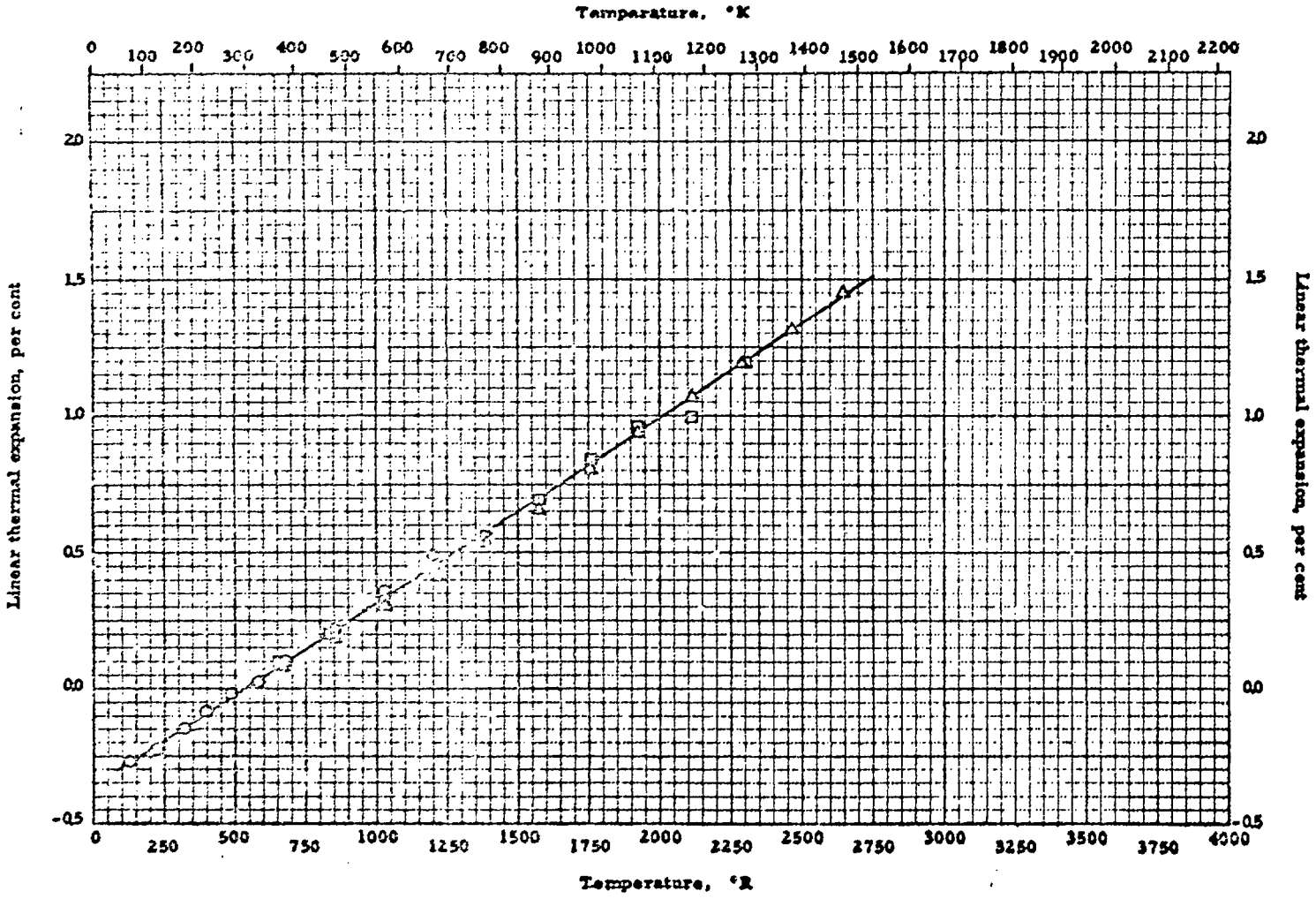
	Btu/lb_m	cal/g
Heat of Vaporization:		

	Btu/lb_m	cal/g
Heat of Sublimation:		

PROPERTIES OF IRON OXIDE

REFERENCE INFORMATION

	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Economos, G.	55-145	Room	Magnetite, Fe_3O_4	ρ: displacement in acetone	Prepared from high purity iron oxide heated 5 hrs. at 800°C in platinum crucibles; firing atmos. of CO-CO_2
□	Ibid.	55-145	Room	Same as above	ρ: same as above	Same as above with firing atmos. of CO_2
△	Ibid.	55-145	Room	Same as above	ρ: same as above	Same as above with firing atmos. of He

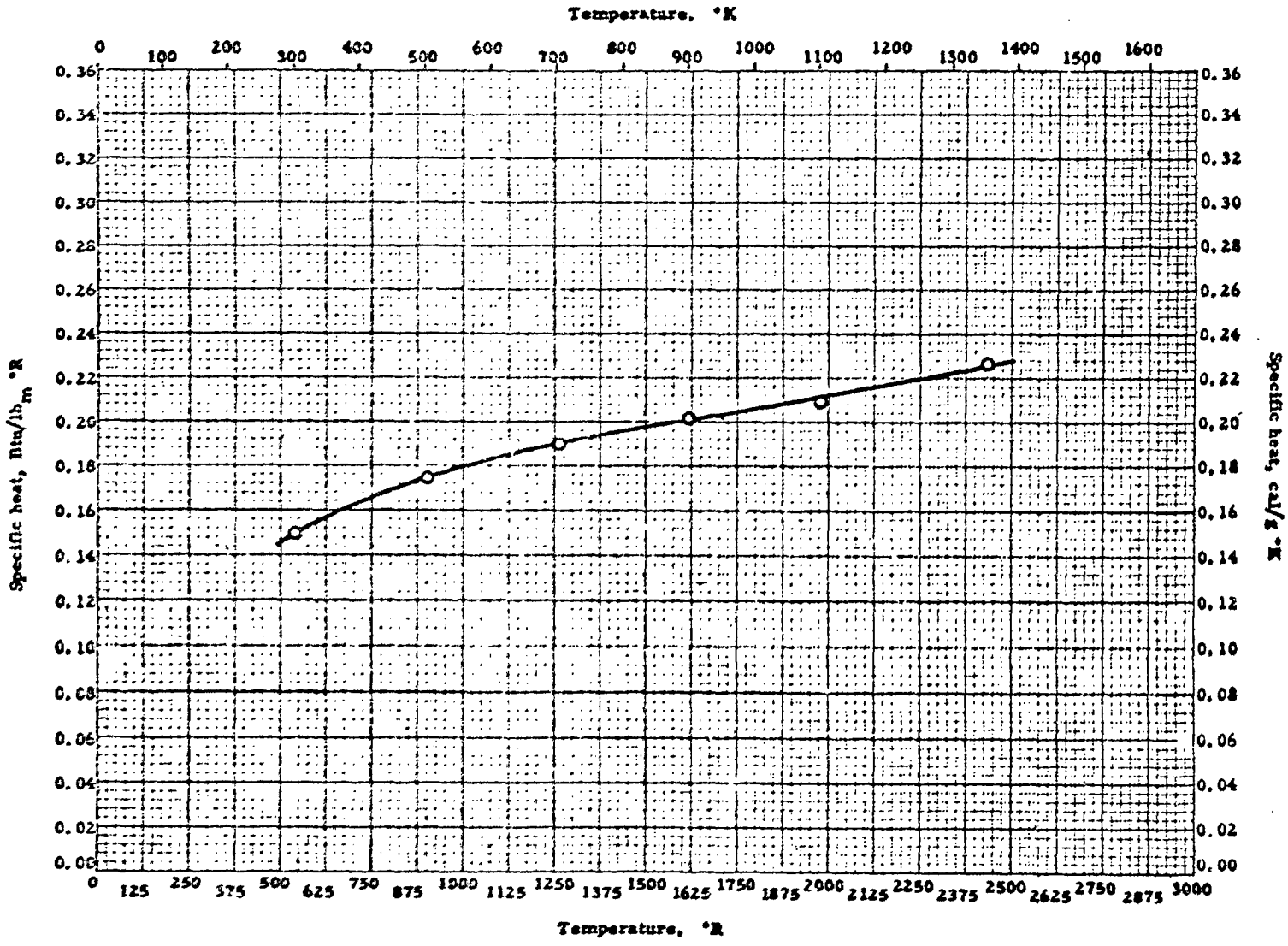


LINEAR THERMAL EXPANSION -- IRON OXIDE

LINEAR THERMAL EXPANSION -- IRON OXIDE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Foex, M.	43-5	132-1212	FeO	Dilatometer	N_2 atmos.
□	Rigby, G.R. Lovell, G.H. Green, A.T.	46-8	672-2472	90% FeO; ρ = 346 lb_m/ft^3	Not given	
△	Ibid.	46-8	672-2652	Fe_2O_3; ρ = 326 lb_m/ft^3	Same as above	

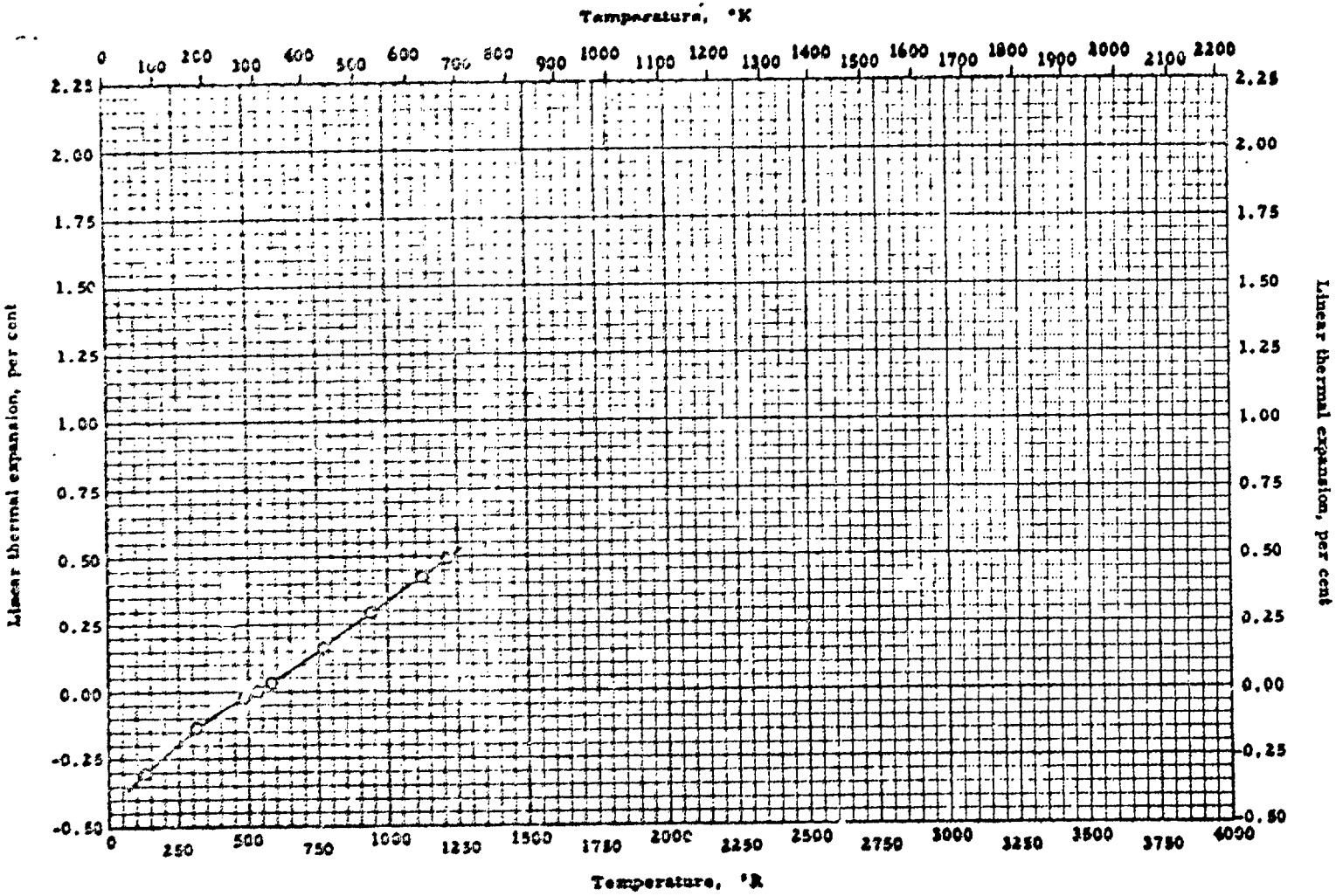


SPECIFIC HEAT -- MANGANESE OXIDE

SPECIFIC HEAT -- MANGANESE OXIDE

REFERENCE INFORMATION

	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Orr, R. L.	54-135	540-2430	Mn_2O_3, manganese sesquioxide; 69.64% Mn; 10.13% O	Drop method	c_p calc. from $C_p\left(\frac{cal}{g\text{-mole }°K}\right) = 24.73 + 8.38T - 3.23 \times 10^5 T^{-2}$ (T in °K); mean deviation of enthalpy points from this eq. is <0.2%.



LINEAR THERMAL EXPANSION -- MANGANESE OXIDE

LINEAR THERMAL EXPANSION -- MANGANESE OXIDE

REFERENCE INFORMATION

Curve	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Foex, M.	48-5	132-1212	MnO	Dilatometer	N_2 atmos.

PROPERTIES OF MOLYBDENUM OXIDE

MOST PROBABLE VALUES

Property	Brit. Engineering Units	C. G. S. Units
Density.	281 lb_m/ft^3 *	4.5 g/cm^3 *
Melting Point	1923 °R	1068°K
Heat of Fusion	157 Btu/lb_m	87 cal/g
Heat of Vaporization. . .		
Heat of Sublimation . . .	$319_{1530°R}$ Btu/lb_m	$177_{850°K}$ cal/g

* Handbook of Chemistry and Physics (Ref. 57-60)

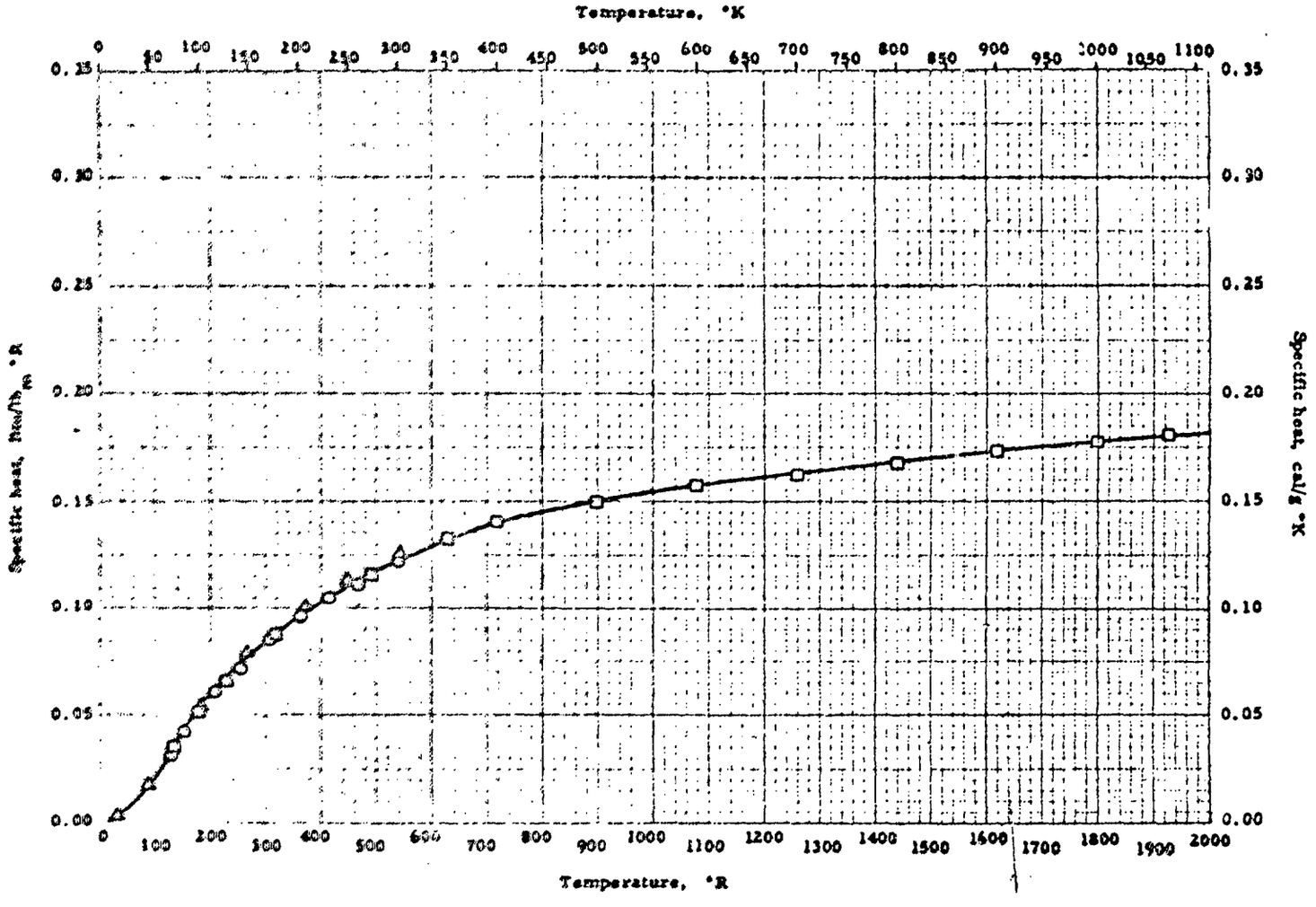
REPORTED VALUES

Density:		lb_m/ft^3	g/cm^3
Melting Point:		°R	°K
	❑	1923.1	1068.4
Heat of Fusion:		Btu/lb_m	cal/g
	○	156.8	87.1
Heat of Vaporization:		Btu/lb_m	cal/g
Heat of Sublimation:		Btu/lb_m	cal/g
	△	$796.5_{1671°R}$	$442.5_{928°K}$
	◇	$335_{1530°R \pm 6}$	$184_{850°K \pm 3}$
	▽	$293_{1530°R \pm 5}$	$163_{850°K \pm 3}$
	○	$264_{1530°R \pm 9}$	$147_{850°K \pm 5}$
	○	$319_{1530°R}$	$177_{850°K}$

PROPERTIES OF MOLYBDENUM OXIDE

REFERENCE INFORMATION

	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
	[illegible], L. A. and [illegible], W. C.	21-1	1923	MoO_3; Eb. 8 ± 0.07% Mo; 0.0°1% insol. in NH_3; 0.03% non-volatile with HCl at 450°C; spectroscopic trace of heavy metals and alkali metals	Δh_f; drop method; ice calorimeter	
D	[illegible]	21-1	1923	Same as above	MP; not given	
A	[illegible], K.	41-3	1671	Not given	Δh_s; from vapor pressure data	Vapor pressure measured 1635-1707°R
B	[illegible], J., [illegible], M. C. and [illegible], W. A.	MD-3	1530	Not given; vapor phase Mo_3O_9	Δh_s; from vapor pressure data by Knudsen cell with mass spectrometer; Pt, Pt-Rh thermocouple	Vapor pressure measured 1440-1600°R. Temp. measured ± 10°C
V	[illegible]	MD-3	1530	Not given; vapor phase Mo_4O_{12}	Δh_s; same as above	Same as above
C	[illegible]	MD-3	1530	Not given; vapor phase Mo_5O_{15}	Δh_s; same as above	Same as above
C	[illegible]	MD-3	1530	Not given; vapor phase 66% Mo_3O_9; 29% Mo_4O_{12}; 5% Mo_5O_{15}	Δh_s; computed from Δh_s for given vapor species	Vapor composition determined using mass-spectrometer

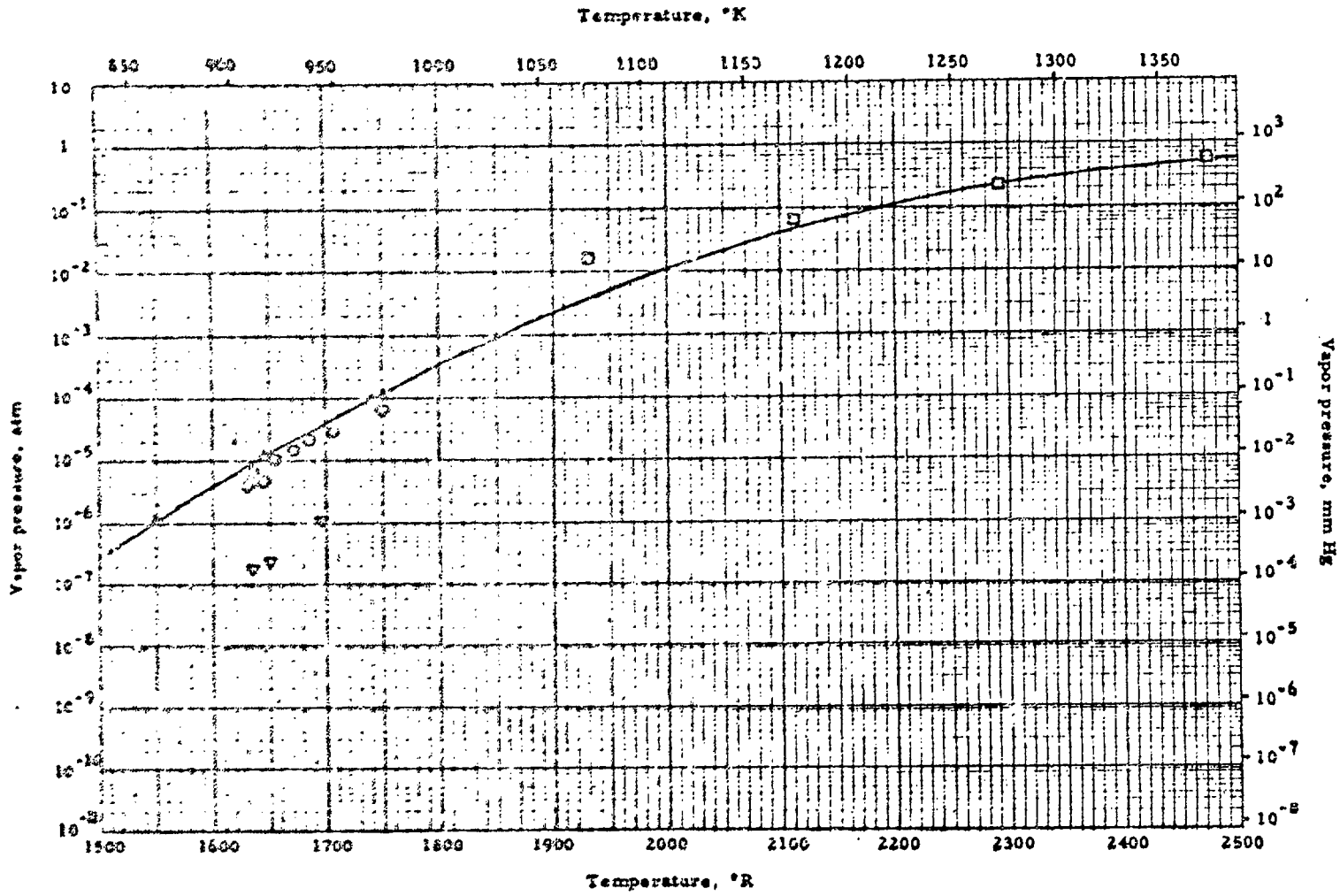


SPECIFIC HEAT -- MOLYBDENUM OXIDE

SPECIFIC HEAT -- MOLYBDENUM OXIDE

REFERENCE INFORMATION

Curve No.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Zavitz, H., Brinkley, F. J. and Dewitt, B. J.	43-3	126-538	99.9% MoO_3	Guarded sample	Small transparent rhombic crystals
□	Craigwave, L. A. and Hayes, P. E.	53-1	127-2340	MoO_3. 66.8 ± 0.07% assayed Mo; 0.001% insoluble in NH_3; 0.005% non-volatile with HCl at 450°C; spectroscopic trace of heavy metals and alkali metals	Drop method; ice calorimeter	Extrapolation to low temps. by method of Debye and Einstein
△	Smith, D. F. Brown, D. et al.	56-150	36-540	MoC_3, C.P. grade	Low temperature adiabatic calorimeter	

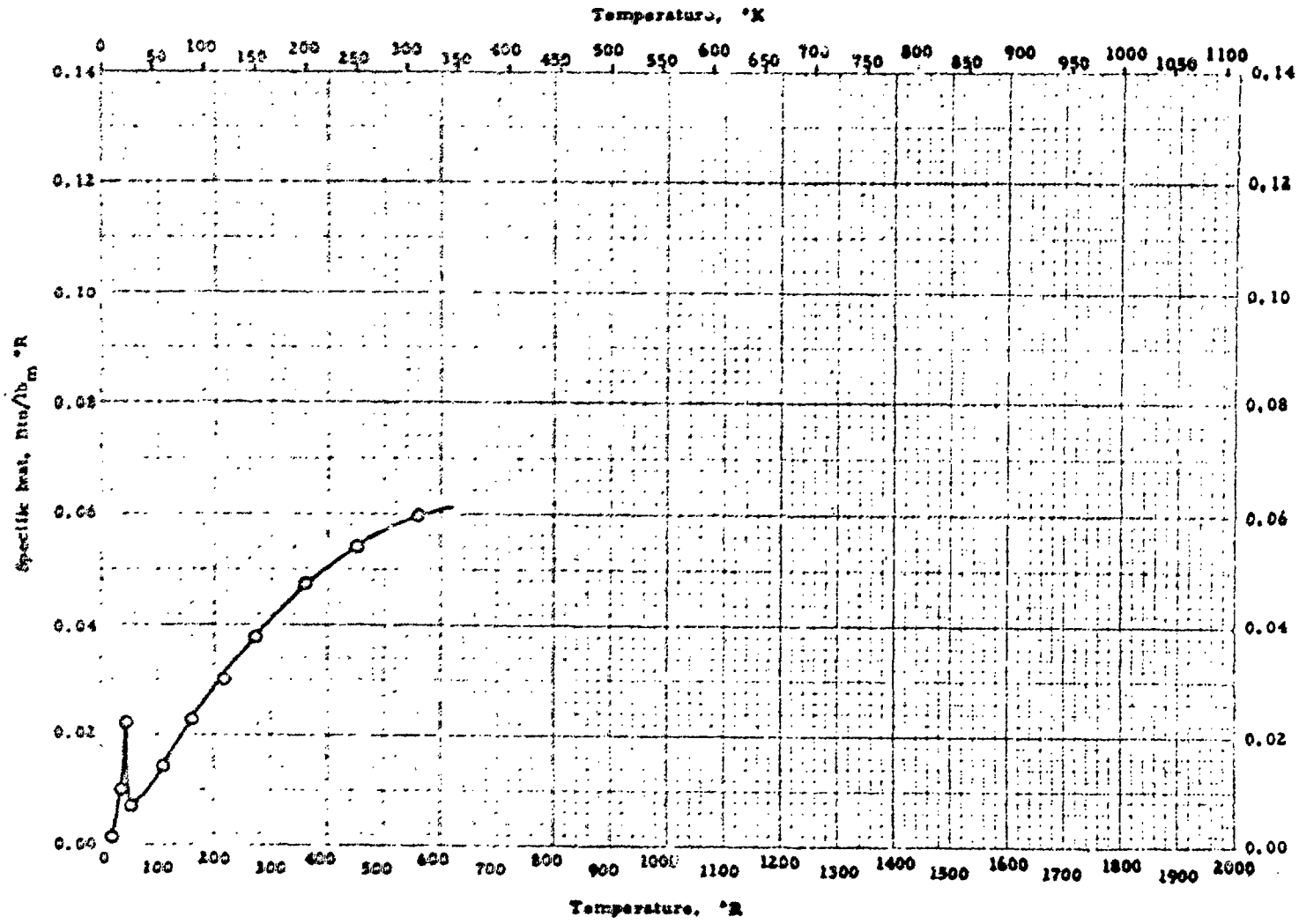


VAPOR PRESSURE -- MOLYBDENUM OXIDE

VAPOR PRESSURE -- MOLYBDENUM OXIDE

REFERENCE INFORMATION

	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Ueno, K.	41-5	1635-1707	MoO_3	Not given here; refers to others	
□	Zelikman, A. N., Cornetti, N. M. and Prosenkova, T. E.	54-4	1932-2472	Chemically "pure" MoO_3	Boiling points at fixed pressures	
△	Barbuetta, J., Ingram, M. G. and Campos, W. A.	ND-3	1550-1751	Mo_3O_9 vapor over MoO_3	Knudsen effusion cell, mass spectrometer	
◇	Ibid.	ND-3	1629-1751	Mo_4O_{12} vapor over MoO_3	Same as above	
▽	Ibid.	ND-3	1634-1697	Mo_5O_{15} vapor over MoO_3	Same as above	

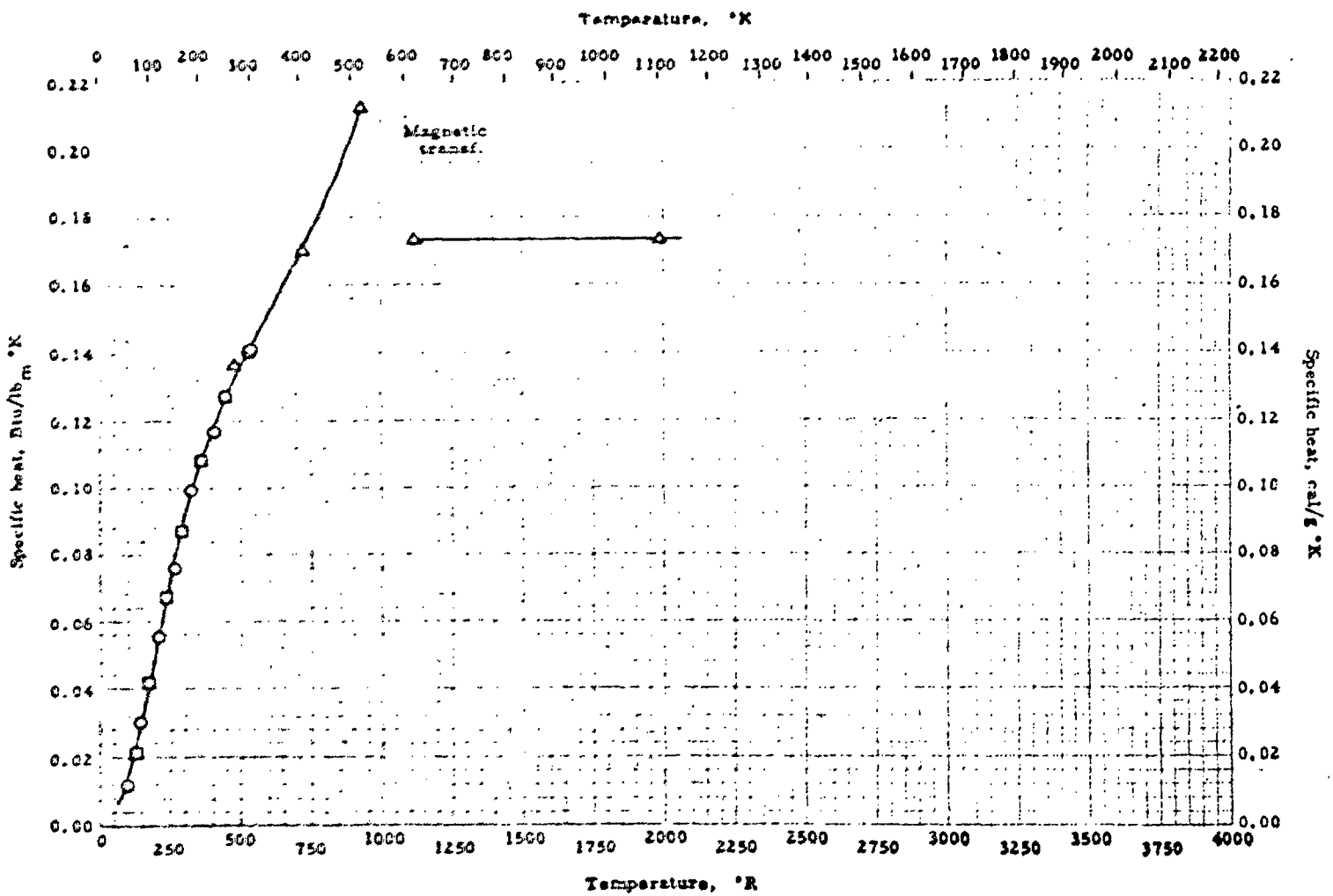


SPECIFIC HEAT -- NEPTUNIUM OXIDE

SPECIFIC HEAT -- NEPTUNIUM OXIDE

REFERENCE INFORMATION

Sym bol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Westrum, Jr. E. F., Hatcher, J. B. and Osborne, D. W.	53-58 also 50-21	20-558	99.94% pure NpO_2; <0.1% total Cr, Fe, Ca	Guarded sample	Np^{237} prepared by U^{238} (n, 2n) U^{237} β^- Np^{237} Hydroxide precipitated from acid solution and ignited to constant wt. in air in Pt boat at 700°C

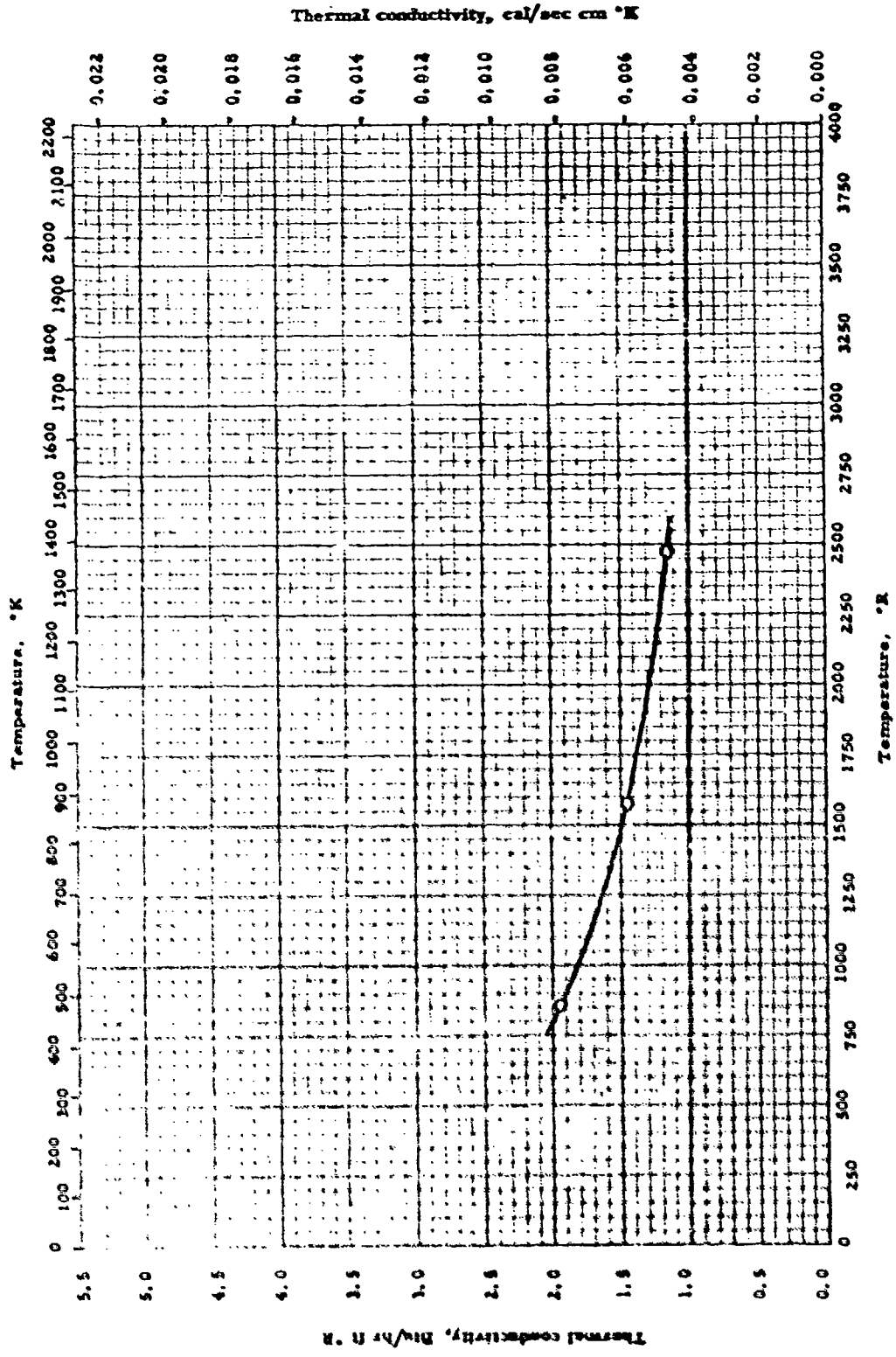


SPECIFIC HEAT -- NICKEL OXIDE (NiO)

SPECIFIC HEAT -- NICKEL OXIDE (NiO)

REFERENCE INFORMATION

	Investigator	Ref.	Range, °K	Material Composition	Test Method	Remarks
O	King, E. G.	57-41	98-533	99.96% NiO; 0.05% CoO; 0.02% acid insoluble; 0.01% Na_2O	Guarded sample	Prepared from reagent grade hexahydrates of nickelous nitrate and nickelous sulfate
□	Seltz, H., DeWitt, B. J. and McDonald, H. J.	40-9	123-556	<0.2% impurities	Guarded sample	Transparent cubic crystals
△	Tomlinson, J. R., Domash, L. et al.	55-38	668-1994	78.51 - 78.54% Ni; 0.01 - 0.1% Si	Drop method; ice calorimeter	Prepared by decomposing $Ni(NO_3)_2 \cdot 6H_2O$ and heating 8 hr. at 1000°C

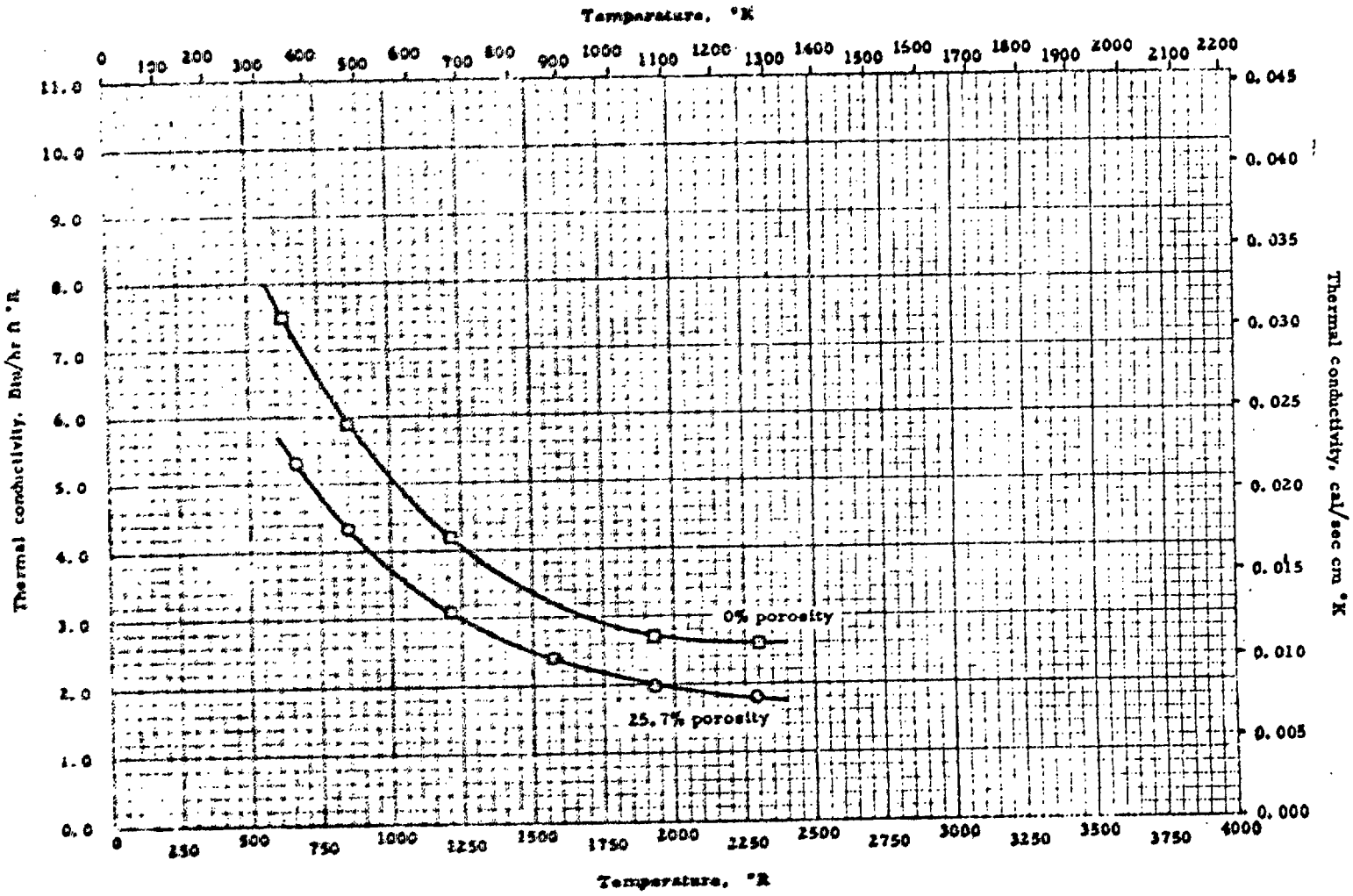


THERMAL CONDUCTIVITY -- NICKEL OXIDE + MAGNESIUM OXIDE

THERMAL CONDUCTIVITY -- NICKEL OXIDE + MAGNESIUM OXIDE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Norton, F. H., Kingery, W. D. et al.	54-144	850-2480	50% NiO : 50% MgO	Ellipsoidal envelope	Data were corrected by auth. to zero porosity



THERMAL CONDUCTIVITY - NICKEL OXIDE

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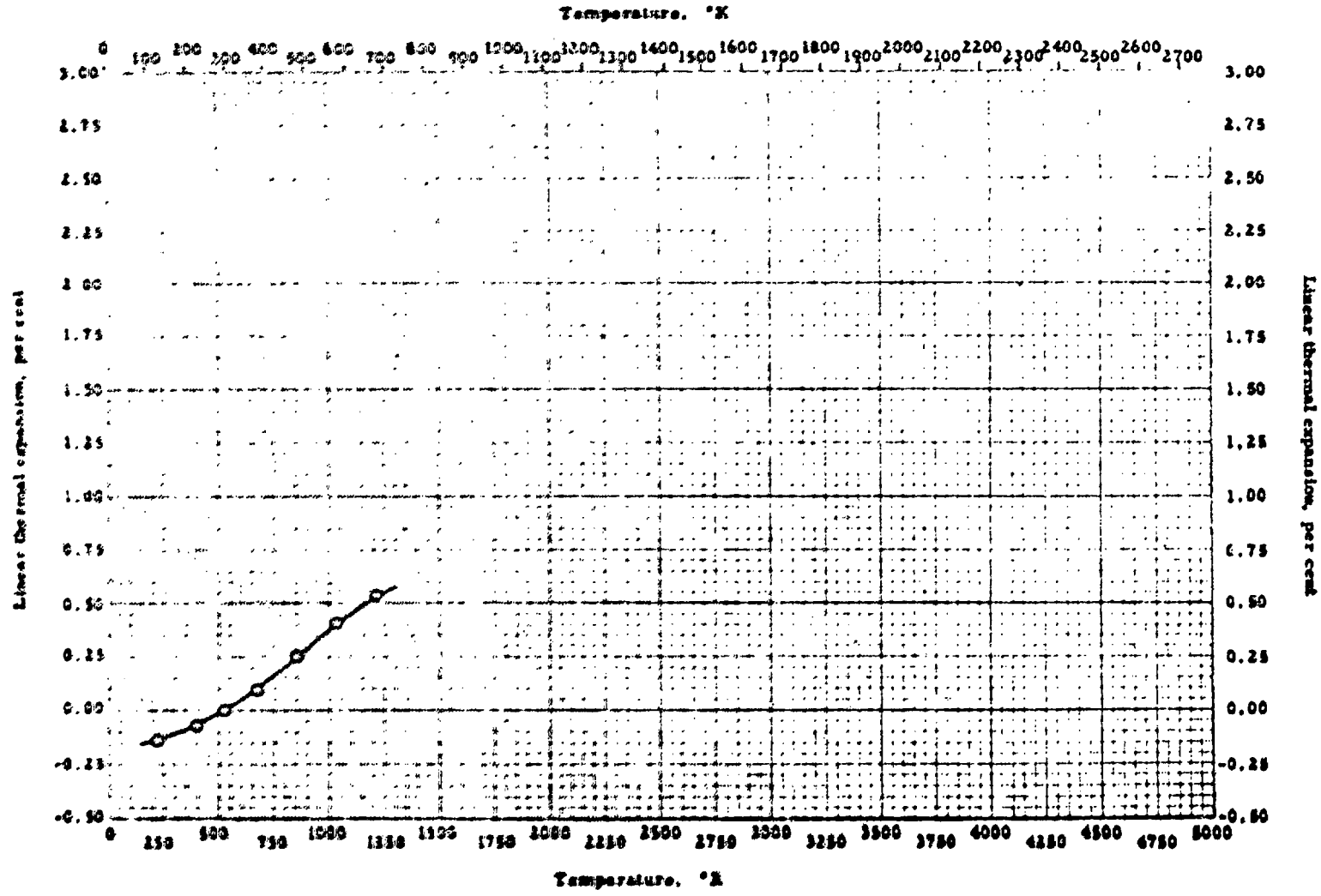
THERMAL CONDUCTIVITY -- NICKEL OXIDE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Kingery, W.D. and Francl, J.	54-1	672-2292	ρ = 315 lb_m/ft^3; porosity = 25.7%	Comparative, rods	Prepared by calcining c.p. NiO at 1000°C, pressing, and firing at 1500°C in oxidizing atmos.
□	Morton, F.H., Kingery, W.D. et al.	54-144	630-2300	NiO	Ellipsoidal envelope	Data were corrected by author to zero porosity



LINEAR THERMAL EXPANSION -- NICKEL OXIDE

LINEAR THERMAL EXPANSION -- NICKEL OXIDE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Foex, M.	48-5	223-1212	NiO	Dilatometer	N_2 atmos.

Symbol	Nominal Composition, % Nb_2O_5	Al_2O_3	BeO	MgO	TiO_2	ZrO_2	Melting Point °R	°K
○	88.78	11.22					3093	1718
	84.07	15.93					3111	1728
	72.59	27.48					3192	1773
	56.88	43.12					3165	1758
□	97.52		2.48				2958	1643
	96.72		3.28				2958	1643
	95.16		4.84				3084	1713
	90.77		9.23				3093	1718
	83.01		16.89				3084	1713
	76.63		23.37				3102	1723
	71.09		28.91				3102	1723
△	96.35			3.65			3075	1708
	95.19			4.81			3057	1698
	92.95			7.05			3075	1708
	86.83			13.17			3165	1758
	69.66			30.34			3237	1798
	68.73			31.27			3273	1818
	62.24			37.76			3282	1823
◇	89.27				10.73		3165	1758
	86.19				13.81		3138	1743
	80.62				19.38		3093	1718
	67.53				32.47		3147	1748
	50.98				49.02		3183	1768
▽	83.22					16.78	3075	1708
	78.81					21.19	3075	1708
	71.26					28.74	3030	1683
	55.35					44.65	3111	1728

MELTING POINT -- NIOBIUM OXIDE + OTHER OXIDES

MELTING POINT -- NIOBIUM OXIDE + OTHER OXIDES

REFERENCE INFORMATION

Sym	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Durbin, E. A. and Harman, C. G.	52-31	3093-3210	Nb_2O_5 + Al_2O_3 system	MP: observed fusion temp. during sintering	Prepared from 99.9% pure Nb_2O_5 and 99.5% pure Al_2O_3
□	Ibid.	52-31	2958-3102	Nb_2O_5 + BeO system	MP: same as above	Prepared from 99.9% pure Nb_2O_5 and 99.5% pure BeO
△	Ibid.	52-31	3057-3282	Nb_2O_5 + MgO system	MP: same as above	Prepared from 99.9% pure Nb_2O_5 and 99.5% pure MgO
◇	Ibid.	52-31	3093-3183	Nb_2O_5 + TiO system	MP: same as above	Prepared from 99.9% pure Nb_2O_5 and 99.5% pure TiO
▽	Ibid.	52-31	3030-3228	Nb_2O_5 + ZrO_2 system	MP: same as above	Prepared from 99.9% pure Nb_2O_5 and 99.5% pure ZrO_2

PROPERTIES OF NIOBIUM OXIDE

MOST PROBABLE VALUES

Property	Brit. Engineering Units	C. G. S. Units
Density.	279 lb_m/ft^3 *	4.47 g/cm^3 *
Melting Point	3210°R	1785°K
Heat of Fusion	167 Btu/lb_m	93 cal/g
Heat of Vaporization. . .		
Heat of Sublimation . . .		

* Handbook Chemistry and Physics (Ref. 59-2)

REPORTED VALUES

Density: lb_m/ft^3 g/cm^3

Melting Point:

	°R	°K
○	3084	1713
□	3213 ± 9	1785 ± 5
△	3167	1759

Heat of Fusion:

	Btu/lb_m	cal/g
□	166.5	92.5

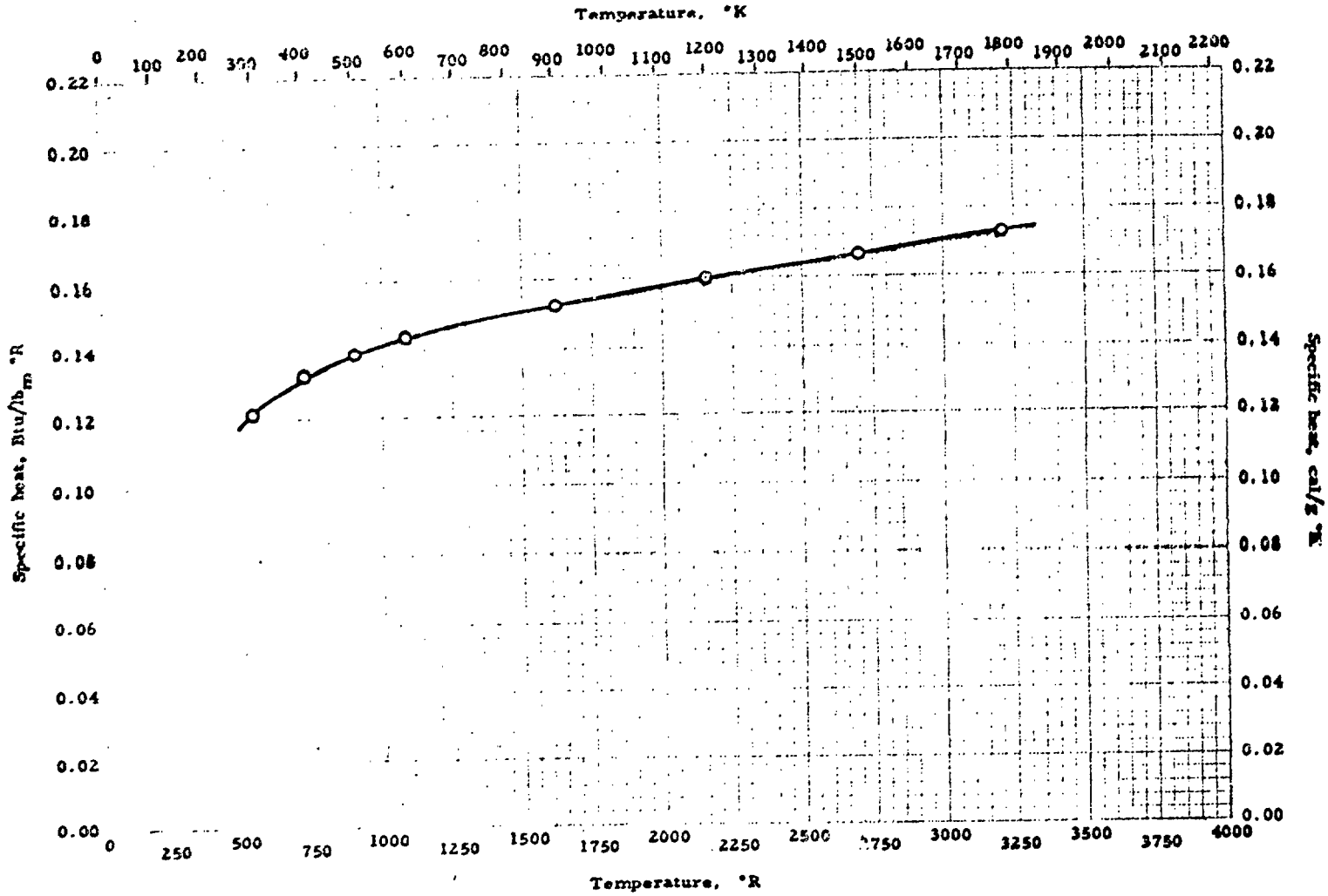
Heat of Vaporization: Btu/lb_m cal/g

Heat of Sublimation: Btu/lb_m cal/g

PROPERTIES OF NIOBIUM OXIDE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Durbin, E.A. and Harman, C.G.	52-31	3084	99.9% Nb_2O_5	MP: meas. approx. fusion temp. during sintering	
□	Orr, R.L.	53-57	3213	Nb_2O_5. 0.03% Si; <0.05% Mg; <0.01% Ti	MP: visual observation; calibrated Pt-Rh thermocouple Δh_f: from enthalpy data above and below MP by drop method into copper block calorimeter	Heated to 1050°C before testing. Premelting observed 1750-1785°K
△	Reisman, A. and Holtzberg, F.	55-146	3167	Nb_2O_5	MP: thermal analysis	Melts congruently

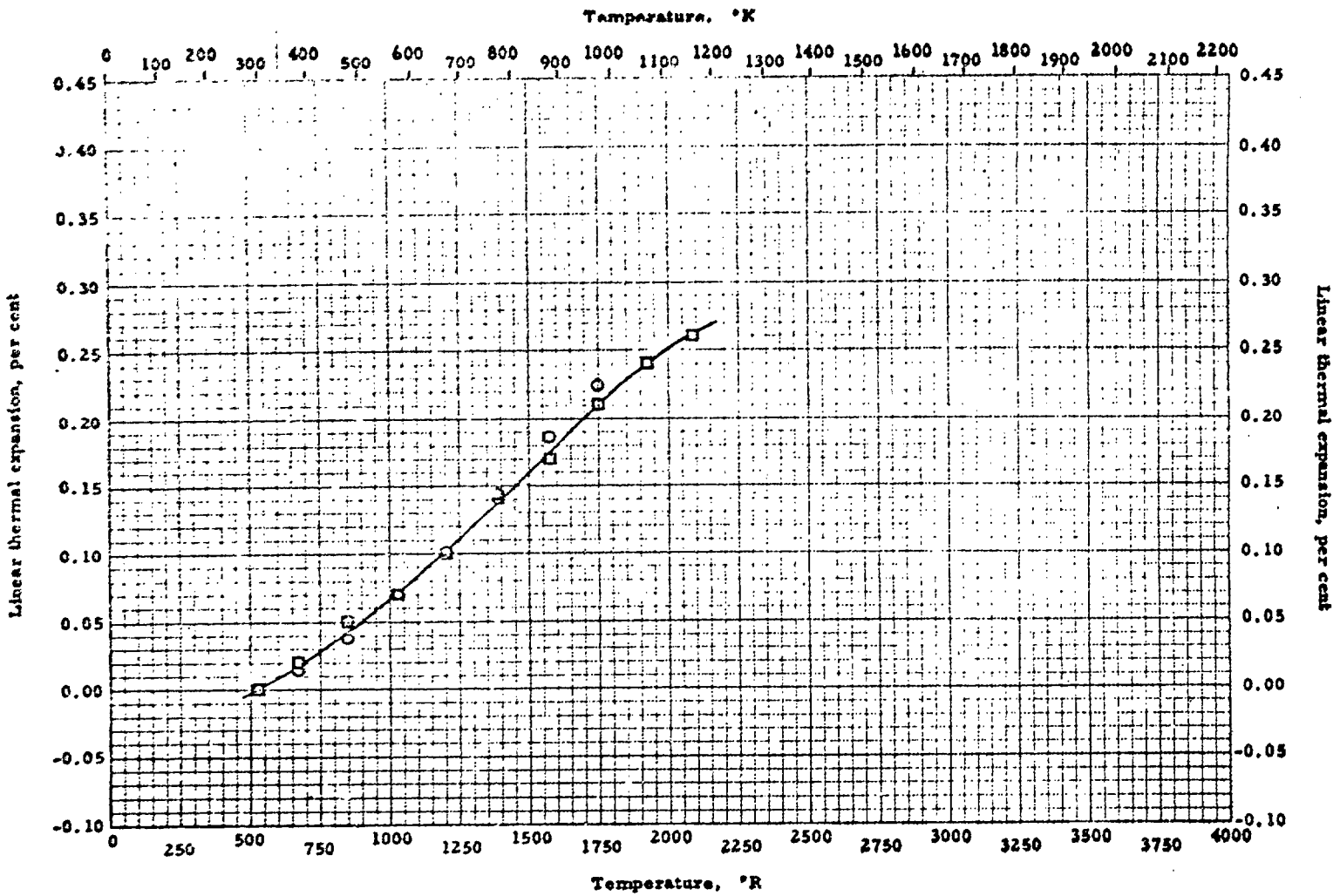


SPECIFIC HEAT -- NIOBIUM OXIDE (Nb_2O_5)

SPECIFIC HEAT -- NIOBIUM OXIDE (Nb_2O_5)

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Orr, R. L.	53-57	686-3257	<0.05% Mg; 0.03% Si; <0.01% Ti	Drop method; copper block calorimeter	Heated to 1050°C before testing

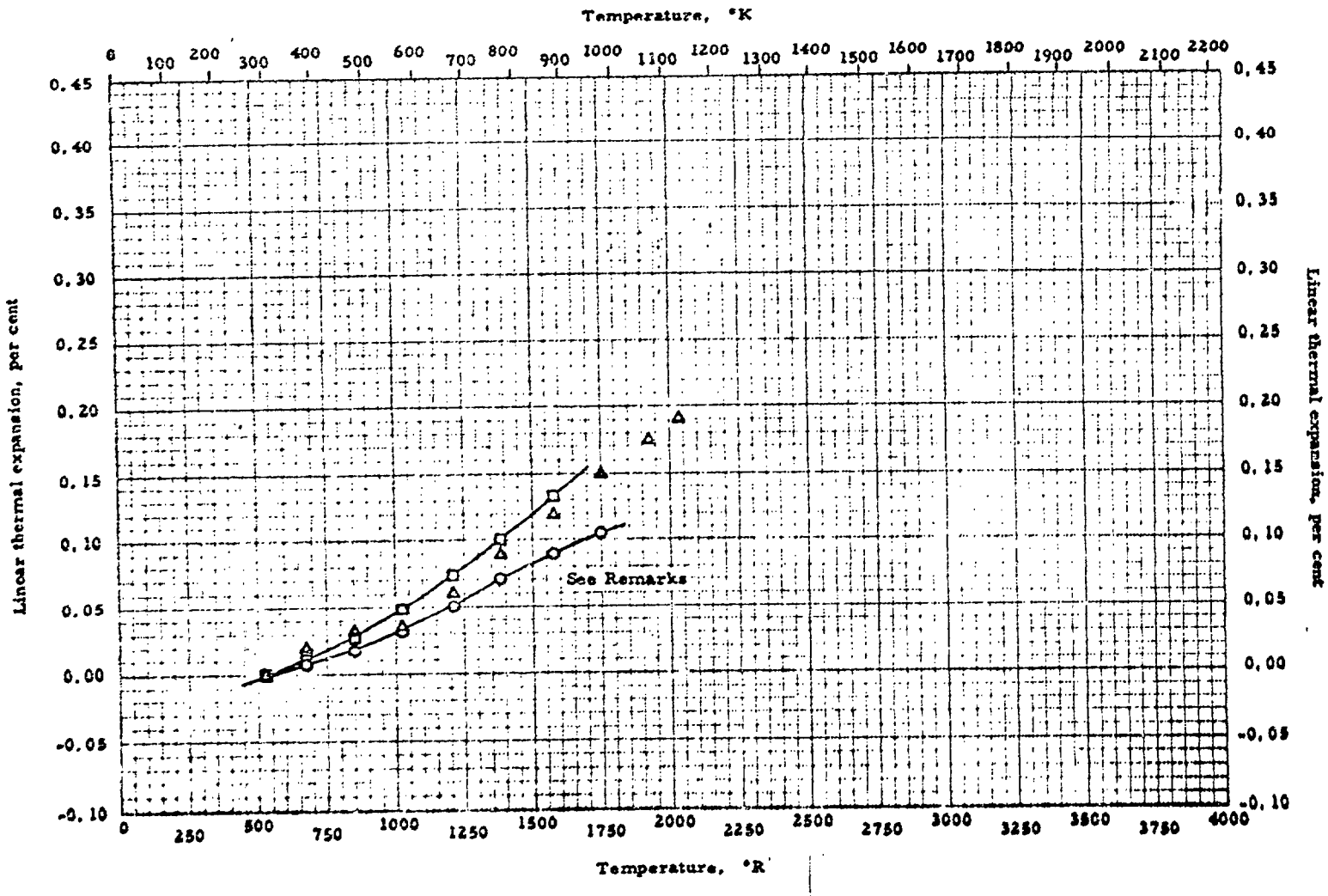


LINEAR THERMAL EXPANSION -- NIOBIUM OXIDE · ALUMINUM OXIDE

LINEAR THERMAL EXPANSION -- NIOBIUM OXIDE · ALUMINUM OXIDE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Durbin, E. A., Wagner, H. E. and Harman, C. G.	52-34	528-1752	~72.3% Nb_2O_5; 27.7% Al_2O_3; prepared from c.p. raw materials (major impurity: Ta_2O_5	Interferometer	Calcined 2 hr. at 1200°C; fired at 1480°C ($Al_2O_3 \cdot Nb_2O_5$)
□	Durbin, E. A. and Harman, C. G.	52-31	528-2094	72.3% Nb_2O_5; 27.7% Al_2O_3	Interferometer	Fired 2 hr. at 1450°C; cooled in 24 hr. ($Al_2O_3 \cdot Nb_2O_5$)

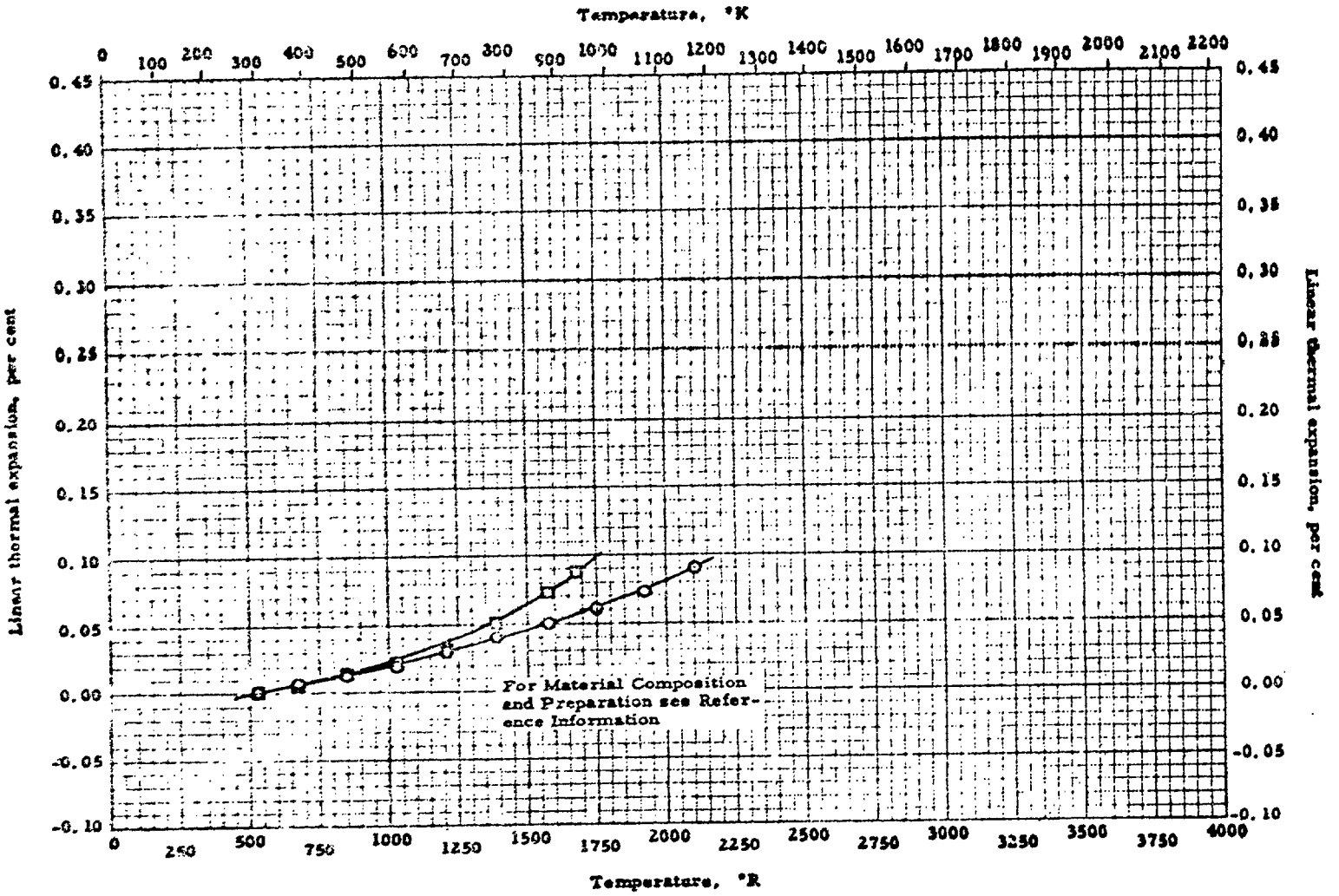


LINEAR THERMAL EXPANSION -- NIOBIUM OXIDE + TITANIUM OXIDE

LINEAR THERMAL EXPANSION -- NIOBIUM OXIDE + TITANIUM OXIDE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Durbin, E. A., Wagner, H. E, and Harman, C. G.	52-34	528-1752	76.9% NbO_2; 23.1% TiO_2; c.p. raw materials (Ta_2O_5 major impurity)	Interferometer	Calcined 2 hr. at 1120°C; fired at 1400°C ($TiO_2 \cdot Nb_2O_5$)
□	Ibid.	52-34	528-1752	62.5% NbO_2; 37.5% TiO_2; raw materials same as above	Same as above	Same as above ($TiO_2 \cdot Nb_2O_5 + TiO_2$)
△	Durbin, E. A. and Harman, C. G.	52-31	528-2040	76.9% NbO_2; 23.1% TiO_2	Same as above	Fired 2 hr. at 1450°C; cooled in 24 hr. ($TiO_2 \cdot Nb_2O_5$)

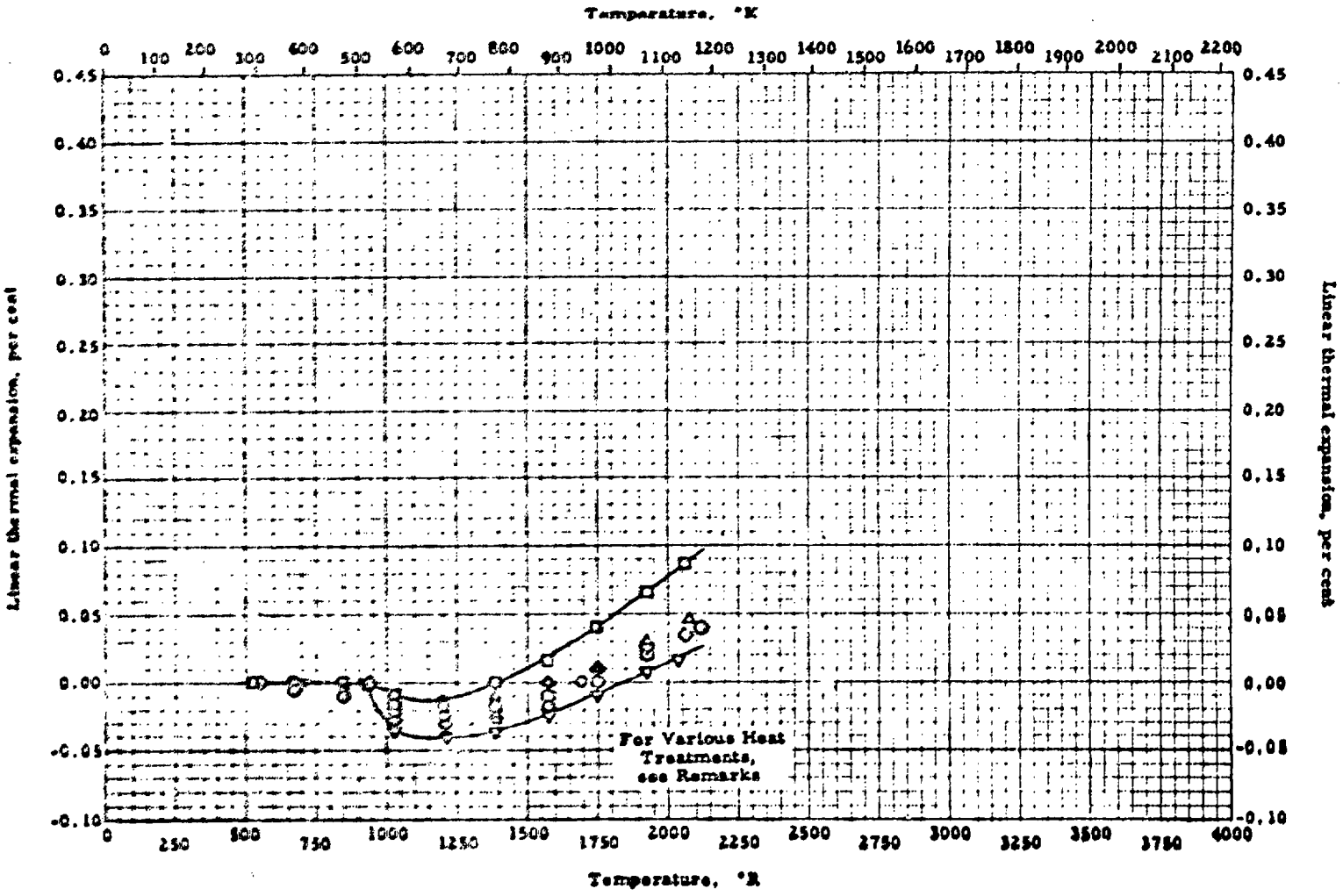


LINEAR THERMAL EXPANSION -- NIOBIUM OXIDE + ZIRCONIUM OXIDE

LINEAR THERMAL EXPANSION -- NIOBIUM OXIDE + ZIRCONIUM OXIDE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Durbin, E. A. and Harman, C. G.	52-31	528-2112	~86.6% Nb_2O_5; 13.4% ZrO_2	Interferometer	Fired 2 hr. at 1400°C; cooled in 24 hr. ($3Nb_2O_5 \cdot ZrO_2$)
□	Durbin, E. A., Wagner, H. E. and Harman, C. G.	52-34	528-1680	~86.6% Nb_2O_5; 13.4% ZrO_2; prepared from c.p. raw materials; (major impurity: Ta_2O_5) Apparent porosity = 15%	Interferometer	Calcined 2 hr. at 1065°C; fired at 1345°C ($3Nb_2O_5 + ZrO_2$)(a form of stabilized zirconia)



LINEAR THERMAL EXPANSION -- NIOBIUM OXIDE

WADC TR 58-476 430 58-183

LINEAR THERMAL EXPANSION -- NIOBIUM OXIDE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Curtis, E. A., Wagner, H. E. and Harman, C. G.	52-34	528-1752	99.6% Nb_2O_5; remainder mostly Ta_2O_5	Interferometer	Fired at 1455°C. Crystals medium coarse to coarse
□	Curtis, E. A., and Harman, C. G.	52-31	528-2052	Not given	Interferometer	Heated 2 hr. at 1315°C, furnace cooled
△	Ibid.	52-31	528-2052	Same as above	Same as above	Heated 2 hr. at 1370°C, furnace cooled
◇	Ibid.	52-31	528-2052	Same as above	Same as above	Heated 2 hr. at 1315°C, air quenched
▽	Ibid.	52-31	528-2040	Same as above	Same as above	Heated 2 hr. at 1370°C, air quenched
○	Ibid.	52-31	528-2112	Same as above	Same as above	Heated 2 hr. at 1370°C, furnace cooled; refired for 100 hr. at 1206°C, furnace cooled

PROPERTIES OF PROTACTINIUM OXIDE

MOST PROBABLE VALUES

Property	Brit. Engineering U. .	C. G. S. Units
Density	838.4 lb_{av}/ft^3	13.43 g/cm^3
Melting Point		
Heat of Fusion		
Heat of Vaporization . . .		
Heat of Sublimation . . .		

REPORTED VALUES

Density:		lb_{av}/ft^3	g/cm^3
	O	838.4	13.43
Melting Point:		°R	°K
Heat of Fusion		Btu/lb_{av}	cal/g
Heat of Vaporization:		Btu/lb_{av}	cal/g
Heat of Sublimation:		Btu/lb_{av}	cal/g

PROPERTIES OF PROTACTINIUM OXIDE

REFERENCE INFORMATION

Form No.	Investigator	Ref.	Range, K	Material Composition	Test Method	Remarks
O	Zachariasen, W. H.	51-53	Room	PaO	ρ: computed from x-ray measurements of lattice	

PROPERTIES OF STRONTIUM OXIDE

MOST PROBABLE VALUES

Property	Brit. Engineering Units	C. G. S. Units
Density.	293 lb_m/ft^3 *	4.7 g/cm^3 *
Melting Point	4860°R	2700°K
Heat of Fusion		
Heat of Vaporization. . .		
Heat of Sublimation . . .	$2189^0_{0°R}$ Btu/lb_m	$1216^0_{0°K}$ cal/g

* Handbook of Chem. and Phys. (Ref. 57-60)

REPORTED VALUES

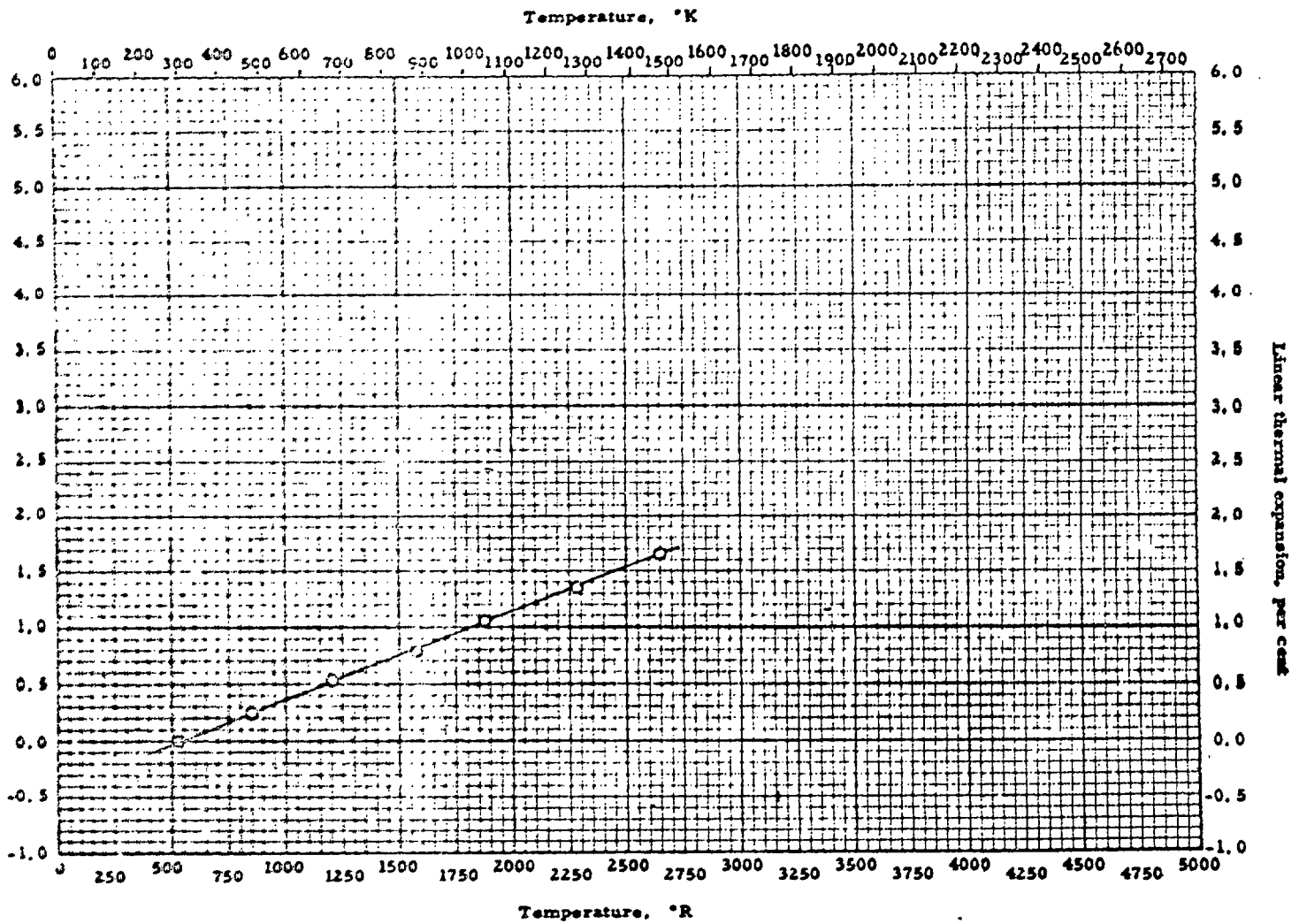
Density:		lb_m/ft^3	g/cm^3
Melting Point:		°R	°K
	O	4865	2703
Heat of Fusion:		Btu/lb_m	cal/g
Heat of Vaporization:		Btu/lb_m	cal/g
Heat of Sublimation:		Btu/lb_m	cal/g
	□	$2189^0_{0°R} \pm 14$	$1216^0_{0°K} \pm 8$

WADC TR 59-610
49-802

PROPERTIES OF STRONTIUM OXIDE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Trombe, F.	49-16	4866	SrO	MP: not given	
□	Moore, G. E., Allison, H. W. and Struthers, J. D.	50-24	0	SrO	Δh_s°: from vapor pressure by weight loss of wire inside bulb using radioactive counting; disappearing filament optical pyrometer	

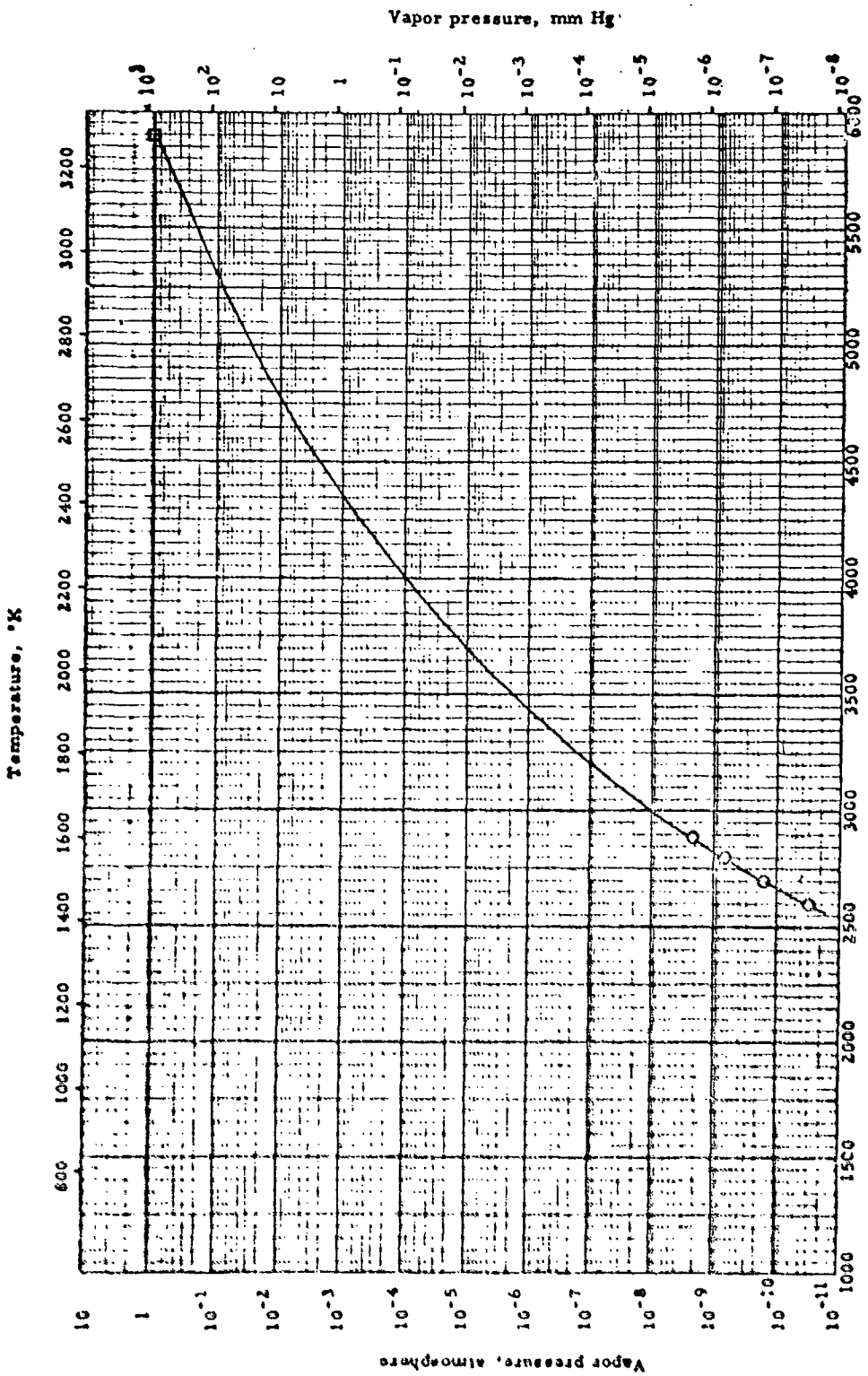


LINEAR THERMAL EXPANSION -- STRONTIUM OXIDE

LINEAR THERMAL EXPANSION -- STRONTIUM OXIDE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Beals, R. J. and Cook, R. L.	57-20	528-2652	Reagent grade SrO	X-ray back reflection	

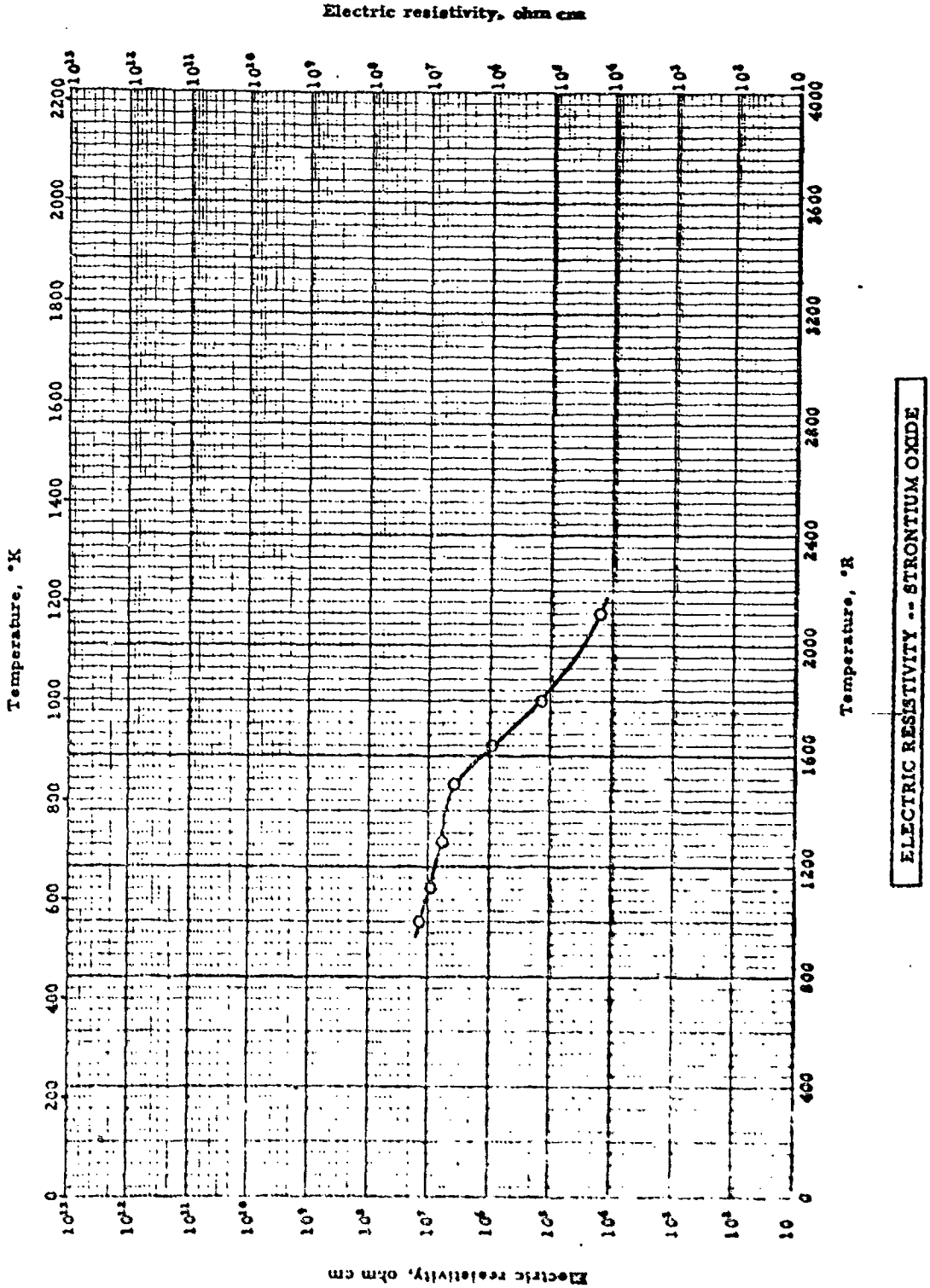


VAPOR PRESSURE -- STRONTIUM OXIDE

VAPOR PRESSURE -- STRONTIUM OXIDE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Moore, G. E., Allison, H. W. and Struthers, J. D.	50-24	1260-2880	Not given	Langmuir weight loss method	Pt filament with SrO coating. Auth. est. accuracy ± 1%
□	Trombe, F.	49-16	589	Not given	Not given	

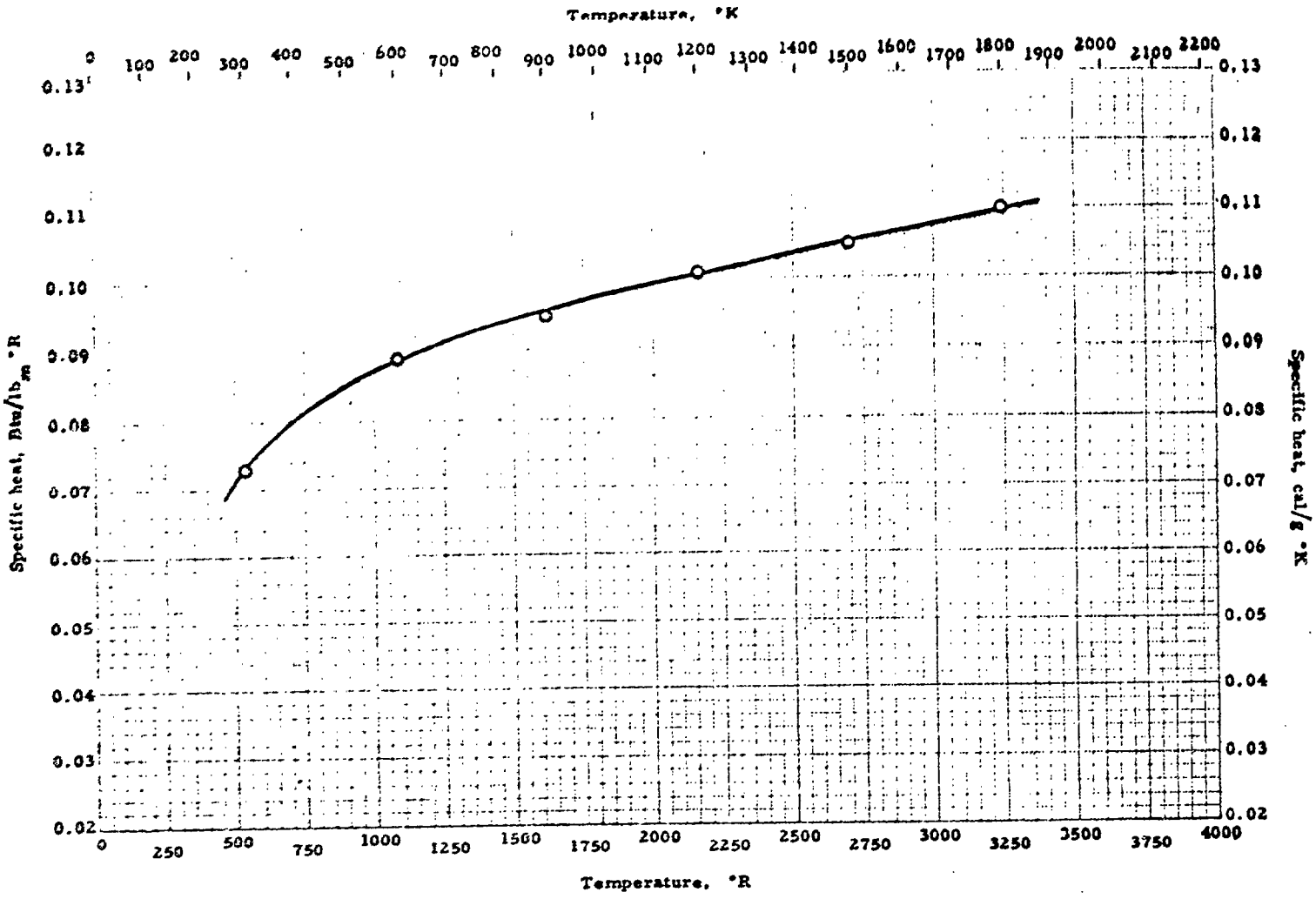


ELECTRIC RESISTIVITY -- STRONTIUM OXIDE

ELECTRIC RESISTIVITY -- STRONTIUM OXIDE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Nakhodnova, A. P.	56-73	1000-2120	SrO	Potential drop; sample temp. by Mo-Ni thermocouple. In range 800-900°C, optical pyrometer was also used.	Formed from chemically pure materials. Baked polycrystalline samples, calcined 2 hr. at const. temp. in furnace. Meas. under 10^{-5} mm Hg vac., const. current

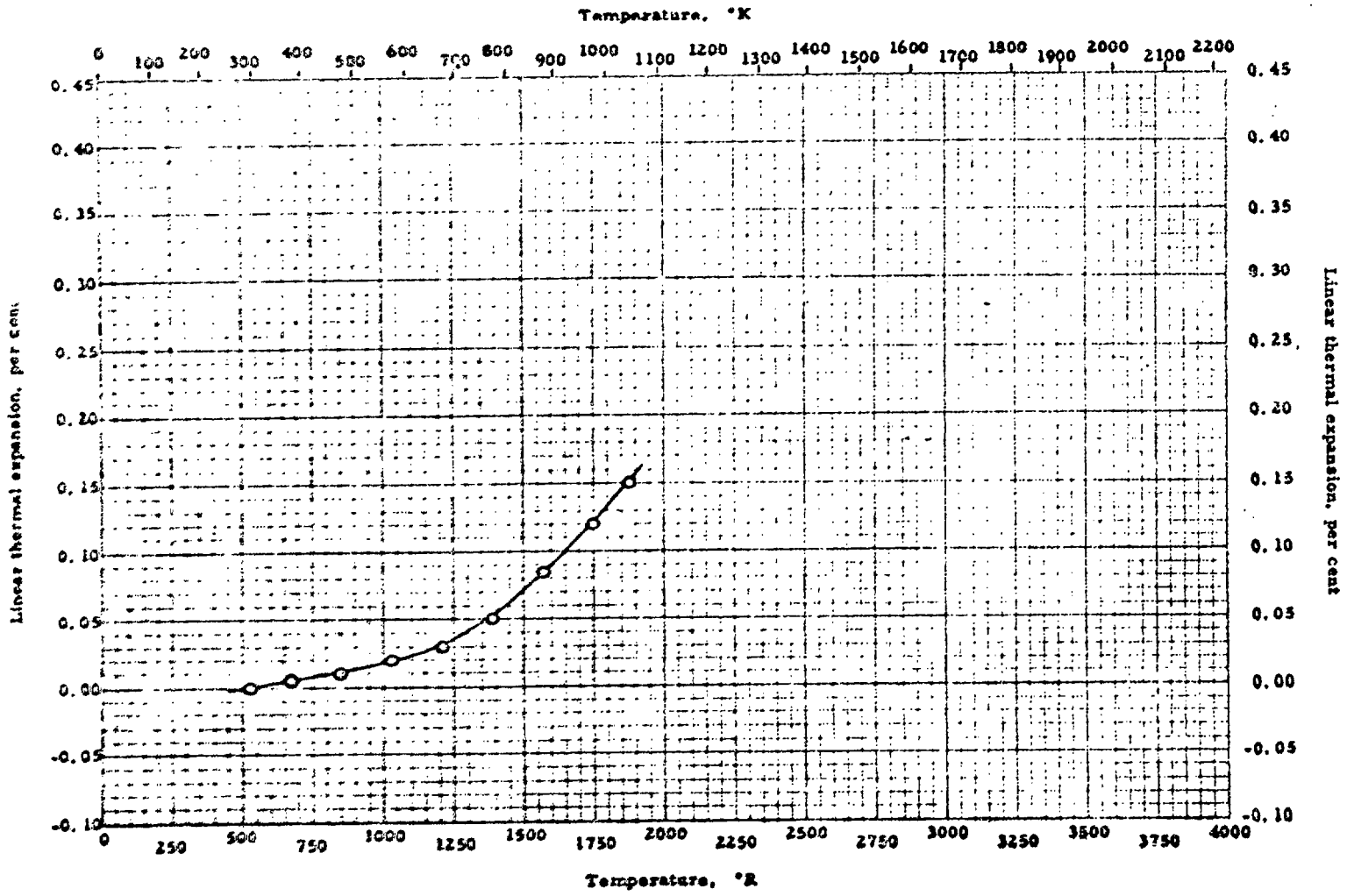


SPECIFIC HEAT -- TANTALUM OXIDE

SPECIFIC HEAT -- TANTALUM OXIDE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Orr, R. L.	53-57	712-3245	Virtually atomic wt. purity Ta_2O_5	Drop method; copper block calorimeter	Heated to 1200°C before testing



LINEAR THERMAL EXPANSION -- TANTALUM OXIDE

LINEAR THERMAL EXPANSION -- TANTALUM OXIDE

REFERENCE INFORMATION

Sym.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Durbin, E. A. and Harman, C. G.	52-31	528-1932	Ta_2O_5	Interferometer	Fired to 1425°C and furnace cooled

PROPERTIES OF TELLURIUM OXIDE

MOST PROBABLE VALUES

Property	Brit. Engineering Units	C. G. S. Units
Density.	356 lb_m/ft^3 *	5.7 g/cm^3 *
Melting Point	1813°R **	1006°K **
Heat of Fusion		
Heat of Vaporization. . .		
Heat of Sublimation . . .	$649_{1630°R}$ Btu/lb_m	$360_{905°K}$ cal/g

* Handbook of Chem. and Phys. (Ref. 57-60)
** Data on Chemicals (Ref. 49-55)

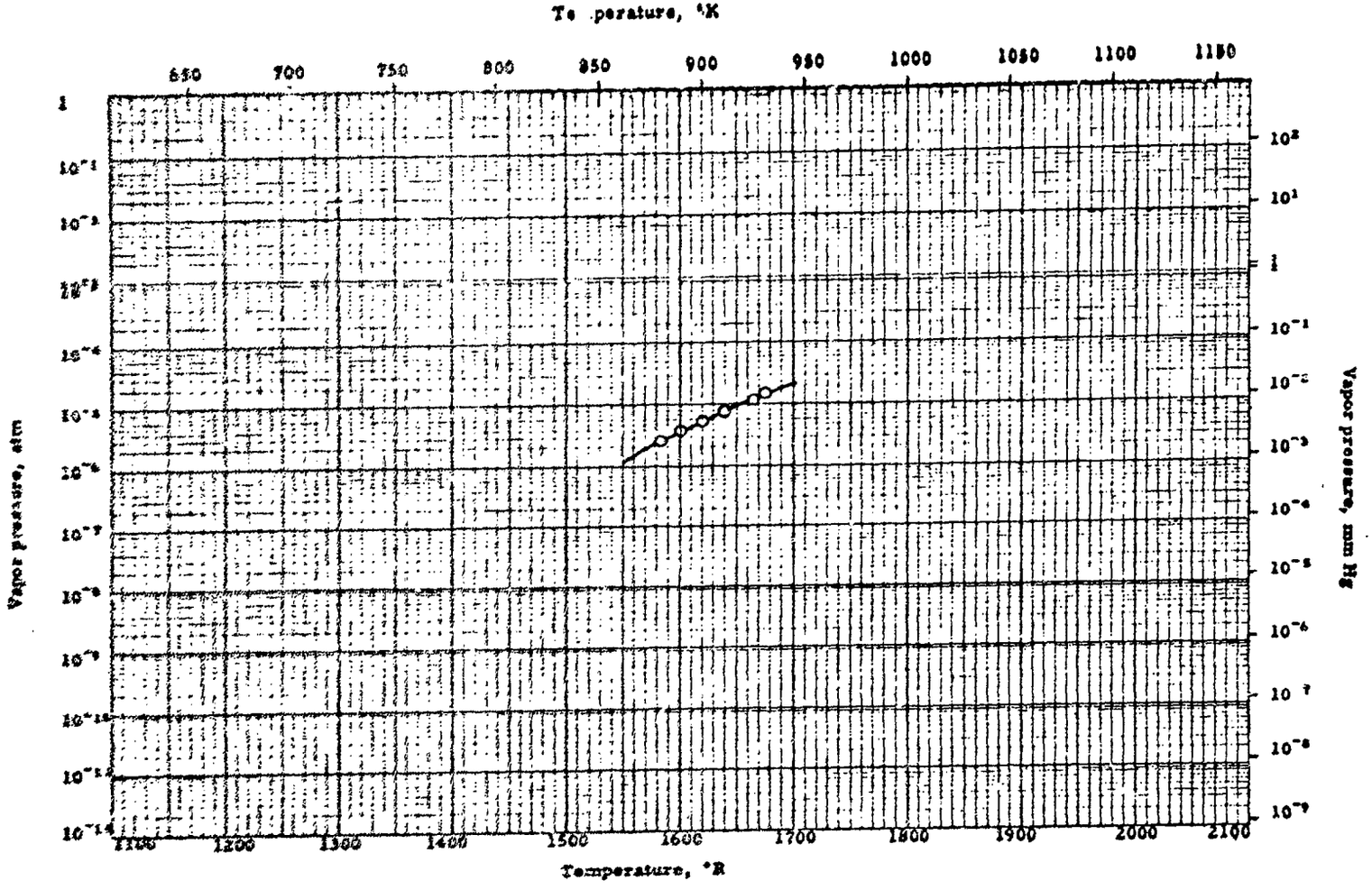
REPORTED VALUES

Density:	lb_m/ft^3	g/cm^3
Melting Point:	°R	°K
Heat of Fusion:	Btu/lb_m	cal/g
Heat of Vaporization:	Btu/lb	cal/g
Heat of Sublimation:	Btu/lb_m	cal/g
	Q $549_{1629°R}$	$360_{905°K}$

PROPERTIES OF TELLURIUM OXIDE

REFERENCE INFORMATION

Curve Ident.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Uyeno, M.	44	1629	TeO_2	Δh_f from vapor pressure measured by Knudsen effusion cell	

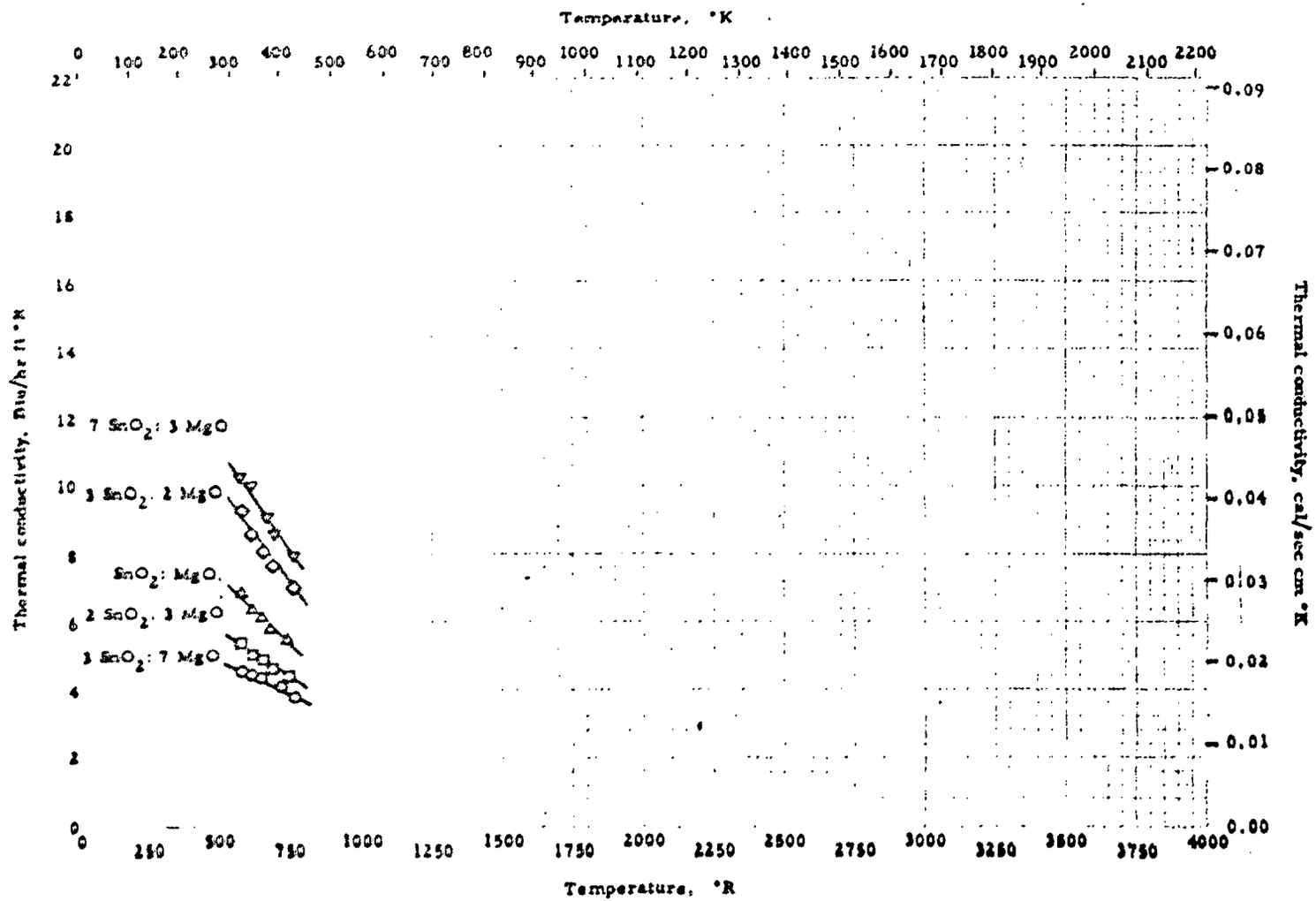


VAPOR PRESSURE -- TELLURIUM OXIDE

VAPOR PRESSURE -- TELLURIUM OXIDE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Uyeno, K.	41-5	1583-1675	TeO_2	Not described here, refers to others	



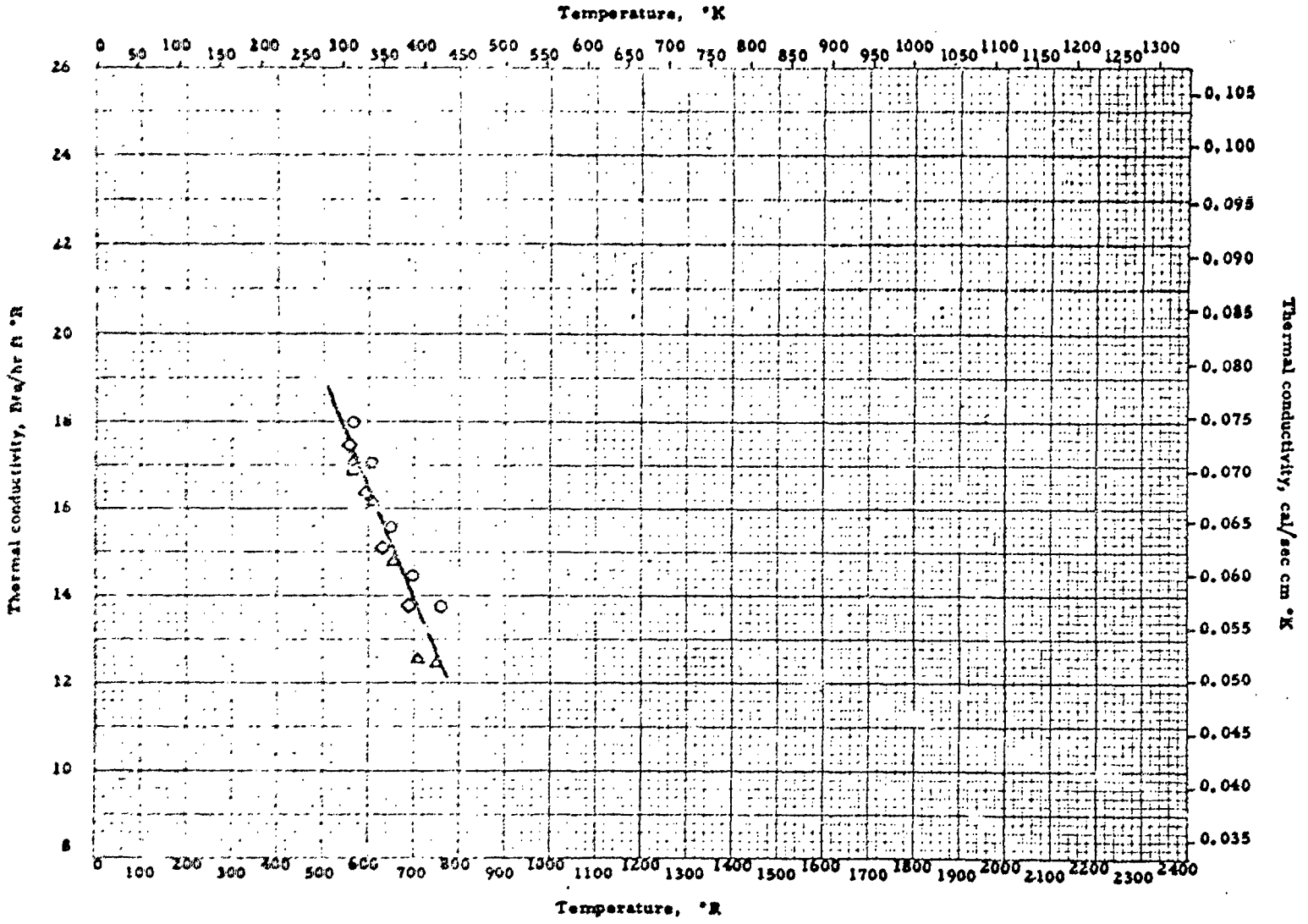
THERMAL CONDUCTIVITY -- TIN OXIDE , MAGNESIUM OXIDE

59-486
WADC TR 58-476
429

THERMAL CONDUCTIVITY -- TIN OXIDE + MAGNESIUM OXIDE

REFERENCE INFORMATION

Sym	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	New Jersey Ceramic Research Station	53-4	573-759	3 SnO_2 : 7 MgO; 61.6% SnO_2; 38.4% MgO (0.12% water absorption); ρ = 266 lb_m/ft^3	Comparative; rods	Fired 1.5 hr. at 2750°F
□	Ibid.	53-4	571-746	2 SnO_2 : 3 MgO; 71.4% SnO_2; 28.6% MgO (0.098% water absorption); ρ = 300 lb_m/ft^3	Same as above	Same as above
△	Ibid.	53-4	574-735	SnO_2 : MgO; 78.9% SnO_2; 21.1% MgO (0.19% water absorption); ρ = 324 lb_m/ft^3	Same as above	Same as above
◇	Ibid.	53-4	577-757	3 SnO_2 : 2 MgO; 84.9% SnO_2; 15.1% MgO (0.46% water absorption); ρ = 340 lb_m/ft^3	Same as above	Same as above
▽	Ibid.	53-4	568-758	7 SnO_2 : 3 MgO; 89.7% SnO_2, 10.3% MgO (0.70% water absorption); ρ = 346 lb_m/ft^3	Same as above	Same as above



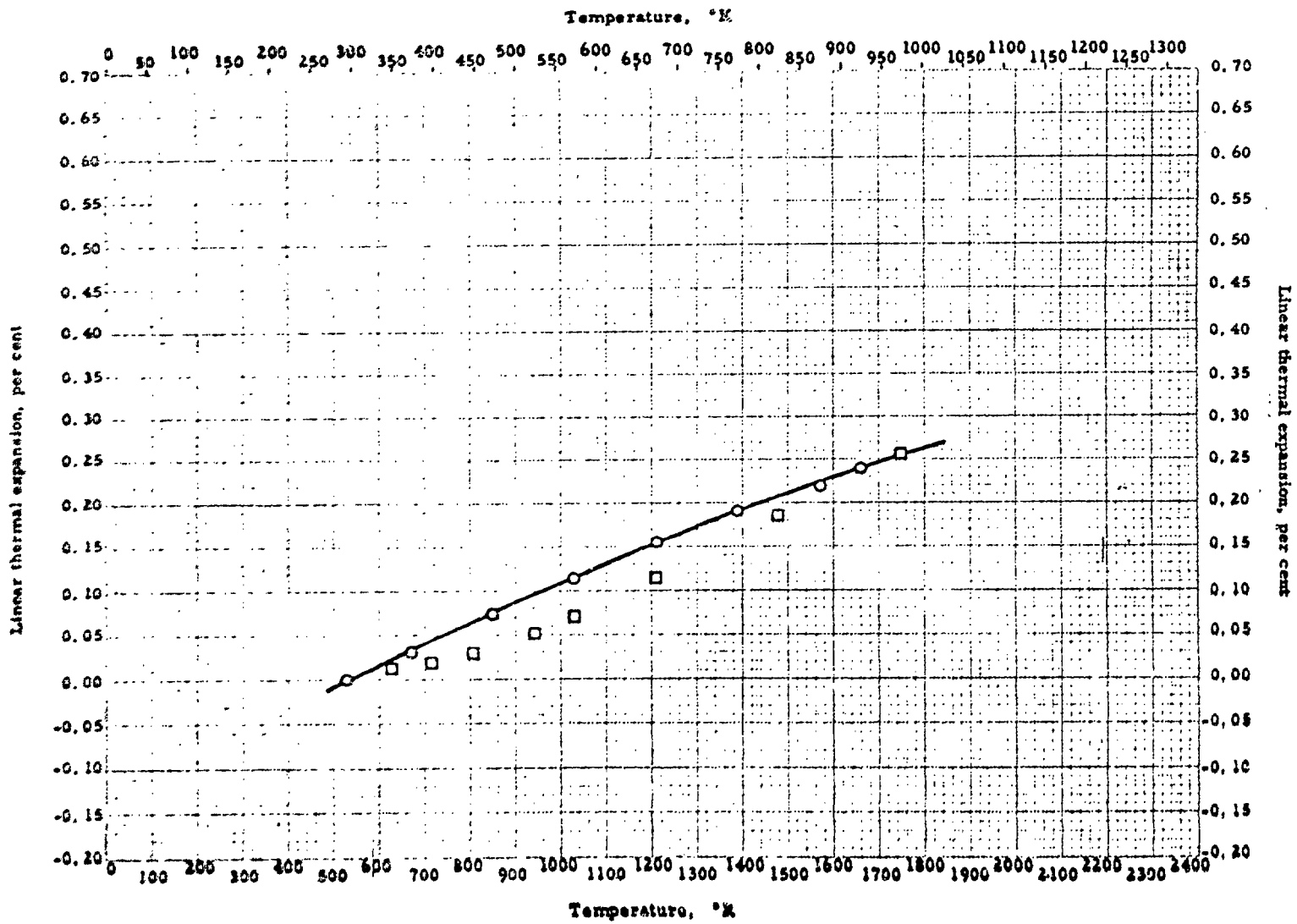
THERMAL CONDUCTIVITY -- TIN OXIDE

NASA TM X-53476 4-1 59-85

THERMAL CONDUCTIVITY -- TIN OXIDE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	New Jersey Ceramic Research Station	53-4	567-762	98% SnO_2; impurities not given; ρ = 406 lb_m/ft^3	Comparative method	Fired 1 hr. at 2600°F; tested in vacuum
□	Quirk, J. and Harmon, C. G.	54-47	564	97% SnO_2 (approx.); 0.1-1.0% Si; 0.9% ZnO; 0.05-0.50% Fe; 0.01-0.10% Ca; others <0.01%; apparent porosity = 2.6%	Comparative, rods	Sintered matrix. Auth. est. accuracy ± 5%
△	New Jersey Ceramic Research Station	53-3	560-760	98% SnO_2, ρ = 413 lb_m/ft^3	Comparative, rods (Cu standard)	Furnished by Metal and Thermit Corp.
◇	Ibid.	53-3	560-690	98% SnO_2, ρ = 410 lb_m/ft^3	Same as above	Same as above



LINEAR THERMAL EXPANSION -- TIN OXIDE

LINEAR THERMAL EXPANSION -- TIN OXIDE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Quirk, J. and Harmon, C. G.	54-47	523-1662	97% SnO_2; 0.9% ZnO; 0.1-1.0% Si; 0.05-0.5% Fe; 0.01-0.1% Ca; < 0.01% others; apparent porosity = 0.4%	Interferometer	Sintered matrix
□	Hummel, F. A. and Henry, E. C.	46-13	528-1752	SnO_2	Probably quartz tube dilatometer	

PROPERTIES OF VANADIUM OXIDE

MOST PROBABLE VALUES

Property	Brit. Engineering Units	C. G. S. Units
Density.	359 lb_m/ft^3 *	5.76 g/cm^3 *
Melting Point		
Heat of Fusion		
Heat of Vaporization. . .		
Heat of Sublimation . . .	3600 Btu/lb_m	2000 cal/g

* Handbook Chemistry and Physics, (Ref. 57-60)

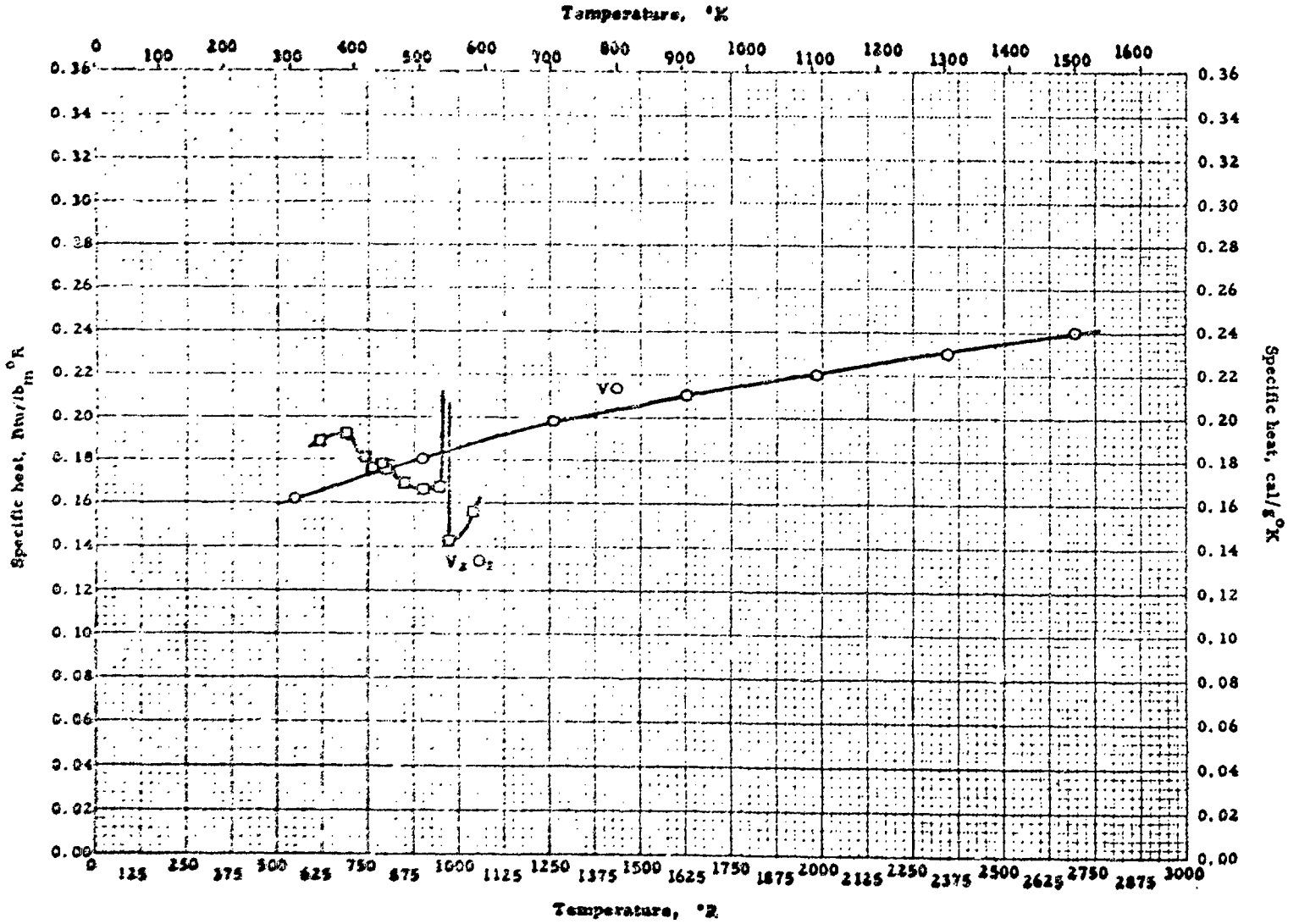
REPORTED VALUES

Density:	....	lb_m/ft^3	g/cm^3
Melting Point:		°R	°K
Heat of Fusion:		Btu/lb_m	cal/g
Heat of Vaporization:		Btu/lb_m	cal/g
Heat of Sublimation:		Btu/lb_m	cal/g
	O	1618°_{0} °R ± 8	$202\frac{0}{0}$ °K ± 4
	□	3479°_{0} °R ± 16	$193\frac{0}{0}$ °K ± 9

PROPERTIES OF VANADIUM OXIDE

REFERENCE INFORMATION

Sym	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Inghram, M. G., Berkowitz, J. and Chupka, W. A.	56-44	0	VO	Δh_s : from vapor pressure measured by Knudsen effusion cell with mass spectrometer; from slope of vapor pressure curve	Vapor pressure measured 3024-3510 R
□	Ibid.	56-44	0	VO	Δh_s : from vapor pressure measured by Knudsen effusion cell with mass spectrometer; from weight loss and estimated entropy	Same as above

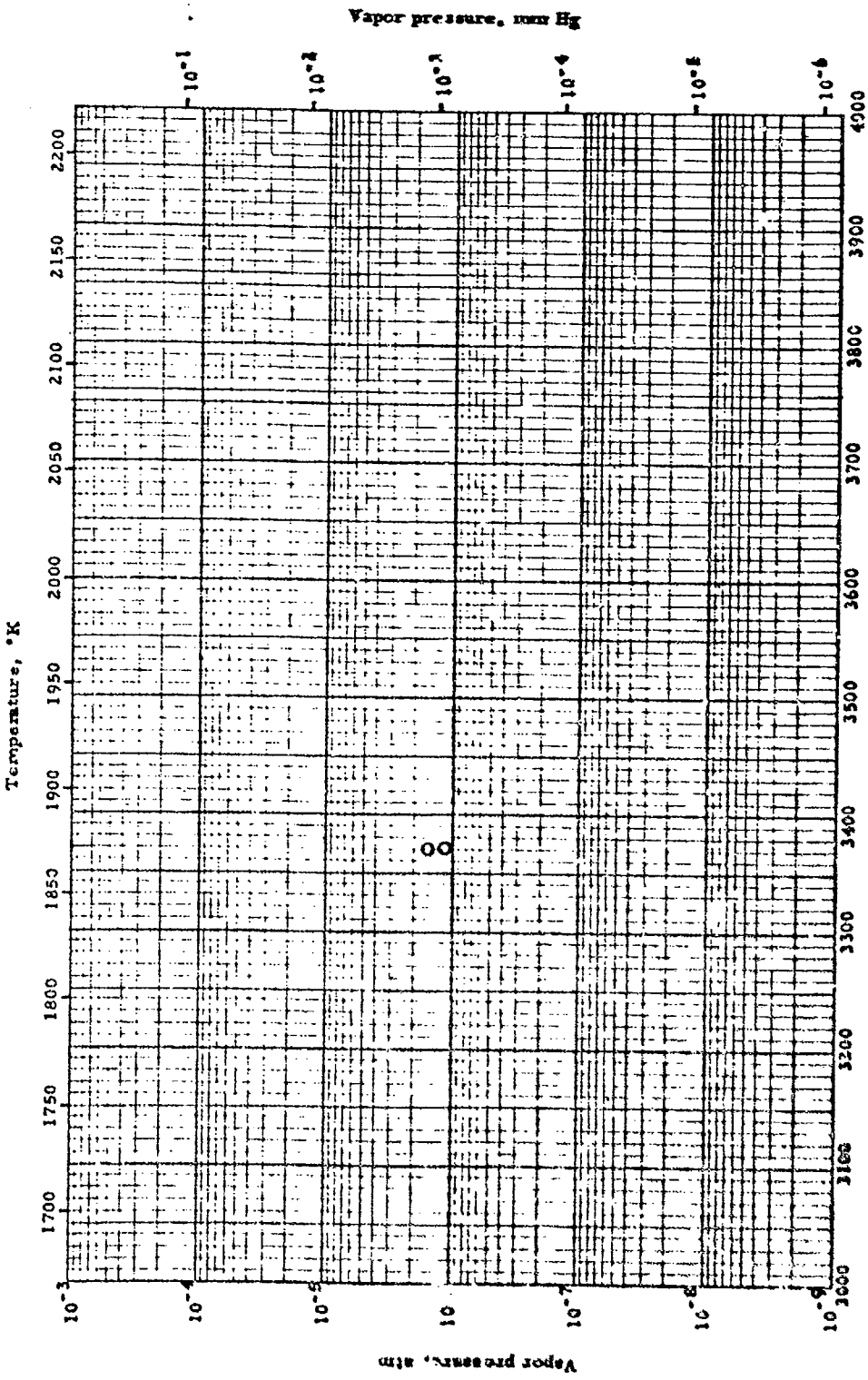


SPECIFIC HEAT -- VANADIUM OXIDE

SPECIFIC HEAT -- VANADIUM OXIDE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Orr, R. L.	54-135	540-2700	98.2% pure VO, small quantity of V_2O_3	Drop method	Computed from $C_p = 11.32 + 3.22 \times 10^{-3} T - 1.26 \times 10^5 T^{-2}$ (T in °K). Mean deviation of exp. values of enthalpy ± 0.2% from values computed by above equation
□	Foex, M., Goldstaub, S. et al.	52-132	618-1032	V_2O_3	Meas. temp. rise of sample for known heat input in adiabatic calorimeter, shielded and in vacuum, calibrated with KCl	Auth. est. accuracy ± 3%



VAPOR PRESSURE -- VANADIUM OXIDE

VAPOR PRESSURE -- VANADIUM OXIDE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Ingraham, M. G., Berkowitz, J., and Chupka, W. A.	56-44	3769.6 - 3871.4	VO	Knudsen effusion cell	$VO_{(s)} = VO_{(g)}$

ELECTRIC RESISTIVITY -- VANADIUM OXIDE

ELECTRIC RESISTIVITY -- VANADIUM OXIDE

REFERENCE INFORMATION

No.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Foex, M., Collongues, R. et al.	52-132 also 149-69	164-2400	V_2O_3	Potential drop in H_2 atm.	Compressed, sintered at 1400°C
□	Ibid.	52-132 also 149-69	164-660	Same as above	Same as above	Compressed, sintered at 1800°C
△	Kain, O. A., and Zyazev, V. L.	57-108	1392-2452	V_2O_5 Russian brand (Ch. D. A.)	Bridge method at 1000 cycles; oscilloscope detector	Auth. est. accuracy + 10% ▲ - heating, △ - cooling
◇	King, E. W. and Huber, L. L.	53-17	515-900	V_2O_5 0.01% ea. Te, Si; 0.001% ea Al, Cr, Cu.	Not given	98% of V_2O_5 coarse crystal; 2% skeleton type crystal stringers

PROPERTIES OF YTTRIUM OXIDE

MOST PROBABLE VALUES

Property	Brit. Engineering Units	C. G. S. Units
Density.	279 lb_m/ft^3	4.47 g/cm^3
Melting Point.	4830° R	2683° K
Heat of Fusion		
Heat of Vaporization. . .		
Heat of Sublimation . . .		

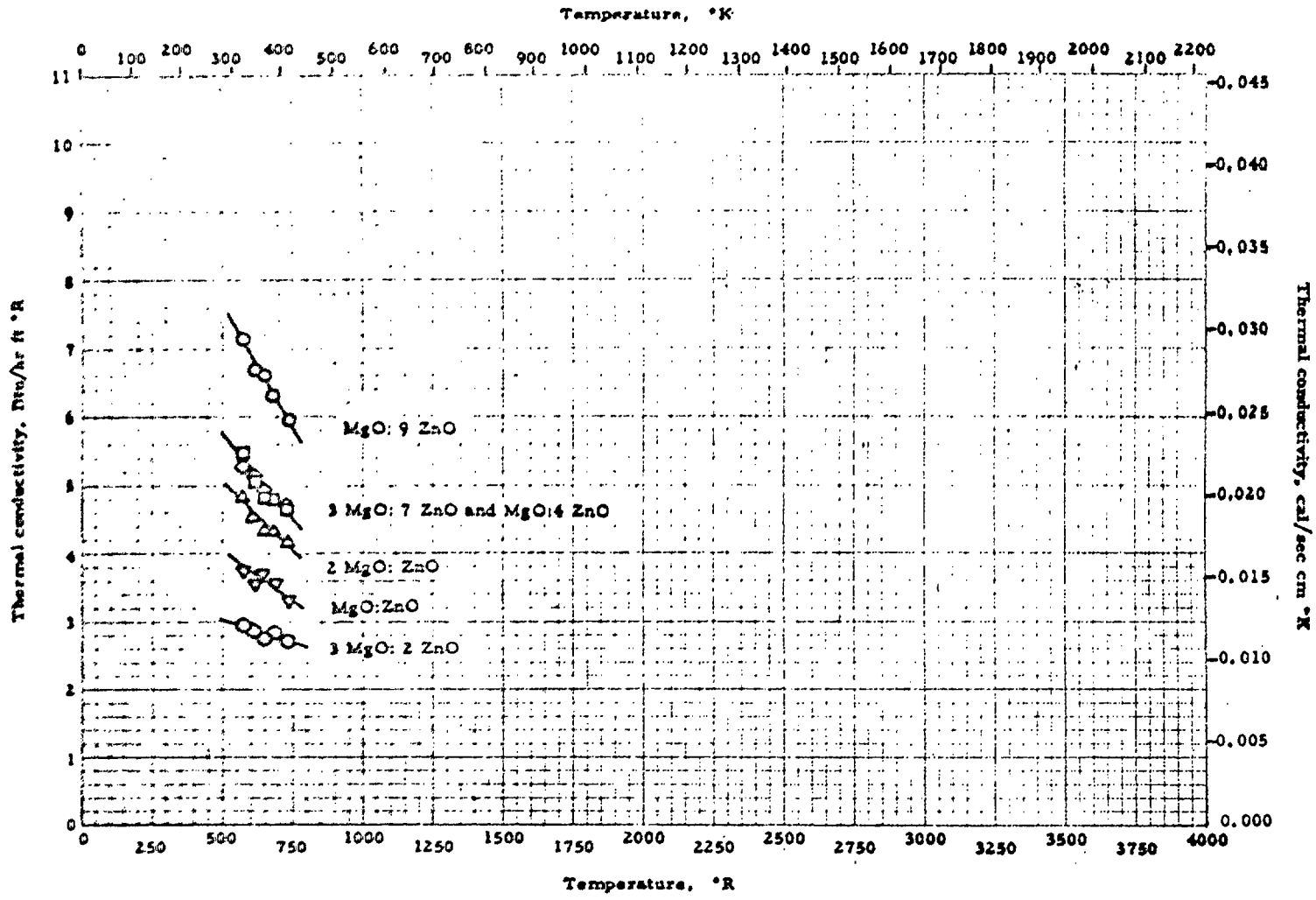
REPORTED VALUES

Density:		lb_m/ft^3	g/cm^3
	□	278	4.46
Melting Point:		°R	°K
	○	4830	2683
Heat of Fusion:		Btu/lb_m	cal/g
Heat of Vaporization:		Btu/lb_m	cal/g
Heat of Sublimation:		Btu/lb_m	cal/g

PROPERTIES OF YTTRIUM OXIDE

REFERENCE INFORMATION

Sym	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Trombe, F.	49-16	4830	Y_2O_3	MP: not given	
□	Curtis, C.E.	57-84	Room	Y_2O_3; <0.1% ea. Nb, Cr, Pb, Zr; < 0.05% ea. Al, Ca, Cu, Ni, Si, < 0.04% ea. Ca, Ce; < 0.03% Na; < 0.02% ea. Ba, Fe, Mg, Mn, Mo, Ti, V; < 0.01% ea. K, Li, Pr, Nd, Sm, Tb, Ho; < 0.004% La; < 0.002% ea. Eu, Gd, Er, Tm, Yb, Be; porosity = 0.3%	ρ: weight and volume by water displacement	Fired at 1800°C

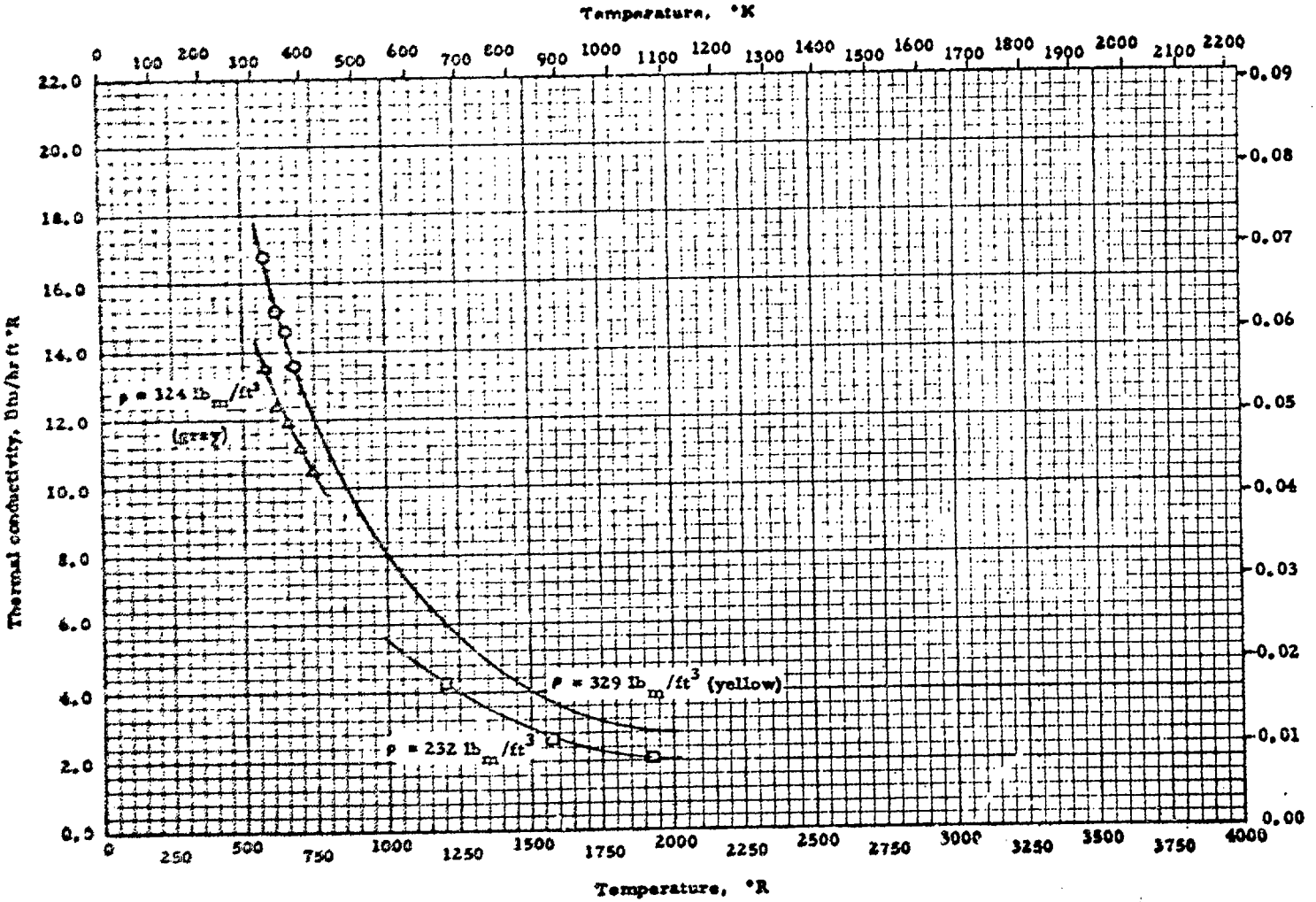


THERMAL CONDUCTIVITY -- ZINC OXIDE + MAGNESIUM OXIDE

THERMAL CONDUCTIVITY -- ZINC OXIDE + MAGNESIUM OXIDE

REFERENCE INFORMATION

Sym	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	New Jersey Ceramic Research Station	53-5	576-742	MgO; 9 ZnO; 94.78% ZnO; 5.22% MgO; water absorption: 0.029%; ρ = 326 lb_m/ft^3	Comparative; rod.	Fired 2 hr. at 2300°F; tested in vacuum
□	Ibid.	53-5	573-736	MgO; 4 ZnO; 88.98% ZnO; 11.02% MgO; water absorption: 0.015%; ρ = 313 lb_m/ft^3	Same as above	Same as above
◇	Ibid.	53-5	575-738	3 MgO; 7 ZnO; 82.49% ZnO; 17.51% MgO; water absorption: 0.003%; ρ = 312 lb_m/ft^3	Same as above	Fired 2 hr. at 2600°F; tested in vacuum
△	Ibid.	53-5	572-738	2 MgO; 3 ZnO; 75.17% ZnO; 24.83% MgO; water absorption: 0.010%; ρ = 303 lb_m/ft^3	Same as above	Same as above
▽	Ibid.	53-5	577-744	MgO; ZnO; 66.67% ZnO; 33.13% MgO; water absorption: 0.040%; ρ = 304 lb_m/ft^3	Same as above	Same as above
○	Ibid.	53-5	524-736	3 MgO; 2 ZnO; 57.37% ZnO; 42.63% MgO; water absorption = 0.006%; ρ = 290 lb_m/ft^3	Same as above	Same as above

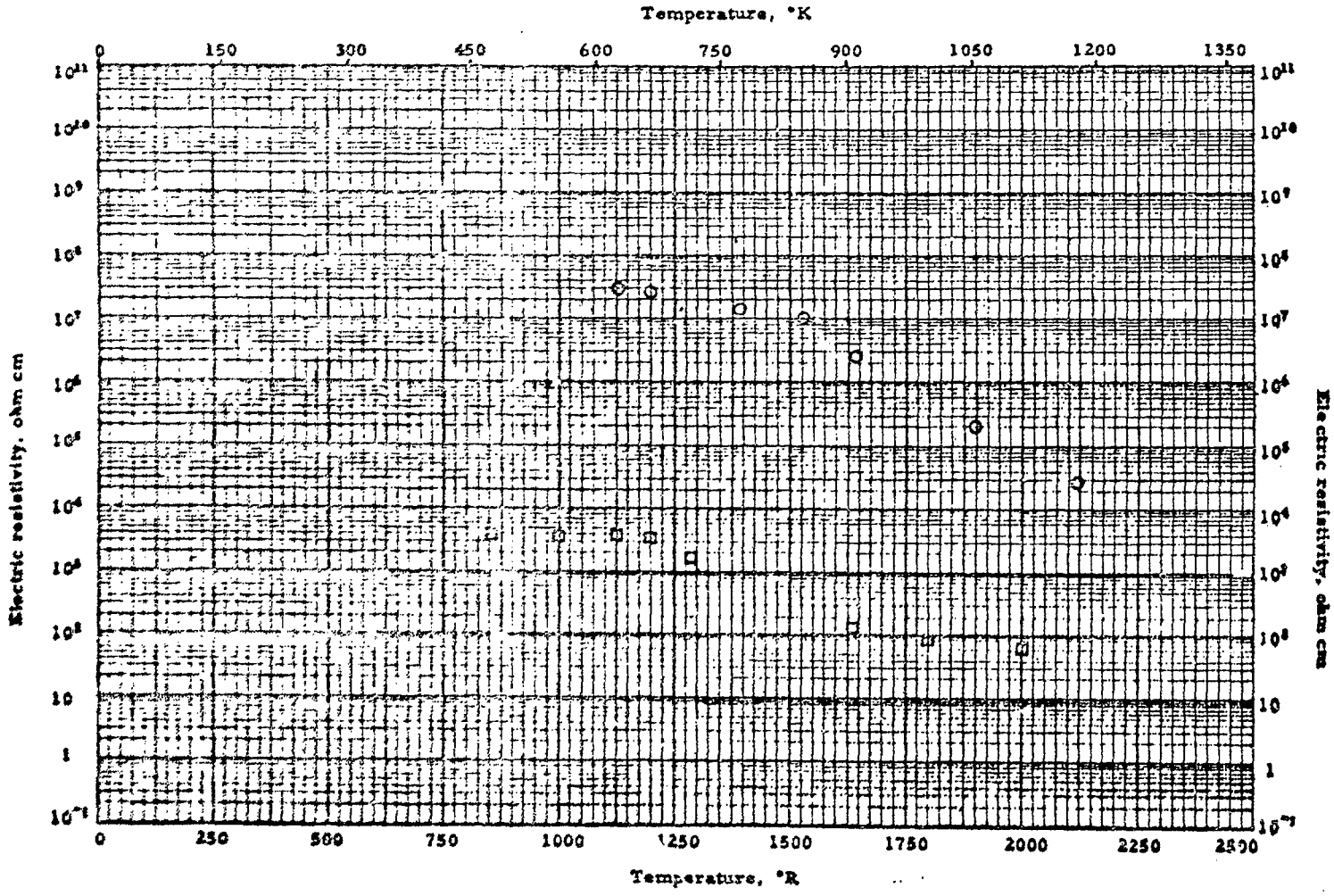


THERMAL CONDUCTIVITY - ZINC OXIDE (ZnO)

THERMAL CONDUCTIVITY -- ZINC OXIDE (ZnO)

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	New Jersey Ceramic Research Station	53-5	575-687	Yellow, ρ = 330 lb_m/ft^3	Comparative; rods	Fired at 2850°R for 1 hr.
△	New Jersey Ceramic Research Station	53-5	580-744	Gray, ρ = 325 lb_m/ft^3	Comparative; rods	Fired at 3010°R for 1 hr.
□	Kingery, W.D. and Francl, J.	54-1 also 53-65	852-1932	ρ = 232 lb_m/ft^3; porosity = 34%	Ellipsoidal envelope	Prepared by calcining c.p. ZnO at 900°C and slip casting



ELECTRIC RESISTIVITY -- ZINC OXIDE

ELECTRIC RESISTIVITY -- ZINC OXIDE

REFERENCE INFORMATION

Curve Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Nakhodnova, A. P.	56-73	1130-2120	ZnO	Potential drop. Sample temp. by Mo-Ni thermocouple. In range 800-900°C, optical pyrometer was also used	Formed from chemically pure materials; baked polycrystalline samples, calcined 2 hr. at const. temp. in furnace; meas. under 10^{-5} mm Hg, const. current
□	Miller, P. H.	41-27	897-2000	ZnO	Potential drop	Values unstable, depend on past history of sample
△	Cowan, J. A.	57-185	140-820	ZnO	Wheatstone bridge	Soaked for 16 hr. at 1300°C, quenched to various temps. for various samples; density changed electric resistivity by factor of 10, so only curve shape of value. Not plotted.

PROPERTIES OF KYANITE

MOST PROBABLE VALUES

Property	Brit. Engineering Units	C. G. S. Units
Density.		
Melting Point	3660°R	1930°K
Heat of Fusion		
Heat of Vaporization. . .		
Heat of Sublimation . . .		

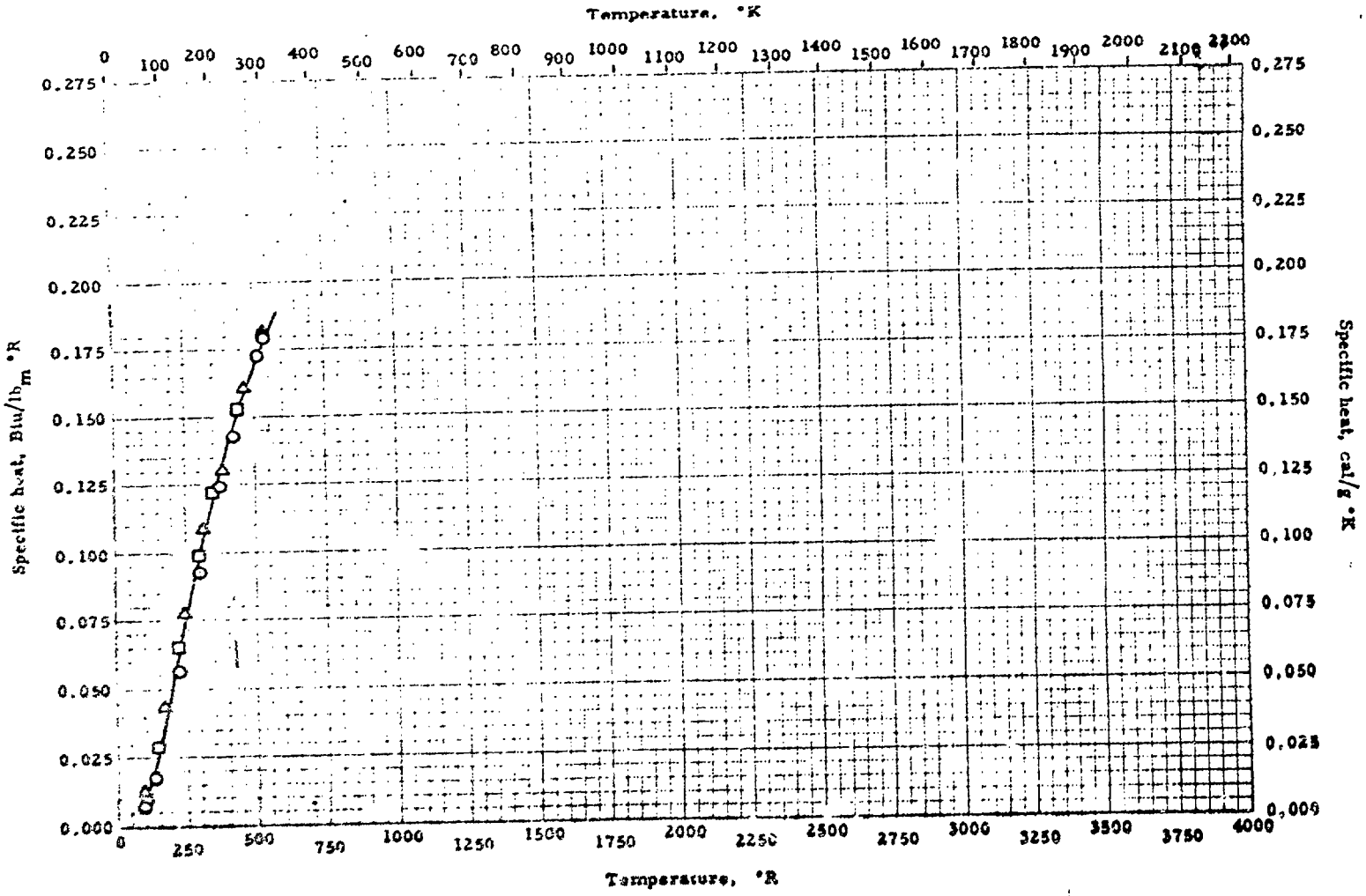
REPORTED VALUES

Density:		lb_m/ft^3	g/cm^3
Melting Point:		°R	°K
	O	3660 ± 54	1930 ± 30
Heat of Fusion:		Btu/lb_m	cal/g
Heat of Vaporization:		Btu/lb_m	cal/g
Heat of Sublimation:		Btu/lb_m	cal/g

PROPERTIES OF KYANITE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Sheehy, J. P. and Killeffer, J. H.	50-67	3600-3720	Fired kyanite containing 3% magnesia	MP: determined by repeated freezing and melting of sample. Temp. measured by optical pyrometer sighting on black body cavity	

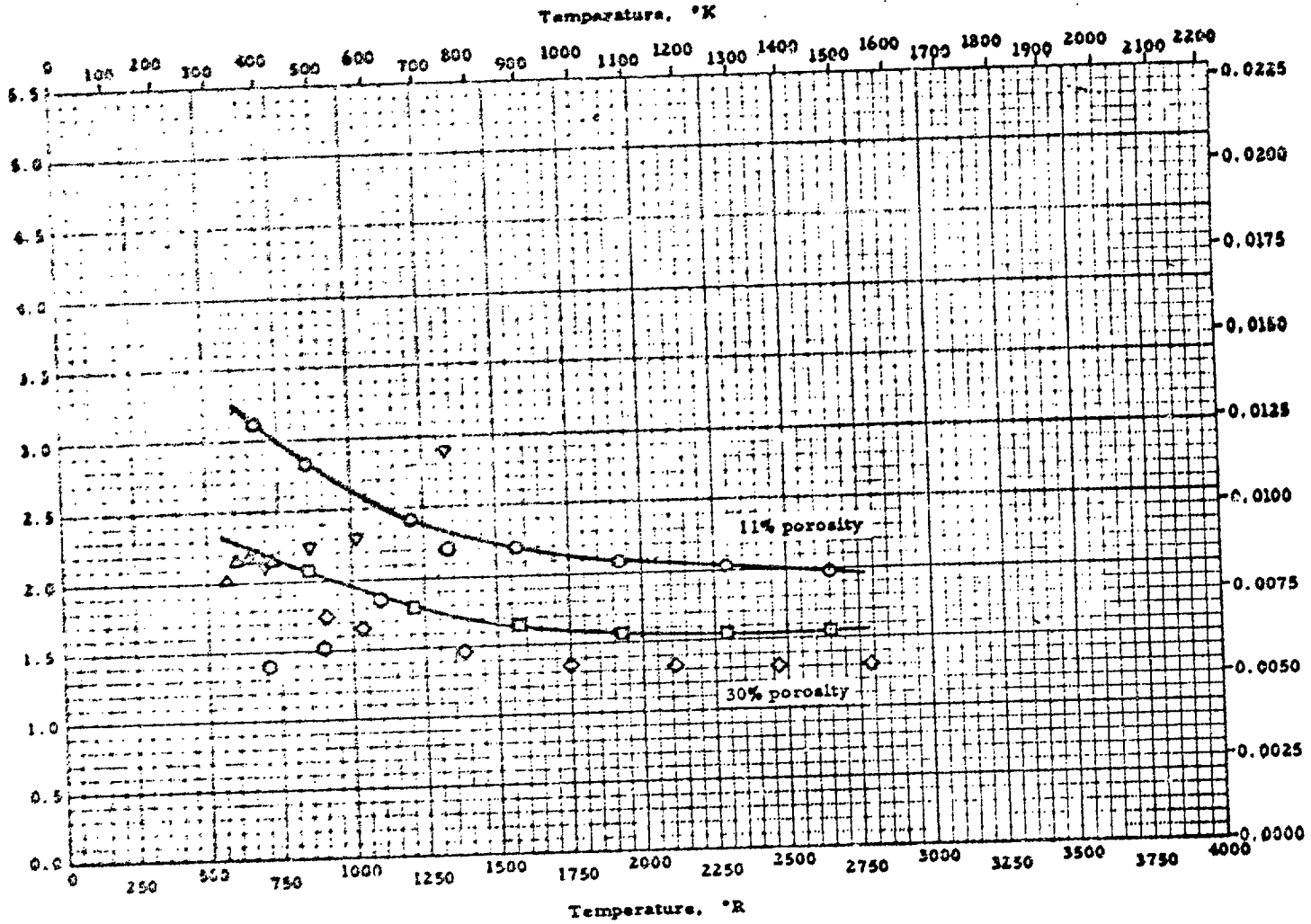


SPECIFIC HEAT -- MINERAL ALUMINO-SILICATE

SPECIFIC HEAT -- MINERAL ALUMINO-SILICATE

REFERENCE INFORMATION

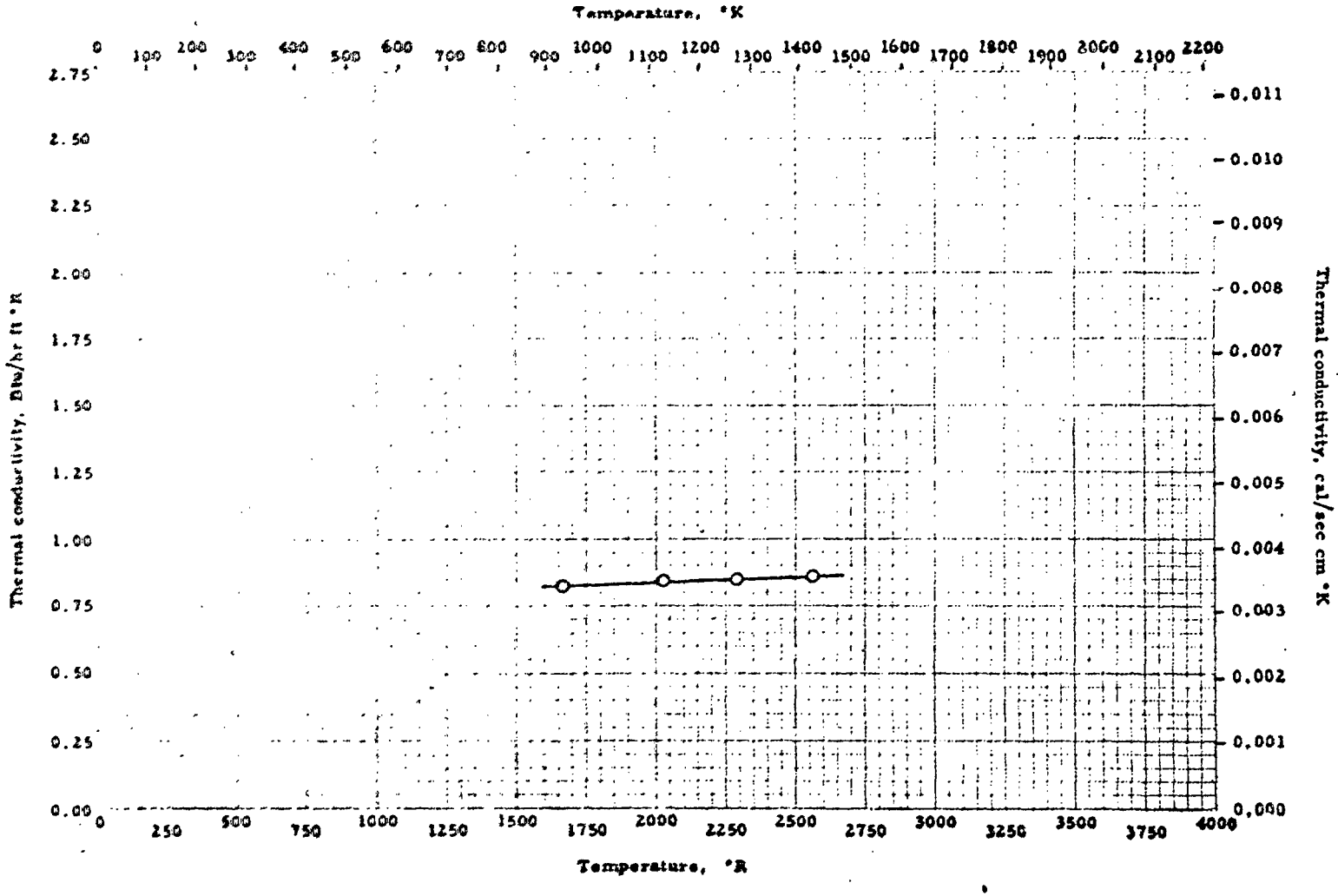
Key	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Todd, S. S.	58-16	99-537	Kyanite; 63.2% Al_2O_3; 36.90% SiO_2; 0.10% Fe_2O_3; 0.05% CaO	Guarded sample	
□	Ibid.	58-16	99-537	Andalusite; 63.15% Al_2O_3; 36.84% SiO_2; 0.11% Fe_2O_3; 0.02% CaO; <0.01% ea. TiO_2, MgO, MnO	Same as above	
Δ	Ibid.	58-16	98-537	Sillimanite; 61.8% Al_2O_3; 36.44% SiO_2; 0.98% Fe_2O_3; 0.28% P_2O_5; 0.24% MgO; 0.14% FeO; 0.07% CaO; 0.04% ea. MnO, F; <0.01% N_2O	Same as above	



THERMAL CONDUCTIVITY -- MULLITE

REFERENCE INFORMATION

Key	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Kingery, W. D., and Francis, J.	54-1	672-2452	69.6% Al_2O_3; 31.9% SiO_2 (sic); Theoretical ρ = 197 lb_m/ft^3; bulk ρ = 174 lb_m/ft^3; porosity = 11.4%	Ellipsoidal envelope	Author quotes theoretical ρ for $Al_6Si_2O_{13}$ as 197 lb_m/ft^3
□	Ibid.	54-1	632-2632	69.6% Al_2O_3; 31.9% SiO_2; Theoretical ρ = 197 lb_m/ft^3; bulk ρ = 138 lb_m/ft^3; porosity = 29.8%	Same as above	
△	New Jersey Ceramic Research Station	54-69	567-727	Mullite	Comparative, rod in vacuum	
◇	Norton, F. H. and Kingery, W. D.	53-75	920-2780	$3Al_2O_3 \cdot 2SiO_2$, pure crystalline	Ellipsoidal envelope, temp. by thermocouple	Grind 24 hr., electromagnetic separation and HCl treatment, dense pieces fired at 1780°C. Auth. est. accuracy ± 8%
▽	Knapp, W. J.	61-11	700-1340	Mullite, polycrystalline	Comparative, rods. Temp. by Chromel-Const. thermocouple	Electrocast, needles well aligned. Meas. parallel to c - axis
○	Ibid.	61-11	700-1340	Same as above	Same as above	Same as above except meas. perpendicular to c - axis

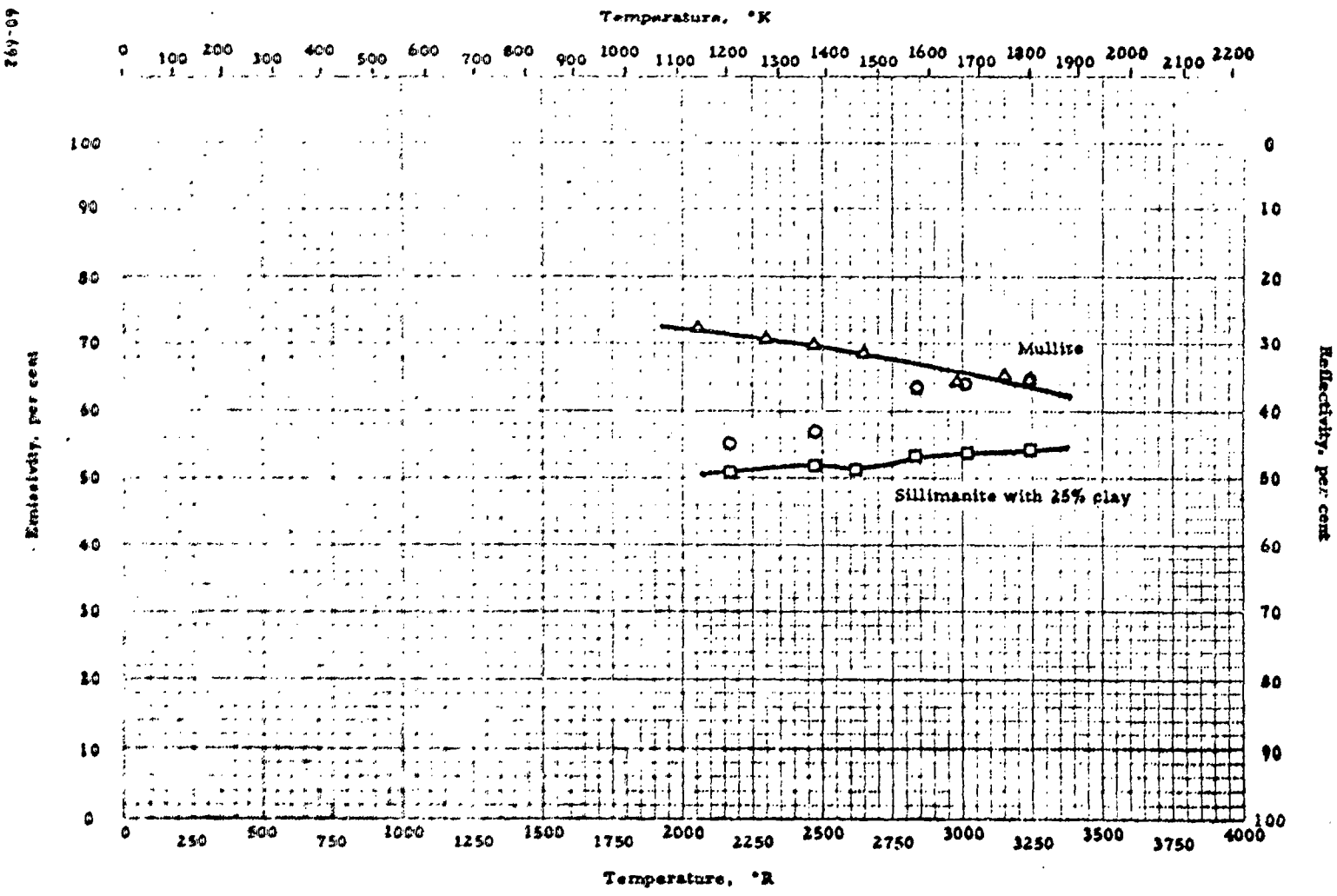


THERMAL CONDUCTIVITY -- SILLIMANITE BRICK

THERMAL CONDUCTIVITY -- SILLIMANITE BRICK

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Clements, J. F. and Vyse, J.	57-26	1662-2562	57.34% Al_2O_3; 39.64% SiO_2; 1.26% TiO_2; 0.70% Fe_2O_3; 0.34% K_2O; 0.25% Na_2O; 0.24% MgO; 0.20% CaO; 0.10% loss on ignition. Bulk ρ = 144 lb_m/ft^3 (cf. theor. ρ = 185); apparent porosity = 22.2%	Not described; apparatus of Brit. Ceramic Research Assoc.	Auth. est. accuracy ± 5%



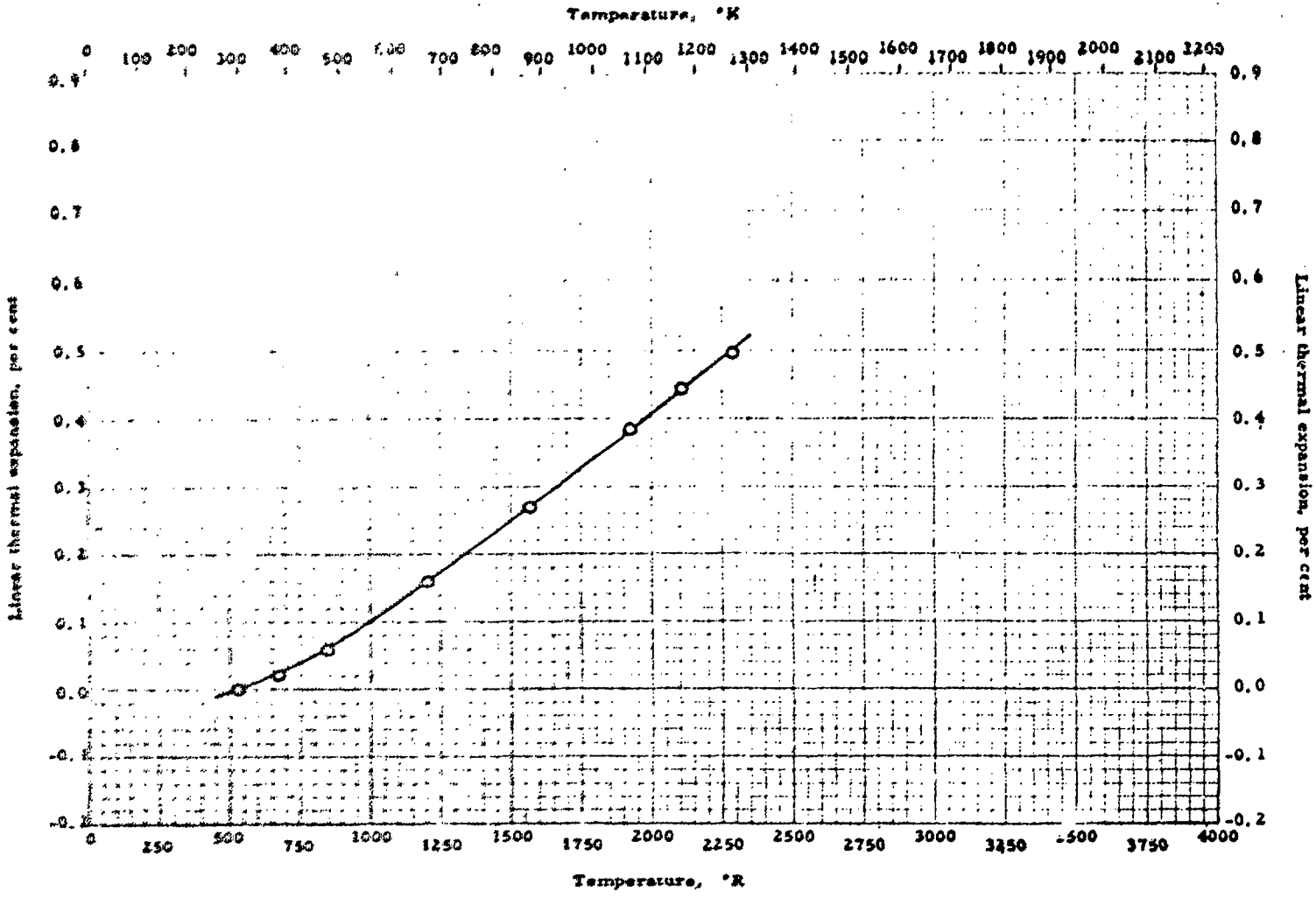
EMISSIVITY -- ALUMINOSILICATE

WADC TR 58-476 459 60-692

EMISSIVITY -- ALUMINOSILICATE

REFERENCE INFORMATION

Sym. No.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Pattison, J. R.	55-86	2166-3246	Silliminite with 25% clay binder	Total normal emissivity; radiant heat meas. with Hilger thermopile. Temp. by optical pyrometer sighting on black body cavity	Before firing
□	Ibid.	55-86	2166-3246	Same as above	Same as above	After firing
△	Ibid.	55-86	2058-3156	Mullite	Same as above	

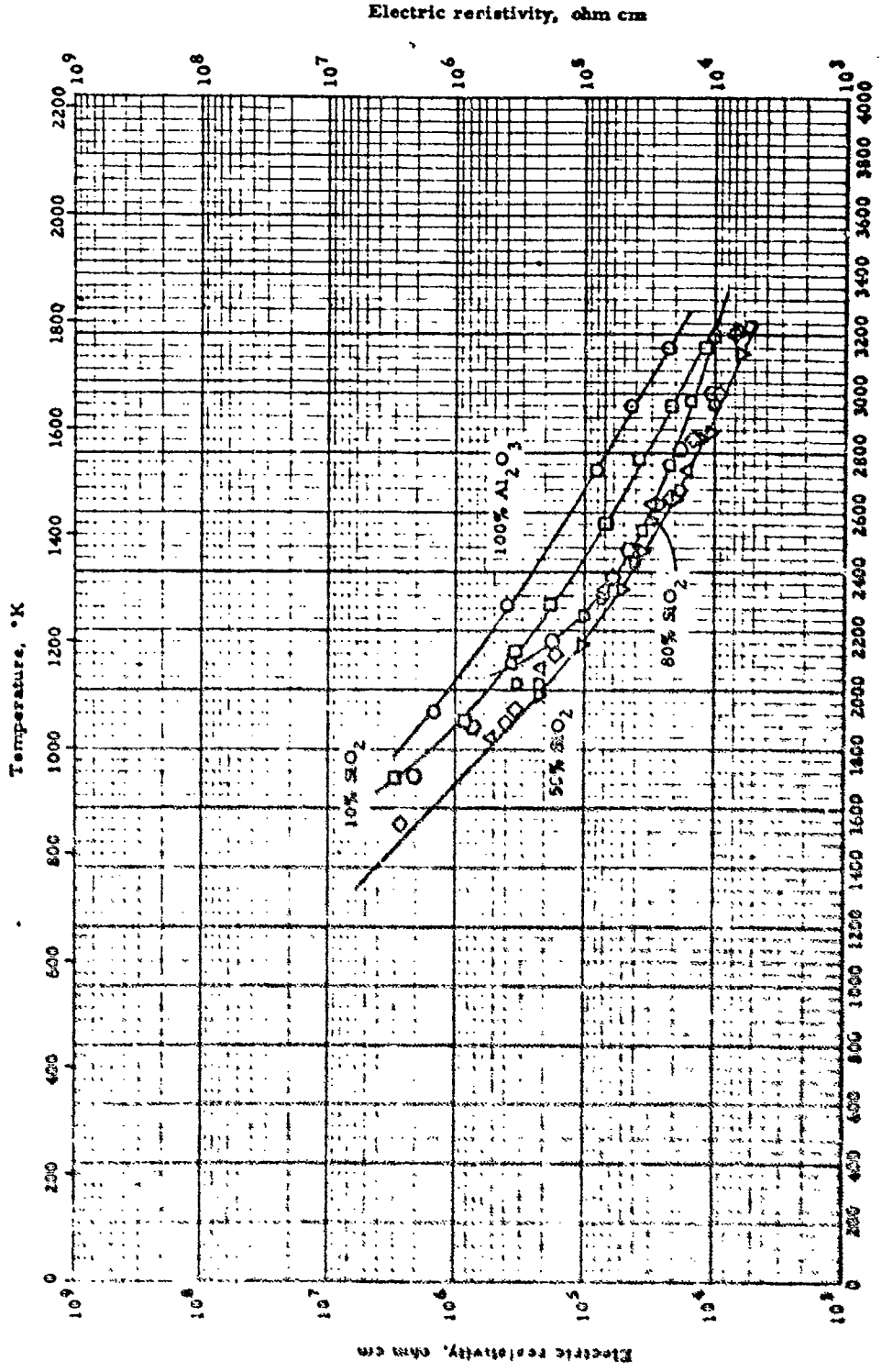


LINEAR THERMAL EXPANSION -- MULLITE

LINEAR THERMAL EXPANSION -- MULLITE

REFERENCE INFORMATION

Type Curve	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	McKinstry, H. A., Hocker, C. F. et al.	49-15	528-2292	3 Al_2O_3 . $2SiO_2$	Not given	

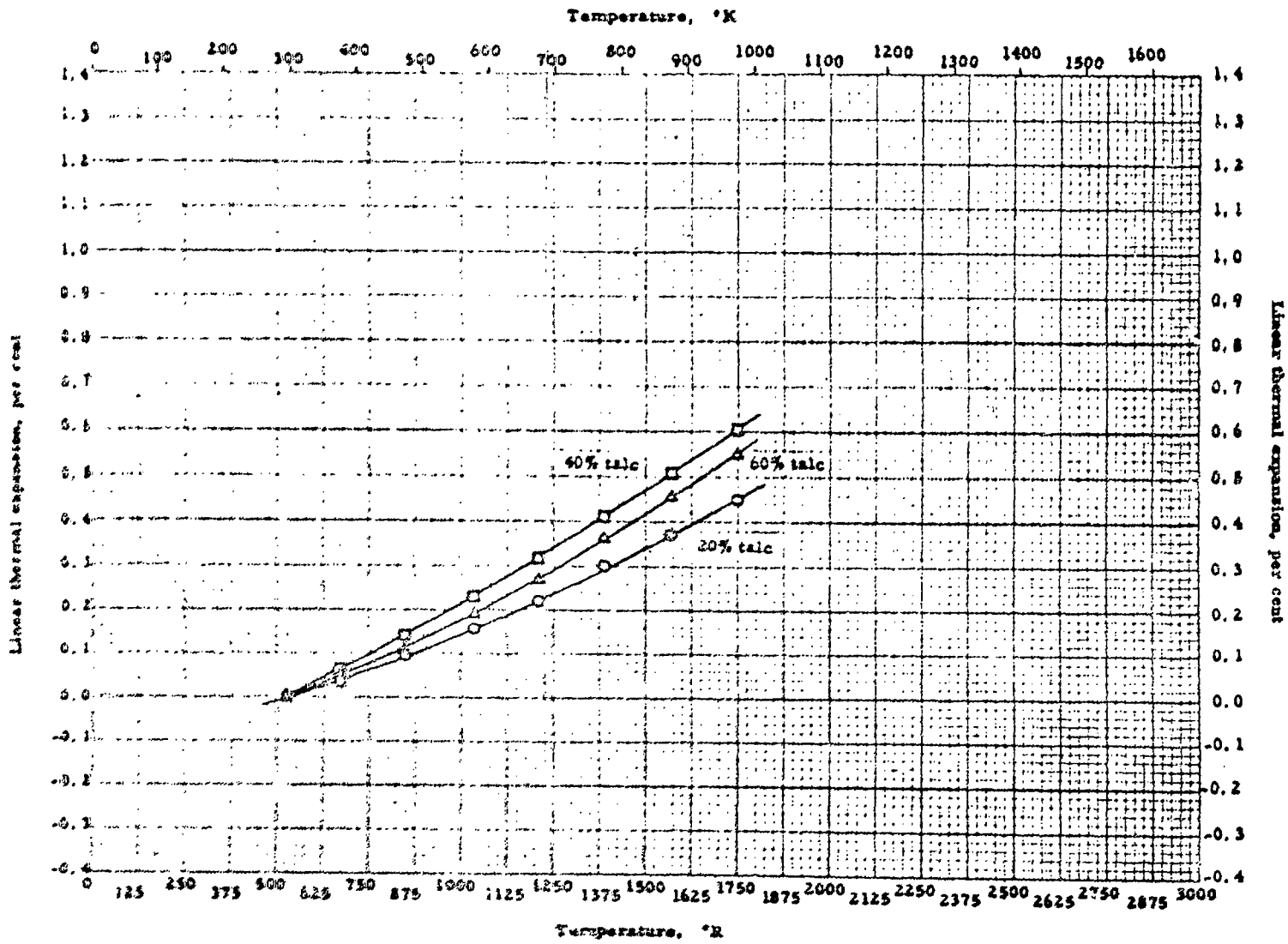


ELECTRIC RESISTIVITY -- MINERAL ALUMINOSILICATE

ELECTRIC RESISTIVITY -- MINERAL ALUMINOSILICATE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °K	Material Composition	Test Method	Remarks
○	Munster, J. R. and Henry, E. C.	53-95	1932-3156	100% Al_2O_3. Sintered; 27% porosity	Wheatstone bridge	Prepared from acid treated Al_2O_3; fired 10 hr. at 1500°C
□	Ibid.	53-95	1698-3156	90% Al_2O_3; 10% SiO_2. Sintered; 35-37% porosity	Same as above	Prepared from acid leached pottery flint and acid treated Al_2O_3; fired 10 hr. at 1500°C
△	Ibid.	53-95	1642-3210	80% Al_2O_3; 20% SiO_2. Sintered; 35-37% porosity	Same as above	Same as above
◇	Ibid.	53-95	1554-3210	70% Al_2O_3; 30% SiO_2. Sintered; 35-37% porosity	Same as above	Same as above
○	Ibid.	53-95	1716-2994	60% Al_2O_3; 40% SiO_2. Sintered; 35-37% porosity	Same as above	Same as above
▽	Ibid.	53-95	1936-3158	50% Al_2O_3; 50% SiO_2. Sintered; 35-37% porosity	Same as above	Same as above
□	Ibid.	53-95	1797-3228	40% Al_2O_3; 60% SiO_2. Sintered; 35-37% porosity	Same as above	Same as above
◇	Ibid.	53-95	1922-3210	30% Al_2O_3; 70% SiO_2. Sintered; 35-37% porosity	Same as above	Same as above
○	Ibid.	53-95	2094-3192	20% Al_2O_3; 80% SiO_2. Sintered; 35-37% porosity	Same as above	Same as above


Temperature, °K
0 100 200 300 400 500 600 700 800 900 1000 1100 1200 1300 1400 1500 1600
Linear thermal expansion, per cent
1.4 1.3 1.2 1.1 1.0 0.9 0.8 0.7 0.6 0.5 0.4 0.3 0.2 0.1 0.0 -0.1 -0.2 -0.3 -0.4
40% talc
60% talc
20% talc
0 125 250 375 500 625 750 875 1000 1125 1250 1375 1500 1625 1750 1875 2000 2125 2250 2375 2500 2625 2750 2875 3000
Temperature, °R
Linear thermal expansion, per cent

19-403
MADE IN U.S.A.
666

LINEAR THERMAL EXPANSION -- BARIUM CALCIUM SILICATE

REFERENCE INFORMATION

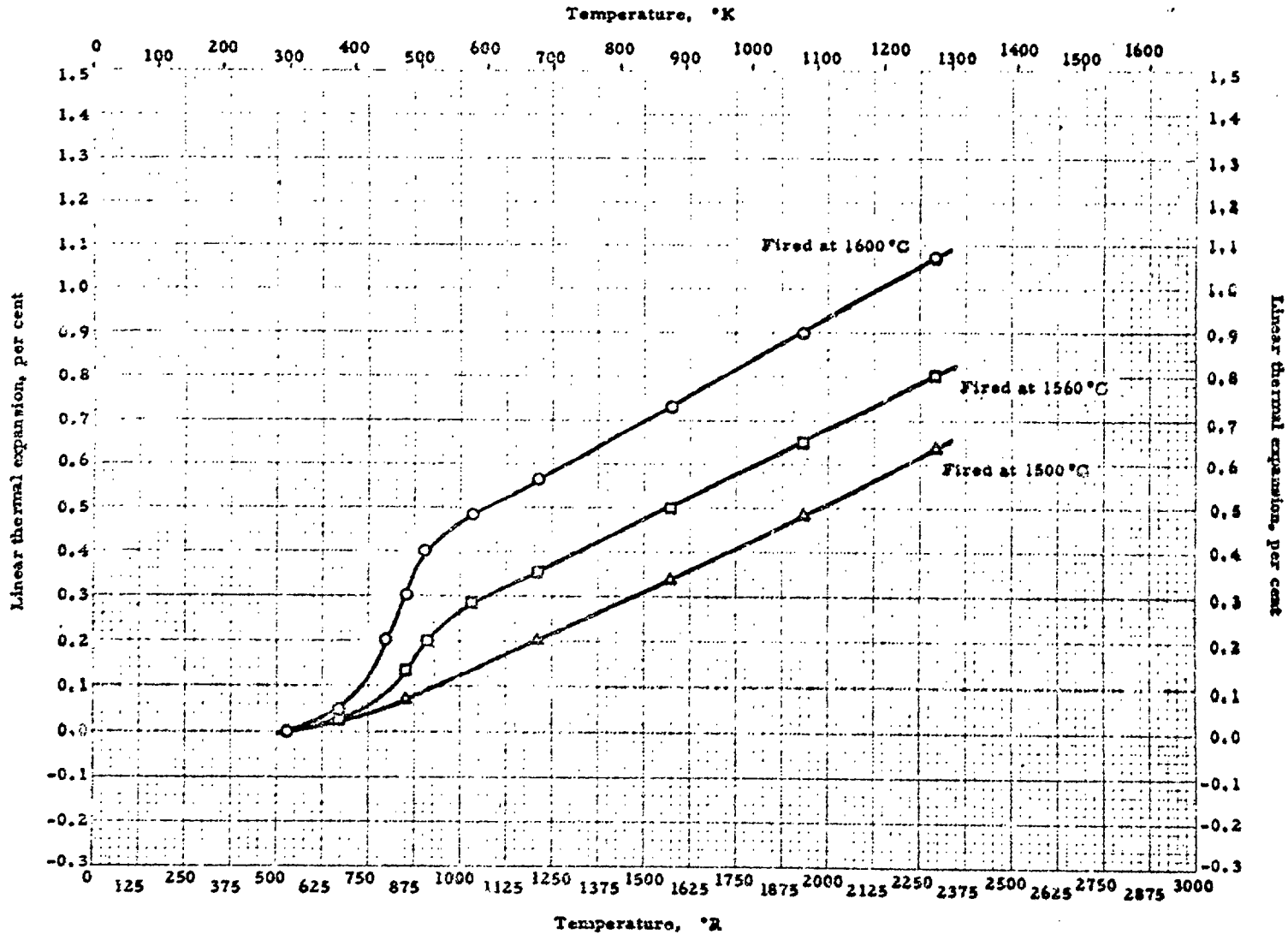
Plot No.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	New Jersey Ceramic Research Station	55-22	672-1752	40% Wollastonite; 20% Sierra high grade talc; 10% $BaCO_3$; 10% E.P.K. clay	Silica tube dilatometer	Tested at 2-3°C/min. rise
□	Ibid.	55-22	672-1752	40% Wollastonite; 40% Sierra high grade talc; 10% $BaCO_3$; 10% E.P.K. clay	Same as above	Same as above
△	Ibid.	55-22	672-1752	40% Sierra high grade talc; 20% Wollastonite; 10% $BaCO_3$; 10% E.P.K. clay	Same as above	Same as above

Linear thermal expansion, per cent
Temperature, °K
Temperature, °R
Linear thermal expansion, per cent

LINEAR THERMAL EXPANSION -- BARIUM MAGNESIUM SILICATE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	New Jersey Ceramic Research Station	55-22	672-1752	54.6% $BaCO_3$; 31.6% talc; 13.8% MgO; final product approx. $BaO \cdot 3MgO \cdot SiO_2$; ρ = 210 lb_m/ft^3	Silica tube dilatometer	Fired at 2660°F; tested at 2-3°C/min. rise
□	Ibid.	55-22	672-1752	58% talc; 33.7% $BaCO_3$; 8.3% MgO; final product approx. $BaO \cdot 4MgO \cdot 3.5SiO_2$; ρ = 192 lb_m/ft^3.	Same as above	Fired at 2450°F; tested at 2-3°C/min. rise

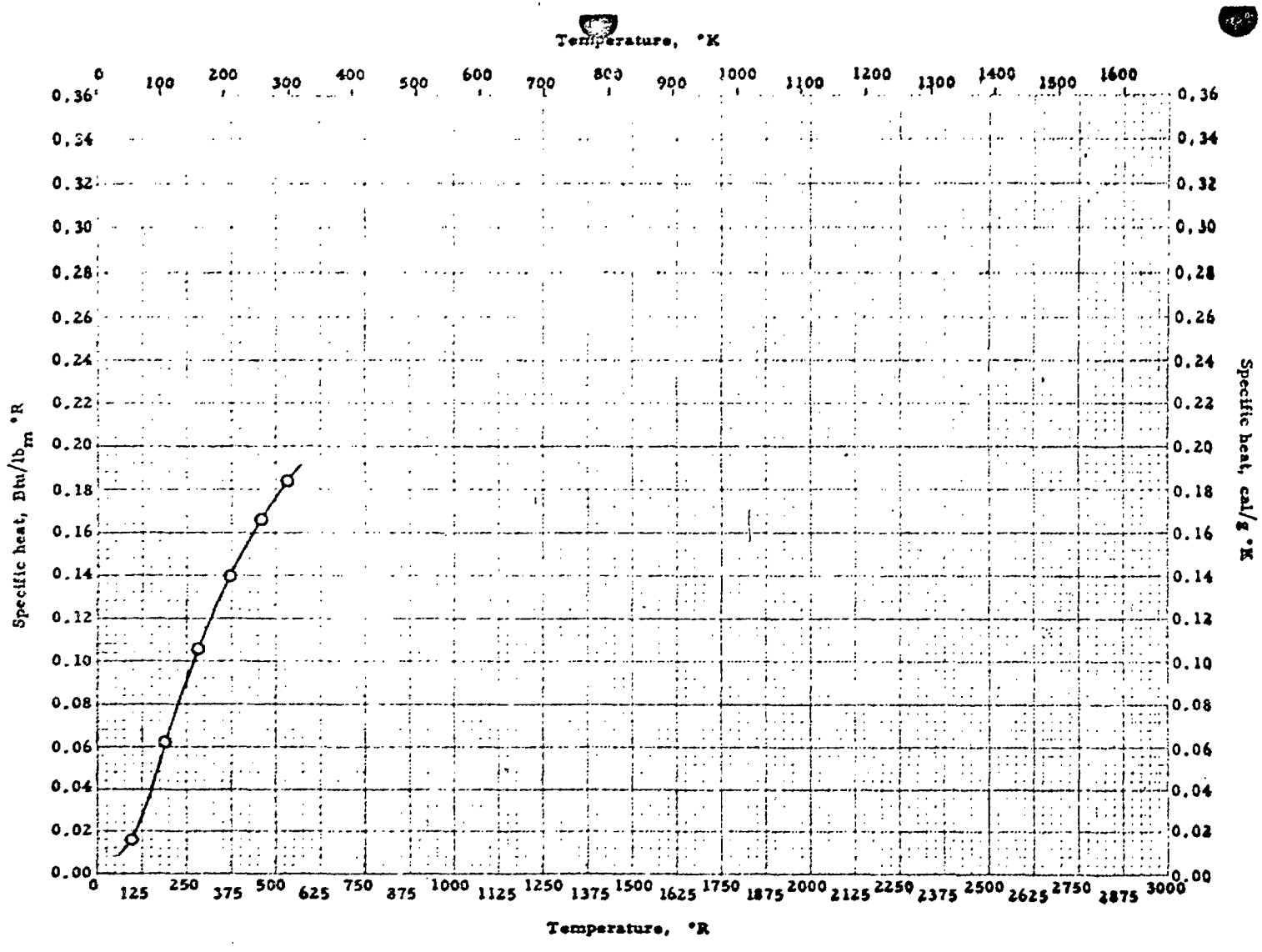


LINEAR THERMAL EXPANSION -- BERYLLIUM SILICATE

LINEAR THERMAL EXPANSION -- BERYLLIUM SILICATE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Penn. State	48-37	528-2292	$2BeO \cdot SiO_2$, synthetic phenacite	Not given	Decomposes at 1560°C into component oxides. Fired at 1600°C
□	Ibid.	48-37	528-2292	Same as above	Same as above	Decomposes at 1560°C into component oxides. Fired at 1560° C
△	Ibid.	48-37	528-2292	Same as above	Same as above	Decomposes at 1560° C into component oxides. Fired at 1500° C

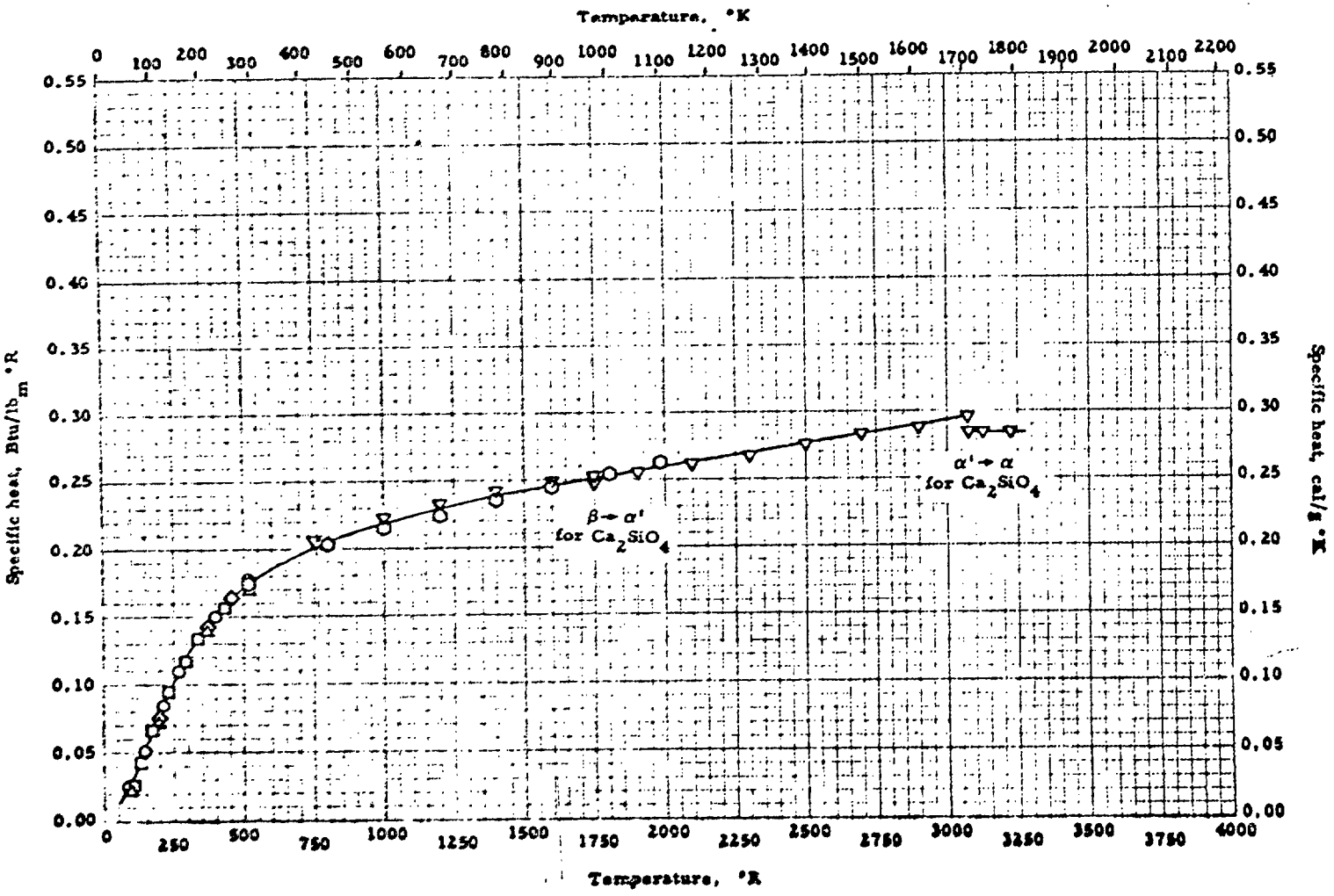


SPECIFIC HEAT -- CALCIUM MAGNESIUM SILICATE

SPECIFIC HEAT -- CALCIUM MAGNESIUM SILICATE

REFERENCE INFORMATION

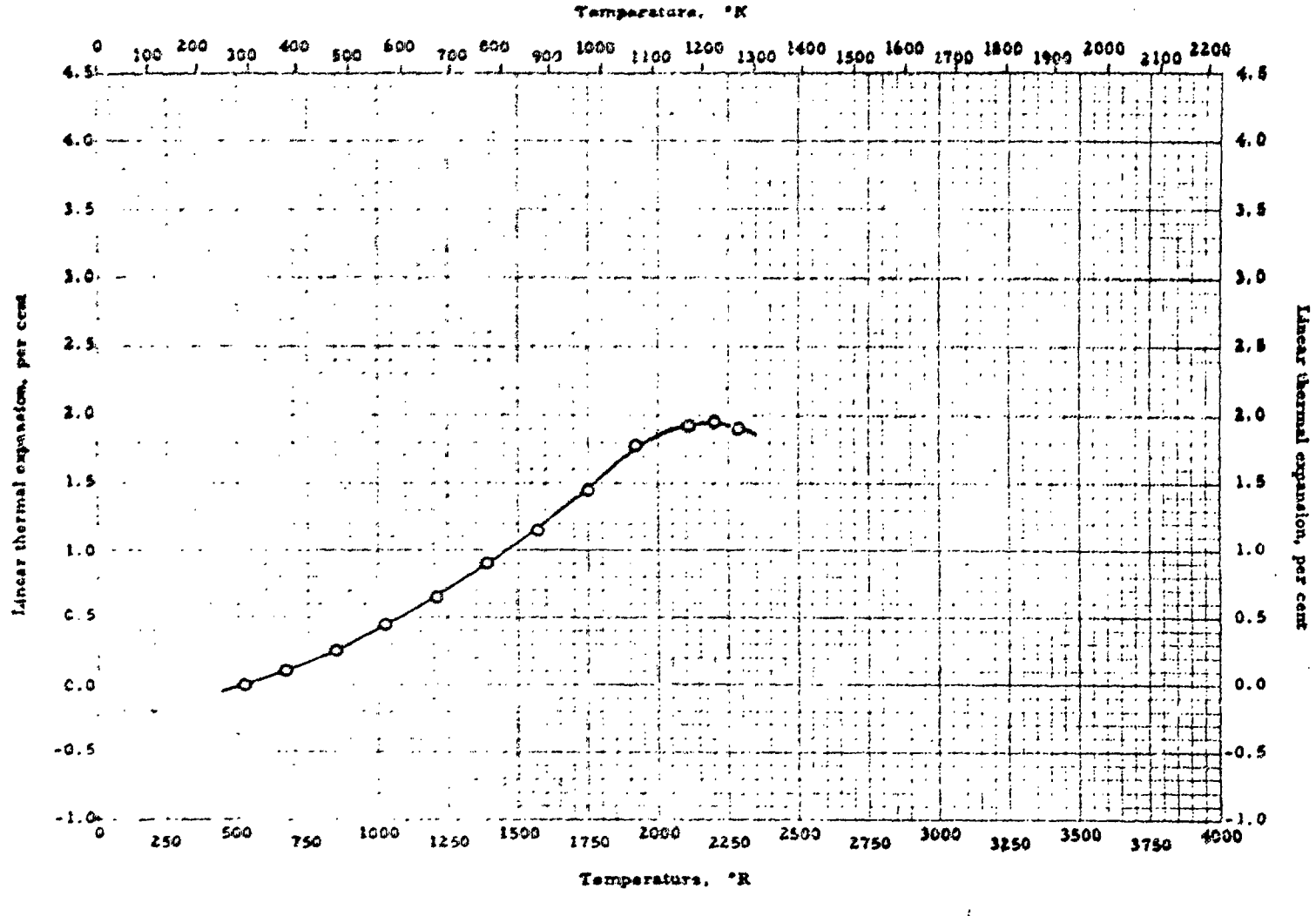
Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	King, E. G.	57-44	90-536	Calcium magnesium silicate, $CaMg(SiO_4)_2$; 54.78% silica; 25.91% lime; 18.82% magnesia; 0.68% ferric oxide; 0.07% ferrous oxide	Guarded sample	



SPECIFIC HEAT -- CALCIUM SILICATE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Todd, S.S.	51-30	96-537	Tricalcium silicate, Ca_3SiO_5. 73.64% CaO (cf. theor. 73.69%); 26.21% SiO_2 (cf. theor. 26.31%); 0.13% ea. Fe_2O_3, Al_2O_3; 0.11% MgO; 0.05% ignition loss	Guarded sample	
□	Ibid.	51-30	96-537	Calcium orthosilicate, crystalline Ca_2SiO_4, β-phase. 64.47% CaO (cf. theor. 65.13%); 34.68% SiO_2 (cf. theor. 34.87%); 0.32% ea. Fe_2O_3, Al_2O_3; 0.14% MgO; 0.02% ignition loss	Same as above	
△	King, E.G.	57-44	90-536	Calcium orthosilicate, Ca_2SiO_4; γ-phase	Guarded sample	
◇	Ibid	57-44	90-536	Tricalcium disilicate, $Ca_3Si_2O_7$, 58.37% lime; 41.62% silica	Same as above	
▽	Coughlin, J.P. and O'Brien, C.J.	57-87	731-3269	Calcium orthosilicate, Ca_2SiO_4, β type. 64.47% CaO; 34.68% silica; 0.32% Al and Fe oxides; 0.14% MgO; 0.02% H_2O	Drop method; copper block calorimeter	
○	Ibid.	57-87	730-2004	Calcium orthosilicate, Ca_2SiO_4, γ type, 34.88% silica	Same as above	Prepared from reagent grade calcium carbonate and silic

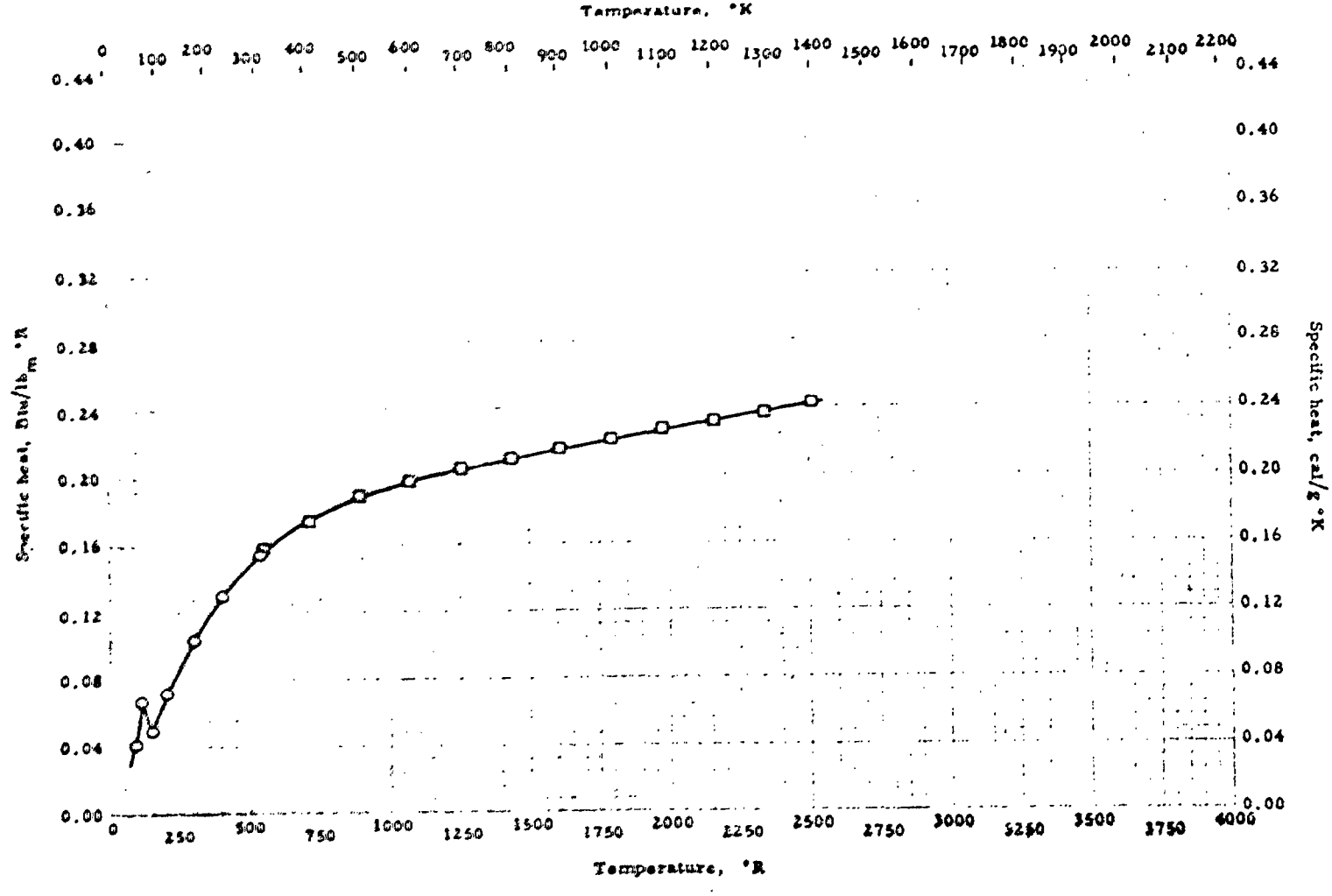


LINEAR THERMAL EXPANSION -- SODIUM CALCIUM SILICATE (Na_2CaSiO_4)

LINEAR THERMAL EXPANSION -- SODIUM CALCIUM SILICATE (Na_2CaSiO_4)

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Hummel, F. A.	49-14	528-2292	34.8% Na_2O; 33.7% SiO_2; 31.5% CaO; prepared from c.p. Na_2CO_3, c.p. $CaCO_3$, pottery flint	Fused silica dilatometer	Wet milled in acetone 12 hr., heated 50 hr. at 1100°C, pressed from 80 mesh, sintered 1 hr. at 1100°C



SPECIFIC HEAT -- IRON SILICATE

SPECIFIC HEAT -- IRON SILICATE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Kelley, K. K.	41-15	94-532	Fe_2SiO_4; 54.5% Fe (cf. theor. 54.8%); 29.5% silica; ρ = 271 lb_m/ft^3	Guarded sample	
□	Orr, R. L.	51-87	540-2680	Fe_2SiO_4; 54.5% Fe (cf. theor. 54.8%); 29.5% silica; ρ = 271 lb_m/ft^3	Drop method	

PROPERTIES OF MAGNESIUM SILICATE

MOST PROBABLE VALUES

Property	Brit. Engineering Units	C. G. S. Units
Density, Forsterite . . .	191 lb_m/ft^3	3.06 g/cm^3
Melting Point, Forsterite	3790°R*	2160°K*
Heat of Fusion		
Heat of Vaporization. . .		
Heat of Sublimation . . .		

*Handbook of Chemistry and Physics (Ref. 59-2)

REPORTED VALUES

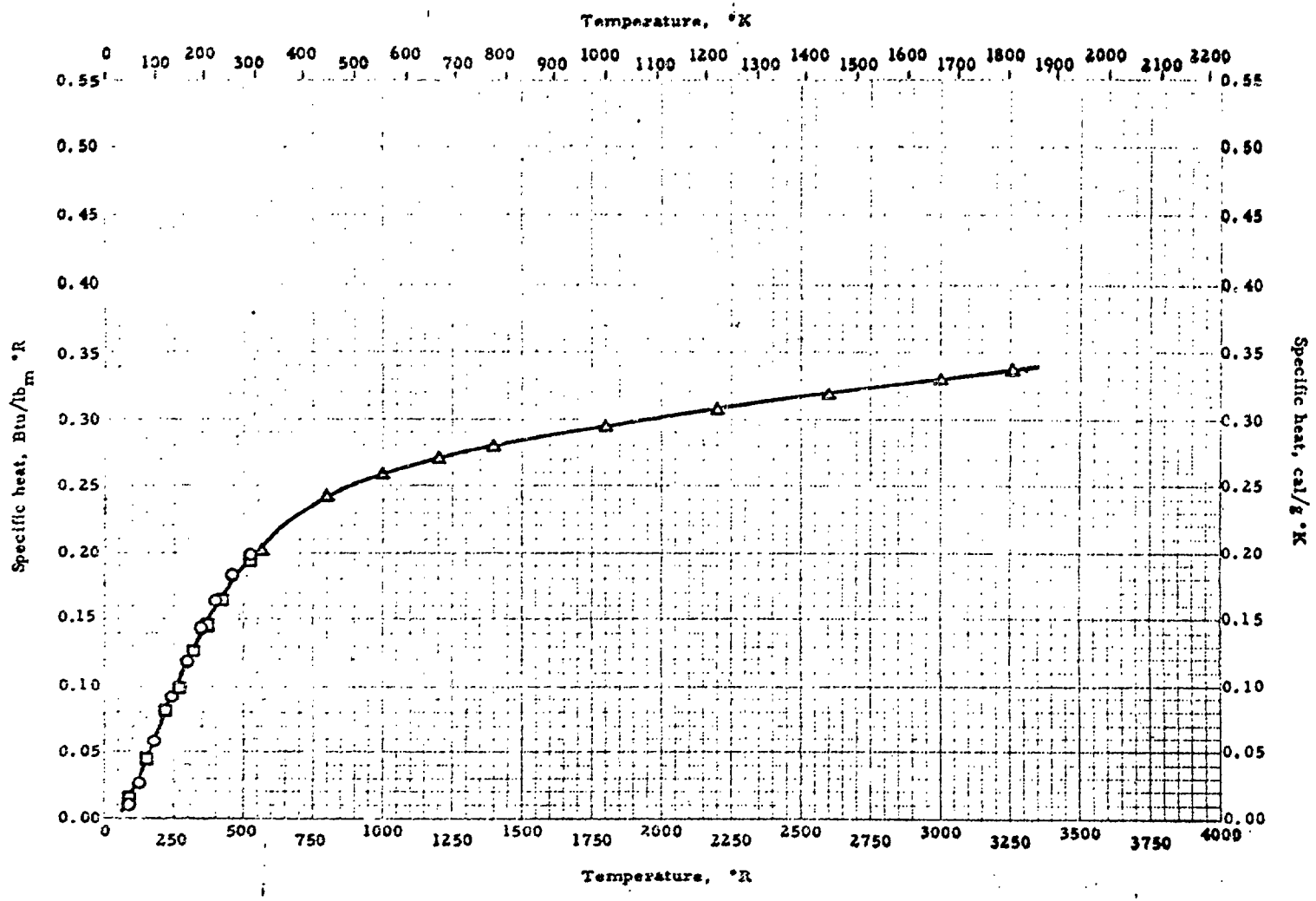
				Material Composition
Density:		lb_m/ft^3	g/cm^3	
	O	190.8 ± 0.2	3.056 ± 0.004	Forsterite 243
	□	174.5 ± 0.5	2.796 ± 0.005	Steatite
Melting Point:		°R	°K	
Heat of Fusion:		Btu/lb_m	cal/g	
Heat of Vaporization:		Btu/lb_m	cal/g	
Heat of Sublimation:		Btu/lb_m	cal/g	

AVCO TR 59-116 AD-105

PROPERTIES OF MAGNESIUM SILICATE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Oak Ridge National Laboratory	57-150	537	Forsterite 243	ρ: weight in air and in kerosene	Measured by O. Sisman, C. D. Bopp and R. L. Towns
□	Ibid.	57-150	537	Steatite	ρ: same as above	Same as above

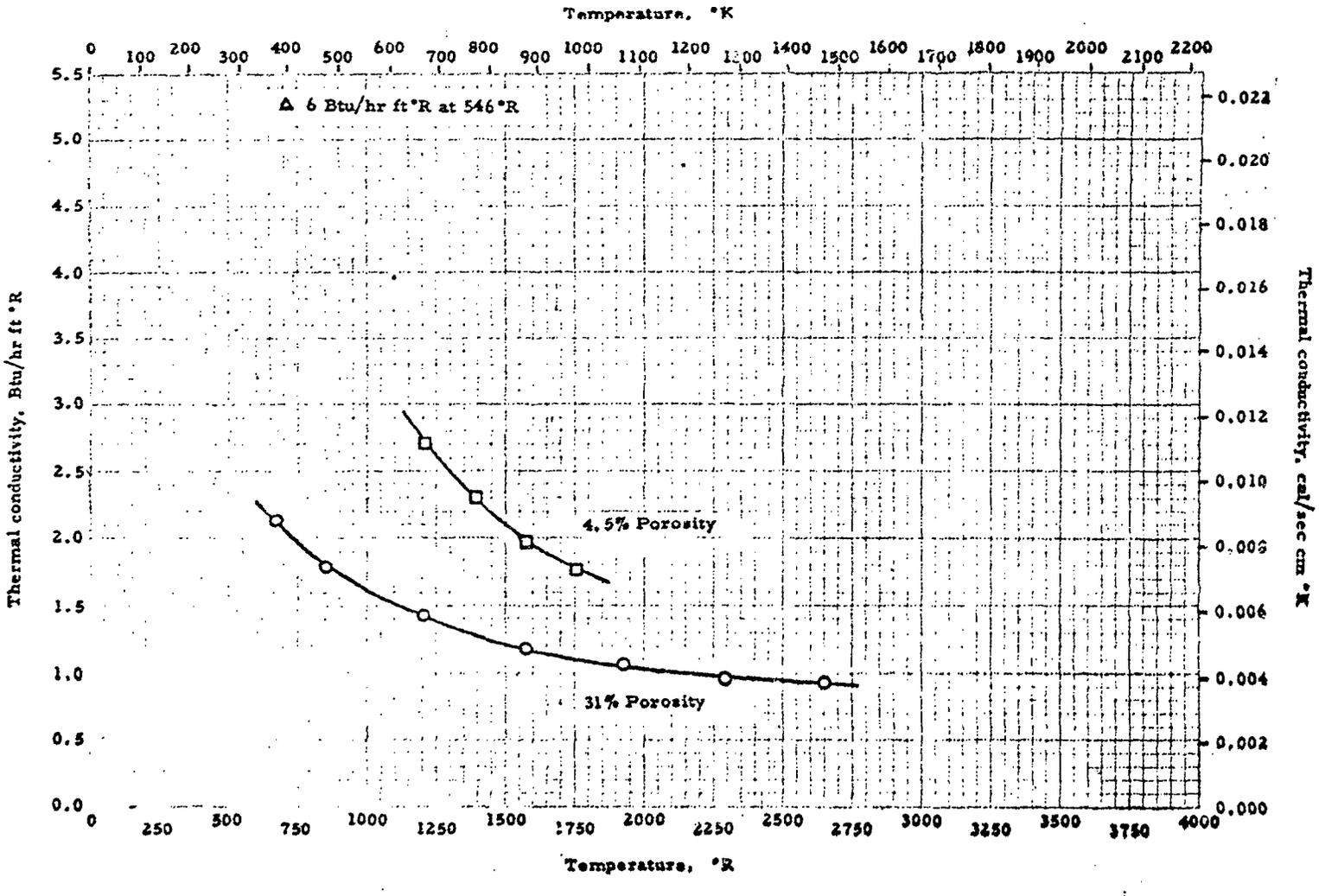


SPECIFIC HEAT -- MAGNESIUM SILICATE

SPECIFIC HEAT -- MAGNESIUM SILICATE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Kelley, K. K.	43-8	96-532	Magnesium orthosilicate, Mg_2SiO_4. 98.6% Mg_2SiO_4; 0.8% uncombined MgO; no free silica or $MgSiO_3$	Guarded sample	Corrected for uncombined MgO. Effect on c_p: 0.31%
□	Ibid.	43-8	96-532	Magnesium metasilicate, $MgSiO_3$. 92.0% $MgSiO_3$; 5.6% Mg_2SiO_4; 2.4% uncombined silica	Same as above	Corrected for uncombined silica. Effect on c_p: 1.26%
△	Orr, R. L.	53-87	716-3254	Magnesium orthosilicate Mg_2SiO_4; 57.51% MgO; 42.60 SiO_2	Drop method	Auth. est. scatter ± 0.4%

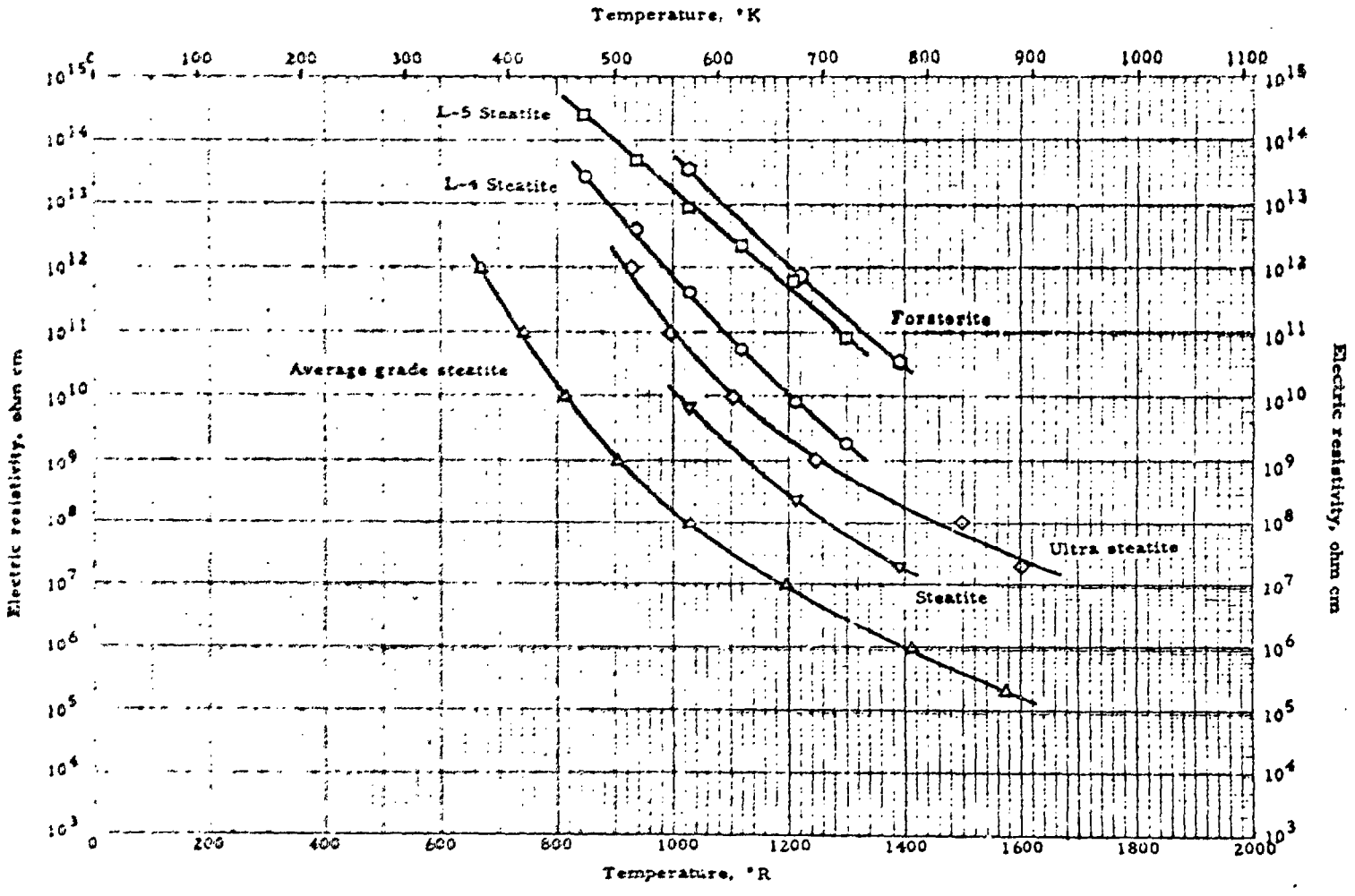


THERMAL CONDUCTIVITY -- MAGNESIUM SILICATE

THERMAL CONDUCTIVITY -- MAGNESIUM SILICATE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Kingery, W.D. and Francl, J.	53-65 also 53-66 54-1	672-2652	Forsterite, Mg_2SiO_4. 59% MgO; 41% SiO_2; bulk ρ = 139 lb_m/ft^3 (*cf.* theor. ρ = 200); porosity = 31.1%	Ellipsoidal envelope	Fired at 1650 °C
□	Francis, R.K., McNamara, E.P. and Tinklepaugh, J.R.	58-7	1212-1752	Forsterite, ρ = 191 lb_m/ft^3	Comparative; rods	
△	Oak Ridge National Laboratory	57-150	546	Forsterite 243.	Not described here, refers to others	Auth. *est.* accuracy ± 20%. Meas. by O. Sisman, C. D. Bopp and R. L. Towns

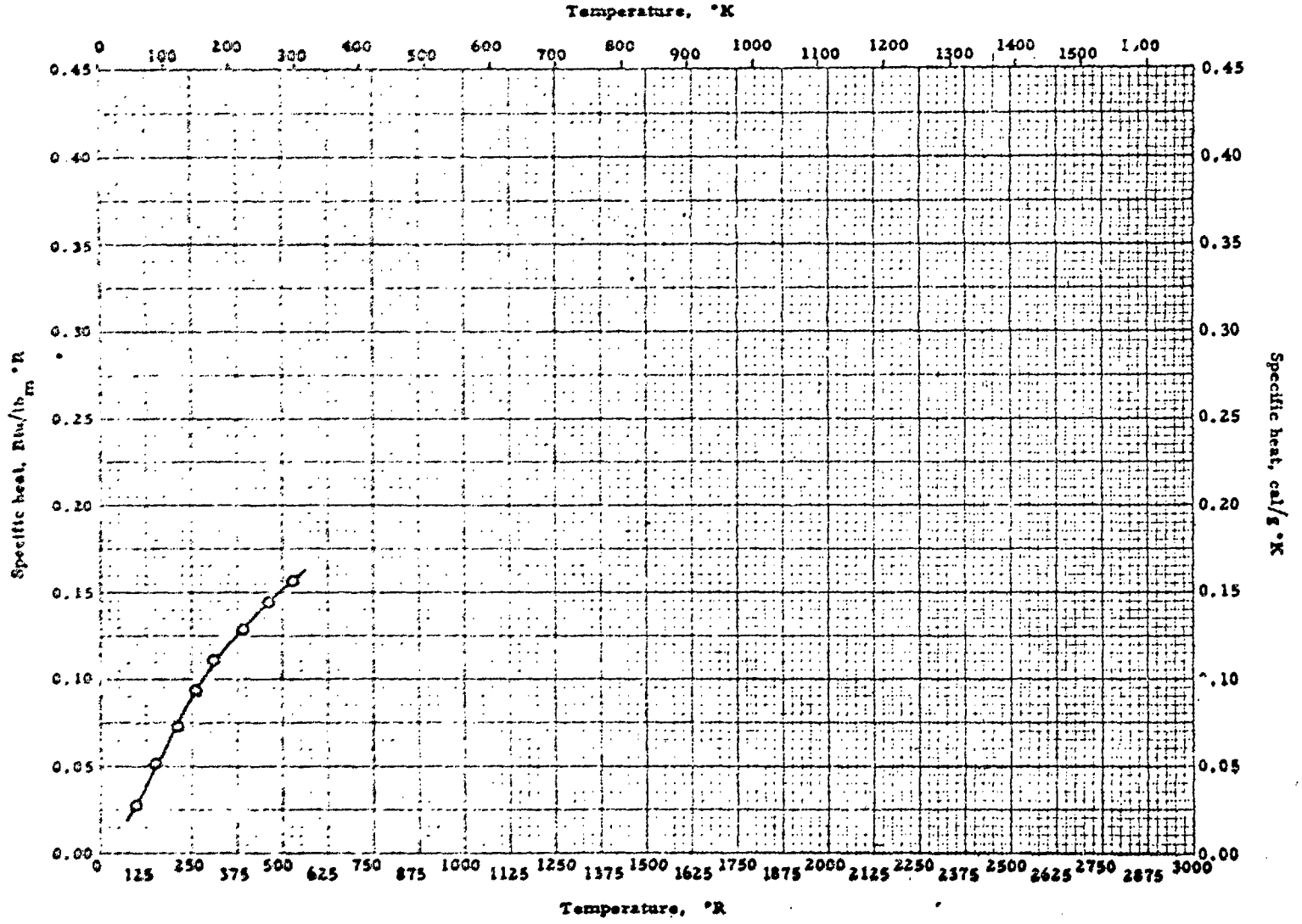


ELECTRIC RESISTIVITY -- MAGNESIUM SILICATE

ELECTRIC RESISTIVITY -- MAGNESIUM SILICATE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Comeforo, J. E. and Hatch, R. A.	54-93	652-1302	Steatite; grade L-4; AlSiMag 196	High resistance DC bridge	
□	Ibid.	54-93	852-1302	Steatite; grade L-5; Pass and Seymour E-211-M	Same as above	
△	Russel Jr., R. and Berberich, L. J.	44-6	672-1572	Commercial steatite; average grade	Potential drop	
◇	Ibid.	44-6	933-1661	Commercial ultra-steatite; low loss type	Same as above	
▽	Hauth, W. E.	56-75	1032-1392	Steatite	Resistance bridge. Temp. measured by thermocouple	
○	Ibid.	56-75	1032-1392	Forsterite, Magnesium silicate	Same as above	

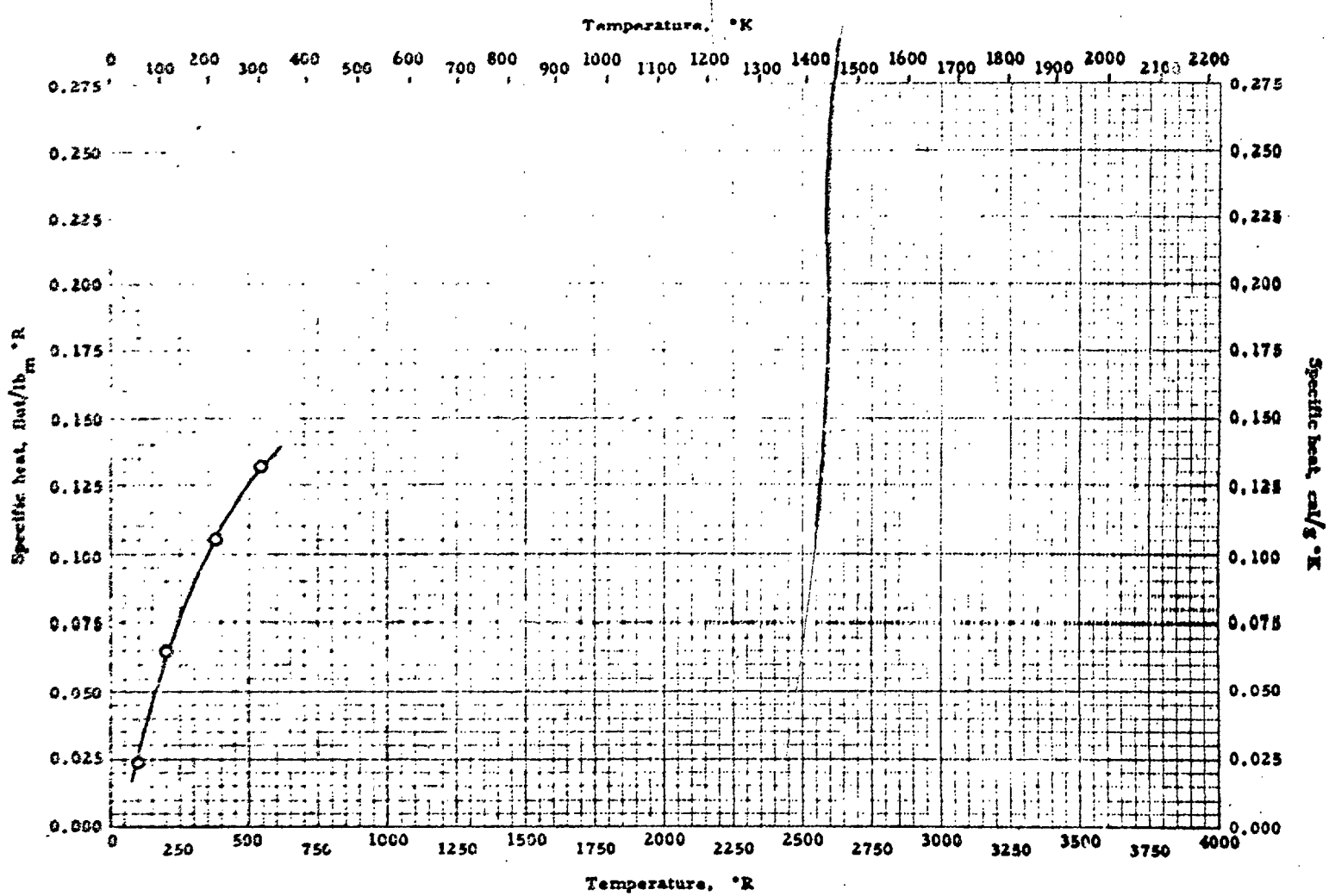


SPECIFIC HEAT -- MANGANOUS SILICATE

SPECIFIC HEAT -- MANGANOUS SILICATE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Kelley, K. K.	41-15	95-531	54.16% MnO (cf. theor. 54.15%); ρ = 230 lb_m/ft^3	Guarded sample	



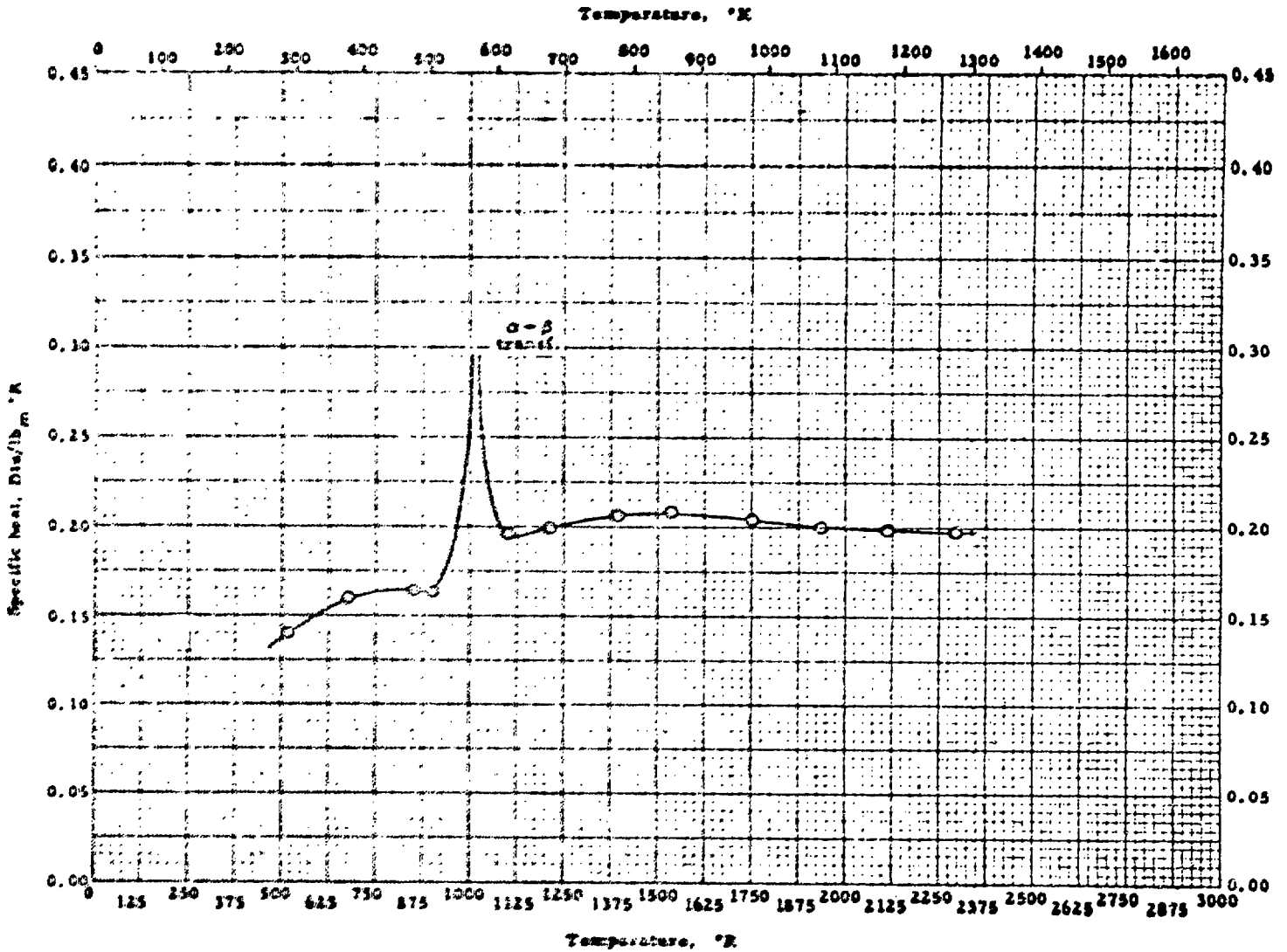
SPECIFIC HEAT -- ZINC SILICATE

WADC TR 58-476 (1951-65)

SPECIFIC HEAT -- ZINC SILICATE

REFERENCE INFORMATION

Curve Symbol	Investigator	Ref.	Range, °K	Material Composition	Test Method	Remarks
O	Todd, S. S.	51-30	96-536	Zinc Orthosilicate, Zn_2SiO_4 Willemite; 72.95% ZnO (cf. theor. 73.05%); 26.92% SiO_2 (cf. theor. 26.95%); remainder impurities, probably Fe_2O_3, Al_2O_3, MgO	Guarded sample	

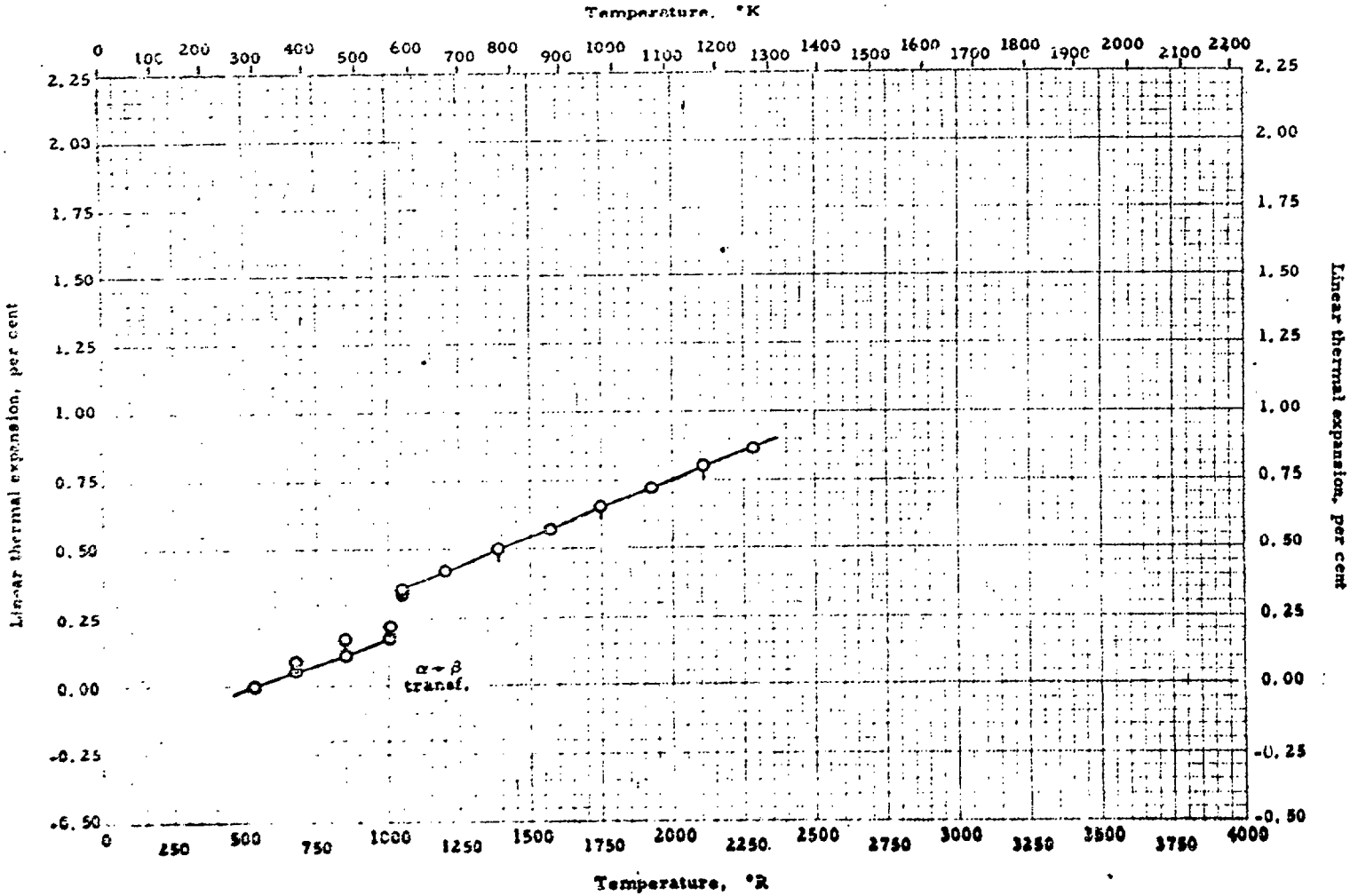


SPECIFIC HEAT -- BARIUM FELDSPAR

SPECIFIC HEAT -- BARIUM FELDSPAR

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °K	Material Composition	Test Method	Remarks
O	Yoshiki, B. and Matsumoto, K.	51-14	310-1294	41.96% BaO; 29.86% SiO_2; 25.67 Al_2O_3; 1.51% CaO; 0.94% Fe_2O_3; ρ = 256 lb$_m$/ft^3; prepared from $BaCO_3$ and kaolin. Nominal: $BaO \cdot Al_2O_3 \cdot 2SiO_2$	Not given	Mixed, kneaded, dried, precalcined at 800°C, electric arc melted, furnace cooled

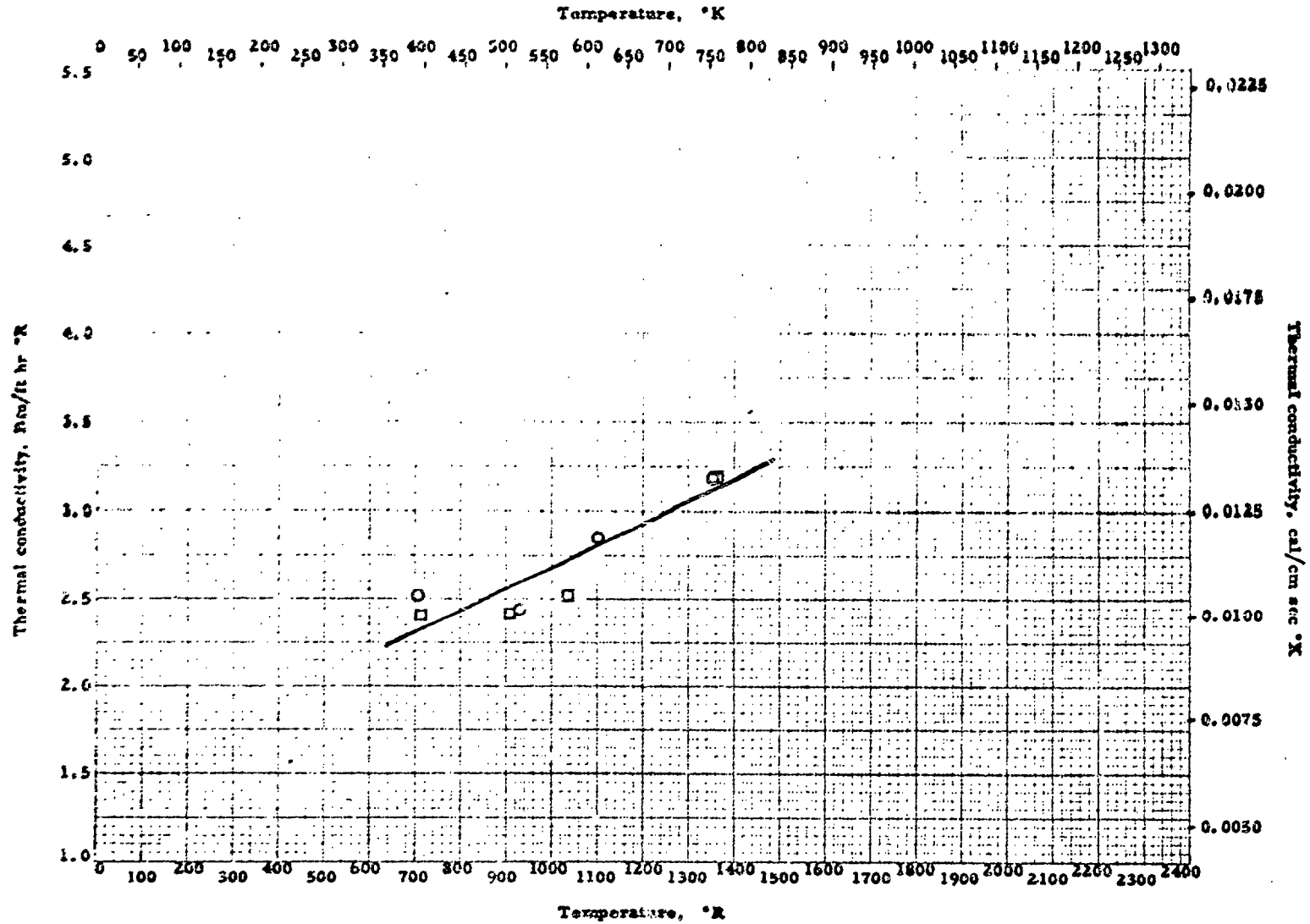


LINEAR THERMAL EXPANSION -- BARIUM FELDSPAR

LINEAR THERMAL EXPANSION -- BARIUM FELDSPAR

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Yoshiki, B. and Matsumoto, K.	51-24	528-2292	41.96% BaO; 29.86% SiO_2; 25.67% Al_2O_3; 1.53% CaO; 0.94% Fe_2O_3; trace of MgO; ρ = 206.2 lb_m/ft^3	Dilatometer	Synthesized from pure barium carbonate and Kaolin, mixed, kneaded, dried, precalcined at 800°C, melted in electric arc furnace, furnace cooled O : heating Q : cooling



THERMAL CONDUCTIVITY -- BERYLLIUM ALUMINOSILICATE

60-627
WADC TR 58-476
495
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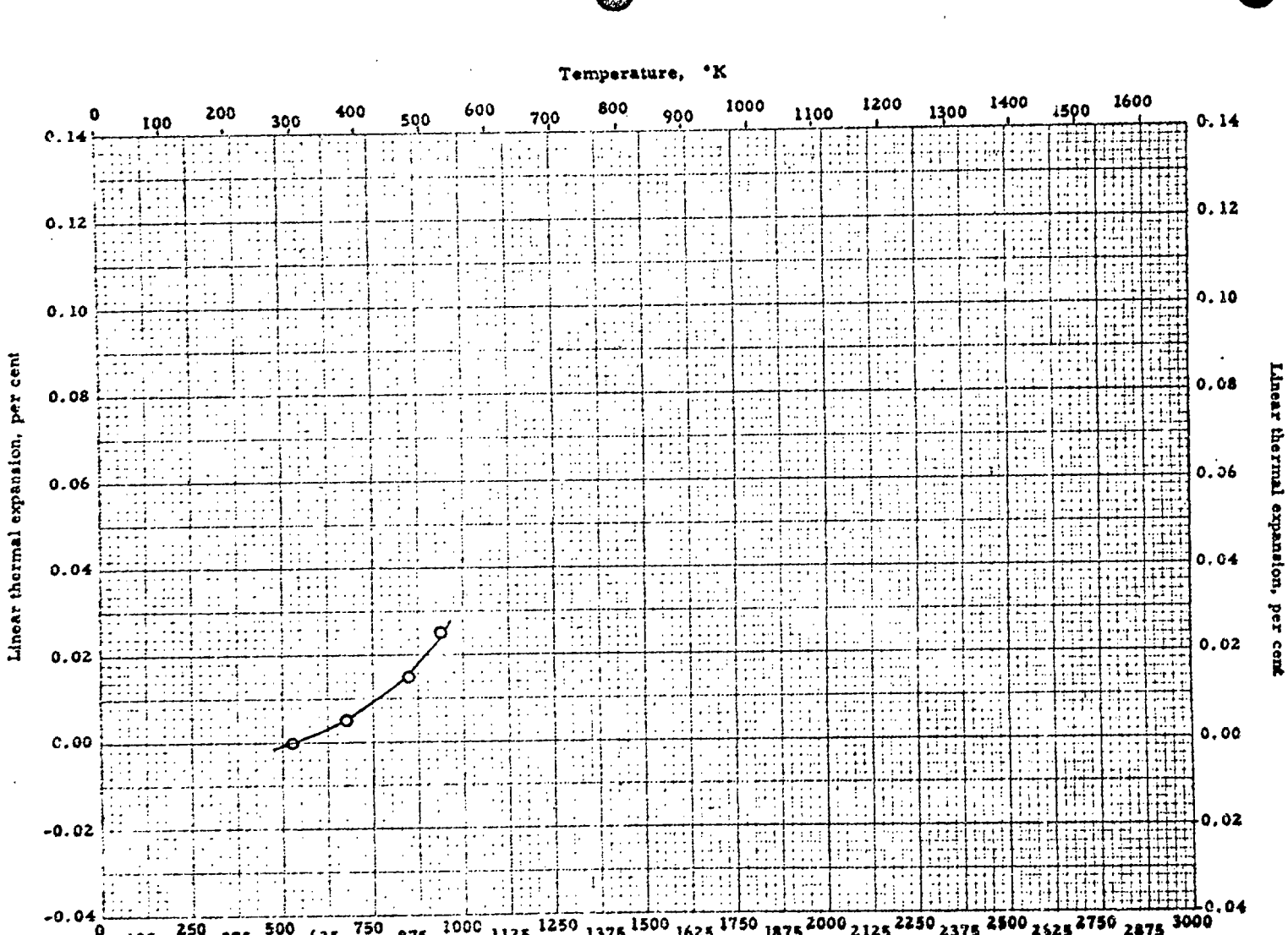
THERMAL CONDUCTIVITY -- BERYLLIUM ALUMINOSILICATE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Knapp, W. J.	43-11	708-1358	Beryl (Brazil), $3BeC \cdot Al_2O_3 \cdot 6SiO_2$	Comparative, rods. Temp. by Chromel-Constantan thermocouple	Meas. parallel to c axis
□	Ibid.	43-11	719-1361	Same as above	Same as above	Meas. normal to c axis

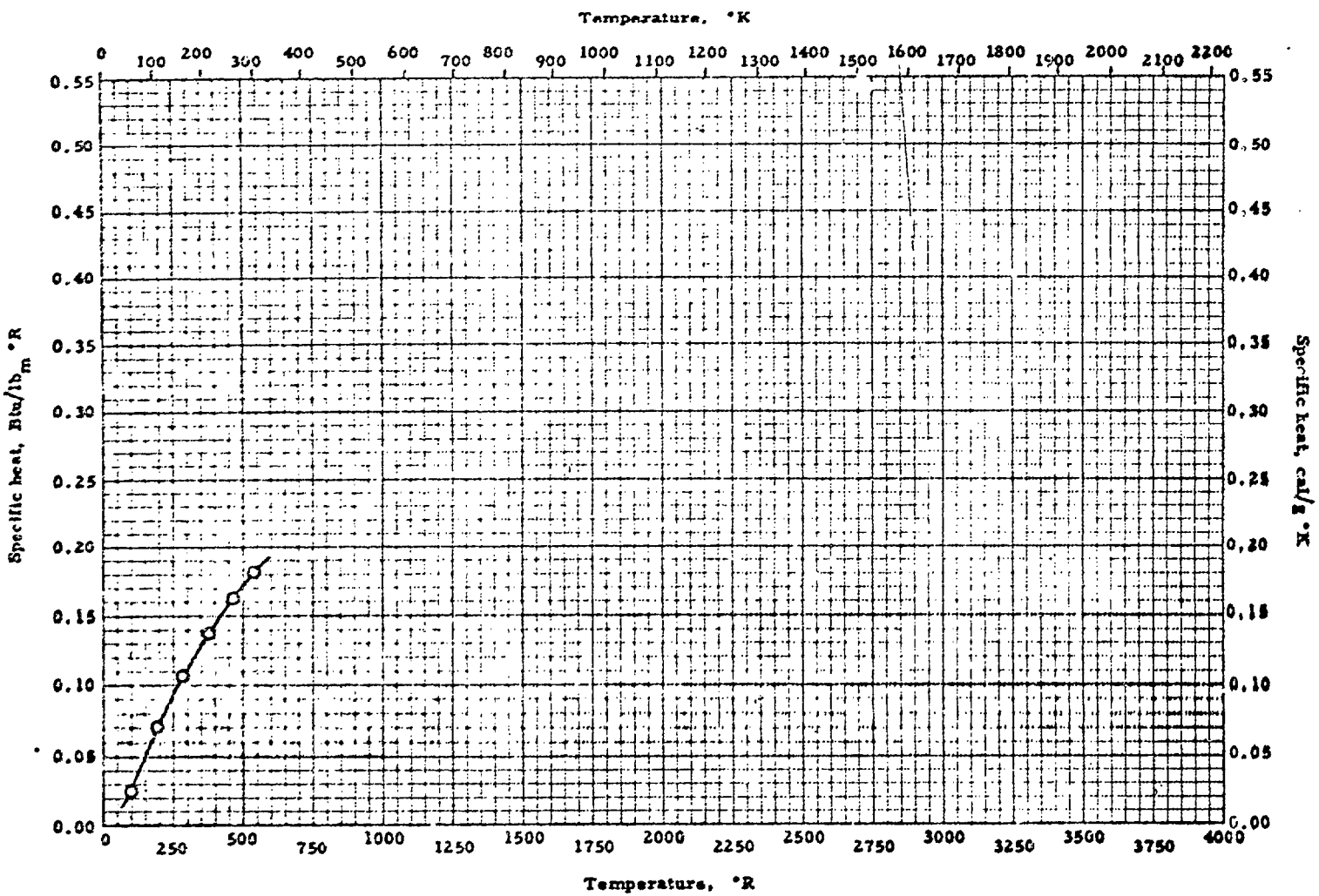


LINEAR THERMAL EXPANSION -- BERYLLIUM ALUMINOSILICATE

LINEAR THERMAL EXPANSION -- BERYLLIUM ALUMINOSILICATE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Durbin, E. A. and Harman, C. G.	52-31	528-942	Beryl	Interferometer	Meas. parallel to c-axis

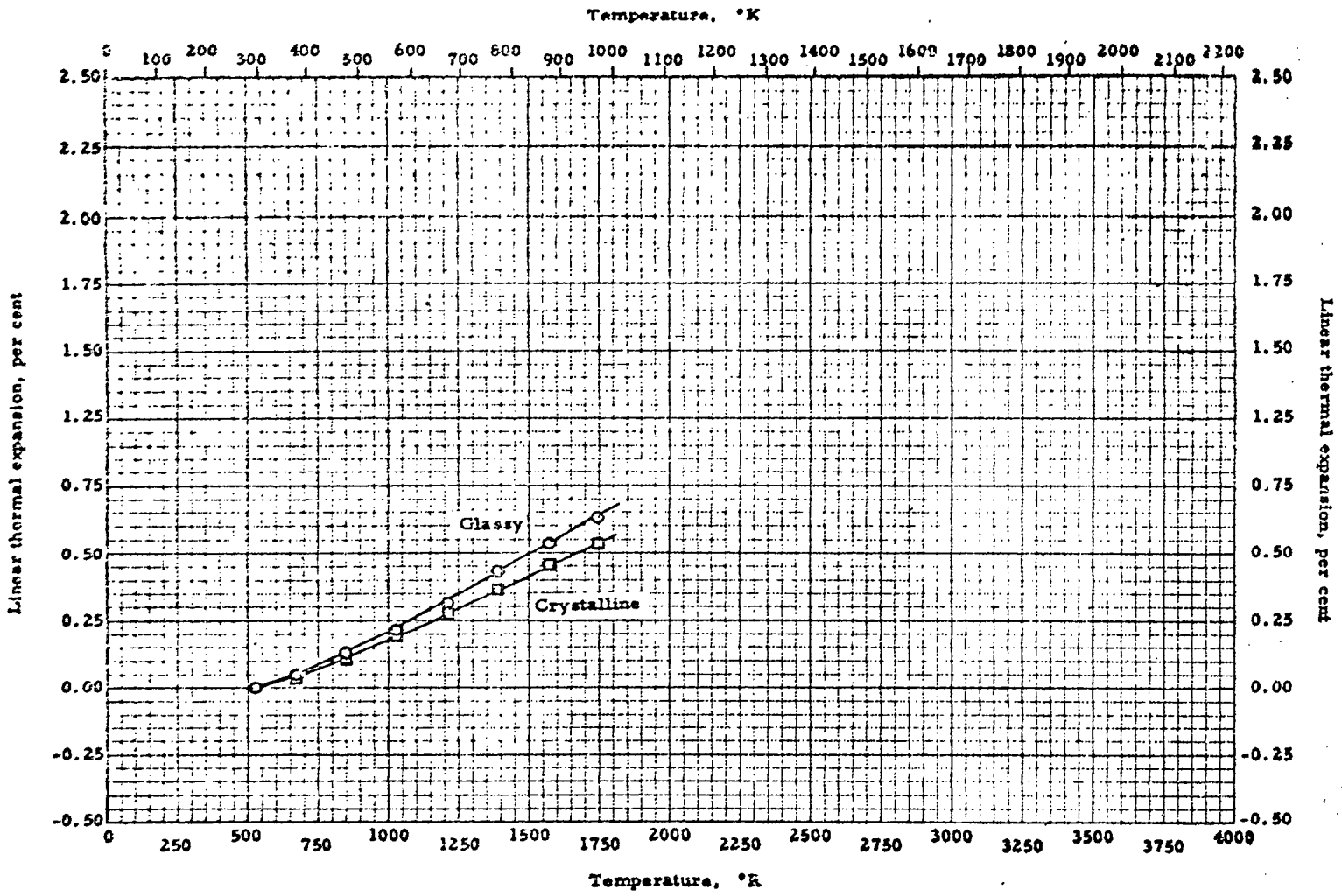


SPECIFIC HEAT -- CALCIUM FELDSPAR

SPECIFIC HEAT -- CALCIUM FELDSPAR

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	King, E. G.	57-44	90-536	43.02% SiO_2; 36.64% Al_2O_3; 20.10% CaO; 0.20% Fe_2O_3	Guarded sample	

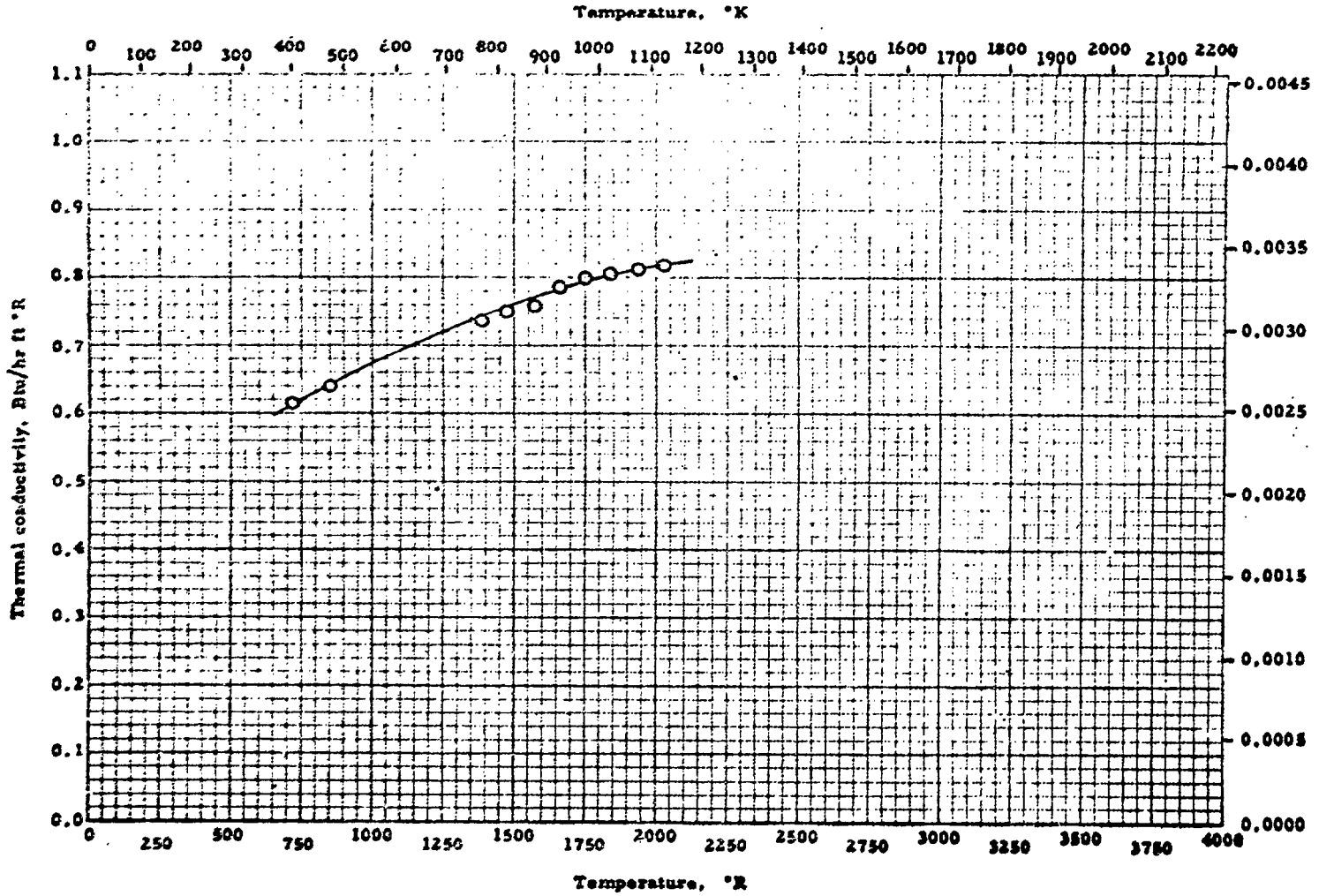


LINEAR THERMAL EXPANSION -- CALCIUM FELDSPAR

LINEAR THERMAL EXPANSION -- CALCIUM FELDSPAR

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Orlowski, H. J., and Koenig, C. J.	41-10	528-1752	50.68% SiO_2; 30.67% Al_2O_3; 13.79% CaO; 3.4% Na_2O; 0.50% Fe_2O_3; 0.42% MgO; 0.09% K_2O; 0.07% TiO_2; glassy state	Interferometer	Annealed 1 hr. at 10°C below softening point, cooled in 15 hr.
□	Ibid.	41-10	528-1752	Same as above; crystalline state	Fused quartz dilatometer	Extruded rod plasticized with small amount of gum, air dried, oven dried at 230°F, fired at cone 06

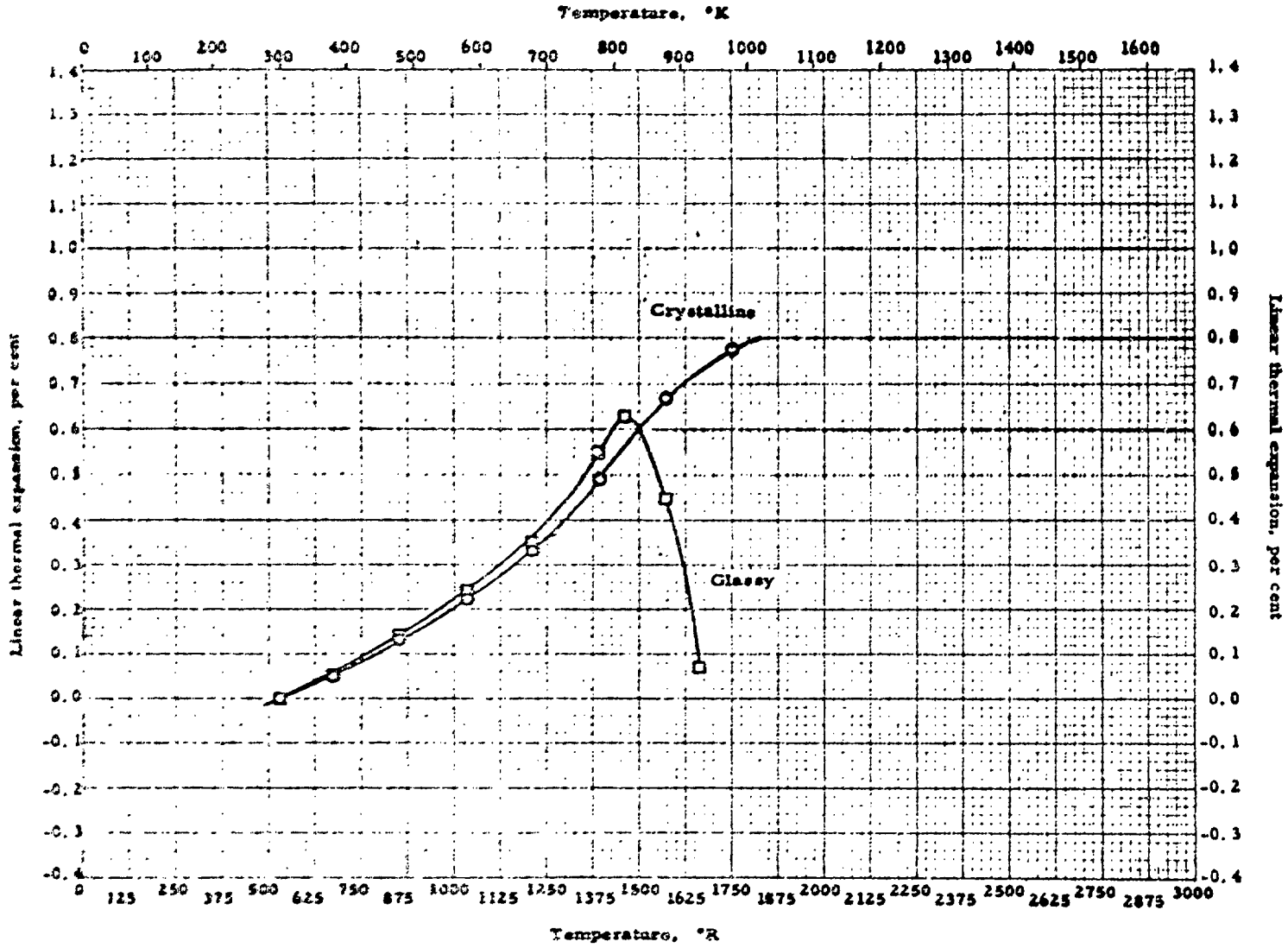


THERMAL CONDUCTIVITY -- LITHIUM FELDSPAR

THERMAL CONDUCTIVITY -- LITHIUM FELDSPAR

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Eussem, W.R. and Bush, E.A.	55-10	717-2022	β-Spodumene. 57.8% pottery flint; 24.5% Al_2O_3; 17.7% Li_2CO_3	Radial heat flow in cylinder	Fired 5 hr. at 1345°C

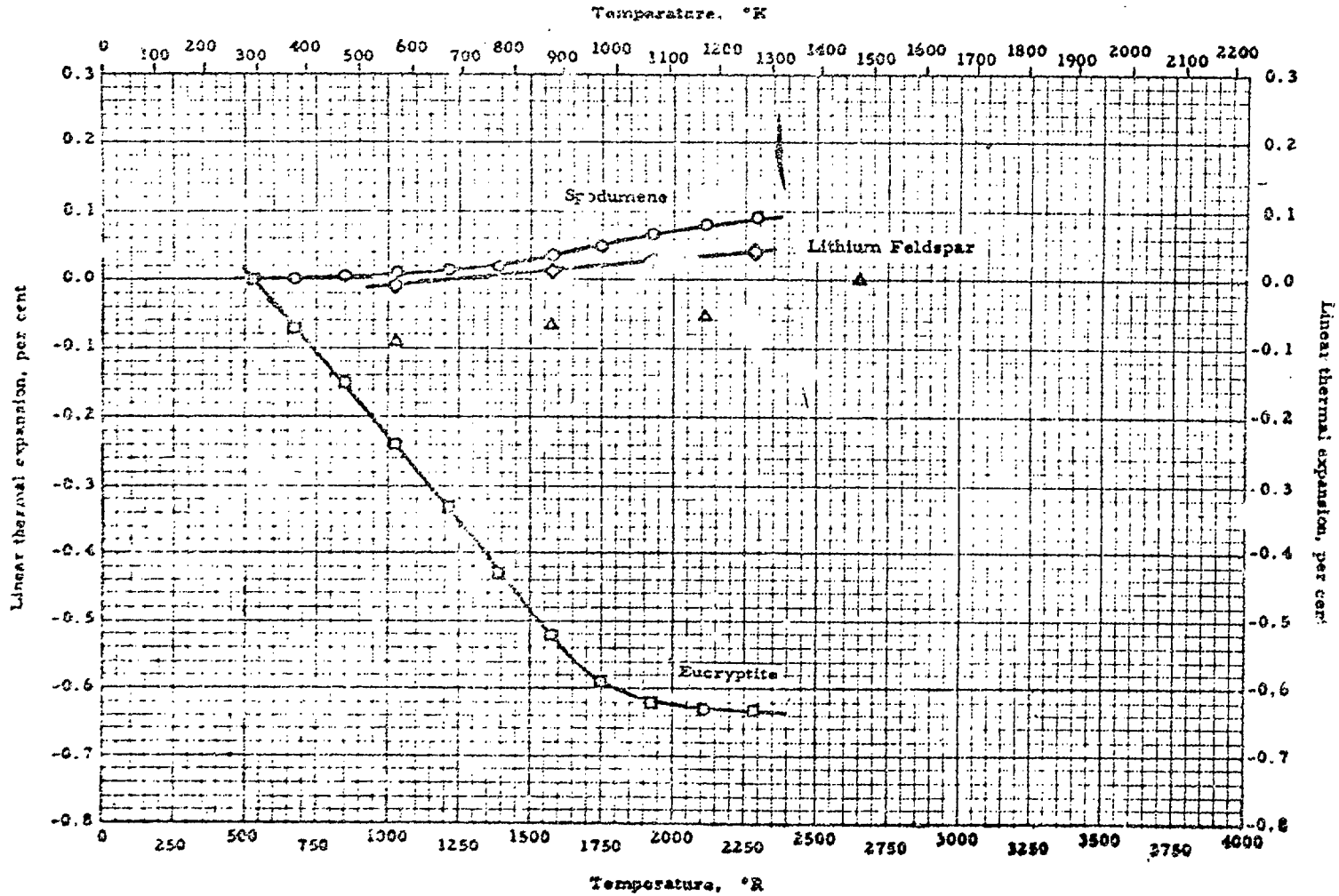


LINEAR THERMAL EXPANSION -- LITHIUM POTASSIUM FELDSPAR

LINEAR THERMAL EXPANSION -- LITHIUM POTASSIUM FELDSPAR

REFERENCE INFORMATION

Curve ID	Investigator	Ref.	Range, °F	Material Composition	Test Method	Remarks
O	Hawkes, H. J., and Koenig, C. J.	41-10	528-1662	52.8% SiO_2; 26.77% Al_2O_3; 10.33% K_2O; 4.65% Li_2O; 3.68% F; 0.92% CaO; 0.59% MnO_2; 0.31% MgO; 0.19% Fe_2O_3; 0.13% Na_2O; crystalline state	Quartz tube dilatometer	Extruded rod plasticized with small amount of gum, air dried, oven dried at 230°F, and fired at cone 06
□	Ibid.	41-10	528-1752	Same as above; glassy state	Interferometer	Annealed 1 hr. at 10°C below softening point



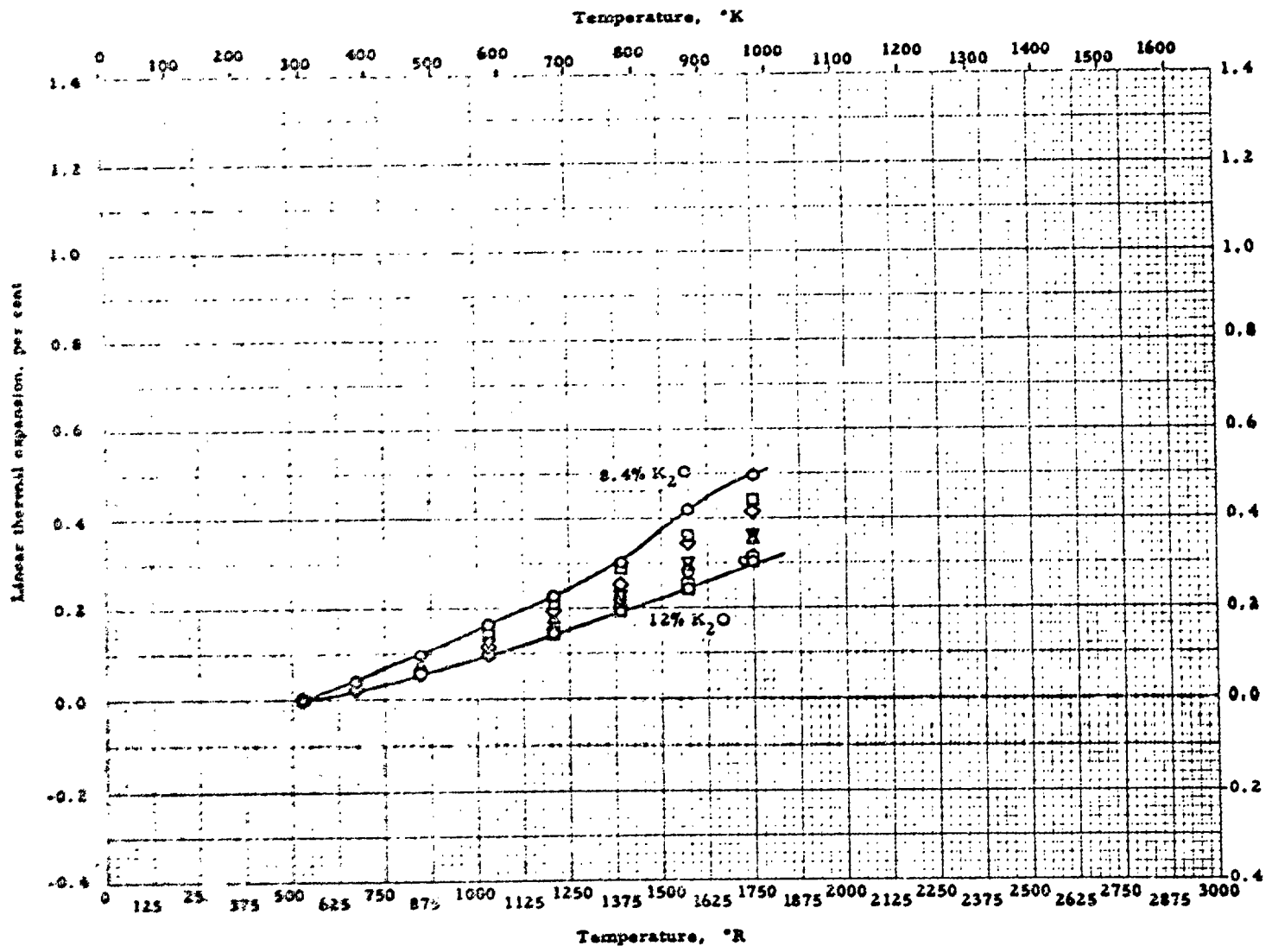
LINEAR THERMAL EXPANSION -- LITHIUM FELDSPAR

LINEAR THERMAL EXPANSION -- LITHIUM FELDSPAR

REFERENCE INFORMATION

Fig. No.	Investigator	Ref.	Temp. Range, °R	Material Composition	Test Method	Remarks
○	Hummel, F. A.	51-21	528-2292	Spodumene; 64.6% SiO_2; 27.4% Al_2O_3; 8.0% Li_2O; prepared from c.p. Li_2CO_3; c.p. Al_2O_3; potter's flint	Dilatometer	$(Li_2O \cdot Al_2O_3 \cdot 4SiO_2)$ 100 mesh calcined material pressed at 1000 lb/in² with Carbowax Methocel binder
□	Ibid.	51-21	528-2292	Eucryptite; 47.7% SiO_2; 40.5% Al_2O_3; 11.8% Li_2O; raw materials same as above	Same as above	$(Li_2O \cdot Al_2O_3 \cdot 2SiO_2)$ Prepared as above
△	Whittemore, O. J. and Ault, N. N.	56-7	1032-2652	Fine grain	Telemicroscopes sighting on pointed ends of sample	Probably spodumene
◇	Hummel, F. A.	51-21	528-2292	Lithium Feldspar ($Li_2O \cdot Al_2O_3 \cdot 6SiO_2$). Nominal: 73.2% SiO_2; 20.7% Al_2O_3; 6.1% Li_2O; prepared from c.p. Li_2CO_3, Al_2O_3, and potter's flint	Dilatometer	100-mesh calcined material pressed at 1000 psi using Carbowax Methocel binder

59-422 W ALIC TH 56-916 SDS

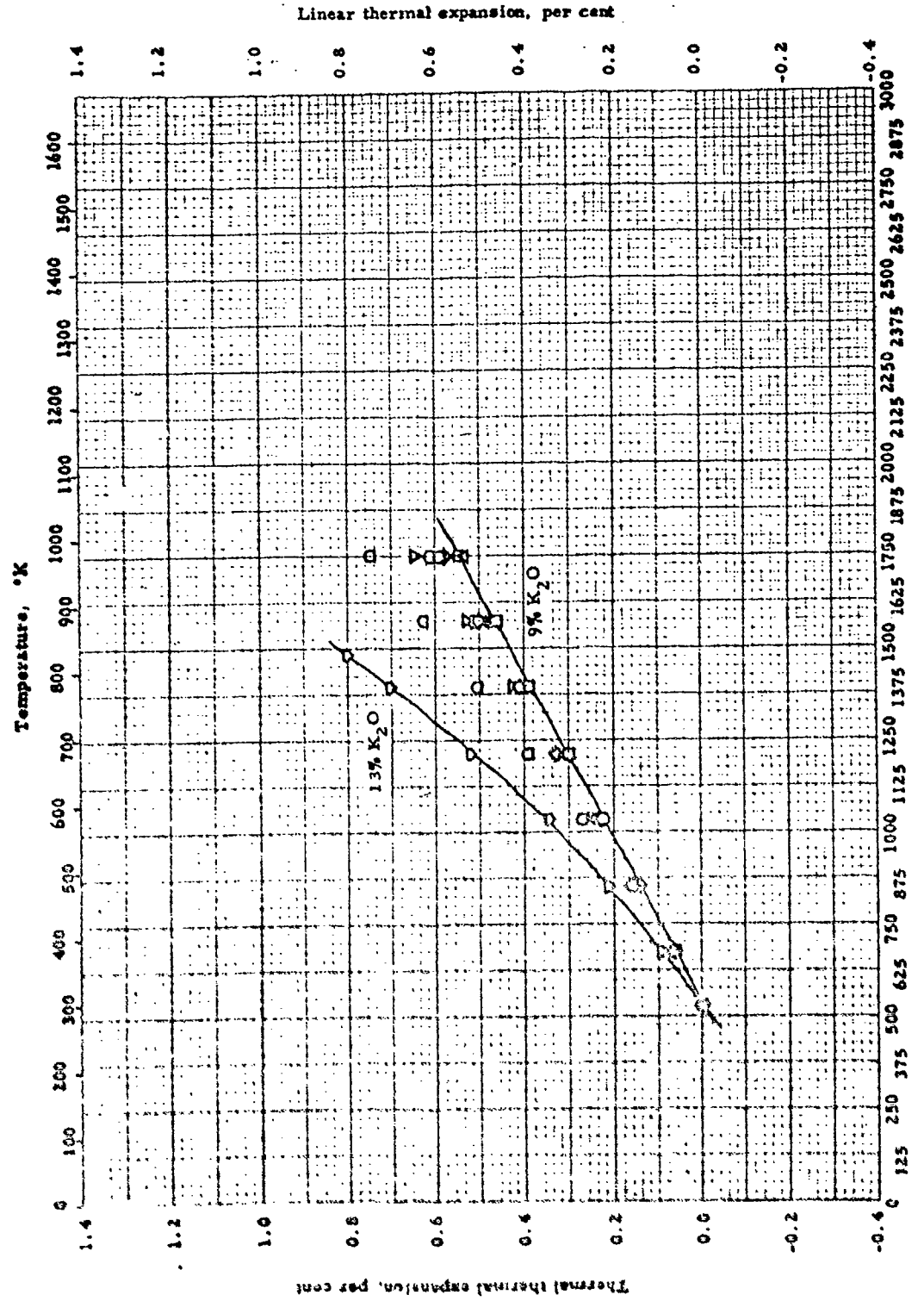


LINEAR THERMAL EXPANSION -- POTASSIUM FELDSPAR - ANISOTROPIC(CRYSTALLINE)

LINEAR THERMAL EXPANSION -- POTASSIUM FELDSPAR - ANISOTROPIC (CRYSTALLINE)

REFERENCE INFORMATION

Sym	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Orlowski, M. J. and Koenig, C. J.	41-10	528-1752	72.84% SiO_2; 15.4% Al_2O_3; 8.42% K_2O; 2.93% Na_2O; 0.27% CaO; 0.11% MgO, 0.11% Fe_2O_3; 0.03% TiO_2	Quarts tube dilatometer	Extruded rods plasticized with small amount of gum, air dried, oven dried at 230°F, and fired at cone 06
□	Ibid.	41-10	528-1752	66.3% SiO_2; 17.90% Al_2O_3; 10.14% K_2O; 3.67% Na_2O; 0.31% CaO; 0.07% Fe_2O_3	Same as above	Same as above
△	Ibid.	41-10	528-1752	66.04% SiO_2; 18.76% Al_2O_3; 10.73% K_2O; 3.56% Na_2O, 0.14% MgO; 0.09% TiO_2; 0.08% Fe_2O_3; 0.62% CaO	Same as above	Same as above
◇	Ibid.	41-10	528-1752	67.68% SiO_2; 18.87% Al_2O_3; 10.74% K_2O; 2.78% Na_2O; 0.49% CaO; 0.05% Fe_2O_3	Same as above	Same as above
▽	Ibid.	41-10	528-1752	64.70% SiO_2; 19.50% Al_2O_3; 11.21% K_2O; 4.19% Na_2O; 0.12% MgO; 0.11% CaO; 0.07% Fe_2O_3; trace of TiO_2	Same as above	Same as above
○	Ibid.	41-10	528-1752	67.8 % SiO_2; 17.27% Al_2O_3; 11.40% K_2O; 2.15% Na_2O; 0.42% MgO; 0.08% CaO; 0.07% Fe_2O_3	Same as above	Same as above
□	Ibid.	41-10	528-1752	65.33% SiO_2; 19.27% Al_2O_3; 12.36% K_2O; 2.67% Na_2O; 0.27% CaO; 0.08% Fe_2O_3; traces of TiO_2, MgO	Same as above	Same as above
▽	Ibid.	41-10	528-1752	65.90% SiO_2; 18.70% Al_2O_3; 13.00% K_2O; 1.70% Na_2O; 0.20% CaO; 0.08% Fe_2O_3; trace of MgO	Same as above	Same as above

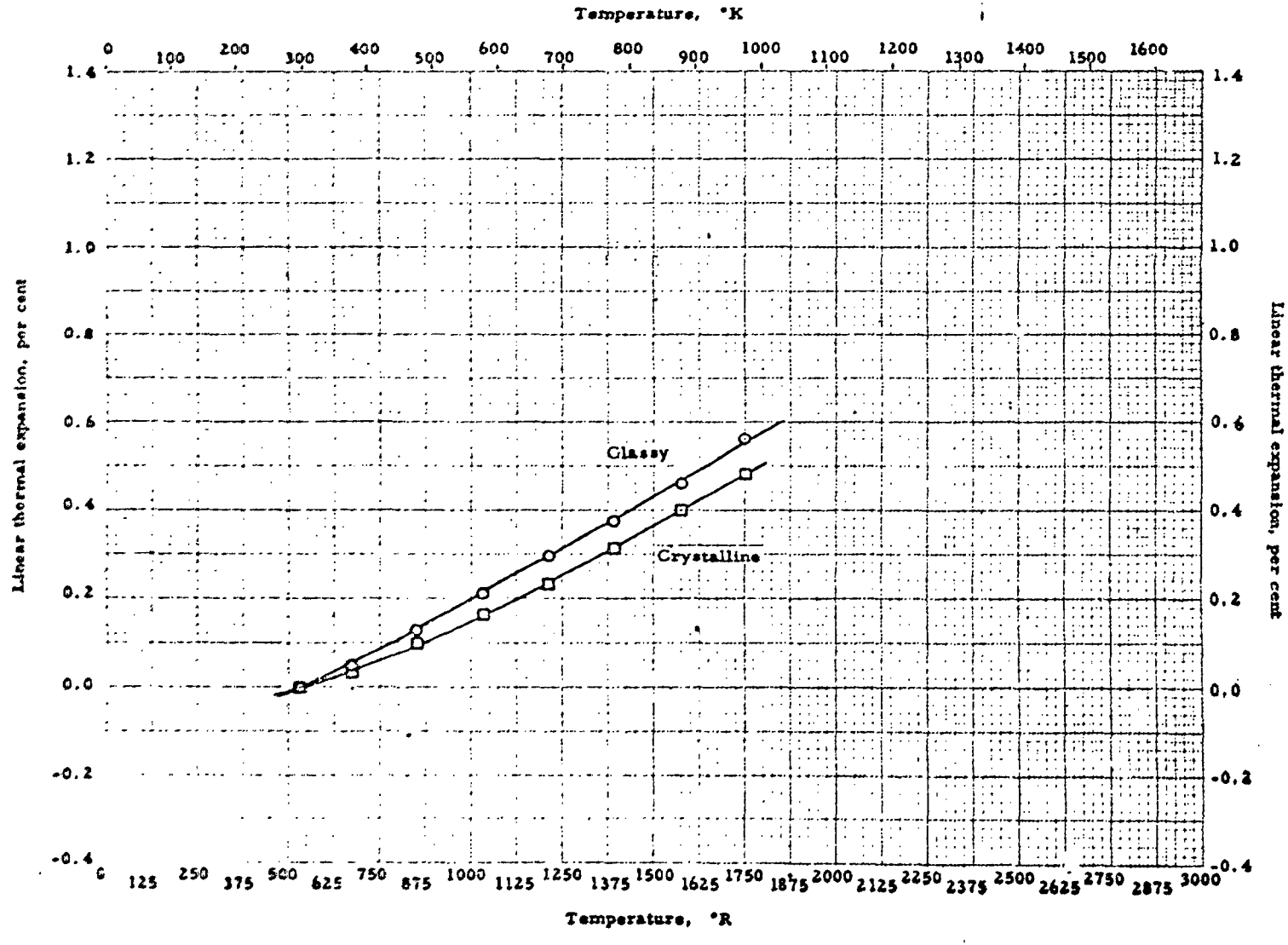


LINEAR THERMAL EXPANSION -- POTASSIUM FELDSPAR - ISOTROPIC (GLASSY)

LINEAR THERMAL EXPANSION -- POTASSIUM FELDSPAR - ISOTROPIC (GLASSY)

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Orlowski, H. J. and Koenig, C. J.	41-10	528-1752	72.84% SiO_2; 15.4% Al_2O_3; 8.42% K_2O; 2.93% Na_2O; 0.27% CaO; 0.11% MgO; 0.11% Fe_2O_3; 0.01% TiO_2	Interferometer	Annealed 1 hr. at 10°C below softening point and cooled in 15 hr.
□	Ibid.	41-10	528-1752	68.30% SiO_2; 17.90% Al_2O_3; 10.14% K_2O; 2.87% Na_2O; 0.31% CaO; 0.07% Fe_2O_3	Same as above	Same as above
△	Ibid.	41-10	528-1752	66.04% SiO_2; 18.76% Al_2O_3; 10.73% K_2O; 3.56% Na_2O; 0.14% MgO; 0.09% TiO_2; 0.08% Fe_2O_3; 0.02% CaO	Same as above	Same as above
◇	Ibid.	41-10	528-1752	67.68% SiO_2; 18.87% Al_2O_3; 10.74% K_2O; 2.78% Na_2O; 0.49% CaO; 0.05% Fe_2O_3	Same as above	Same as above
▽	Ibid.	41-10	528-1752	64.70% SiO_2; 19.50% Al_2O_3; 11.21% K_2O; 4.19% Na_2O; 0.12% MgO; 0.11% CaO; 0.07% Fe_2O_3; trace of TiO_2	Same as above	Same as above
○	Ibid.	41-10	528-1752	67.84% SiO_2; 17.27% Al_2O_3; 11.40% K_2O; 2.15% Na_2O; 0.42% MgO; 0.08% CaO; 0.07% Fe_2O_3	Same as above	Same as above
□	Ibid.	41-10	528-1752	65.33% SiO_2; 19.27% Al_2O_3; 12.36% K_2O; 2.67% Na_2O; 0.27% CaO; 0.08% Fe_2O_3; traces of TiO_2, MgO	Same as above	Same as above
▽	Ibid.	41-10	528-1752	65.90% SiO_2; 18.70% Al_2O_3; 13.00% K_2O; 1.70% Na_2O; 0.20% CaO; 0.08% Fe_2O_3; trace of MgO	Same as above	Same as above

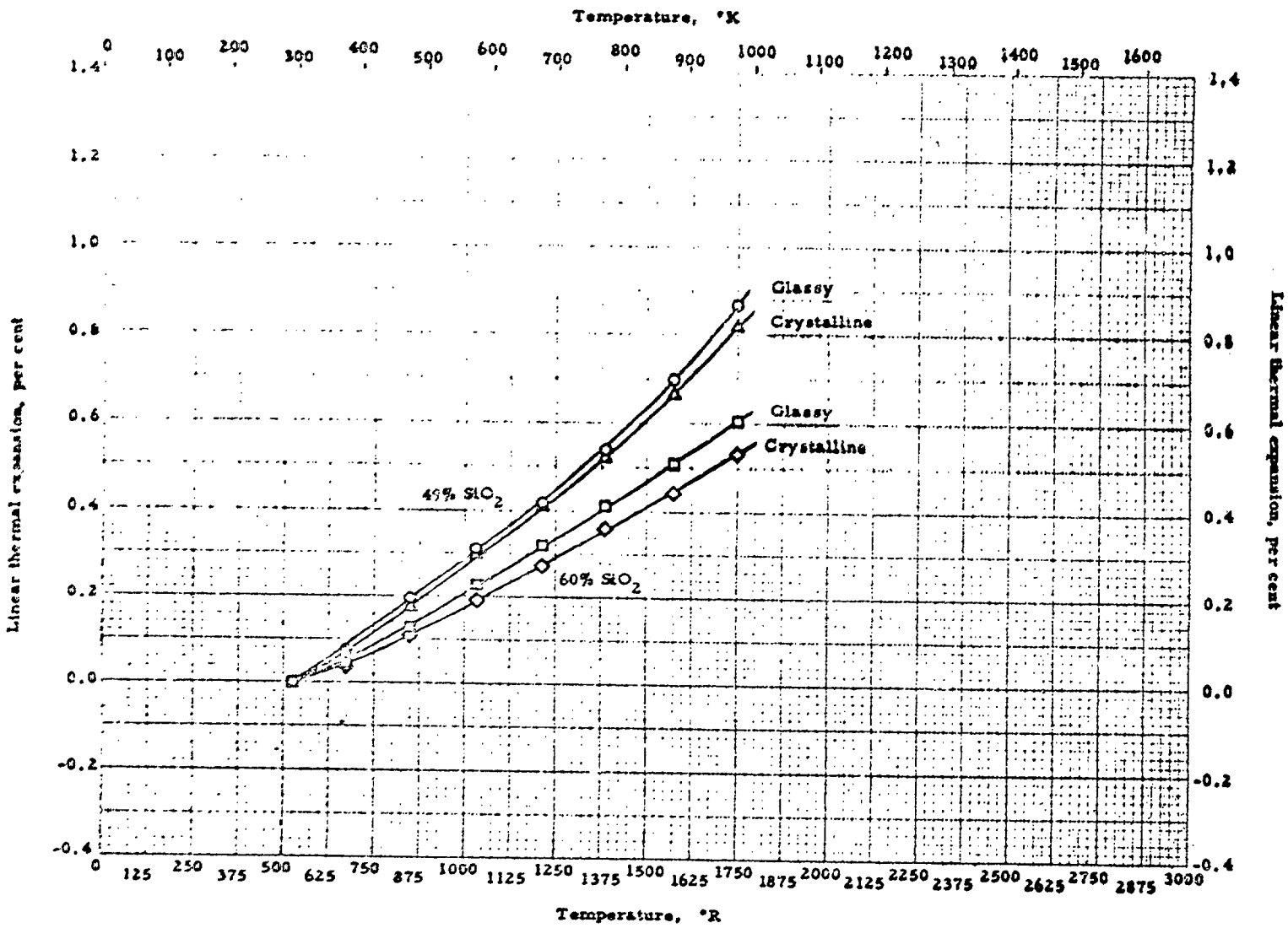


LINEAR THERMAL EXPANSION -- SODIUM-POTASSIUM FELDSPAR

LINEAR THERMAL EXPANSION -- SODIUM-POTASSIUM FELDSPAR

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Orlowski, H. J. and Koenig, C. J.	41-10	528-1752	69.12% SiO_2; 18.04% Al_2O_3; 6.70% K_2O; 5.18% Na_2O; 0.98% CaO; 0.08% Fe_2O_3; traces of MgO; isotropic (glassy)	Interferometer	Melted, annealed 1 hr. at 10°C below softening point, cooled in 15 hr.
□	Ibid.	41-10	528-1752	Same as above; anisotropic (crystalline)	Quartz tube dilatometer	Extruded, air dried, oven dried at 230°F, fired at cone 06

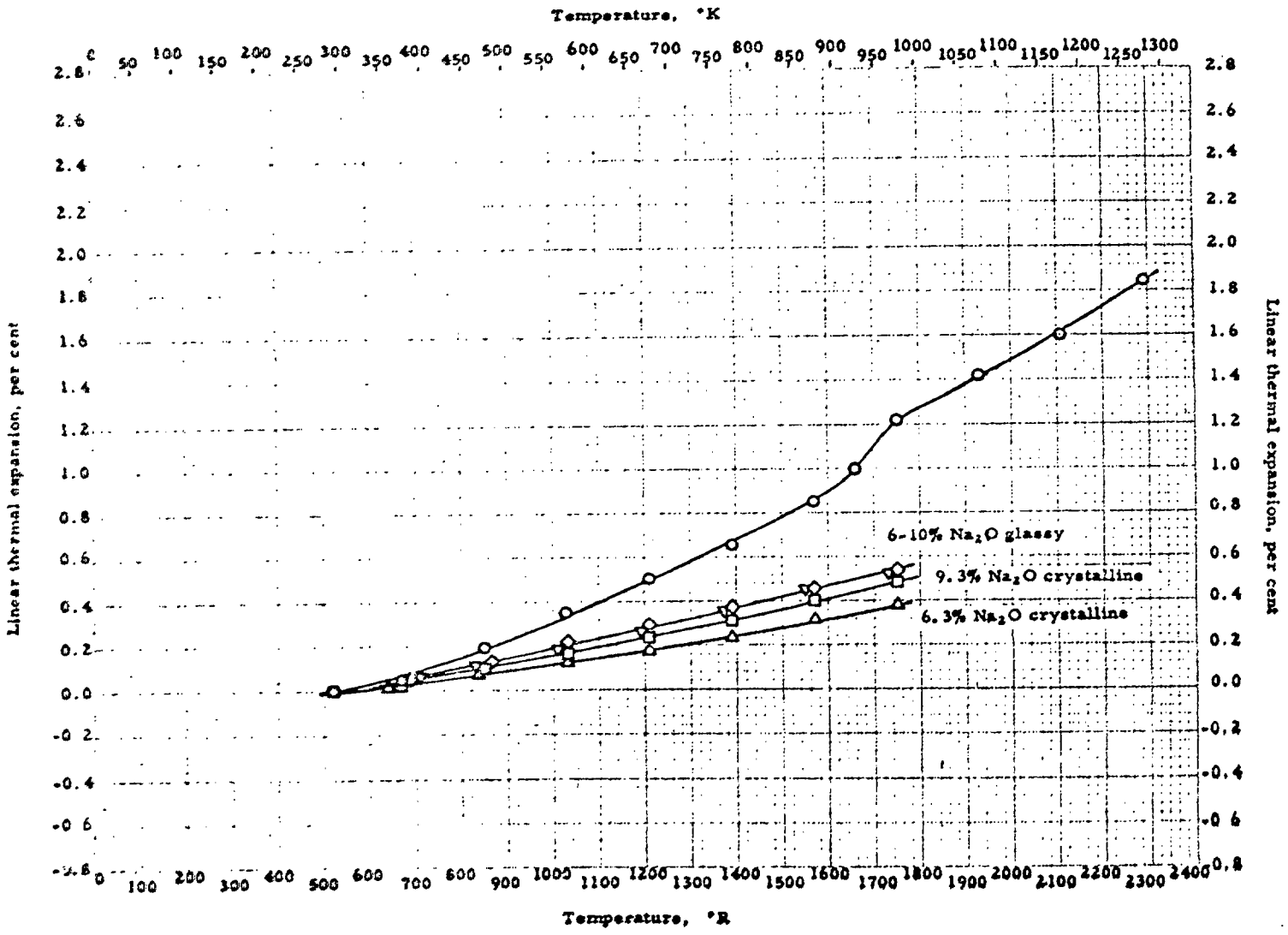


LINEAR THERMAL EXPANSION -- NEPHELINE SYENITE

LINEAR THERMAL EXPANSION -- NEPHELINE SYENITE

REFERENCE INFORMATION

SYM	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Orlowski, H. J., and Koenig, C.J.	41-10	528-1752	48.92% SiO_2; 31.69% Al_2O_3; 13.70% Na_2O; 4.06% K_2O; 0.86% CaO; 0.19% Fe_2O_3; 0.06% MgO; 0.01% TiO_2; ign. loss 0.43%; isotropic (glassy)	Interferometer	Melted, annealed 1 hr. at 10°C below the softening point, cooled in 15 hr.
△	Ibid.	41-10	528-1752	Same as above; anisotropic (crystalline)	Quartz tube dilatometer	Extruded, air dried, oven dried at 230°F, fired at cone 06
□	Ibid.	41-10	528-1752	60.24% SiO_2; 24.05% Al_2O_3; 10.03% Na_2O; 5.01% K_2O; 0.15% CaO; 0.06% Fe_2O_3; 0.02% MgO; 0.002% TiO_2; isotropic (glassy)	Interferometer	Melted, annealed 1 hr. at 10°C below the softening point, cooled in 15 hr.
◇	Ibid.	41-10	528-1752	Same as above; anisotropic (crystalline)	Quartz tube dilatometer	Extruded, air dried, oven dried at 230°F, fired at cone 06

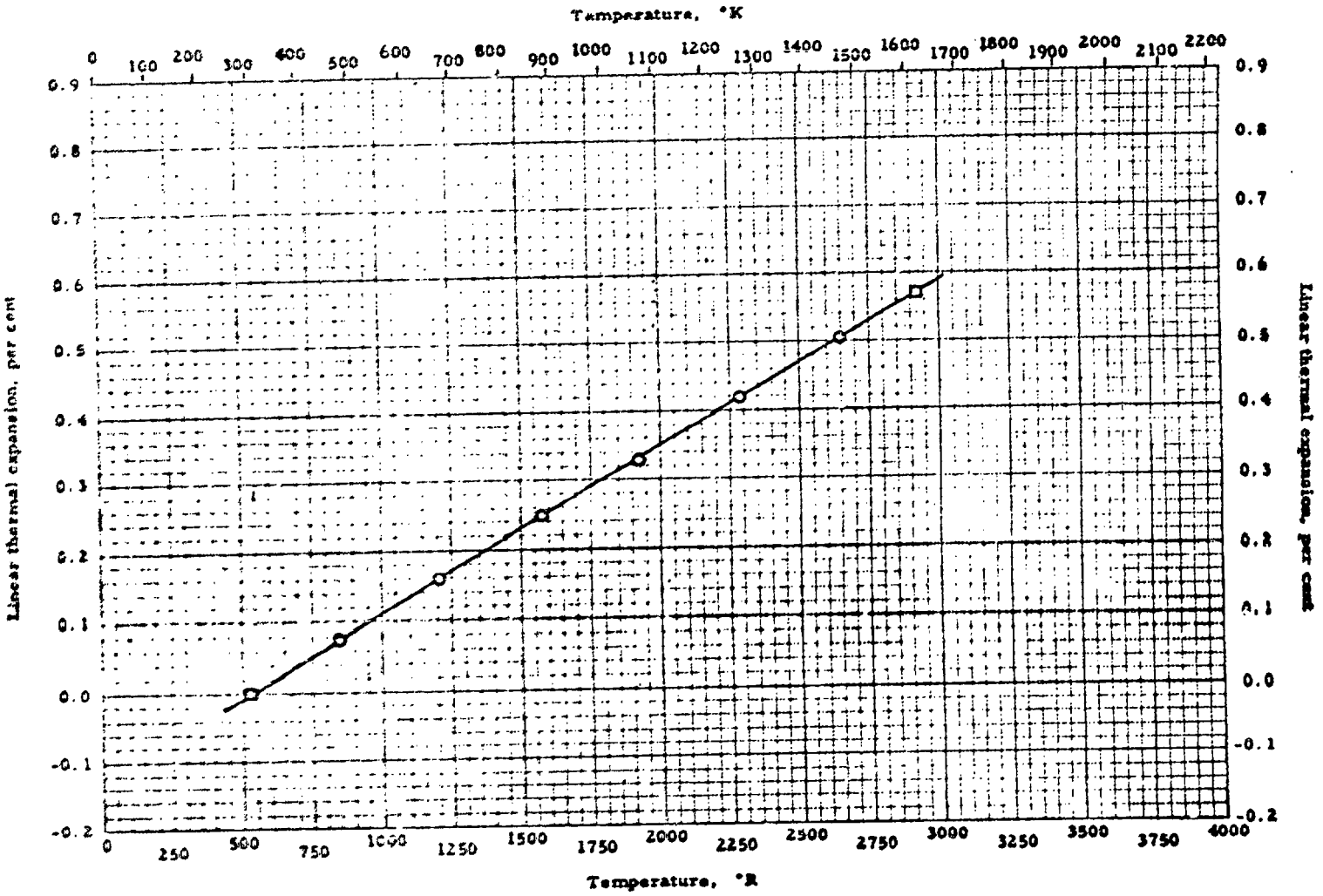


LINEAR THERMAL EXPANSION -- SODIUM FELDSPAR

LINEAR THERMAL EXPANSION -- SODIUM FELDSPAR

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Hummell, F. A.	49-14	528-2292	42.3 % SiO_2; 35.9% Al_2O_3; 21.8% Na_2O, prepared from pottery flint, c.p. Al_2O_3, c.p. Na_2CO_3	Fused silica dilatometer	Wet milled in acetone, held 50 hrs at 1100°C, 4 hr at 1400°C, pressed and sintered 1 hr at 1400°C
□	Orlowski, H.J. and Kownig, C.J.	41-10	528-1752	68.40% SiO_2; 19.40% Al_2O_3; 9.30% Na_2O; 1.40% K_2O; 1.00% CaO; 0.07% Fe_2O_3; trace of MgO	Quartz tube dilatometer	Extruded rods plasticized with small amount of gum, air dried, oven dried at 230°F, and fired at cone 6
△	Ibid.	41-10	528-1752	60.64% SiO_2; 23.69% Al_2O_3; 6.28% Na_2O; 3.27% K_2O; 5.14% Cao: 0.25% Fe_2O_3; trace of MgO	Same as above	Same as above
◇	Ibid.	41-10	528-1752	68.40% SiO_2; 19.40% Al_2O_3; 9.30% Na_2O; 1.40% K_2O; 1.00% CaO; 0.07% Fe_2O_3; trace of MgO	Interferometer	Annealed 1 hr. at 10°C below softening point and cooled in 15 hr.
▽	Ibid.	41-10	528-1752	60.64% SiO_2; 23.69% Al_2O_3; 6.28% Na_2O; 3.27% K_2O; 5.14% CaO; 0.25% Fe_2O_3; trace of MgO	Same as above	Same as above



LINEAR THERMAL EXPANSION -- HAFNIUM SILICATE (HAFNON)

LINEAR THERMAL EXPANSION -- HAFNIUM SILICATE (HAFNON)

REFERENCE INFORMATION

Key	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Curtis, C.E., Doney, L.M., and Johnson, J.R.	54-65 also 54-66	672-2832	Prepared from 99.6 + % pure HfO_2 and quartz	Sapphire dilatometer	Equimolar 325 mesh powders heated to 1550°C, milled, reheated, pressed at 20,000 lb/in.^{2}, fired 2 hr. at 1550°C
□	Kline, C.F., and Lewis, C.	57-83	520-3960	Prepared from HfO_2 containing 1% excess Hf, 1% Zr, 0.5-1.0% ea. Fe, Al; 0.1-0.5% Mg; 0.05-0.10% ea. Ti, Ca; 0.005-0.010 % Al; 0.001-0.005% ea. Mn, Cu. The HfO_2 contained 1% excess Si; 0.01-0.05% Al; 0.001-0.005% Mg; 0.0001-0.0005% ea. Ca, Cu, Ti	Not given	

PROPERTIES OF ZIRCONIUM SILICATE

MOST PROBABLE VALUES

Property	Brit. Engineering Units	C. G. S. Units
Density.	290 lb_m/ft^3	4.7 g/cm^3
Melting Point	5080°R *	2823°K *
Heat of Fusion		
Heat of Vaporization. . .		
Heat of Sublimation . . .		

* Handbook Chem. and Phys. (Ref. 57-60)

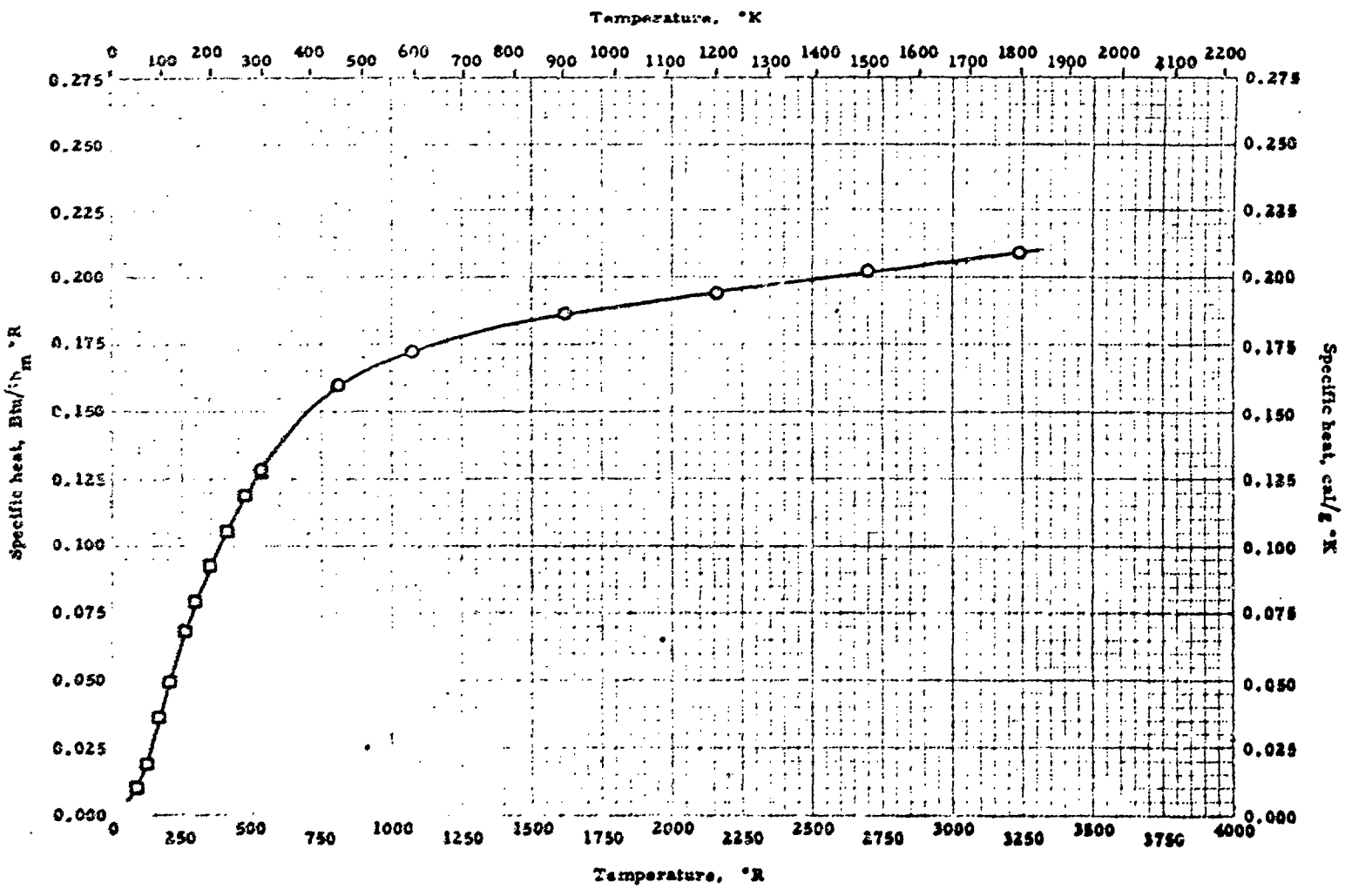
REPORTED VALUES

Density:		lb_m/ft^3	g/cm^3
	○	283	4.54
	□	232.8 ± 0.6	3.73 ± 0.01
Melting Point:		°R	°K
Heat of Fusion:		Btu/lb_m	cal/g
Heat of Vaporization:		Btu/lb_m	cal/g
Heat of Sublimation:		Btu/lb_m	cal/g

PROPERTIES OF ZIRCONIUM SILICATE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Gangler, J. J.	50-10	Room	48.80% Zr; 33.98% O_2; 15.86% Si; 0.82% combined C; <0.01% free C (Zircon)	ρ: weight in air and in distilled water	Fabricated by hot pressing in graphite mold. Auth. computes ρ = 4.72 g/cm^3 from lattice measured by others
□	Oak Ridge National Lab.	57-150	537	Zircon 475	ρ: weight in air and in kerosene	Measured by O. Sisman, C. D. Bopp and R. L. Towns

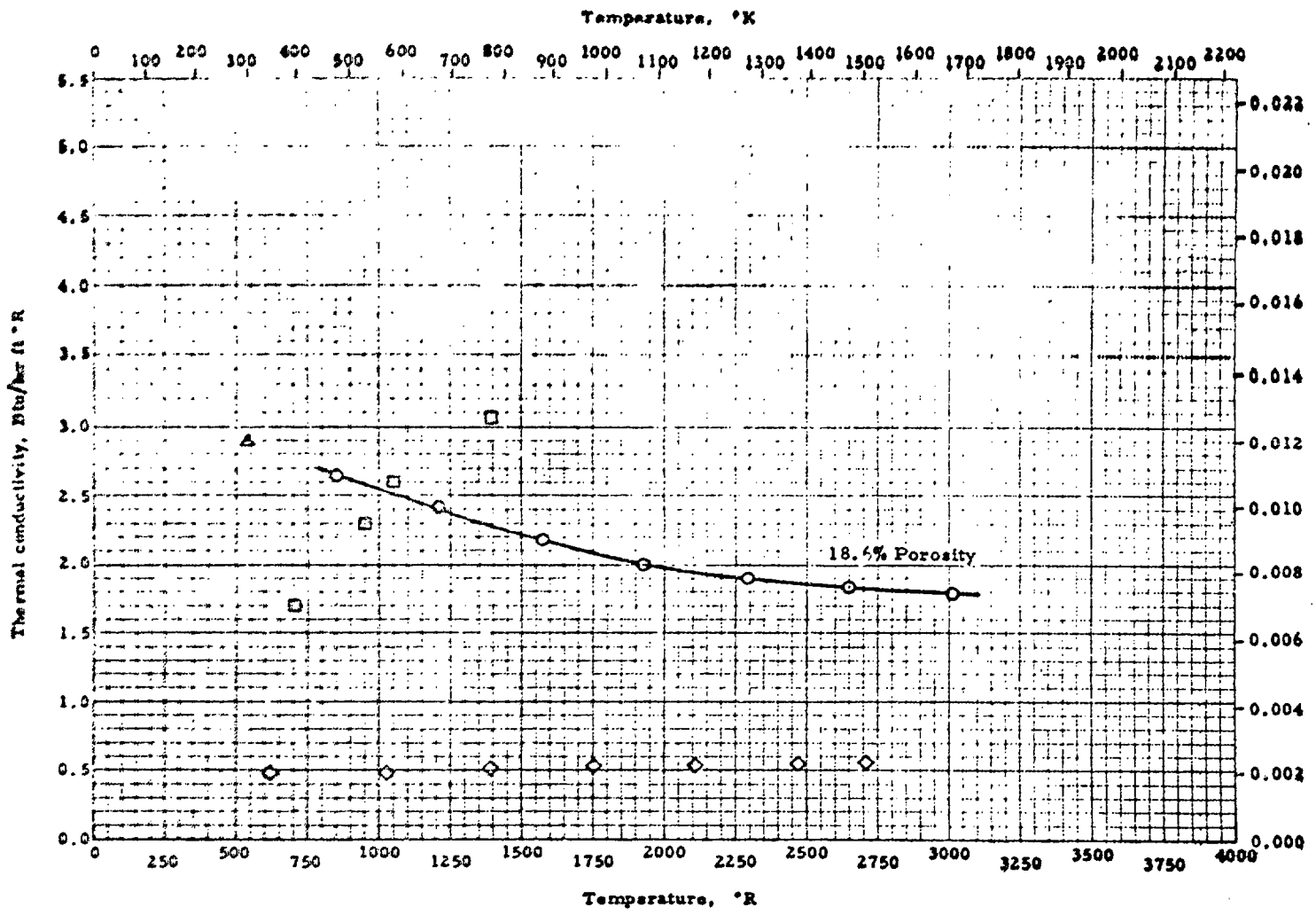


SPECIFIC HEAT -- ZIRCONIUM SILICATE

SPECIFIC HEAT -- ZIRCONIUM SILICATE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Coughlin, J. P. and King, E. G.	50-3	693-3281	$ZrSiO_4$. 66.3% ZrO_2 including HfO_2 with 1.15% Hf; 33.6% SiO_2; 0.4% Fe_2O_3	Drop method; copper block calorimeter	
□	Kelley, K. K.	41-15	95-531	98.6% $ZrSiO_4$; 1.3% SiO_2; 0.4% Fe_2O_3	Guarded sample	Corrected for Fe_2O_3 and excess SiO_2



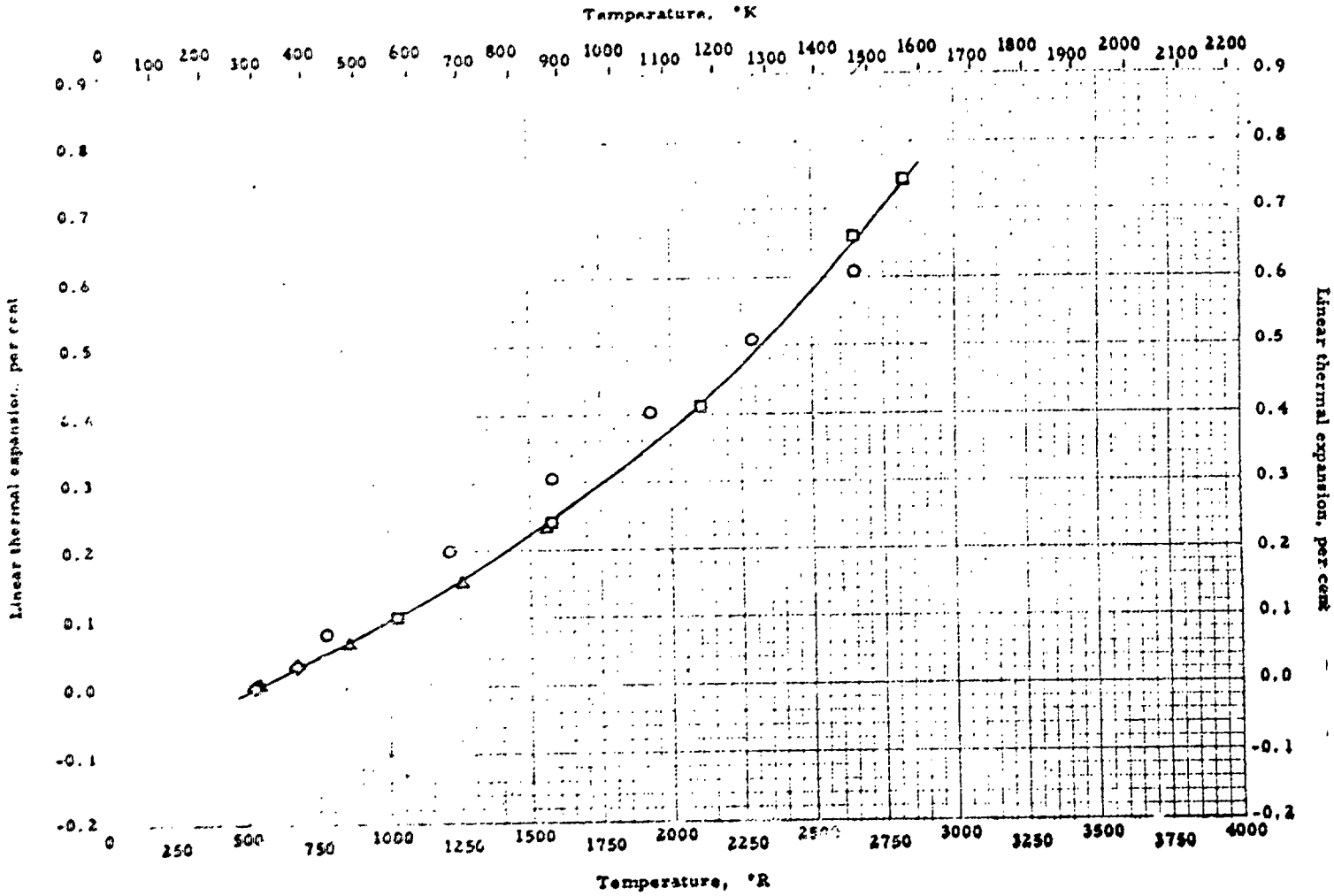
THERMAL CONDUCTIVITY -- ZIRCONIUM SILICATE

WADC TR 59-416 59-352 926

THERMAL CONDUCTIVITY -- ZIRCONIUM SILICATE

REFERENCE INFORMATION

Sym bol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Kingery, W. D. and Francl, J.	52-65 also 53-65 also 54-1	852-3012	Bulk ρ = 230 lb_m/ft^3; porosity = 18.6%	Ellipsoidal envelope	Slip cast and fired at 1550°C
□	Knapp, W. J.	43-11	700-1390	Brazil Zircon	Comparative; rods	Single crystal normal to c-axis
△	Oak Ridge National Laboratory	57-150	546	Zircon 475	Not described here; refers to others	Auth. est. accuracy ± 8%; measured by O. Sisman, C. D. Bopp and R. L. Towns
◇	Norton, F. H. and Kingery, W. D.	51-75	670-2710	"Pure" Zircon, porosity = 2%	Ellipsoidal envelope with resistance heater; temp. by thermocouple	Superpax Zircon of Natl. Lead Co. treated with HCl, fired at 1550°C, zero open pores; auth. est. accuracy ± 8%

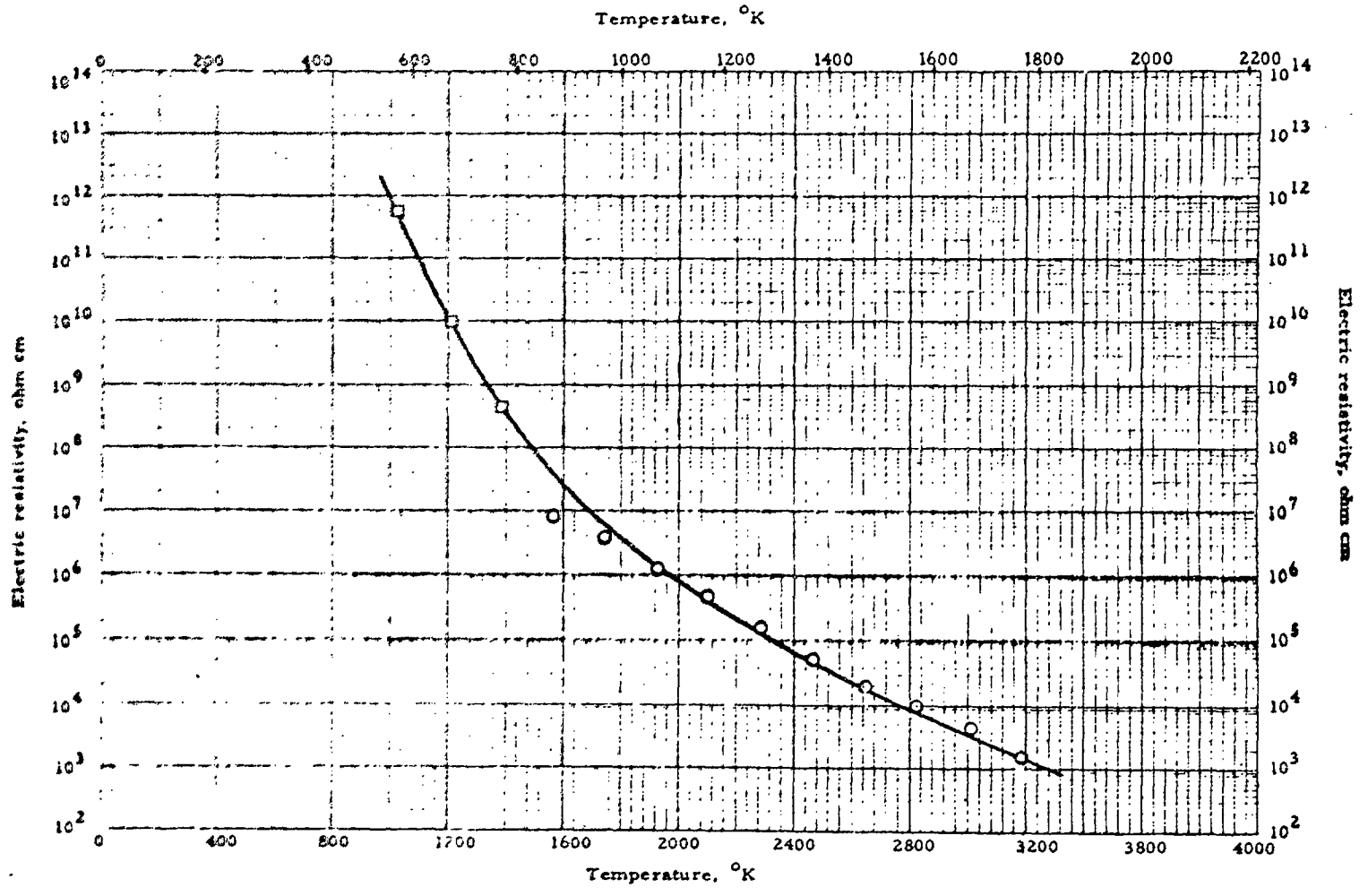


LINEAR THERMAL EXPANSION -- ZIRCONIUM SILICATE

LINEAR THERMAL EXPANSION -- ZIRCONIUM SILICATE

REFERENCE INFORMATION

Sym.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Curtis, C. E., Doney, L. M. and Johnson, J. R.	54-45 also 54-46	528-2832	Prepared from 99.9% pure ZrO_2 and quarts	Sapphire dilatometer	Equimolar 325 mesh powders heated to 1550°C, milled, heated again; pressed at 20,000 lb/in.^{2}; fired 2 hr at 1550°C
□	Whitemore, O. J. and Ault, N. N.	56-7	1032-2832	Fine grain circon, $ZrSO_4$	Telemicroscopes sighting on pointed ends of rods	
△	Gangler, J. J.	50-10	540-1560	48.80% Zr, 33.98% O_2; 15.86% Si; 0.82% combined C; < 0.61% free C. ρ = 283 lb/ft^3	Interferometer	Hot pressed in graphite mold tested at 4° C/min rise
◇	McKee, J. H. and Adams, A. M.	50-11	528-672	66.45% total ZrO_2 + HfO_2; 32.45% SiO_2; 0.99% total Al_2O_3, rare earth oxides; 0.29% FeO_3; 0.15% TiO_2; 0.08% Mn_3O_4, trace BaO; no CaO or MgO	Not given	Fired at 1750°C

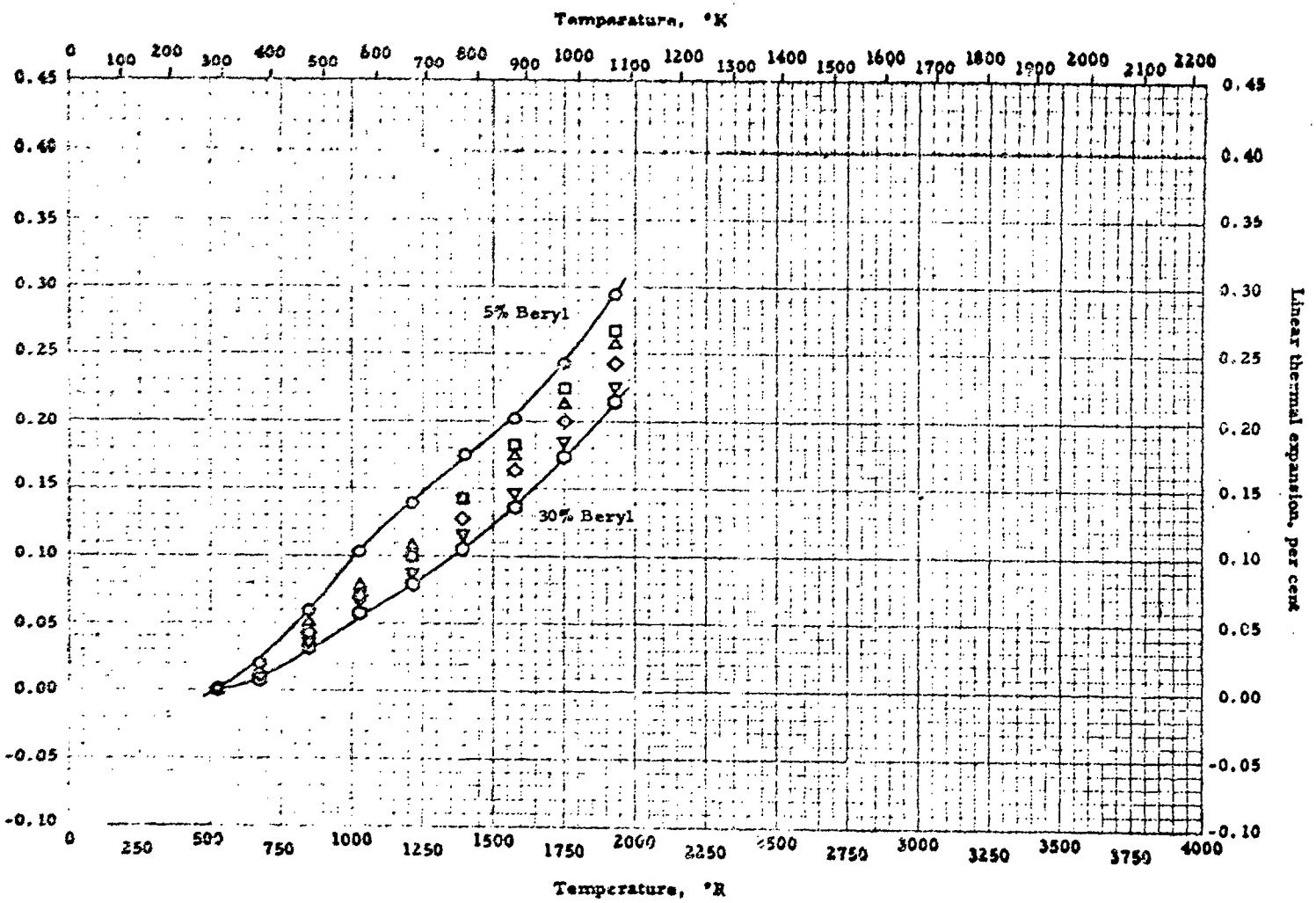


ELECTRIC RESISTIVITY -- ZIRCONIUM SILICATE

ELECTRIC RESISTIVITY -- ZIRCONIUM SILICATE

REFERENCE INFORMATION

	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Chiorbetti, V.E. and Henry, E.C.	53-94	1572-3192	Zircon, 65% ZrO_2; 35% SiO_2	Wheatstone bridge at 965 cycles	Apparent Porosity 30%, > 42 pyrometric cone equivalent
□	Hauth, W.E.	56-75	1032-1392	Zircon	Bridge method, temp. by thermocouple	



LINEAR THERMAL EXPANSION -- ZIRCONIUM SILICATE + BERYLLIUM ALUMINOSILICATE

LINEAR THERMAL EXPANSION -- ZIRCONIUM SILICATE + BERYLLIUM ALUMINOSILICATE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Rummel, F. A. and Henry, E. C.	46-5	528-1932	95% $ZrSiO_4$; 5% $BeO \cdot Al_2O_3 \cdot 6SiO_2$ (zircon + beryl system)	Quartz dilatometer	
□	Ibid.	46-5	528-1932	90% $ZrSiO_4$; 10% $BeO \cdot Al_2O_3 \cdot 6SiO_2$	Same as above	
△	Ibid.	46-5	528-1932	85% $ZrSiO_4$; 15% $BeO \cdot Al_2O_3 \cdot 6SiO_2$	Same as above	
◇	Ibid.	46-5	528-1932	80% $ZrSiO_4$; 20% $BeO \cdot Al_2O_3 \cdot 6SiO_2$	Same as above	
▽	Ibid.	46-5	528-1932	75% $ZrSiO_4$; 25% $BeO \cdot Al_2O_3 \cdot 6SiO_2$	Same as above	
C	Ibid.	46-5	528-1932	70% $ZrSiO_4$; 30% $BeO \cdot Al_2O_3 \cdot 6SiO_2$	Same as above	

Symbol	Nominal Composition	Melting Point °R	Melting Point °K	Heat of Fusion Btu/lb$_m$	Heat of Fusion cal/g
O	$3\,CaO \cdot B_2O_3$	3168	1760	269	149
	$2\,CaO \cdot B_2O_3$	2855	1585	239	133
	$CaO \cdot B_2O_3$	2583	1435	253	141
	$CaO \cdot 2B_2O_3$	2268	1260	249	139

PROPERTIES OF CALCIUM BORATE

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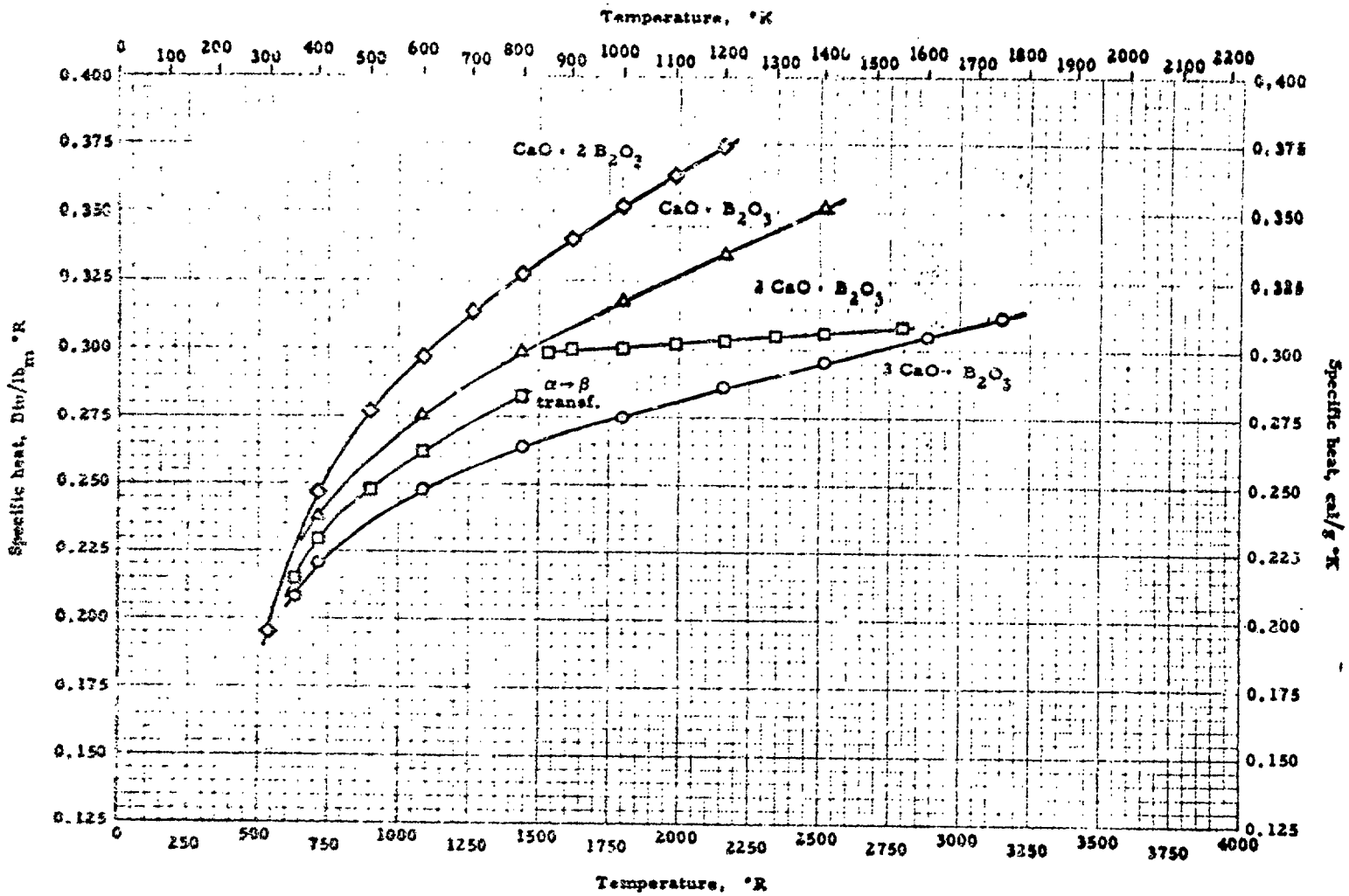
PROPERTIES OF CALCIUM BORATE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	King, E.G., Torgeson, D.R. and Cook, O.A.	48-7	2268-3168	Calcium borate	Δh_f: enthalpy difference at MP between liquid and solid phases. Enthalpy by drop method. MP: not given	

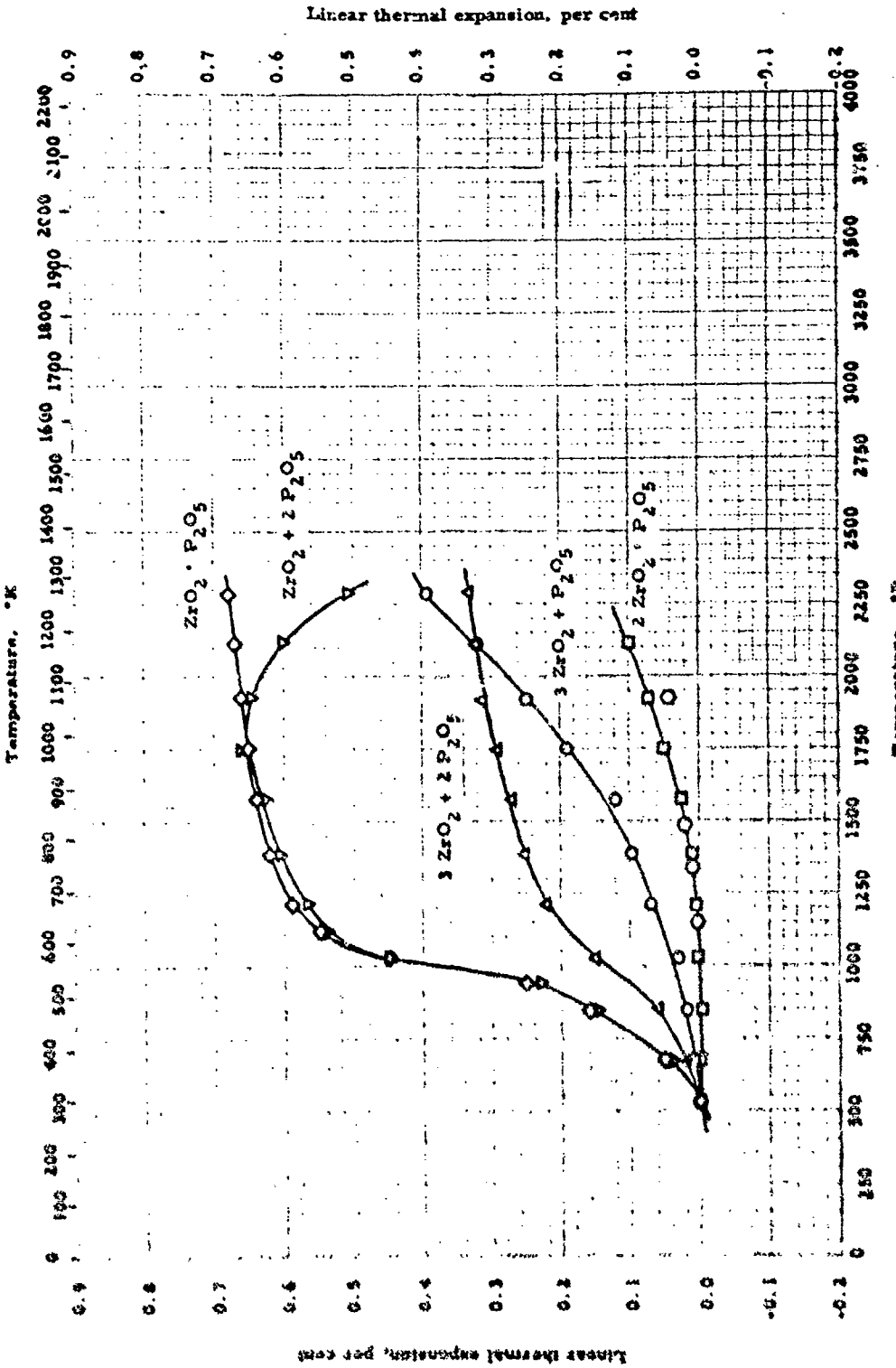


SPECIFIC HEAT -- CALCIUM BORATE

SPECIFIC HEAT -- CALCIUM BORATE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	King, E. G., Torgeson, D. R. and Cook, O. A.	48-7	670-3340	$3CaO \cdot B_2O_3$; Colemanite	Drop method; copper block calorimeter	
□	Ibid.	48-7	687-3278	$2CaO \cdot B_2O_3$; α and β crystals	Same as above	
△	Ibid.	48-7	784-3020	$CaO \cdot B_2O_3$	Same as above	
◇	Ibid.	48-7	665-3240	$CaO \cdot 2B_2O_3$	Same as above	



LINEAR THERMAL EXPANSION -- ZIRCONIUM PHOSPHATE

LINEAR THERMAL EXPANSION -- ZIRCONIUM PHOSPHATE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Harrison, D. E., McKinstry, H. A. and Hummel, F. A.	54-48	528-2292	3 ZrO_2 + P_2O_5. 72.2% ZrO_2; 27.8% P_2O_5	Fused silica dilatometer	Mixture calcined 4 hr. at 1550°C
□	Ibid.	54-48	528-2112	2 ZrO_2 · P_2O_5. 63.4% ZrO_2; 36.5% P_2O_5	Same as above	Compound, Treated as above
△	Ibid.	54-48	528-2292	3 ZrO_2 + 2 P_2O_5. 56.5% ZrO_2; 43.5% P_2O_5	Same as above	Mixture calcined 10 hr. at 1380°C
◇	Ibid.	54-48	528-2292	ZrO_2 · P_2O_5. 46.5% ZrO_2; 53.5% P_2O_5	Same as above	Compound, Treated as above
▽	Ibid.	54-48	528-2292	ZrO_2 + 2 P_2O_5. 30.3% ZrO_2; 69.7% P_2O_5	Same as above	Mixture calcined 10 hr. at 1300°C
○	Hummel, F. A. and Henry, E. C.	46-13	528-1932	Zirconium phosphate	Fused silica dilatometer	Calcined at 1400°C

PROPERTIES OF CALCIUM HAFNATE

MOST PROBABLE VALUES

Property	Brit. Engineering Units	C. G. S. Units
Density.	410 lb_m/ft^3	6.5 g/cm^3
Melting Point	4940°R	2740°K
Heat of Fusion		
Heat of Vaporization. . .		
Heat of Sublimation . . .		

REPORTED VALUES

Density:		lb_m/ft^3	g/cm^3	Porosity, %
	O	358	5.73	12.3

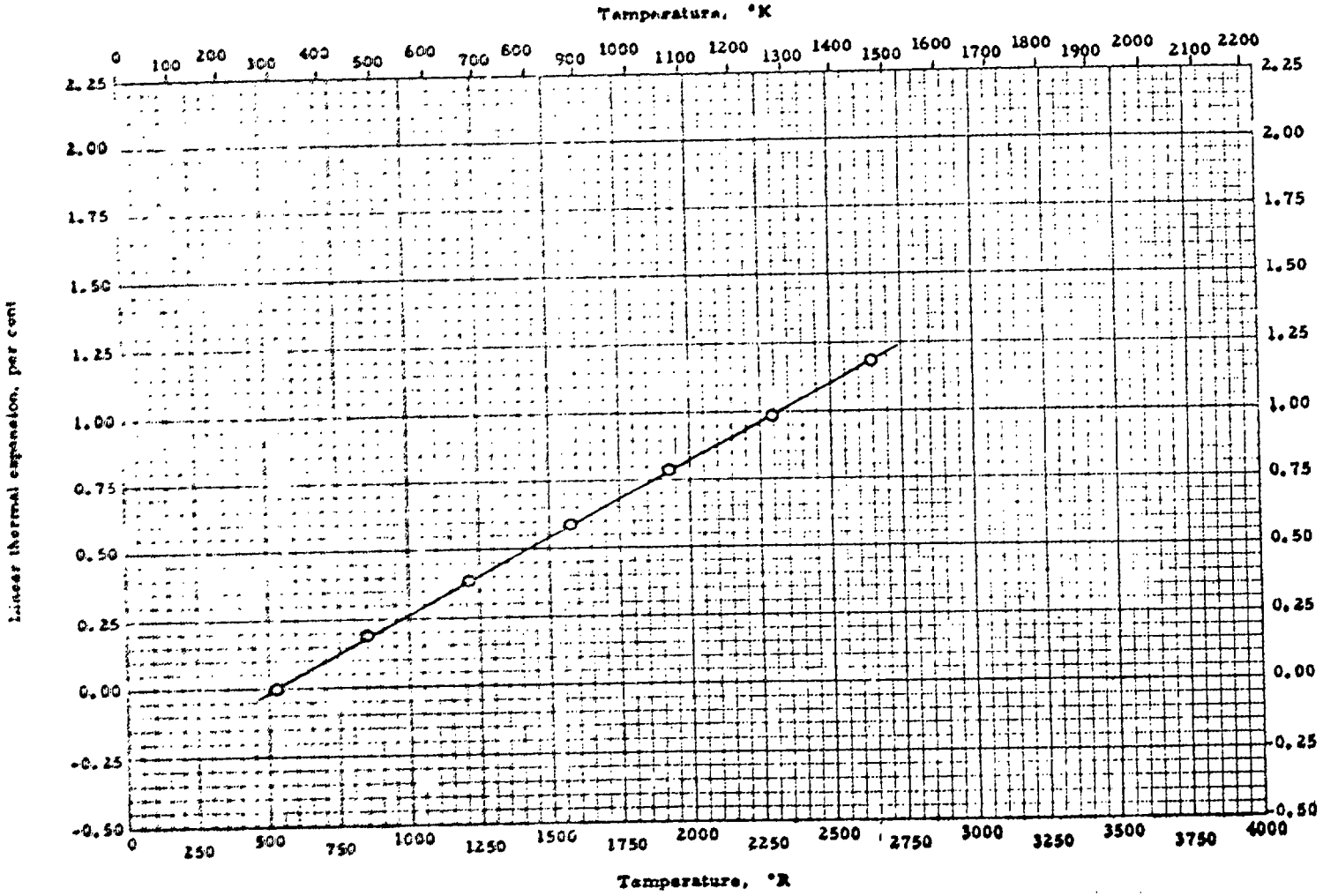
Melting Point:		°R	°K
	O	4938 ± 36	2743 ± 20

Heat of Fusion:		Btu/lb_m	cal/g
Heat of Vaporization:		Btu/lb_m	cal/g
Heat of Sublimation:		Btu/lb_m	cal/g

PROPERTIES OF CALCIUM HAFNATE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Curtis, C. E., Doney, L. M. and Johnson, J. R.	54-45	Room	$CaHfO_3$	ρ: Not given MP: not given	Equimolar composition of Ca O and HfO_2, calcined 2 hr. at 1550° C, reground to 200 mesh, pressed with 5% water and 2% dextrin; fired 2 hr. at 1550°C, cooled slowly. Orthorhombic crystal structure

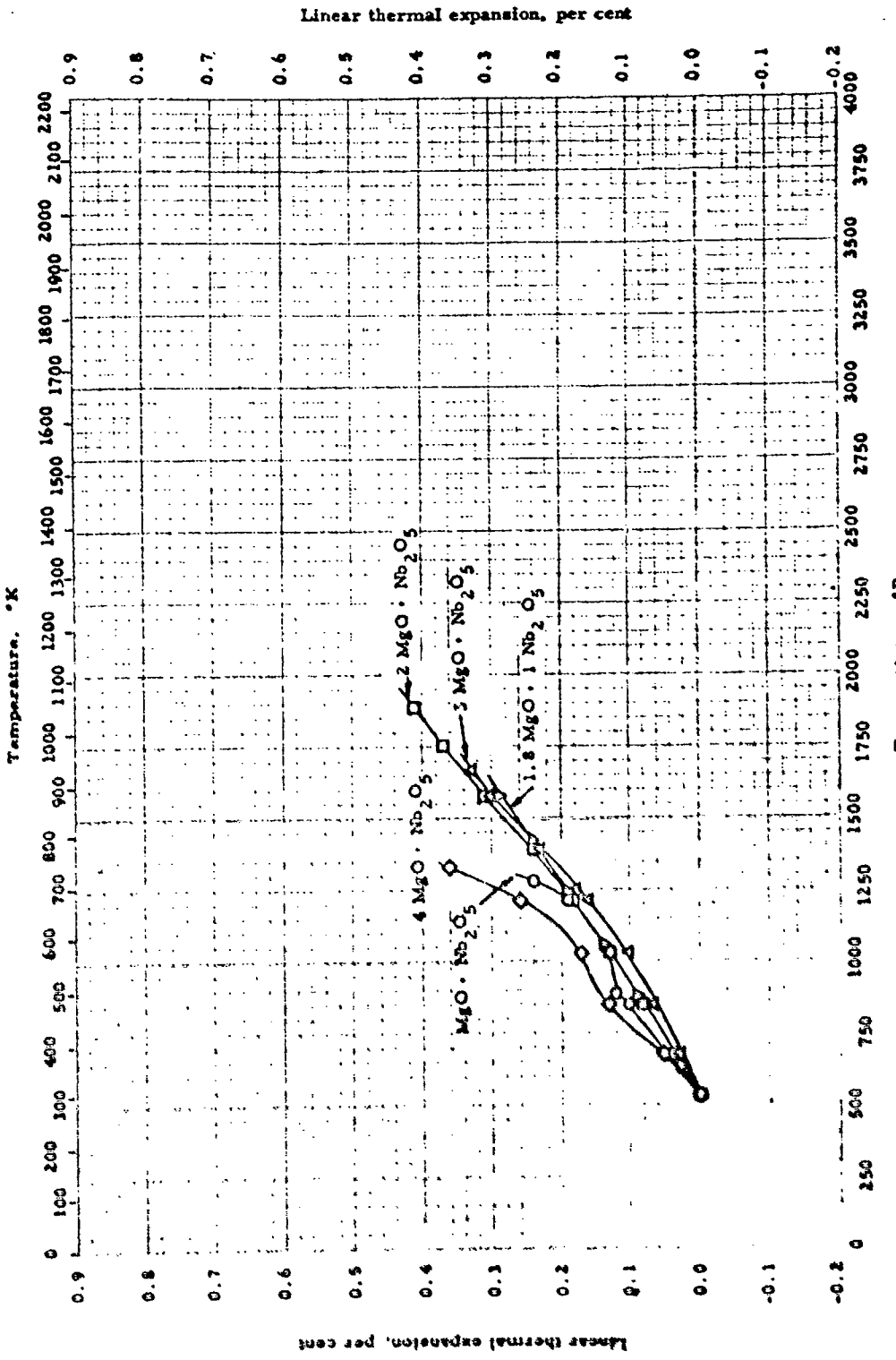


LINEAR THERMAL EXPANSION -- CALCIUM HAFNATE

LINEAR THERMAL EXPANSION -- CALCIUM HAFNATE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Curtis, C. E., Doney, L. M. and Johnson, J. R.	54-46	528-2652	$CaHfO_3$. ρ = 358 lb/ft^3	Sapphire dilatometer	



LINEAR THERMAL EXPANSION -- MAGNESIUM NIOBATE

LINEAR THERMAL EXPANSION -- MAGNESIUM NIOBATE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Durbin, E. A. and Harman, C. G.	52-31	528-1284	86.8% Nb_2O_5; 13.2% MgO	Interferometer	MgO · Nb_2O_5 Fired 2 hr. at 1450°C, cooled in 24 hr.
□	Ibid.	52-31	528-1878	76.7% Nb_2O_5; 23.3% MgO	Same as above	2 MgO · Nb_2O_5 Fired 2 hr. at 1500°C, cooled in 24 hr.
△	Ibid.	52-31	528-1662	68.7% Nb_2O_5; 31.3% MgO	Same as above	3 MgO · Nb_2O_5 Fired as above
◇	Ibid.	52-31	528-1338	62.2% Nb_2O_5; 37.8% MgO	Same as above	4 MgO · Nb_2O_5 Fired as above
▽	Durbin, E. A., Wagner, H. E. and Harman, C. G.	52-34	528-1752	78.55% Nb_2O_5; 21.45% MgO; prepared from c.p. raw materials	Interferometer	MgO · Nb_2O_5 + 2 MgO · Nb_2O_5 (in proportion of 1.8 MgO to 1 Nb_2O_5) calcined 2 hr. at 1220°C. Fired at 1495°C

PROPERTIES OF CALCIUM ZIRCONATE

MOST PROBABLE VALUES

Property	Brit. Engineering Units	C. G. S. Units
Density.	290 lb_m/ft^3	4.6 g/cm^3
Melting Point	4686°R	2603°K
Heat of Fusion		
Heat of Vaporization. . .		
Heat of Sublimation . . .		

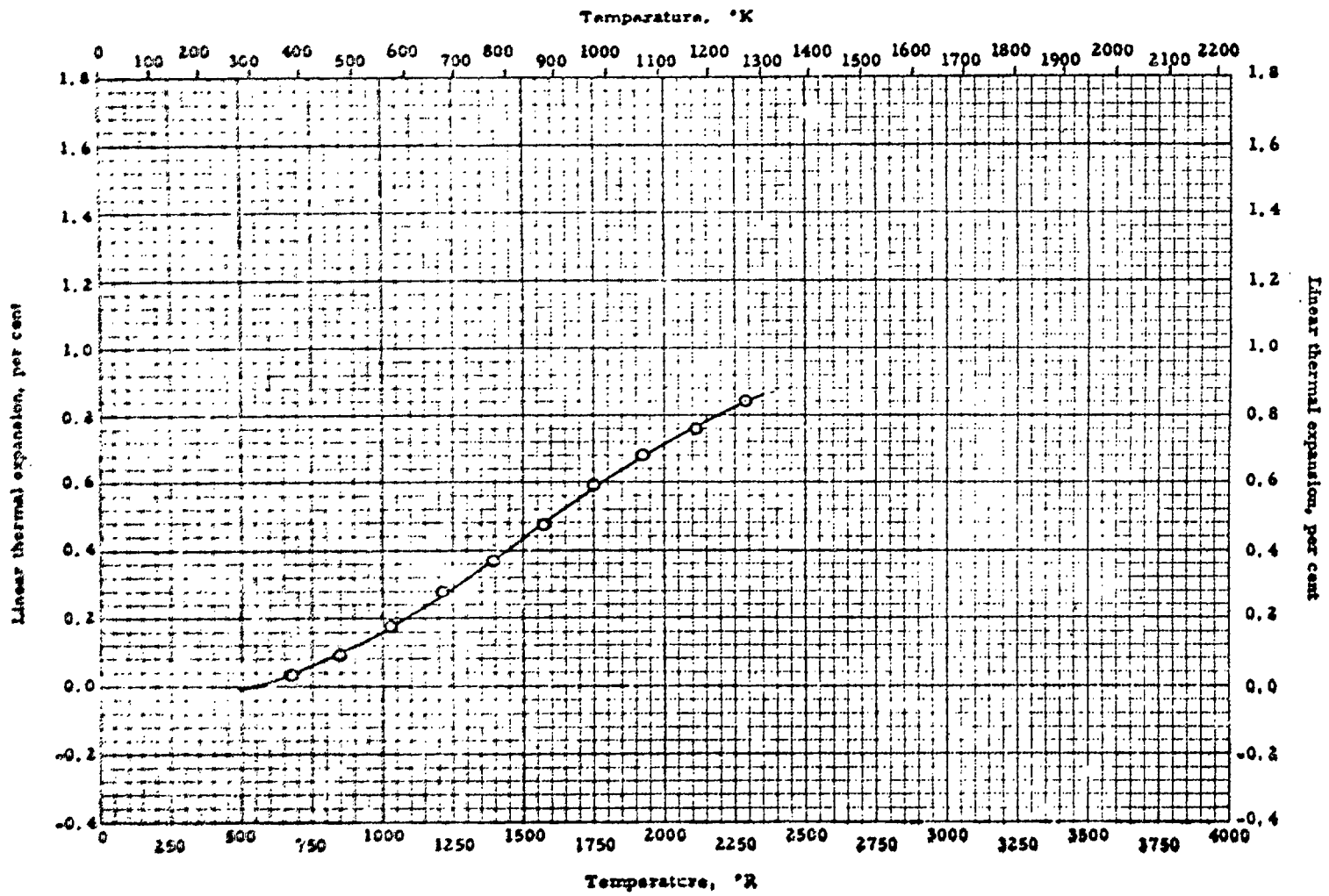
REPORTED VALUES

Density:		lb_m/ft^3	g/cm^3
	○	281.5	4.509
	□	278.4	4.460
	△	291	4.66
Melting Point:		°R	°K
	△	4686	2603
Heat of Fusion:		Btu/lb_m	cal/g
Heat of Vaporization:		Btu/lb_m	cal/g
Heat of Sublimation:		Btu/lb_m	cal/g

PROPERTIES OF CALCIUM ZIRCONATE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Nadler, M.R.	53-37	Room	$CaZrO_3$. Made from ZrO_2 (cont. 0.097% Si; 0.043% Ti; 0.030% Fe; 0.020% Mg) and $CaCO_3$ (cont. 0.16% Mg; 0.001% Fe)	ρ: pycnometer	Mixed from equal moles of ZrO_2 and $CaCO_3$, pressed at 10,000 psi, fired at 1750°C
□	Ibid.	53-37	Room	Same as above	ρ: same as above	Mixed from equal moles of ZrO_2 and $CaCO_3$, pressed at 10,000 psi; fired at 1850°C
△	Nadler, M.R. and Fitzsimmons, E.S.	55-20	Room	99% pure $CaZrO_3$; 0.08% Mg	ρ: pycnometer MP: observation during heating with oxyacetylene; optical pyrometer	Mixed from equal moles of ZrO_2 and $CaCO_3$; fired 1 hr. at 1850°C



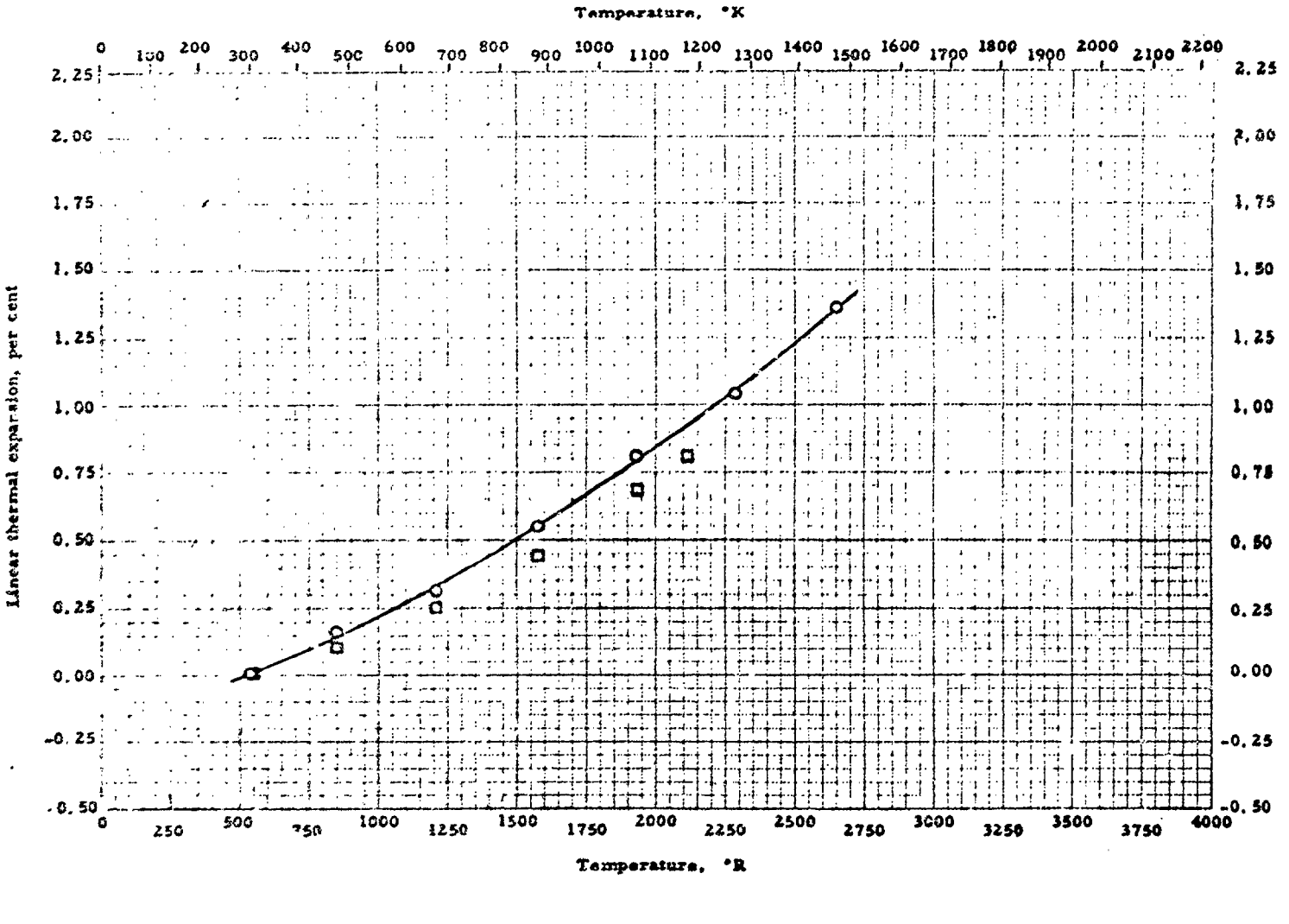
LINEAR THERMAL EXPANSION -- BARIUM ZIRCONATE

NASA TN D-6176

LINEAR THERMAL EXPANSION -- BARIUM ZIRCONATE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Beetle, R., McKinstry, H. et al.	48-4	672-2292	$BaO \cdot ZrO_2$	Not given	Fired 1 hr. at 1350°C



LINEAR THERMAL EXPANSION -- CALCIUM ZIRCONATE

LINEAR THERMAL EXPANSION -- CALCIUM ZIRCONATE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Nadler, M. R. and Fitzsimmons, E. S.	53-39	537-2652	99% pure $CaZrO_3$; prepared from c.p. ZrO_2 (0.1-0.5% CaO) and c.p. $CaCO_3$ (0.16% Mg)	Telemicroscope	Fired 1 hr. at 1650°C
□	Nadler, M. R.	53-37	555-2114	Prepared from c.p. ZrO_2 (0.097% Si; 0.045% Ti; 0.030% Fe; 0.020% Mg) and c.p. $CaCO_3$ (0.16% Mg; 0.001% Fe)	Telemicroscope	Pressed at 10,000 psi; fired to 1750°C

PROPERTIES OF ALUMINUM TITANATE

MOST PROBABLE VALUES

Property	Brit. Engineering Units	C. G. S. Units
Density.	230 lb_m/ft^3	3.68 g/cm^3
Melting Point	3890°R	2160°K
Heat of Fusion		
Heat of Vaporization. . .		
Heat of Sublimation . . .		

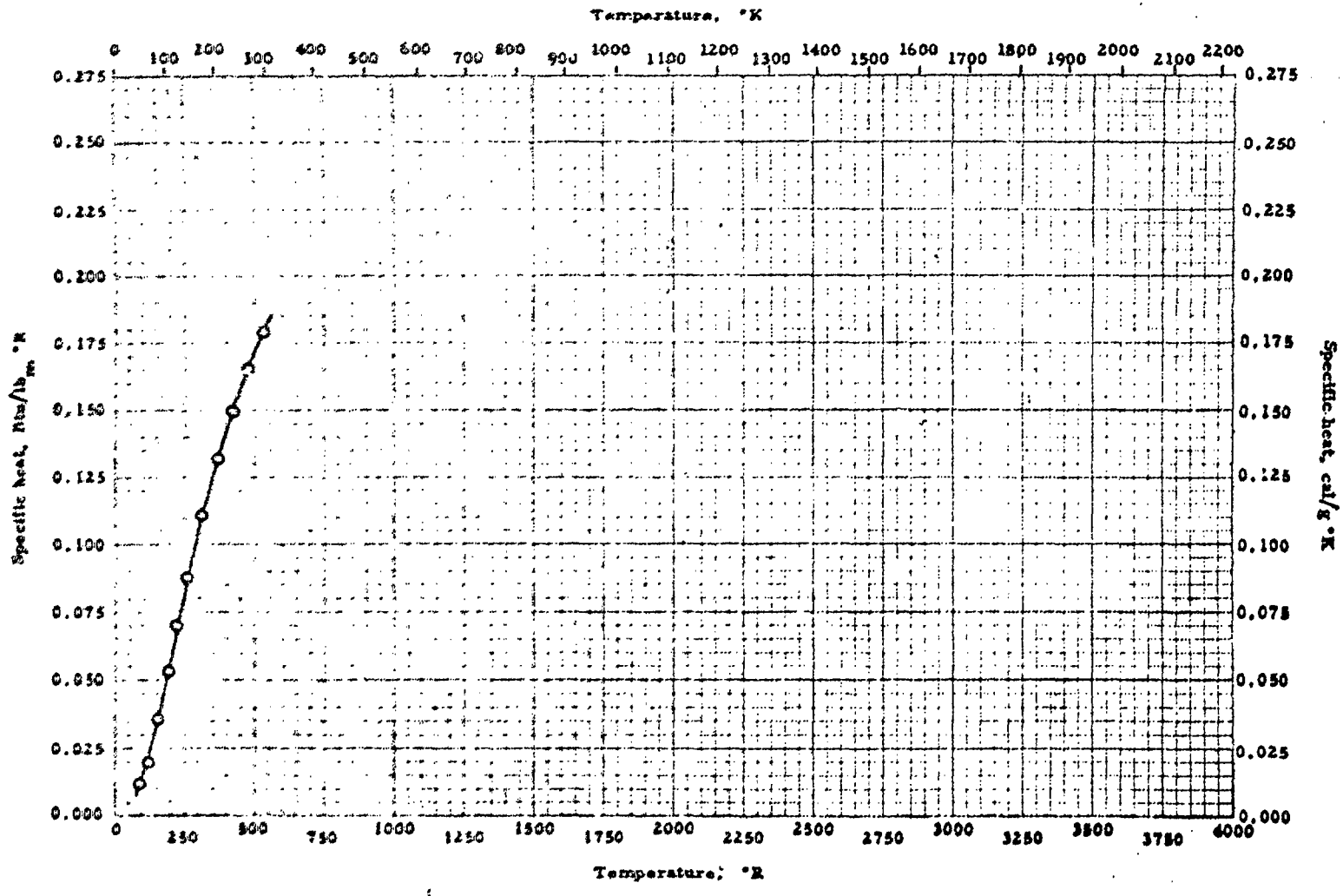
REPORTED VALUES

Density:		lb_m/ft^3	g/cm^3
	O	229.8	3.681
Melting Point:		°R	°K
	O	3893 ± 18	4163 ± 10
Heat of Fusion:		Btu/lb_m	cal/g
Heat of Vaporization:		Btu/lb_m	cal/g
Heat of Sublimation:		Btu/lb_m	cal/g

PROPERTIES OF ALUMINUM TITANATE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Brom, V. A. and Podnogin, A. F.	53-145	Room 3870-3910	Al_2TiO_5 ($Al_2O_3 \cdot TiO_2$)	ρ: not given MP: not given	Fired at 1600°C

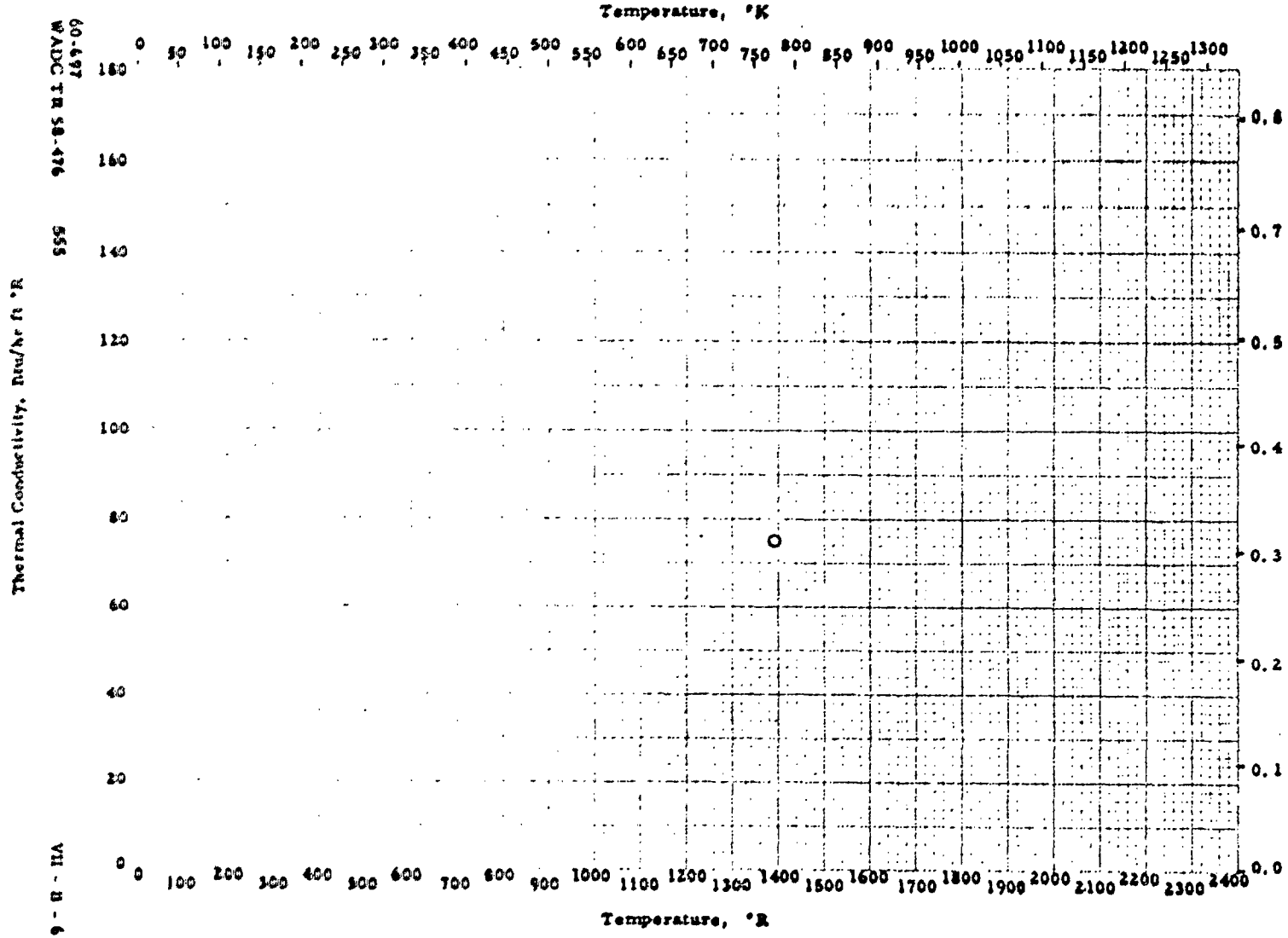


SPECIFIC HEAT -- ALUMINUM TITANATE

SPECIFIC HEAT -- ALUMINUM TITANATE

REFERENCE INFORMATION

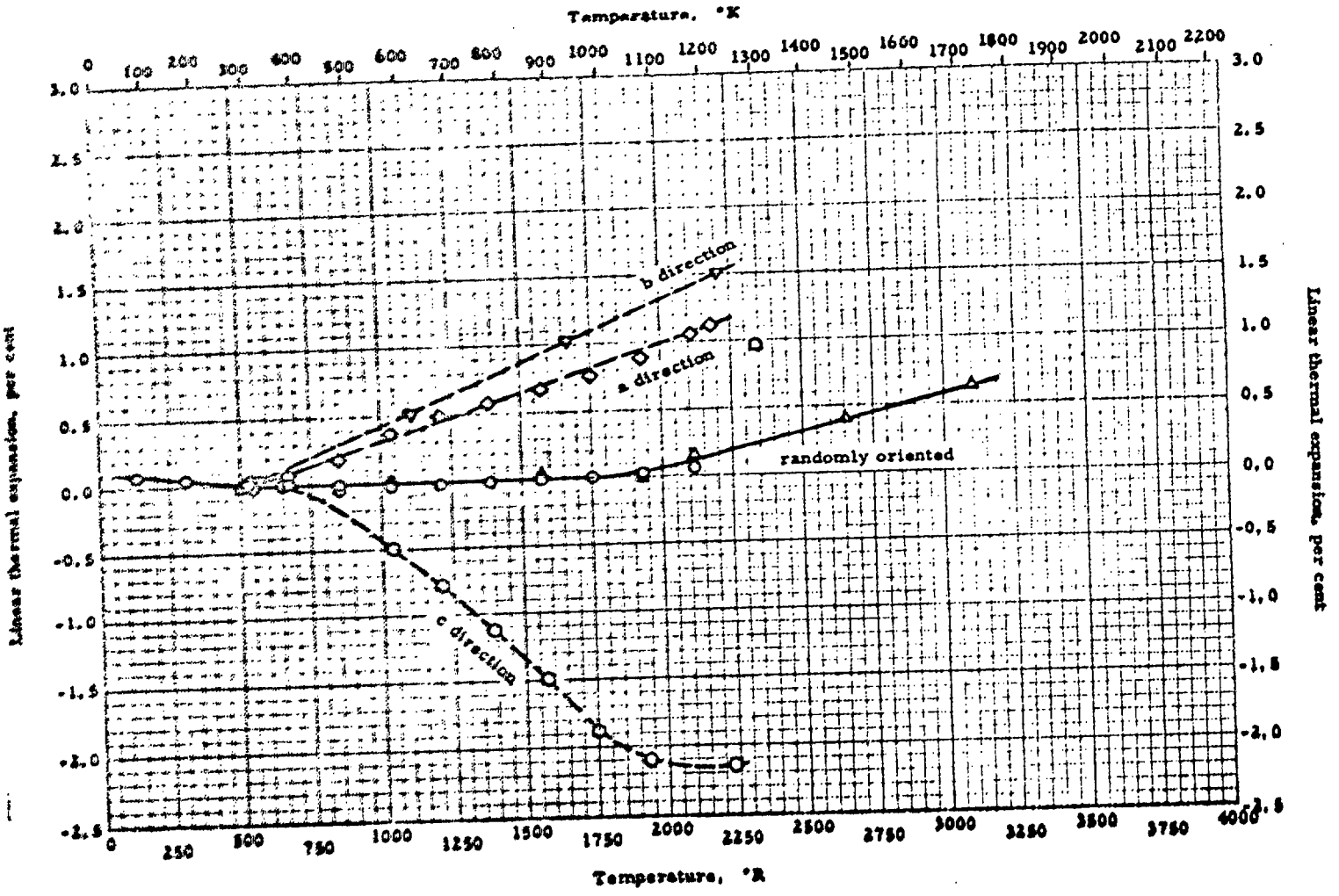
Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	King, E. G.	53-42	96-536	Al_2TiO_5; 43.95% TiO (cf. theor. 43.93%); 0.06% SiO	Guarded sample	


Temperature, °K
0 50 100 150 200 250 300 350 400 450 500 550 600 650 700 750 800 850 900 950 1000 1050 1100 1150 1200 1250 1300
Thermal Conductivity, Btu/hr ft °R
180 160 140 120 100 80 60 40 20 0
0 100 200 300 400 500 600 700 800 900 1000 1100 1200 1300 1400 1500 1600 1700 1800 1900 2000 2100 2200 2300 2400
Temperature, °R
Thermal Conductivity, cal/sec cm °K
0.8 0.7 0.6 0.5 0.4 0.3 0.2 0.1 0.0
60-697
WADC TR 58-476
555
F - 9 - B - 6 - HA

THERMAL CONDUCTIVITY -- ALUMINUM TITANATE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Buessem, W. R., Earhart, W. R. et al.	52-133	1392	Aluminum titanate	Simple measurement of heat flow in shock test rig	



LINEAR THERMAL EXPANSION -- ALUMINUM TITANATE

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LINEAR THERMAL EXPANSION -- ALUMINUM TITANATE

REFERENCE INFORMATION

Key	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Koch, W. J. and Harman, C. G.	50-12	132-2112	$Al_2O_3 \cdot TiO_2$ 56.1% Al_2O_3; 43.9% TiO_2	Not given	Equimolar mix of Al_2O_3 and TiO_2 ball-milled, dried at 110°C, 5% wax added as binder, pressed at 10,000 psi, fired to 650°C in 8 hr. to remove binder, then to 1820°C in 26 hr., held 1 hr., furnace cooled to room temp. crushed, ground to 6μ, dried, pressed, fired to 1700°C in 29 hr., held 1 hr.
□	Bron, V. A. and Podnegin, A. K.	51-145	492-1932	$Al_2O_3 \cdot TiO_2$	Not given	Fired at 1600°C
△	Whitemore, O. J. and Ault, N. N.	54-7	1032-2102	$Al_2O_3 \cdot TiO_2$	Telemicroscopes sighting on ends of sample. Temp. meas. by Pt, Pt-Rh thermocouples	Fine grain
◇	Buessem, W. R., Earhart, W. R. et al.	52-133	537-2184	Aluminum titanate body. Porosity = 18%	Probably by X-ray measurement of lattice dimensions of unit cell	Dry pressed, held 5 hr. at 1400°C. Orthorombic structure from X-ray photographs. Meas. in direction "a"
▽	Ibid.	52-133	528-2102	Same as above	Same as above	Same as above, but meas. in direction "b"
○	Ibid.	52-133	546-2238	Same as above	Same as above	Same as above, but meas. in direction "c"
○	Ibid.	52-133	546-2348	Same as above	Same as above	Same as above, but random oriented

PROPERTIES OF BARIUM TITANATE

MOST PROBABLE VALUES

Property	Brit. Engineering Units	C. G. S. Units
Density.		
Melting Point	3400°R *	1890°K *
Heat of Fusion		
Heat of Vaporization. . .		
Heat of Sublimation . . .		

* Value for $BaTiO_3$; for others see Reported Values below.

REPORTED VALUES

Density: lb_m/ft^3 g/cm^3

Melting Point:

	°R	°K	Material
O	3372	1873	$BaTiO_3$
□	3404	1891	$BaTiO_3$
△	3394	1885	$BaTiO_3$
◇	3408	1893	$BaTiO_3$
▽	3839	2133	Ba_2TiO_4
○	3336	1853	

Heat of Fusion: Btu/lb_m cal/g

Heat of Vaporization: Btu/lb_m cal/g

Heat of Sublimation: Btu/lb_m cal/g

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °K	Material Composition	Test Method	Remarks
○	Rasmussen, J. A. and DeVries, R. C.	57-42	1272	99.6% $BaTiO_3$; 0.4% $SrTiO_3$	MP: 3 methods (1) metallographic inspection of quenched samples (2) visual with calibrated Pt-Rh thermocouple (3) visual with optical pyrometer	
□	DeVries, R. C. and Roy, R.	55-72	1404	$BaTiO_3$; barium metatitanate	MP: same as above	
△	Rase, D. E. and Roy, R.	55-73	1394	$BaTiO_3$	MP: break in time-temp. curve; Pt-Rh thermocouple	Prepared from c.p. grade $BaCO_3$ and TiO_2 by mixing and sintering for 24 hr. at about 100°C below solidus
◇	Ibid.	55-73	1408	Same as above	MP: visual observation; optical pyrometer; melted on resistance heated Pt-Rh strip	Same as above
▽	Ibid.	55-73	1539	Ba_2TiO_4; barium orthotitanate	Same as above	Prepared as above. Auth. suspects reaction with heater strip
○	DeVries, R. C. and Roy, R.	55-72	1336	82% $BaTiO_3$; 18% $CaTiO_3$	MP: 3 methods. (1) metallographic inspection of quenched samples (2) visual with calibrated Pt-Rh thermocouple (3) visual with optical pyrometer	

57-135
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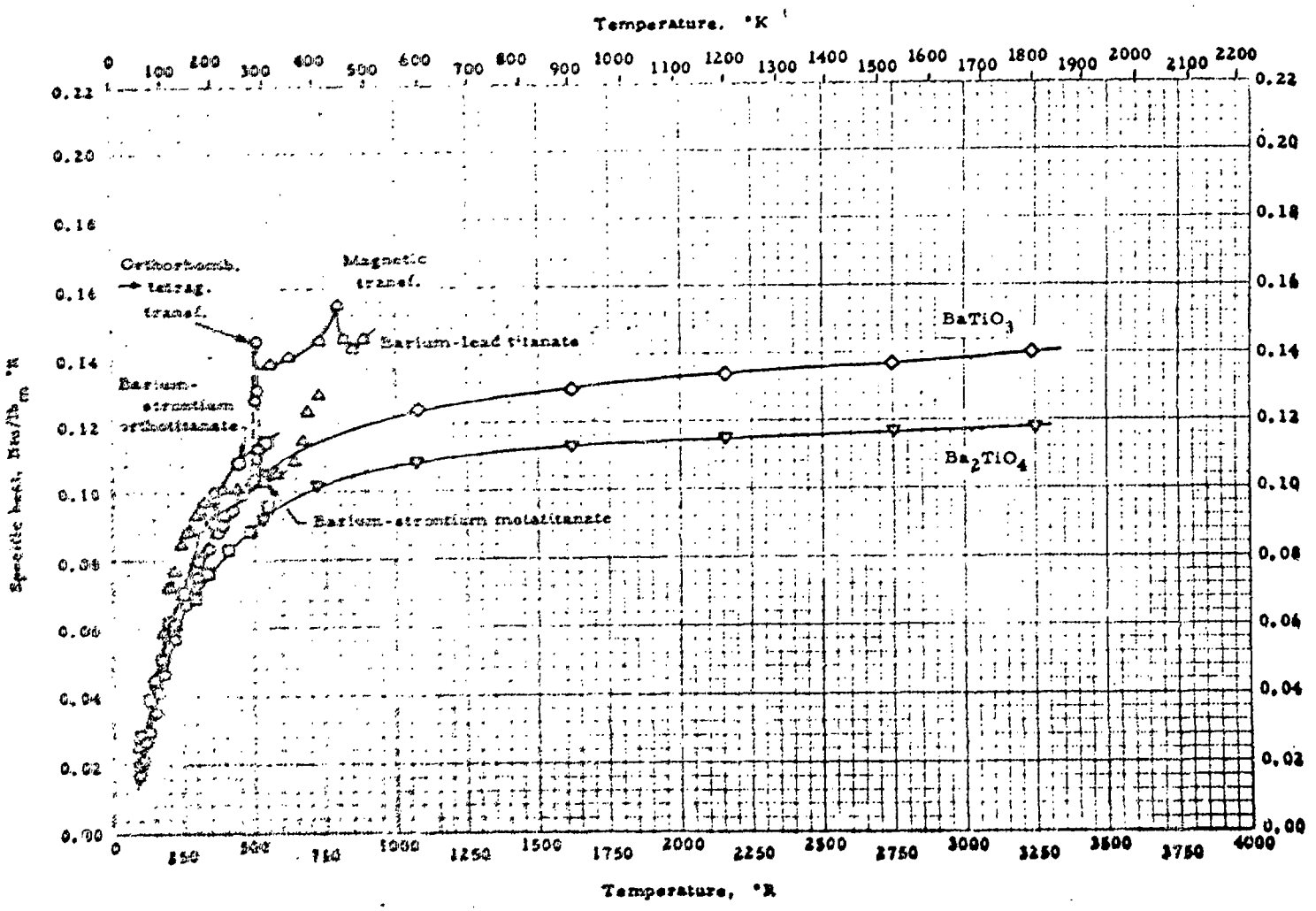
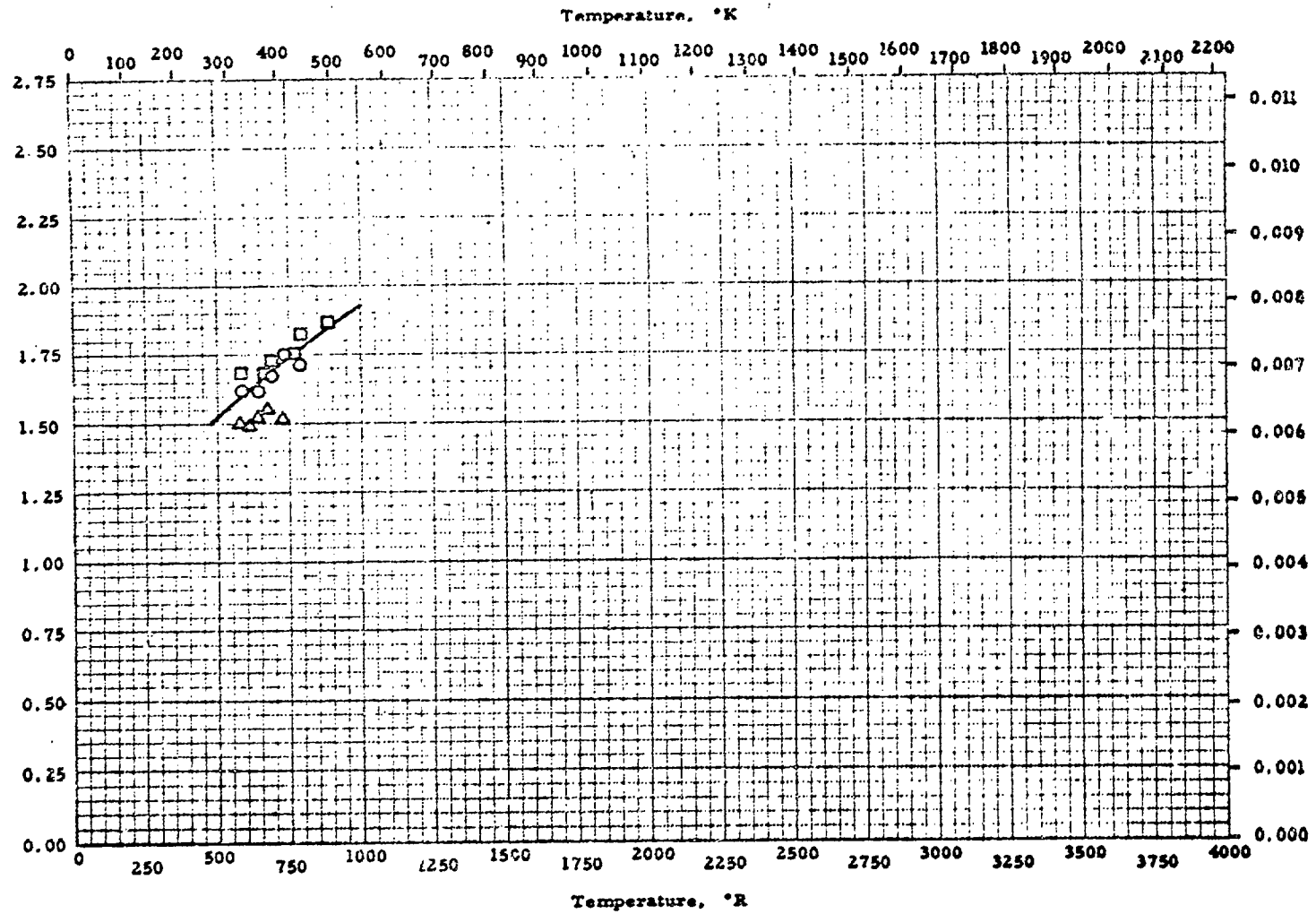


SPECIFIC HEAT -- BARIUM TITANATE

SPECIFIC HEAT -- BARIUM TITANATE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Todd, S. S., and Lorenson, R. E.	52-13	6-542	$BaTiO_3$; 99.7% pure	Guarded sample	Prepared from reagent grade barium hydroxide, and titania (99.8% pure after ignition) by prolonged heating at 1350 C Auth. est. accuracy 0.1%
◇	Coughlin, J. P., and Orr, R. L.	52-11	440-1296	$BaTiO_3$; apparently same sample as above	Drop method; copper block calorimeter	
△	Volger, J.	52-16	179-723	$BaTiO_3$; polycrystalline	Guarded sample	
□	Todd, S. S., and Lorenson, R. E.	52-19	98-542	$BaTiO_3$; est. 99.2% pure; 20.80 at.% TiO_2 (cf. theor. 20.67%); 0.36% CaO; 0.02% SiO_2; no unreacted oxide or metatitanate	Guarded sample	
▽	Coughlin, J. P., and Orr, R. L.	52-11	716-1296	$BaTiO_3$; apparently same sample as above	Drop method; copper block calorimeter	
⬡	Todd, S. S. and Lorenson, R. E.	52-13	96-536	94.3 mol % $BaTiO_3$; 45.7 mol % $SrTiO_3$; crystalline solution	Guarded sample	Prolonged heating at 1400 °C to assure uniform product. Auth. est. accuracy 0.1%
⬠	Todd, S. S. and Lorenson, R. E.	52-19	98-536	Equimolar solid solution Ba_2TiO_4 and Sr_2TiO_4; 57.38% Ba_2TiO_4 (99.2% pure); 42.62% Sr_2TiO_4; (99.5% pure)	Guarded sample	
⊘	Nomura, S., and Sawada, S.	51-10	144-888	80% $BaTiO_3$; 20% $PbTiO_3$	Guarded sample	Fired at 1200-1400 °C

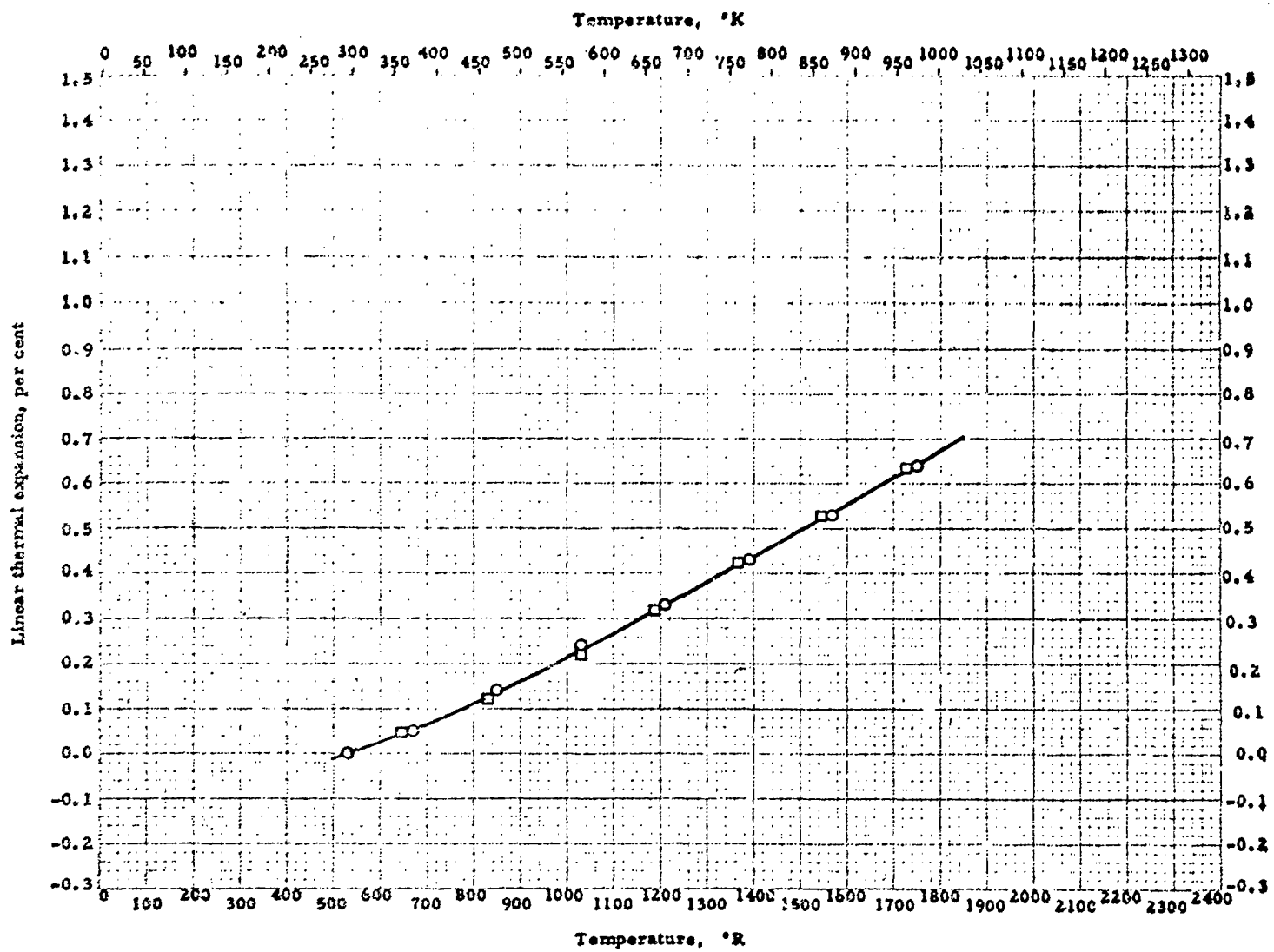


THERMAL CONDUCTIVITY -- BARIUM TITANATE

THERMAL CONDUCTIVITY -- BAPIUM TITANATE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	New Jersey Ceramic Research Station	53-43	580-900	Barium titanate	Comparative, rods tested in vac.	Sample 1
□	Ibid.	53-43	580-900	Same as above	Same as above	Sample 2
△	New Jersey Ceramic Research Station	54-69	572-730	Barium titanate	Comparative, rods tested in vac.	

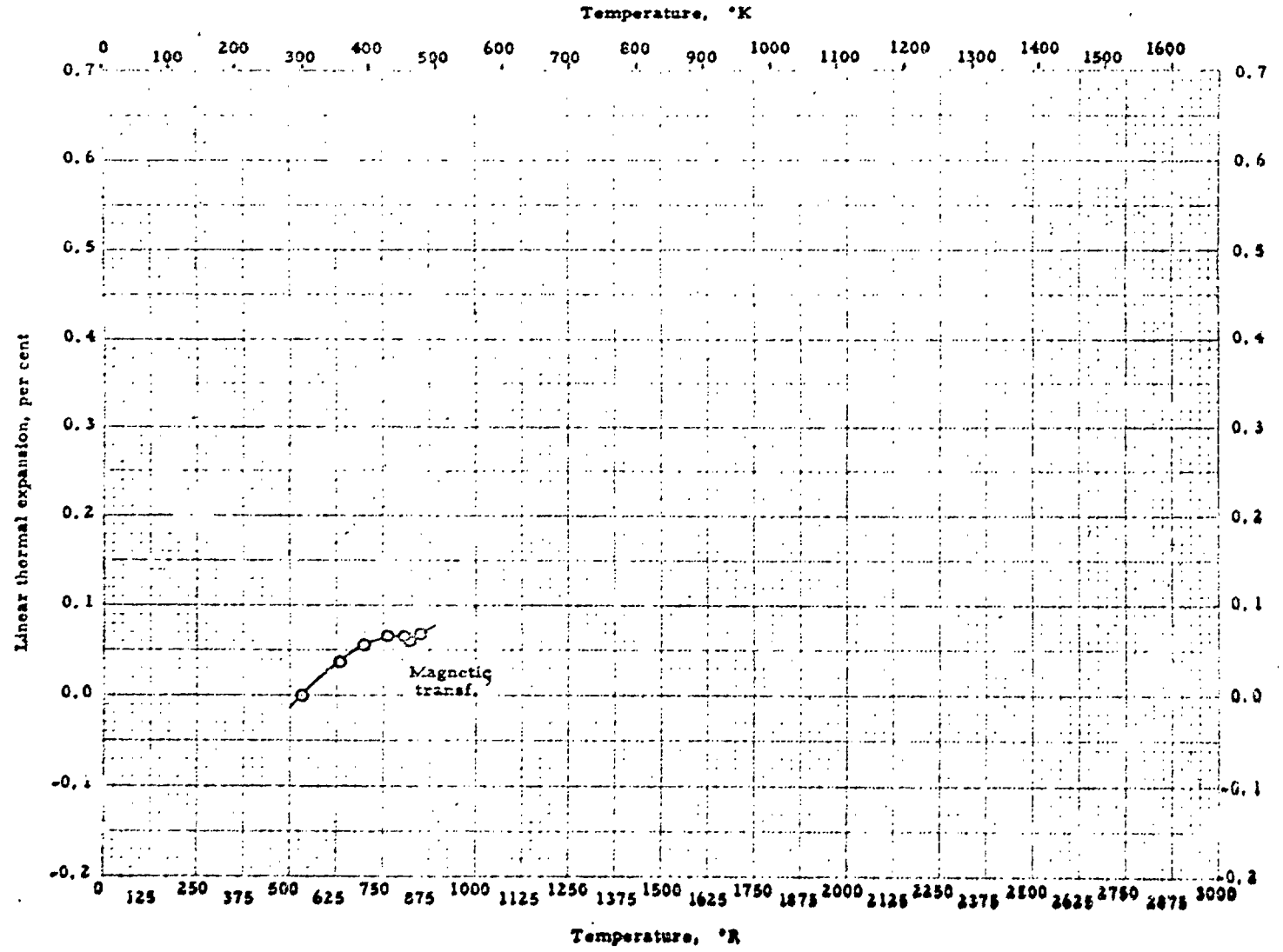


LINEAR THERMAL EXPANSION -- BARIUM BERYLLIUM TITANATE

LINEAR THERMAL EXPANSION -- BARIUM BERYLLIUM TITANATE

REFERENCE INFORMATION

Sym bol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Bunting, E. N., Shelton, G. R. et al	51-86	537-1752	50% $5BeO \cdot 4TiO_2$; 50% $BaO \cdot 5TiO_2$	Interferometer	
□	Ibid.	51-86	537-1752	50% $6BeO \cdot TiO_2$; 50% $BrO \cdot TiO_2$	Same as above	

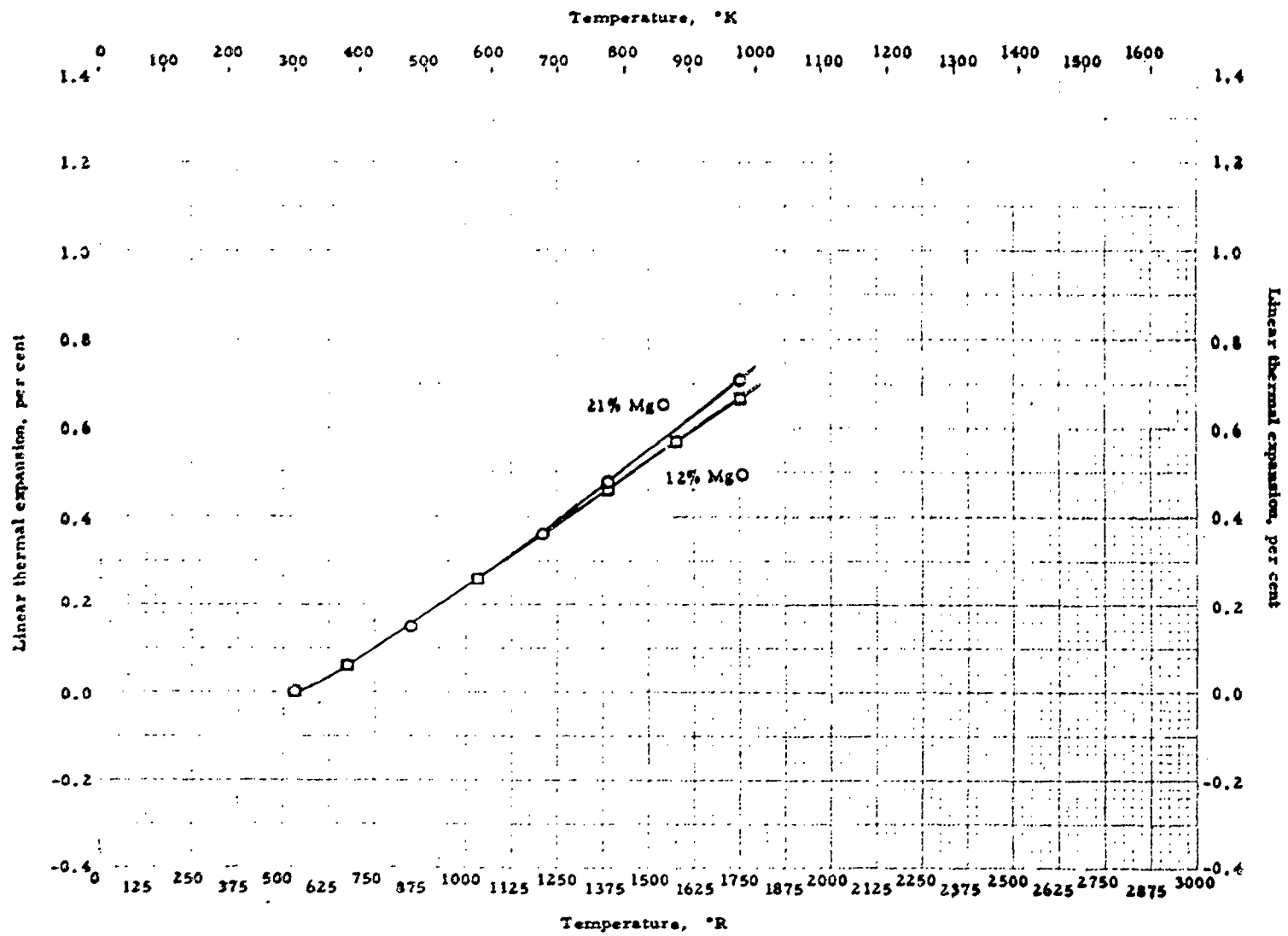


LINEAR THERMAL EXPANSION -- BARIUM LEAD TITANATE

LINEAR THERMAL EXPANSION -- BARIUM LEAD TITANATE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Nomura, S. and Sawada, S.	51-20	528-852	80% $BaTiO_3$; 20% $PbTiO_3$	Cone type dilatometer	

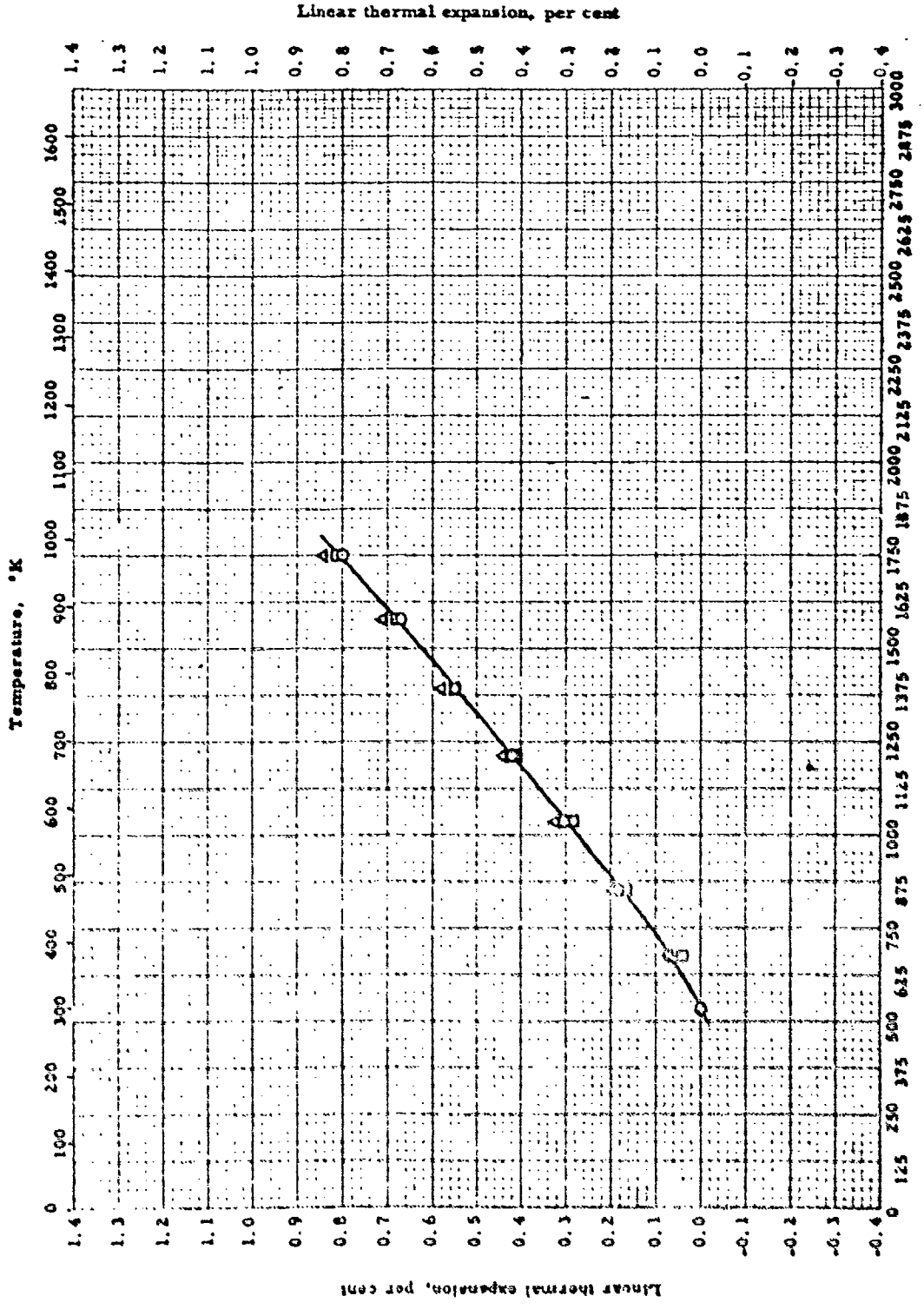


LINEAR THERMAL EXPANSION -- BARIUM MAGNESIUM TITANATE

LINEAR THERMAL EXPANSION -- BARIUM MAGNESIUM TITANATE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Shelton, G. R., Creamer, A. S. and Bunting, E. N.	48-3	672-1752	54.5% TiO_2; 24.5% BaO; 21.0% MgO	Interferometer	Heated 12 hr. at 1100°C; matured 6 hr. at 1250-1450°C
□	Ibid.	48-3	672-1752	75.1% TiO_2; 13.0% BaO; 11.9% MgO	Same as above	Same as above

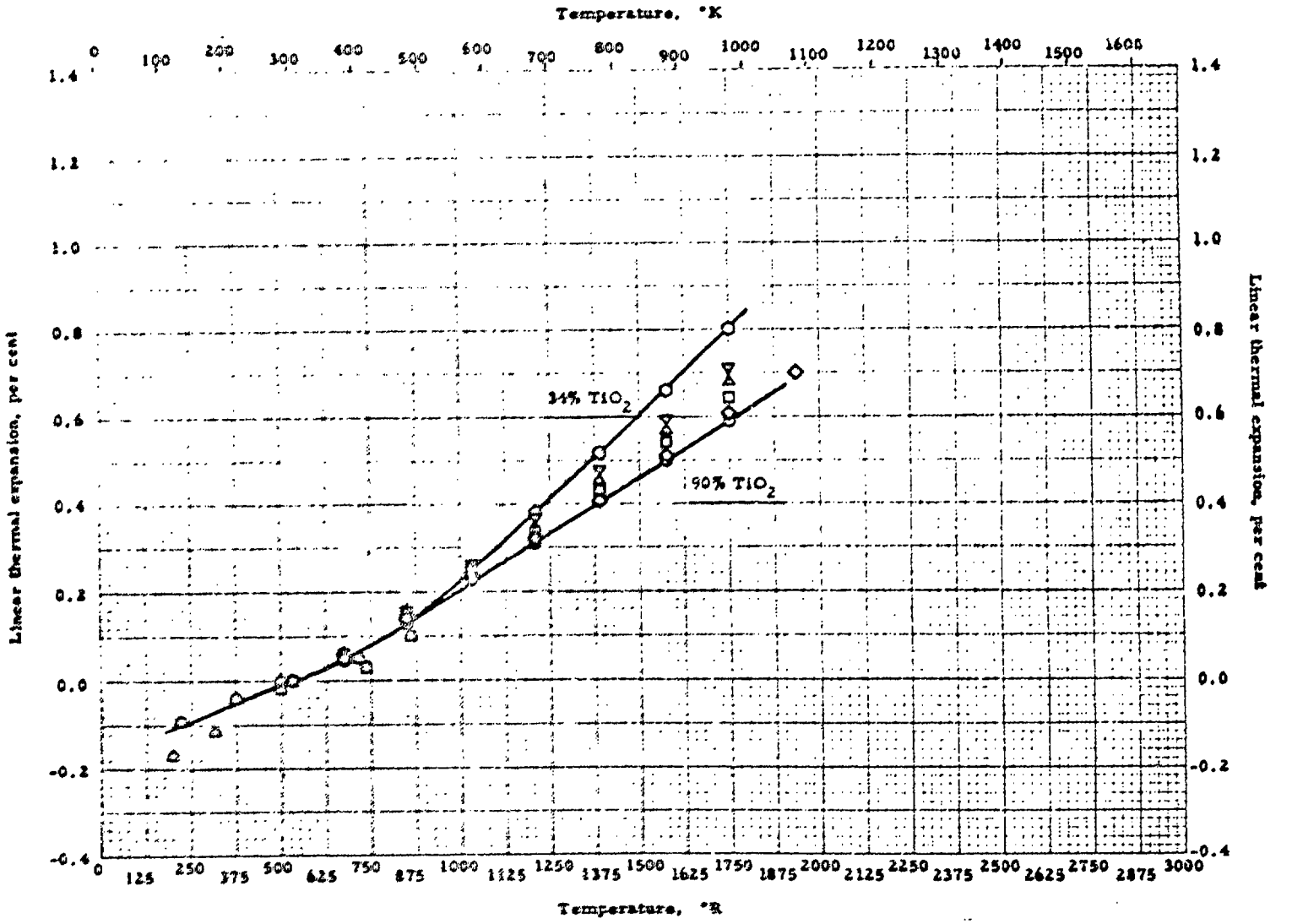


LINEAR THERMAL EXPANSION -- BARIUM STRONTIUM TITANATE

LINEAR THERMAL EXPANSION -- BARIUM STRONTIUM TITANATE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Bunting, E. N., Shelton, G. R., and Creamer, A. S.	47-9	672-1752	41.0% TiO_2; 35.0% SrO; 23.7% BaO; prepared from 64.0% (SrO + TiO_2); 36.0% (BaO + TiO_2)	Interferometer	Heated 12 hr. at 1100°C, matured 6 hr. at 1250-1430°C
□	Ibid.	47-9	672-1752	55.1% BaO; 35.8% TiO_2; 9.1% SrO; prepared from 83.8% (BaO + TiO_2); 16.2% (SrO + TiO_2)	Same as above	Same as above
△	Ibid.	47-9	672-1752	46.7% BaO; 37.0% TiO_2; 16.3% SrO; prepared from 71.0% (BaO + TiO_2); 29.0% (SrO + TiO_2)	Same as above	Same as above

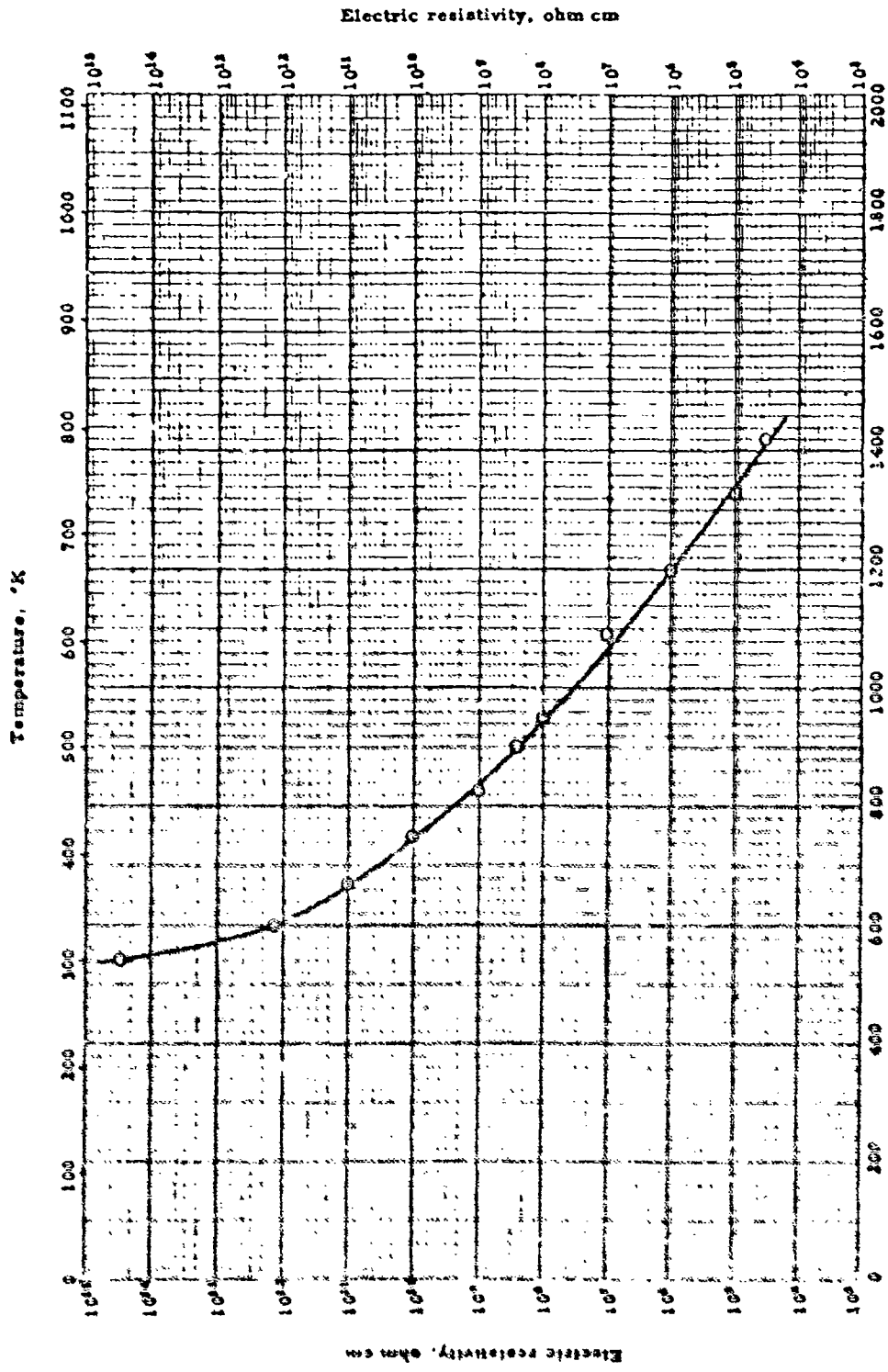


LINEAR THERMAL EXPANSION -- BARIUM TITANATE

LINEAR THERMAL EXPANSION -- BARIUM TITANATE

REFERENCE INFORMATION

	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Harding, E. M., Skelton, G. R. and Creamer, A. S.	47-9	528-1752	$BaO: 1.6TiO_2$. 40.4% TiO_2; 9.4% BaO	Interferometer	Heated to 1100°C for 12 hrs.; matured at 1250 to 1430°C for 6 hrs.
□	Ibid.	47-9	528-1752	$BaO: 4TiO_2$. 75.7% TiO_2; 24.3% BaO	Same as above	Same as above
△	Ibid.	47-9	528-1752	$BaO: 5TiO_2$. 77.3% TiO_2; 22.7% BaO	Same as above	Same as above
◇	Ibid.	47-9	528-1932	$BaO: 6TiO_2$. 67.6% TiO_2; 32.4% BaO	Same as above	Same as above
▽	Ibid.	47-9	528-1752	$BaO: 7TiO_2$. 61.0% TiO_2; 39.0% BaO	Same as above	Same as above
○	Ibid.	47-9	528-1752	$BaO: TiO_2$. 65.7% BaO; 34.3% TiO_2	Same as above	Same as above
◘	Strnad, C. and Takeda, A.	51-87	528-648	$BaTiO_3$	Quartz differential dilatometer	Calcined from 99.2% TiO_2 and 99.6% $BaCO_3$, sintered at 1400°C. Auth. report transformations at -77°C, 16°C and 125°C
◇	Rhodes, R. G.	51-88	204-528	$BaTiO_3$	From vol. change computed from x-ray meas. of unit cell dimensions	Auth. reports transformations at -100°C trigonal ⟶ orthorombic; at 4°C orthorombic ⟶ tetragonal; a third transformation at 120°C



ELECTRIC RESISTIVITY -- BARIUM TITANATE

ELECTRIC RESISTIVITY -- BARIUM TITANATE

REFERENCE INFORMATION

Curve Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Weiss, E. K. and Andrews, M. C.	56-152	542-1420	$BaTiO_3$	Potential drop, using vacuum tube electrometer	Temp. controlled to $\leq 0.1°C$

PROPERTIES OF CALCIUM TITANATE

MOST PROBABLE VALUES

Property	Brit. Engineering Units	C. G. S. Units
Density.	256 lb_m/ft^3 *	4.10 g/cm^3 *
Melting Point	4038°R	2243°K
Heat of Fusion		
Heat of Vaporization. . .		
Heat of Sublimation . . .		

* Handbook of Chemistry and Physics (Ref. 57-60)

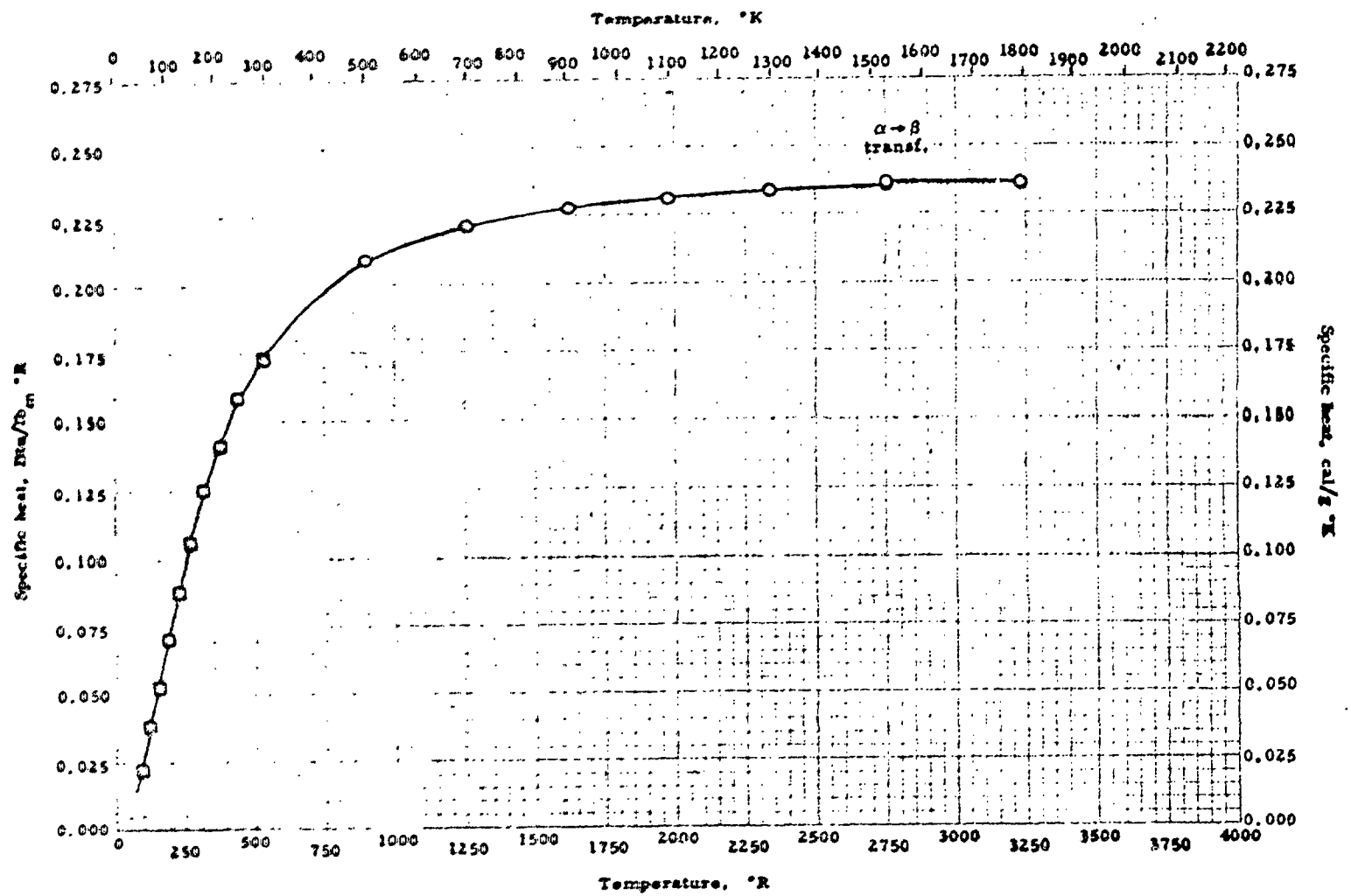
REPORTED VALUES

Density:		lb_m/ft^3	g/cm^3
Melting Point:		°R	°K
	O	4038	2243
Heat of Fusion:		Btu/lb_m	cal/g
Heat of Vaporization:		Btu/lb_m	cal/g
Heat of Sublimation:		Btu/lb_m	cal/g

PROPERTIES OF CALCIUM TITANATE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	DeVries, R. C. and Roy, R.	55-72	4038	$CaTiO_3$	MP: 3 methods: (1) metallographic inspection of quenched samples (2) visual with calibrated Pt-Rh thermocouple (3) visual with optical pyrometer	



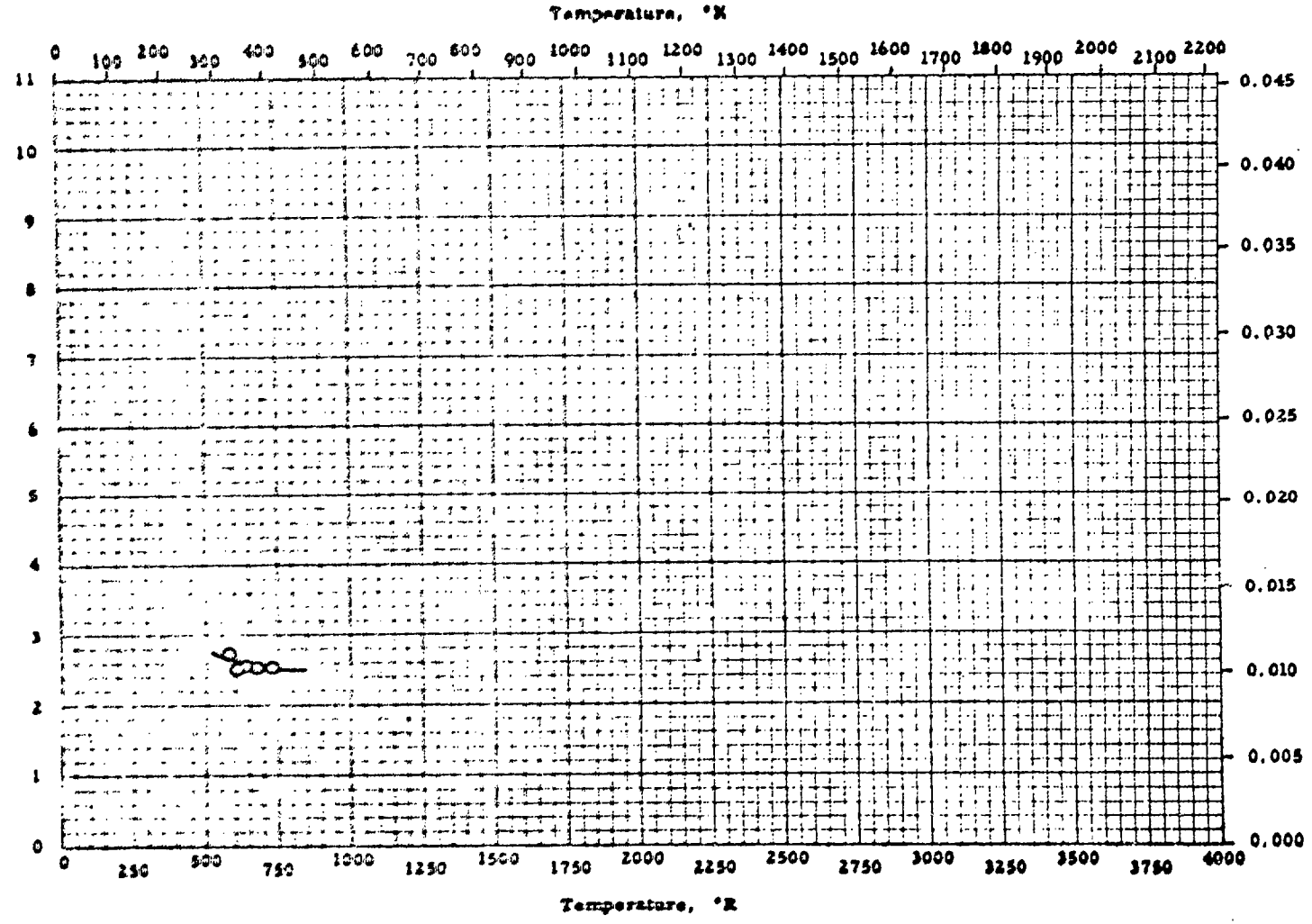
SPECIFIC HEAT -- CALCIUM TITANATE

WADC TR 58-476 59-186

SPECIFIC HEAT -- CALCIUM TITANATE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Naylor, B. F. and Cook, D. A.	46-6	231-2230	Calcium metatitanate, $CaTiO_3$ · 0.69% CaO; 0.05% CO_2	Drop method; copper block calorimeter	$\alpha \rightarrow \beta$ transition at 1530 °K with $\Delta h_{transf.}$ = 4.04 Btu/lb
□	King, E. G.	55-62	96-537	Tricalcium dititanate, $Ca_3Ti_2O_7$ · 48.61% titania (cf. theor. 48.71%)	Guarded sample	

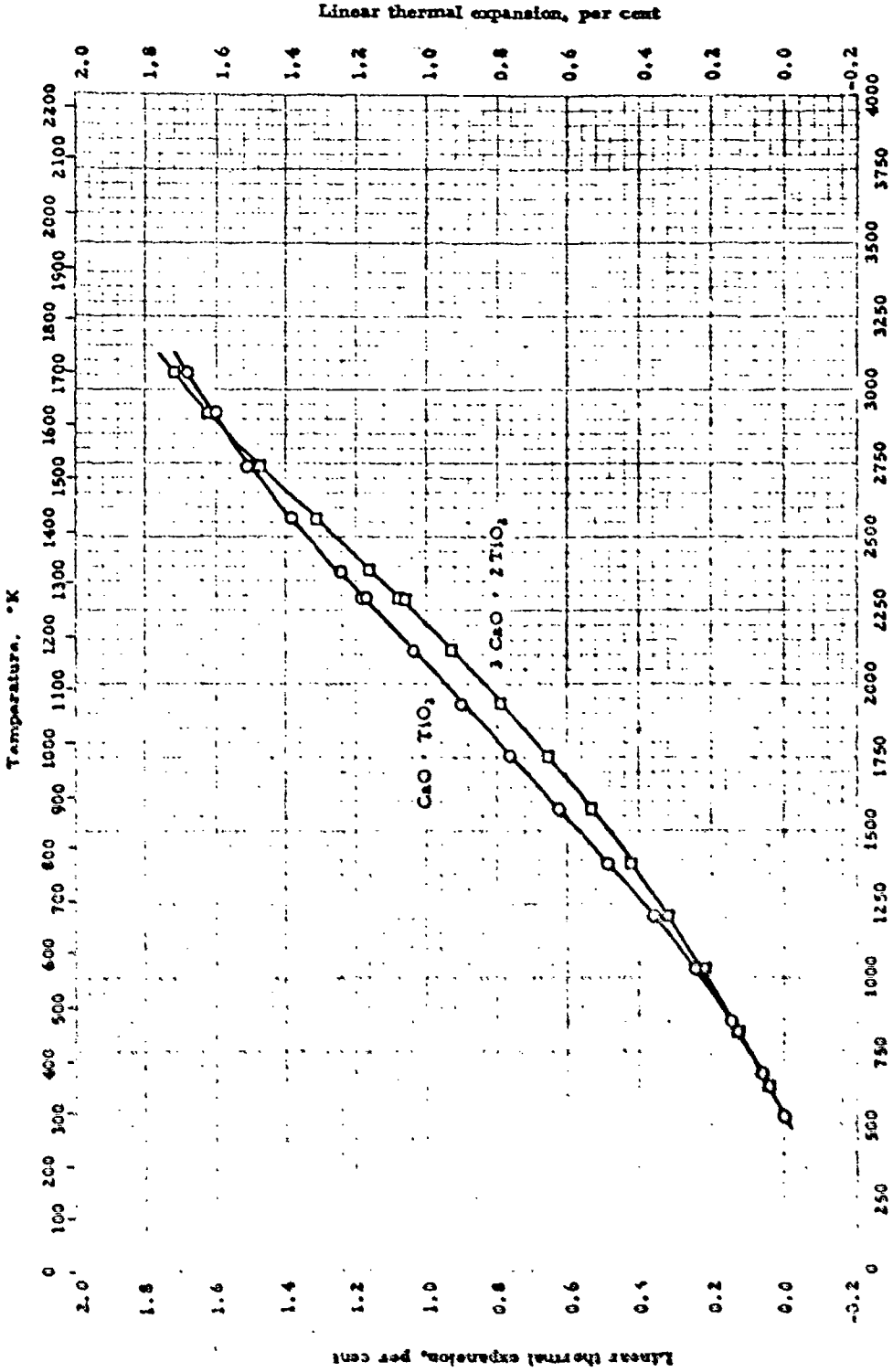


THERMAL CONDUCTIVITY -- CALCIUM TITANATE

THERMAL CONDUCTIVITY -- CALCIUM TITANATE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	New Jersey Ceramic Research Station	54-69	572-1730	Calcium titanate	Comparative; rods	Tested in vac.

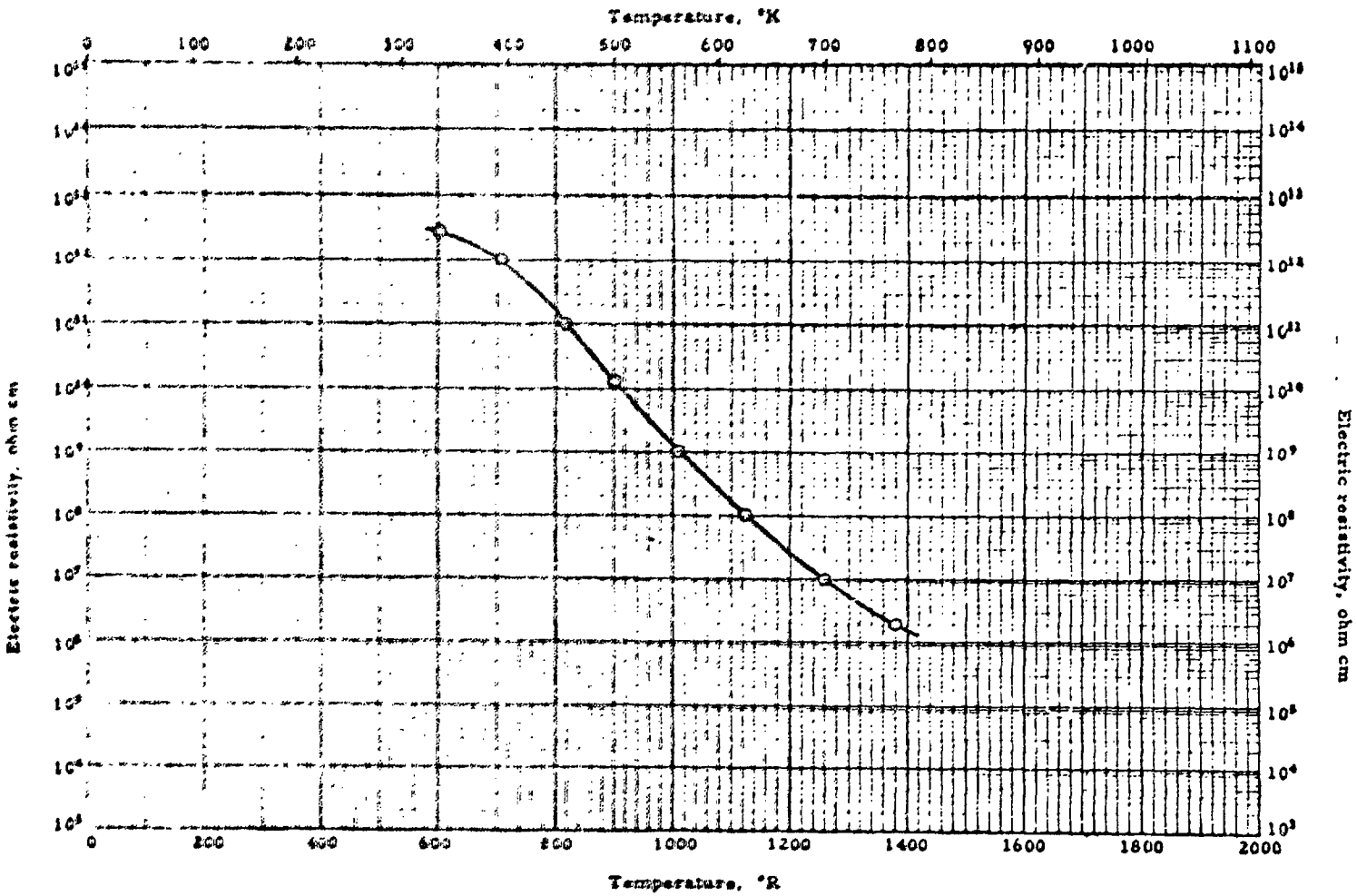


LINEAR THERMAL EXPANSION -- CALCIUM TITANATE

LINEAR THERMAL EXPANSION -- CALCIUM TITANATE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Eichelberger, R. L.	54-146	672-3057	$CaO \cdot TiO_2$, calcium metatitanate	Two methods: a. below 1000° C, interferometer b. above 1000°C, dilatometer	Pressed, fired to 1600°C
□	Ibid.	54-146	672-3057	$3CaO \cdot 2TiO_2$	Same as above	Same as above



ELECTRIC RESISTIVITY -- CALCIUM TITANATE

ELECTRIC RESISTIVITY -- CALCIUM TITANATE

REFERENCE INFORMATION

Fig. No.	Investigator	Ref.	Range, °K	Material Composition	Test Method	Remarks
O	Weise, E. K. and Andrews, M. C.	56-152	600-1180	$CaTiO_3$	Potential drop, using vacuum tube electrometer	Temp. controlled to $\leq 0.1°C$

PROPERTIES OF IRON TITANATE

MOST PROBABLE VALUES

Property	Brit. Engineering Units	C. G. S. Units
Density.		
Melting Point	2750°R	1640°K
Heat of Fusion	257 Btu/lb_m	143 cal/g
Heat of Vaporization. . .		
Heat of Sublimation . . .		

REPORTED VALUES

		lb_m/ft^3	g/cm^3
Density:			

		°R	°K
Melting Point:	O	2953	1640

		Btu/lb_m	cal/g
Heat of Fusion:	O	257	142.8

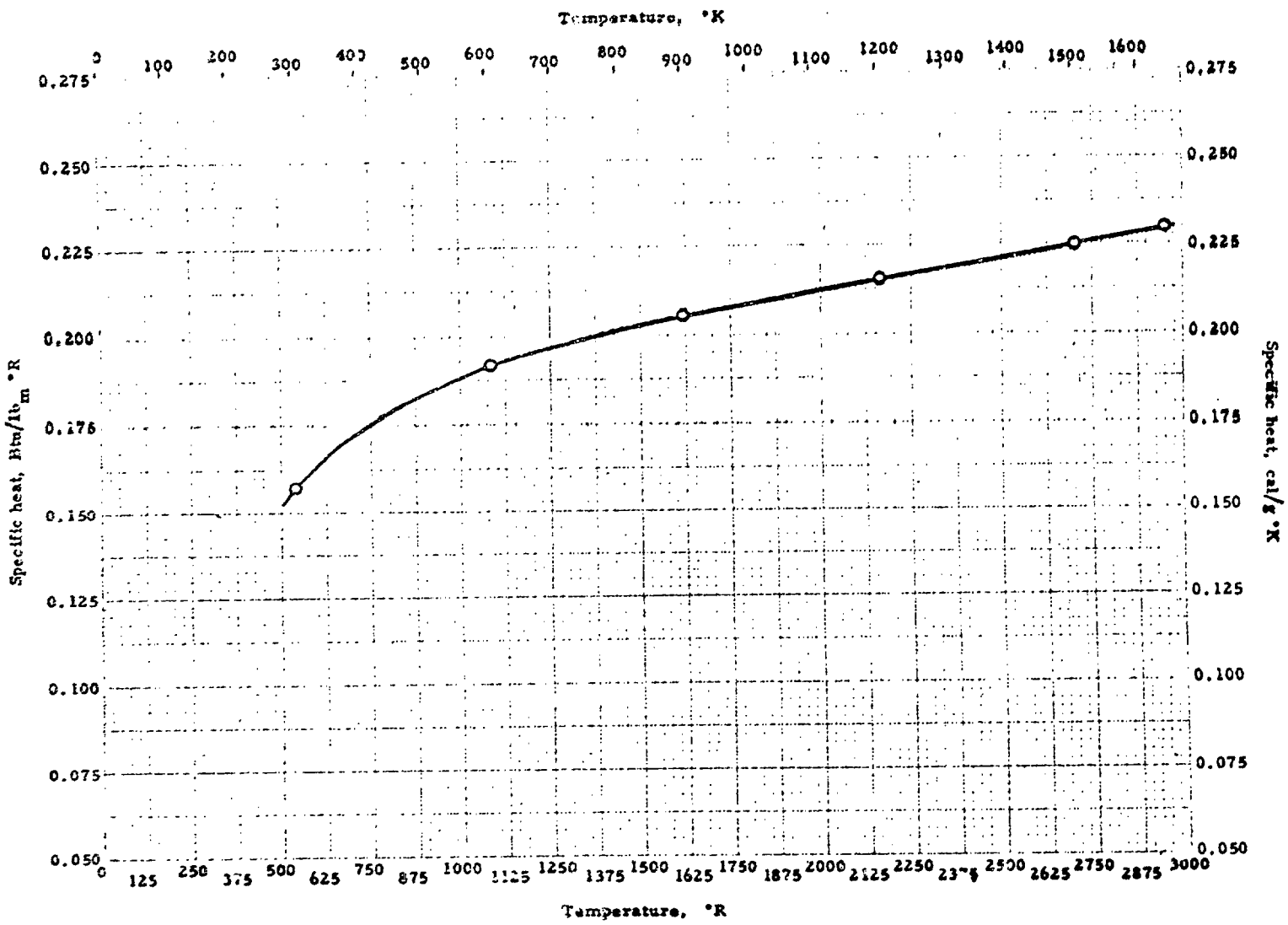
		Btu/lb_m	cal/g
Heat of Vaporization:			

		Btu/lb_m	cal/g
Heat of Sublimation:			

PROPERTIES OF IRON TITANATE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °K	Material Composition	Test Method	Remarks
O	Naylor, B. F. and Cook, O. A.	66-4	1443	99.4% $FeTiO_3$, 0.6% SiO_2; (Ilmenite)	MP: visual observation; calibrated Pt-Rh thermocouple Δh_f: from enthalpy data above and below MP by drop method into copper calorimeter	Powdered ingredients mixed and heated in vacuum 30 hr. at 1165-1300°C

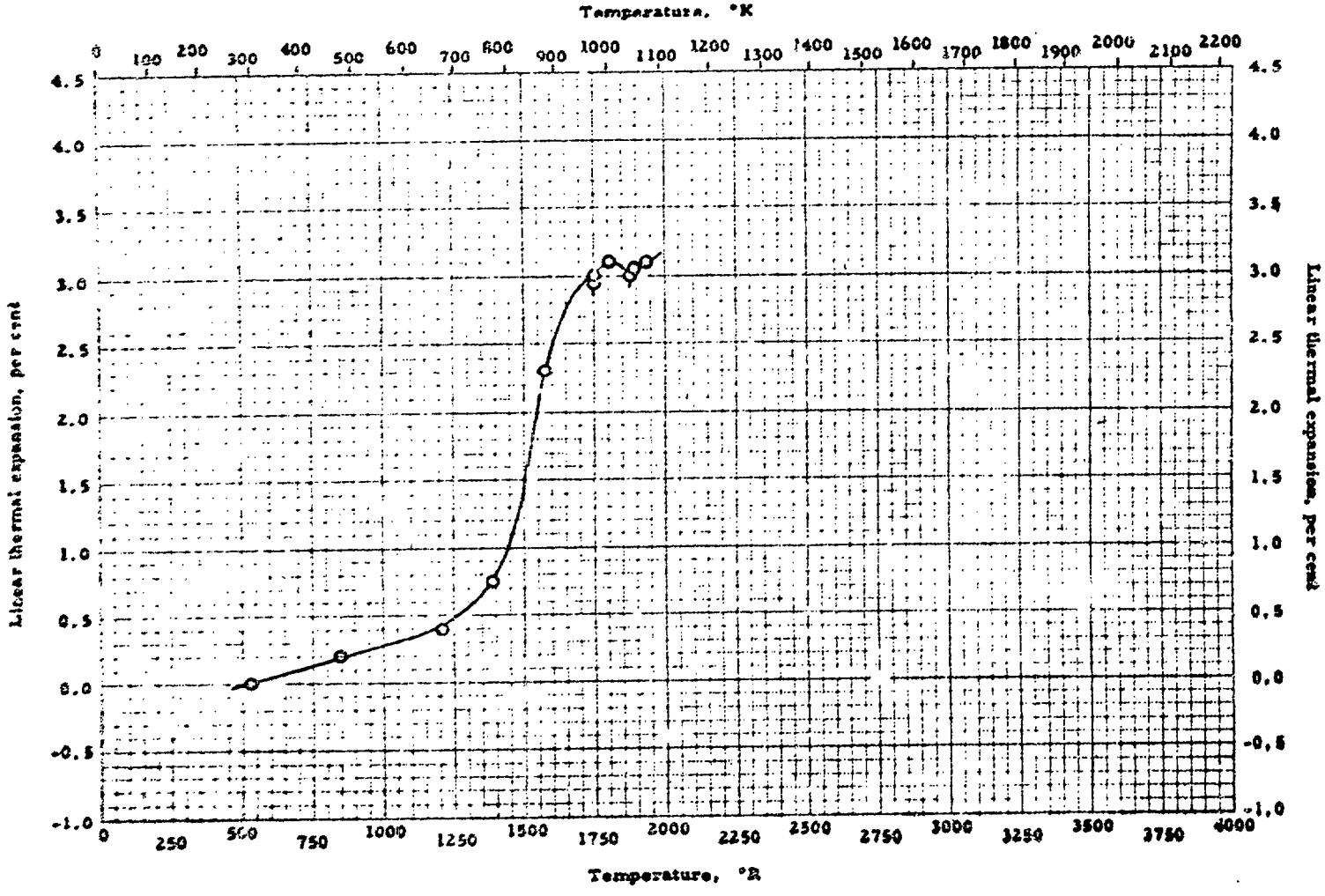


SPECIFIC HEAT -- IRON TITANATE

SPECIFIC H[illegible] -- IRON TITANATE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Naylor, B. F., and Cook, O. A.	46-6	536-3240	Ilmenite; 99.4% $FeTiO_3$; 0.6% silica	Drop method; copper block calorimeter	Powdered raw materials mixed and heated in vacuum 30 hr. at 1165-1300°C

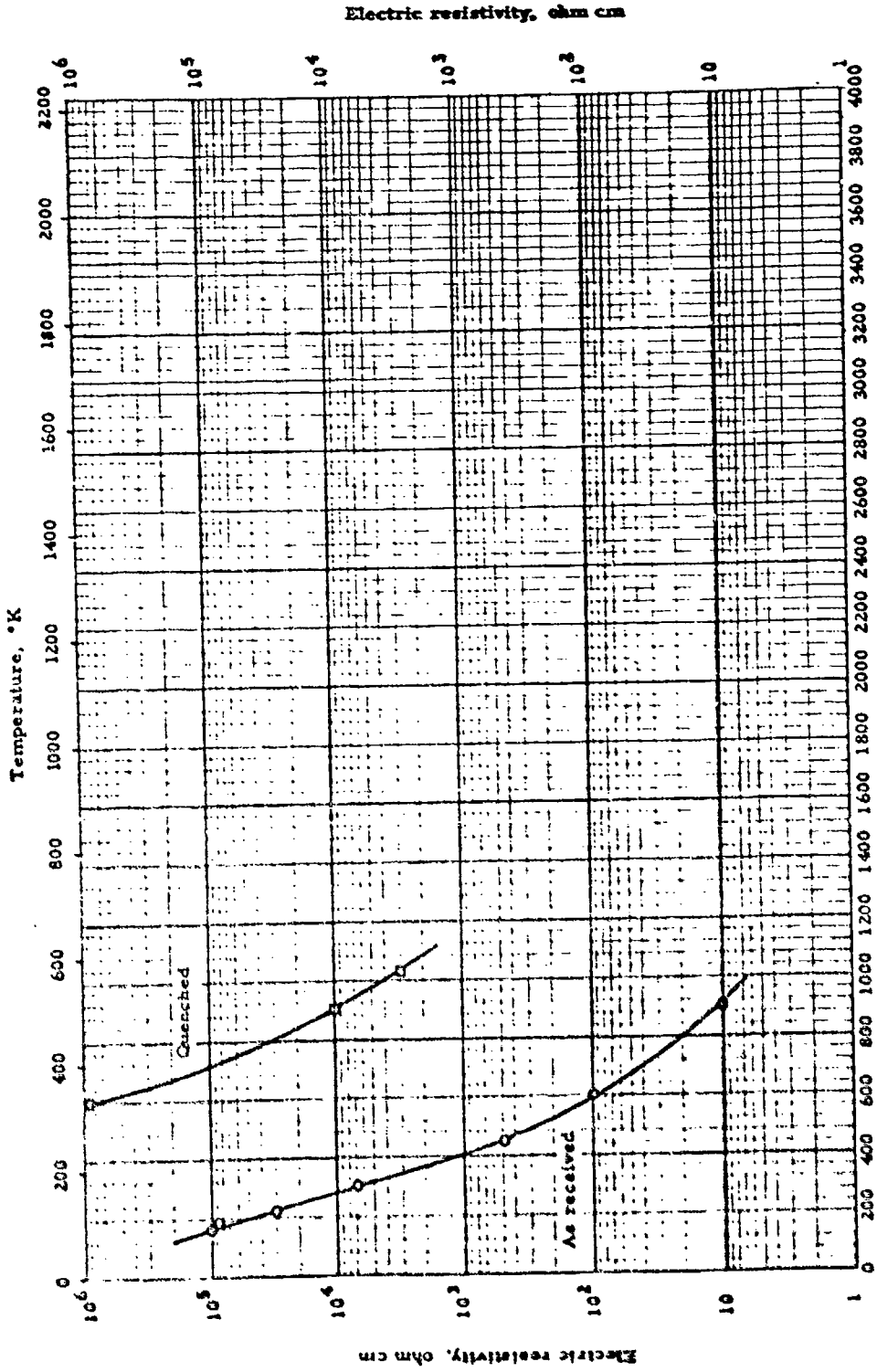


LINEAR THERMAL EXPANSION -- IRON TITANATE

LINEAR THERMAL EXPANSION -- IRON TITANATE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °F	Material Composition	Test Method	Remarks
O	Ishikawa, Y. and Sawada, S.	56-19	570-1932	Ilmenite. Prepared by $Fe_2O_3 + 3TiO_2 + Fe = 2FeTiO_3$; final mol ratio Fe:Ti = 0.9945:1	Dilatometer	O - heating, 2°C/sec.; O - cooling; powders milled, pressed, sintered 6 hr. at 1350°C in vacuum

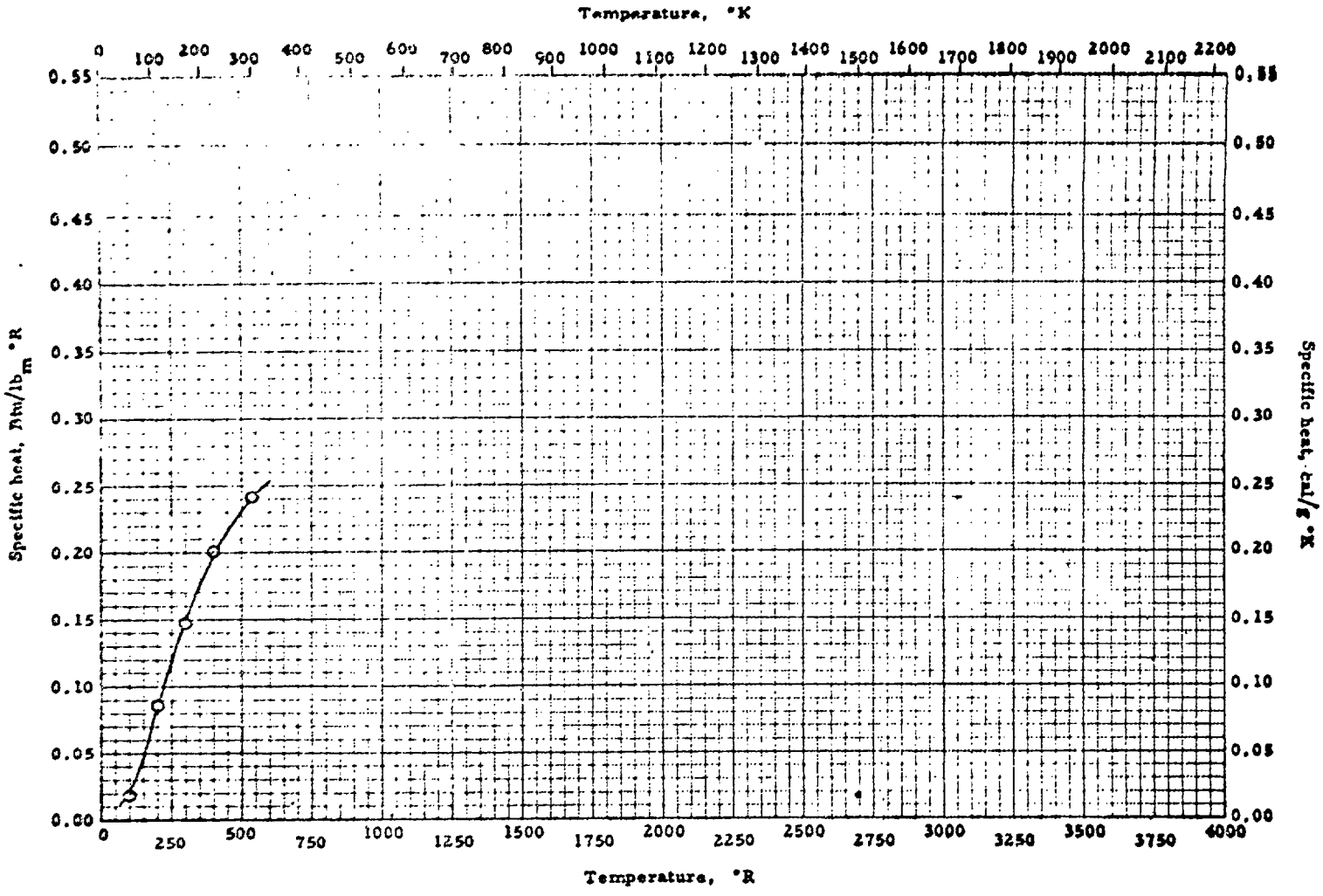


ELECTRIC RESISTIVITY -- IRON TITANATE

ELECTRIC RESISTIVITY -- IRON TITANATE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Ishikawa, Y. and Sawada, S.	56-19	164-1800	$FeTiO_3$. Ilmenite. Actual ratio Fe to Ti = 0.9945:1	Potential drop	Auth. gives $r = r_o e^{E/akT}$ Measured in air and in vacuum
□	Ibid.	56-19	514-1092	Same as above	Same as above	Quenched. Meas. in vacuum

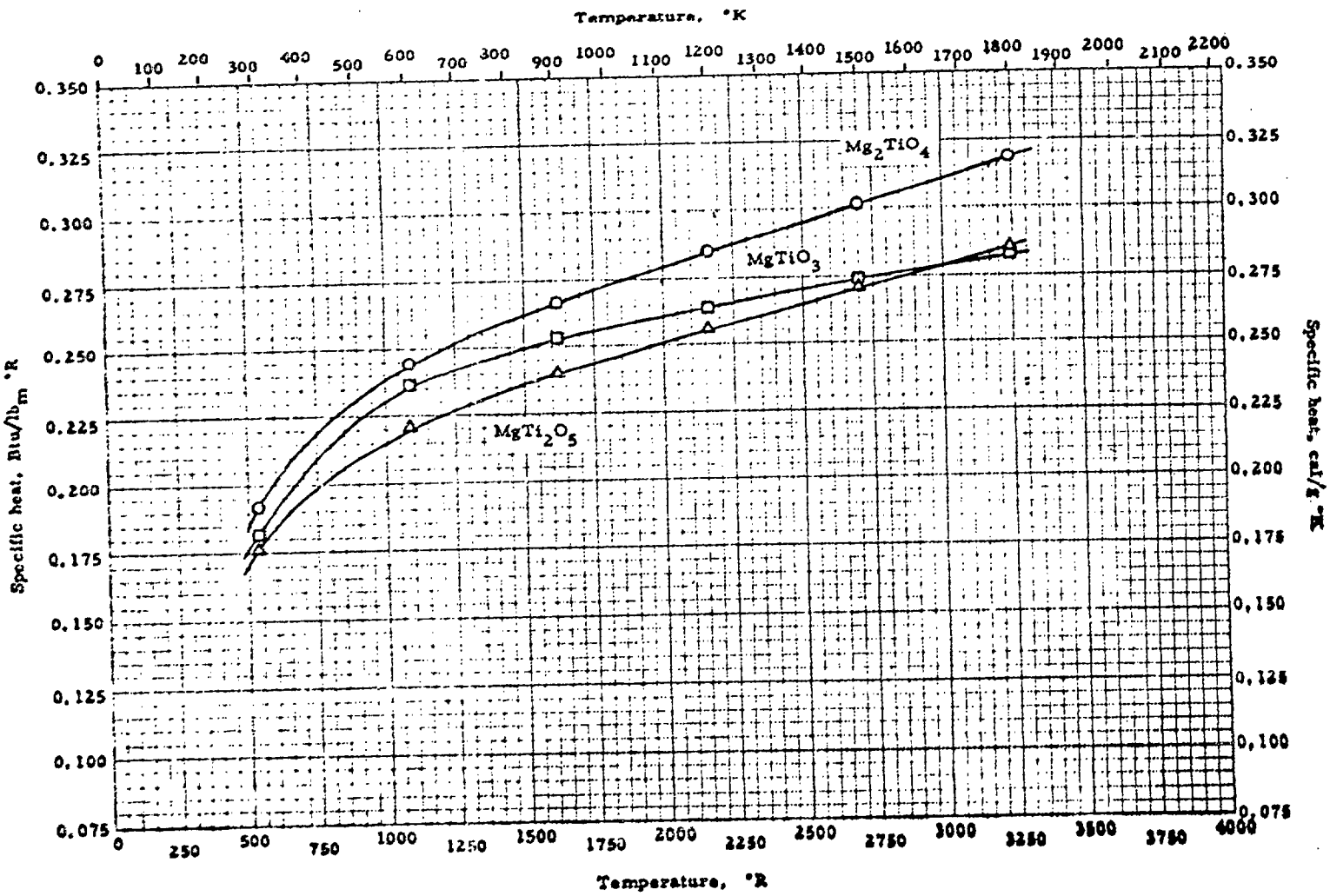


SPECIFIC HEAT -- LITHIUM METATITANATE

SPECIFIC HEAT -- LITHIUM METATITANATE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	King, E. G.	55-42	99-537	Li_2TiO_3. 72.70% titania (cf. theor. 72.78%); 0.06% Ni + Pt; 0.03% silica	Guarded sample	

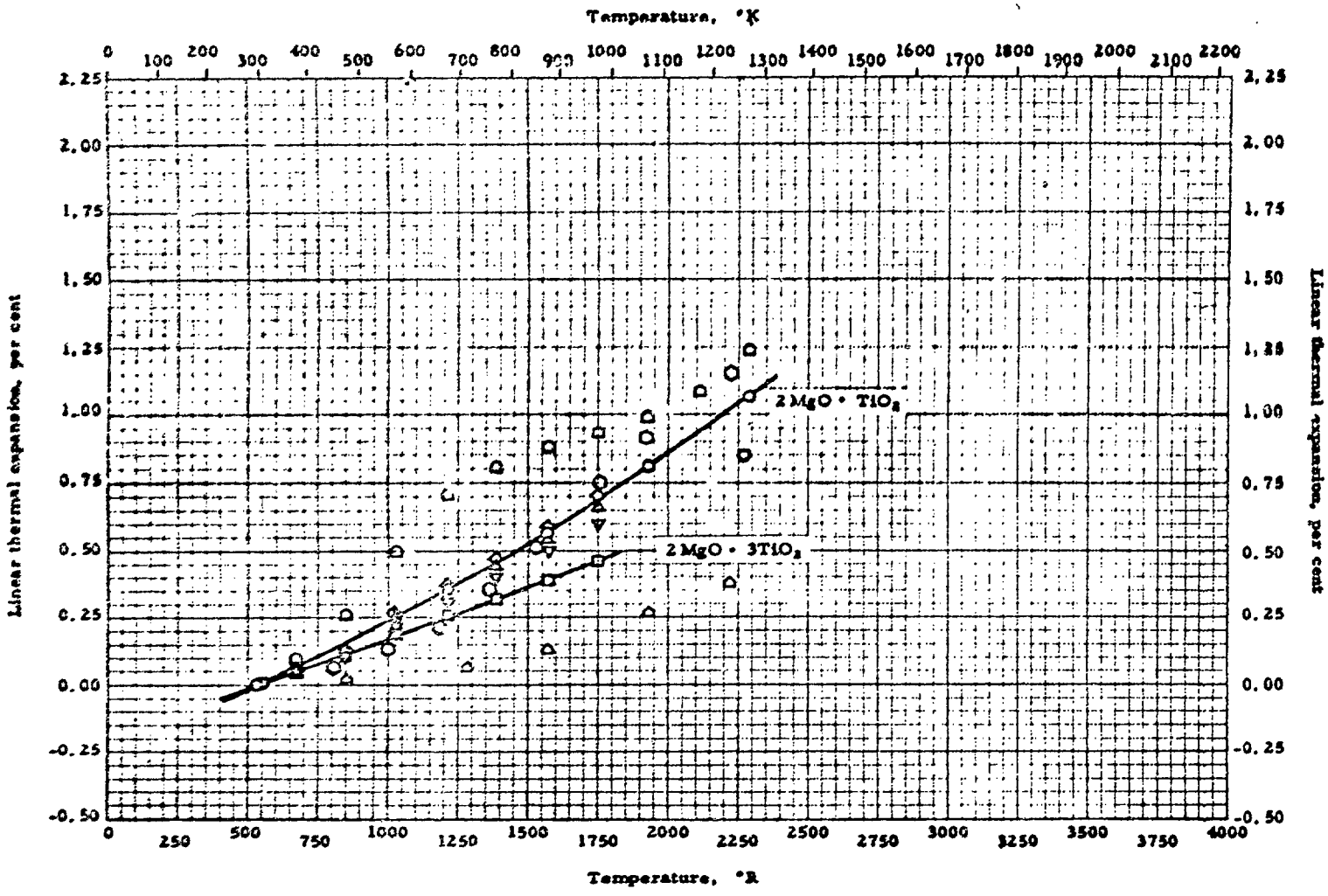


SPECIFIC HEAT -- MAGNESIUM TITANATE

SPECIFIC HEAT -- MAGNESIUM TITANATE

REFERENCE INFORMATION

Sym.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Orr, R. L. and Coughlin, J. P.	52-61	536-3240	Mg_2TiO_4, 49.53% TiO_2 (cf. theor. 49.77%); 0.21% SiO_2	Drop method; copper block calorimeter	Oxides were mixed, pressed at 15,000 psi, and heated for long periods at 1300 - 1500 °C. Auth. est. accuracy of heat content data 0.5%
△	Ibid.	52-61	536-3240	$Mg_2Ti_2O_5$, 79.63% TiO_2 (cf. theor. 79.85%); 0.16% TiO_3	Same as above	Same as above
□	Naylor, B. F. and Cook, O. A.	46-6	536-3240	99% $MgTiO_3$, 0.45% MgO	Drop method; copper block calorimeter	

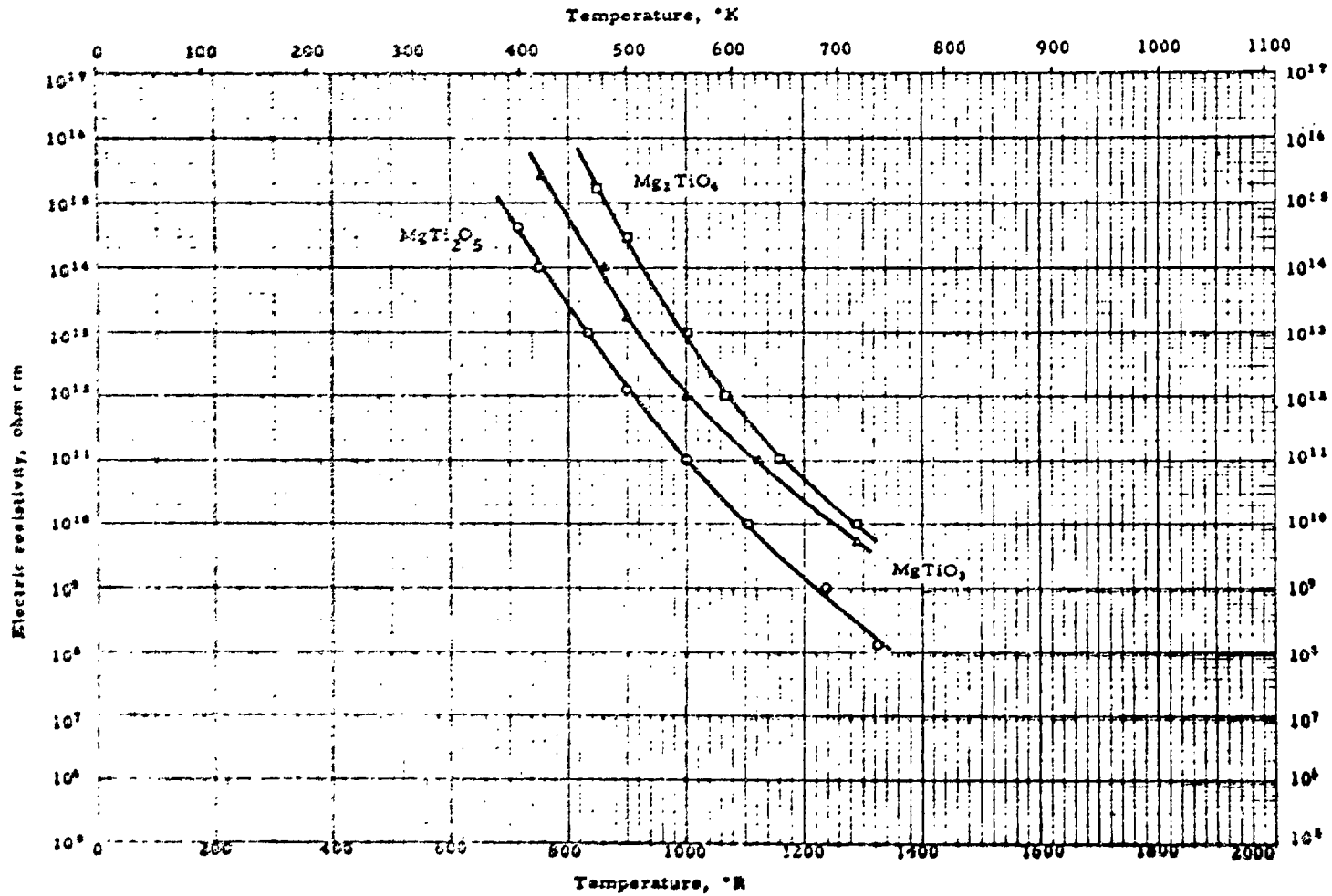


LINEAR THERMAL EXPANSION -- MAGNESIUM TITANATE

LINEAR THERMAL EXPANSION -- MAGNESIUM TITANATE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	McKinstry, H. A., Hocker, C. F. et al.	49-15	528-2292	50.2% MgO; 49.8% TiO_2 ($2MgO \cdot TiO_2$)	Not given	Fired 2 hr. at 1400°C
△	Shelton, G. R., Creamer, A.S. and Bunting, E. N.	48-3	672-1752	50.2% TiO_2; 49.8% MgO ($2MgO \cdot TiO_2$)	Interferometer	Heated 12 hr. at 1100°C, matured 5 hr. at 1250-1450°C
◇	Ibid.	48-3	672-1752	66.5% TiO_2; 33.5% MgO ($MgO \cdot TiO_2$)	Same as above	Same as above
□	Ibid.	48-3	672-1752	74.8% TiO_2; 25.2% MgO ($2MgO \cdot 3TiO_2$)	Same as above	Same as above
▽	Ibid.	48-3	672-1752	90.8% TiO_2; 9.2% MgO ($MgO \cdot 5TiO_2$)	Same as above	Same as above
○	Buessem, W. R., Earhart, W. R. et al.	52-133	582-2220	Magnesium dititanate	Unit cell meas. by x-ray diffraction	Meas. along a axis of crystal
□	Ibid.	52-133	555-2292	Same as above	Same as above	Meas. along b axis of crystal
△	Ibid.	52-133	615-2220	Same as above	Same as above	Meas. along c axis of crystal
▽	Ibid.	52-133	537-2256	Same as above	Same as above	Random



ELECTRIC RESISTIVITY -- MAGNESIUM TITANATE

AMRL-TR-64-176

ELECTRIC RESISTIVITY -- MAGNESIUM TITANATE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °F	Material Composition	Test Method	Remarks
○	Weise, E. K. and Andrews, M. C.	56-152	717-1323	$MgTi_2O_5$	Potential drop with vacuum tube electrometer	
□	Ibid.	56-152	833-1290	Mg_2TiO_4	Same as above	
△	Ibid.	56-152	750-1290	$MgTiO_3$	Same as above	

PROPERTIES OF STRONTIUM TITANATE

MOST PROBABLE VALUES

Property	Brit. Engineering Units	C. G. S. Units
Density.		
Melting Point.	≈4180°R	2320°K
Heat of Fusion		
Heat of Vaporization. . .		
Heat of Sublimation . . .		

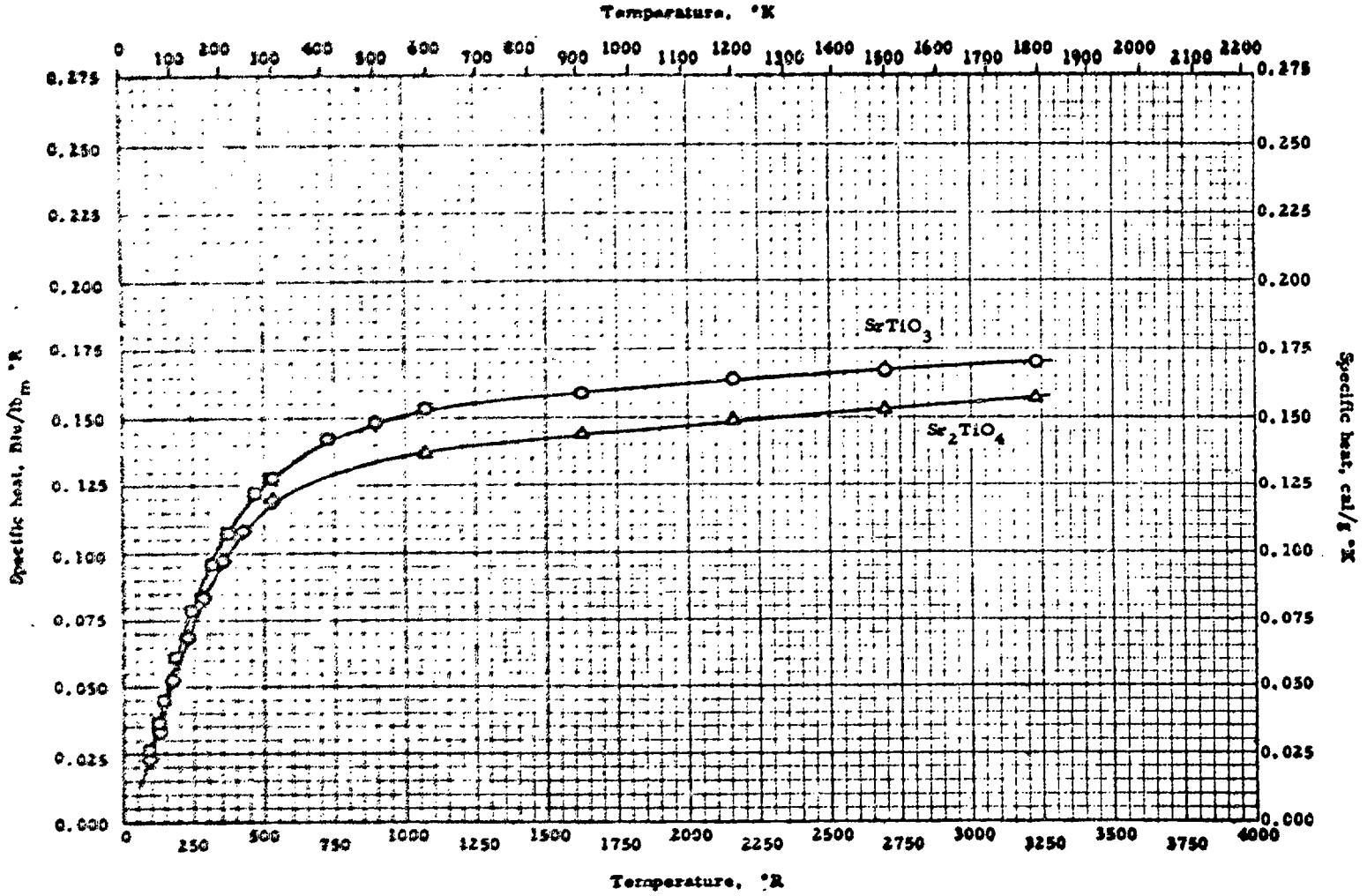
REPORTED VALUES

Density:		lb_m/ft^3	g/cm^3
Melting Point:		°R	°K
	○	4182	2323
	□	4128 ± 36	2293 ± 20
	△	4164 ± 36	2313 ± 20
	◇	3084 ± 18	1713 ± 10
	▽	3732 ± 36	2073 ± 20
	○	3624	2013
Heat of Fusion:		Btu/lb_m	cal/g
Heat of Vaporization:		Btu/lb_m	cal/g
Heat of Sublimation:		Btu/lb_m	cal/g

PROPERTIES OF STRONTIUM TITANATE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Basmajian, J. A. and De Vries, R. C.	57-82	4182	$SrTiO_3$	MP: 3 methods: (1) metallographic inspection of quenched samples (2) visual with calibrated Pt-Rh thermocouples (3) visual with optical pyrometer	
□	Trzebiatowski, W. and Drys, M.	55-74	4092-4164	$SrTiO_3$	MP: visual observation; optical pyrometer	Presintered at 1100°C; sintered at 1350-1500°C
△	Drys, M. and Trzebiatowski, W.	57-82	4123-4200	$SrTiO_3$	MP: not given	
◇	Trzebiatowski, W. and Drys, M.	55-74	3966-4002	Eutectic between TiO_2 and $SrTiO_3$ containing 70-80% TiO_2	MP: visual observation; optical pyrometer	Presintered at 1100°C; sintered at 1350-1500°C
▽	Ibid.	55-74	3696-3768	$2SrO \cdot TiO_2$	MP: same as above	Same as above
C	Ibid.	55-74	3624	Eutectic of $ZrO - TiO_2$ and SrO; 20-30% mole of TiO_2	MP: same as above	Same as above

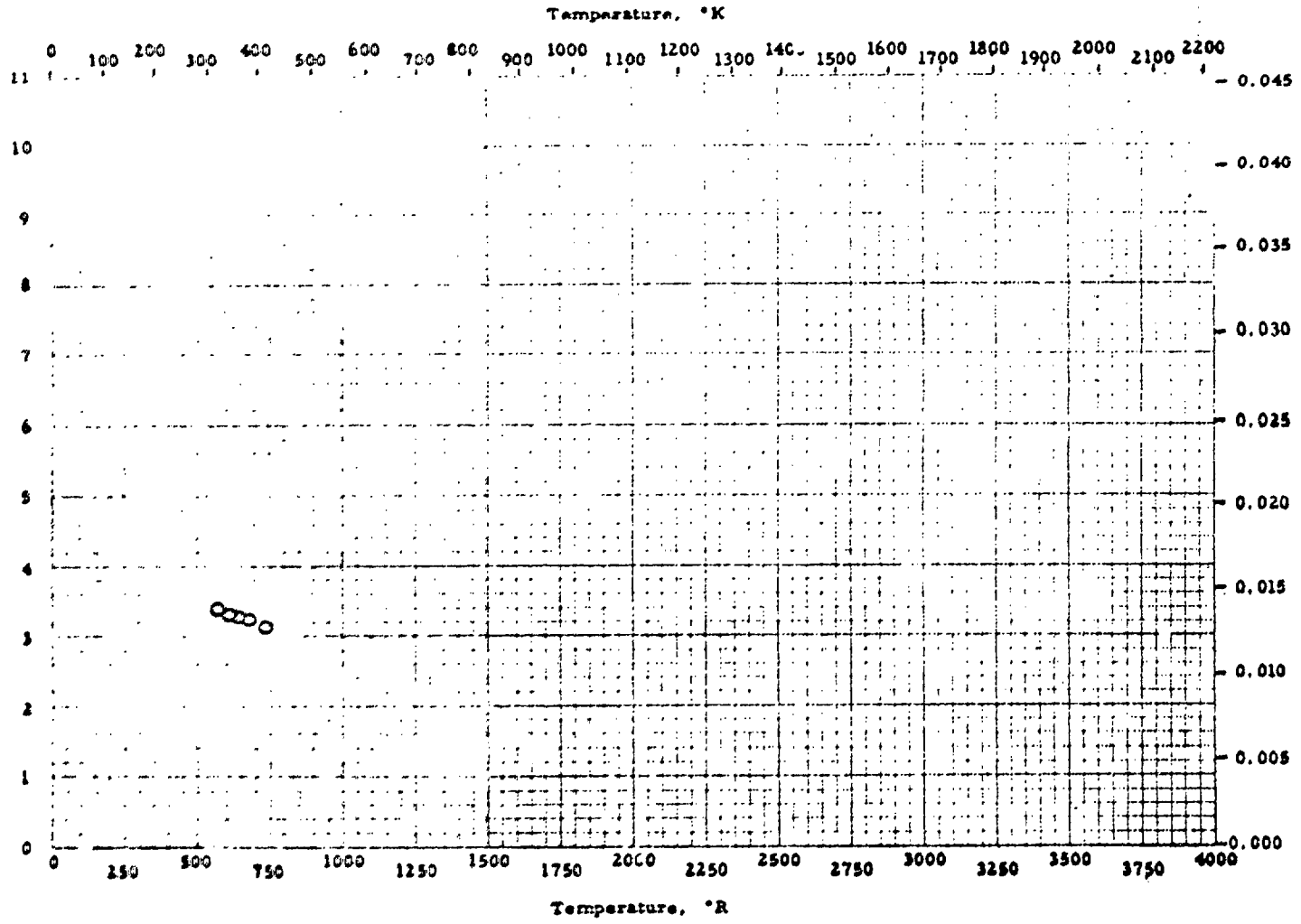


SPECIFIC HEAT -- STRONTIUM TITANATE

SPECIFIC HEAT -- STRONTIUM TITANATE

REFERENCE INFORMATION

Sym.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Coughlin, J.P. and Orr, R.L.	53-13	692-3297	Strontium metatitanate, $SrTiO_3$ · 99.5% pure	Drop method; copper block calorimeter	Prepared from reagent grade Sr carbonate and titania by prolonged heating at 1350°C
□	Todd, S.S. and Lorenson, R.E.	52-13	99-537	Strontium metatitanate, $SrTiO_3$ · 99.5% pure	Guarded sample	Prepared from reagent grade Sr carbonate and titania by prolonged heating at 1350°C
△	Coughlin, J.D. and Orr, R.L.	53-13	706-3769	Strontium orthotitanate, Sr_2TiO_4 · 99.5% pure; 0.17% CaO; 0.03% SiO_2. Analyzed 27.85 at % TiO_2 (cf. theor. 27.82%)	Drop method; copper block calorimeter	
◇	Todd, S.S. and Lorenson, R.E.	52-59	97-527	Strontium orthotitanate, Sr_2TiO_4 · 99.5% pure; 0.17% CaO; 0.03% SiO_2. Analyzed 27.85 at % TiO_2 (cf. theor. 27.82%)	Guarded sample	

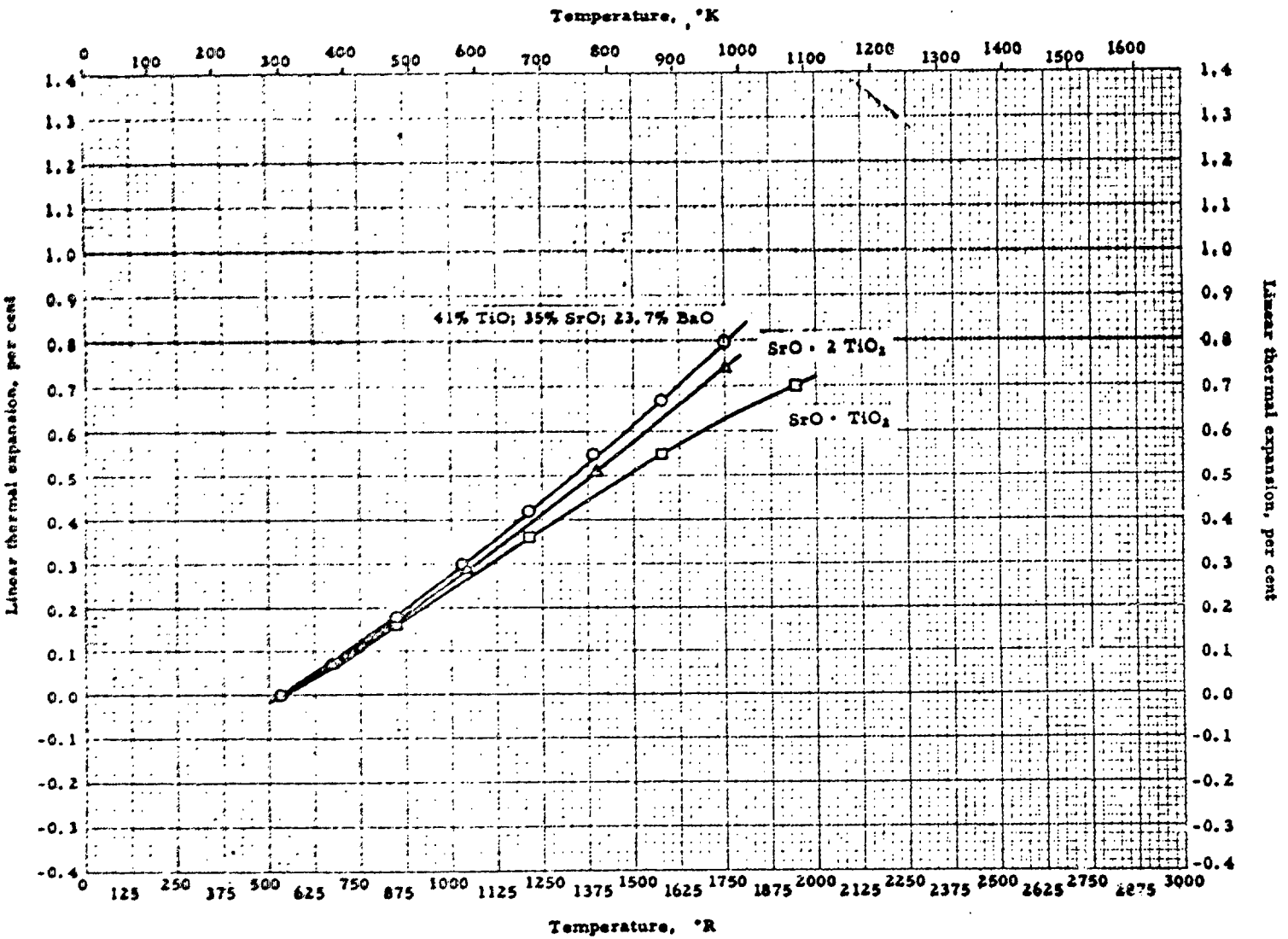


THERMAL CONDUCTIVITY -- STRONTIUM TITANATE

THERMAL CONDUCTIVITY -- STRONTIUM TITANATE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	New Jersey Ceramic Research Station	54-69	569-738	Strontium titanate	Comparative; rods	Tested in vac.

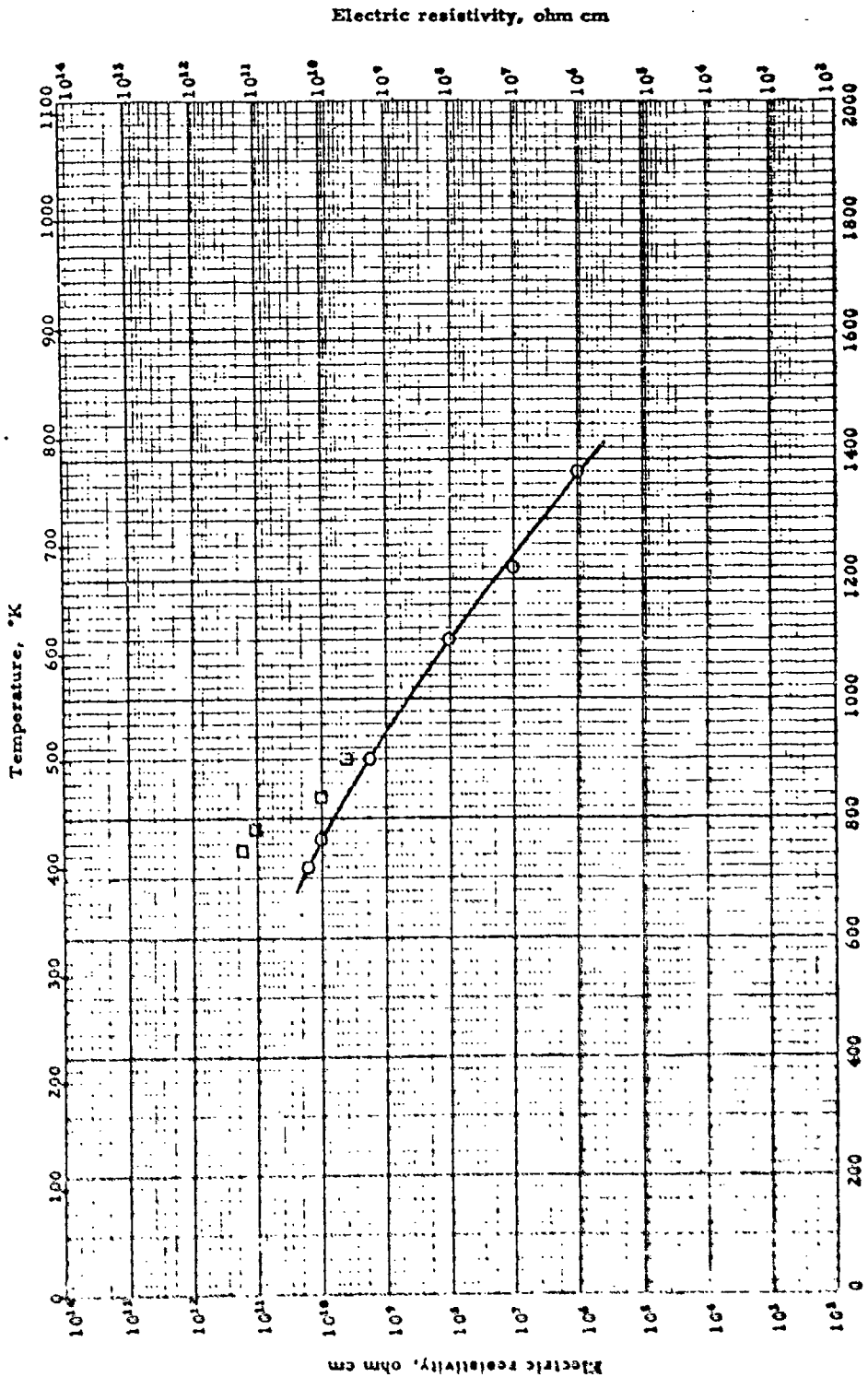


LINEAR THERMAL EXPANSION -- STRONTIUM TITANATE

LINEAR THERMAL EXPANSION -- STRONTIUM TITANATE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Bunting, E. N., Shelton, G. R. and Creamer, A. S.	47-9	672-1752	41.0% TiO_2; 35.0% SrO; 23.7% BaO; prepared from 64% (SrO + TiO_2); 36% (BaO + TiO_2)	Interferometer	Heated 12 hr. at 1100°C, matured 6 hr. at 1250-1430 °C
□	Ibid.	47-9	672-1752	60.7% TiO_2; 39.3% SrO; ($SrO \cdot 2TiO_2$)	Same as above	Same as above
△	Ibid.	47-9	672-1752	43.6% TiO_2; 56.4% SrO; ($SrO \cdot TiO_2$)	Same as above	Same as above

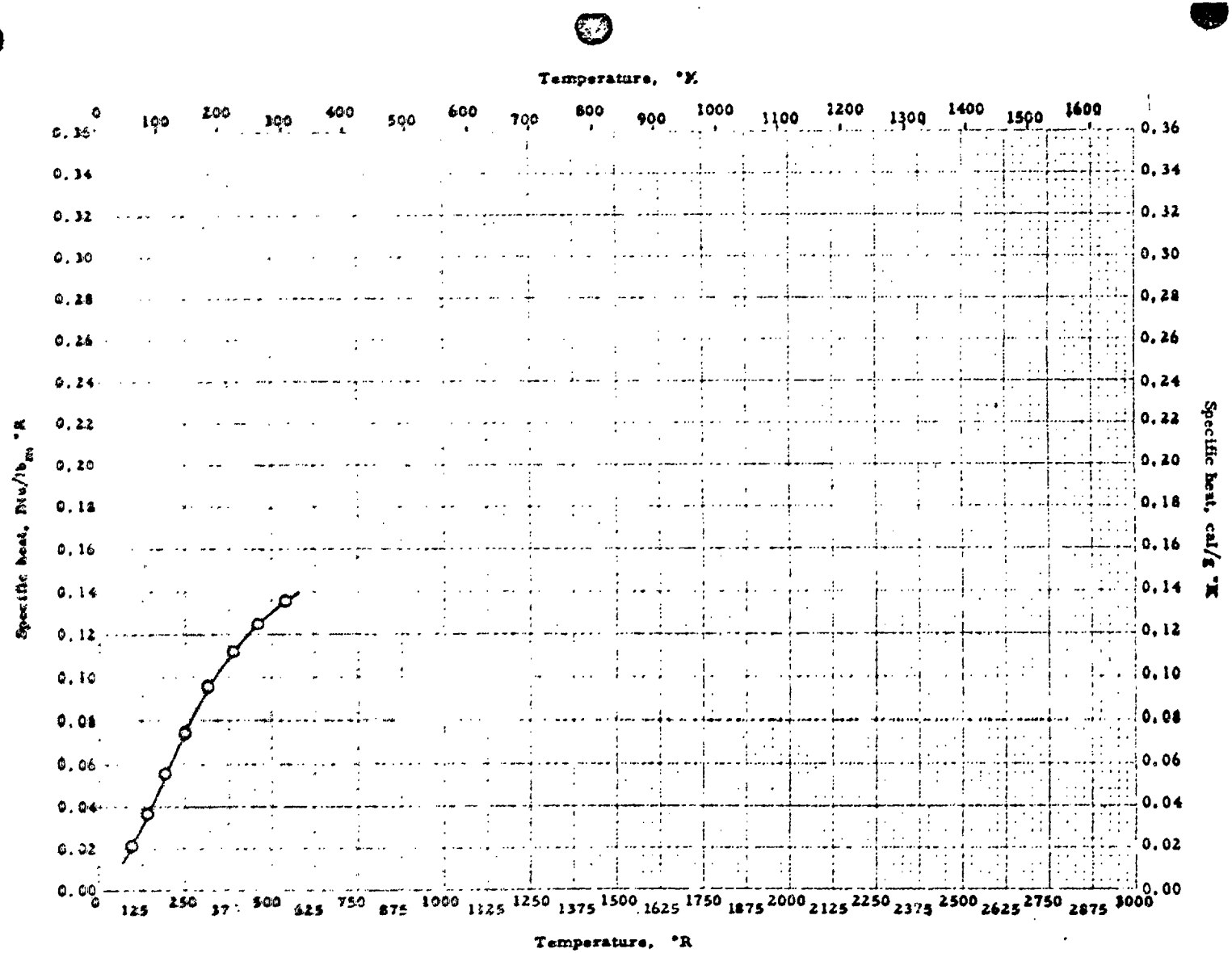


ELECTRIC RESISTIVITY -- STRONTIUM TITANATE

ELECTRIC RESISTIVITY -- STRONTIUM TITANATE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Weise, E. K. and Andrews, M. C.	56-152	720-1380	$SrTiO_3$	Potential drop, using vacuum tube electrometer	Temp. controlled to ≤0.1°C meas. in air
□	Ibid.	56-152	650-900	Same as above	Same as above	Temp. controlled to ≤0.1°C meas. in O_2

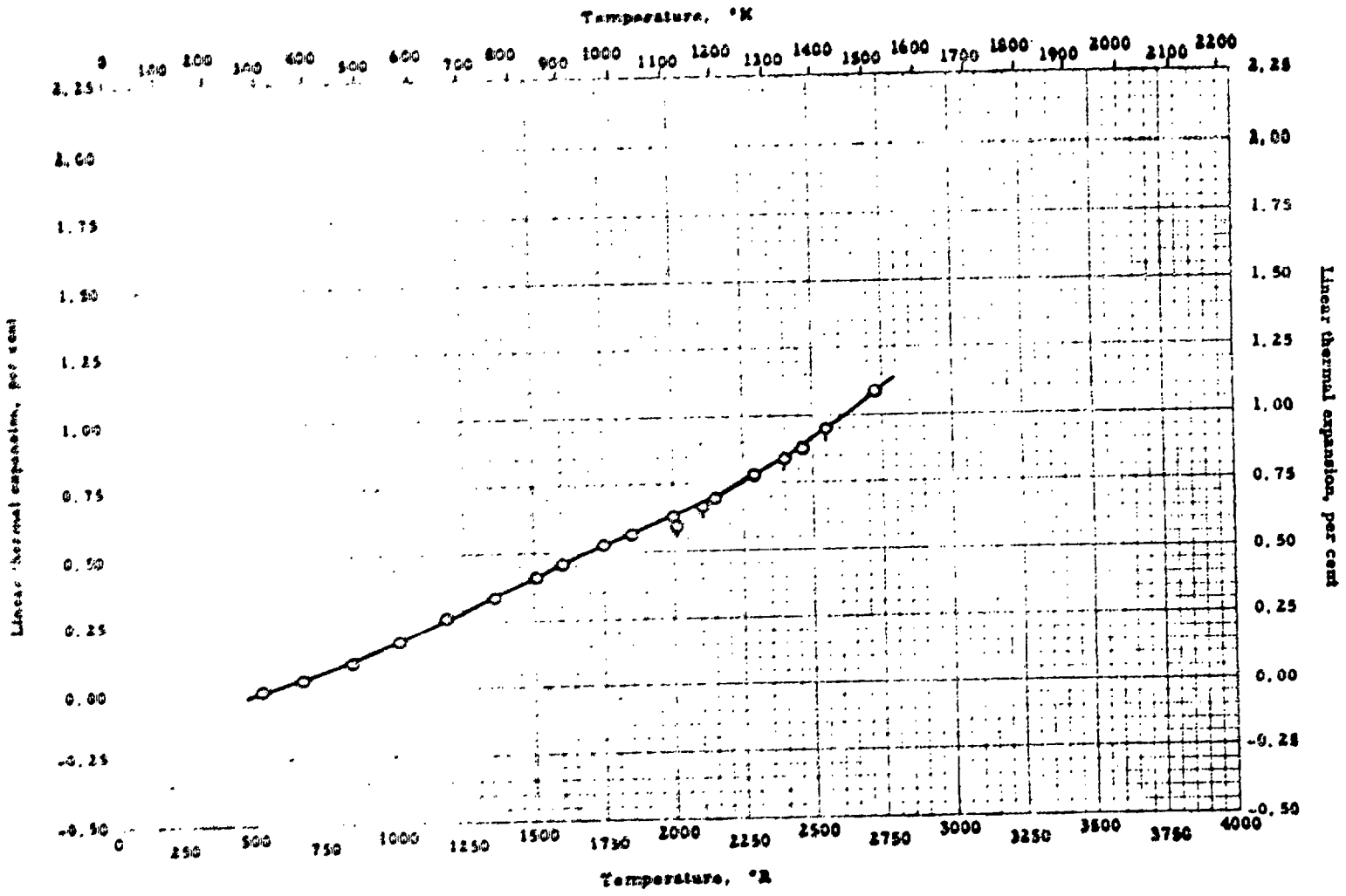


SPECIFIC HEAT -- ZINC ORTHOTITANATE

SPECIFIC HEAT -- ZINC ORTHOTITANATE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	King, E. G.	55-42	97-537	Zn_2TiO_4 + 67.08% ZnO; 32.86% TiO; (cf. theor. 67.07% and 32.93%); 0.05% insoluble in HCl	Guarded sample	

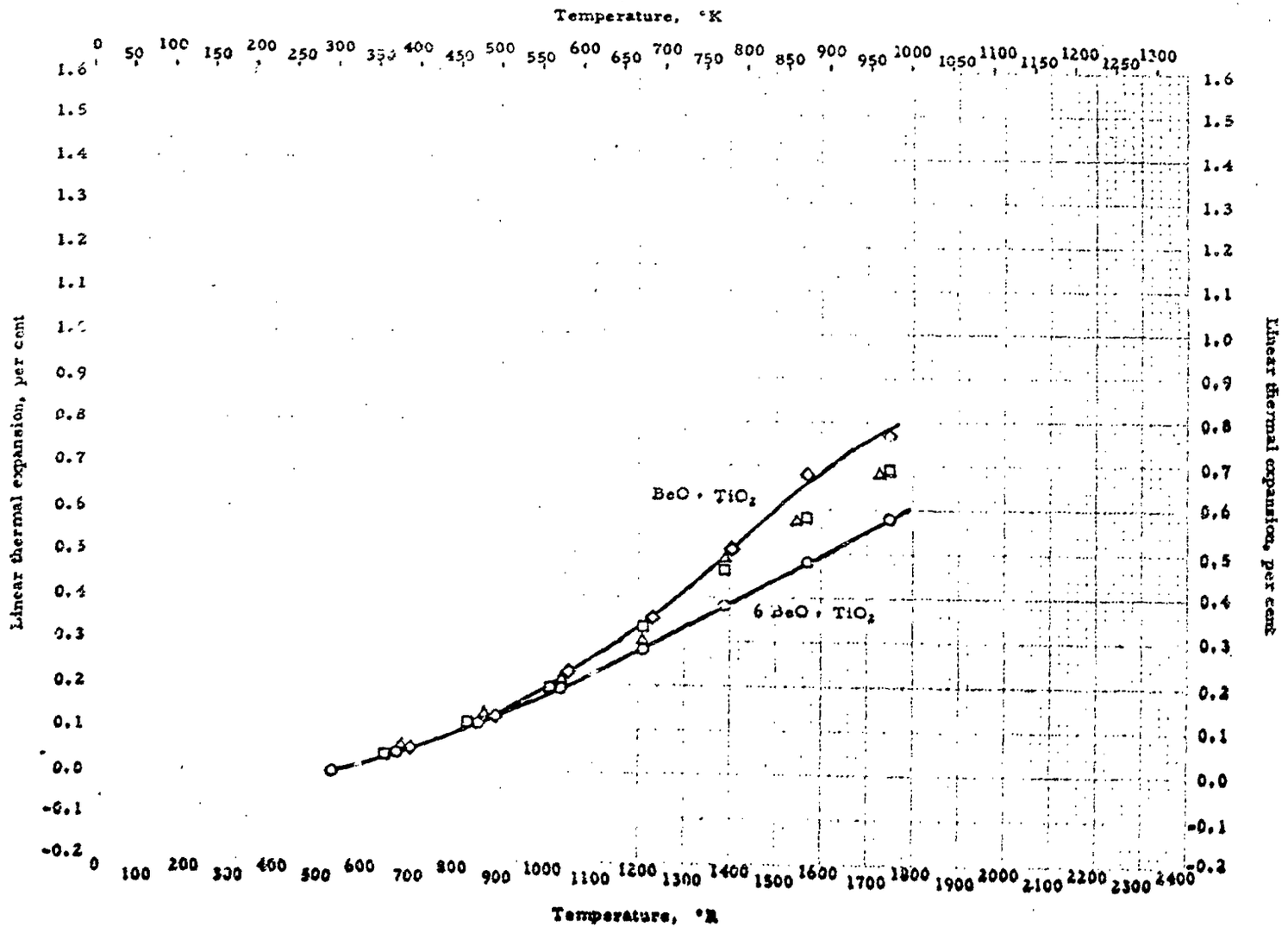


LINEAR THERMAL EXPANSION -- ZIRCONIUM TITANATE

LINEAR THERMAL EXPANSION -- ZIRCONIUM TITANATE

REFERENCE INFORMATION

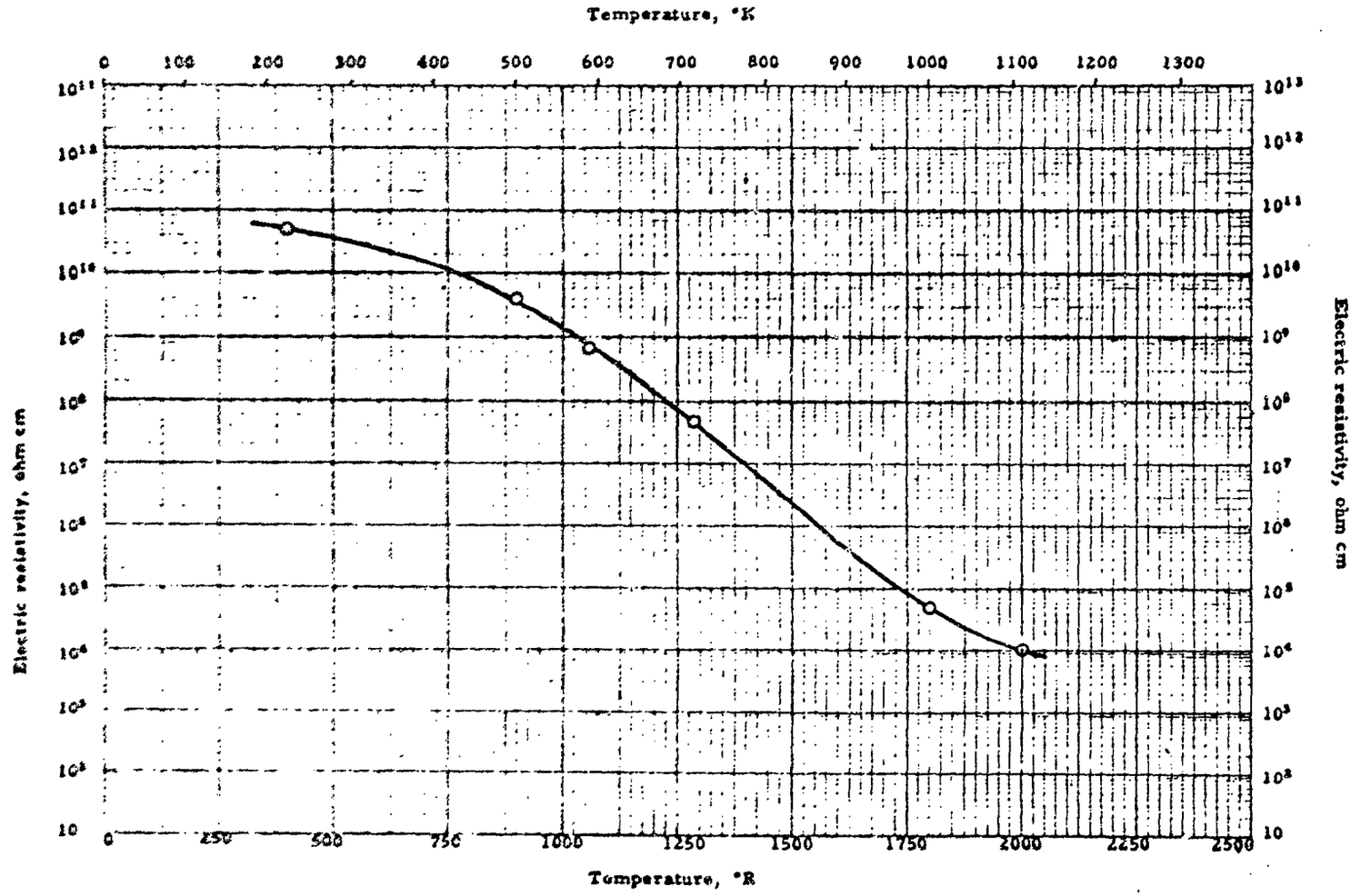
Spec. Col.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
C	Meyer, F. A. and Bole, L. H.	56-8 also 57-62	492-2722	$ZrTiO_4$	Dilatometer with differential transformer pickup	Quenched from 1400°C; O - heating; ♀ - cooling


Temperature, °K
0 50 100 150 200 250 300 350 400 450 500 550 600 650 700 750 800 850 900 950 1000 1050 1100 1150 1200 1250 1300
Linear thermal expansion, per cent
1.6 1.5 1.4 1.3 1.2 1.1 1.0 0.9 0.8 0.7 0.6 0.5 0.4 0.3 0.2 0.1 0.0 -0.1 -0.2
BeO · TiO2
6 BeO · TiO2
0 100 200 300 400 500 600 700 800 900 1000 1100 1200 1300 1400 1500 1600 1700 1800 1900 2000 2100 2200 2300 2400
Temperature, °R
Linear thermal expansion, per cent

LINEAR THERMAL EXPANSION -- BERYLLIUM TITANATE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Bunting, E. N, Shelton, G. R. et al.	51-86	537-1752	$6BeO \cdot TiO_2$	Interferometer	
□	Ibid.	51-86	537-1752	$4BeO \cdot TiO_2$	Same as above	
△	Ibid.	51-86	537-1752	$2BeO \cdot TiO_2$	Same as above	
◇	Ibid.	51-86	537-1752	$BeO \cdot TiO_2$	Same as above	



ELECTRIC RESISTIVITY -- NICKEL METATITANATE

ELECTRIC RESISTIVITY -- NICKEL METATITANATE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Ishikawa, Y. and Sawada, S.	56-19	600-2000	$NiTiO_3$	Potential drop	Stoichiometric mixture of NiO and TiO_2 heated 3 hr. at 1350°C. Tested in air

PROPERTIES OF MAGNESIUM ALUMINATE

MOST PROBABLE VALUES

Property	Brit. Engineering Units	C. G. S. Units
Density.	225 lb_m/ft^3	3.60 g/cm^3
Melting Point	4320°R*	2400°K*
Heat of Fusion		
Heat of Vaporization. . .		
Heat of Sublimation . . .		

*Handbook of Chemisty and Physics (Ref. 59-2)

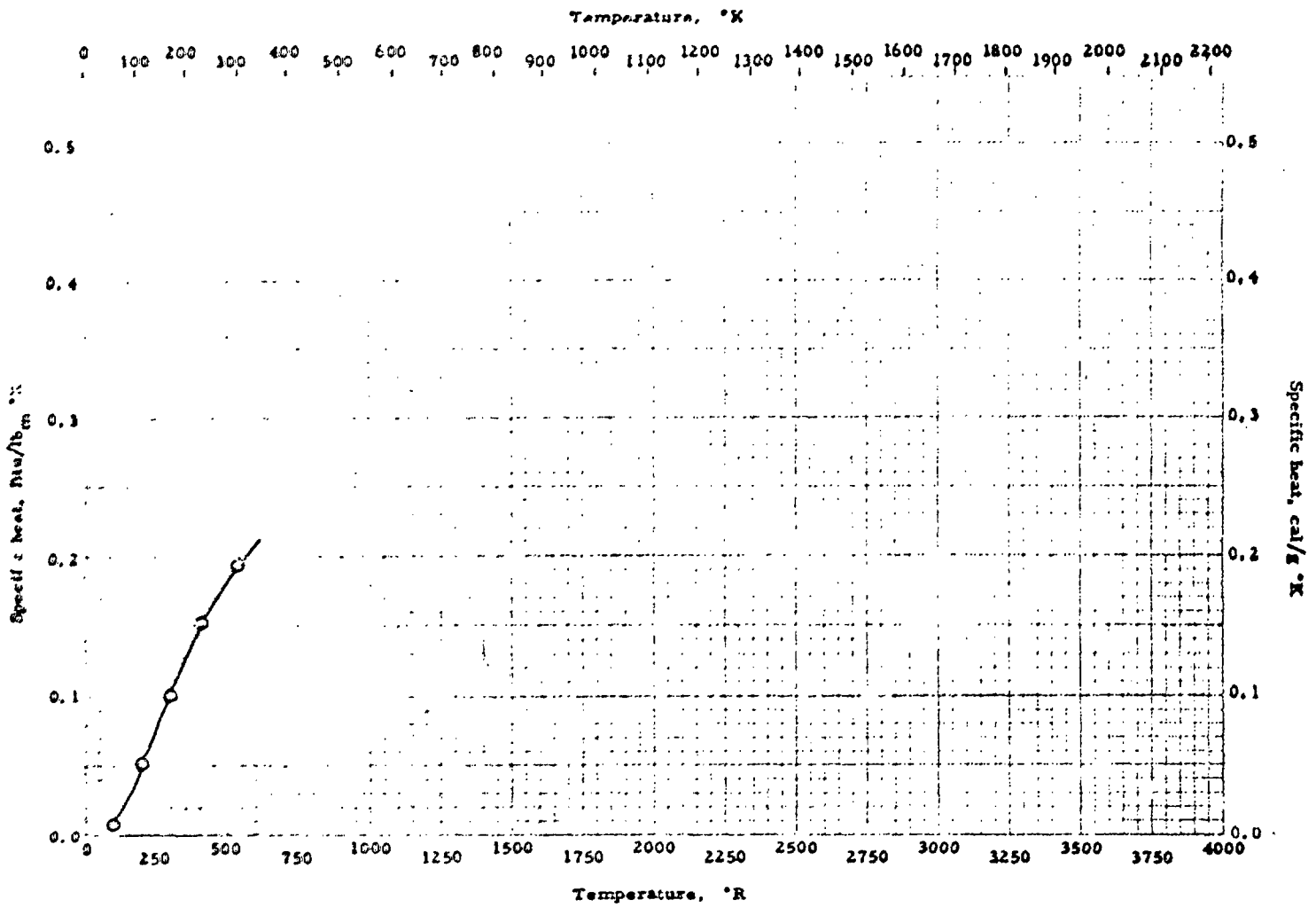
REPORTED VALUES

Density:		lb_m/ft^3	g/cm^3
	O	225 ± 0.6	3.60 ± 0.01
Melting Point:		°R	°K
Heat of Fusion:		Btu/lb_m	cal/g
Heat of Vaporization:		Btu/lb_m	cal/g
Heat of Sublimation:		Btu/lb_m	cal/g

PROPERTIES OF MAGNESIUM ALUMINATE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Oak Ridge National Laboratory	57-150	537	Spinel, magnesium aluminate	ρ: weight in air and in kerosene	Measured by O. Sisman, C. D. Bopp and R. L. Towns

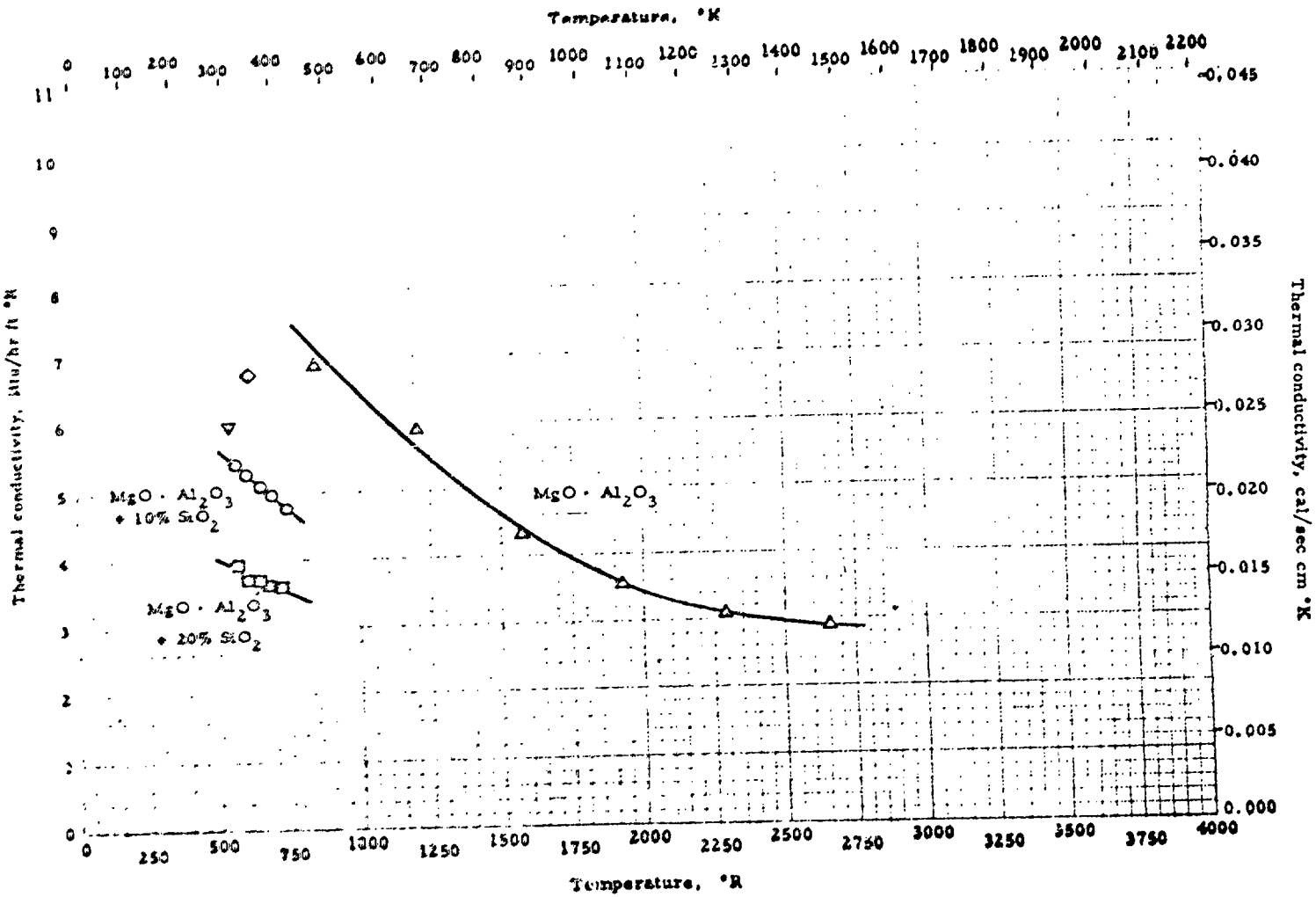


SPECIFIC HEAT -- MAGNESIUM ALUMINATE

SPECIFIC HEAT -- MAGNESIUM ALUMINATE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °K	Material Composition	Test Method	Remarks
O	King, E. G.	55-44	97-536	71.62% Al_2O_3 (71.66% theoretical); 28.33% MgO (28.34% theoretical) (Spinel)	Guarded sample	



THERMAL CONDUCTIVITY -- MAGNESIUM ALUMINATE

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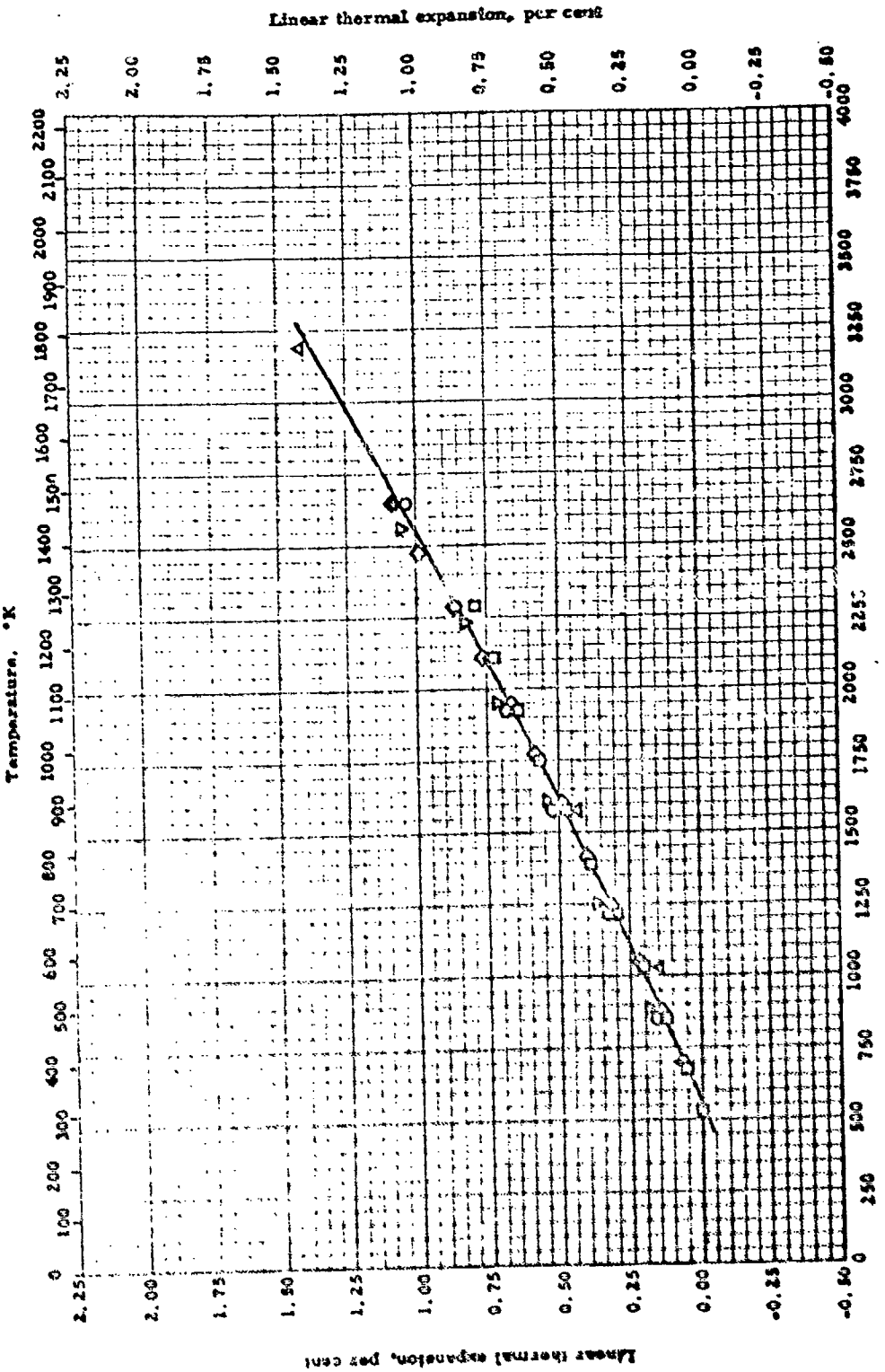
THERMAL CONDUCTIVITY -- MAGNESIUM ALUMINATE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	New Jersey Ceramic Research Station	54-69	566-742	$MgO \cdot Al_2O_3$ + 10% SiO_2	Comparative; rods	Tested in vacuum
□	Ibid.	54-69	570-721	$MgO \cdot Al_2O_3$ + 20% SiO_2	Same as above	Same as above
△	Kingery, W. D. and Francl, T.	54-1	672-2192	$MgO \cdot Al_2O_3$ 71.9% Al_2O_3 29.0% MgO Bulk ρ = 204 lb_m/ft^3 (cf theoretical 221); porosity: 7.65%	Ellipsoidal envelope	
◇	Weeks, J. L. and Seifert, R. A.	53-17	618	Spinel; single crystal ρ = 225 lb_m/ft^3	Comparative; Armco iron standard	
▽	Oak Ridge National Laboratory	57-150	546	Spinel	Not described here, refers to others	Auth. est. accuracy ± 20% Measured by O. Sisman, C. D. Bopp and R. L. Towns

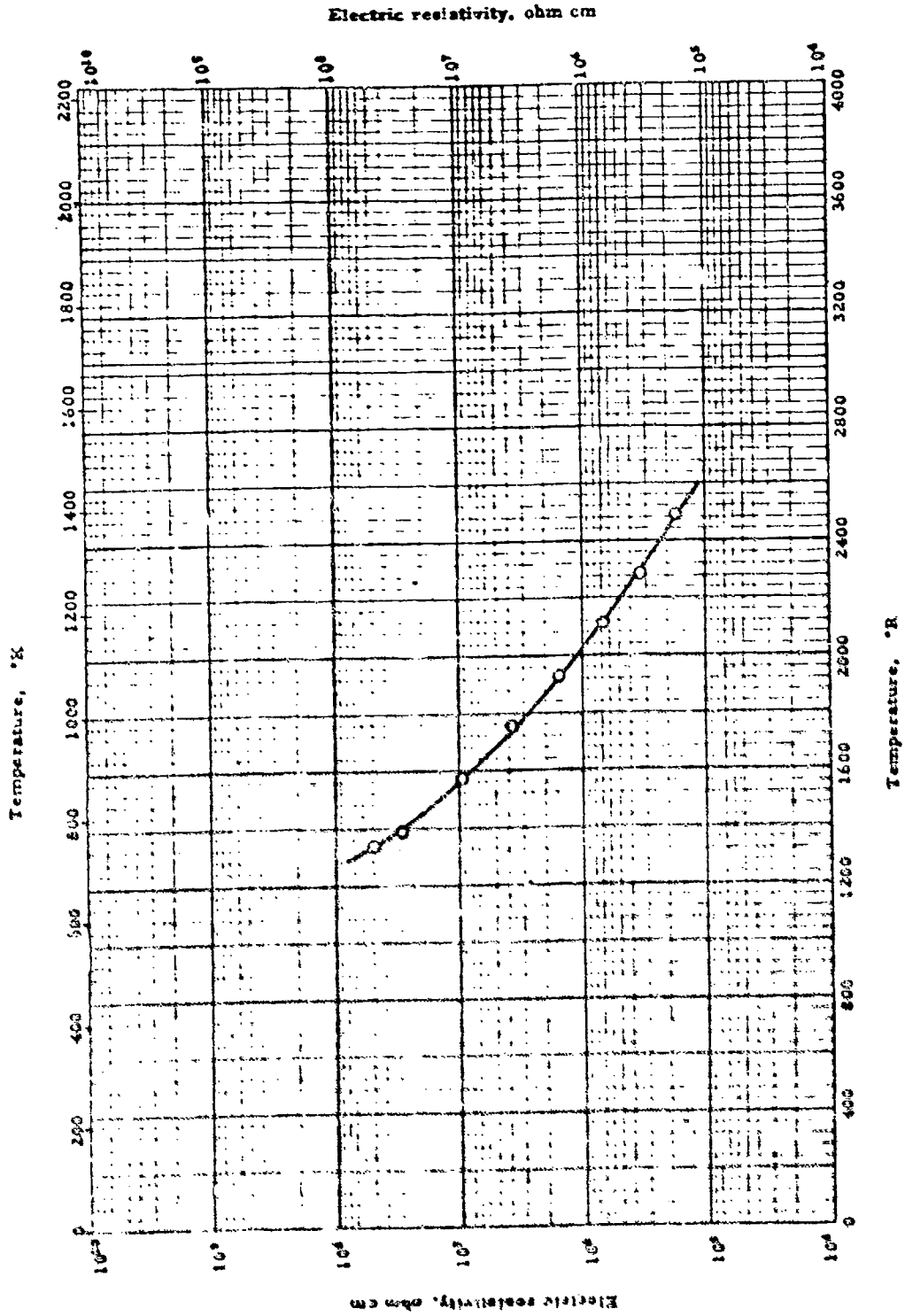


LINEAR THERMAL EXPANSION -- MAGNESIUM ALUMINATE

LINEAR THERMAL EXPANSION -- MAGNESIUM ALUMINATE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Beals, R. J. and Cook, R. L.	57-20	528-2652	Prepared from reagent grade materials	X-ray back reflection	
□	Geller, R. F., Yavorski, P. J. et al.	46-4	528-2292	Prepared from 99+% Al_2O_3; 97% MgO (periclase)	Interferometer	Sample reacted with fused silica interferometer plates
△	Whittemore, O. J. and Ault, N. N.	56-7	1032-3192	Coarse fused grain, $MgO \cdot Al_2O_3$	Telemicroscopes sighting on pointed ends of sample	
◇	Rigby, G. R., Lovell, G.H.B. and Green, A. T.	46-8 also 43-15	672-2652	Spinel, $MgO \cdot Al_2O_3$ $\rho = 222$ lb_m/ft^3	Not given	Oxides mixed with 5% boric acid, molded, fired 2 hr. at 1530°C; crushed, molded, refired to 1530°C; repeated
▽	Zimmerman, W. F. and Allen, A. W.	56-166	524-2620	$MgO \cdot Al_2O_3$	X-ray back reflection	

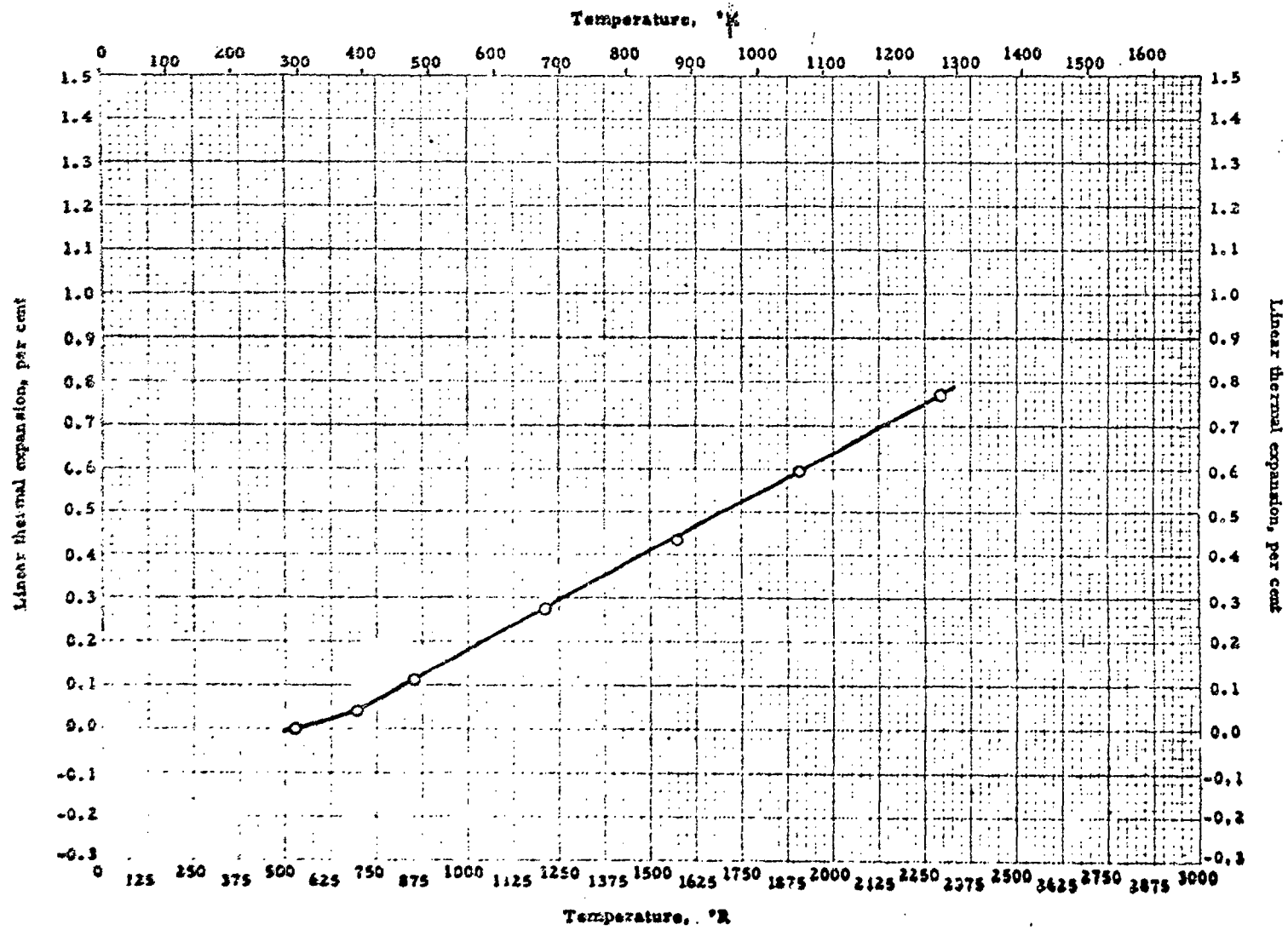


ELECTRIC RESISTIVITY -- MAGNESIUM ALUMINATE

ELECTRIC RESISTIVITY -- MAGNESIUM ALUMINATE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Rogener, H.	40-20	1329-2490	Spinel	Potential drop. Voltage by electrometer. Sample temp. by Pt-PtRh thermocouple	1 cm cube samples, platinized end faces. Auth. est. accuracy only order of magnitude

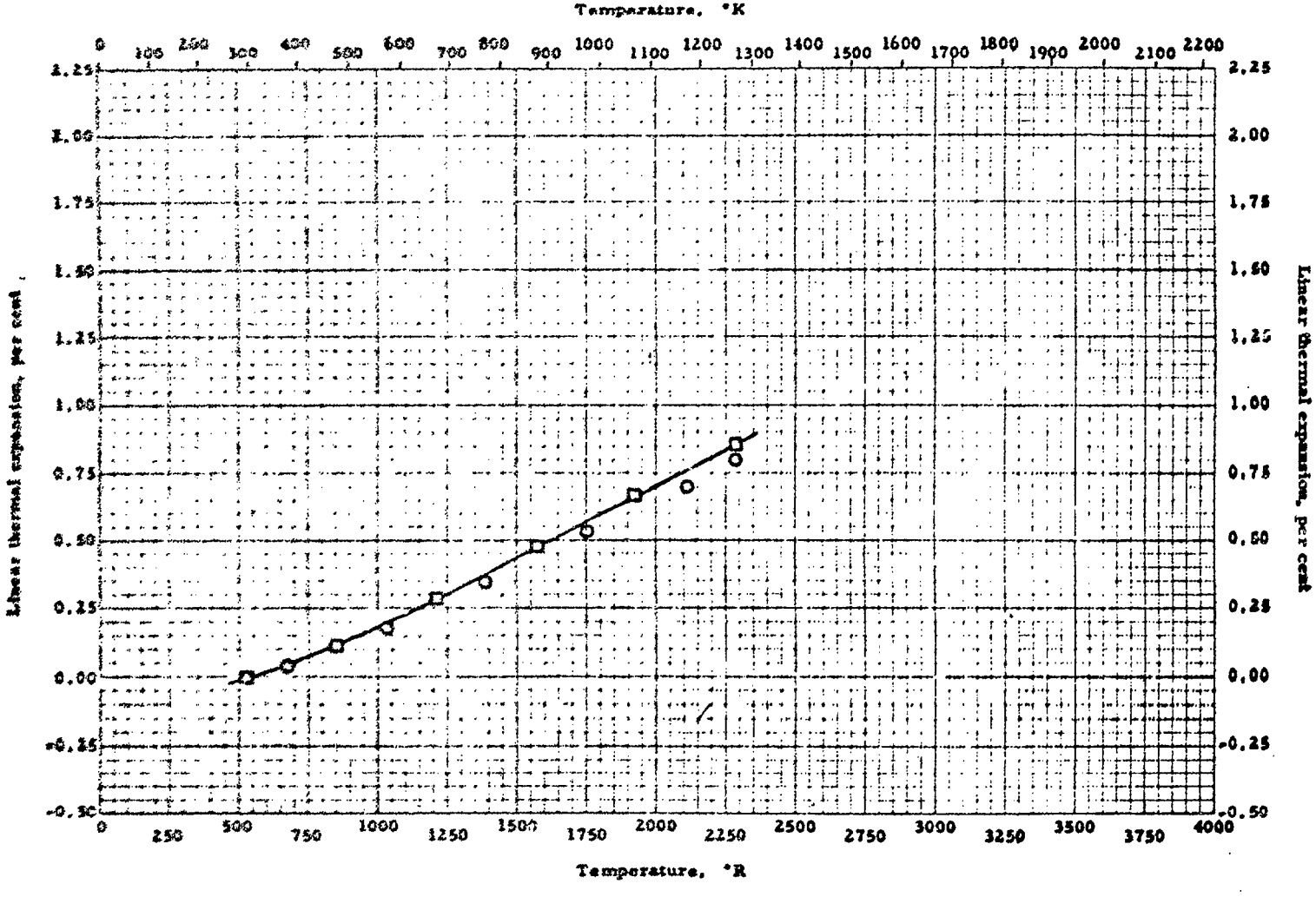


LINEAR THERMAL EXPANSION -- BARIUM ALUMINATE

LINEAR THERMAL EXPANSION -- BARIUM ALUMINATE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Penn. State	48-37	528-2292	$BaO \cdot Al_2O_3$	Not given	Fired 1 hr. at 1700 C



LINEAR THERMAL EXPANSION -- BERYLLIUM ALUMINATE
($BeO \cdot Al_2O_3$) - CHRYSOBERYL

LINEAR THERMAL EXPANSION -- BERYLLIUM ALUMINATE ($BeO \cdot Al_2O_3$) - CHRYSOBERYL

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Bezlia, R., McKinstry, H. et al.	48-4	528-2292	Not given; nominal: 80.3% Al_2O_3; 19.7% BeO	Not given	Fired 1 hr. at 1500°C
□	Geller, R. F., Yavorsky, P. J. et al.	46-4	528-2292	Prepared from 99.7% pure BeO; 99+% pure Al_2O_3	Interferometer	

PROPERTIES OF CALCIUM ALUMINATE

MOST PROBABLE VALUES

Property	Brit. Engineering Units	C. G. S. Units
Density.	180 lb_m/ft^3	2.9 g/cm^3
Melting Point	3633°R	2018°K
Heat of Fusion		
Heat of Vaporization. . .		
Heat of Sublimation . . .		

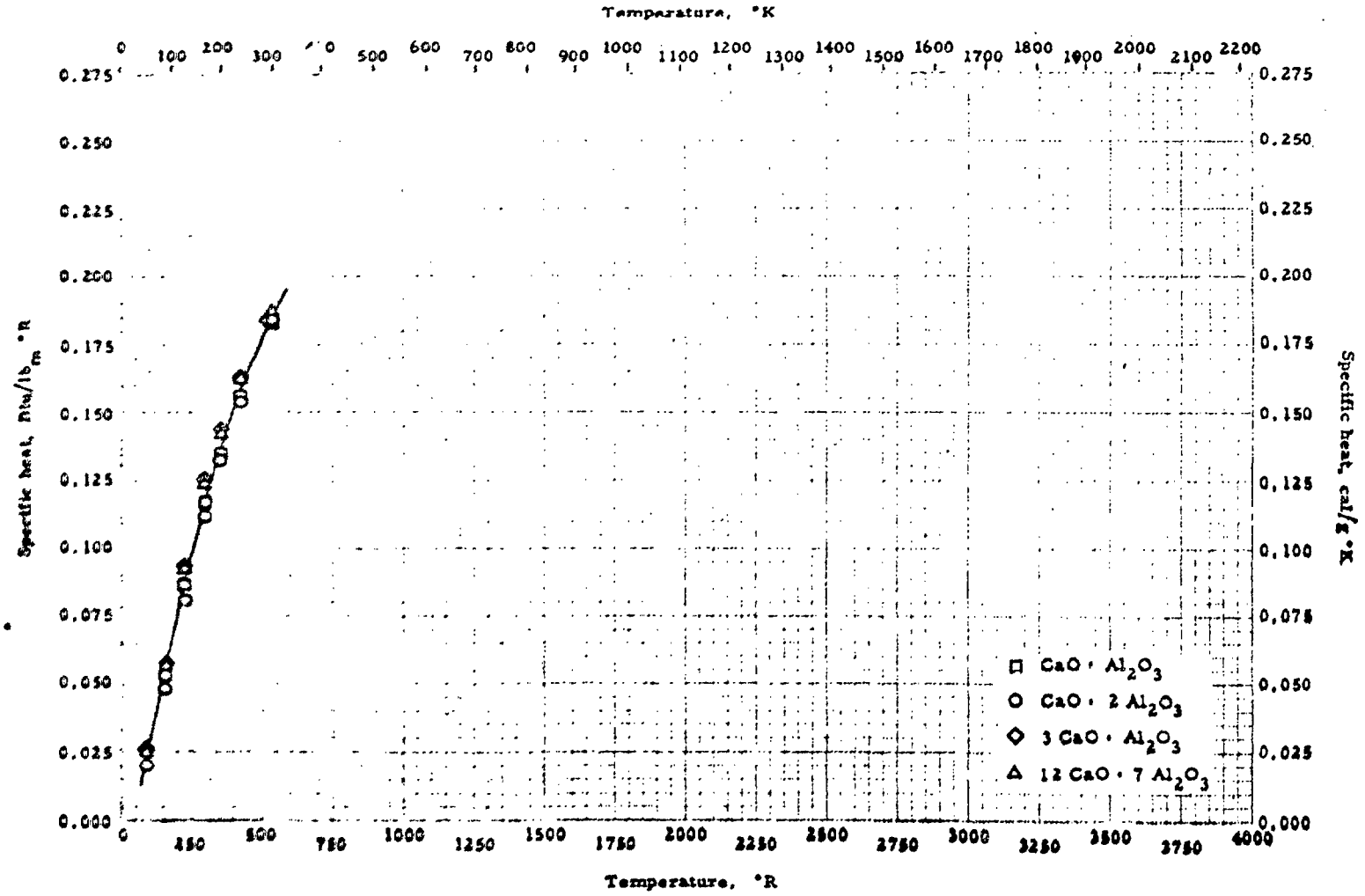
REPORTED VALUES

Density:		lb_m/ft^3	g/cm^3
	□	181	2.90
Melting Point:		°R	°K
	○	3633 ± 27	2018 ± 15
	□	3633 ± 27	2018 ± 15
Heat of Fusion:		Btu/lb_m	cal/g
Heat of Vaporization:		Btu/lb_m	cal/g
Heat of Sublimation:		Btu/lb_m	cal/g

PROPERTIES OF CALCIUM ALUMINATE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Boyko, E. R. and Wisnyi, L. G.	57-196	3600-3660	$CaO \cdot 2Al_2O_3$	MP: thermal arrest during slow cooling to obtain single crystals, temp. by W-Mo thermocouple	
□	Bruch, C. A. and Cashin, W. M.	56-109	3600-3660 Room	$CaO \cdot 2Al_2O_3$	MP: observation of first liquid drop on V-shaped ribbon, temp. by calibrated optical pyrometer ρ: not given	

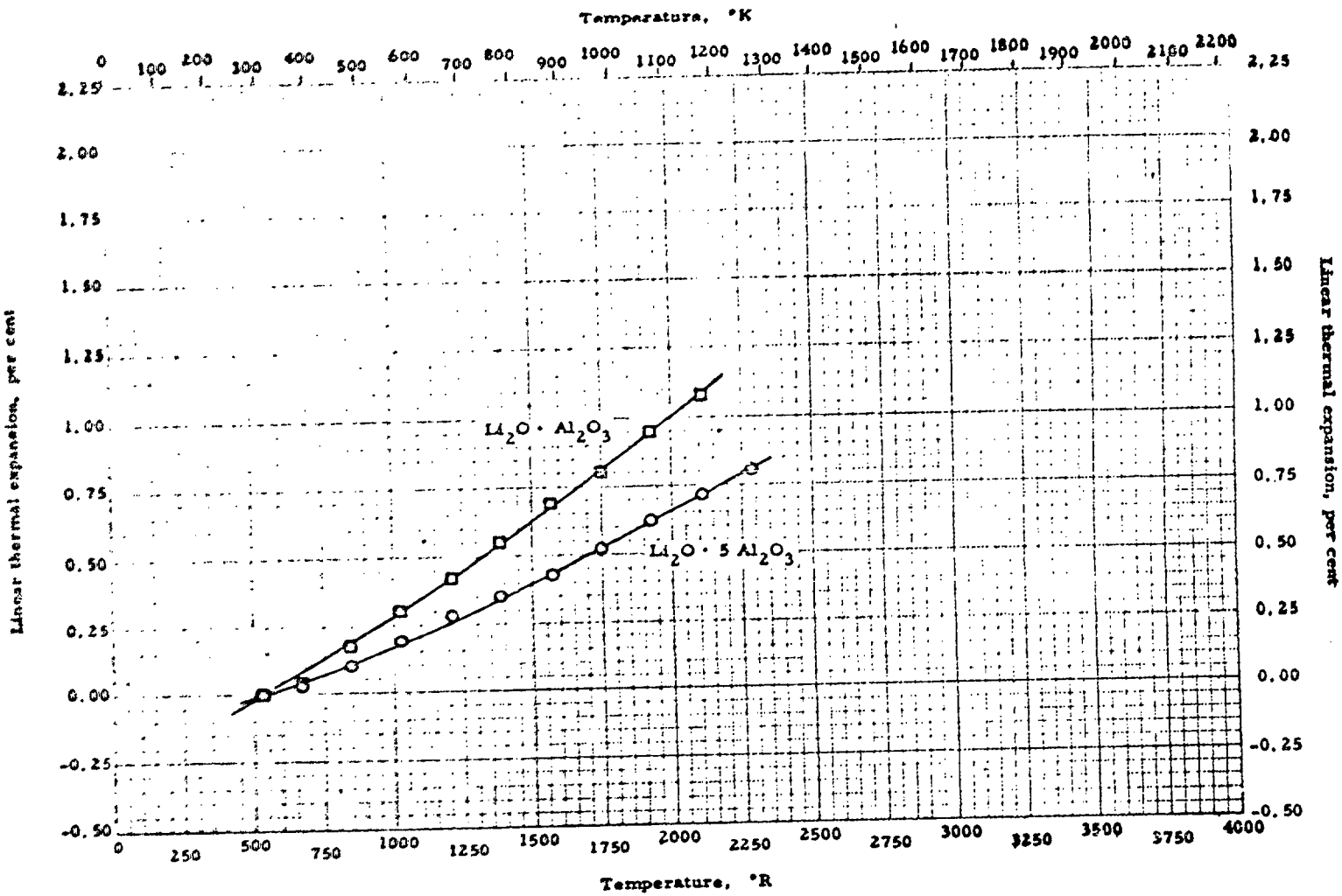


SPECIFIC HEAT -- CALCIUM ALUMINATE

SPECIFIC HEAT -- CALCIUM ALUMINATE

REFERENCE INFORMATION

Sym.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	King, E. G.	55-44	96-537	$CaO \cdot 2Al_2O_3$; 78.49% Al_2O_3; 21.58% CaO (cf, theor. 78.43% and 21.57%)	Guarded sample	
□	Ibid.	55-44	96-537	$CaO \cdot Al_2O_3$; 64.44% Al_2O_3; 35.49% CaO (cf, theor. 64.51% and 35.49%)	Same as above	
△	Ibid.	55-44	96-537	$12\,CaO \cdot 7Al_2O_3$; 51.2% Al_2O_3; 48.32% CaO (cf, theor. 51.47% and 48.53%); 0.25% MgO + alkali oxides; 0.10% Fe_2O_3	Same as above	
◇	Ibid.	55-44	96-537	$3CaO \cdot Al_2O_3$; 62.25% CaO; 37.84% Al_2O_3 (cf, theor. 62.26% and 37.74%)	Same as above	



LINEAR THERMAL EXPANSION -- LITHIUM ALUMINATE

LINEAR THERMAL EXPANSION -- LITHIUM ALUMINATE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Hummel, F. A.	51-21	528-2292	94.5% Al_2O_3; 5.5% Li_2O ($Li_2O \cdot 5Al_2O_3$); from c.p. Li_2CO_3; c.p. Al_2O_3; potter's flint	Dilatometer	Pressed 100 mesh calcined material at 1000 psi using Carbowax Methocel binder
□	Ibid.	51-21	528-2112	77.3% Al_2O_3; 22.7% Li_2O ($Li_2O \cdot Al_2O_3$); from c.p. Li_2CO_3; c.p. Al_2O_3; potter's flint	Same as above	Same as above

PROPERTIES OF STRONTIUM ALUMINATE

MOST PROBABLE VALUES

Property	Brit. Engineering Units	C. G. S. Units
Density.		
Melting Point	3690°R	2050°K
Heat of Fusion		
Heat of Vaporization. . .		
Heat of Sublimation . . .		

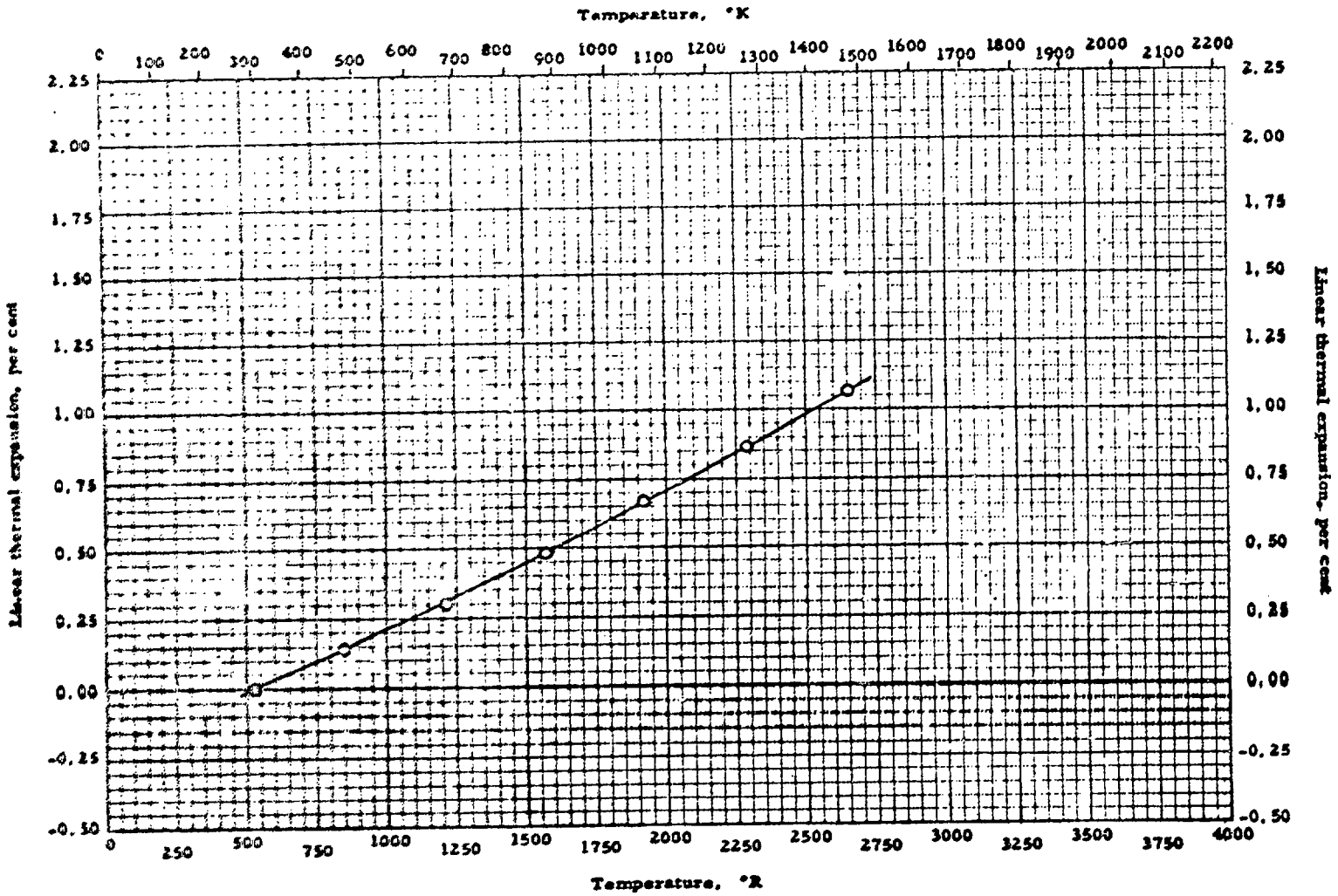
REPORTED VALUES

Density:		lb_m/ft^3	g/cm^3
Melting Point:		°R	°K
	O	3678 ± 27	2043 ± 15
	□	3696 ± 36	2053 ± 20
Heat of Fusion:		Btu/lb_m	cal/g
Heat of Vaporization:		Btu/lb_m	cal/g
Heat of Sublimation:		Btu/lb_m	cal/g

PROPERTIES OF STRONTIUM ALUMINATE

REFERENCE INFORMATION

Sym bol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Boyko, E. R. and Wisnyi, L. G.	57-196	3650-3715	$SrO \cdot 2Al_2O_3$	MP: thermal arrest during slow cooling to obtain single crystal. Temp. by W-Mo thermo couple	
□	Bruch, C. A. and Cashin, W. M.	56-109	3660-3730	$SrO \cdot 2Al_2O_3$	MP: visual observation of sample in V-shaped ribbon; temp. by calibrated optical pyrometer	



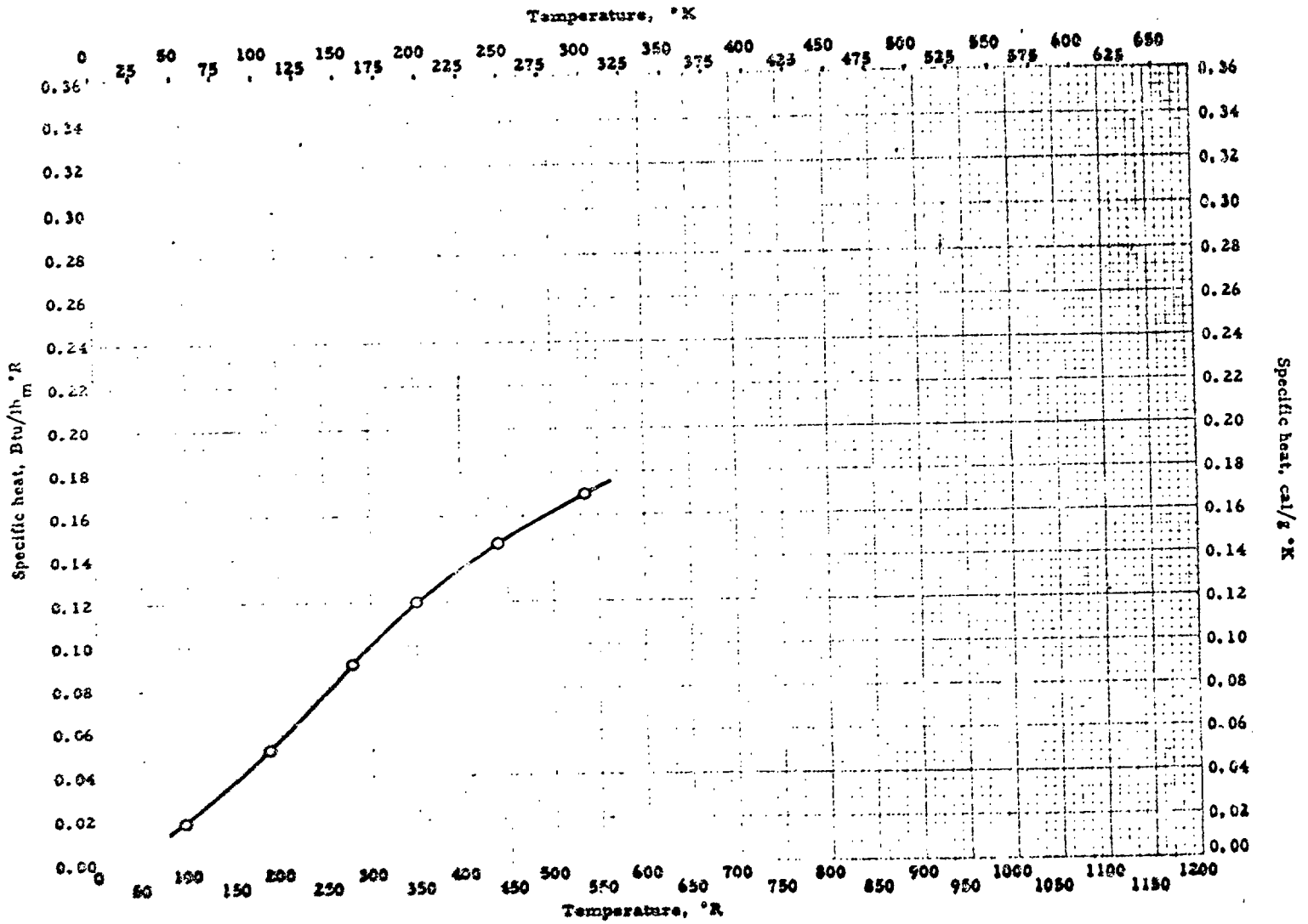
LINEAR THERMAL EXPANSION -- ZINC ALUMINATE

WADC TR 58-476
Pt 2

LINEAR THERMAL EXPANSION -- ZINC ALUMINATE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Beals, R. J. and Cook, R. L.	57-20	528-2652	Prepared from reagent grade materials	X-ray back reflection	

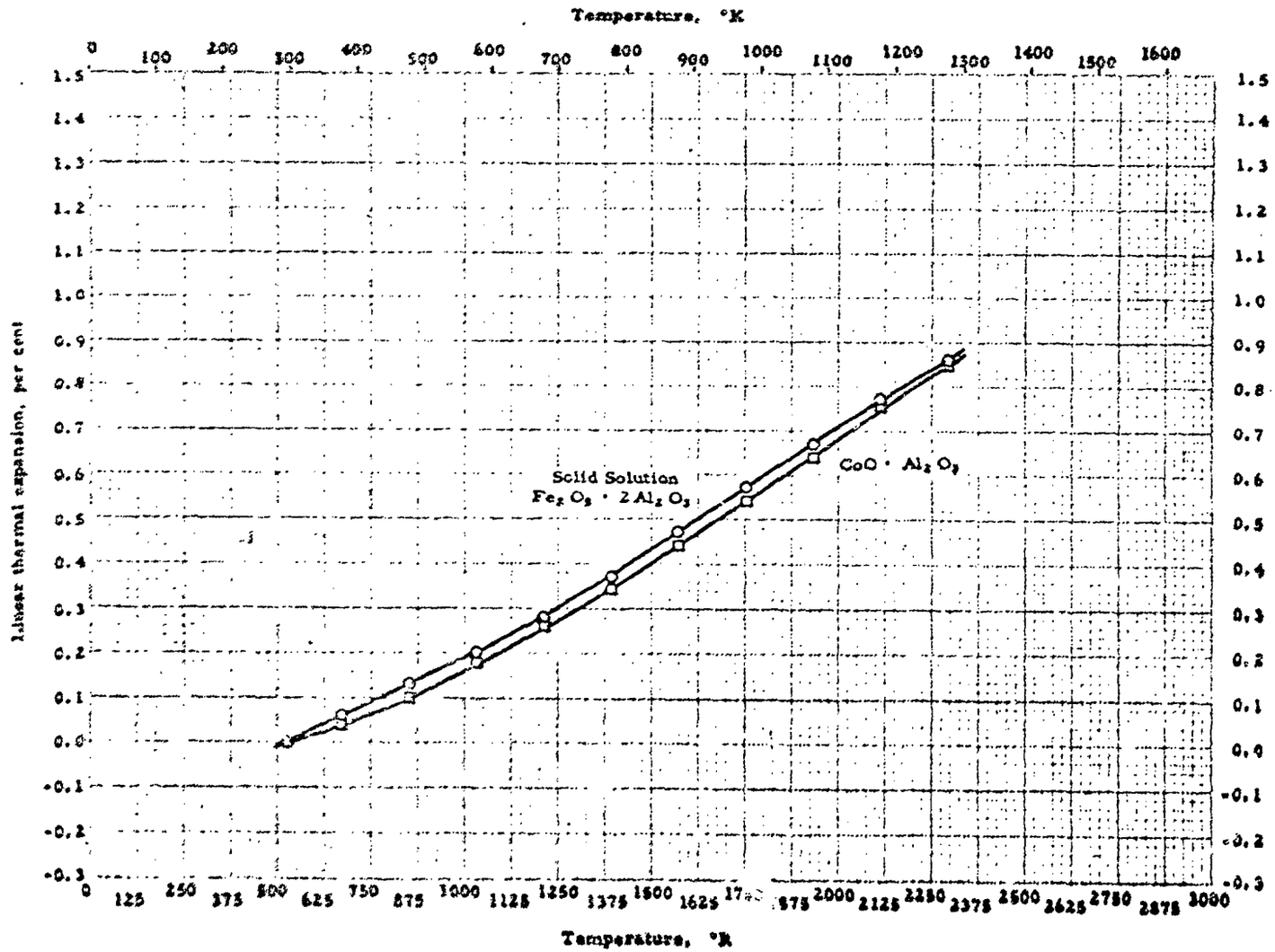


SPECIFIC HEAT -- IRON ALUMINATE

SPECIFIC HEAT -- IRON ALUMINATE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	King, E. G.	56-165	95-540	$FeAl_2O_4$ spinel: 58.62% Al_2O_3; 41.24% FeO; 0.12% SiO_2. Theoretical: 58.66% Al_2O_3; 41.34% FeO	Not given	No evidence of uncombined oxides; metallic Fe on magnetic particles found by x-ray diffraction; 7 heats totalling 40 hr, at 1250-1330°C with grinding, mixing, etc. in between

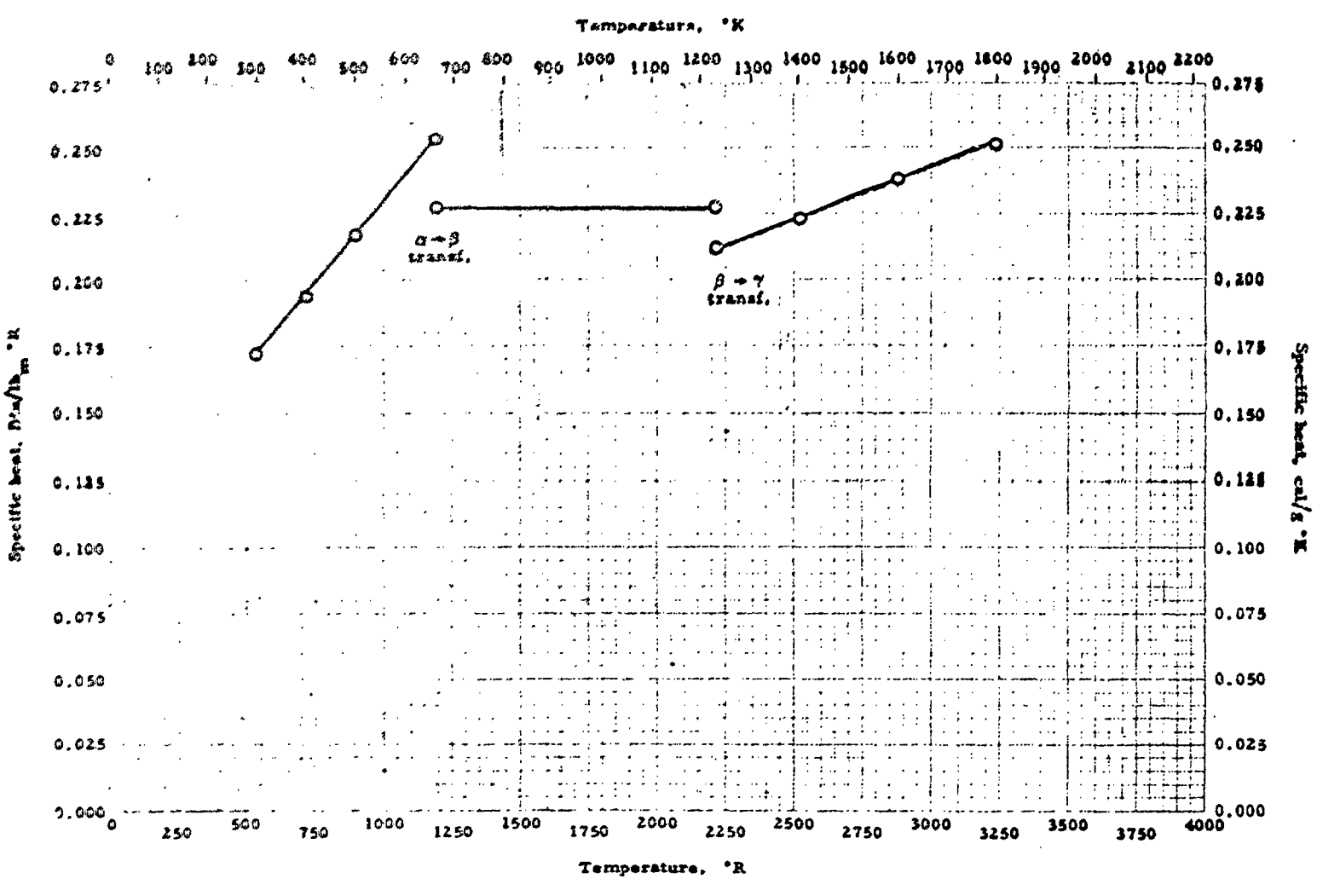


LINEAR THERMAL EXPANSION -- ALUMINATES OF IRON AND COBALT

LINEAR THERMAL EXPANSION -- ALUMINATES OF IRON AND COBALT

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Rigby, G. R., Lovell, G. H. B. and Green, A. T.	46-3	672-2292	Solid solution $Fe_2O_3 \cdot 2Al_2O_3$ $\rho = 272$ lb_m/ft^3	Not given	
□	Penn. State College	48-37	528-2292	$CoO \cdot Al_2O_3$	Not given	Fired 1 hr. at 1700°C

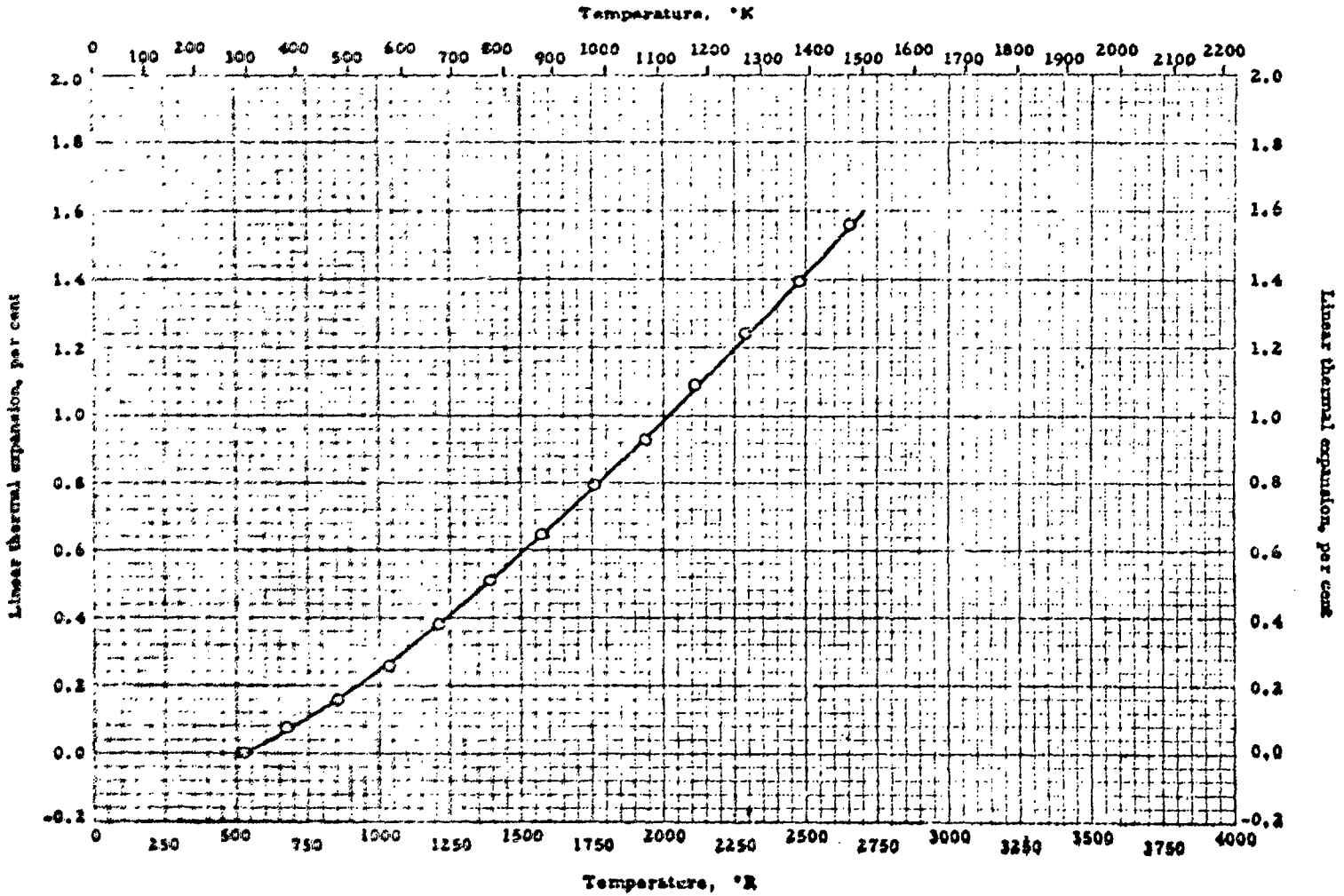


SPECIFIC HEAT -- MAGNESIUM FERRITE

SPECIFIC HEAT -- MAGNESIUM FERRITE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Bommickson, K. R.	56-62	535-3310	$MgFe_2O_4$; 79.74% Fe_2O_3; 20.22% MgO (cf. theor. 79.84% and 20.16%); 0.14% SiO_2	Drop method; metal block calorimeter	Prepared from reagent grade Fe_2O_3 and MgO; heated repeatedly 900-1300°C; material analyzed and composition adjusted between heats



LINEAR THERMAL EXPANSION -- MAGNESIUM FERRITE

LINEAR THERMAL EXPANSION -- MAGNESIUM FERRITE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Rigby, G. R., Lovell, G. H. B. and Green, A. T.	46-8	672-2652	$MgFe_2O_4$. ρ = 262 lb_m/ft^3	Not given	MgO and Fe_2O_3 mixed, heated 2 hr. at 1200 C in air, crushed, reheated

59-1089
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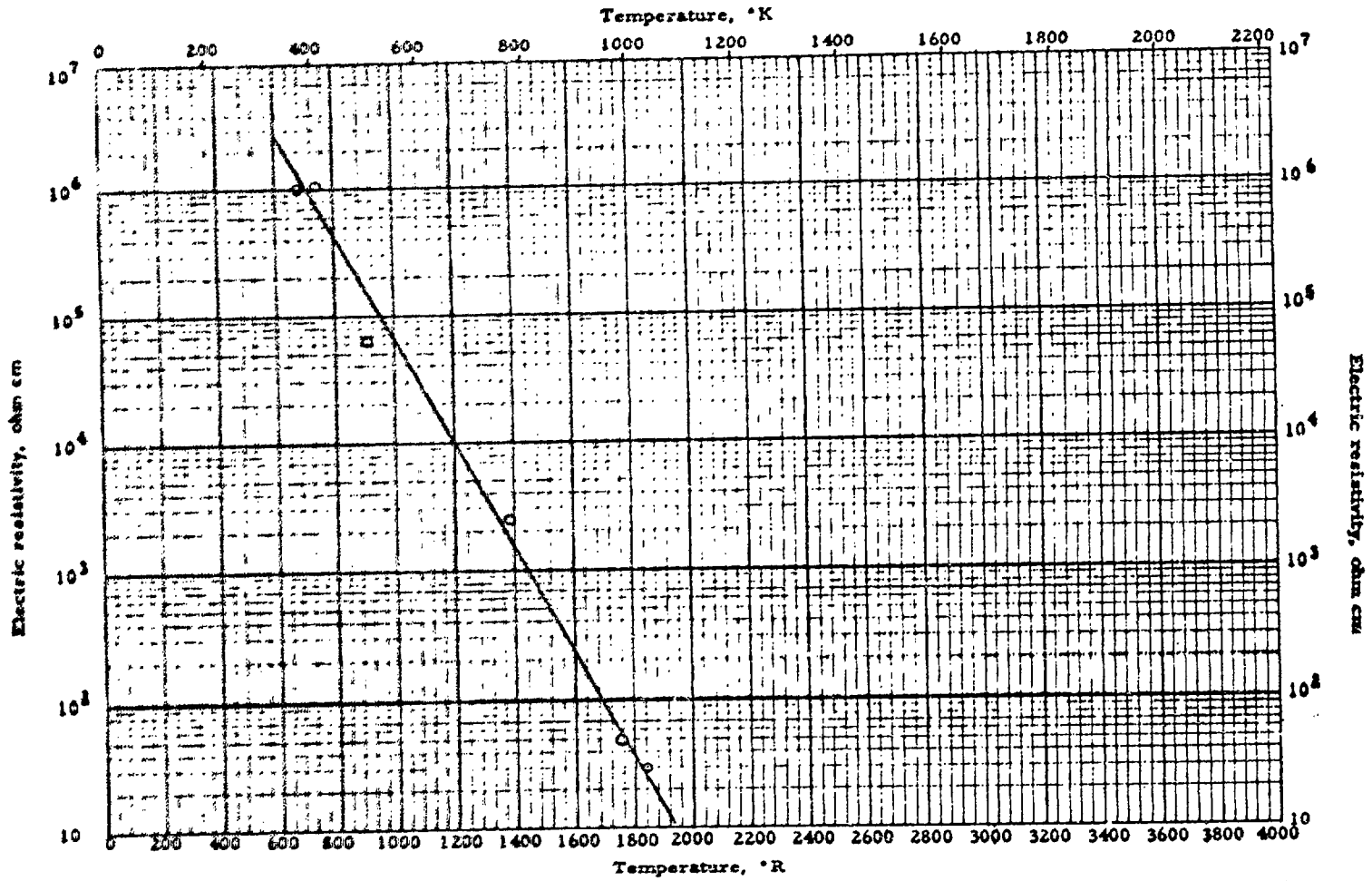
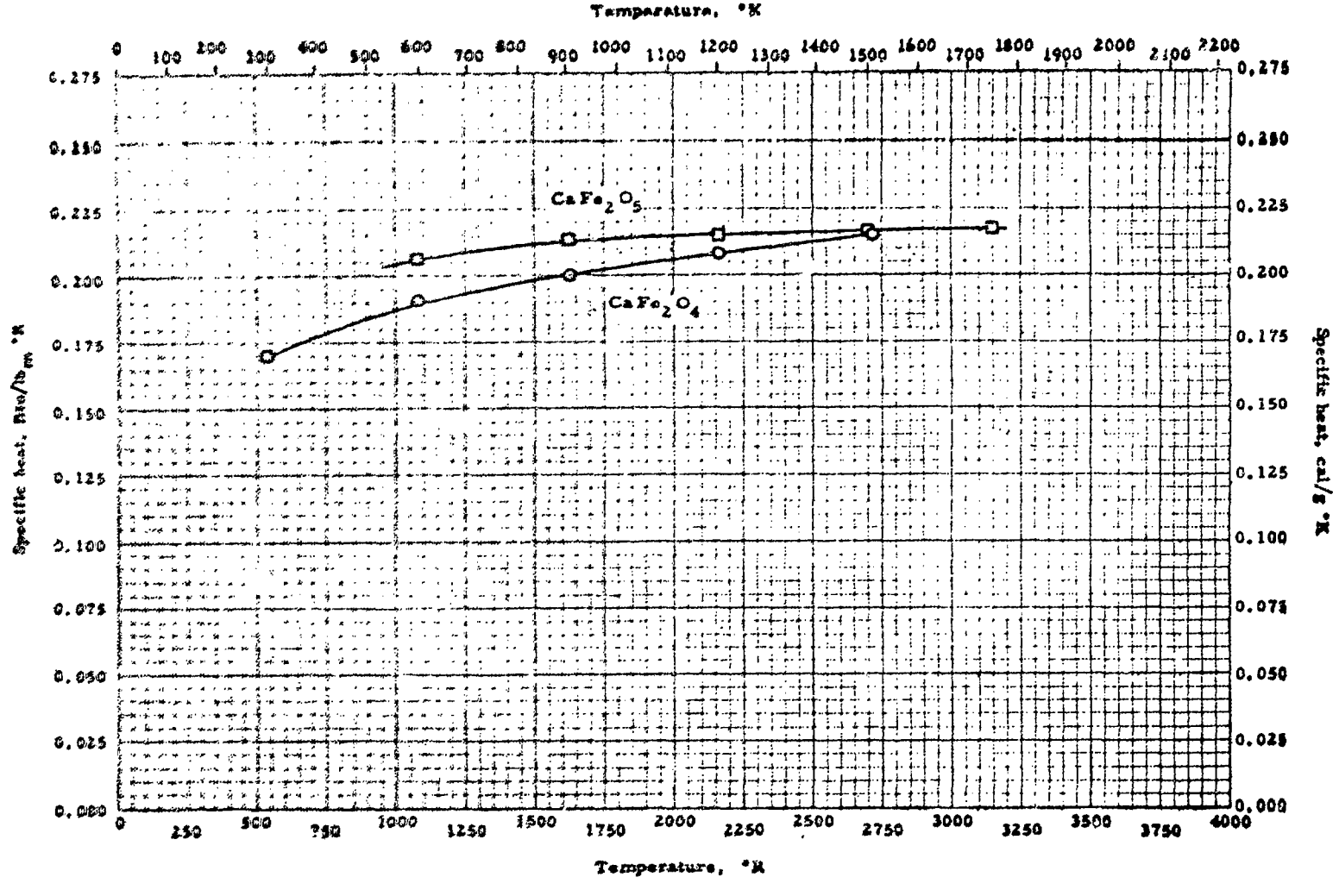


ELECTRIC RESISTIVITY -- MAGNESIUM FERRITE

ELECTRIC RESISTIVITY -- MAGNESIUM FERRITE

REFERENCE INFORMATION

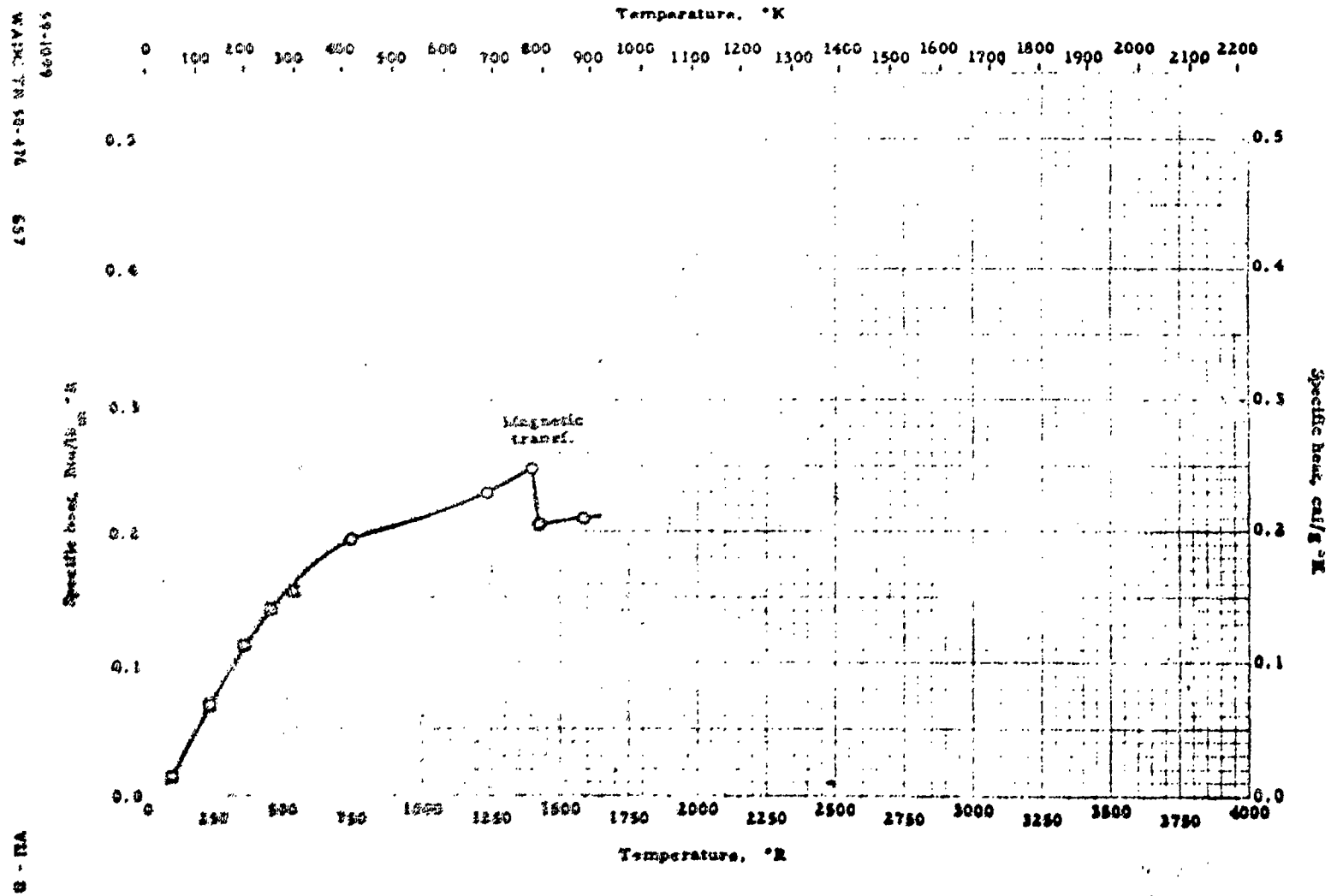
Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Bochirol, L.	51-49	672-1836	$MgO \cdot Fe_2O_3$	Potential drop	



SPECIFIC HEAT -- CALCIUM FERRITE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Bonnickson, K. R.	54-62	535-3335	$CaFe_2O_4$: 74.05% Fe_2O_3 (74.0% theoretical) 26.05% CaO (25.99% theoretical) prepared from reagent grade Fe_2O_3 and $CaCO_3$	Drop method; copper block calorimeter	Ground mixed; heated to 1000 - 1200°C for several hours; repeated several times adjusting composition between heating cycles
□	Ibid.	54-62	535-3310	$Ca_2Fe_2O_5$: 58.71% Fe_2O_3: 41.27% CaO; raw material same as above	Same as above	Same as above except heated to 850 to 1230°C

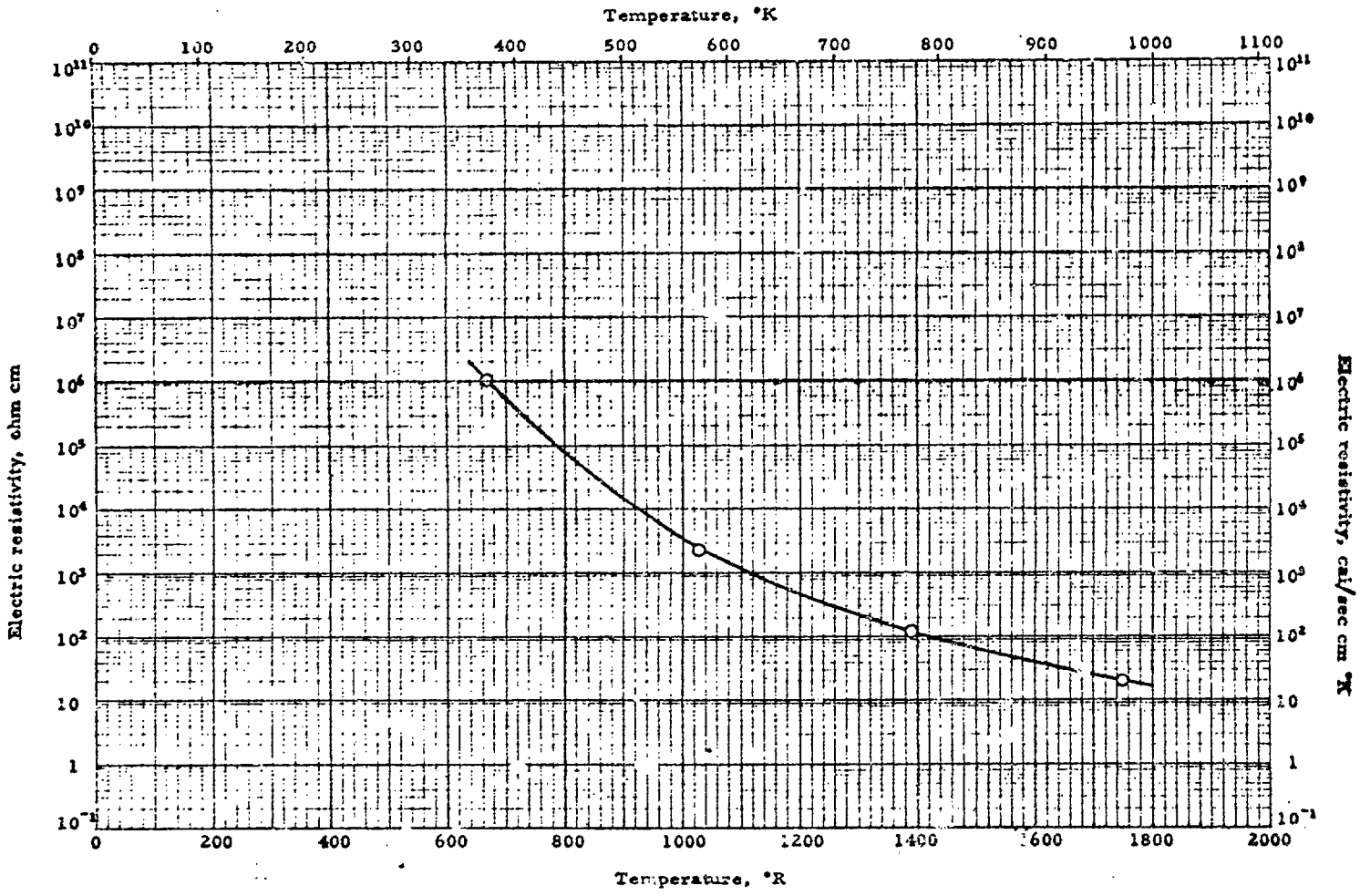


SPECIFIC HEAT -- COBALT FERRITE

SPECIFIC HEAT -- COBALT FERRITE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °K	Material Composition	Test Method	Remarks
○	Hechtel, L.	51 - 32	744-1590	$Fe_2O_3 \cdot CoO$	Not given here, refers to others	
□	King, E. G.	56-145	95-537	$CoFe_2O_4$ spinel, 68.02% Fe_2O_3 (68.06% theo.); 31.96% CoO (31.99% theo.); 0.07% SiO_2	Quarded sample	X-ray diffraction agreed with ASTM; no evidence of uncombined oxides, Ground, mixed, analysed, composition adjusted, heated 5 times for total of 9 days in temp. range 950-1350°C

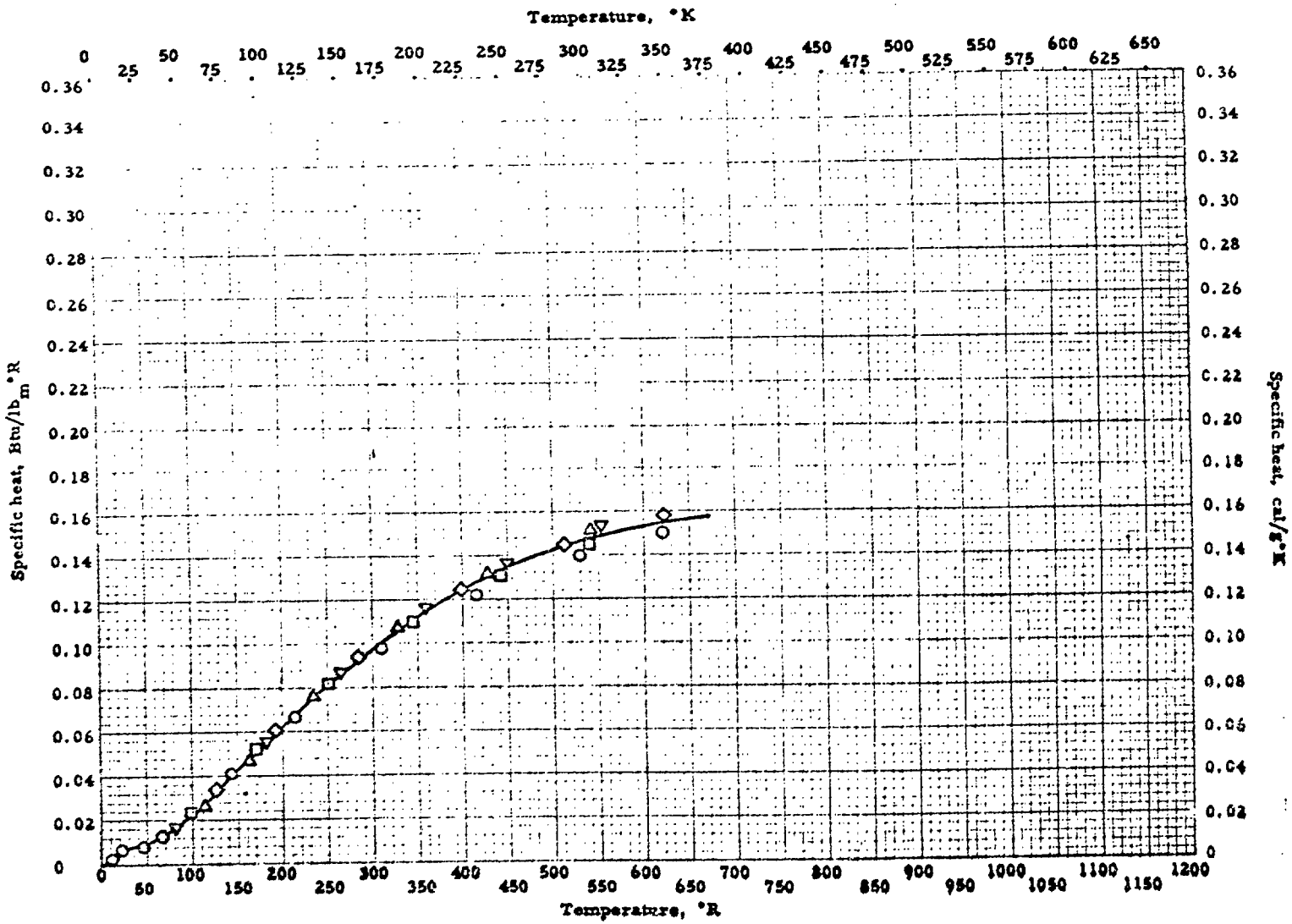


ELECTRIC RESISTIVITY -- COBALT FERRITE

ELECTRIC RESISTIVITY -- COBALT FERRITE

REFERENCE INFORMATION

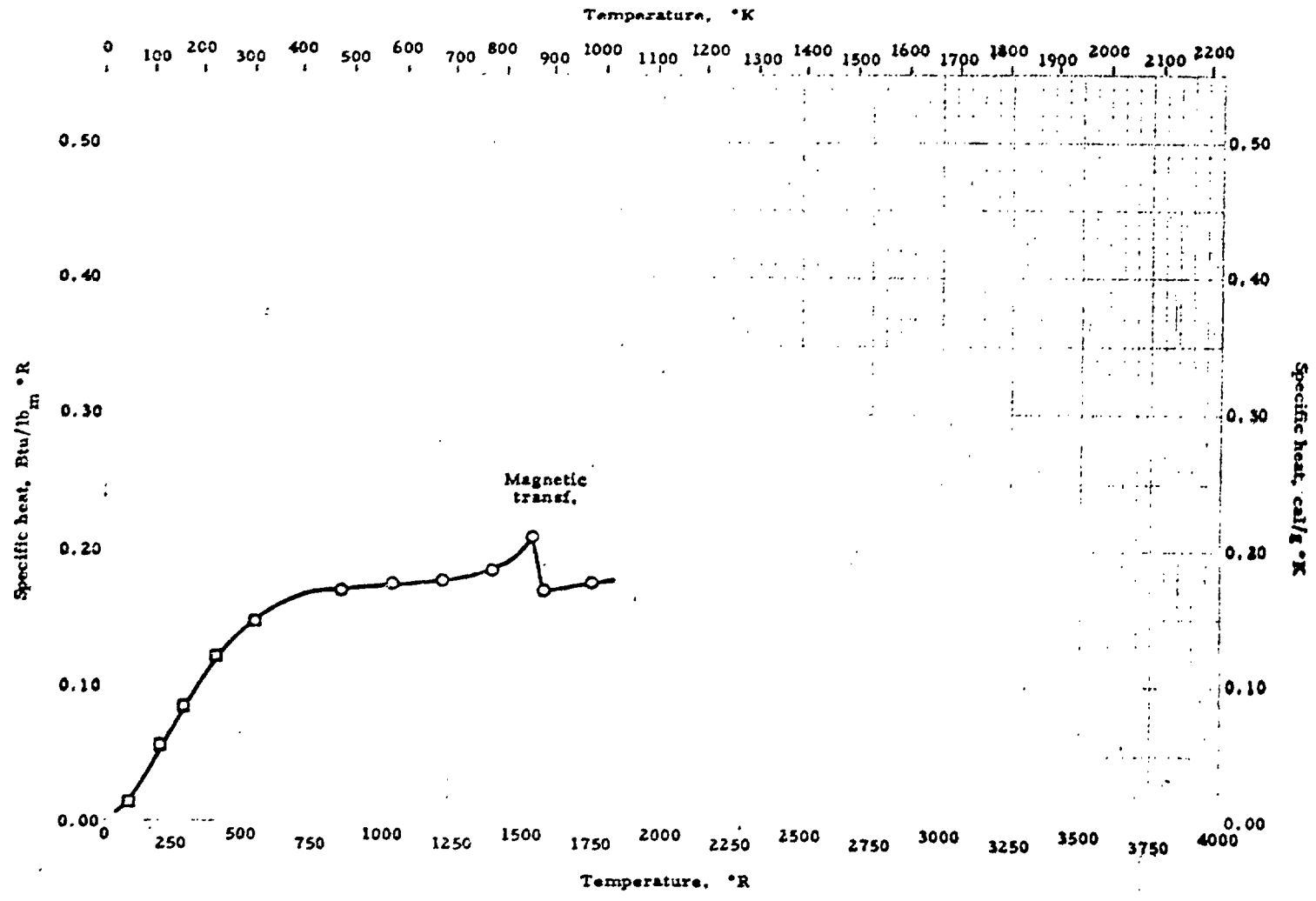
Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Bochirol, L.	51-49	672-1752	Fe_2O_3;CoO	Potential drop, using potentiometer	Sintered discs


Temperature, °K
0 25 50 75 100 125 150 175 200 225 250 275 300 325 350 375 400 425 450 475 500 525 550 575 600 625 650
Specific heat, Btu/lb$_m$ °R
0.36 0.34 0.32 0.30 0.28 0.26 0.24 0.22 0.20 0.18 0.16 0.14 0.12 0.10 0.08 0.06 0.04 0.02 0
Specific heat, cal/g°K
0.36 0.34 0.32 0.30 0.28 0.26 0.24 0.22 0.20 0.18 0.16 0.14 0.12 0.10 0.08 0.06 0.04 0.02 0
0 50 100 150 200 250 300 350 400 450 500 550 600 650 700 750 800 850 900 950 1000 1050 1100 1150 1200
Temperature, °R

69-533
WADC TR 58-476 Pt 2

REFERENCE INFORMATION

Sym	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Grimes, D. M., Westrum, E. F. and Legvold, S.	57-195	10-622	$Ni_{0.1}Zn_{0.9}Fe_2O_4$	Guarded sample, temp. by platinum resistance thermometer	Annealed at 1200°C, very pure sample, carefully prepared
□	Ibid.	57-195	8-536	$Ni_{0.2}Zn_{0.3}Fe_2O_4$: 46.7 ± 0.1% Fe (theoretical 46.59%)	Same as above	Same as above
△	Ibid.	57-195	8-542	$Ni_{0.4}Zn_{0.6}Fe_2O_4$: 46.8 ± 0.1% Fe (theoretical 46.84%)	Same as above	Same as above, but annealed at 900° C
◇	Ibid.	57-195	10-623	$Ni_{0.3}Zn_{0.7}Fe_2O_4$	Same as above	Same as above, but annealed at 1200°C
▽	Ibid.	57-195	10-550	Ferramic E: $Ni_{0.4}Zn_{0.6}Fe_2O_4$ commercial grade material	Same as above	

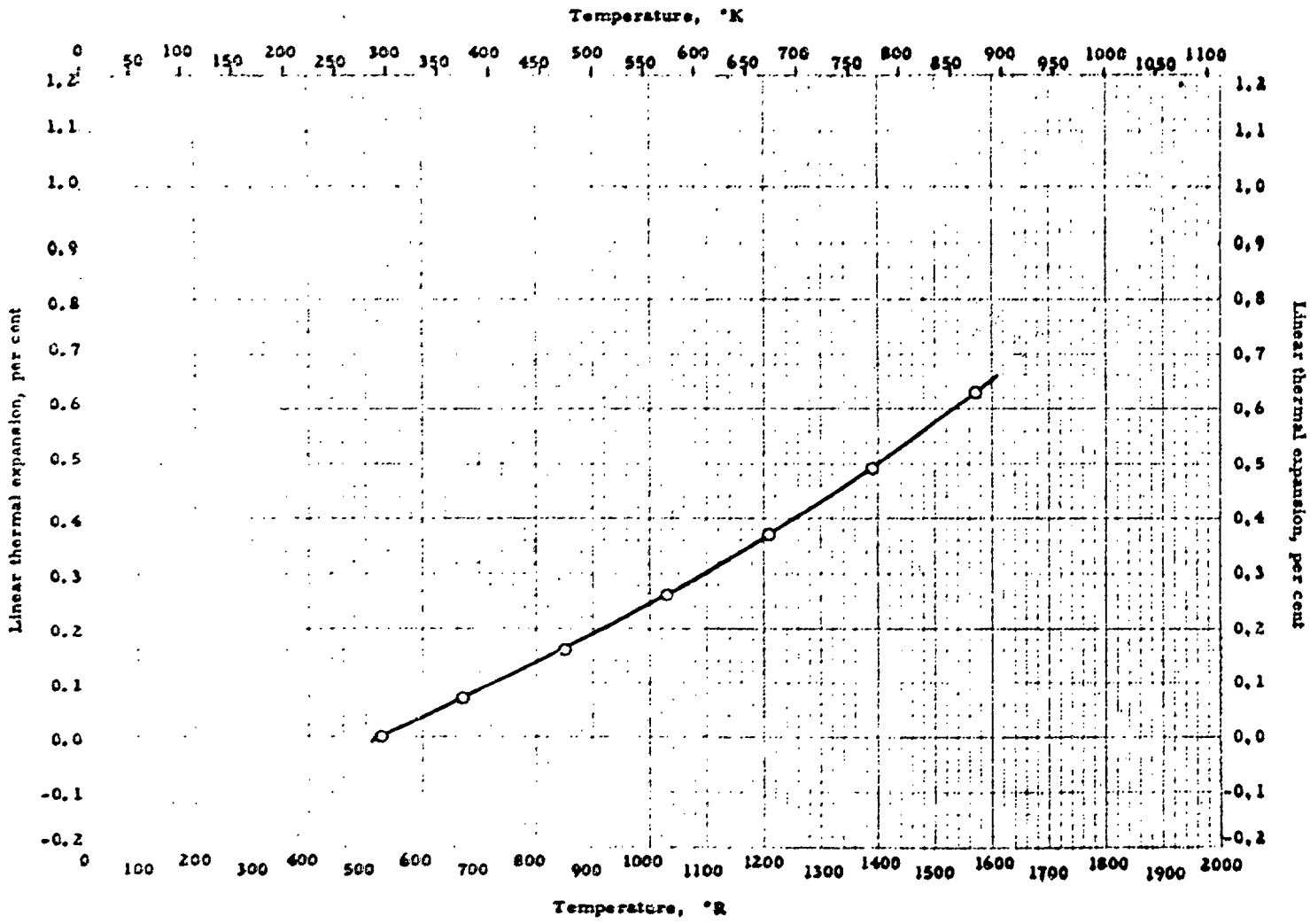


SPECIFIC HEAT -- NICKEL FERRITE

SPECIFIC HEAT -- NICKEL FERRITE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Bochirol, L.	51-32	852-1752	$NiO \cdot Fe_2O_3$	Not given here; refers to others	
□	King, E. G.	56-165	96-537	$NiFe_2O_4$ spinel: 68.11% Fe_2O_3 (68.13% theo.); 31.86% NiO (31.87% theo.); 27.22% O_2 (27.33% theo.); 0.03% SiO_2	Guarded sample	X-ray diffraction agreed with ASTM; no impurity line detected. Heated to 990-1270°C for prolonged periods, with grinding, mixing, etc. in between heats

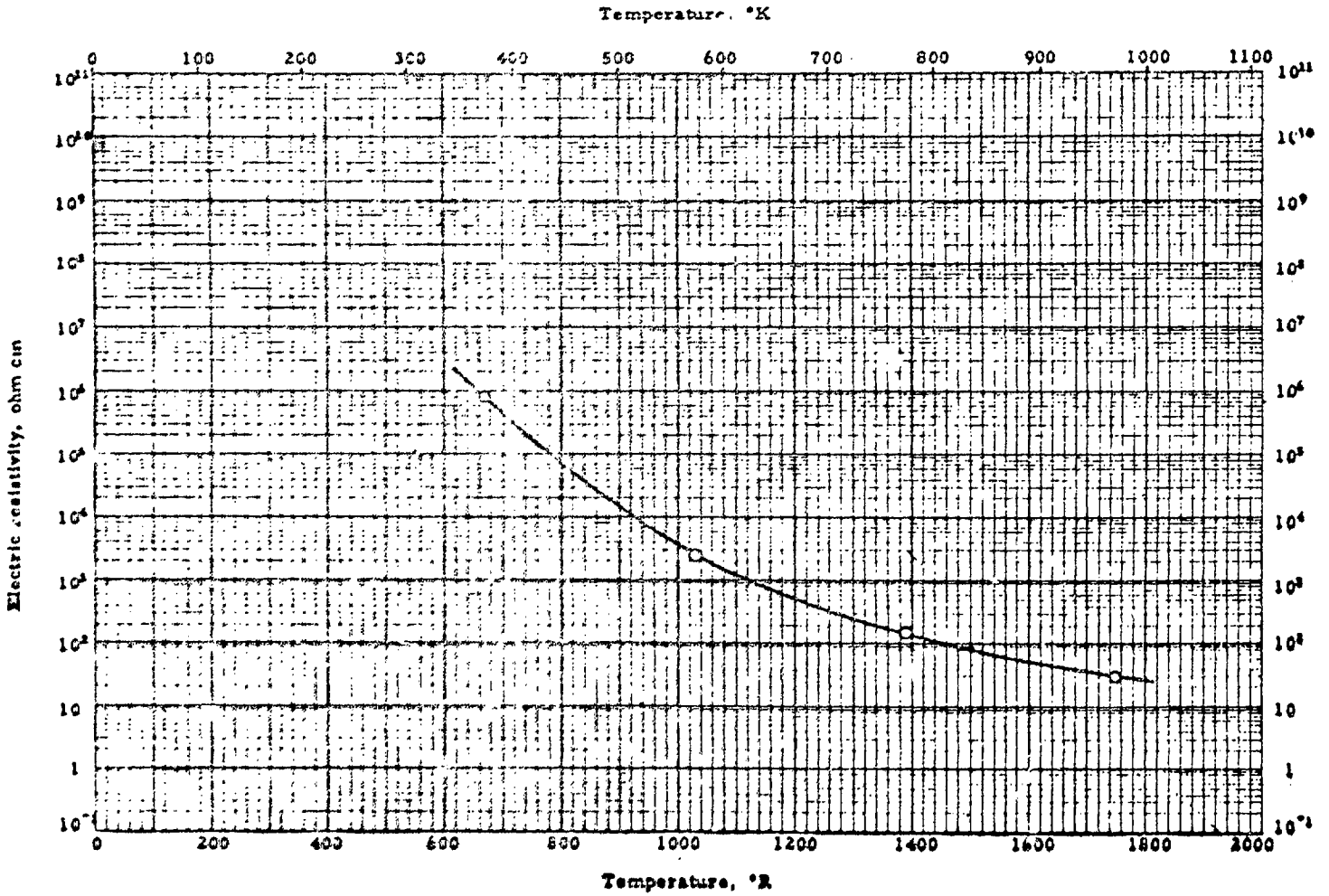


LINEAR THERMAL EXPANSION -- NICKEL FERRITE

LINEAR THERMAL EXPANSION -- NICKEL FERRITE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Augustinik, A. I. and Vasil'ev, E. L.	56-162	672-1572	$NiO \cdot Fe_2O_3$; 68.13% Fe_2O_3; 31.87% NiO	Dilatometer	

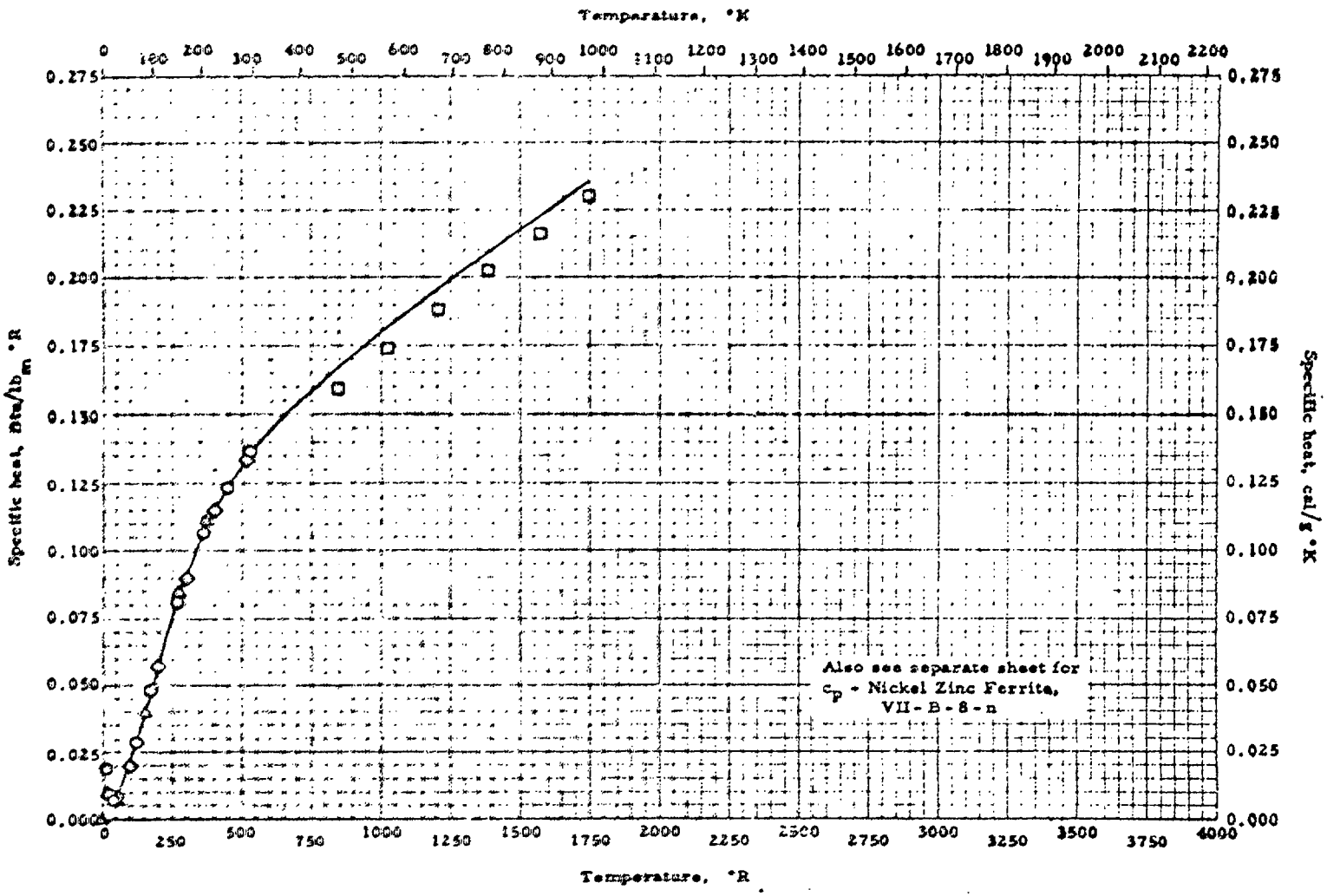


ELECTRIC RESISTIVITY -- NICKEL FERRITE

ELECTRIC RESISTIVITY -- NICKEL FERRITE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Bochirol, L.	51-49	672-1752	Fe_2O_3 · NiO	Potential drop, using potentiometer	Sintered discs

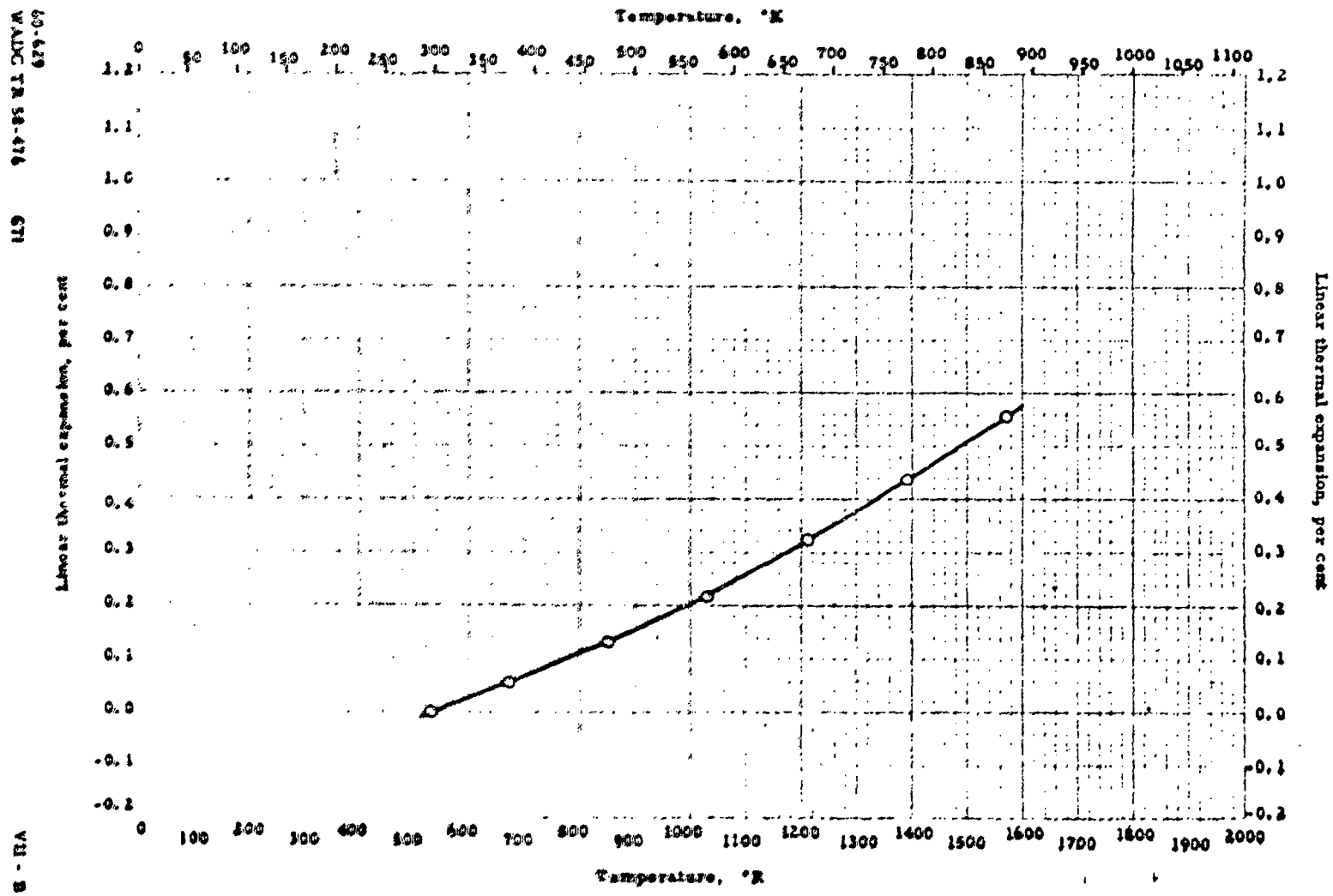


SPECIFIC HEAT -- ZINC FERRITE

SPECIFIC HEAT -- ZINC FERRITE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °K	Material Composition	Test Method	Remarks
○	Westrum, Jr., E. F. and Grimes, D. M.	57-49 also 57-195	18-536	$ZnFe_2O_4$. 46.24 ± 0.1% Fe (cf. theor. 46.33); 27.2 ± 0.1% Zn (cf. theor. 27.12); <0.1% ferrous Fe; 0.01-0.1% ea. Al, Mn; 0.001-0.01% ea. Ca, Cu, Mg, Ni, S	Guarded sample	Pressed, fired 14 hr. at 1100°C in air, fragmented to pass 30-mesh screen, reformed into slugs, fired 12 hr. at 1100°C, and furnace cooled in 16 hr.
□	Dochirol, L.	51-32	852-1752	$Fe_2O_3 \cdot ZnO$	Not given. (lists ref.)	
△	Friedberg, S. A.	46-12	0-360	$ZnO \cdot Fe_2O_3$	Not described here, refers to others	
◇	King, E. G.	56-165	95-540	$ZnFe_2O_4$. Spinel: 66.36% Fe_2O_3; 33.64% ZnO	Guarded sample	Heated to 940-1280°C several times (total 18 days) with grinding, mixing, etc. in between heatings



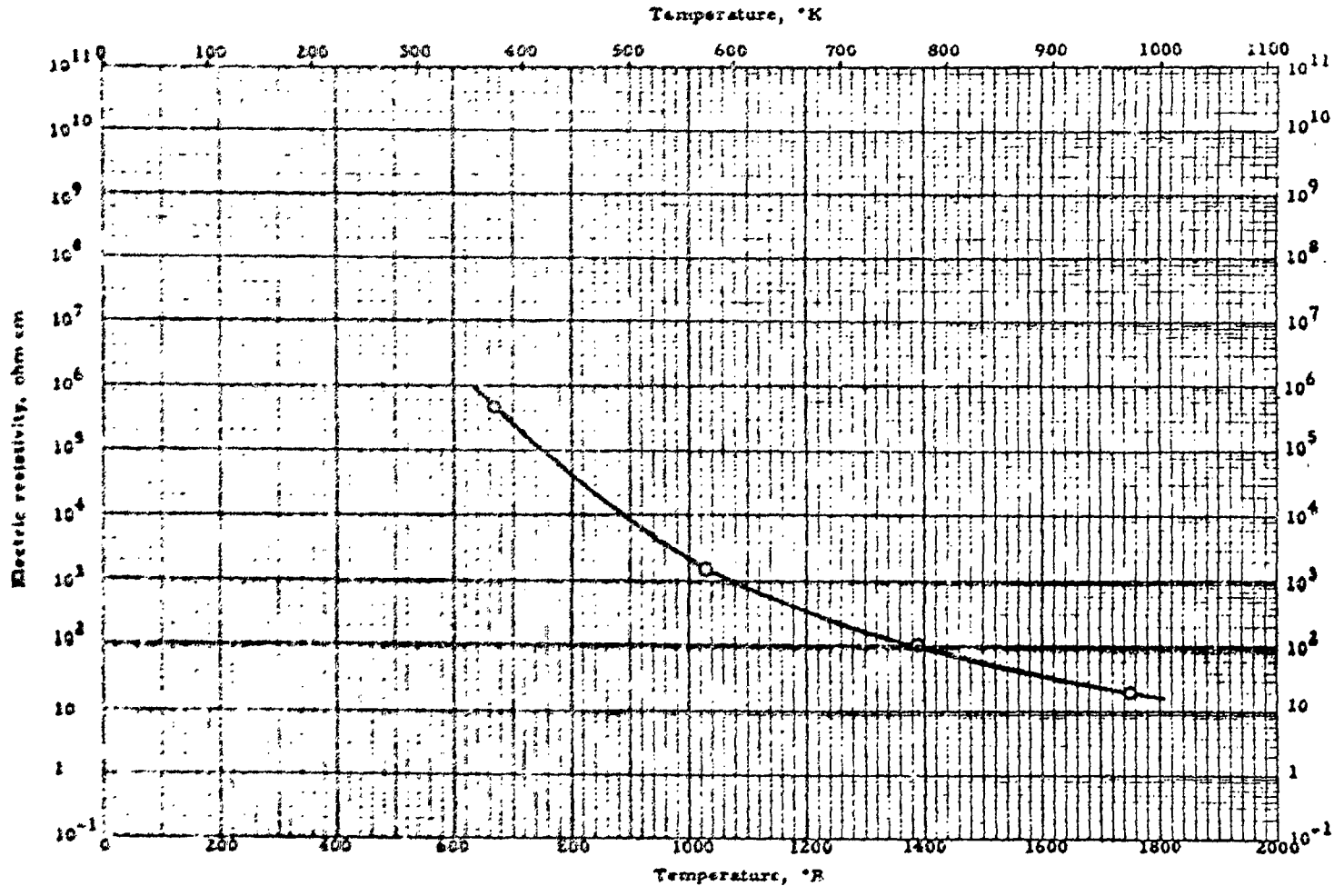
LINEAR THERMAL EXPANSION -- ZINC FERRITE

MATC TR 54-616
69-629

LINEAR THERMAL EXPANSION -- ZINC FERRITE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Avgustinik, A. I. and Vasil'ev, E. L.	58-162	672-1572	$ZnO \cdot Fe_2O_3$: 66.2% Fe_2O_3; 33.8% ZnO	Dilatometer	



ELECTRIC RESISTIVITY -- ZINC FERRITE

ELECTRIC RESISTIVITY -- ZINC FERRITE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Bochirol, L.	51-49	672-1752	Fe_2O_3 ZnO	Potential drop, using potentiometer	Sintered discs

PROPERTIES OF MANGANESE FERRITE

MOST PROBABLE VALUES

Property	Brit. Engineering Units	C. G. S. Units
Density.	293 lb_m/ft^3	4.7 g/cm^3
Melting Point		
Heat of Fusion		
Heat of Vaporization. . . .		
Heat of Sublimation . . .		

REPORTED VALUES

		lb_m/ft^3	g/cm^3
Density:	○	291.4	4.67
	□	300.8	4.82
	△	290.8	4.66
	◇	292.7	4.69

	°R	°K
Melting Point:		

	Btu/lb_m	cal/g
Heat of Fusion:		

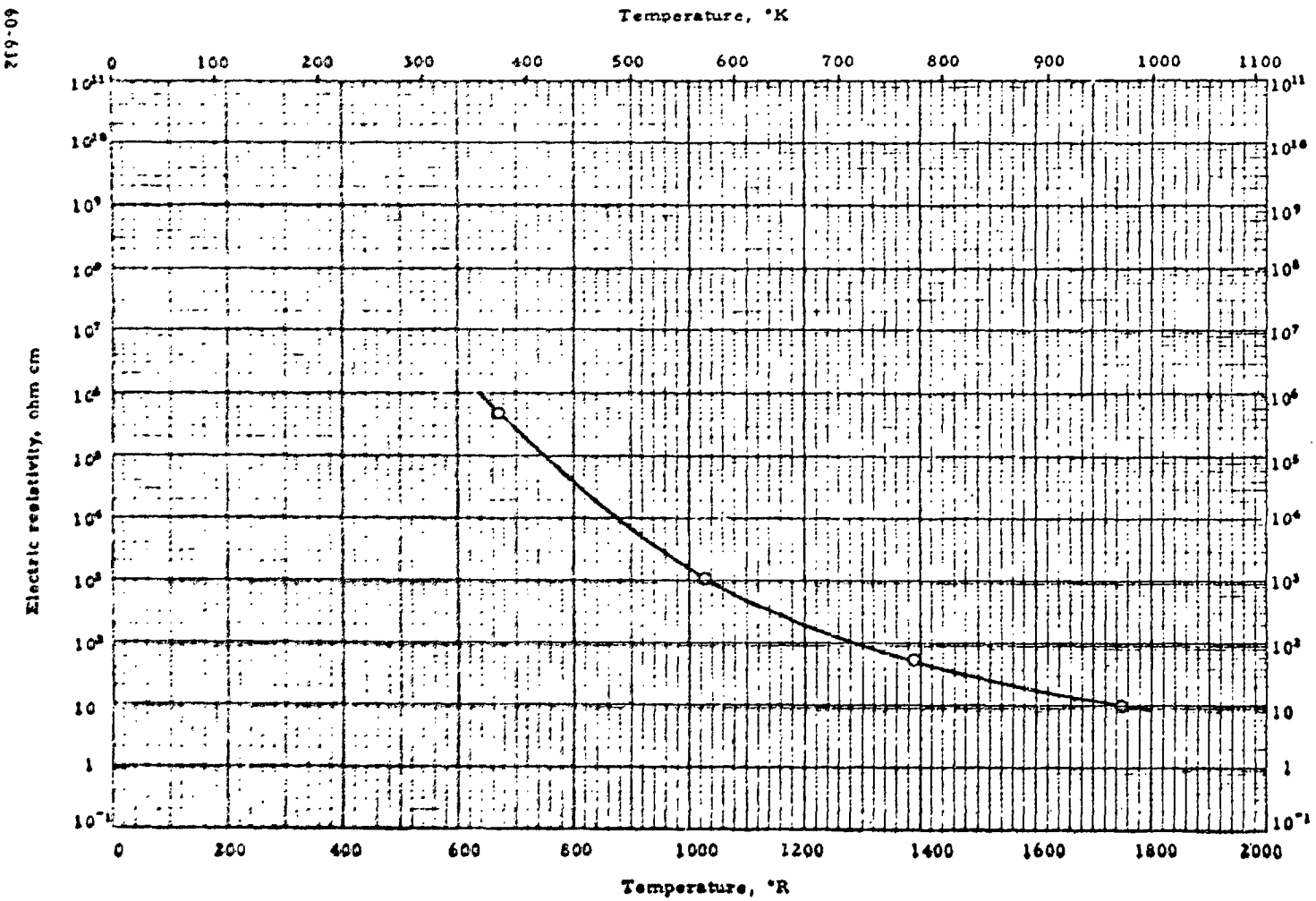
	Btu/lb_m	cal/g
Heat of Vaporization:		

	Btu/lb_m	cal/g
Heat of Sublimation:		

PROPERTIES OF MANGANESE FERRITE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Economos, G.	55-145	Room	$MnFe_2O_4$	ρ: displacement in acetone	$MnCO_3$ and iron oxide heated 6 hrs. at 550°C; mixing and more heating gave final mixtures which were pressed and sintered. Fired in stagnant air
□	Ibid.	55-145	Room	Same as above	ρ: same as above	Same as above but fired in CO-CO_2 (an equilibrium atmos.)
△	Ibid.	55-145	Room	Same as above	ρ: same as above	Same as above but fired in CO_2
◇	Ibid.	55-145	Room	Same as above	ρ: same as above	Same as above but fired in He



ELECTRIC RESISTIVITY -- COPPER FERRITE

ELECTRIC RESISTIVITY -- COPPER FERRITE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Bochirol, L.	51-49	672-1752	Fe_2O_3CuO	Potential drop, using potentiometer	Sintered discs

DENSITY -- MICA

MOST PROBABLE VALUES

Property	Brit. Engineering Units	C. G. S. Units
Density.	177.6 lb_m/ft^3	2.845 g/cm^3
Melting Point		
Heat of Fusion		
Heat of Vaporization. . .		
Heat of Sublimation . . .		

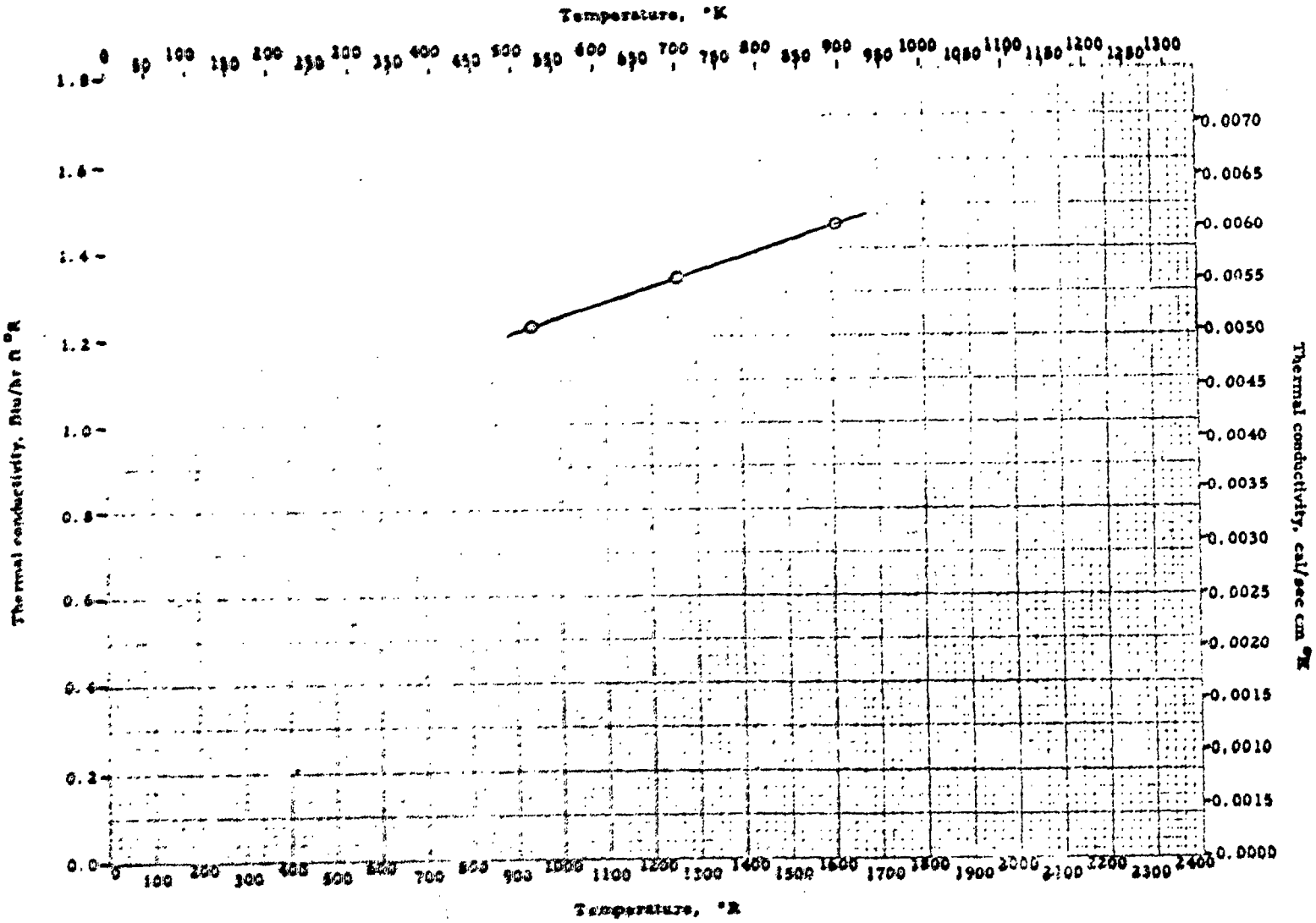
REPORTED VALUES

Density:		lb_m/ft^3	g/cm^3
	O	177.6 $\pm$ 0.06	2845 $\pm$ 0.001
Melting Point:		°R	°K
Heat of Fusion:		Btu/lb_m	cal/g
Heat of Vaporization:		Btu/lb_m	cal/g
Heat of Sublimation:		Btu/lb_m	cal/g

DENSITY -- MICA

REFERENCE INFORMATION

Curve Ident.	Investigator	Ref	Range, °R	Material Composition	Test Method	Remarks
O	Oak Ridge National Laboratory	57-150	537	Mica	ρ: weight in air and in kerosene	Measured by O. Sisman, C. D. Bopp and R. L. Towns



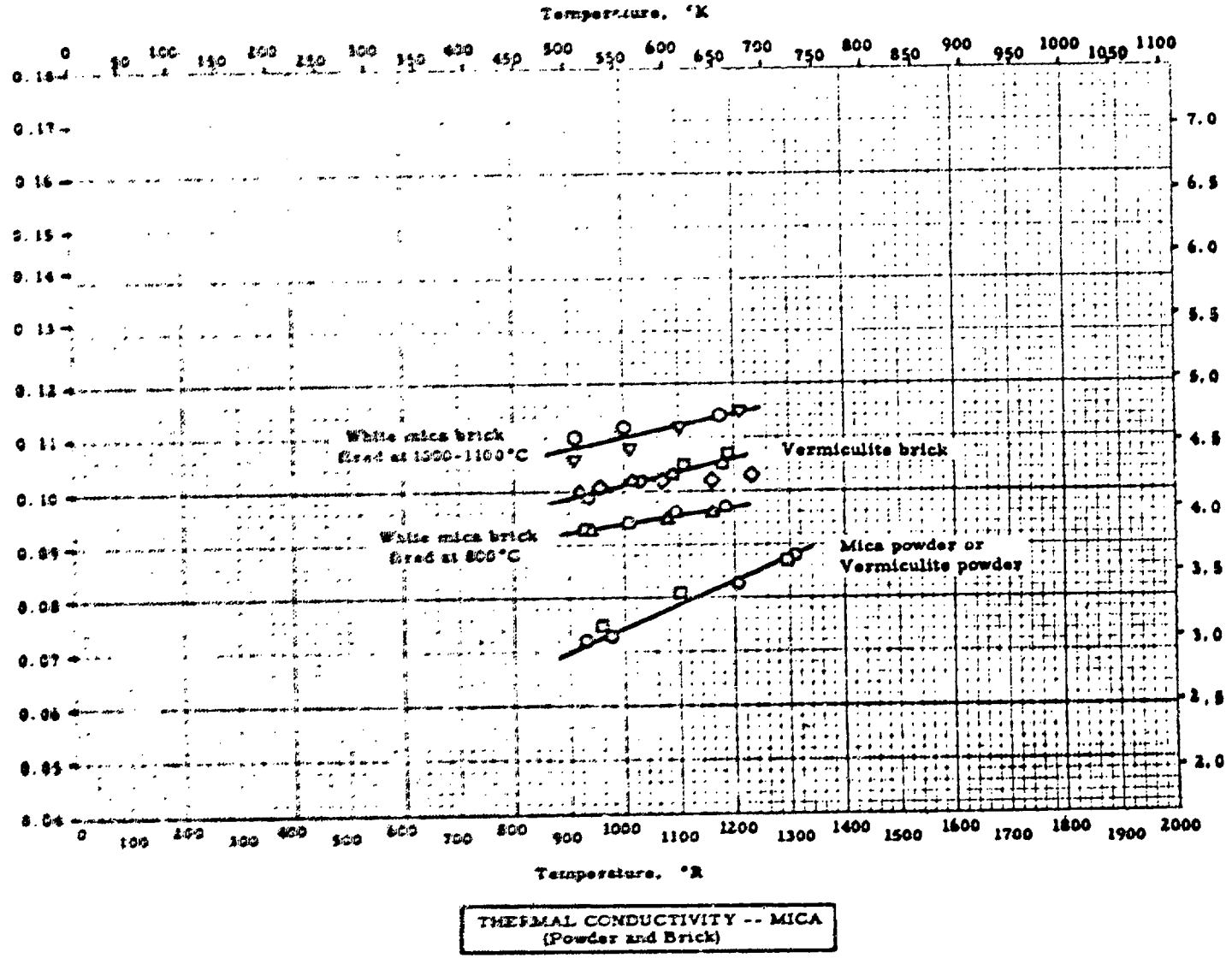
THERMAL CONDUCTIVITY -- SYNTHETIC MICA

WADC TR 59-610 692

THERMAL CONDUCTIVITY -- SYNTHETIC MICA

REFERENCE INFORMATION

Curve No.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	McCreight, L. R.	57-148	942-1802	ρ = 98% of theor.		



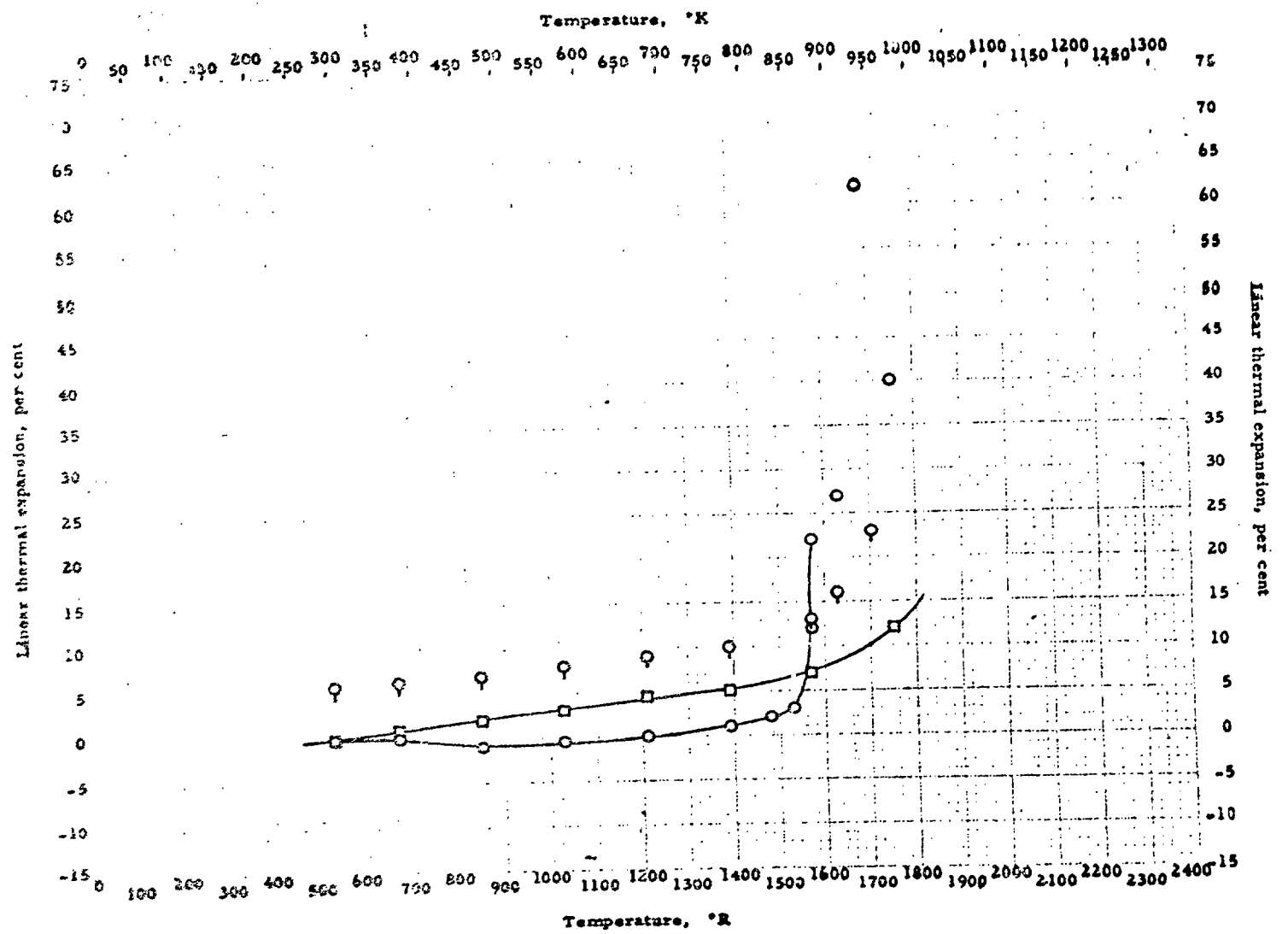
THERMAL CONDUCTIVITY -- MICA
(Powder and Brick)

WADC TR 56-616 VII - 9

THERMAL CONDUCTIVITY -- MICA
(Powder and Brick)

REFERENCE INFORMATION

Sym.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Sveton, S. M. and Prasad, J.	57-	932-1512	Mica insulating powders, ρ = 20.7 lb_m/ft^3	Single flat plate; water calorimeter	
□	Ibid.		956-1297	Vermiculite insulating powders, ρ = 16.7 lb_m/ft^3	Same as above	
△	Ibid.		962-1160	White mica brick, ρ = 42.7 lb_m/ft^3	Same as above	Fired at 850°C
◇	Ibid.		936-1232	Same as above, ρ = 41.2 lb_m/ft^3	Same as above	Fired at 900°C
▽	Ibid.		919-1212	Same as above, ρ = 41.5 lb_m/ft^3	Same as above	Fired at 1000°C
○	Ibid.		912-1179	Same as above, ρ = 41.6 lb_m/ft^3	Same as above	Fired at 1100°C
○	Ibid.		928-1186	White mica insulating brick, ρ = 43.9 lb_m/ft^3	Same as above	
◇	Ibid.		933-1181	Red mica insulating brick, ρ = 44.0 lb_m/ft^3	Same as above	
○	Ibid.		937-1187	Vermiculite insulating brick, ρ = 30.2 lb_m/ft^3	Same as above	



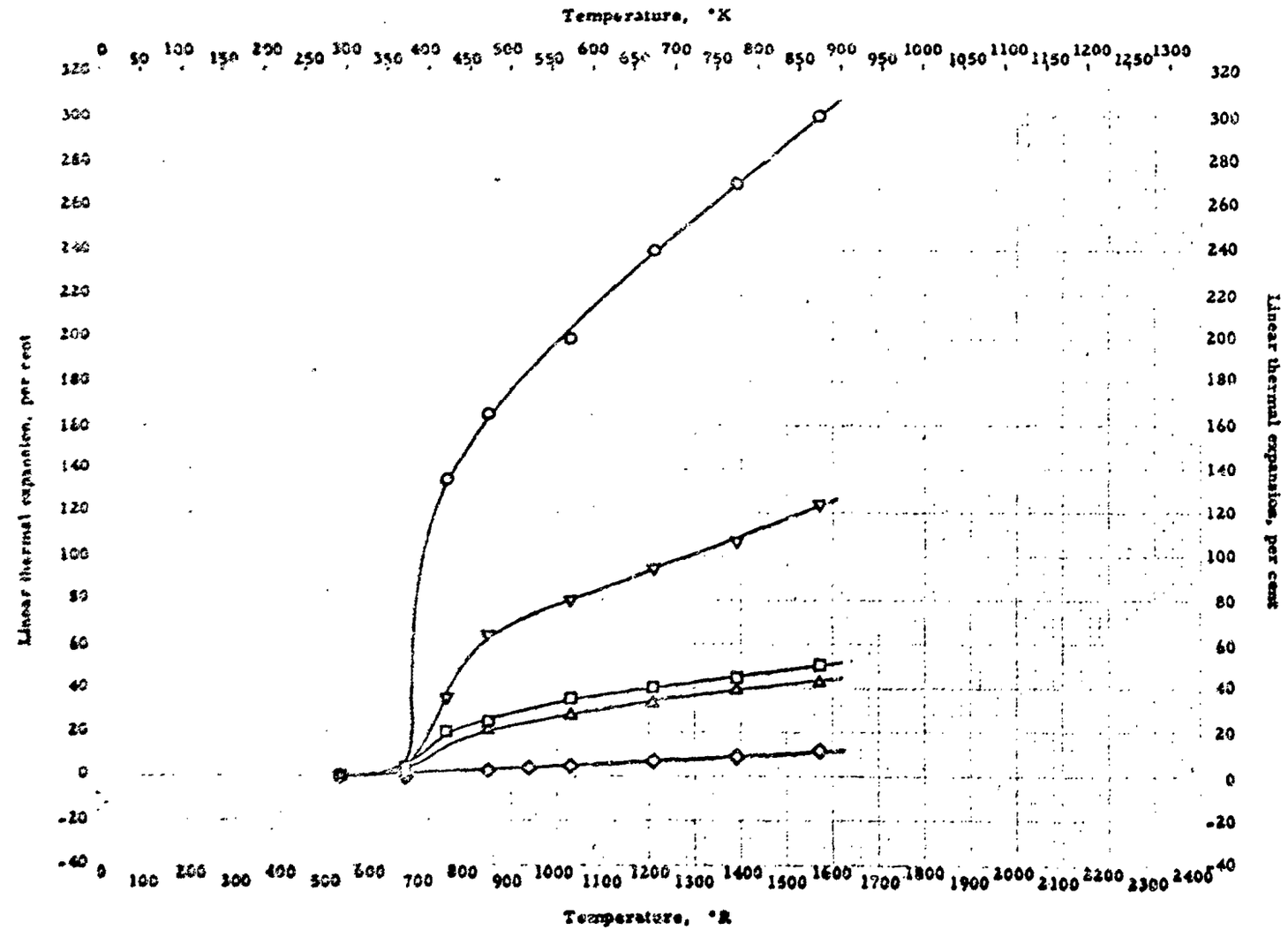
LINEAR THERMAL EXPANSION -- IRON MICA (BIOTITE)

WADC TR 58-476 695

LINEAR THERMAL EXPANSION -- IRON MICA (BIOTITE)*

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Hidnert, P., and Dixon, G.	45-2	528-1752	From Oxford County, Maine	Fused quarts dilatometer	Measured perpendicular to cleavage plane; 1st heating and cooling cycle. O - heating; Q - cooling
□	Ibid.	45-2	528-1752	From Newdale, N. C.	Same as above	Measured perpendicular to cleavage plane; 6th heating cycle. *The above data are representative; for additional information see original article. 1 hr. at 700°C increased room temp. thickness as much as 60% in some samples



LINEAR THERMAL EXPANSION -- MAGNESIUM MICA (PHLOGOPHITE)

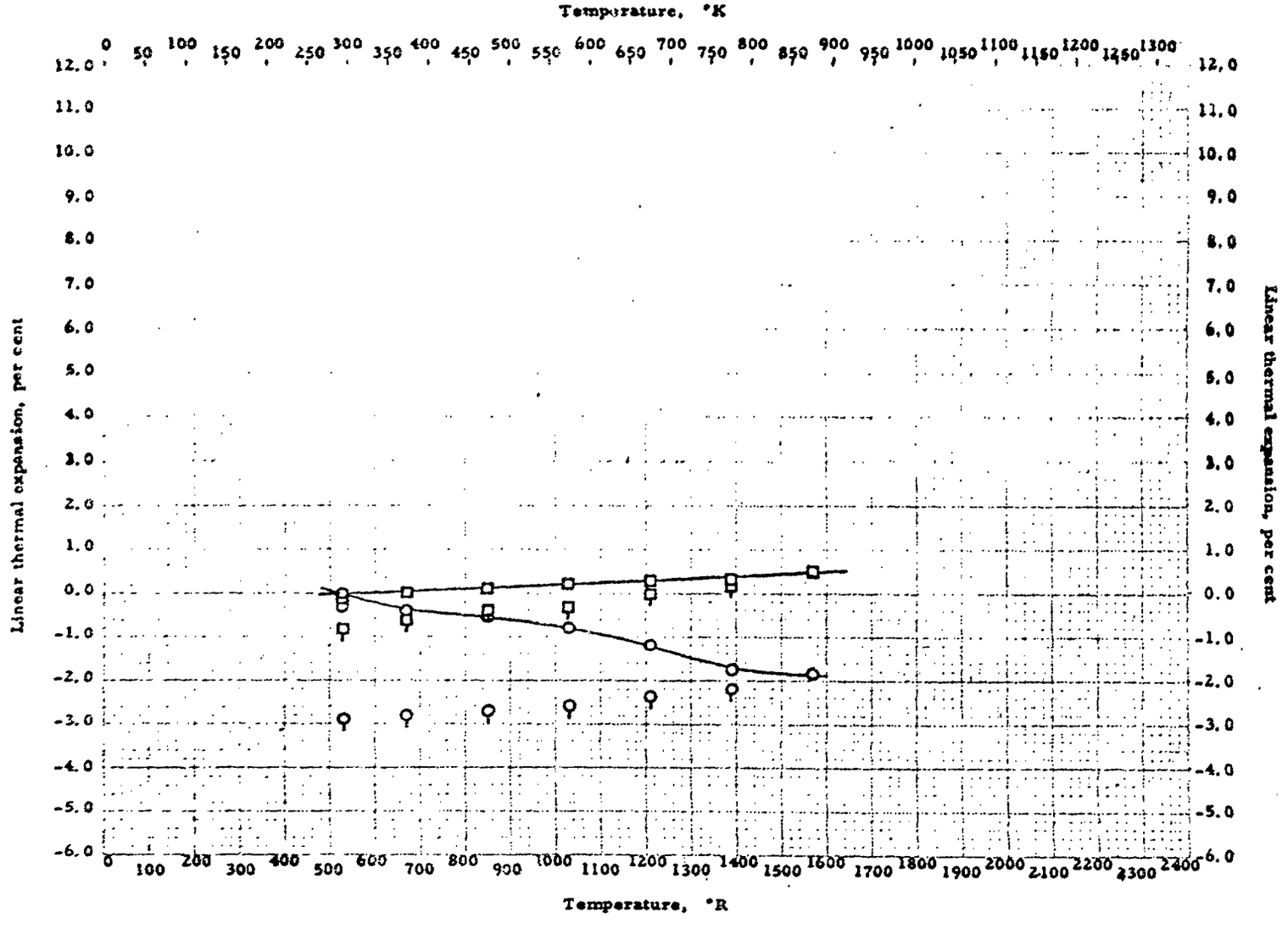
59-413
WADC TR 58-476

LINEAR THERMAL EXPANSION -- MAGNESIUM MICA (PHLOGOPITE)*

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Hidnert, P. and Dixon, G.	45-2	528-1572	From Burgess, Canada	Fused quartz dilatometer	Measured perpendicular to cleavage plane; 1 psi compressive load; max. values are shown
□	Ibid.	45-2	528-1572	Same as above	Same as above	Same as above with 30 psi compressive load
△	Ibid.	45-2	528-1572	From Madagascar, Block No. 995	Same as above	Measured perpendicular to cleavage plane; formed from 80 disks; 3rd heating
▽	Ibid.	45-2	528-1572	From same sample as above	Same as above	Same as above; one solid disk; 1st heating
◇	Ibid.	45-2	528-1572	Same material as above	Same as above	Measured perpendicular to cleavage plane; minimum values are shown

*The above data are representative; for additional information, see original article. 1 hr. at 700°C increased room temp. thickness as much as 60% in some samples

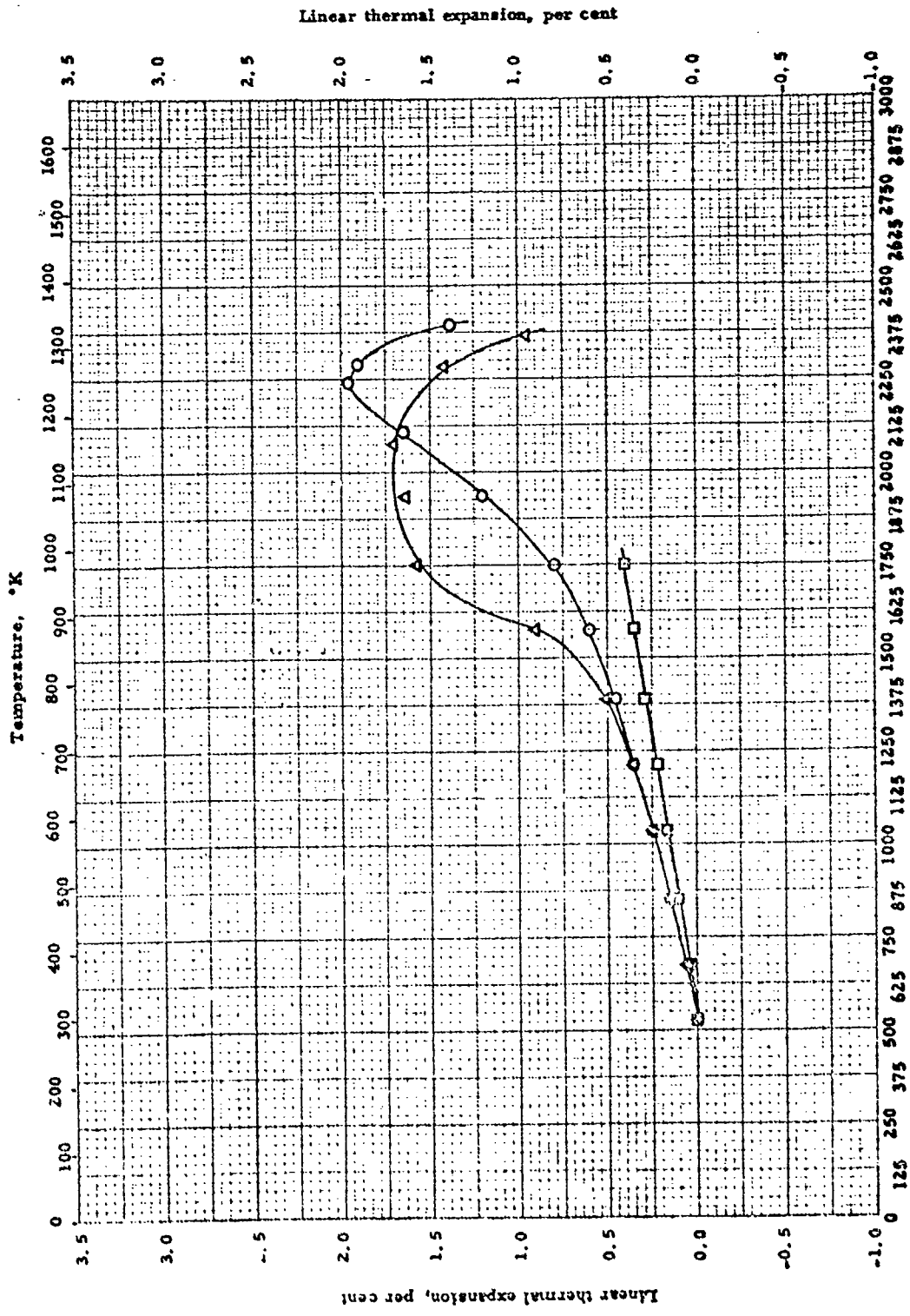


LINEAR THERMAL EXPANSION -- POTASSIUM MICA (MUSCOVITE)

LINEAR THERMAL EXPANSION -- POTASSIUM MICA (MUSCOVITE)*

REFERENCE INFORMATION

Curve No.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Hidnert, P. and Dixon, G.	45-2	528-1572	From Mitchell County, N. C.	Fused quartz dilatometer	Measurements perpendicular to cleavage plane. O - initial heating; O - cooling and reheating. Max. in muscovite group
□	Ibid.	45-2	528-1572	From Brazil, White 1441 (ruby, first quality)	Same as above	Measurements perpendicular to cleavage plane. □ - initial heating; □ - cooling and reheating. *Above data are representative; for additional information see original article. 1 hr. at 700°C increased room temp. thickness as much as 60% in some samples

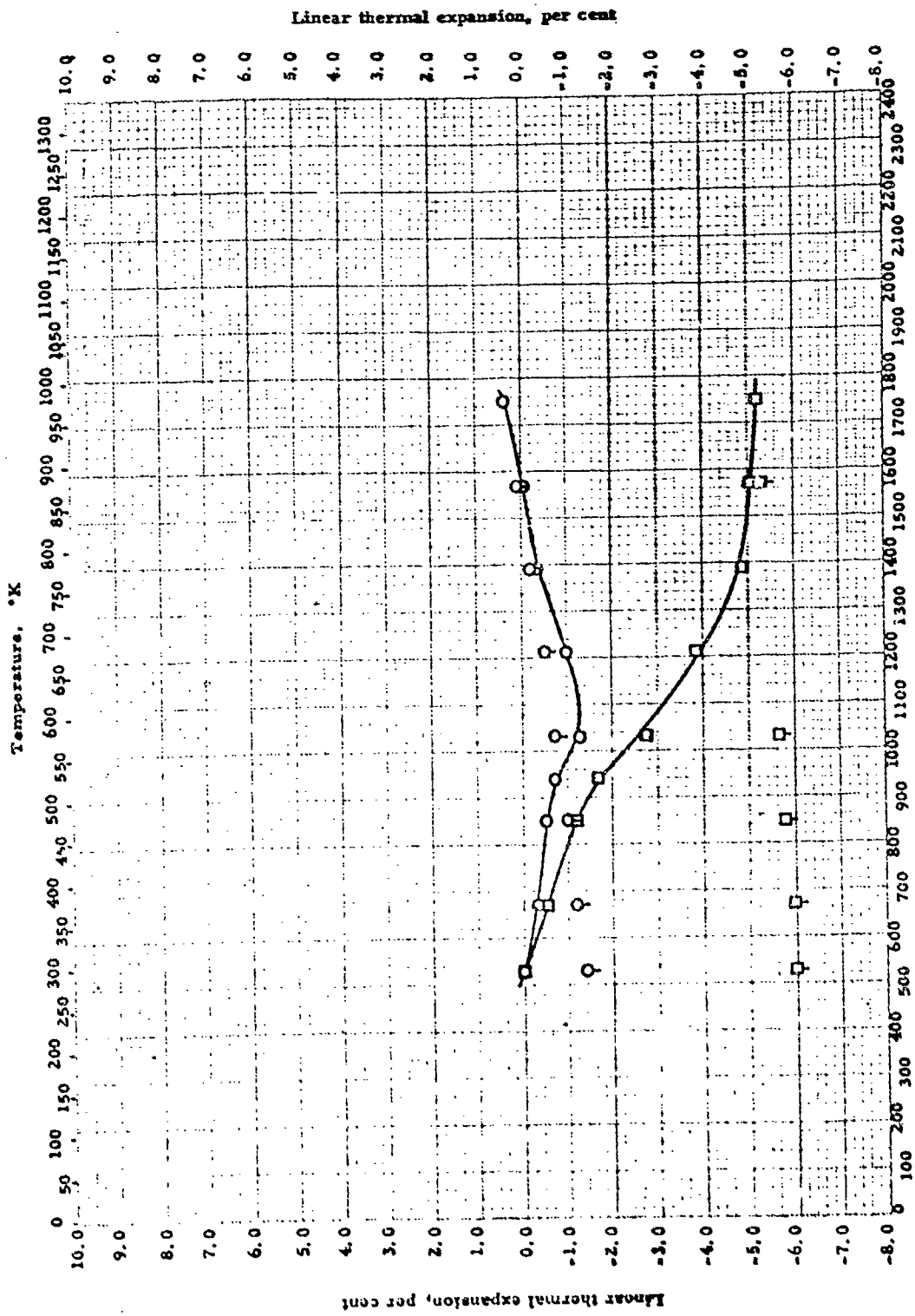


LINEAR THERMAL EXPANSION -- MICA (CERICITE, ILLITE)

LINEAR THERMAL EXPANSION -- MICA (CERICITE, ILLITE)

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Zwetsch, A.	55-21	528-2382	From LeBoulou Pyrenees Orientales; 50.74% SiO_2; 31.81% Al_2O_3; 1.27% Fe_2O_3; 0.58% CaO; 0.63% MgO; 10.27% K_2O; 0.84% Na_2O. Cericite	Dilatometer	Apparently random orientation
□	Ibid.	55-21	528-1752	Above material; fired	Same as above	Loss on firing: 4.07%
△	Ibid.	55-21	528-2364	Illite	Same as above	Apparently random orientation

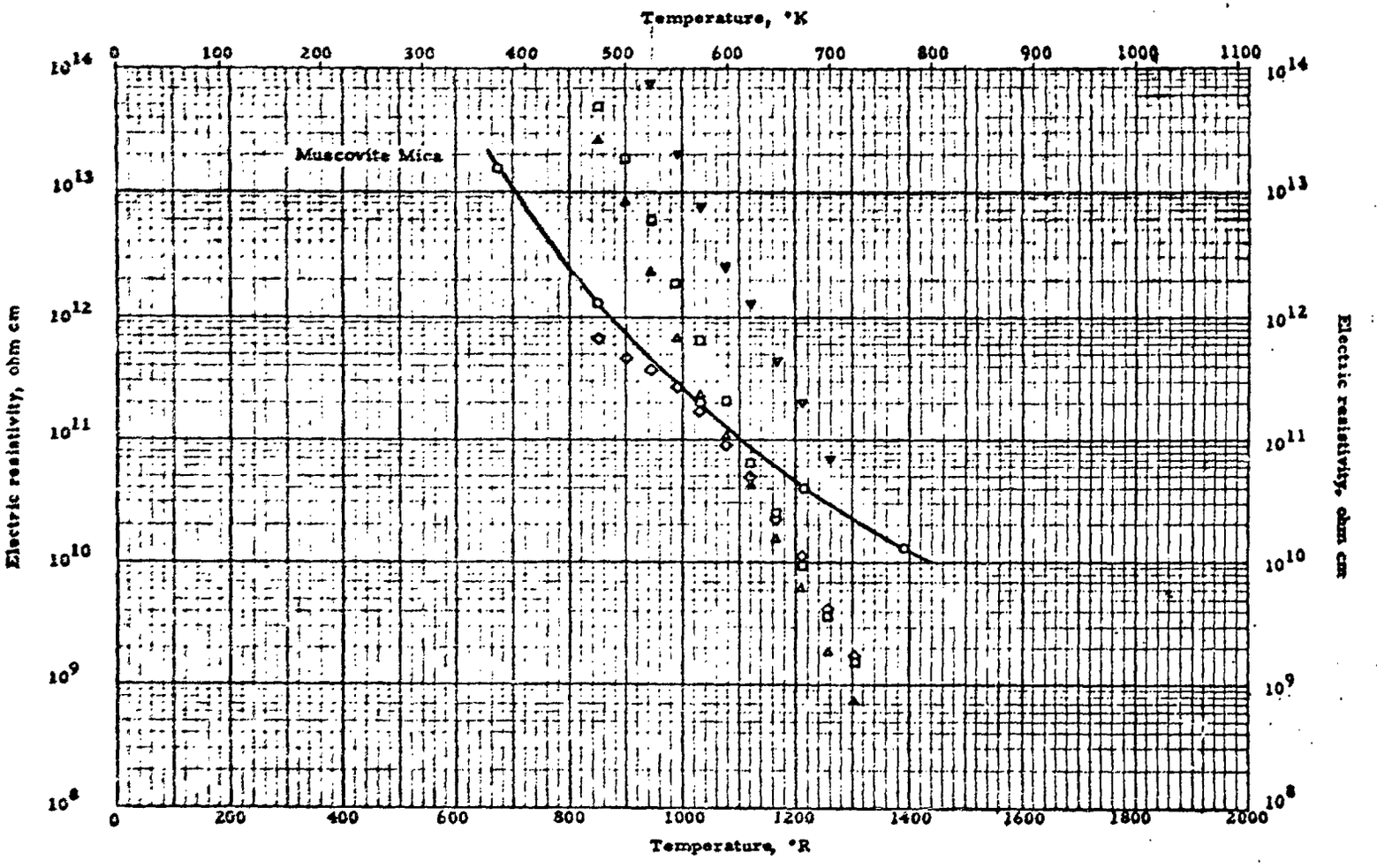


LINEAR THERMAL EXPANSION -- MICA (RIPIDOLITE and ZINN WALDITE TYPES)

LINEAR THERMAL EXPANSION -- MICA (RIPIDOLITE and ZINN WALDITE TYPES)*

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Hidnert, P. and Dixon, G.	45-2	528-1752	Zinn Waldite type from Virginia	Fused quartz dilatometer	Measurements perpendicular to cleavage plane, O - heating; Q - cooling
□	Ibid.	45-2	528-1752	Ripidolite type from Pennsylvania	Same as above	Measurements perpendicular to cleavage plane, □ - initial heating; □ - cooling and reheating. *Above data are representative; for additional information see original article. 1 hr. at 700°C increased room temp. thickness as much as 60% in some samples



ELECTRIC RESISTIVITY--MICA

ELECTRIC RESISTIVITY -- MICA

REFERENCE INFORMATION

	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Strauss, S. W., Richards, L. E. and Moore, D. G.	53-136	672-1932	High grade muscovite mica Thickness = 0.002-0.017 in.	Potential drop. Temp. by Fe-Const. thermocouple, with 10° C/min. rise	Cleaved, dried 24 hr. before test. Polarity reversed every 2 min.
□	Comeforo, J. E. and Hatch, R. A.	54-95	852-1302	Synthetic barium mica	High resistance DC bridge. Temp. rise 3° C/min.	Hot pressed, water absorption <0.1%.
△	Ibid.	54-95	852-1302	Same as above	Same as above	Same as above
◇	Ibid.	54-95	852-1302	Same as above	Same as above	Same as above
▽	Ibid.	54-95	852-1302	Same as above	Same as above	Same as above, but water absorption is 4.6%

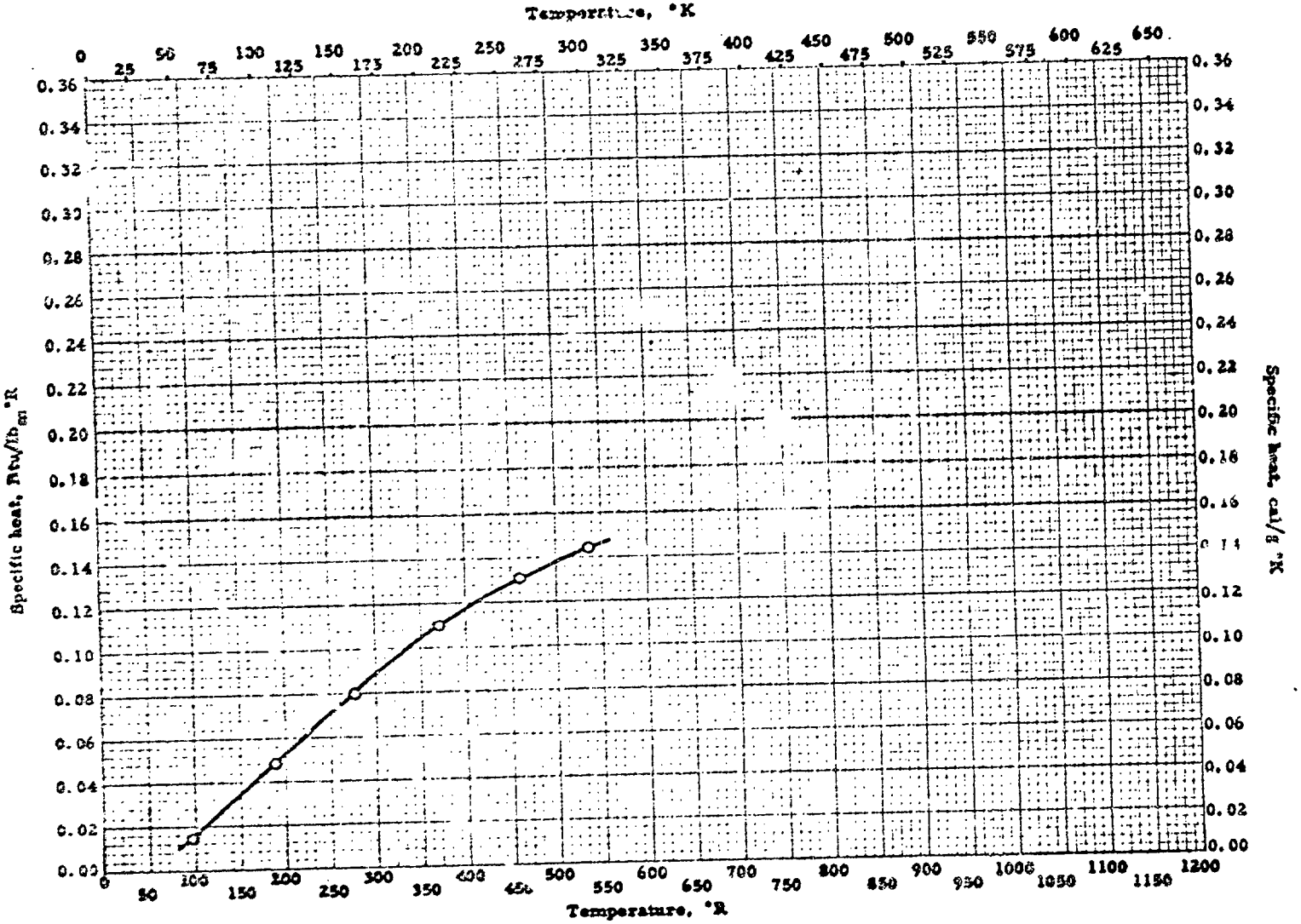
Symbol	Material Composition	Melting Point °K	Melting Point °K
○	Li_2UO_4	2950 ± 18	1638 ± 10
□	Na_2UO_4	3430 ± 18	1908 ± 10
△	K_2UO_4	3410 ± 18	1893 ± 10
◇	$MgUO_4$	3640 ± 45	2023 ± 25
▽	$MgUO_4$	3550 ± 45	1973 ± 25
⬡	$MgUO_4$	3260 ± 45	1813 ± 25
⬠	$CaUO_4$	3730 ± 18	2070 ± 10
⬠	$CaUO_4$	3730 ± 18	2070 ± 10
⬠	$CaUO_4$	3400 ± 63	1888 ± 35
⬡	$SrUO_4$	3730 ± 45	2070 ± 25
◭	$SrUO_4$	3470 ± 18	1928 ± 10
⬢	$SrUO_4$	2890 ± 45	1608 ± 25
⬠	$BaUO_4$	3110 ± 18	1730 ± 10
⬡	$2\,NaO \cdot UO_3 \cdot P_2O_5$	about 2196	about 1220
⬡	$UC_2 \cdot P_2O_5$	about 2750	about 1530

MELTING POINT -- URANATES

MELTING POINT -- URANATES

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Brush, C. A., Caslim, W. M. and White, D. W.	56-167	3150 ±18	Li_2UO_4	MP: not given	In air medium
□	Ibid.	56-167	3438 ±18	Na_2UO_4	MP: same as above	Same as above
△	Ibid.	56-167	3410 ±18	K_2UO_4	MP: same as above	Same as above
◇	Ibid.	56-167	3440 ±45	$MgUO_4$	MP: same as above	In air medium, decomposed
▽	Ibid.	56-167	3550 ±45	$MgUO_4$	MP: same as above	In O_2 medium, decomposed
○	Ibid.	56-167	3240 ±45	$MgUO_4$	MP: same as above	In He medium, decomposed
□	Ibid.	56-167	3730 ±18	$CaUO_4$	MP: same as above	In air medium
◎	Ibid.	56-167	3730 ±18	$CaUO_4$	MP: same as above	In O_2 medium
C	Ibid.	56-167	3400 ±63	$CaUO_4$	MP: same as above	In He medium, decomposed
◇	Ibid.	56-167	3730 ±45	$SrUO_4$	MP: same as above	In air medium, same decomposition
▲	Ibid.	56-167	3470 ±18	$SrUO_4$	MP: same as above	In O_2 medium
◇	Ibid.	56-167	3890 ±45	$SrUO_4$	MP: same as above	In He medium, decomposed
▽	Ibid.	56-167	3110 ±18	$BaUO_4$	MP: same as above	Appears to melt
◇	Ibid.	56-167	2196	$2\,MnO \cdot UO_3 \cdot P_2O_5$	MP: same as above	
○	Ibid.	56-167	2748	$UO_3 \cdot P_2O_5$	MP: same as above	

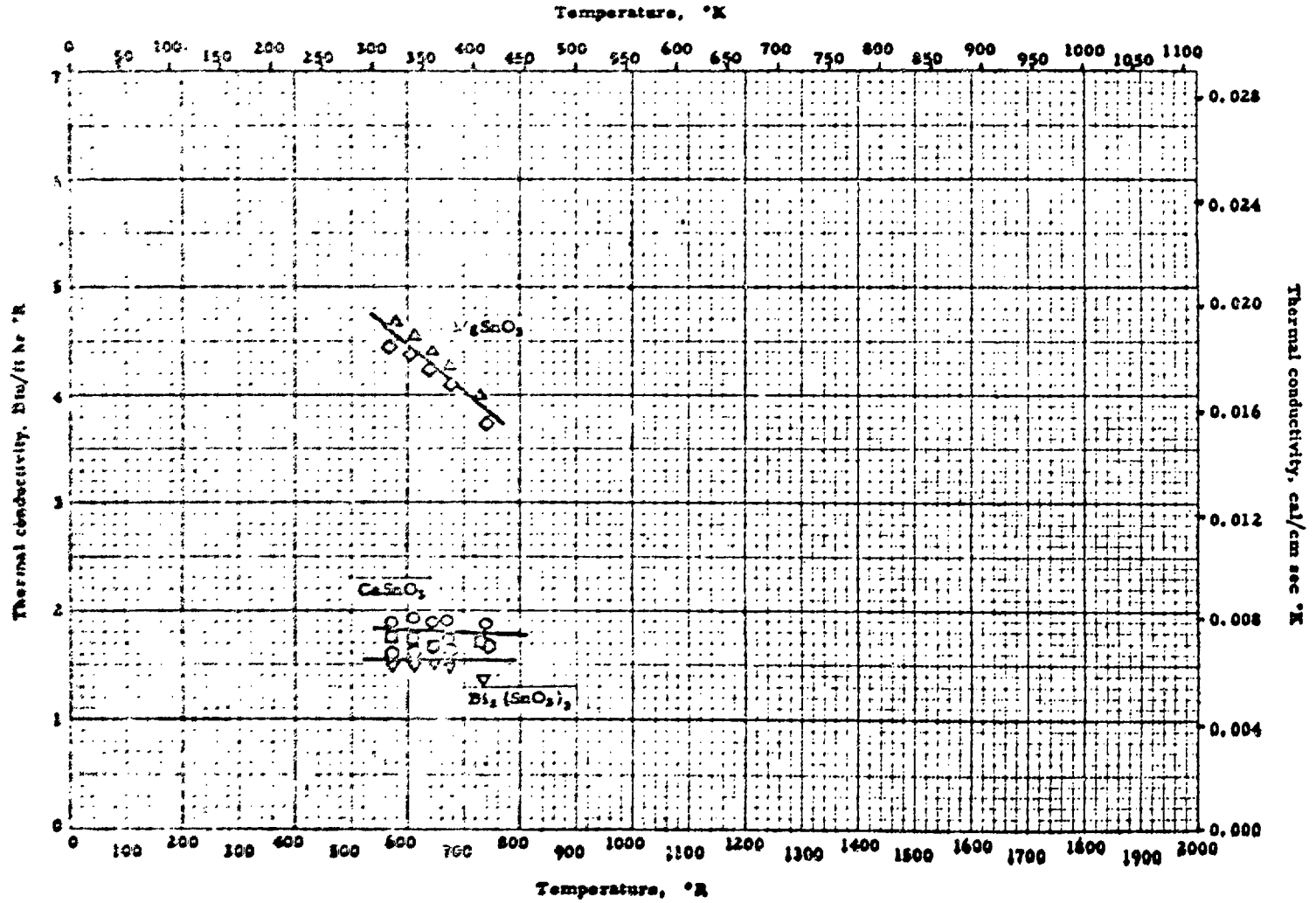


SPECIFIC HEAT - IRON COBALTITE

SPECIFIC HEAT -- IRON COBALTITE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	King, E. G.	56-165	96.9-516.7	$FeCo_2O_4$ Spinel: 49.6% Co (by diff.) 26.88% O; 23.47% Fe (theor. 26.92% O; 23.49% Fe.	Guarded sample	No uncombined oxides found by x-ray diffraction. During preparation heated 4 times in air for a total of 130 hr. at 1050°C with grinding mixing etc. between heats

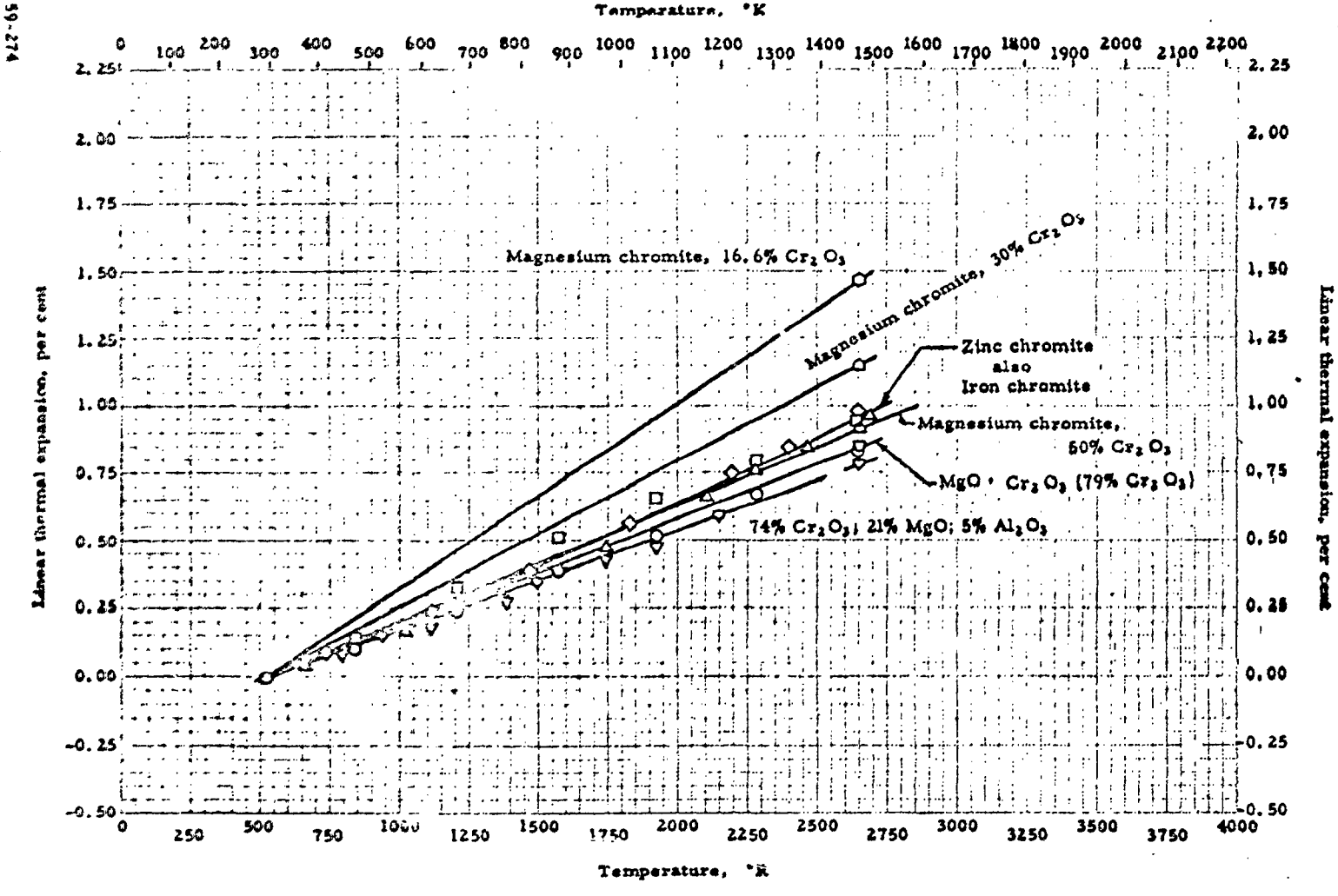


THERMAL CONDUCTIVITY -- STANNATES

THERMAL CONDUCTIVITY -- STANNATES

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °K	Material Composition	Test Method	Remarks
○	Koenig, J. H., Snyder, M. H. et al.	53-3	574-740	$CaSnO_3$, ρ = 318 lb_m/ft^3	Comparative, rod in vacuum (Cu standard)	Used Pt alloy glaze for ceramic to Cu bond. Run I
□	Ibid.	53-3	572-733	Same as above	Same as above	Same as above, Run II
△	Ibid.	53-3	579-730	$MgSnO_3$, ρ = 323 lb_m/ft^3	Same as above	Same as above, Run I
◇	Ibid.	53-3	571-744	Same as above	Same as above	Same as above, Run II
▽	Ibid.	53-3	574-715	$Bi_2(SnO_3)_3$, ρ = 477 lb_m/ft^3	Same as above	Same as above, Sample #1
○	Ibid.	53-3	574-743	$Bi_2(SnO_3)_3$, ρ = 474 lb_m/ft^3	Same as above	Same as above, Sample #2

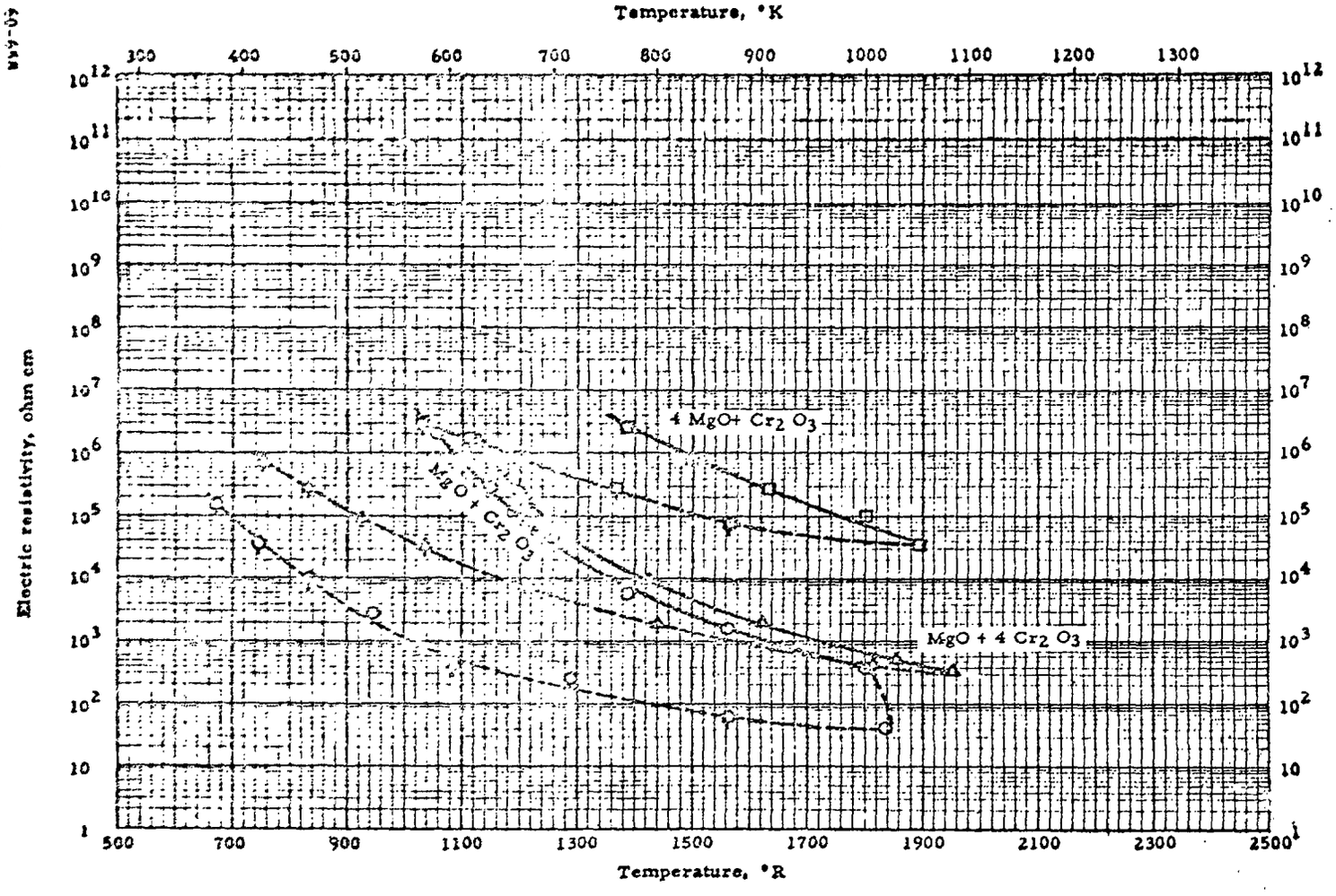


LINEAR THERMAL EXPANSION -- CHROMITE

LINEAR THERMAL EXPANSION -- CHROMITE

REFERENCE INFORMATION

Sym	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Beals, R. J. and Cook, R. L.	57-20	528-2652	Magnesium chromite (spinel)	X-ray back reflection. Pt-PtRh thermocouples	Prepared from reagent grade materials
□	Ibid.	57-20	528-2652	Zinc chromite (spinel)	Same as above	Same as above
△	Rigby, G. R., Lovell, G. H. B. and Green, A. T.	46-8 also 54-7	670-2650	Picrochromite, $MgCr_2O_4$, ρ = 274 lb_m/ft^3	Not given	Oxides mixed with 5% boric acid, molded, fired 2 hr. at 1530 °C, crushed, molded, fired to 1530 °C, crushed, molded, reheated to 1530 °C
◇	Ibid.	46-8 also 54-7	670-2650	Solid solution, $Fe_2O_3 \cdot 3\ Cr_2O_3$, ρ = 320 lb_m/ft^3	Same as above	
▽	Hummel, F. A. and Henry, E. C.	46-13	528-1930	Zinc chromite	Quartz tube dilatometer	
○	Pole, G. R., Beinlich Jr., A. W. and Gilbert, M.	46-14	528-2652	83.4% MgO; 16.6% Cr_2O_3	Not described here, refers to others. Probably quartz tube dilatometer with dial gauge	Heated at 4 °C/min
□	Ibid.	46-14	528-2652	70% MgO; 30% Cr_2O_3	Same as above	Same as above
△	Ibid.	46-14	528-2652	50% MgO; 50% Cr_2O_3	Same as above	Same as above
○	Ibid.	46-14	528-2652	Magnesium chromite, $MgO \cdot Cr_2O_3$; 79% Cr_2O_3; 21% MgO	Same as above	Same as above
○	Ibid.	46-14	528-2652	74% Cr_2O_3; 21% MgO; 5% Al_2O_3	Same as above	Same as above



ELECTRIC RESISTIVITY -- MAGNESIUM CHROMITE

ELECTRIC RESISTIVITY -- MAGNESIUM CHROMITE

REFERENCE INFORMATION

Sym bol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Diclanski, A. and Doren, J.	55-150	674-1838	$MgO + Cr_2O_3$	Not described here, refers to others	Not sintered. ○ - heating ○ - cooling
□	Ibid.	55-150	1035-1895	$4MgO + Cr_2O_3$	Same as above	Not sintered. □ - heating □ - cooling
△	Ibid.	55-150	756-1955	$MgO + 4Cr_2O_3$	Same as above	Not sintered. △ - heating △ - cooling

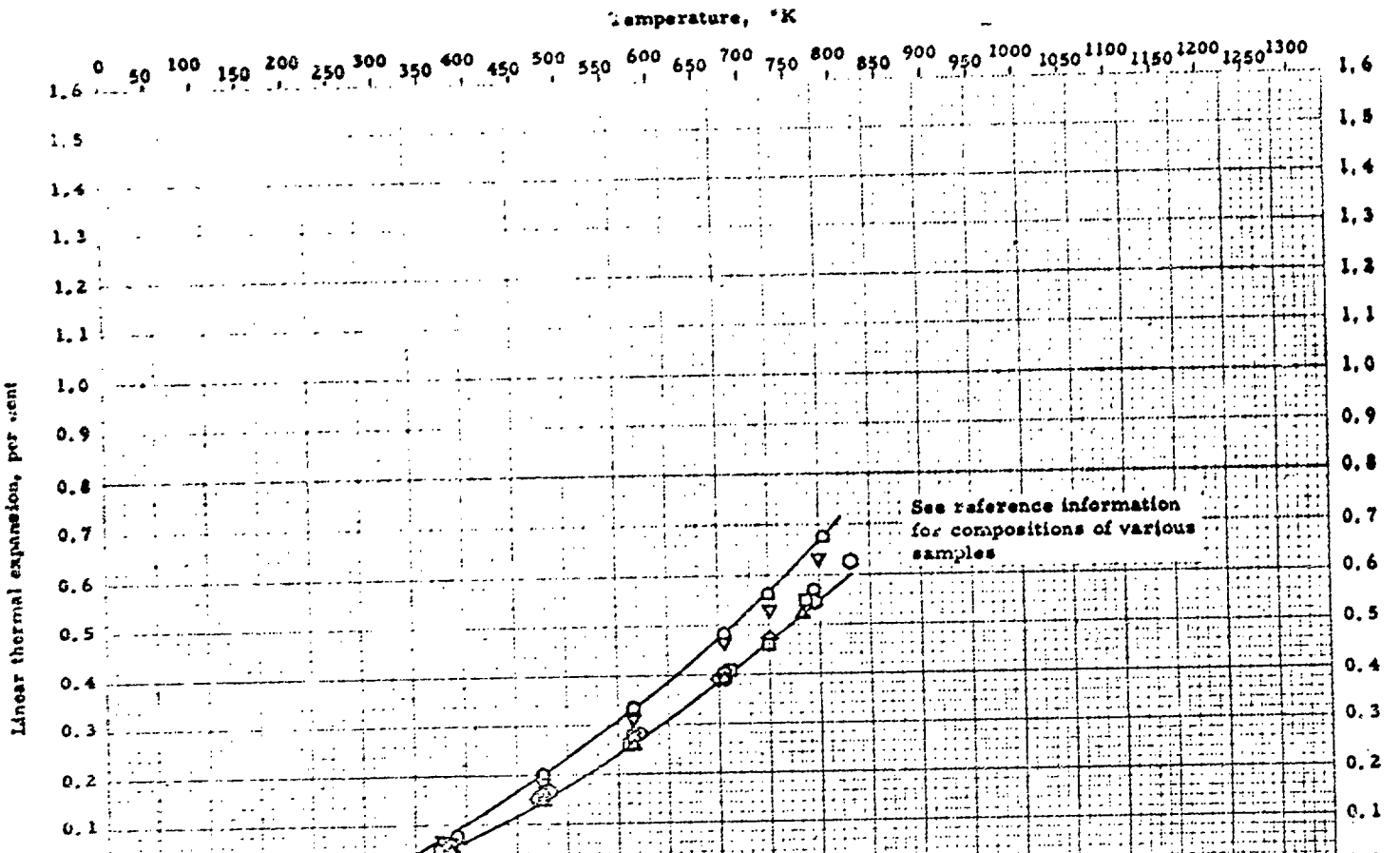
Symbol	Material Composition	Softening Point °R	Softening Point °K
O	75.67% SiO_2 ; 13.56% Li_2O; 9.35% CaO; 0.54% F_2 ; 0.31% R_2O_3	1378	765
	74.15% SiO_2 ; 13.45% Li_2O; 10.45% CaO; 0.58% R_2O_3	1385	769
	73.95% SiO_2 ; 13.26% Li_2O; 10.50% CaO; 0.69% R_2O_3; 0.38% F_2	1361	756
	73.75% SiO_2 ; 13.05% Li_2O; 9.94% CaO; 2.74% F_2 ; 0.27% R_2O_3	1302	723
	64.88% SiO_2 ; 19.20% CaO; 14.59% Li_2O; 0.33% R_2O_3	1394	774
	64.54% SiO_2 ; 25.42% CaO; 9.35% Li_2O; 0.36% R_2O_3	1462	812
	49.39% SiO_2 ; 35.42% CaO; 14.58% Li_2O	1397	776

SOFTENING POINT -- LITHIUM CALCIUM SILICATE GLASS

SOFTENING POINT -- LITHIUM CALCIUM SILICATE GLASS

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Handwerk, J.H. and McVay, T.N.	54-44	1362-1462	49.39 - 64.54% SiO_2; 9.35 - 35.42% CaO; 0.35 - 14.59% Li_2O; <2.74% F_2; <0.69% R_2O_3	Interferometer	

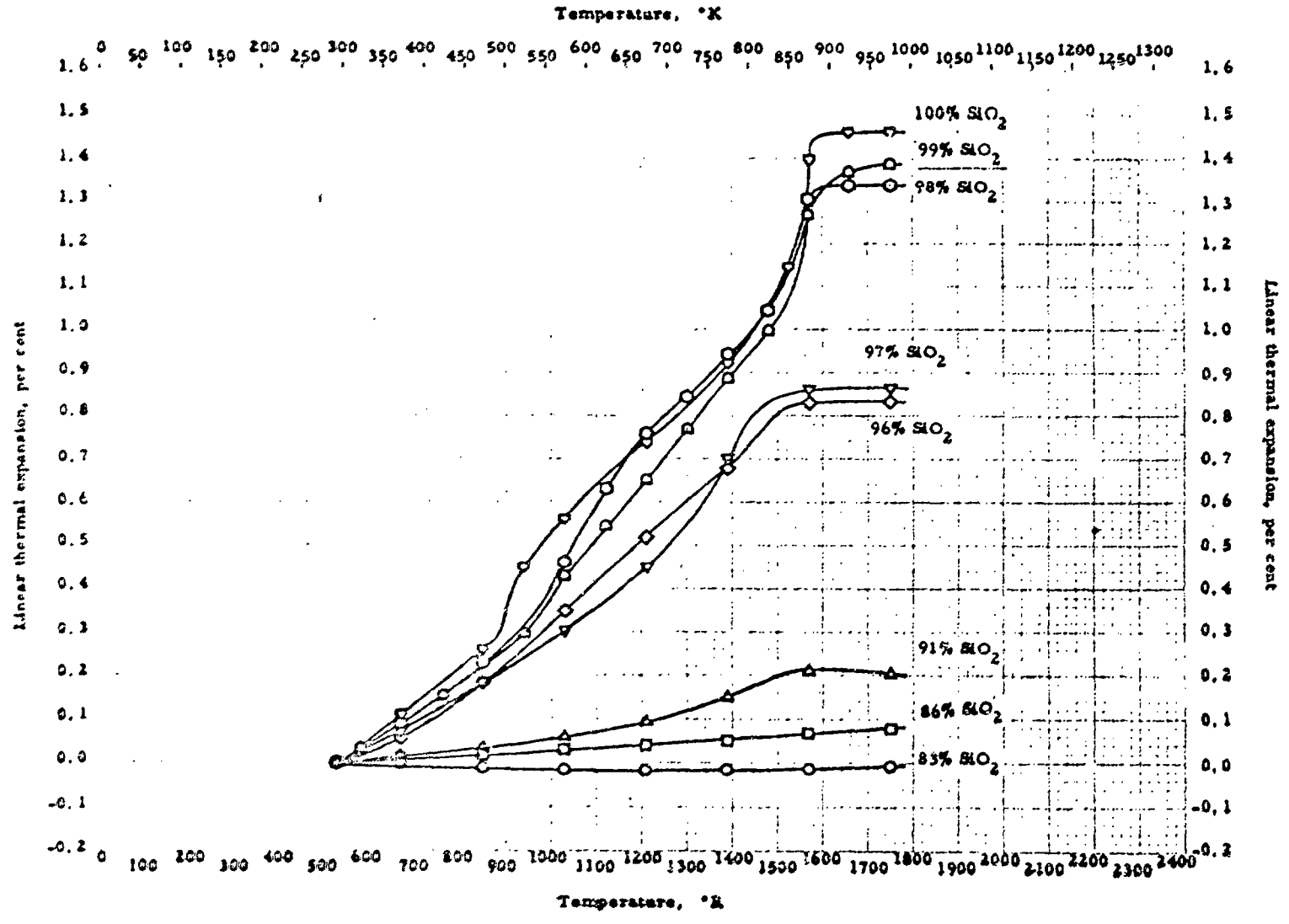


LINEAR THERMAL EXPANSION -- LITHIUM CALCIUM SILICATE GLASS

LINEAR THERMAL EXPANSION -- LITHIUM CALCIUM SILICATE GLASS

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Handwerk, J. H., and McVay, T. N.	54-44	528-1392	75.67% SiO_2; 13.56% Li_2O; 9.35% CaO; 0.54% F_2; 0.31% R_2O_3	Interferometer	
□	Ibid.	54-44	528-1374	74.15% SiO_2; 13.45% Li_2O; 10.45% CaO; 0.50% R_2O_3	Same as above	
△	Ibid.	54-44	528-1365	73.95% SiO_2; 13.26% Li_2O; 10.50% CaO; 0.69% R_2O_3; 0.36% F_2	Same as above	
◇	Ibid.	54-44	528-1302	73.75% SiO_2; 13.05% Li_2O; 9.94% CaO; 2.74% F_2; 0.27% R_2O_3	Same as above	
▽	Ibid.	54-44	528-1399	64.83% SiO_2; 19.20% CaO; 15.59% Li_2O; 0.33% R_2O_3	Same as above	
○	Ibid.	54-44	528-1464	64.54% SiO_2; 25.42% CaO; 9.35% Li_2O; 0.36% R_2O_3	Same as above	
○	Ibid.	54-44	528-1406	49.39% SiO_2; 35.42% CaO; 14.58% Li_2O_3, 0.30% R_2O_3	Same as above	

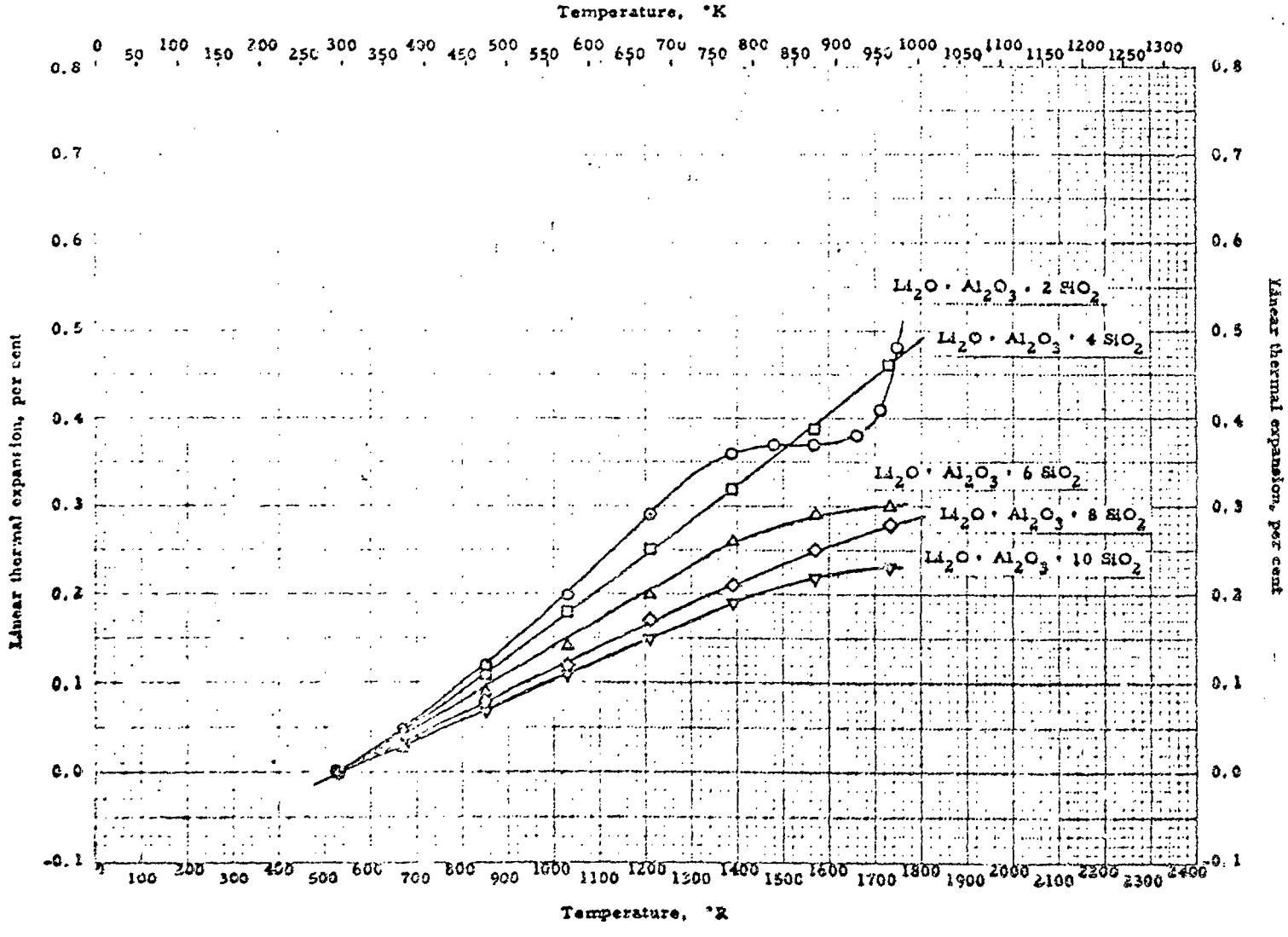


LINEAR THERMAL EXPANSION -- LITHIUM ALUMINOSILICATE GLASS

LINEAR THERMAL EXPANSION -- LITHIUM ALUMINOSILICATE GLASS

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Smoke, E. J.	54-43	528-1752	82% SiO_2; 12% Al_2O_3; 5% Li_2O; prepared from E.P.K.; flint; Li_2CO_3	Fused silica tube dilatometer	Fired to 2200°F in 5 hr., soaked 1 hr.
□	Ibid.	54-43	528-1752	88% SiO_2; 9% Al_2O_3; 3% Li_2O; raw materials same as above	Same as above	Same as above
△	Ibid.	54-43	528-1752	91% SiO_2; 6% Al_2O_3; 3% Li_2O; raw materials same as above	Same as above	Same as above
◇	Ibid.	54-43	528-1752	94% SiO_2; 3% Al_2O_3; 1% Li_2O; raw materials same as above	Same as above	Same as above
▽	Ibid.	54-43	528-1752	97% SiO_2; 2.3% Al_2O_3; 0.7% Li_2O; raw materials same as above	Same as above	Same as above
⊂	Ibid.	54-43	528-1752	98% SiO_2; 1.5% Al_2O_3; 0.5% Li_2O; raw materials same as above	Same as above	Same as above
⊃	Ibid.	54-43	528-1752	99% SiO_2; 0.8% Al_2O_3; 0.2% Li_2O; raw materials same as above	Same as above	Same as above
▽	Ibid.	54-43	528-1752	100% SiO_2; (Clad)	Same as above	Same as above

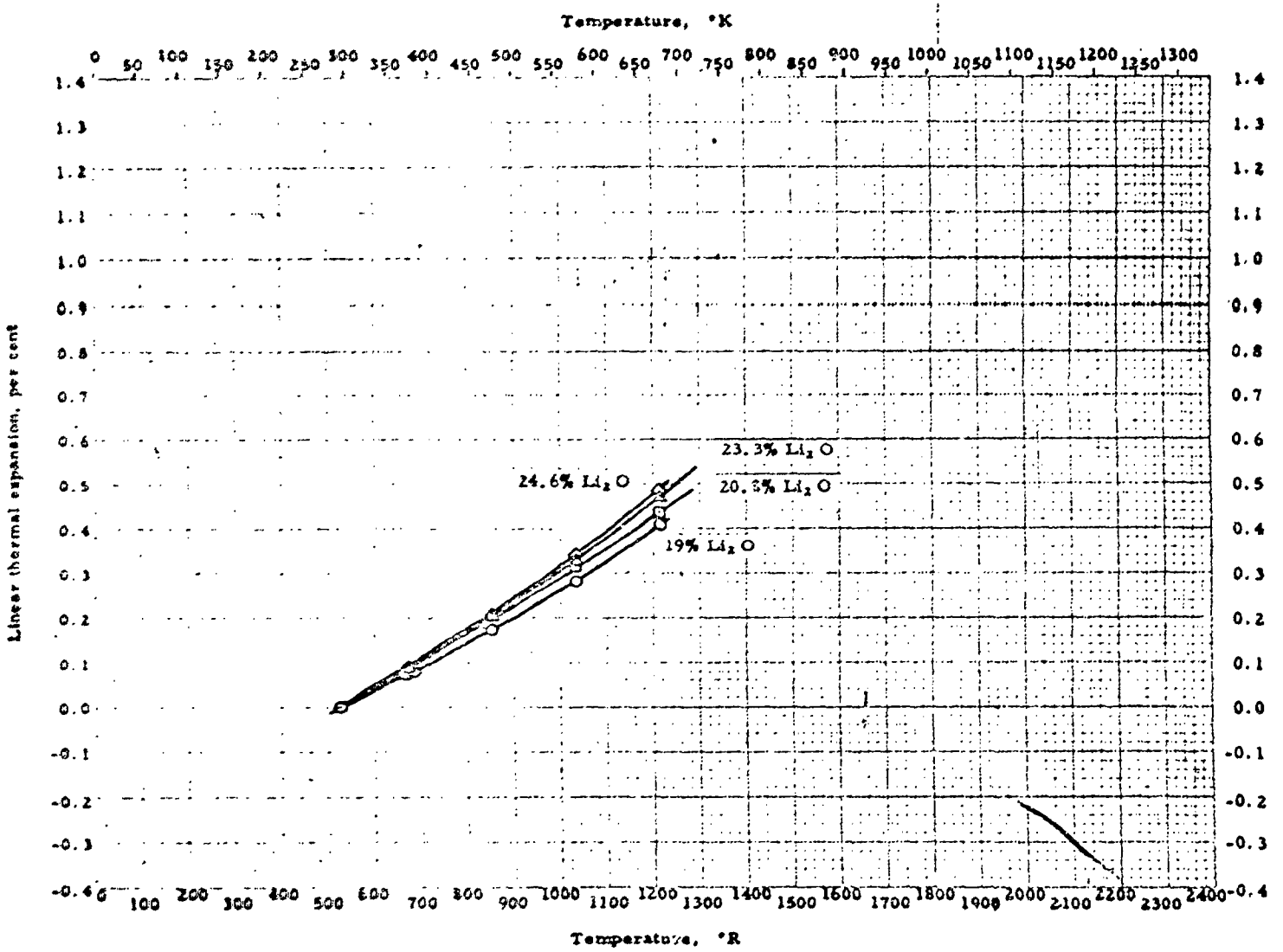


LINEAR THERMAL EXPANSION -- LITHIUM ALUMINUM SILICATE GLASS.

LINEAR THERMAL EXPANSION -- LITHIUM ALUMINUM SILICATE GLASS

REFERENCE INFORMATION

Plot Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Brackbill, C. E., McKinstry, H. A. and Hummel, F. A.	51-22	528-1752	Nominal 47.7% SiO_2; 40.5% Al_2O_3; 11.8% Li_2O	Interferometer	$Li_2O \cdot Al_2O_3 \cdot 2SiO_2$
□	Ibid.	51-22	528-1734	Nominal 64.6% SiO_2; 27.4% Al_2O_3; 8.0% Li_2O	Same as above	$Li_2O \cdot Al_2O_3 \cdot 4SiO_2$
△	Ibid.	51-22	528-1736	Nominal 73.2% SiO_2; 20.7% Al_2O_3; 6.1% Li_2O	Same as above	$Li_2O \cdot Al_2O_3 \cdot 6SiO_2$
◇	Ibid	51-22	528-1734	Nominal 78.5% SiO_2; 16.6% Al_2O_3; 4.9% Li_2O	Same as above	$Li_2O \cdot Al_2O_3 \cdot 8SiO_2$
▽	Ibid.	51-22	528-1736	Nominal 82.0% SiO_2; 13.9% Al_2O_3; 4.1% Li_2O Actual 81.58% SiO_2; 14.34% Al_2O_3; 4.08% Li_2O	Same as above	$Li_2O \cdot Al_2O_3 \cdot 10SiO_2$



LINEAR THERMAL EXPANSION -- LITHIUM SILICATE GLASS

LINEAR THERMAL EXPANSION -- LITHIUM SILICATE GLASS

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Shermer, H. F.	56-166	528-1212	81% SiO_2 ; 19% Li_2O. ρ = 145.8 lb_m/ft^3	Interferometer	
□	Ibid.	56-166	528-1212	79.2% SiO_2 ; 20.8% Li_2O. ρ = 146.6 lb_m/ft^3	Same as above	
△	Ibid.	56-166	528-1212	76.7% SiO_2 ; 23.3% Li_2O. ρ = 147.0 lb_m/ft^3	Same as above	
◇	Ibid.	56-166	528-1212	75.4% SiO_2 ; 24.6% Li_2O. ρ = 146.9 lb_m/ft^3	Same as above	

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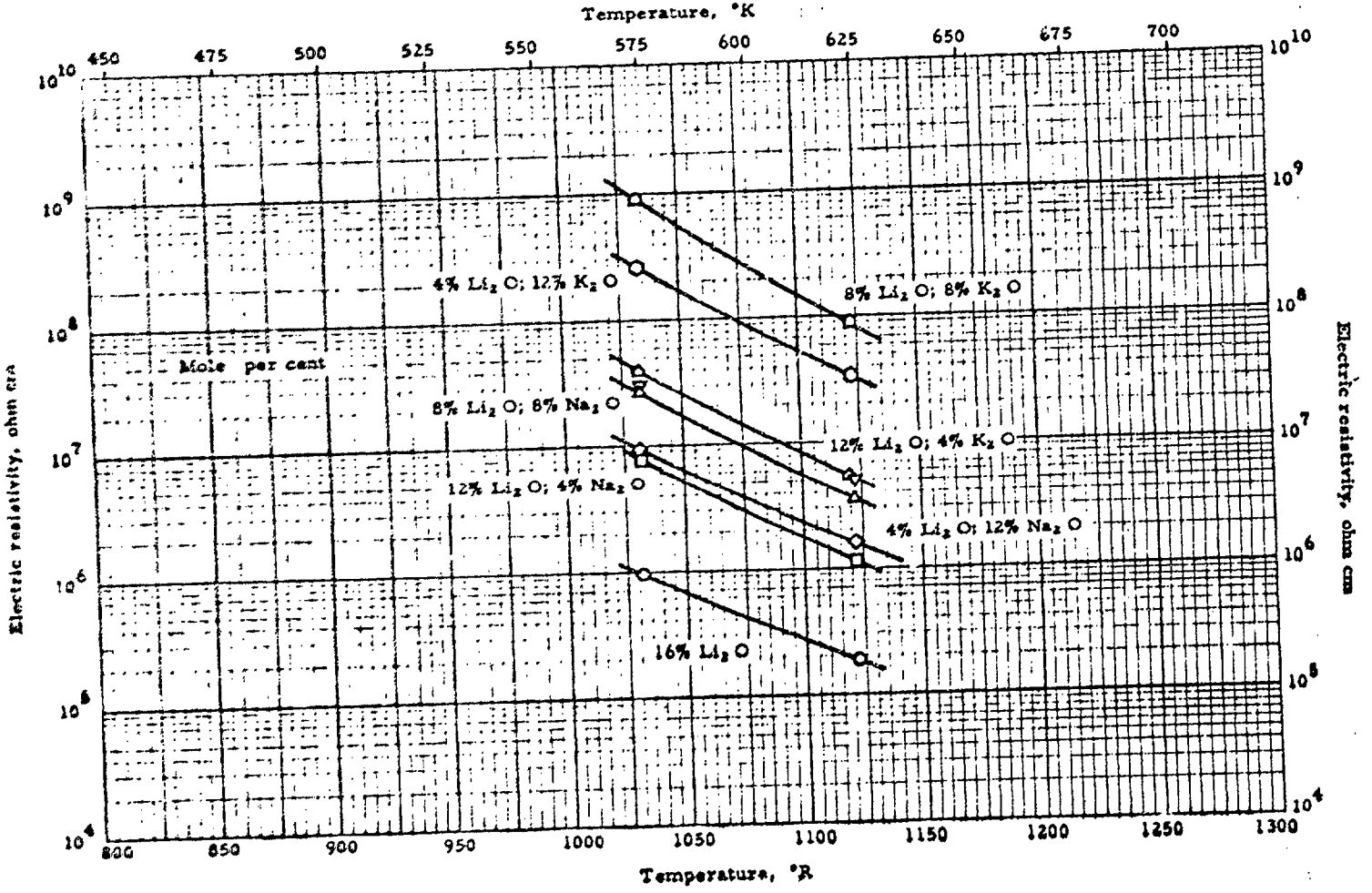
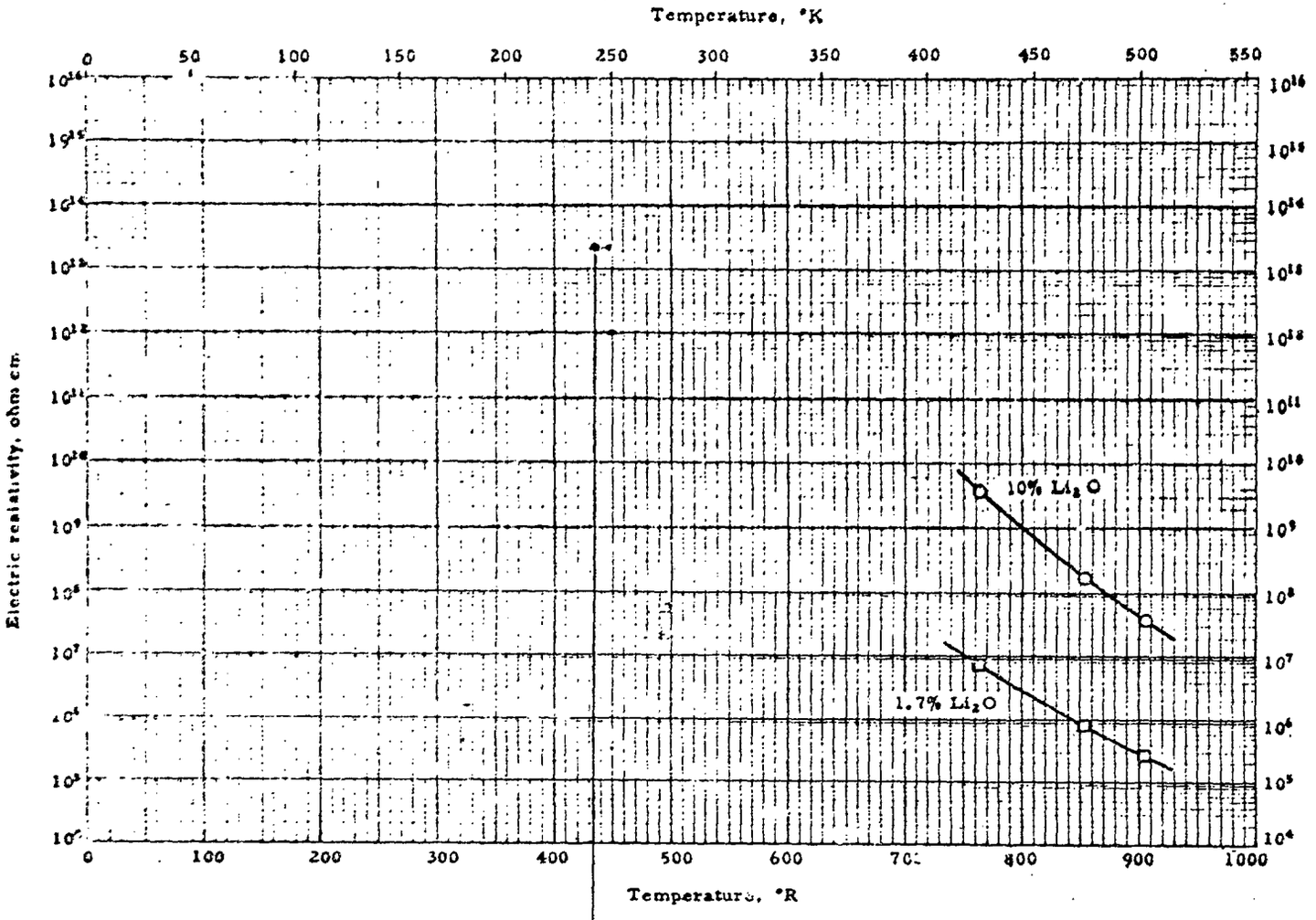


ELECTRIC RESISTIVITY -- LITHIUM-MAGNESIUM-BARIUM SILICATE GLASS

ELECTRIC RESISTIVITY -- LITHIUM-MAGNESIUM-BARIUM SILICATE GLASS

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Lengyel, B. and Eckstay, Z.	55-149	1032-1122	68% SiO_2; 16% Li_2O; 8% BaO; 8% MgO (mole %)	AC bridge; sample temp. by resistance thermometer	Ground from pure ingredients, melted in furnace at 1260 °C, held 8 hr. at 1200 °C. Samples had Pt electrodes fired on ends
□	Ibid.	55-149	1032-1122	68% SiO_2; 12% Li_2O; 8% BaO; 8% MgO; 4% Na_2O (mole %)	Same as above	Same as above
△	Ibid.	55-149	1032-1122	68% SiO_2; 8% BaO; 8% Li_2O; 8% MgO; 8% Na_2O (mole %)	Same as above	Same as above
◇	Ibid.	55-149	1032-1122	68% SiO_2; 12% Na_2O; 8% BaO; 8% MgO; 4% Li_2O (mole %)	Same as above	Same as above
▽	Ibid.	55-149	1032-1122	68% SiO_2; 14.1% K_2O; 8% BaO; 8% MgO; 1.9% Li_2O (mole %)	Same as above	Same as above
○	Ibid.	55-149	1032-1122	68% SiO_2; 12% K_2O; 8% BaO; 8% MgO; 4% Li_2O (mole %)	Same as above	Same as above
□	Ibid.	55-149	1032-1122	68% SiO_2; 8% BaO; 8% MgO; 8% Li_2O; 8% K_2O (mole %)	Same as above	Same as above
△	Ibid.	55-149	1032-1122	68% SiO_2; 12% Li_2O; 8% BaO; 8% MgO; 4% K_2O (mole %)	Same as above	Same as above



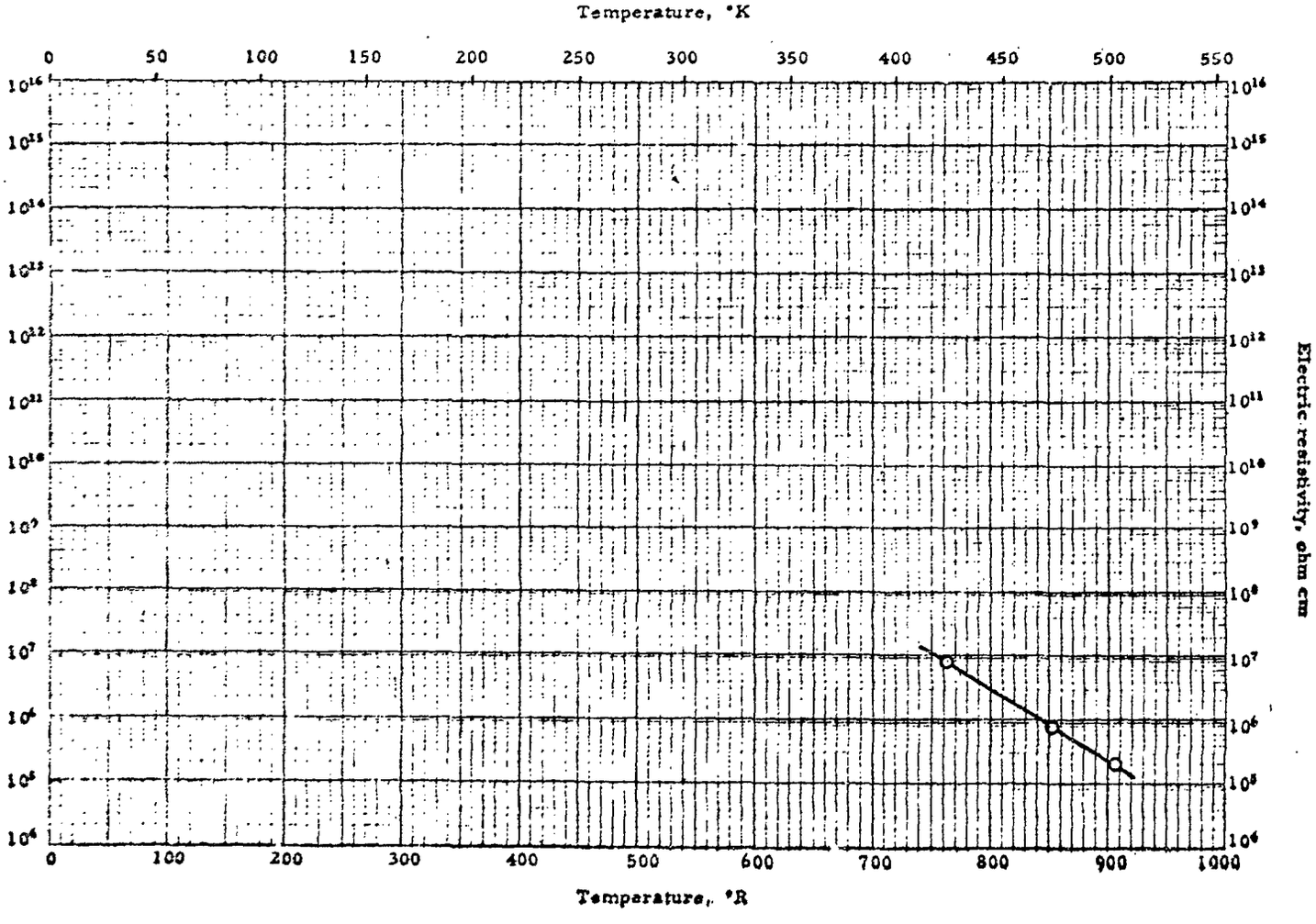
ELECTRIC RESISTIVITY - - LITHIUM SODIUM SILICATE GLASS

60-585
WADC TR 58-476
720

ELECTRIC RESISTIVITY -- LITHIUM SODIUM SILICATE GLASS

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Strauss, S. W.	56-163	762-906	73.1% SiO_2 ; 16.9% Na_2O; 10.0% Li_2O	Potential drop, D. C. reversal, Fe-Const. thermocouple	Made from reagent grade materials
□	Ibid.	56-163	762-906	67.1% SiO_2 ; 31.2% Na_2O; 1.7% Li_2O	Same as above	Same as above. Auth. reports additional detailed data for system (0 to 1.00) Li_2O:(1.00 to 0)Na_2O: $2SiO_2$. Only extreme values are shown here



ELECTRIC RESISTIVITY -- LITHIUM SILICATE GLASS

ELECTRIC RESISTIVITY -- LITHIUM SILICATE GLASS

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Strauss, S. W.	56-163	762-906	80.1% SiO_2 ; 19.9% Li_2O	Potential drop, DC reversal	Made from reagent grade materials

Symbol	Material Composition, %					Density	
	SiO_2	Na_2O	SrO	Al_2O_3	SO_3	lb_m/ft^3	g/cm^3
O	77.7	13.9	6.1	2.1	0.1	152.87	2.4488
	77.7	13.8	8.2	0.2	0.1	154.54	2.4754
	76.1	15.8	6.1	2.0	0.2	154.03	2.4673
	76.0	15.4	8.1	0.2	0.2	155.79	2.4955
	75.4	14.2	6.1	4.0	0.1	153.84	2.4643
	74.8	17.2	4.0	4.0	0.2	153.07	2.4520
	74.7	17.1	6.0	2.0	0.2	154.81	2.4798
	74.3	15.5	6.1	4.1	0.2	154.67	2.4776
	74.1	17.3	7.9	0.3	0.2	156.76	2.5110
	73.5	14.1	10.0	2.0	0.2	157.67	2.5257
	73.5	13.9	12.0	0.3	0.1	159.64	2.5571
	72.2	15.5	10.1	2.1	0.1	158.92	2.5456
	71.9	15.7	12.2	0.1	0.1	160.92	2.5777
	71.5	14.2	10.0	4.1	0.2	158.44	2.5380
	70.7	17.0	11.9	0.1	0.2	161.48	2.5866
	70.6	17.2	8.0	4.0	0.2	158.30	2.5357
	70.5	17.3	10.1	2.0	0.2	159.62	2.5569
	70.1	15.5	10.1	4.1	0.1	159.46	2.5543
	69.6	14.1	13.9	2.0	0.2	162.84	2.6085
	69.5	14.0	16.0	0.2	0.2	164.76	2.6392
	68.0	15.8	16.0	0.1	0.2	165.97	2.6585
	68.0	15.7	14.0	2.0	0.2	163.86	2.6247
	67.9	14.2	13.9	4.1	0.2	163.34	2.6165
	66.6	17.3	15.6	0.2	0.2	166.60	2.6686
	66.6	17.3	13.6	2.1	0.2	164.57	2.6362
	66.8	17.2	11.7	4.0	0.2	162.68	2.6059
	66.1	15.5	14.0	4.1	0.2	164.37	2.6329

DENSITY -- SODIUM STRONTIUM ALUMINOSILICATE GLASS

DENSITY -- SODIUM STRONTIUM ALUMINOSILICATE GLASS

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Owens Illinois Glass Co. Research Labs	48-38	Room	Series of glasses	Not given here; refers to earlier work	

Symbol	Density		Softening Point	
	lb_m/ft^3	g/cm^3	°R	°K
○	95.066	1.5235		
□	94.91	1.521		
△	94.72	1.518		
◇	94.505	1.5145		
▽	94.28	1.511		
⌂	154.1	2.46[illegible]		
▭	154.3	2.472		
▽	154.2	2.470		
◺	154.3	2.472		
◇	155.1	2.485		
▷	156.3	2.504		
○			1460	809
□			1640	909

PROPERTIES OF SODIUM CALCIUM SILICATE GLASS

PROPERTIES OF SODIUM CALCIUM SILICATE GLASS

REFERENCE INFORMATION

	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	[illegible], R. M. and [illegible], M. E.	55-143	Room	68.8% SiO_2; 21.5% Na_2O; 9.7% CaO	ρ: weight and volume by water displacement	
□	Ibid.	55-143	Room	68.74% SiO_2; 23.24% Na_2O; 8.08% CaO	ρ: same as above	
◁	Ibid.	55-143	Room	68.6% SiO_2; 25.0% Na_2O; 6.45% CaO	ρ: same as above	
▷	Ibid.	55-143	Room	68.5% SiO_2; 26.8% Na_2O; 4.85% CaO	ρ: same as above	
▽	Ibid.	55-143	Room	68.3% SiO_2; 28.5% Na_2O; 3.22% CaO	ρ: same as above	
○	Mandlewick, I. H. and McVay, T. N.	56-44	1457	64.51% SiO_2; 25.76% Na_2O; 8.60% CaO; 0.22% R_2O_3	Softening point is temp. at which elongation of thread under its own weight is 1mm min	
□	Ibid.	56-44	1637	50.90% SiO_2; 35.59% CaO; 13.67% Na_2O; 0.25% R_2O_3	Same as above	
△	Vickery, R. C. and Sedlack, R.	57-187	530-537	51.4% SiO_2; 7.08% CaO; 6.88% Na; 3.22% MgO; 1.22% B_2O_3; 0.26% Fe_2O_3; 0.05% Cs + No oxide	ρ: pycnometer with CO_2 free water	water temp. meas. to 0.1°C
○	Ibid.	57-187	530-537	Same as above + 0.1% Nd_2O_3	ρ: same as above	Same as above
▽	Ibid.	57-187	530-537	Same as above + 0.2% Nd_2O_3	ρ: same as above	Same as above
▷	Ibid.	57-187	530-537	Same as above + 0.5% Nd_2O_3	ρ: same as above	Same as above
◇	Ibid.	57-187	530-537	Same as above + 1.0% Nd_2O_3	ρ: same as above	Same as above
⬠	Ibid.	57-187	530-537	Same as above + 2.0% Nd_2O_3	ρ: same as above	Same as above. Auth also gives additional density data for additives of 0.1 - 2.0% of other rare earth oxides

PROPERTIES OF SODIUM SILICATE GLASS

MOST PROBABLE VALUES

Property	Brit. Engineering Units	C. G. S. Units
Density.	157 lb_m/ft^3	2.52 g/cm^3
Melting Point		
Heat of Fusion		
Heat of Vaporization . . .		
Heat of Sublimation . . .		

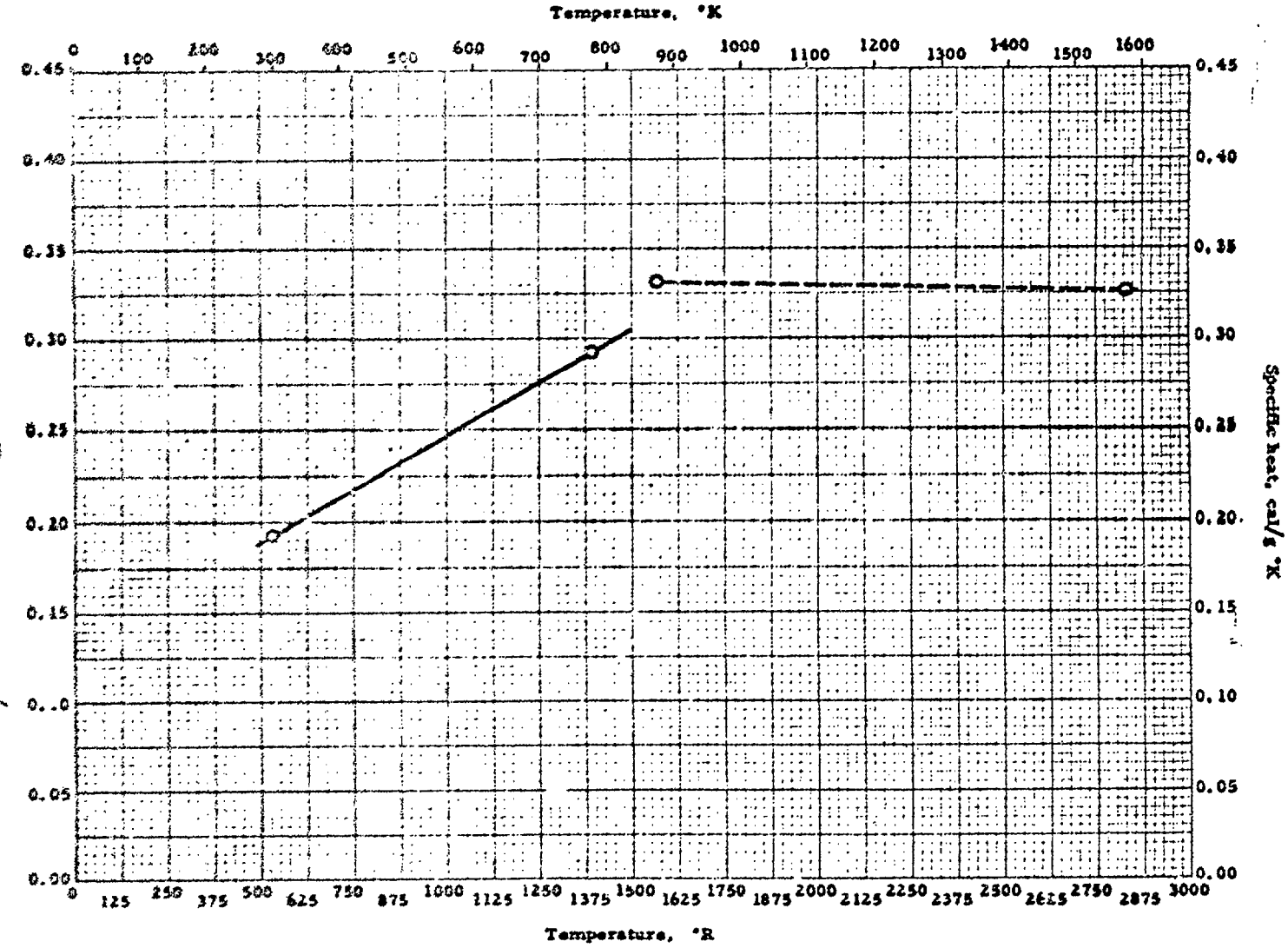
REPORTED VALUES

Density:		lb_m/ft^3	g/cm^3
	O	156.6 ± 0.06	2.509 ± 0.001
	□	157.40	2.5213
	△	157.52	2.5232
	◇	158.16	2.5334
Melting Point:		°F	°K
Heat of Fusion:		Btu/lb_m	cal/g
Heat of Vaporization:		Btu/lb_m	cal/g
Heat of Sublimation:		Btu/lb_m	cal/g

PROPERTIES OF SODIUM SILICATE GLASS

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °F	Material Composition	Test Method	Remarks
○	Oak Ridge National Lab.	57-150	537	Plate glass	ρ: weight in air and in kerosene	Measured by O. Sisman, C. D. Bopp and R. L. Towns
□	Locke, C. F. and Bing, G. F.	52-33 also 51-65	528	White clear plate glass	ρ: weight and volume by water displacement	From Pittsburgh Plate Glass Co.
△	Ibid.	52-33 also 51-65	528	Solex "S" plate glass	ρ: same as above	
◇	Ibid.	52-33 also 51-65	528	Solex 22C8X plate glass	ρ: same as above	



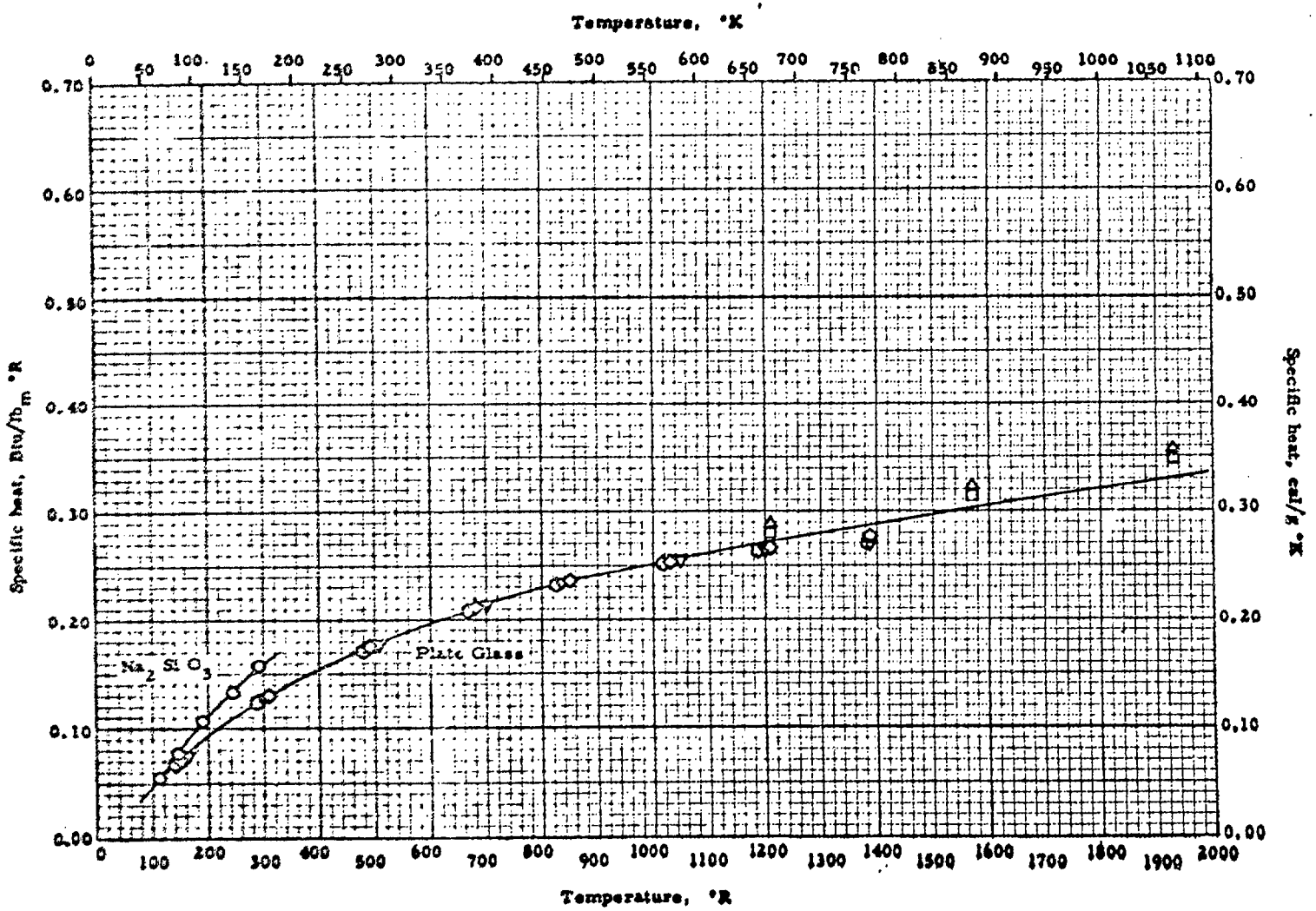
SPECIFIC HEAT -- SODIUM-CALCIUM SILICATE GLASS

60-657
WADC TR 59-414
728
VH-C-1-1

SPECIFIC HEAT -- SODIUM-CALCIUM SILICATE GLASS

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Hartmann, H. and Brand, H.	54-150	528-2832	Brown glass: 72.26% SiO_2; 14.68% Na_2O; 9.77% CaO; 1.99% Al_2O_3; 1.08% K_2O; 0.12% Fe_2O_3; trace MgO	Drop method into water calorimeter. Sample temp. meas. by Pt-PtRh thermocouple in furnace	Auth. note sudden enthalpy increase at 550 °C

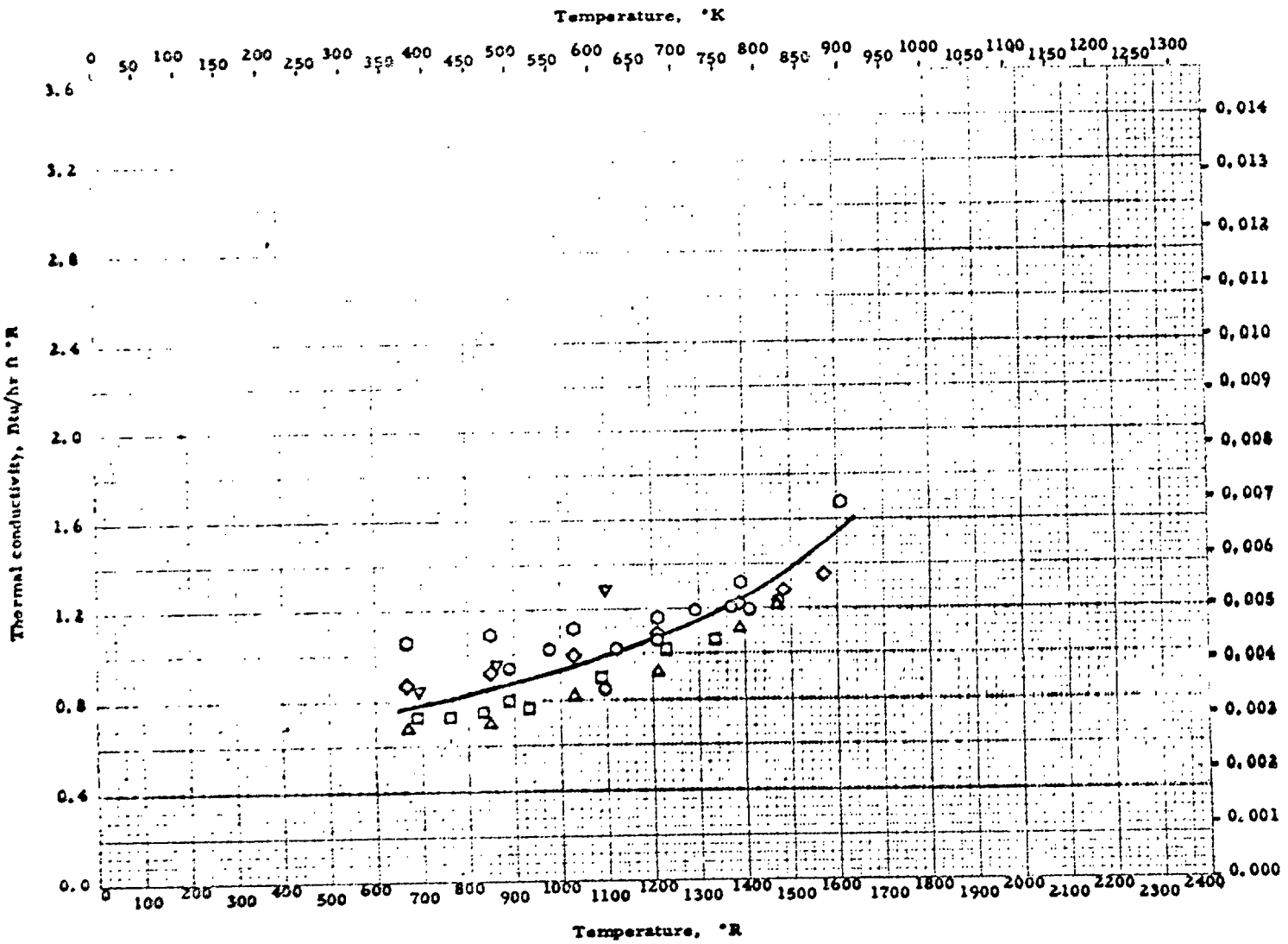


SPECIFIC HEAT -- SODIUM SILICATE GLASS

SPECIFIC HEAT -- SODIUM SILICATE GLASS

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Tarasov, V.V. and Savitskaya, Ya. S.	53-64	110-295	Na_2SiO_3	Guarded sample	
□	Anderson, S.	46-7	1212-2472	Plate glass: 72% SiO_2; 13.7% Na_2O. 11.5% CaO; 2.5% MgO; 0.3% Al_2O_3	Drop method; mercury bath calorimeter	
△	Ibid.	46-7	1212-2472	Solex "S" Glass: same as above with small amount of iron oxide	Same as above	
◇	Lucks, C.F., Matolich, J., and Van Valzor, J.A.	54-27	141-1392	Solex 2808X plate glass	Drop method: ice calorimeter	
▽	Ibid.	54-27	141-1392	White clear plate glass	Same as above	
○	Ibid.	54-27	141-1392	Solex "S" glass	Same as above	

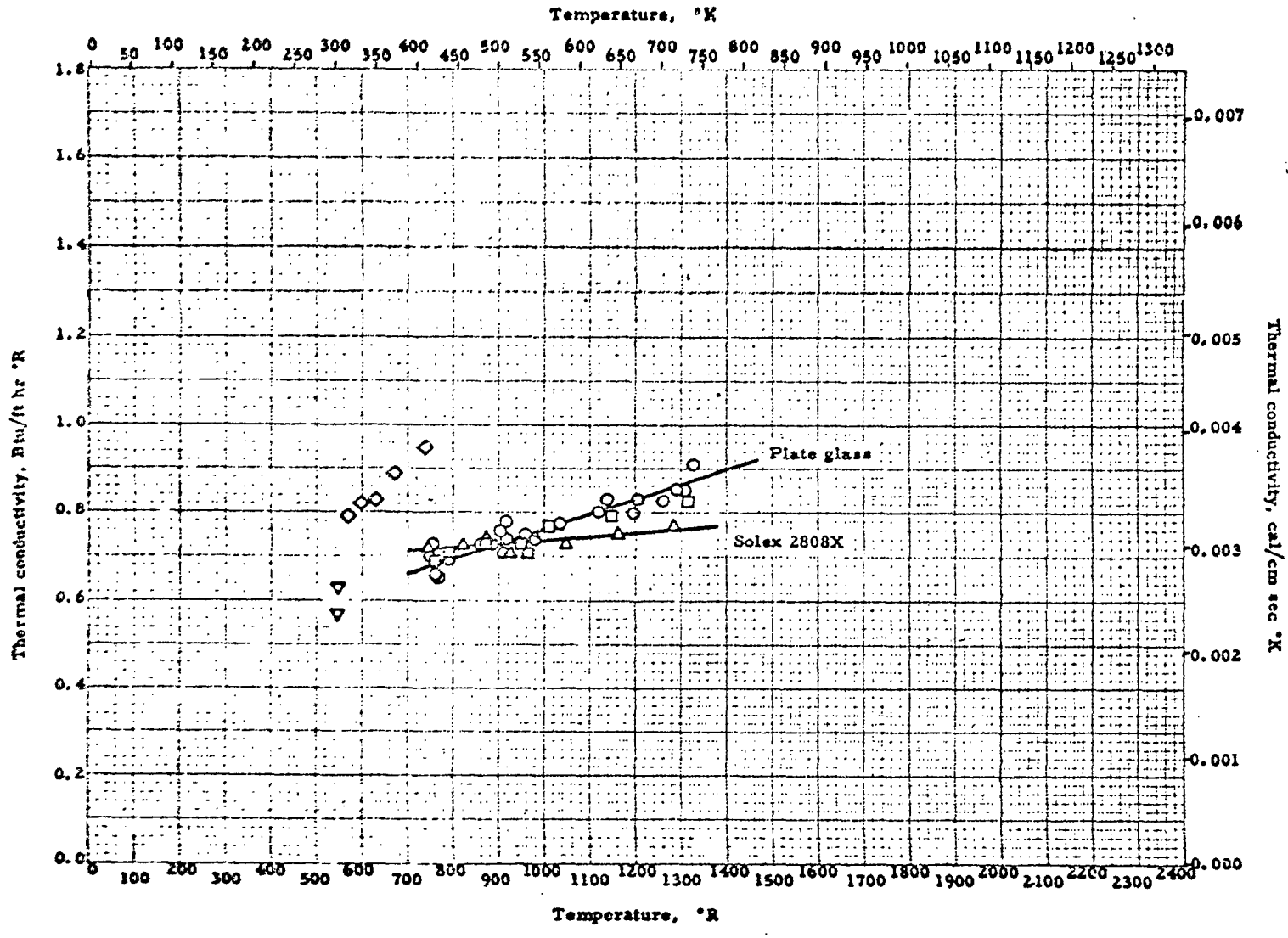


THERMAL CONDUCTIVITY -- SODIUM CALCIUM SILICATE GLASS

THERMAL CONDUCTIVITY -- SODIUM CALCIUM SILICATE GLASS

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Kingery, W. D. and Norton, F. H.	55-57	888-1473	71.25% SiO_2; 13.35% Na_2O; 11.82% CaO; 2.44% MgO; 0.68% Na_2SO_4; 0.26% Al_2O_3; 0.14% Fe_2O_3 0.06% NaCl	Ellipsoidal envelope	
□	Ibid.	55-57	690-1338	Same as above	Comparative; rods	Sample in form of cube
△	Kingery, W. D. and Norton, F. H.	54-64	672-1473	70.84% SiO_2; 13.32% Na_2O; 11.75% CaO; 2.64% MgO; 0.61% Na_2SO_4; 0.56% Fe_2O_3; 0.22% Al_2O_3 0.06% NaCl	Comparative; rods	
◇	Norton, F. H., Kingery, W. D. et al.	54-449	672-1572	Four samples: 58.4-71.3% SiO_2; 13-19.3% Na_2O 6-11.8% CaO; 0.22-7.89% Al_2O_3; 0-4.3% K_2O; 2.44-3.51% MgO; 0.24-0.68% Na_2SO_4; 0.09-0.56% Fe_2O_3; 0.06-0.12% NaCl	Ellipsoidal envelope	
▽	Knapp, W. J.	43-11	695.4-1100.4	69.73% SiO_2; 20.96% Na_2O; 9.05% CaO; 0.18% R_2O_3; trace K_2O	Comparative; rods. Chromel-Constantan thermocouples	Sample in form of cube
○	Norton, F. H., Kingery, W. D. et al.	53-68	672-1602	Corning No. 0080	Ellipsoidal envelope	

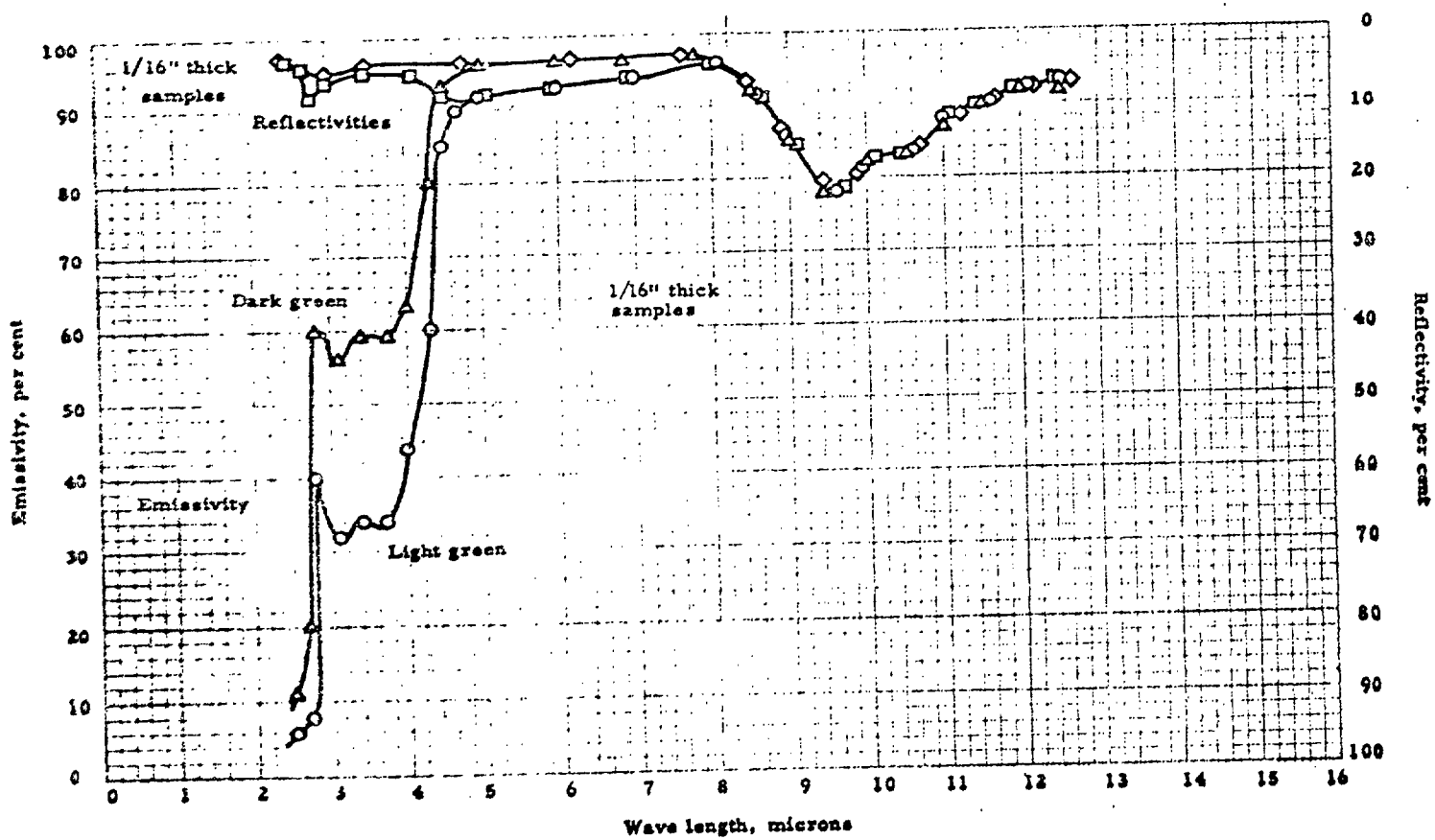


THERMAL CONDUCTIVITY -- SODIUM SILICATE GLASS

THERMAL CONDUCTIVITY -- SODIUM SILICATE GLASS

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Lucks, C. F., Matolich, J. and Van Valzor, J. A.	54-27	755-1325	White clear plate glass	Not described here, refers to others	
□	Ibid.	54-27	758-1316	Solex "S" plate glass	Same as above	
△	Ibid.	54-27	744-1206	Solex 2808X plate glass	Same as above	
◇	Koenig, J. H. and New Jersey Ceramic Research Station	53-43	109.6 - 280.7	Plate glass. ρ = 156 lb_m/ft^3	Comparative: rods in vacuum, inconel standard	
▽	Oak Ridge National Laboratory	57-150	546	Plate glass	Not described here, refers to others	

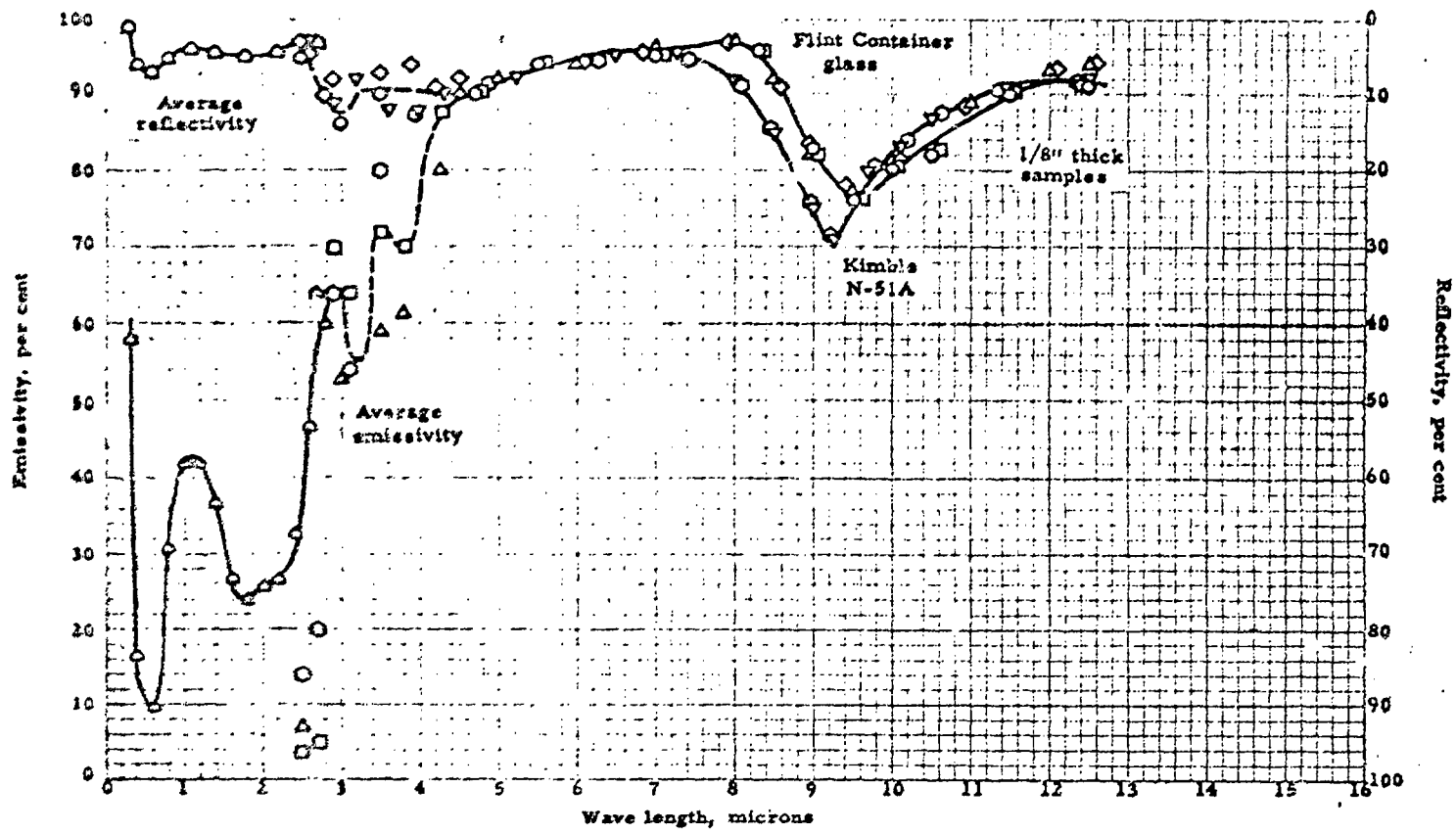


SPECTRAL EMISSIVITY -- GREEN CONTAINER GLASS

SPECTRAL EMISSIVITY -- GREEN CONTAINER GLASS

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	McMahon, H.	51-80	1460	Light chrome green container glass: 71.0% SiO_2 ; 13.1% $Na_2O + K_2O$; 11.2% CaO; 2.8% MgO; 2.8% MgO; 1.3% R_2O_3; 0.6% BaO	Spectral emissivity: Perkin Elmer spectrometer	1/16 in. thick at 1000°F
□	Ibid.	51-80	1460	Same as above	Spectral reflectivity: computed from measurement of spectral transmissivity and spectral emissivity above	Same as above; Reflectivity = 1 - transmissivity - emissivity
△	Ibid.	51-80	1460	Dark chrome green container glass: 70.9% SiO_2; 16.6% $Na_2O + K_2O$; 6.7% CaO; 3.6% MgO; 3.6% MgO; 1.5% R_2O_3; 0.5% BaO	Spectral emissivity: Perkin Elmer spectrometer	1/16 in. thick at 1000°F
◇	Ibid.	51-80	1460	Same as above. Reflectivity = 1 - transmissivity - emissivity	Spectral reflectivity: computed from measurement of spectral transmissivity and spectral emissivity above	Same as above; Reflectivity = 1 - transmissivity - emissivity

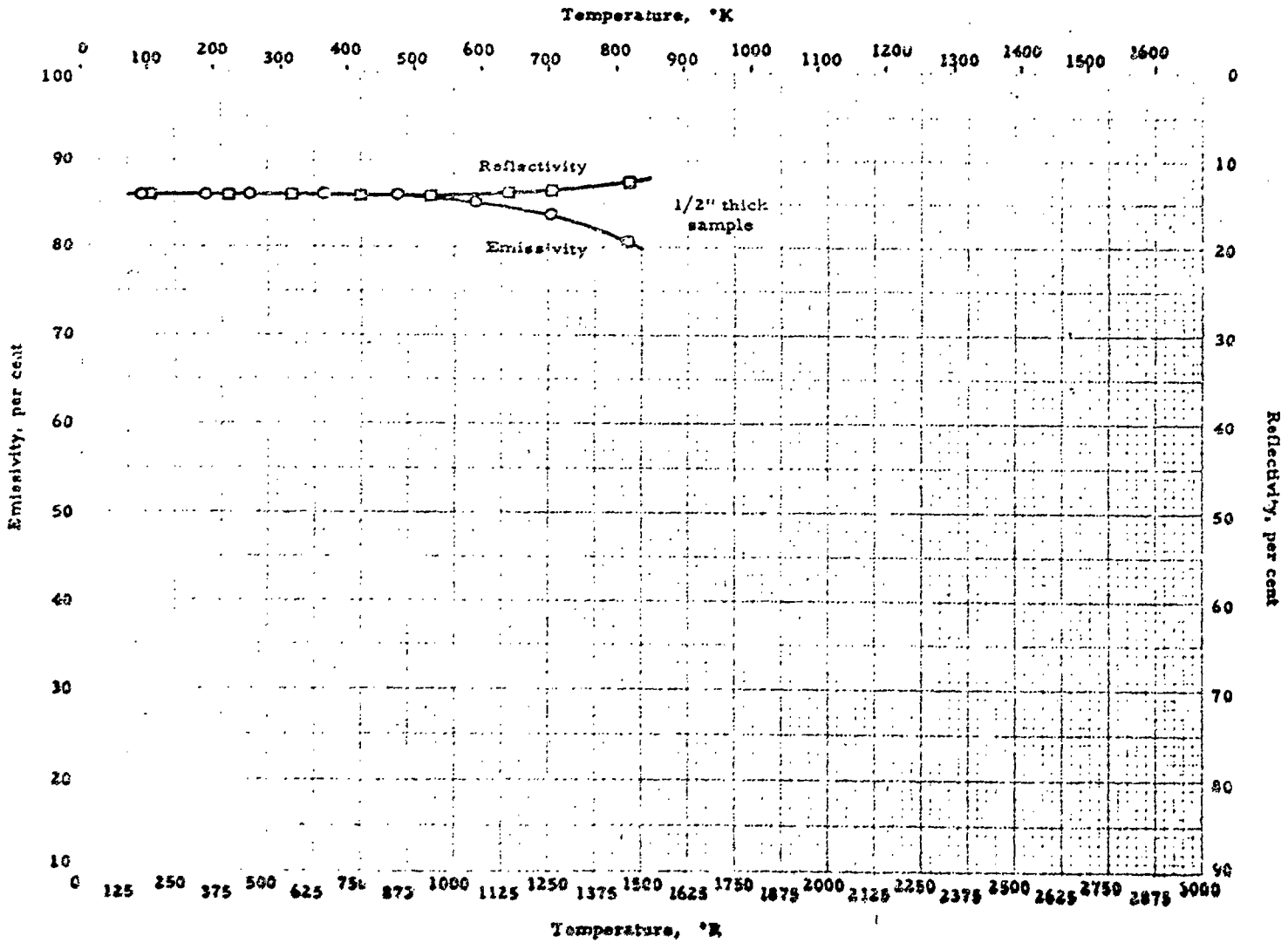


SPECTRAL EMISSIVITY -- SODIUM CALCIUM SILICATE GLASS

SPECTRAL EMISSIVITY -- SODIUM CALCIUM SILICATE GLASS

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	McMahon, H.	51-80	1460	Low-iron flint glass: 72.2% SiO_2; 13.0% (Na_2O and K_2O); 12.7% CaO; 1.1% R_2O_3	Spectral reflectivity: computed from measurement of emissivity and transmissivity	1/8 in. thick at 1000°F. Reflectivity = 1-transmissivity-emissivity
□	Ibid.	51-80	1460	Same as above	Spectral emissivity: Perkins Elmer spectrometer	1/8 in. thick at 1000°F
△	Ibid.	51-80	1460	Flint container glass: 71.7% SiO_2; 13.3% (Na_2O and K_2O); 11.9% CaO; 1.8% R_2O_3; 0.6% BaO; 0.3% MgO	Spectral emissivity: same as above	Same as above
◇	Ibid.	51-80	1460	Same as above	Spectral reflectivity: same as for ○ above	Reflectivity = 1-transmissivity-emissivity
▽	Ibid.	51-80	1460	Glass -- Kimble N-51A: 74.7% SiO_2; 9.6% B_2O_3; 6.9% (Na_2O and K_2O); 5.6% R_2O_3; 2.2% BaO; 0.9% CaO	Spectral reflectivity: same as above	Same as above
○	Ibid.	51-80	1460	Same as above	Spectral emissivity: same as for □ above	1/8 in. thick at 1000°F

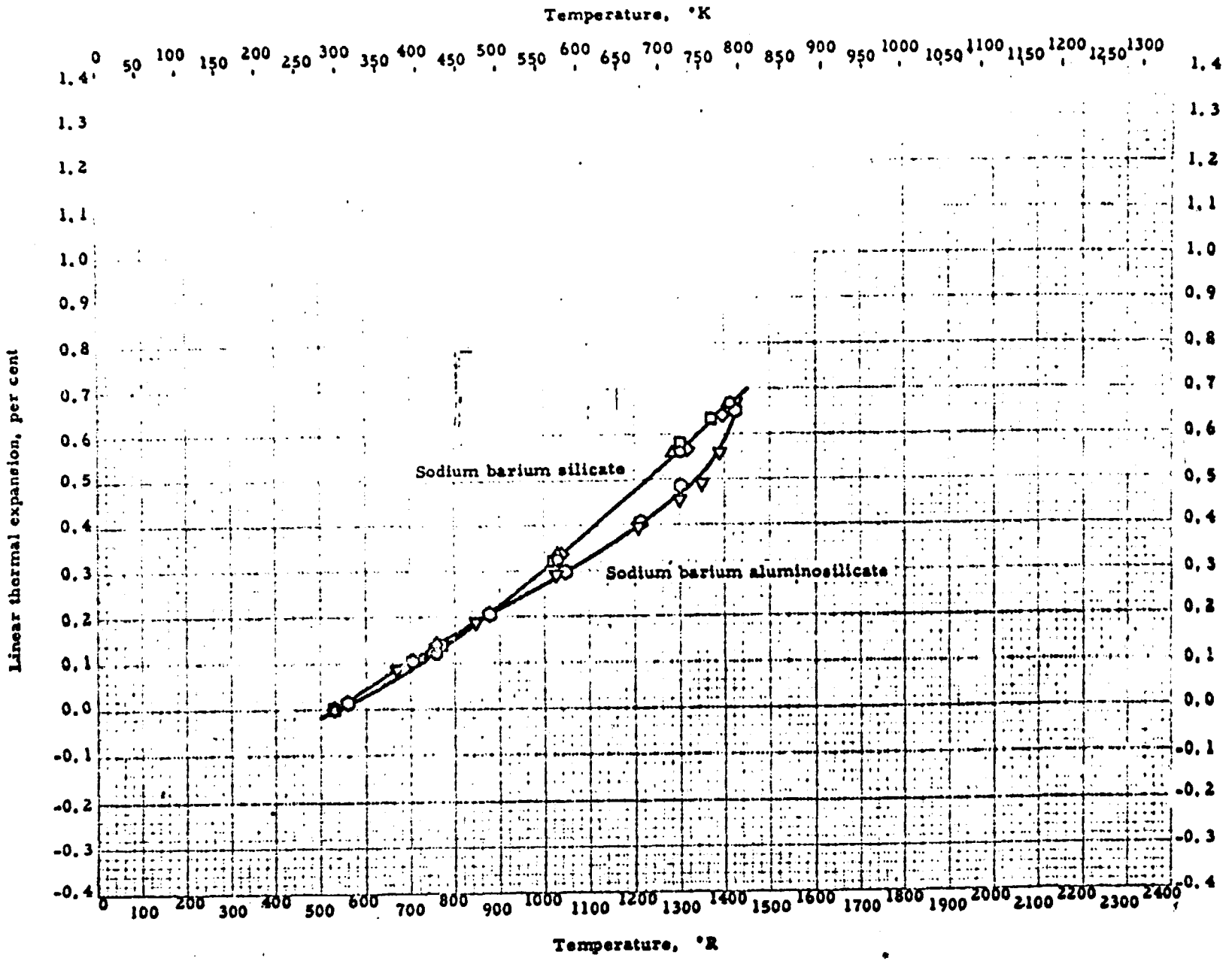


EMISSIVITY -- SODA LIME GLASS

EMISSIVITY -- SODA LIME GLASS (L.O.F.)

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Olson, O. H. and Morris, J. C.	59-1	160-1360	Glass - soda lime, L.O.F.	Total normal emissivity: comparative: surface brightness compared with that of a black body hole; quartz lens thermocouple, accuracy ± 3%	1/2 in. sample in air
□	Ibid.	59-1	160-1360	Same as above	Total normal reflectivity: meas. emissivity as above, and apparent transmissivity from black body at sample temp.	Same as above. Reflectivity = 1-emissivity-transmissivity

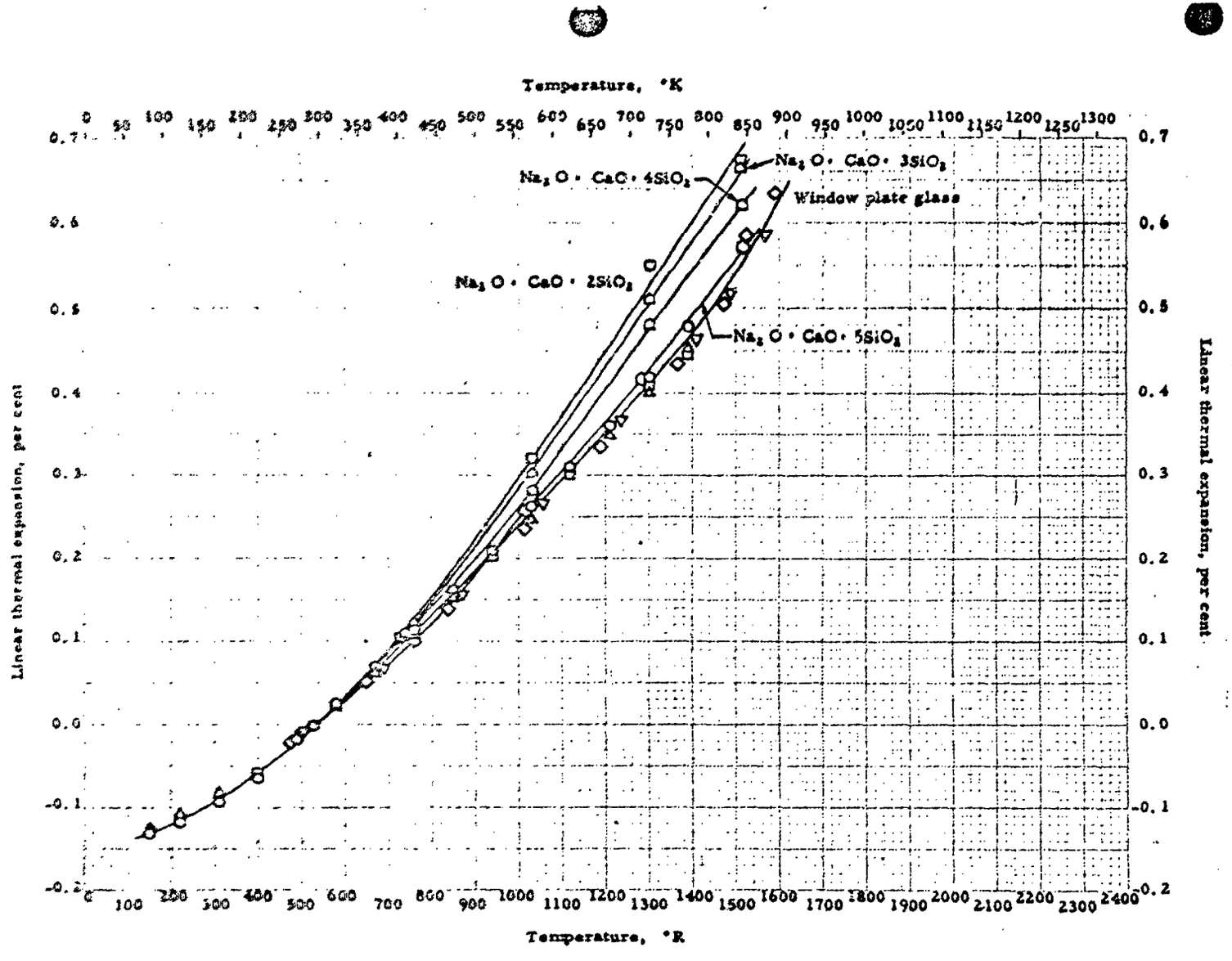


LINEAR THERMAL EXPANSION -- SODIUM BARIUM SILICATE GLASS.

LINEAR THERMAL EXPANSION -- SODIUM BARIUM SILICATE GLASS

REFERENCE INFORMATION

Sym	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Karkhanavala, M. D. and Hummel, F. A.	52-32	528-1410	58.25% SiO_2; 29.74% BaO; 12.02% Na_2O	Interferometer and vitreous silica dilatometer	$Na_2O \cdot BaO \cdot 5SiO_2$ Mixed, melted in kyanite crucible, cast in graphite mold, annealed
□	Ibid.	52-32	528-1370	52.75% SiO_2; 33.65% BaO; 13.6% Na_2O	Same as above	$Na_2O \cdot BaO \cdot 4SiO_2$ Formed as above
△	Ibid.	52-32	528-1406	45.56% SiO_2; 38.76% BaO; 15.65% Na_2O	Same as above	$Na_2O \cdot BaO \cdot 3SiO_2$ Formed as above
◇	Ibid.	52-32	528-1399	45.71% BaO; 35.81% SiO_2; 18.48% Na_2O	Same as above	$Na_2O \cdot BaO \cdot 2SiO_2$ Formed as above
▽	Hagy, H. E. and Ritland, H. N.	57-124	528-1392	Sodium barium aluminosilicate glass. 71.3% SiO_2; 17.4% Na_2O; 9.0% BaO; 2.0% Al_2O_3	Quartz differential dilatometer, dial guages	Refractive index = 1.508 at room temp. 100°C/hr. heating rate. Heating data
○	Ibid.	57-124	537-1428	Same as above	Telemicroscopes sighting on sample	Same as above. Cooling data

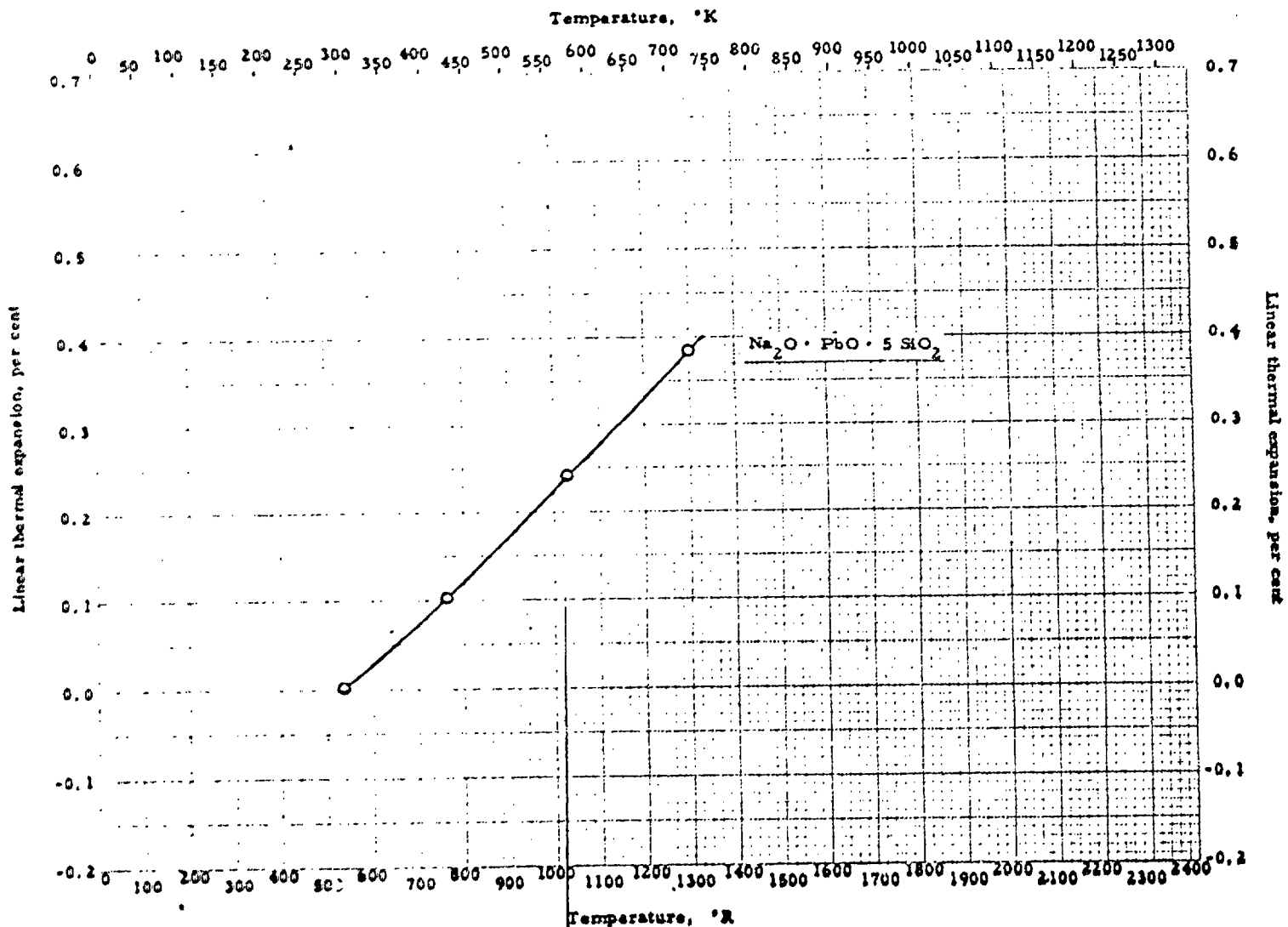


LINEAR THERMAL EXPANSION -- SODIUM CALCIUM SILICATE GLASS

LINEAR THERMAL EXPANSION -- SODIUM CALCIUM SILICATE GLASS

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Lucks, C. F. and Bing, G. F.	52-33	150-1392	Solex 2808X Plate Glass by Pittsburgh Plate Glass Co.	Dilatometer	
□	Ibid.	52-33	150-1392	Solex "S" Plate Glass by Pittsburgh Plate Glass Co.	Same as above	
△	Ibid.	52-33	150-1392	White (clear) Plate Glass by Pittsburgh Plate Glass Co.	Same as above	
◇	Hamilton, E. H., Waxler, R. and Nivert, J. H.	57-182	492-1590	Ordinary plate glass	Interferometer, with 2° C/min rise	
▽	Ibid.	57-182	492-1572	Water white plate glass	Same as above	
○	Karkhanavala, M. D. and Hummel, F. A.	52-32	528-1536	71.78% SiO_2; 14.82% Na_2O; 13.40% CaO	Interferometer and vitreous silica dilatometer	$Na_2O \cdot CaO \cdot 5SiO_2$ mixed, melted in kyanite crucible, cast in graphite mold, annealed
□	Ibid.	52-82	528-1518	67.05% SiO_2; 17.30% Na_2O; 15.65% CaO	Same as above	$Na_2O \cdot CaO \cdot 4SiO_2$ formed as above
△	Ibid.	52-82	528-1510	60.42% SiO_2; 20.78% Na_2O; 18.80% CaO	Same as above	$Na_2O \cdot CaO \cdot 3SiO_2$ formed as above
▽	Ibid.	52-82	528-1500	50.44% SiO_2; 26.02% Na_2O; 23.44%	Same as above	$Na_2O \cdot CaO \cdot 2SiO_2$ formed as above

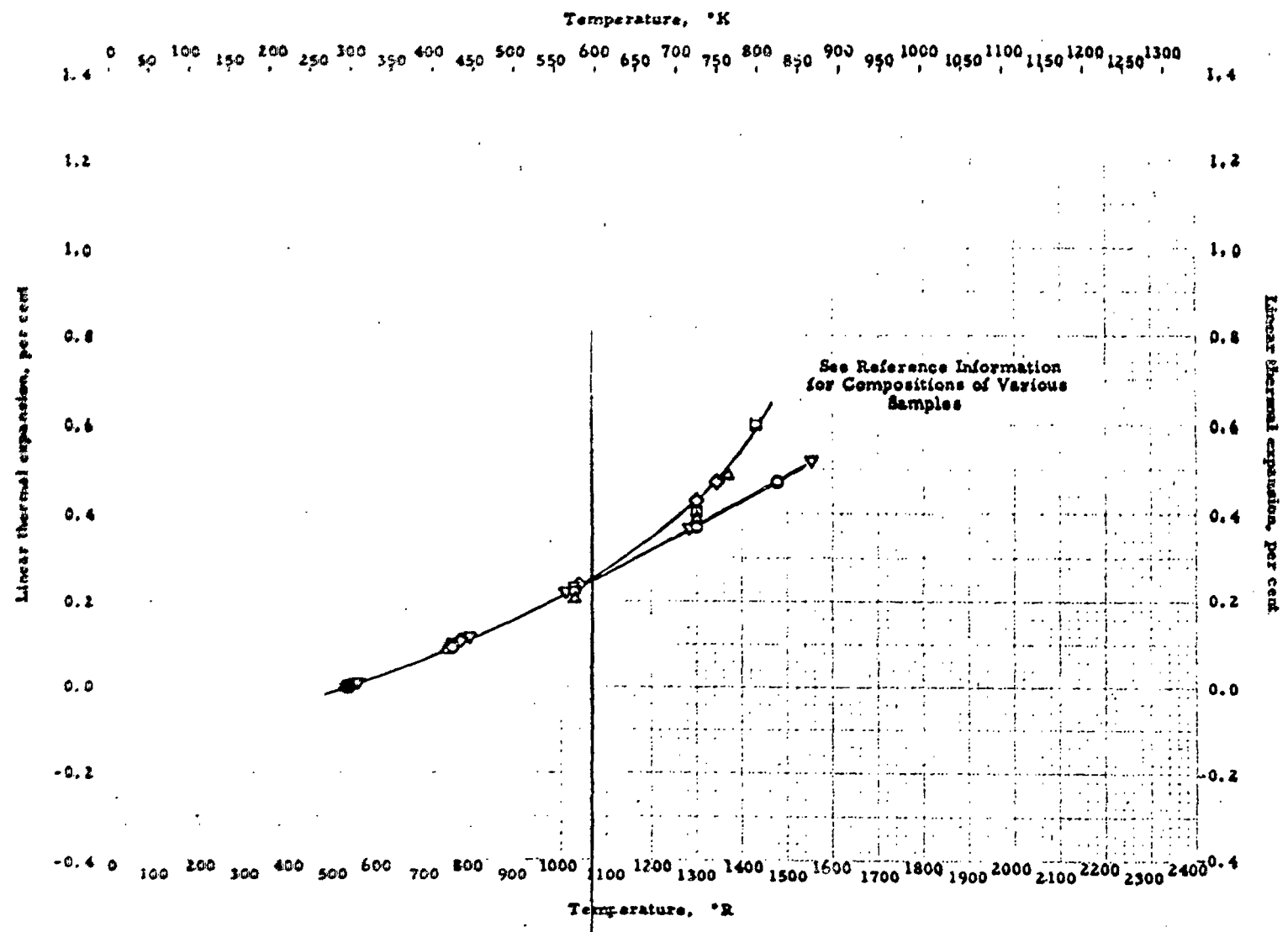


LINEAR THERMAL EXPANSION -- SODIUM LEAD SILICATE GLASS

LINEAR THERMAL EXPANSION -- SODIUM LEAD SILICATE GLASS

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Karkhanavala, M. D., and Hummel, F. A.	52-32	528-1202	51.4% SiO_2; 38.0% PbO; 10.6% Na_2O	Interferometer and vitreous silica dilatometer	$Na_2O \cdot PbO \cdot 5\,SiO_2$ mixed, melted in kyanite crucible cast in graphite mold, annealed, tested at 4° C/min rise. Auth. est. accuracy ± 2%



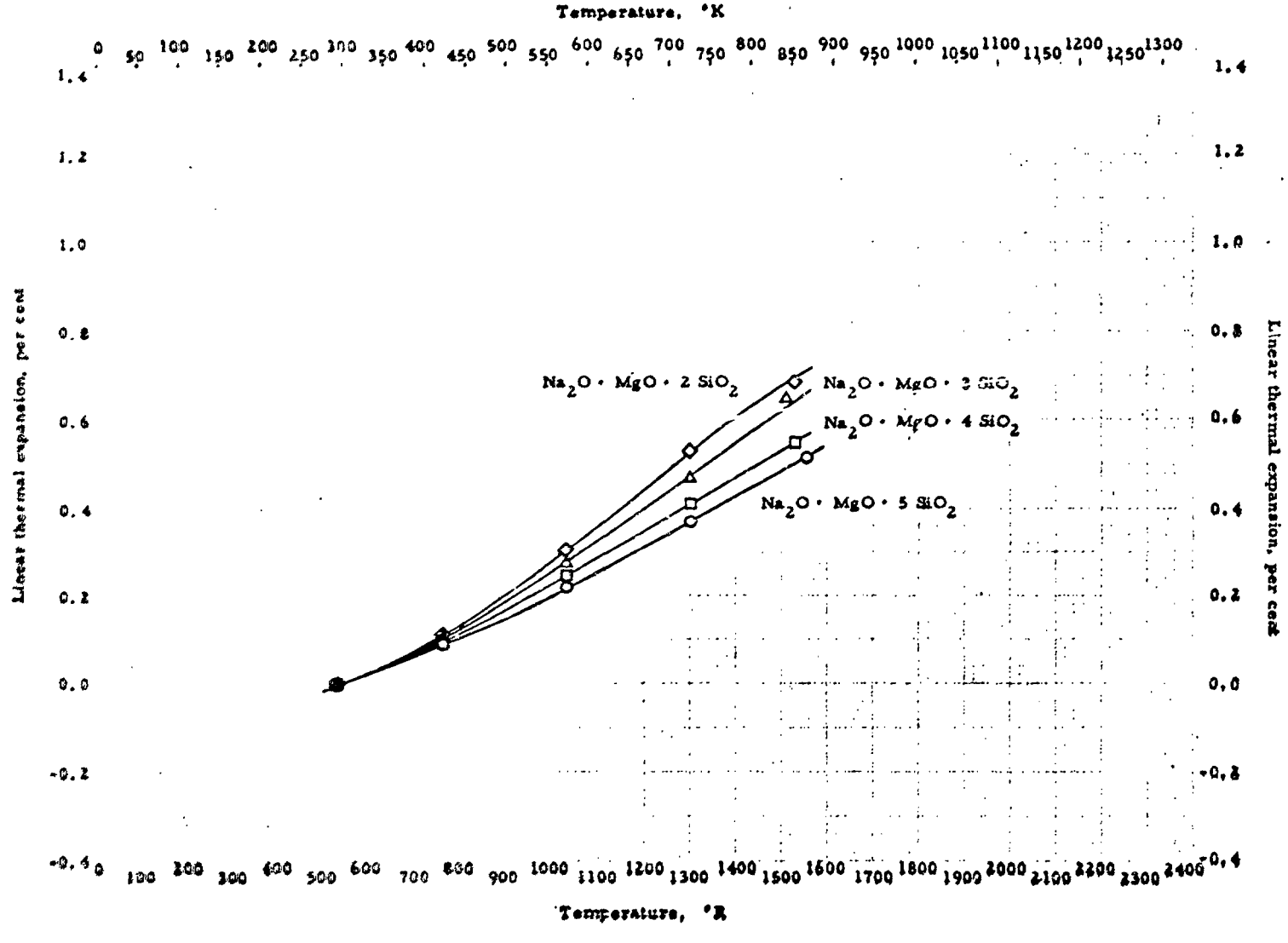
LINEAR THERMAL EXPANSION -- SODIUM MAGNESIUM COPPER SILICATE GLASS

WADC TR 59-644 750

LINEAR THERMAL EXPANSION -- SODIUM MAGNESIUM COPPER SILICATE GLASS

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
▽	Karkhanavala, M. D. and Hummel, F. A.	52-32	528-1555	74.6% SiO_2; 15.4% Na_2O; 10.0% MgO	Interferometer and vitreous silica dilatometer	Na_2O · MgO · 5 SiO_2 mixed, melted in kyanite crucibles, cast in graphite mold, annealed; tested at 4°C/min. rise. Auth. est. accuracy ± 2%
○	Ibid.	52-32	528-1482	72.6% SiO_2; 15.0% Na_2O; 7.4% MgO; 4.8% CuO	Same as above	Na_2O · 0.75 MgO · 0.25 CuO · 5 SiO_2; other remarks as above
□	Ibid.	52-32	528-1428	71.1% SiO_2; 14.7% Na_2O; 9.4% CuO; 4.8% MgO	Same as above	Na_2O · 0.5 MgO · 0.5 CuO · 5 SiO_2; other remarks as above
△	Ibid.	52-32	528-1374	69.66% SiO_2; 14.40 Na_2O; 13.58% CuO; 2.34% MgO	Same as above	Na_2O · 0.25 MgO · 0.75 CuO · 5 SiO_2; other remarks as above
◇	Ibid.	52-32	528-1345	68.94% SiO_2; 18.0% CuO; 14.1% Na_2O	Same as above	Na_2O · CuO · 5 SiO_2; other remarks as above



LINEAR THERMAL EXPANSION -- SODIUM MAGNESIUM SILICATE GLASS

LINEAR THERMAL EXPANSION -- SODIUM MAGNESIUM SILICATE GLASS

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Kerkhamavala, M. D. and Hummel, F. A.	52-32	528-1555	74.6% SiO_2; 15.4% Na_2O; 10.0% MgO	Interferometer and vitreous silica dilatometer	$Na_2O \cdot MgO \cdot 5\,SiO_2$ mixed, melted in kyanite crucibles, cast in graphite mold, annealed. Tested at 4°C/min rise. Auth. est. accuracy ± 4%
□	Ibid.	52-32	528-1527	70.1% SiO_2; 18.1% Na_2O; 11.8% MgO	Same as above	$Na_2O \cdot MgO \cdot 4\,SiO_2$ other remarks as above
△	Ibid.	52-32	528-1509	63.8% SiO_2; 21.9% Na_2O; 14.3% MgO	Same as above	$Na_2O \cdot MgO \cdot 3\,SiO_2$ other remarks as above
◇	Ibid.	52-32	528-1527	54.0% SiO_2; 27.9% Na_2O; 18.1% MgO	Same as above	$Na_2O \cdot MgO \cdot 2\,SiO_2$ other remarks as above

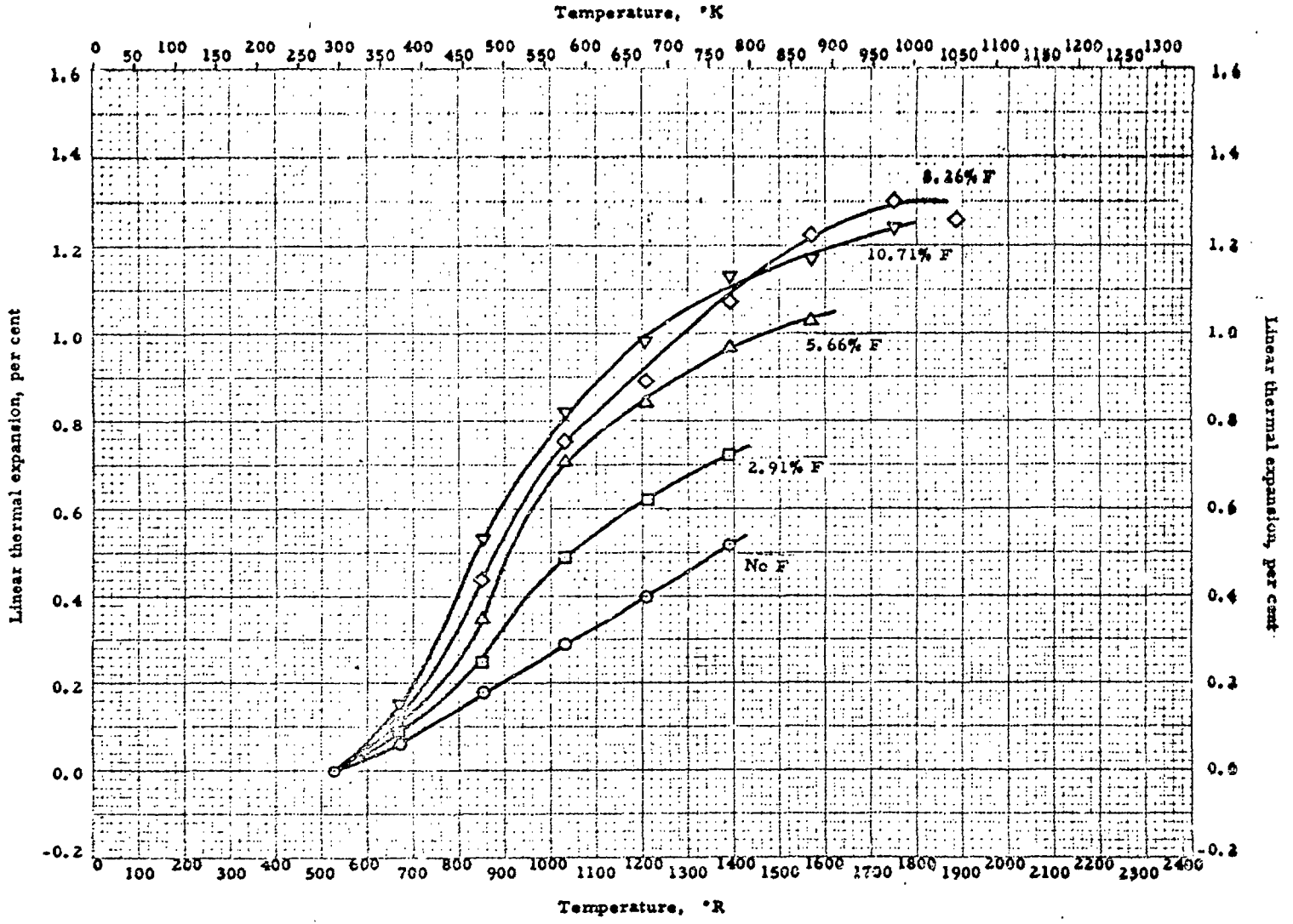
Symbol	Material Composition, % SiO_2	Na_2O	SrO	Al_2O_3	SO_3	Density g/cm^3	Coefficient of linear expansion x 10^6 at room temperature per °R	per °K
O	77.7	13.9	6.1	2.1	0.1	2.4488	47.0	84.6
	77.7	13.8	8.2	0.2	0.1	2.4754	47.9	86.3
	76.1	15.8	6.1	3.0	0.2	2.4673	50.5	90.9
	76.0	15.4	8.1	0.2	0.2	2.4955	51.8	93.2
	75.4	14.2	6.1	4.0	0.1	2.4643	45.6	82.0
	74.8	17.2	4.0	4.0	0.2	2.4520	51.3	92.4
	74.7	17.1	6.0	2.0	0.2	2.4798	53.7	96.6
	74.3	15.5	6.1	4.1	0.2	2.4776	50.2	90.4
	74.1	17.3	7.9	0.3	0.2	2.5110	55.9	100.6
	73.5	14.1	10.0	2.0	0.2	2.5257	49.1	88.3
	73.5	13.9	12.0	0.3	0.1	2.5571	50.4	90.8
	72.2	15.5	10.1	2.1	0.1	2.5456	53.1	95.5
	71.9	15.7	12.2	0.1	0.1	2.5777	54.6	98.2
	71.5	14.2	10.0	4.1	0.2	2.5380	48.2	86.7
	70.7	17.0	11.9	0.1	0.2	2.5866	58.4	105.2
	70.6	17.2	8.0	4.0	0.2	2.5357	54.2	97.5
	70.5	17.3	10.1	2.0	0.2	2.5569	56.4	101.5
	70.1	15.5	10.1	4.1	0.1	2.5543	52.7	94.9
	69.6	14.1	13.9	2.0	0.2	2.6085	52.5	94.5
	69.5	14.0	16.0	0.2	0.2	2.6392	50.4	95.1
	68.0	15.8	16.0	0.1	0.2	2.6585	57.9	104.2
	68.0	15.7	14.0	2.0	0.2	2.6247	56.7	102.0
	67.9	14.2	13.9	4.1	0.2	2.6165	51.3	92.4
	66.6	17.3	15.6	0.2	0.2	2.6686	61.8	111.2
	66.6	17.3	13.6	2.1	0.2	2.6362	59.6	107.2
	66.8	17.2	11.7	4.0	0.2	2.6059	58.2	104.8
	66.1	15.5	14.0	4.1	0.2	2.6329	56.6	101.9

LINEAR THERMAL EXPANSION -- SODIUM STRONTIUM ALUMINOSILICATE GLASS

LINEAR THERMAL EXPANSION -- SODIUM STRONTIUM ALUMINOSILICATE GLASS

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Owens Illinois Glass Co. Research Labs	48-38	Room	Series of glasses	Not given here; refers to earlier work	

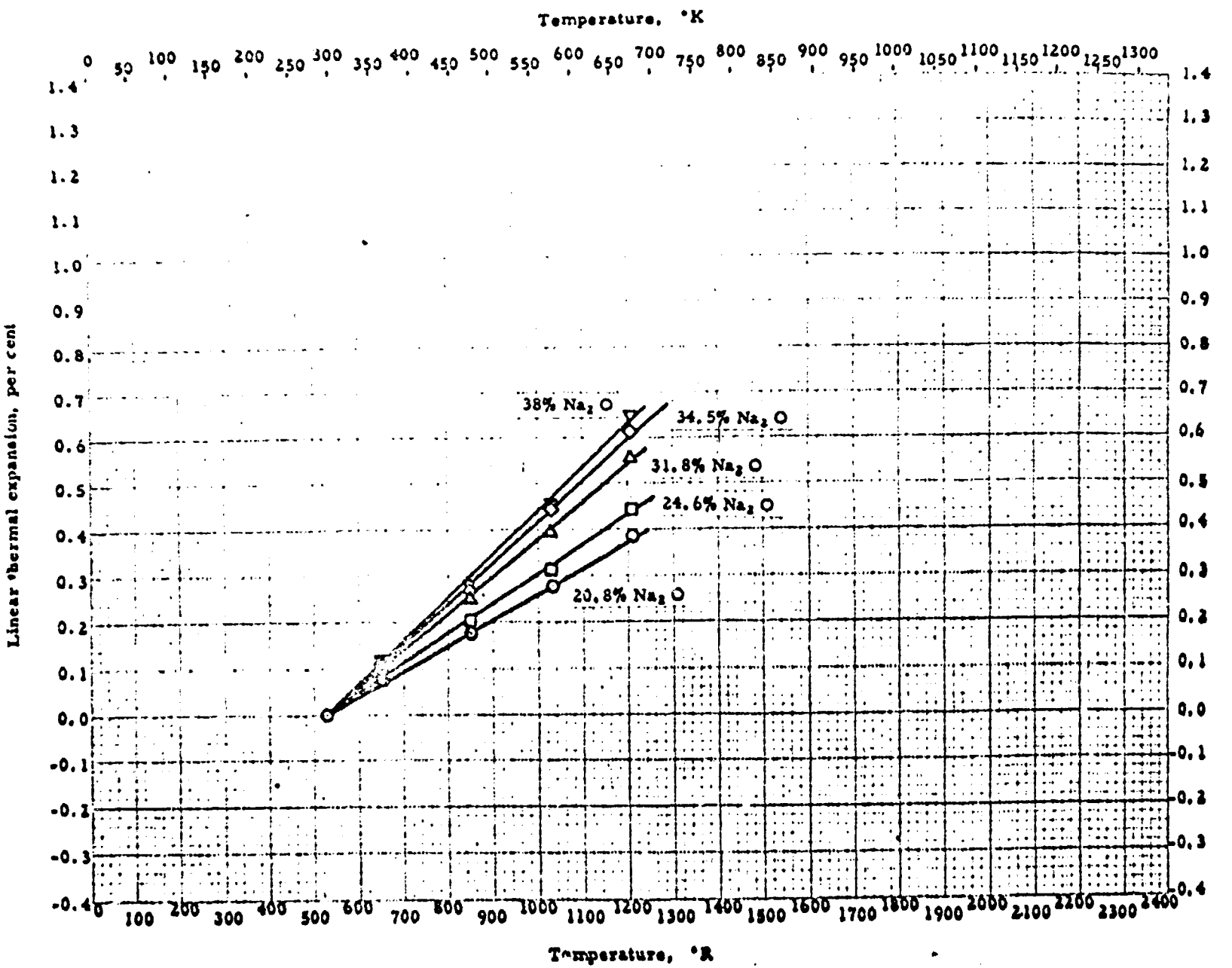


LINEAR THERMAL EXPANSION -- SODIUM SILICATE GLASS WITH FLUORINE

LINEAR THERMAL EXPANSION -- SODIUM SILICATE GLASS WITH FLUORINE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Vargin, V. V. and Krasotkina, N. I.	56-168	672-1392	74.41% SiO_2 ; 25.59% Na_2O	Quartz tube dilatometer with dial gauge	Pure materials heated to 780°C in muffle furnace, furnace cooled. Auth. est. accuracy ± 1.5%
□	Ibid.	56-168	672-1392	72.24% SiO_2 ; 24.85% Na_2O; 2.91% F	Same as above	Same as above
△	Ibid.	56-168	672-1572	70.20% SiO_2 ; 24.14% Na_2O; 5.66% F	Same as above	Same as above
◇	Ibid.	56-168	672-1842	68.27% SiO_2 ; 23.47% Na_2O; 8.26% F	Same as above	Same as above
▽	Ibid.	56-168	672-1752	66.44% SiO_2 ; 22.85% Na_2O; 10.71% F	Same as above	Same as above. Auth. also report values for various heat treatments in the system 66-75% SiO_2 + 22-26% Na_2O + 0-10% F

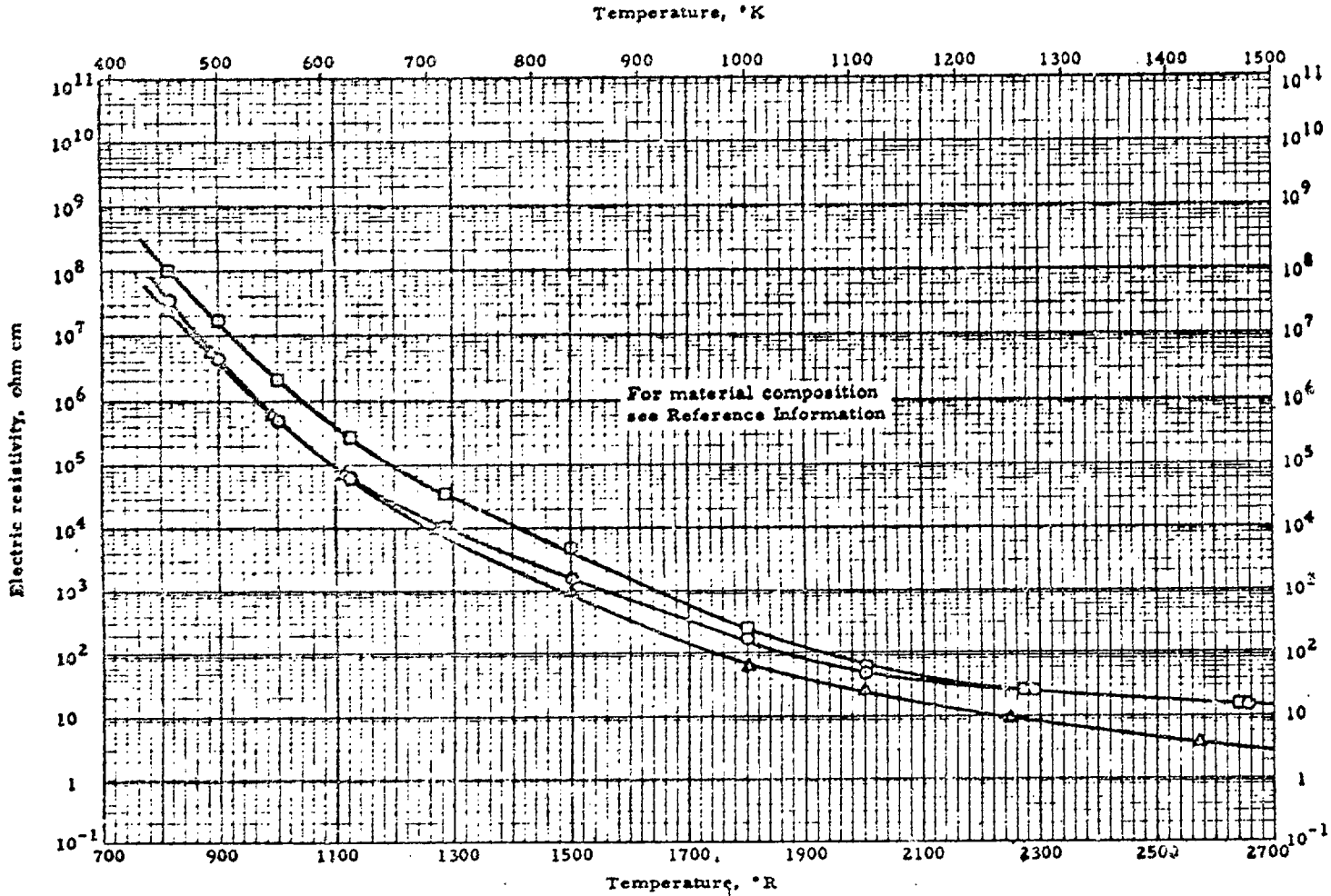


LINEAR THERMAL EXPANSION -- SODIUM SILICATE GLASS

LINEAR THERMAL EXPANSION -- SODIUM SILICATE GLASS

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Shermer, H. F.	56-166	528-1212	79.2% SiO_2 ; 20.8% Na_2O, ρ = 148.8 lb_m/ft^3	Interferometer	
□	Ibid.	56-166	528-1212	75.4% SiO_2 ; 24.6% Na_2O, ρ = 151.1 lb_m/ft^3	Same as above	
△	Ibid.	56-166	528-1212	68.2% SiO_2 ; 31.8% Na_2O, ρ = 154.3 lb_m/ft^3	Same as above	
◇	Ibid.	56-166	528-1212	65.5% SiO_2 ; 34.5% Na_2O, ρ = 155.5 lb_m/ft^3	Same as above	
▽	Ibid.	56-166	528-1212	62.0% SiO_2 ; 38.0% Na_2O, ρ = 156.5 lb_m/ft^3	Same as above	

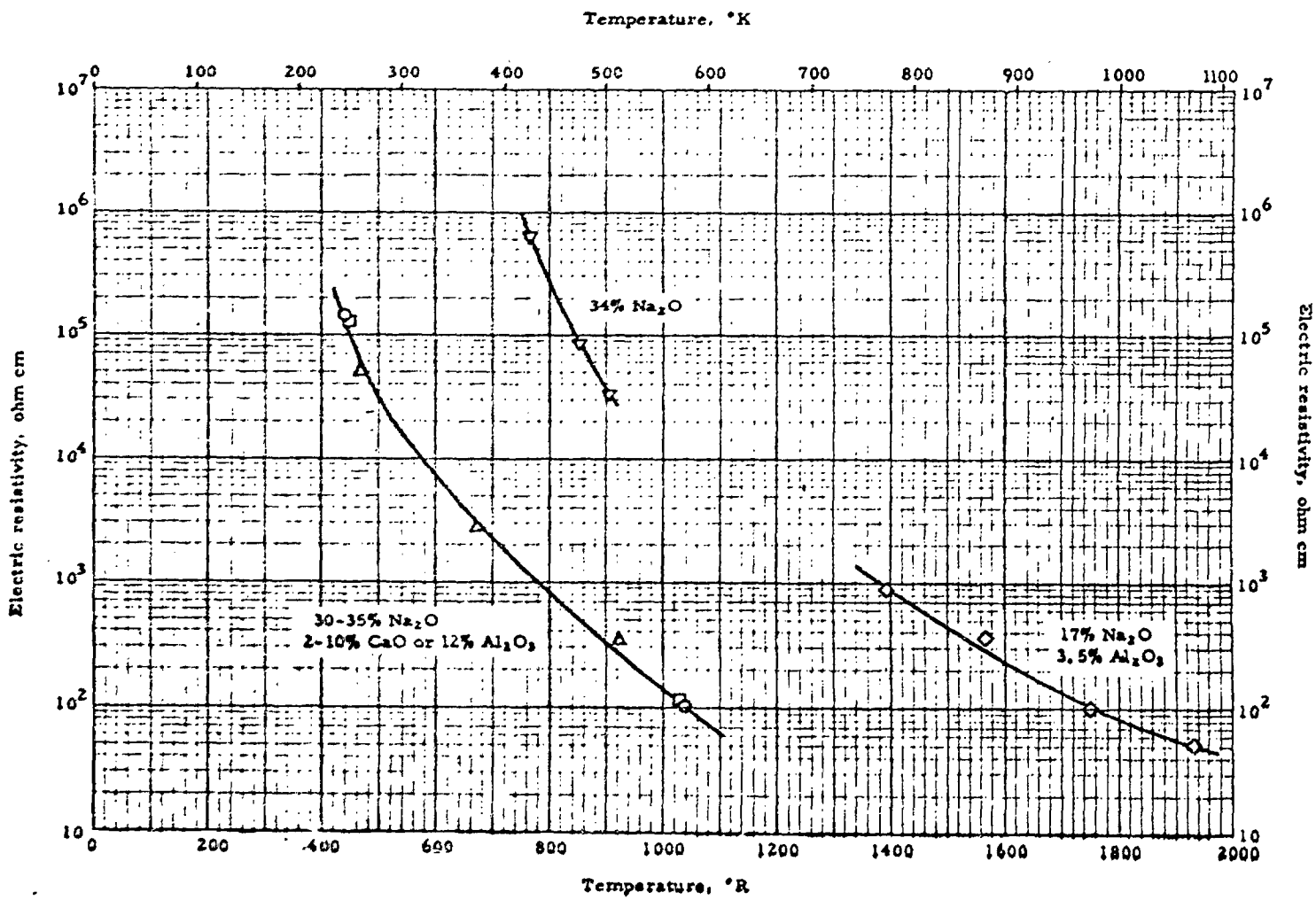


ELECTRIC RESISTIVITY -- SODA LIME ALUMINOSILICATE GLASS

ELECTRIC RESISTIVITY -- SODA LIME ALUMINOSILICATE GLASS

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Kostanyan, K. A.	57-188	818-2652	75.77% SiO_2 ; 12.43% Na_2O; 7.36% CaO; 4.33% Al_2O_3; 0.25% MgO, before melting	Two methods: a. $10^7 < r < 10^{10}$ ohm: lamp megohmmeter b. $r < 10^7$ ohm AC impedance bridge at 50 cycles	Melted from chemically pure materials in fire clay single liter crucibles in petroleum furnace
□	Ibid.	57-188	818-2571	74.0% SiO_2 ; 13.0% Na_2O; 11.0% CaO 2.0% Al_2O_3, before melting	Same as above	Same as above
△	Ibid.	57-188	818-2571	72.0% SiO_2 ; 17.0% Na_2O; 7.0% CaO; 2.0% ea. Al_2O_3, MgO, before melting	Same as above	Same as above. Auth. reports additional detailed data for system, 72-76% SiO_2, 12.4-17% Na_2O, 7-10% CaO, 2-4.3% Al_2O_3, 0.2% MgO. Only extreme ranges of resistivity are shown here.

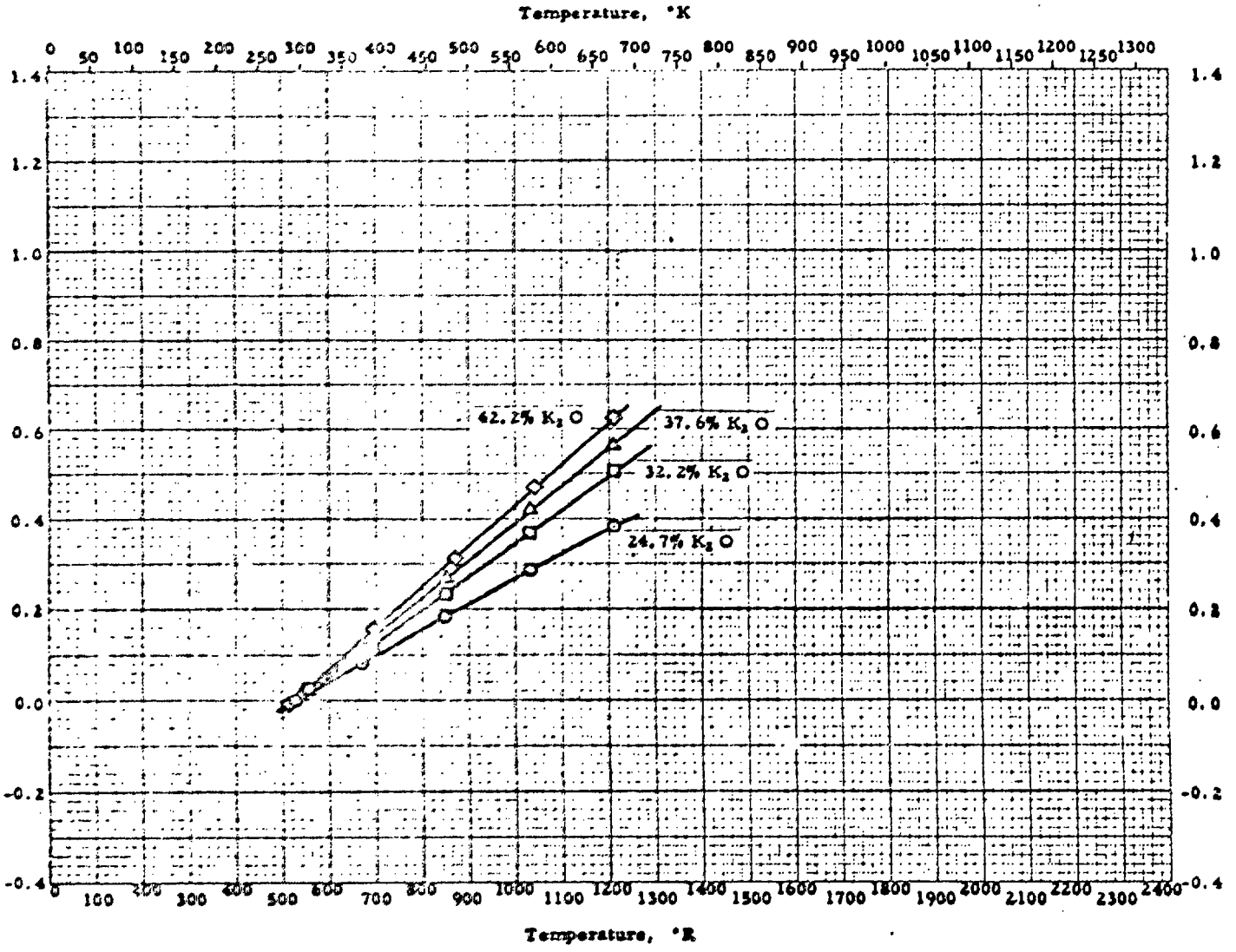


ELECTRIC RESISTIVITY -- SODIUM SILICATE GLASS

ELECTRIC RESISTIVITY -- SODIUM SILICATE GLASS

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Joyner, B. L. and Bell, W. C.	53-105	440-1040	60% SiO_2 ; 30% Na_2O; 10% CaO	Two methods: a: $r < 10^5$ ohms: Wheatstone bridge b: $r > 10^5$ ohms: megohmmeter	
□	Ibid.	53-105	440-1040	63% SiO_2 ; 35% Na_2O; 2% CaO	Same as above	
△	Ibid.	53-105	464-924	56% SiO_2 ; 32.5% Na_2O; 11.5% Al_2O_3	Same as above	
◇	Leung, K.	46-15	1392-2112	67.5% SiO_2 ; 17.0% Na_2O; 12.0% CaO; 3.5% Al_2O_3	AC impedance bridge at 10^3 cycles. Sample temp. by Pt-Pt Rh thermocouple	
▽	Strauss, S. W.	56-163	762-906	66.0% SiO_2 ; 34.0% Na_2O	Potential drop, DC reversal	Made from reagent grade materials

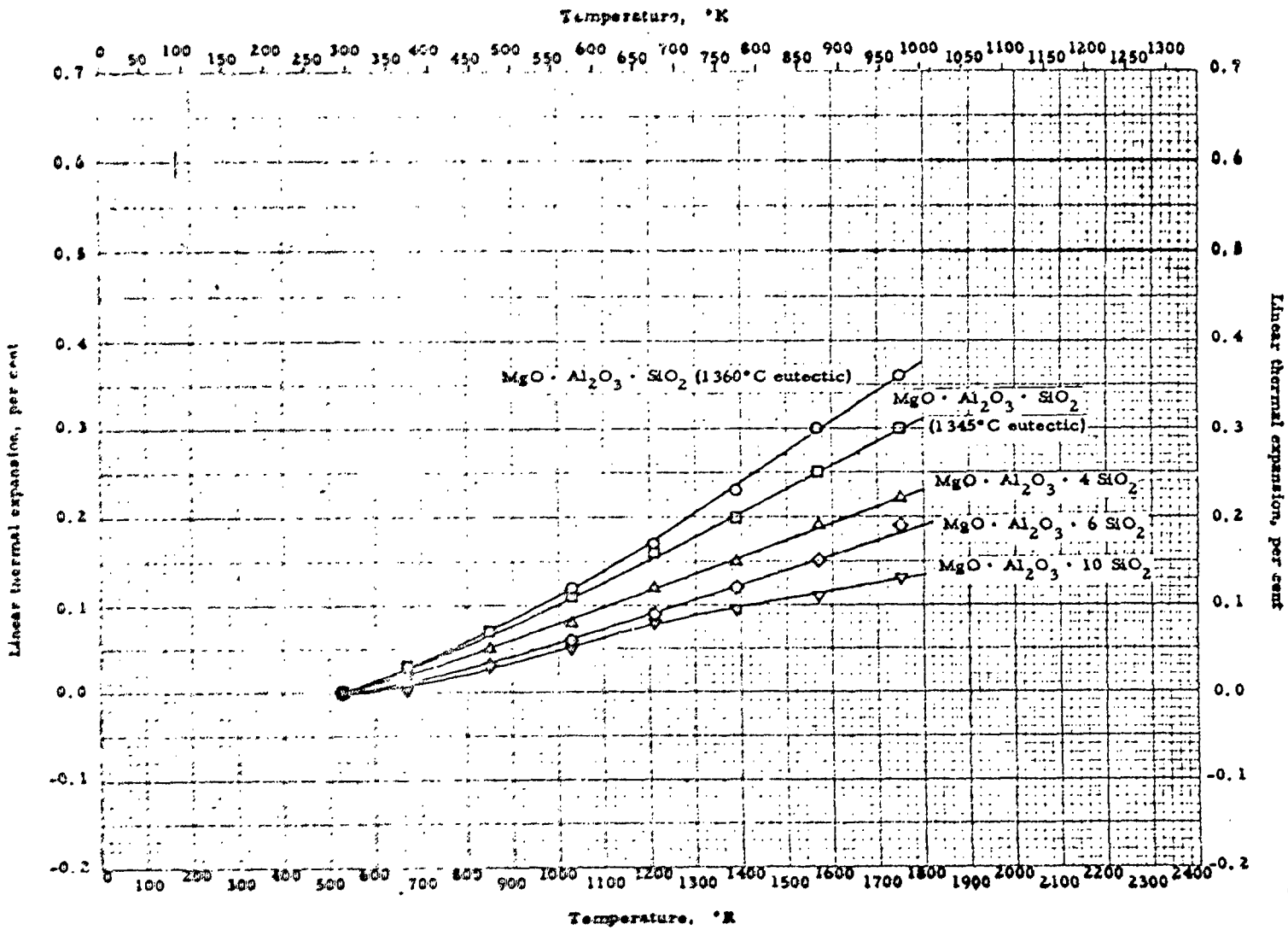


LINEAR THERMAL EXPANSION -- POTASSIUM SILICATE GLASS

LINEAR THERMAL EXPANSION -- POTASSIUM SILICATE GLASS

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Shermer, H. F.	56-166	528-1212	75.3% SiO_2 ; 24.7% K_2O ρ = 147.6 lb_m/ft^3	Interferometer	2 specimens, one of which was reannealed
□	Ibid.	56-166	528-1212	67.8% SiO_2 ; 32.2% K_2O ρ = 144.8 lb_m/ft^3	Same as above	Reannealed
△	Ibid.	56-166	528-1212	62.4% SiO_2 ; 37.6% K_2O ρ = 151.9 lb_m/ft^3	Same as above	2 specimens, one of which was reannealed
◇	Ibid.	56-166	528-1212	57.8% SiO_2 ; 42.2% K_2O ρ = 153.3 lb_m/ft^3	Same as above	Reannealed

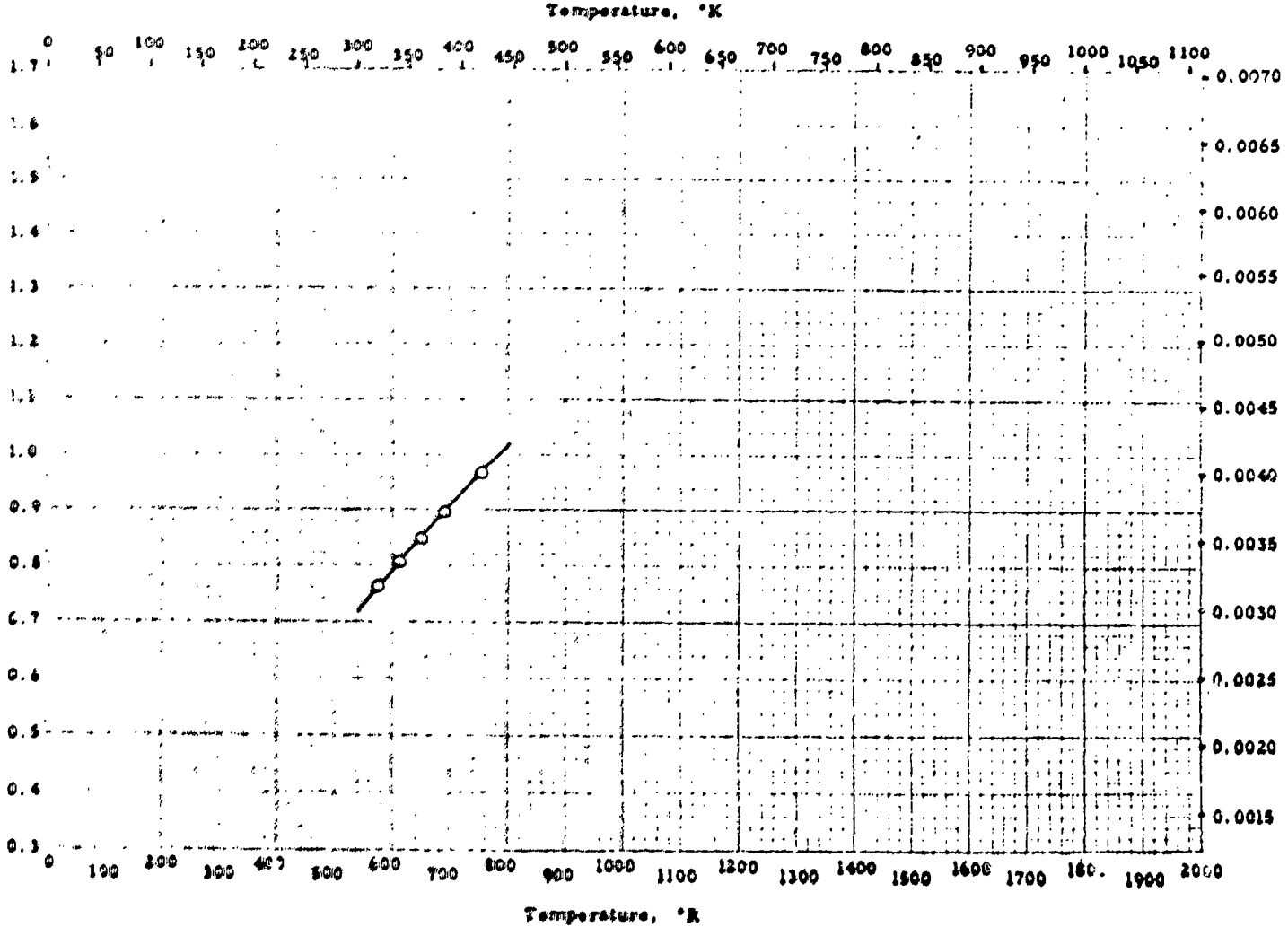


LINEAR THERMAL EXPANSION -- MAGNESIUM ALUMINUM SILICATE GLASSES

LINEAR THERMAL EXPANSION -- MAGNESIUM ALUMINUM SILICATE GLASSES

REFERENCE INFORMATION

Sym.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Hummel, F. A., and Reid, H. W.	51-23	528-1752	24.0% SiO_2; 25.0% MgO; 21.0% Al_2O_3; prepared from c.p. MgO, c.p. Al_2O_3, potter's flint (99.8% SiO_2)	Interferometer	1360°C eutectic MgO · Al_2O_3 · SiO_2
□	Ibid.	51-23	528-1752	61.4% SiO_2; 20.3% MgO; 18.3% Al_2O_3; raw materials same as above	Same as above	1345°C eutectic MgO · Al_2O_3 · SiO_2
△	Ibid.	51-23	528-1752	62.8% SiO_2; 26.65% Al_2O_3; 10.54% MgO; raw materials same as above	Same as above	MgO · Al_2O_3 · 4 SiO_2
◇	Ibid.	51-23	528-1752	71.7% SiO_2; 20.28% Al_2O_3; 8.02% MgO; raw materials same as above	Same as above	MgO · Al_2O_3 · 6 SiO_2
▽	Ibid.	51-23	528-1752	85.86% SiO_2; 13.72% Al_2O_3; 5.42% MgO; raw materials same as above	Same as above	MgO · Al_2O_3 · 10 SiO_2

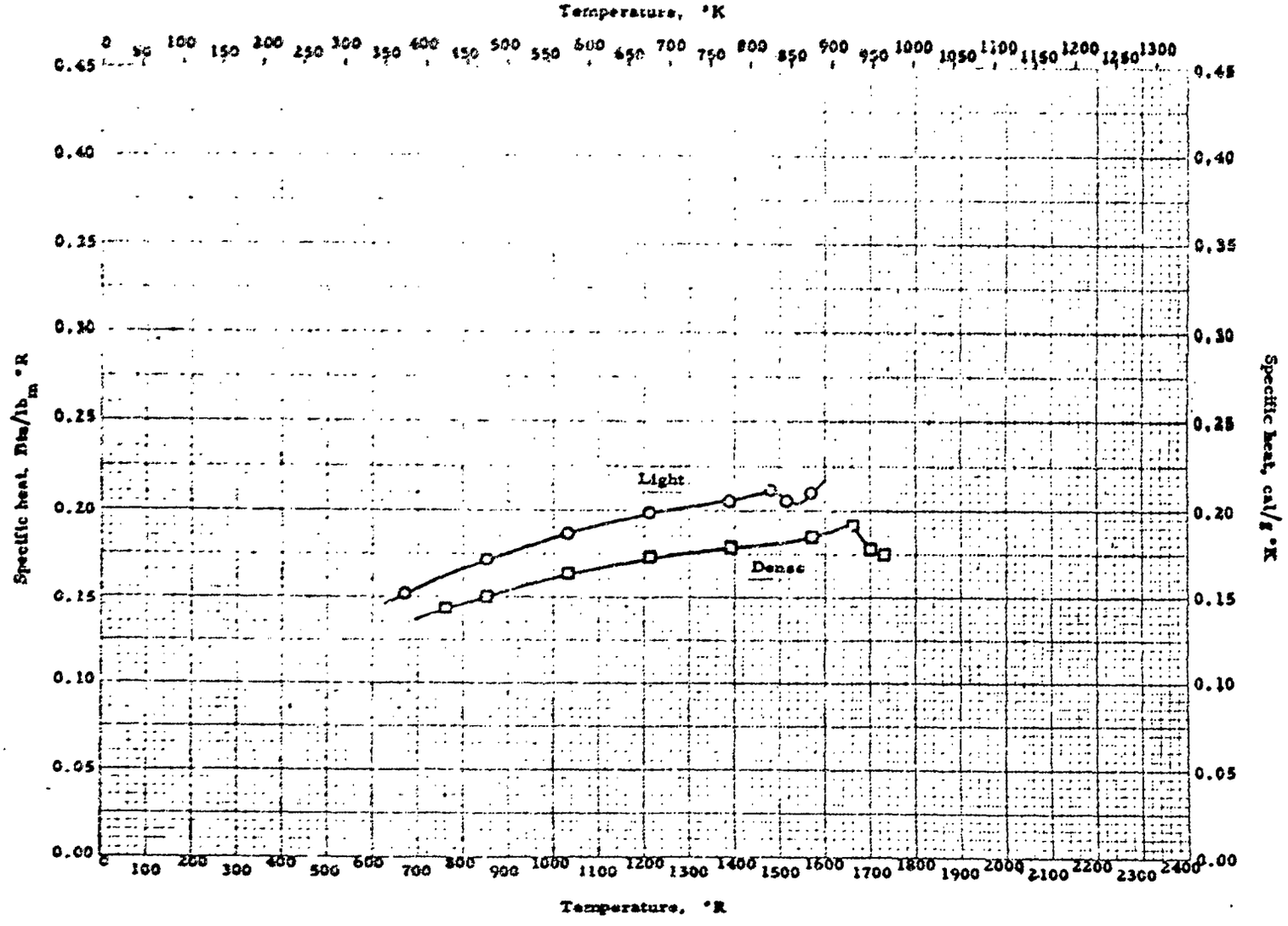


THERMAL CONDUCTIVITY -- LIME WINDOW GLASS

THERMAL CONDUCTIVITY -- LIME WINDOW GLASS

REFERENCE INFORMATION

Sym bol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Koenig, J. H.	53-43	575-760	Lime window glass. American Ceramic Society Standard Glass ρ=155 lb_m/ft^3	Comparative; rod in vacuum; inconel standards	Used Pt alloy glaze for ceramic to metal bond

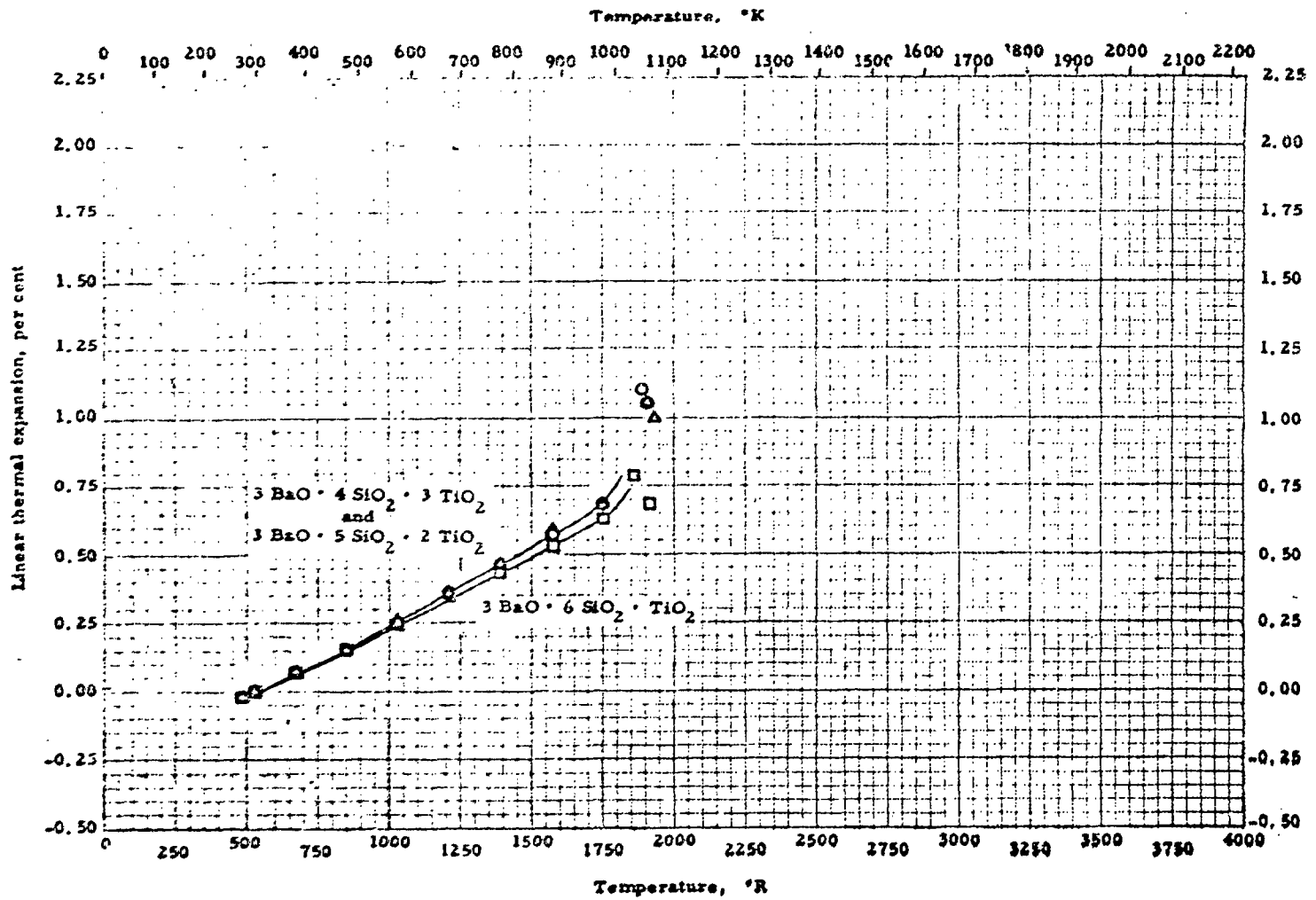


SPECIFIC HEAT -- BARIUM CROWN GLASS

SPECIFIC HEAT -- BARIUM CROWN GLASS

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Prod'homme, M.	55-43	672-1572	Light barium crown glass	Comparative; rate of temp. rise in sample compared with standard under same heating conditions	Auth. believes second-order transformation at 550°C
□	Ibid.	55-43	762-1734	Dense barium crown glass	Same as above	Auth. believes second-order transformation at 650°C



LINEAR THERMAL EXPANSION -- BARIUM TITANIUM SILICATE GLASS

59-157
WADC TR 58-476 772

LINEAR THERMAL EXPANSION -- BARIUM TITANIUM SILICATE GLASS

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Clark, G. W. and Hamilton, E. H.	56-20	492-1914	48.9% BaO; 25.6% SiO_2; 25.5% TiO_2	Interferometer	3 BaO : 4 SiO_2 : 3 TiO_2
△	Ibid.	56-20	492-1932	50.0% BaO; 32.6% SiO_2; 17.4% TiO_2	Same as above	3 BaO : 5 SiO_2 : 2 TiO_2
□	Ibid.	56-20	492-1914	51.1% BaO; 40.0% SiO_2; 8.9% TiO_2	Same as above	3 BaO : 6 SiO_2 : TiO_2

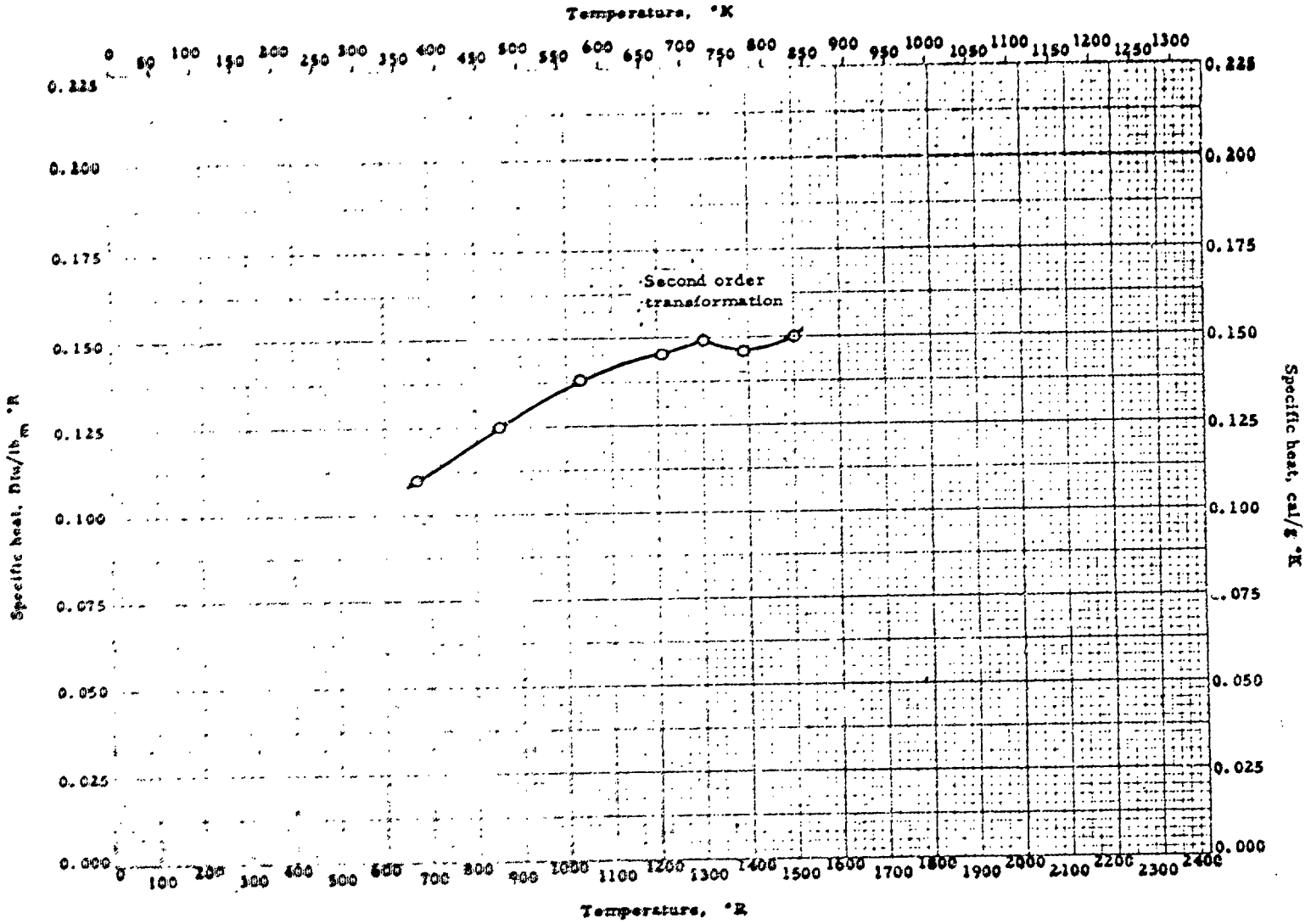
Symbol	Density lb_m/ft^3	Density g/cm^3
○	189.74	3.0394
□	189.64	3.0377
△	190.34	3.0489
◇	190.59	3.0529
▽	191.46	3.0668
○	192.96	3.0909
□	189.64	3.0377
△	190.34	3.0489
◇	190.59	3.0529
▽	191.46	3.0668
◁	192.96	3.0909

DENSITY -- LEAD SILICATE GLASS

DENSITY -- LEAD SILICATE GLASS

REFERENCE INFORMATION

Key No.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Vickery, R. C. and Sedlack, R.	57-197	530-535	"Corning 0120" glass	ρ: pycnometer with water free of CO_2 and air bubbles	
□	Ibid.	57-197	530-535	"Corning 0120" glass + 0.1% Nd_2O_3	ρ: same as above	Ground base glass mixtures were milled, melted, reground, milled, remelted, annealed 4-8 hrs. at 500°C
△	Ibid.	57-197	530-535	"Corning 0120" glass + 0.2% Nd_2O_3	ρ: same as above	Same as above
◇	Ibid.	57-197	530-535	"Corning 0120" glass + 0.5% Nd_2O_3	ρ: same as above	Same as above
▽	Ibid.	57-197	530-535	"Corning 0120" glass + 1.0% Nd_2O_3	ρ: same as above	Same as above
⬡	Ibid.	57-197	530-535	"Corning 0120" glass + 2.0% Nd_2O_3	ρ: same as above	Same as above; auth. also report additional density data for additives of 0.1-2.0% of other rare earth oxides
⊡	Vickery, R. C. and Sedlack, R.	57-187	530-535	"Corning 0120" glass + 0.26% Nd_2O_3	ρ: pycnometer with water free of CO_2	
⊙	Ibid.	57-187	530-535	"Corning 0120" glass + 0.53% Nd_2O_3	ρ: same as above	
⊕	Ibid.	57-187	530-535	"Corning 0120" glass + 1.29% Nd_2O_3	ρ: same as above	
⊗	Ibid.	57-187	530-535	"Corning 0120" glass + 2.50% Nd_2O_3	ρ: same as above	
◭	Ibid.	57-187	530-535	"Corning 0120" glass + 4.96% Nd_2O_3	ρ: same as above	Auth. also report additional density data for additives of 0.1-2.0% of other rare earth oxides



SPECIFIC HEAT -- DENSE FLINT GLASS

WADC TR 58-476 115 60-771

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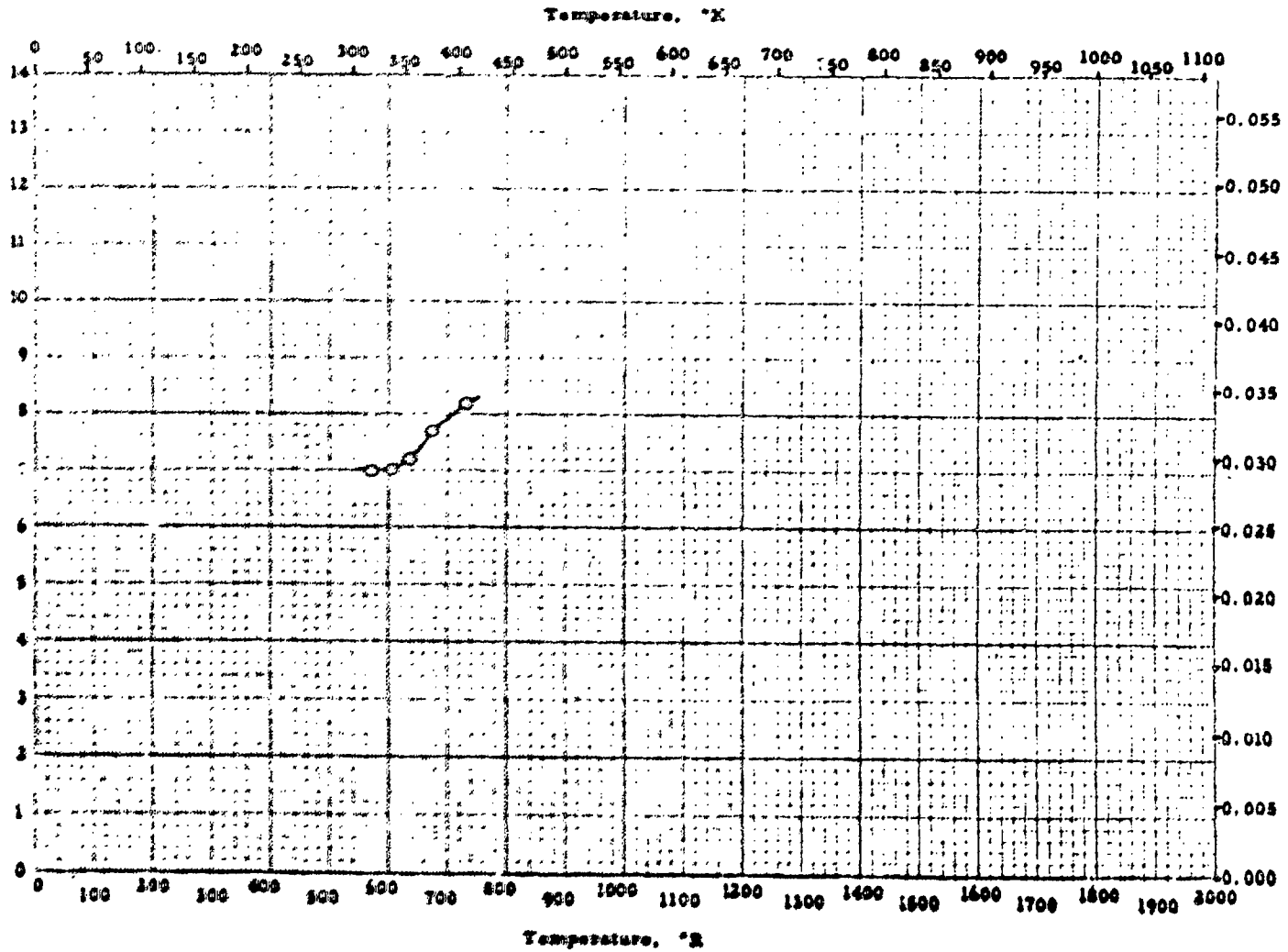
SPECIFIC HEAT -- DENSE FLINT GLASS

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Prod'homme, M.	55-43	672-1540	Very dense flint glass	Thermal analysis, silica reference	

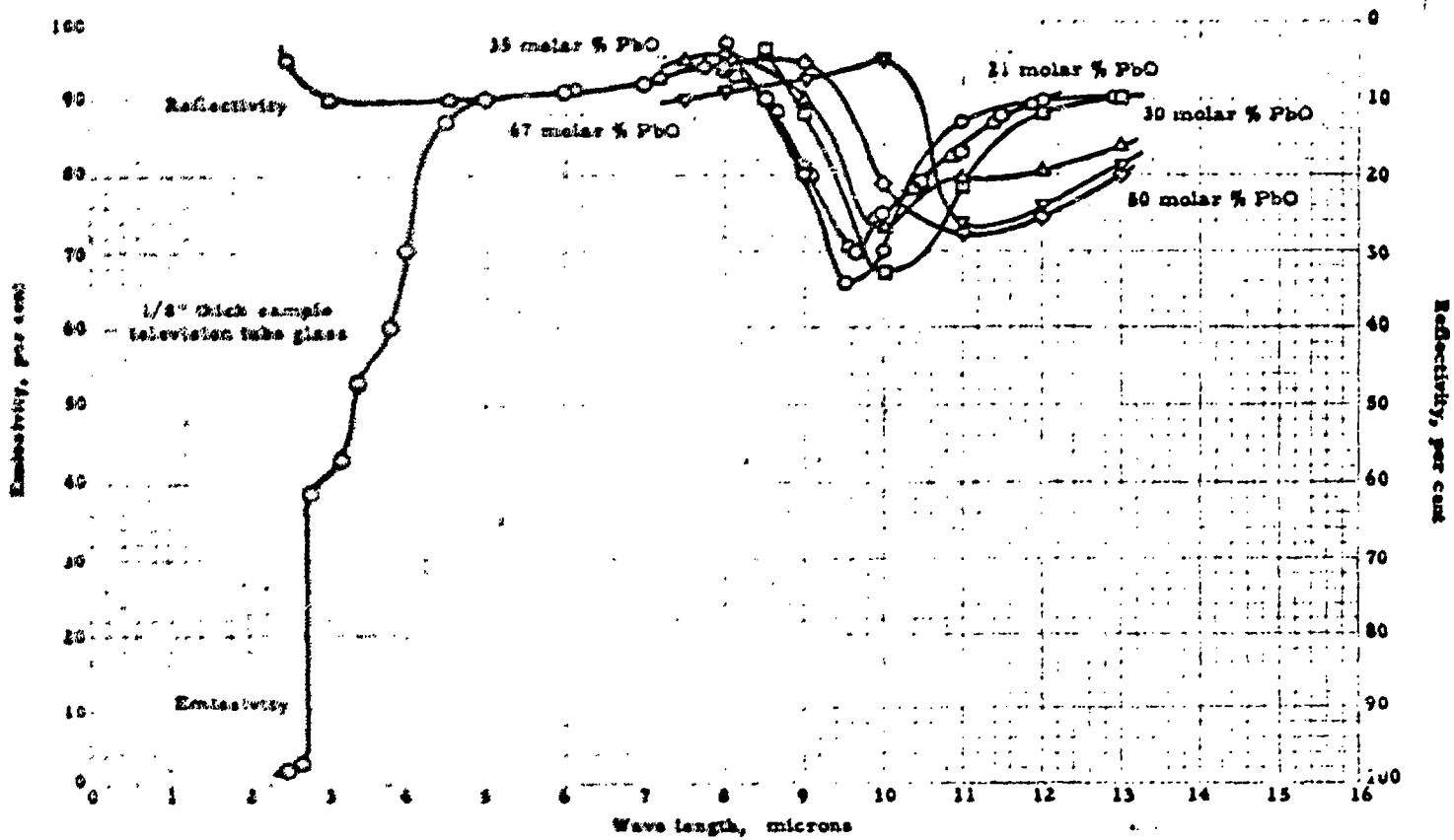


THERMAL CONDUCTIVITY -- LEAD SILICATE GLASS

THERMAL CONDUCTIVITY -- LEAD SILICATE GLASS

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Koenig, J. H.	53-63	570-740	Lead glass - American Ceramic Soc. standard glass ρ = 3.04 g/cm³	Comparative: rods in vacuum; inconel standard	Used Pt alloy glaze for ceramic to metal bond



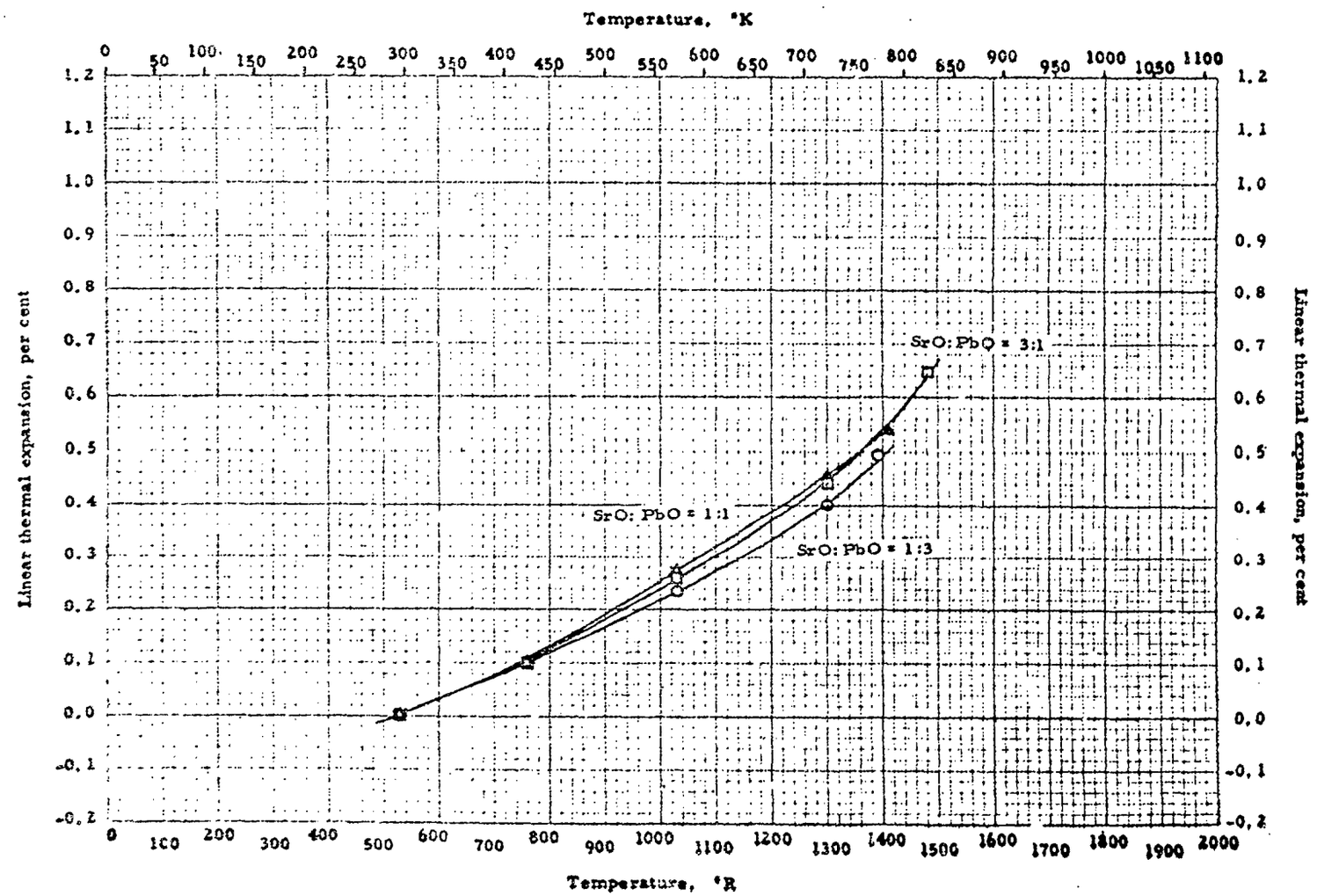
SPECTRAL EMISSIVITY--LEAD SILICATE GLASS

WADC TR 59-676

SPECTRAL EMISSIVITY -- LEAD SILICATE GLASS

REFERENCE INFORMATION

Sym.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Fiorilenkaya, V. A.	51-146	Room	Average optical flint glass, 21 molar% PbO	Spectral reflectivity at 13°; compared reflection from sample with aluminum standard mirror by thermopile	Repolished before experiment; author reports fine structure on small scale graphs
□	Ibid.	51-146	Room	Heavy optical flint glass, 10 molar% PbO	Same as above	Same as above
△	Ibid.	51-146	Room	Heavy optical flint glass, 15 molar% PbO	Same as above	Same as above
◇	Ibid.	51-146	Room	Heavy optical flint glass, 50 molar% PbO	Same as above	Same as above
▽	Ibid.	51-146	Room	Heavy optical flint glass, 66.66 molar% PbO	Same as above	Same as above
○	McMahon, H.	51-82	1460	Television tube glass containing approx. 30% lead oxide	Spectral emissivity: Perkin-Elmer spectrometer and thermocouple	1/8 in. thick at 1000°F
□	Ibid.	51-82	1460	Same as above	Spectral reflectivity: computed from measurement of spectral transmissivity and spectral emissivity above	Same as above; Reflectivity = 1-transmissivity-emissivity

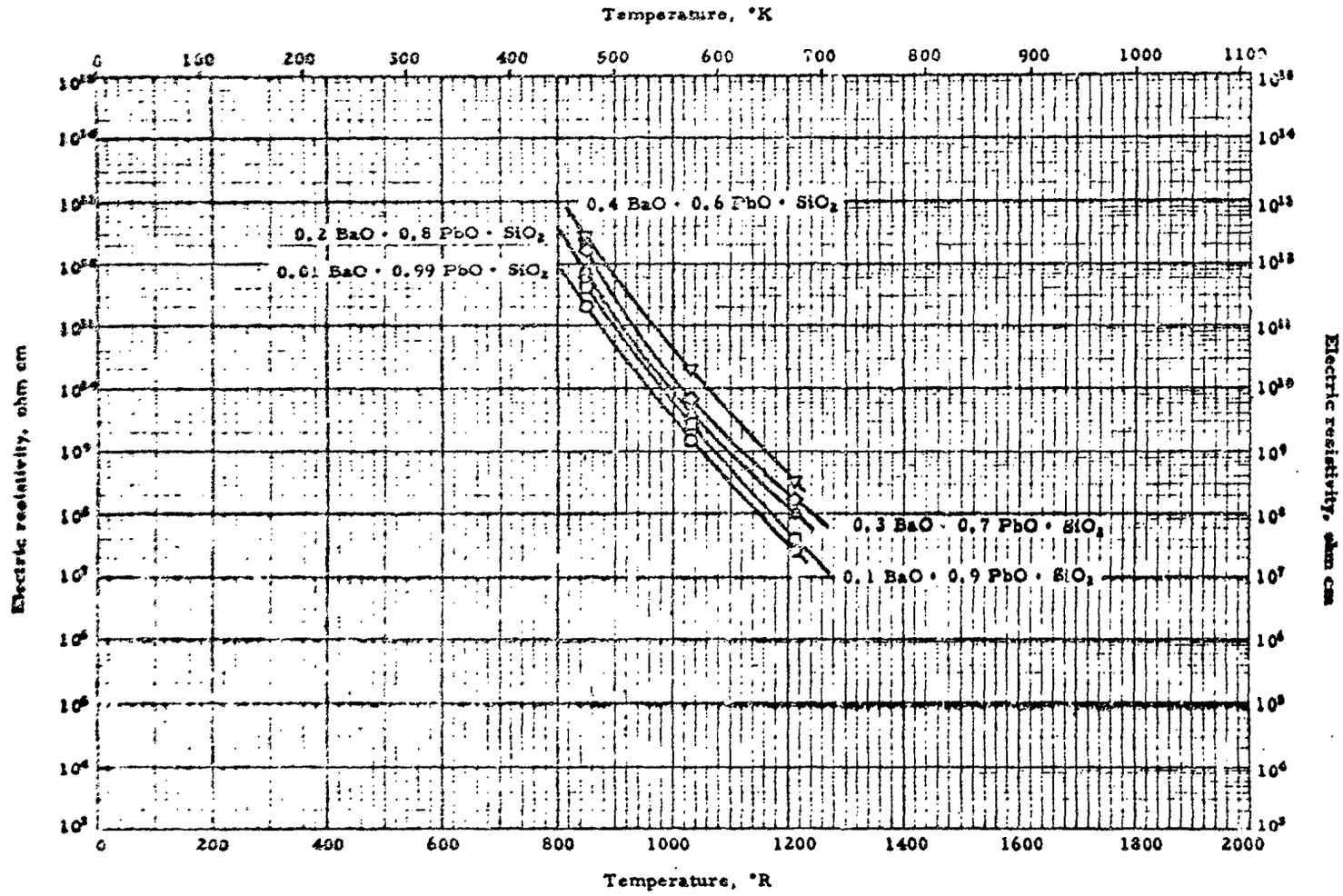


LINEAR THERMAL EXPANSION -- LEAD STRONTIUM SILICATE GLASS

LINEAR THERMAL EXPANSION -- LEAD STRONTIUM SILICATE GLASS

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Karkhanevala, M.D. and Hummel, F. A.	52-32	528-1390	54.1% SiO_2; 30% PbO; 11.2% Na_2O; 4.7% SrO	Interferometer and vitreous silica dilatometer	Cast, annealed. $Na_2O \cdot 0.25SrO \cdot 0.75PbO \cdot 5SiO_2$
△	Ibid.	52-32	528-1410	57.2% SiO_2; 21.2% PbO; 11.8% Na_2O; 9.8% SrO	Same as above	Cast, annealed. $Na_2O \cdot 0.5SrO \cdot 0.5PbO \cdot 5SiO_2$
□	Ibid.	52-32	528-1482	60.5% SiO_2; 15.7% SrO; 12.5% Na_2O; 11.3% PbO	Same as above	Cast, annealed. $Na_2O \cdot 0.75SrO \cdot 0.25PbO \cdot 5SiO_2$

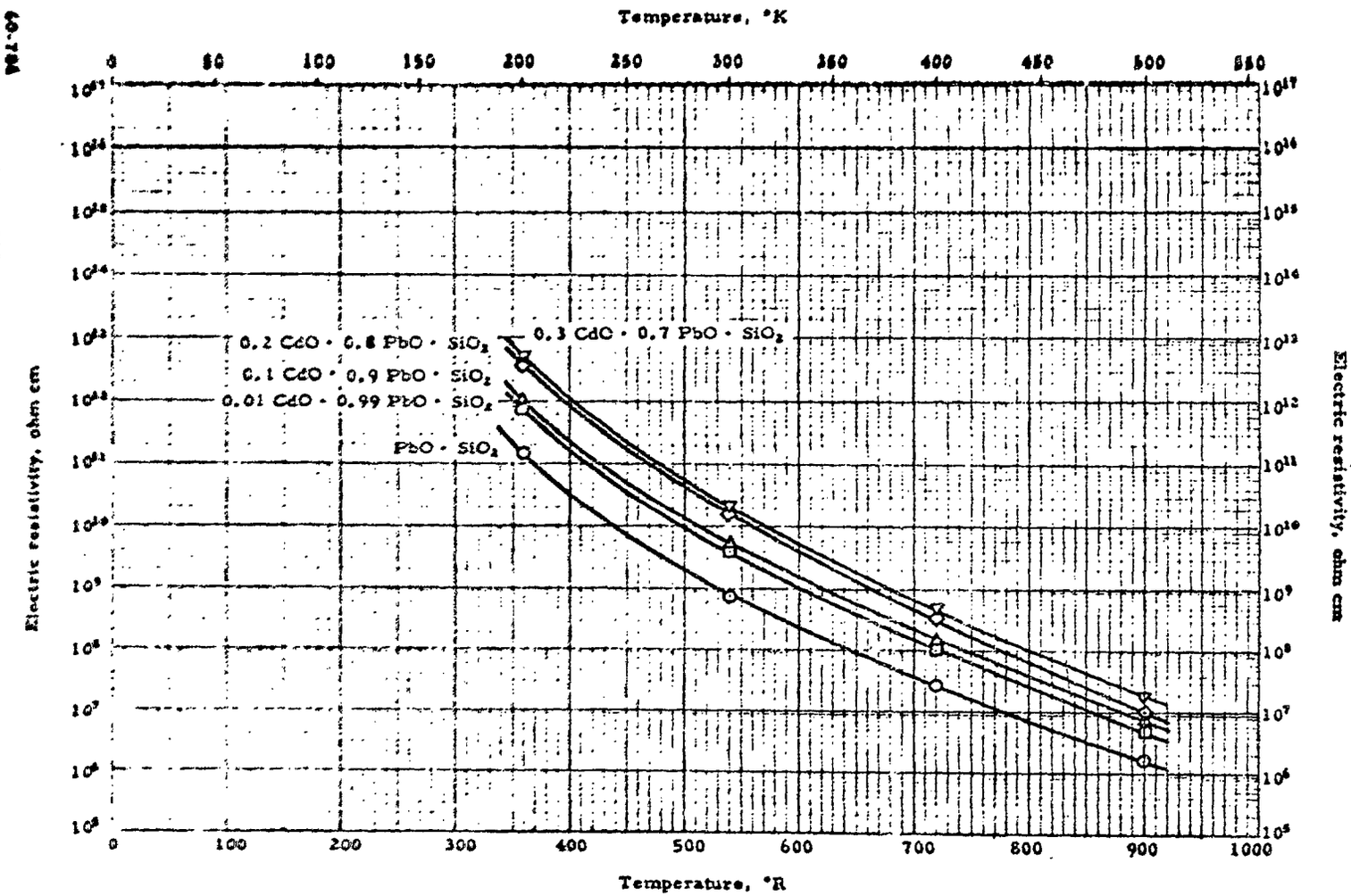


ELECTRIC RESISTIVITY -- BARIUM LEAD SILICATE GLASS

ELECTRIC RESISTIVITY -- BARIUM LEAD SILICATE GLASS

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Strauss, S. W., Moore, D. C. et al.	56-69	852-1212	0.01 BaO · 0.99 PbO · SiO_2	Potential drop; DC reversal; temp. by Fe-Const thermocouple	Made from reagent grade materials; ground, melted, cast, annealed overnight, ground flad. Heated at 10 °C/min
□	Ibid.	56-69	852-1212	0.1 BaO · 0.9 PbO · SiO_2	Same as above	Same as above
△	Ibid.	56-69	852-1212	0.2 BaO · 0.8 PbO · SiO_2	Same as above	Same as above
◇	Ibid.	56-69	852-1212	0.3 BaO · 0.7 PbO · SiO_2	Same as above	Same as above
▽	Ibid.	56-69	852-1212	0.4 BaO · 0.6 PbO · SiO_2	Same as above	Same as above

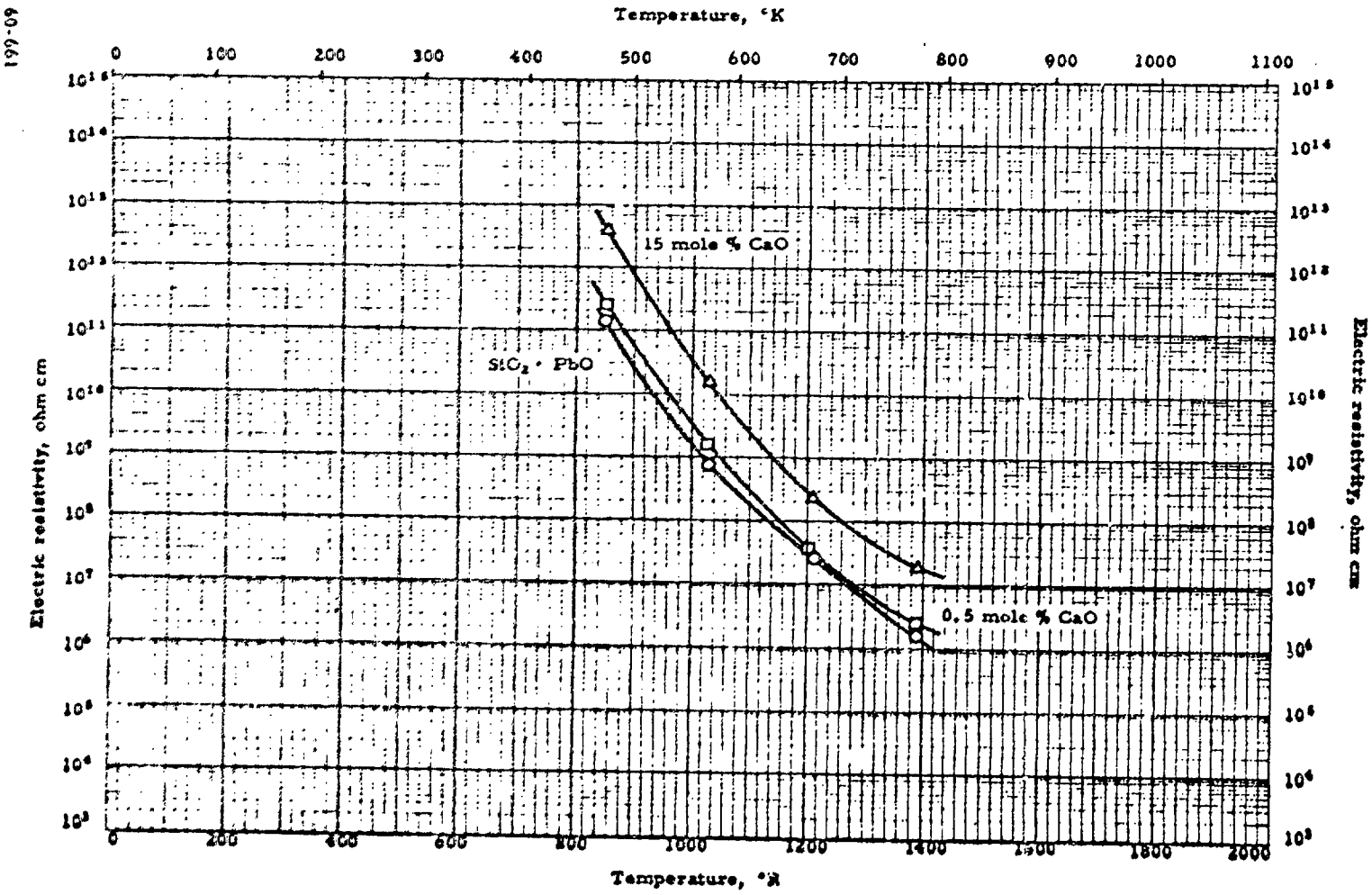


ELECTRIC RESISTIVITY -- CADMIUM LEAD SILICATE GLASS

ELECTRIC RESISTIVITY -- CADMIUM LEAD SILICATE GLASS

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	National Bureau of Standards	53-143	360-900	$PbO \cdot SiO_2$	Potential drop; DC reversal	
□	Ibid.	53-143	360-900	$0.01\ CdO \cdot 0.99\ PbO \cdot SiO_2$	Same as above	
△	Ibid.	53-143	360-900	$0.1\ CdO \cdot 0.9\ PbO \cdot SiO_2$	Same as above	
◇	Ibid.	53-143	360-900	$0.2\ CdO \cdot 0.8\ PbO \cdot SiO_2$	Same as above	
▽	Ibid.	53-143	360-900	$0.3\ CdO \cdot 0.7\ PbO \cdot SiO_2$	Same as above	

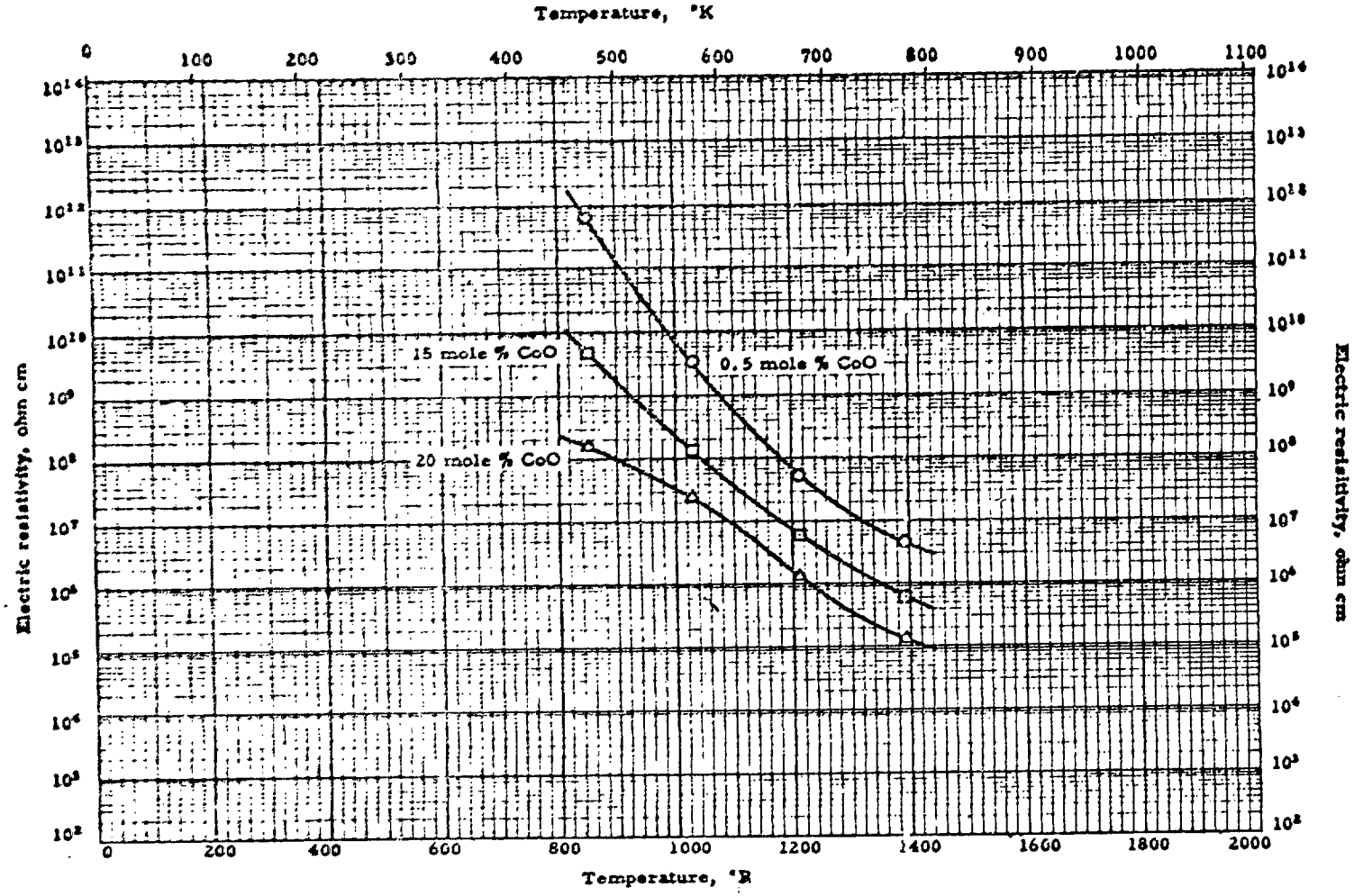


ELECTRIC RESISTIVITY -- CALCIUM LEAD SILICATE GLASS

ELECTRIC RESISTIVITY -- CALCIUM LEAD SILICATE GLASS

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Strauss, S. W., Moore, D. G. et al.	53-143 also 56-69	852-1392	SiO_2 · PbO	Potential drop, DC reversal. Sample temperature by Fe-Const thermocouple	Ground from reagent grade materials, melted, cast, annealed overnight, ground flat. Heated at 10°C/min.
□	Ibid.	53-143 also 56-69	852-1392	50.0% SiO_2 ; 49.5% PbO; 0.5% CaO (Mole %)	Same as above	Same as above
△	Ibid.	53-143 also 56-69	852-1392	50.0% SiO_2 ; 35% PbO; 15% CaO (Mole %)	Same as above	Same as above

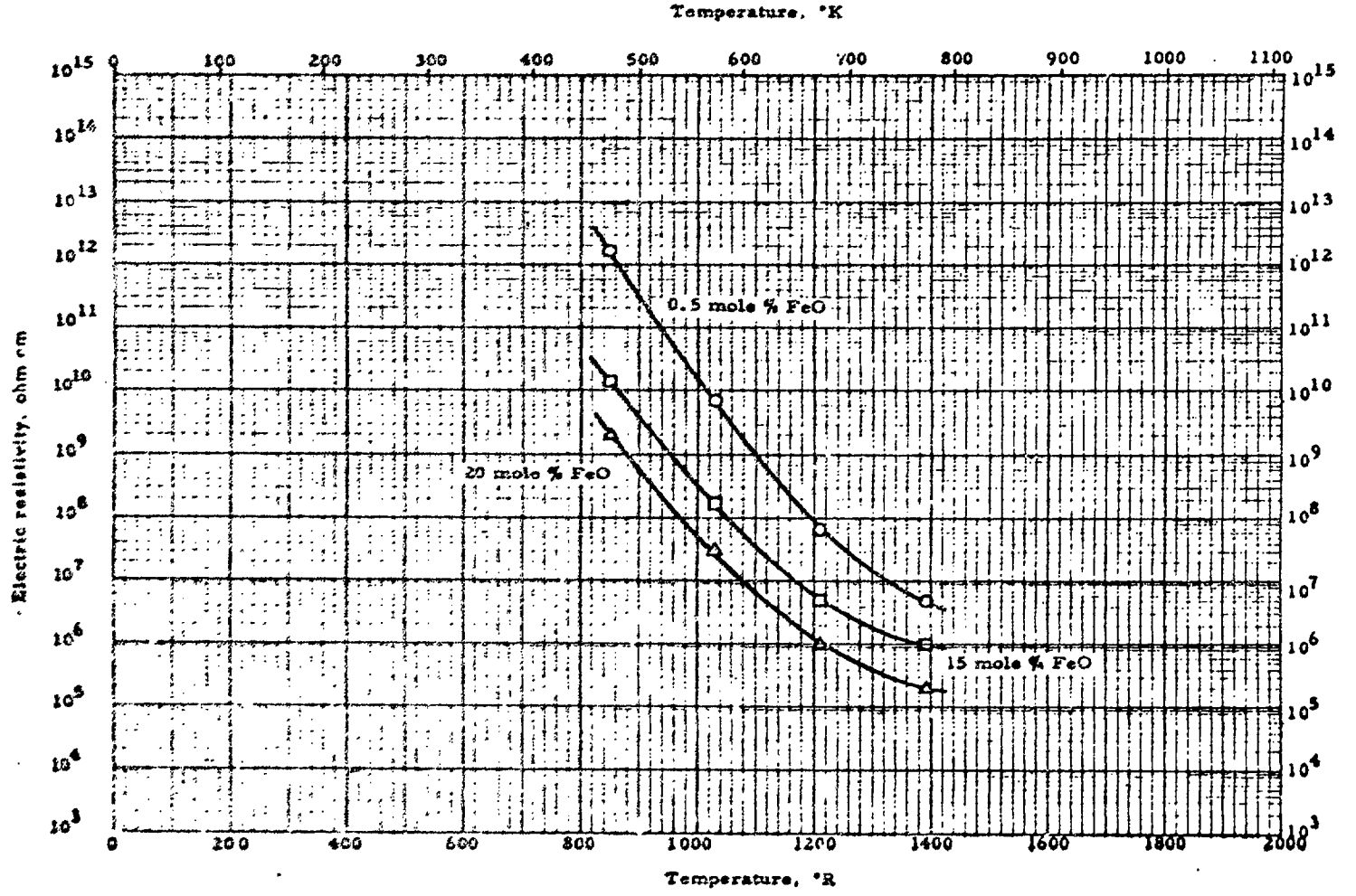


ELECTRIC RESISTIVITY -- COBALT-LEAD SILICATE GLASS

ELECTRIC RESISTIVITY -- COBALT-LEAD SILICATE GLASS

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Strauss, S. W., Moore, D. G. et al.	56-69 also 54-145	852-1392	50.0% SiO_2 ; 49.5% PbO; 0.5% CoO (Mole %)	Potential drop; DC reversal; sample temp. by Fe-Const.thermocouple	Ground from reagent grade materials, melted, cast, annealed overnight, ground flat. Heated at 10° C/min.
□	Ibid.	56-69 also 54-145	852-1392	50.0% SiO_2 ; 35% PbO; 15% CoO (Mole %)	Same as above	Same as above
△	Ibid.	56-69 also 54-145	852-1392	50.0% SiO_2 ; 30% PbO; 20% CoO (Mole %)	Same as above	Same as above

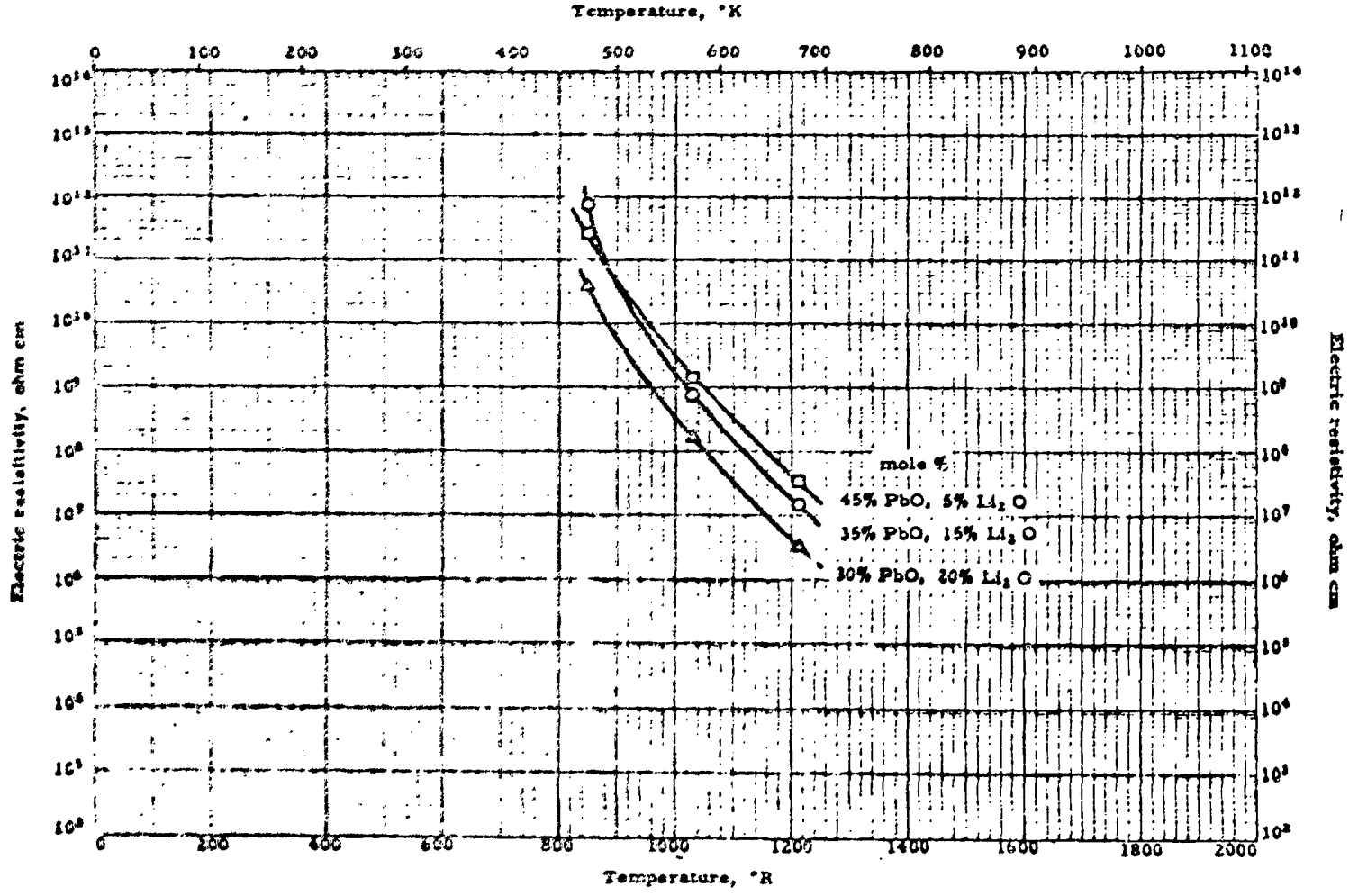


ELECTRIC RESISTIVITY -- IRON LEAD SILICATE GLASS

ELECTRIC RESISTIVITY -- IRON LEAD SILICATE GLASS

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Strauss, S. W., Moore, D. G. et al.	56-69	852-1392	50.0% SiO_2; 49.5% PbO; 0.5% FeO (Mole %)	Potential drop; DC reversal; sample temp. by Fe-Const thermocouple	Ground from reagent grade materials, melted, cast, annealed overnight, ground flat. Heated at 10°C/min
□	Ibid.	56-69	852-1392	50.0% SiO_2; 35% PbO; 15% FeO (Mole %)	Same as above	Same as above
△	Ibid.	56-69	852-1392	50.0% SiO_2; 30% PbO; 20% FeO (Mole %)	Same as above	Same as above

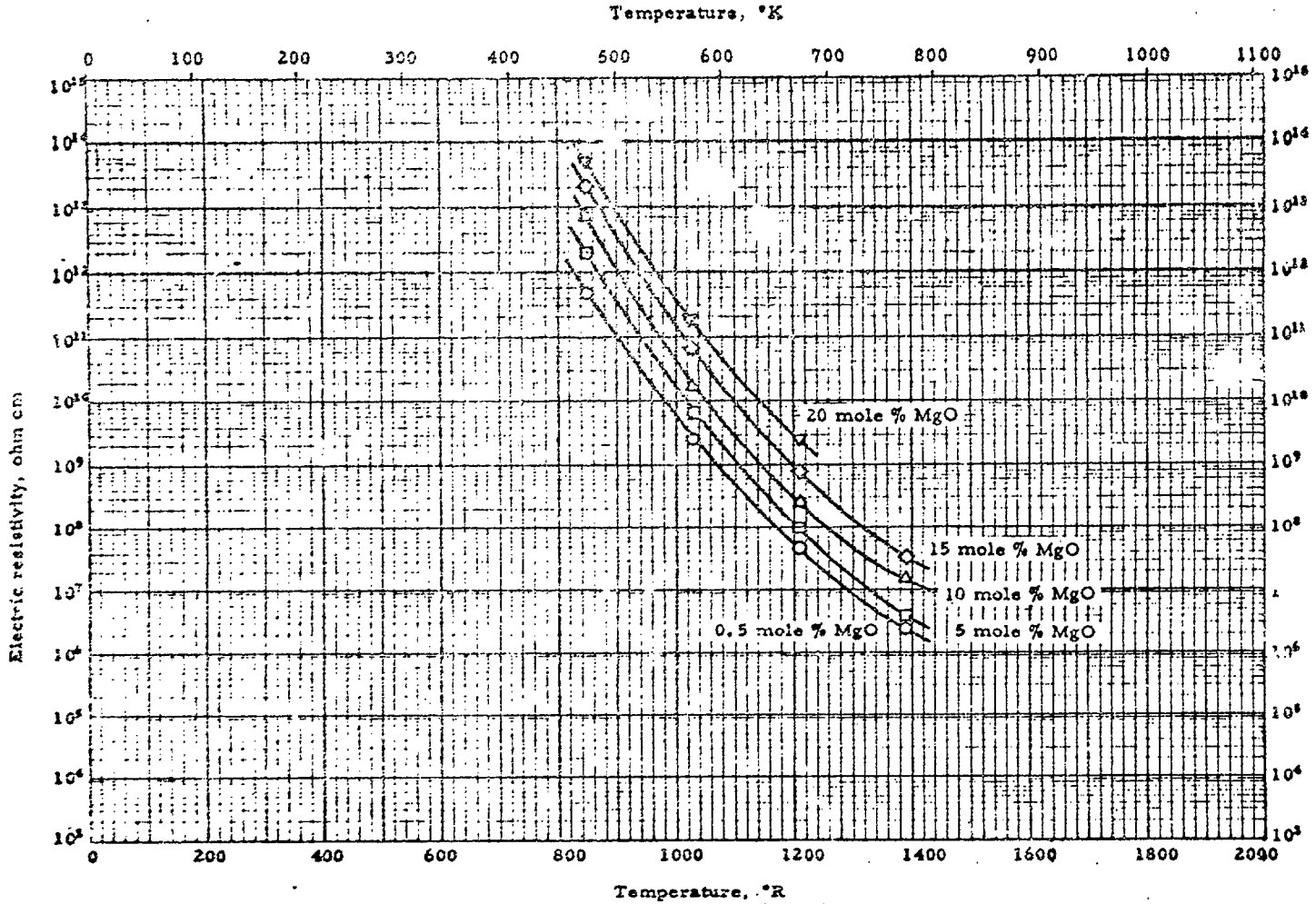


ELECTRIC RESISTIVITY -- LITHIUM LEAD SILICATE GLASS

ELECTRIC RESISTIVITY -- LITHIUM LEAD SILICATE GLASS

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Strauss, S. W., Moore, D. C. et al.	56-69	852-1212	50% SiO_2; 35% PbO; 15% Li_2O (Mole %)	Potential drop; DC reversal; sample temp. by Fe-Const.thermocouple	Ground from reagent grade chemicals, melted, cast, annealed over night, ground flat, heated at 10° C/min.
□	Ibid.	56-69	852-1212	50% SiO_2; 45% PbO; 5% Li_2O (Mole %)	Same as above	Same as above
△	Ibid.	56-69	852-1212	50% SiO_2; 30% PbO; 20% Li_2O (Mole %)	Same as above	Same as above; auth. report additional detailed data for system (0.01 - 0.4) $Li_2O \cdot$ (0.99 - 0.6) $PbO \cdot SiO_2$

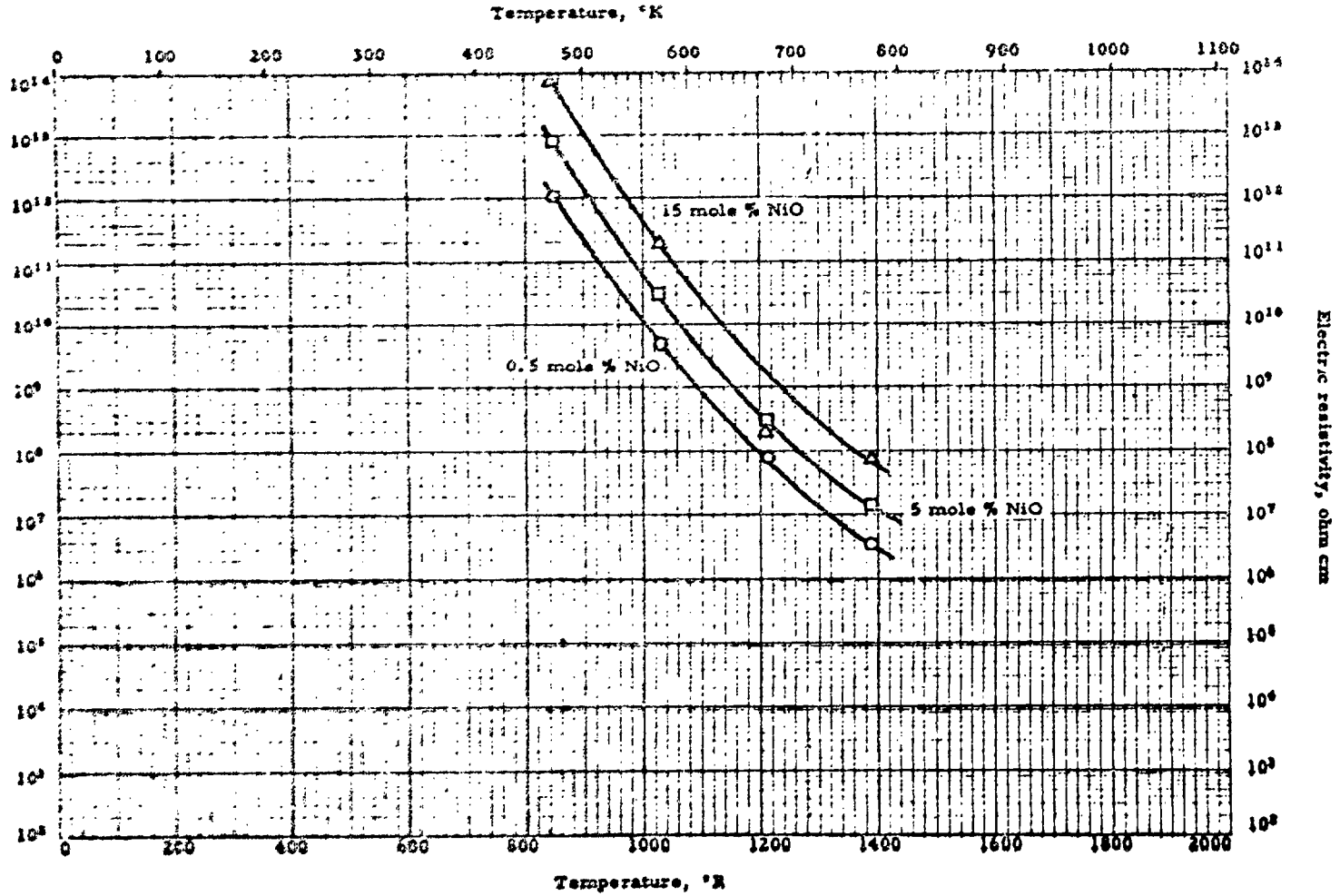


ELECTRIC RESISTIVITY -- MAGNESIUM LEAD SILICATE GLASS

ELECTRIC RESISTIVITY -- MAGNESIUM LEAD SILICATE GLASS

REFERENCE INFORMATION

	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Strawe, S. W., Moore, D. G. et al.	56-69 also 53-143	852-1392	SiO_2 + 0.99 PbO + 0.01 MgO	Potential drop, DC reversal; sample temp. by Fe-Const thermocouple	Ground from reagent grade materials, melted, cast, annealed overnight, ground flat Heated at 10° C/min.
□	Ibid.	56-69 also 53-143	852-1392	SiO_2 + 0.9 PbO + 0.1 MgO	Same as above	Same as above
△	Ibid.	56-69 also 53-143	852-1392	SiO_2 + 0.8 PbO + 0.2 MgO	Same as above	Same as above
◇	Ibid.	56-69 also 53-143	852-1392	SiO_2 + 0.7 PbO + 0.3 MgO	Same as above	Same as above
▽	Ibid.	56-69 also 53-143	852-1392	SiO_2 + 0.6 PbO + 0.4 MgO	Same as above	Same as above



ELECTRIC RESISTIVITY -- NICKEL-LEAD SILICATE GLASS

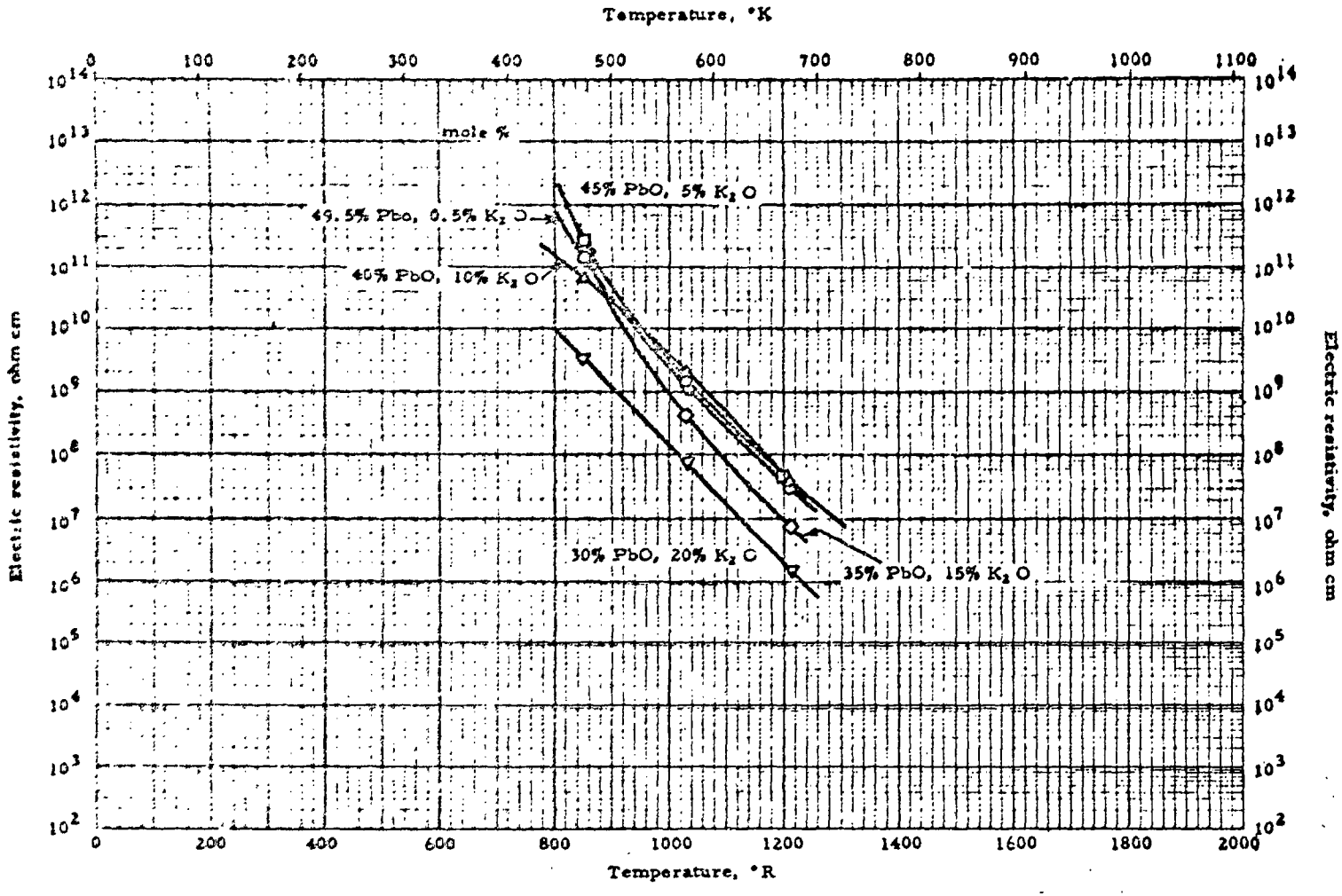
50-580 VANT TR 54-416 797

VII - C - 1

ELECTRIC RESISTIVITY -- NICKEL-LEAD SILICATE GLASS

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	National Bureau of Standards	54-145 also 56-69	852-1392	50.0% SiO_2; 49.5% PbO; 0.5% NiO (Mole %)	Potential drop; DC reversal; sample temp. by Fe-Const. thermocouple	
□	Ibid.	54-145 also 56-69	852-1392	50.0% SiO_2; 45% PbO; 5% NiO (Mole %)	Same as above	
△	Ibid.	54-145 also 56-69	852-1392	50.0% SiO_2; 35% PbO; 15% NiO (Mole %)	Same as above	

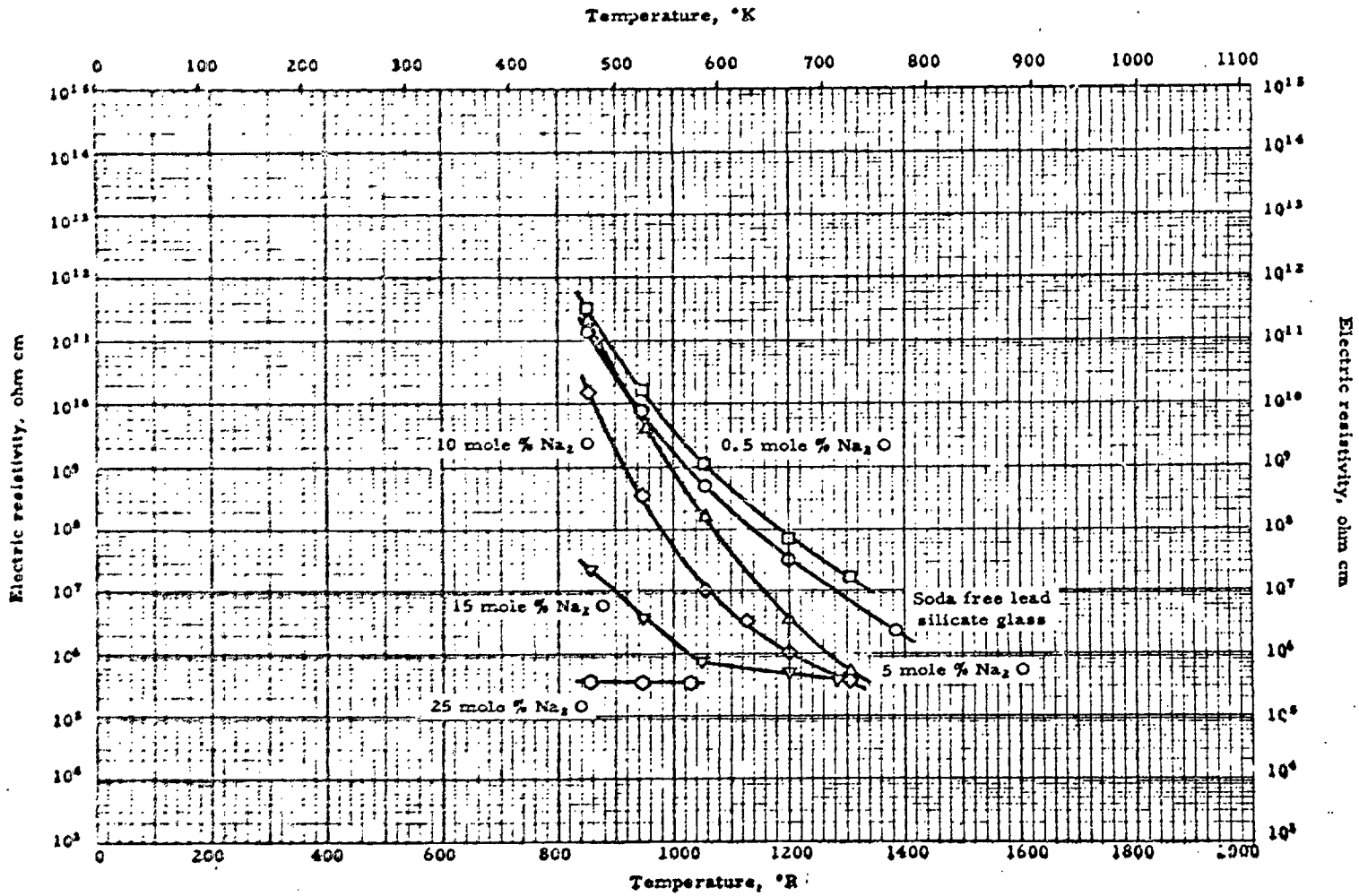


ELECTRIC RESISTIVITY -- POTASSIUM LEAD SILICATE GLASS

ELECTRIC RESISTIVITY -- POTASSIUM LEAD SILICATE GLASS

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °K	Material Composition	Test Method	Remarks
○	Strauss, S. W., Moore, D. G. et al.	56-69	852-1212	50.0% SiO_2 ; 49.5% PbO; 0.5% K_2O (mole %)	Potential drop; DC reversal; sample temp. by Fe-Const thermocouple	Ground from reagent grade materials, melted, cast, annealed overnight, ground flat. Heated at 10°C/min
□	Ibid.	56-69	852-1212	50.0% SiO_2 ; 45% PbO; 5% K_2O (mole %)	Same as above	Same as above
△	Ibid.	56-69	852-1212	50.0% SiO_2 ; 40% PbO; 10% K_2O (mole %)	Same as above	Same as above
◇	Ibid.	56-69	852-1212	50.0% SiO_2 ; 35% PbO; 15% K_2O (mole %)	Same as above	Same as above
▽	Ibid.	56-69	852-1212	50.0% SiO_2 ; 30% PbO; 20% K_2O (mole %)	Same as above	Same as above

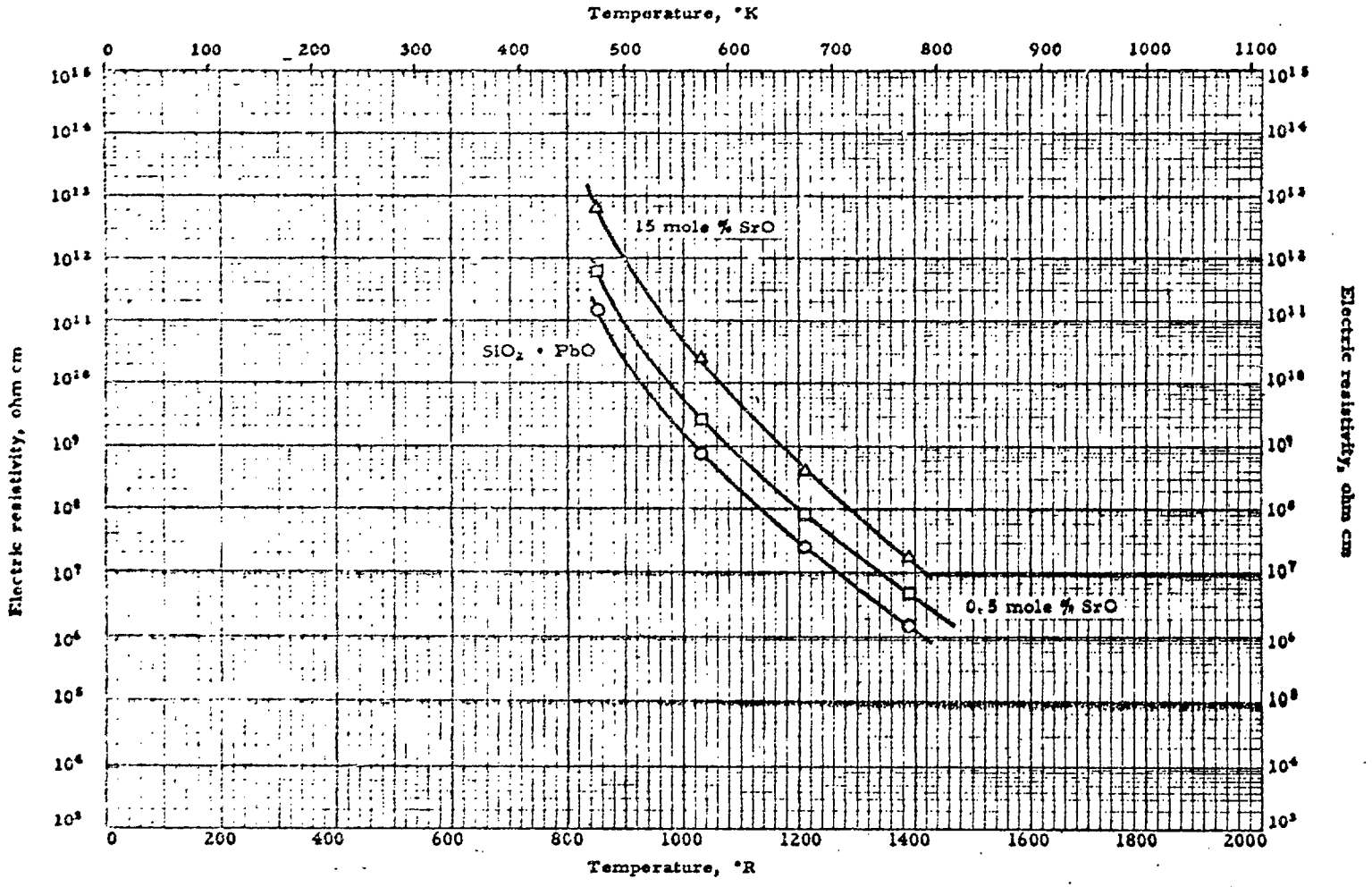


ELECTRIC RESISTIVITY -- SODIUM LEAD SILICATE GLASS

ELECTRIC RESISTIVITY -- SODIUM LEAD SILICATE GLASS

REFERENCE INFORMATION

	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Strauss, S. W., Moore, D. G. et al.	56-69 also 53-96 also 53-142	857-1392	50% SiO_2; 50% PbO (Mole %)	Potential drop; DC reversal	
□	Ibid.	56-69 also 53-96 also 53-142	857-1304	50% SiO_2; 49.5% PbO; 0.5% NaO_2 (Mole%)	Same as above	
△	Ibid.	56-69 also 53-96 also 53-142	857-1304	50% SiO_2; 45% PbO; 5% Na_2O (Mole %)	Same as above	
◇	Ibid.	56-69 also 53-96 also 53-142	857-1304	50% SiO_2; 40% PbO; 10% Na_2O (Mole %)	Same as above	
▽	Ibid.	56-69 also 53-96 also 53-142	857-1304	50% SiO_2; 35% PbO; 15% Na_2O (Mole %)	Same as above	
O	Ibid.	56-69 also 53-96 also 53-142	857-1026	50% SiO_2; 25% PbO; 25% Na_2O (Mole %)	Same as above	Auth. report additional detailed data for system (1-0.2)PbO: (0-0.8)Na_2O:1.0 SiO_2

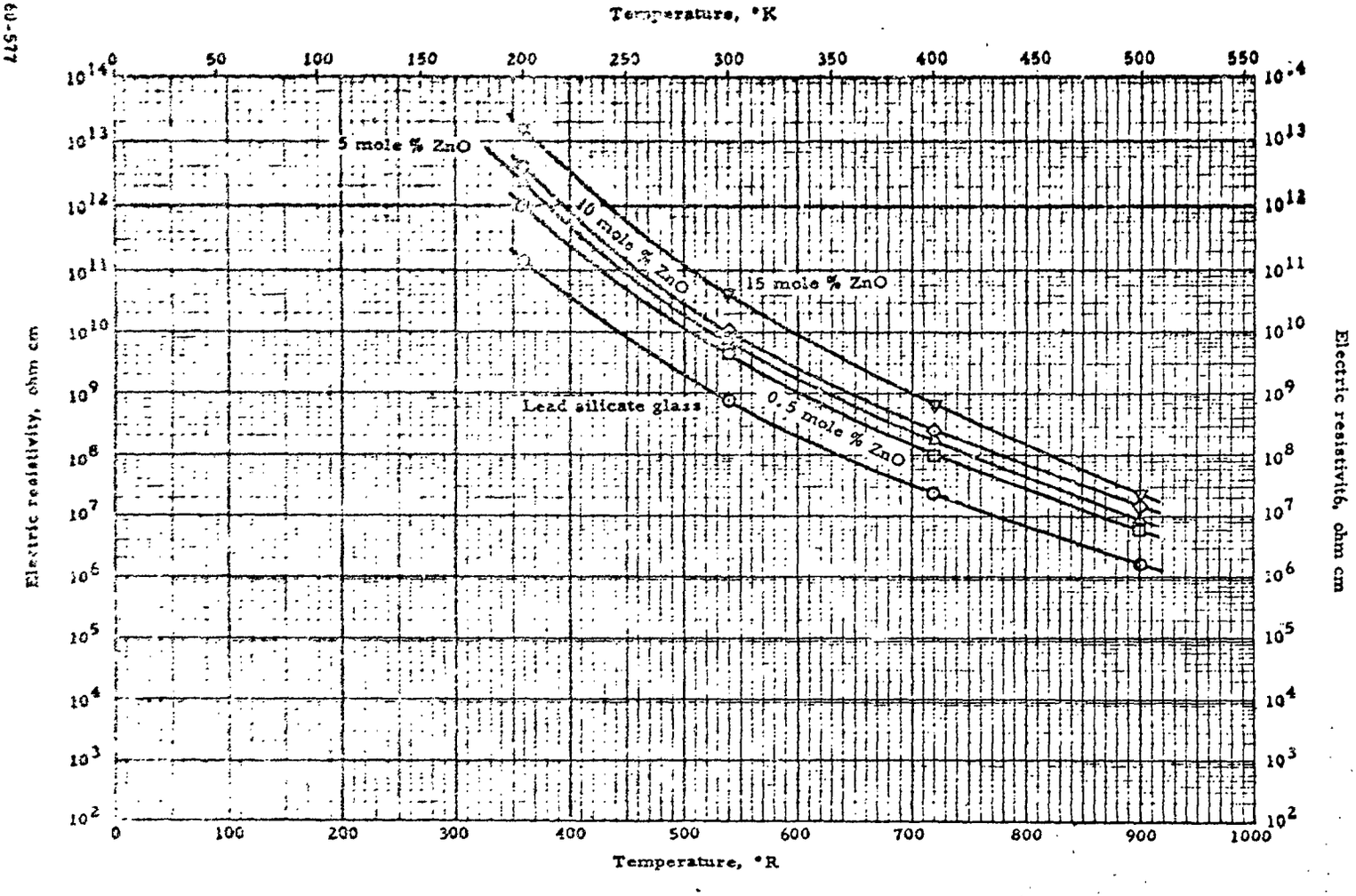


ELECTRIC RESISTIVITY -- STRONTIUM LEAD SILICATE GLASS

ELECTRIC RESISTIVITY -- STRONTIUM LEAD SILICATE GLASS

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Strauss, S. W., Moore, D. G., et al.	56-69 also 53-143	852-1392	SiO_2 · PbO	Potential drop, D C reversal; sample temp. by Fe-Const. thermocouple	Ground from reagent grade materials, melted, cast, annealed overnight, ground flat. Heated at 10°C/min.
□	Ibid.	56-69 also 53-143	852-1392	50.0% SiO_2 ; 49.5% PbO; 0.5% SrO (Mole %)	Same as above	Same as above
△	Ibid.	56-69 also 53-143	852-1392	50% SiO_2 ; 35% PbO; 15% SrO (Mole %)	Same as above	Same as above

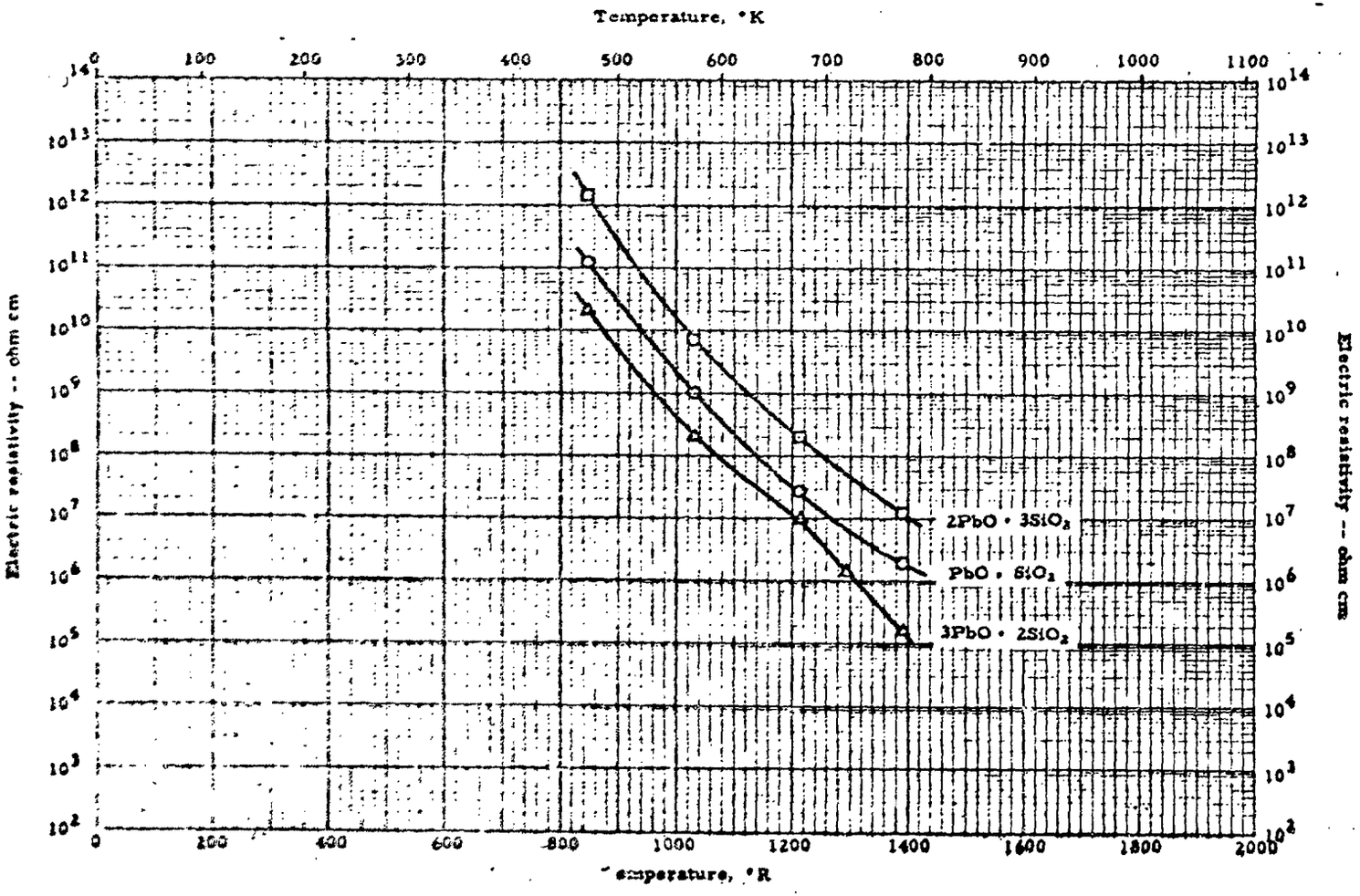


ELECTRIC RESISTIVITY -- ZINC LEAD SILICATE GLASS

ELECTRIC RESISTIVITY -- ZINC LEAD SILICATE GLASS

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	National Bureau of Standards	53-143	360-900	SiO_2 · PbO	Potential drop; DC reversal	
□	Ibid.	53-143	360-900	50.0% SiO_2; 49.5% PbO; 0.5% ZnO (Mole %)	Same as above	
△	Ibid.	53-143	360-900	50% SiO_2; 45% PbO; 5% ZnO (Mole %)	Same as above	
◇	Ibid.	53-143	360-900	50% SiO_2; 40% PbO; 10% ZnO (Mole%)	Same as above	
▽	Ibid.	53-143	360-900	50% SiO_2; 35% PbO; 15% ZnO (Mole %)	Same as above	



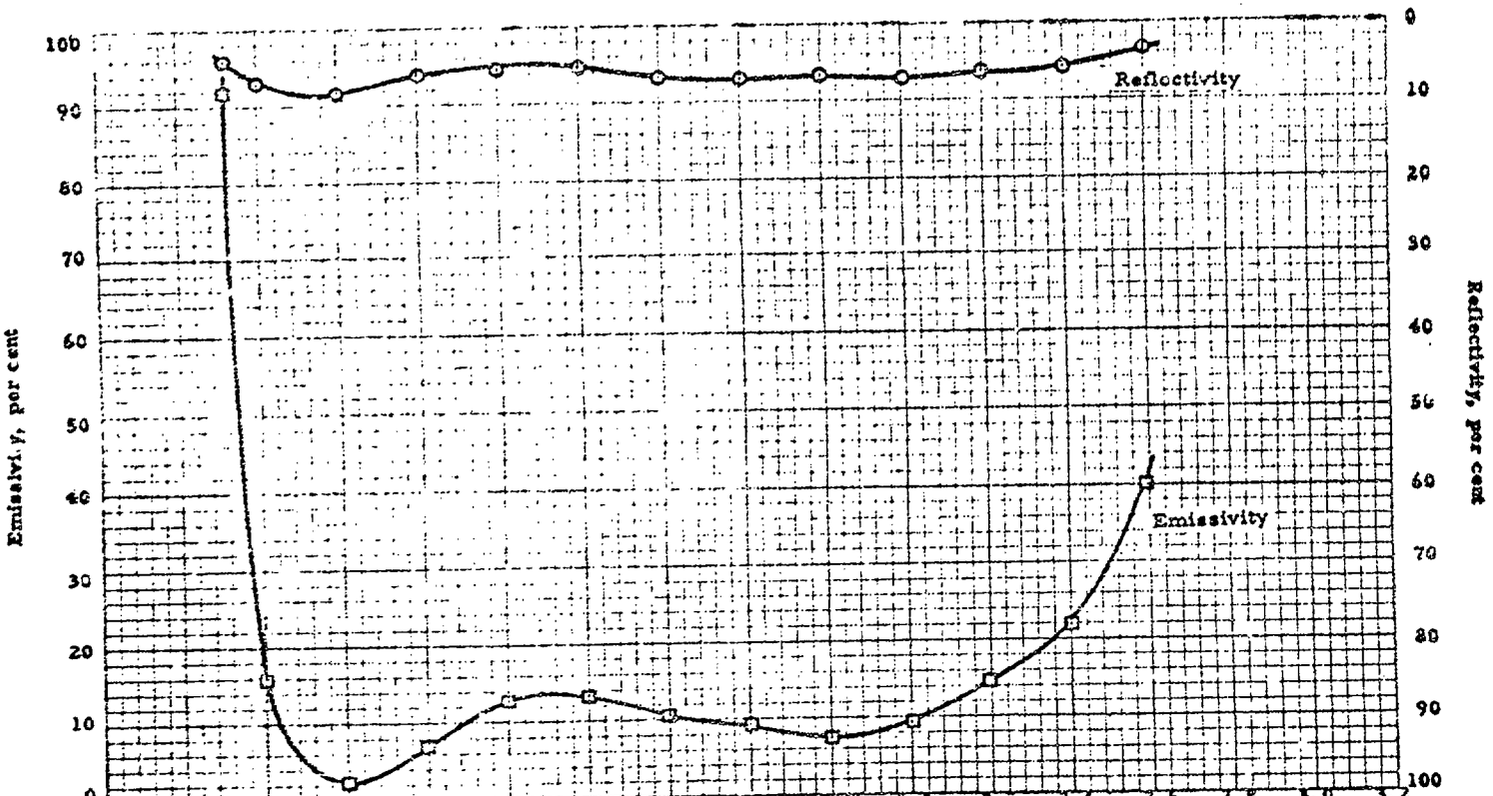
ELECTRIC RESISTIVITY -- LEAD SILICATE GLASS

ELECTRIC RESISTIVITY -- LEAD SILICATE GLASS

REFERENCE INFORMATION

Sym.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	National Bureau of Standards	53-96	852-1392	$PbO \cdot SiO_2$	Potential drop; DC reversal	High purity material
□	Ibid.	53-96	852-1392	$2PbO \cdot 3SiO_2$	Same as above	Same as above
△	Ibid.	53-96	852-1392	$3PbO \cdot 2SiO_2$	Same as above	Same as above

WADC TR 58-476 809 60-636



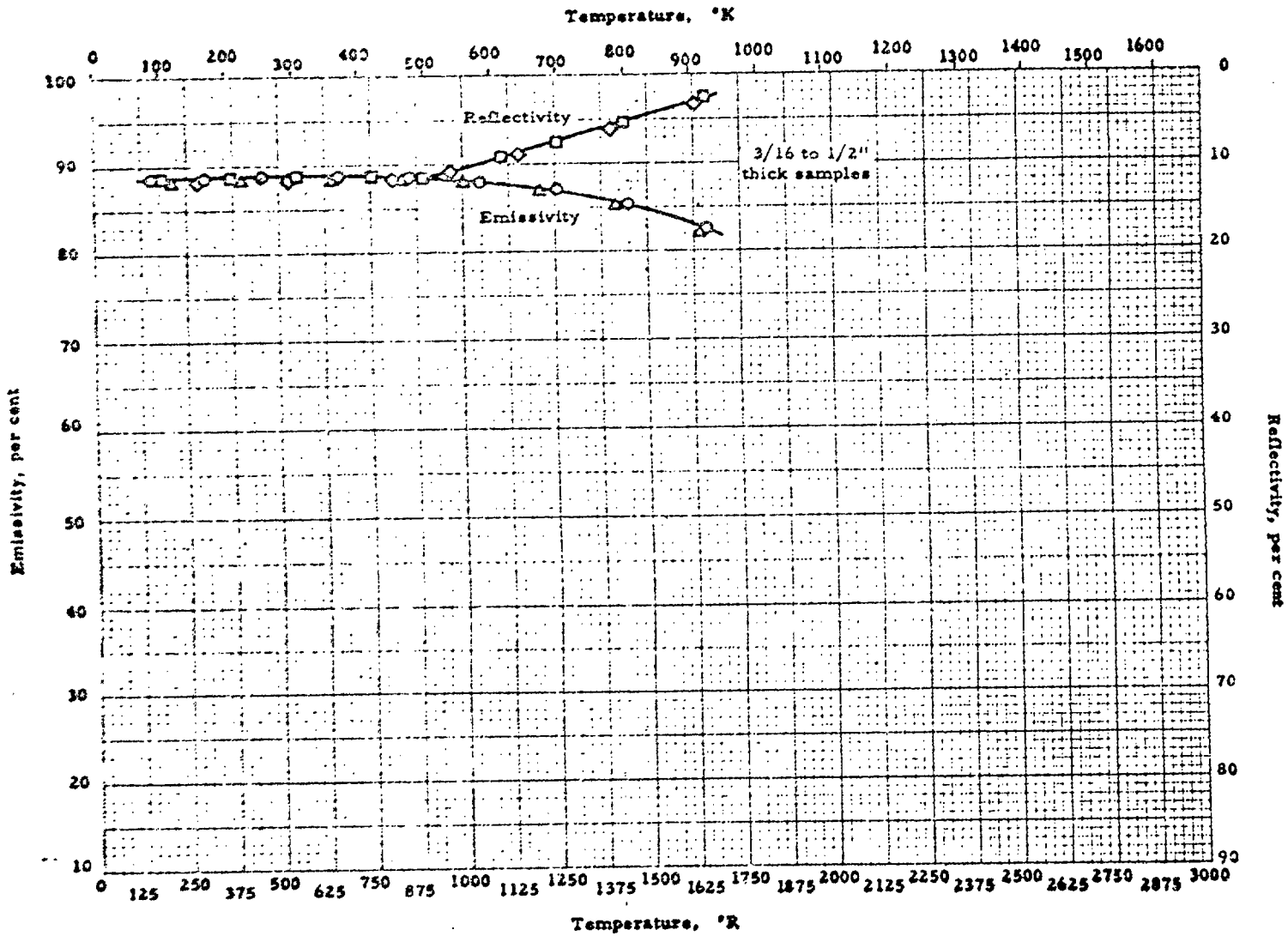
SPECTRAL EMISSIVITY -- ALUMINUM SILICATE GLASS
(Corning No. 1723)

60-616
WADC TR 58-476 Pt 10

SPECTRAL EMISSIVITY -- ALUMINUM SILICATE GLASS
(Corning No. 1723)

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Olson, O. H. and Morris, J. C.	59-1	Room	Corning No. 1723 Glass	Spectral reflectivity at 9°: sample compared with $MgCO_3$ standard in MgO integrating sphere, quartz lens, PbS detector	1/2 in. thick sample
□	Ibid.	59-1	Room	Same as above	Spectral emissivity: meas. spectral reflectivity as above, and spectral transmissivity: comparative: radiation through sample compared with incident radiation by integrating sphere	Same as above Emissivity = 1 - reflectivity -transmissivity



EMISSIVITY -- ALUMINUM SILICATE GLASS
(Corning No. 1723)

EMISSIVITY -- ALUMINUM SILICATE GLASS
(Corning No. 1723)

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Olson, O. H. and Morris, J. C.	59-1	160-1660	Corning No. 1723 aluminum silicate glass	Total normal emissivity: comparative: surface brightness compared with that of a black body hole using thermopile. Sample temp. by thermocouple	1/2 in. sample in air
□	Ibid.	59-1	160-1660	Same as above	Total normal reflectivity: meas. emissivity as above, and apparent transmissivity of radiation from black body at sample temp.	Same as above; reflectivity = 1-emissivity-transmissivity
△	Ibid.	59-1	160-1660	Same as above	Total normal emissivity: comparative: surface brightness compared with that of a black body hole using thermopile. Sample temp. by thermocouple	3/16 in. sample in air
◇	Ibid.	59-1	160-1660	Same as above	Total normal reflectivity: meas. emissivity as above, and apparent transmissivity of radiation from black body at sample temp.	Same as above; reflectivity = 1-emissivity-transmissivity

Symbol	Nominal Composition, %				Density		Deformation Temperature	
	B_2O_3	BaO	CaO	SrO	lb_m/ft^3	g/cm^3	°R	°K
○	68.4	31.6			167.2	2.678	1464	813.2
	64.2	35.8			175.6	2.813	1536	853.2
	59.4	40.6			187.0	2.996	1563	868.2
	54.9	45.1			199.2	3.190	1583	879.2
	52.5	47.5			205.3	3.289	1583	879.2
	49.4	50.6			214.1	3.429	1590	883.2
	44.6	55.4			226.6	3.630	1588	882.2
□	75.0		25.0		155.1	2.484	1676	931.2
	73.0		27.0		158.0	2.531	1689	938.2
	69.8		30.2		162.0	2.595	1694	941.2
	67.7		32.3		164.4	2.633	1696	942.2
△	71.0			29.0	165.4	2.649	1597	887.2
	70.6			29.4	167.1	2.677	1610	894.2
	65.6			34.4	174.9	2.802	1635	908.2
	64.5			35.5	178.1	2.852	1640	911.2
	62.7			37.3	183.0	2.931	1646	914.2
	60.4			39.6	187.7	3.007	1660	922.2
	57.4			42.6	193.6	3.101	1660	922.2
◇	100.0				116.1	1.859		

PROPERTIES OF ALKALINE EARTH BORATE GLASS

PROPERTIES OF ALKALINE EARTH BORATE GLASS

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Shermer, H. F.	56-157	528 1464-1588	B_2O_3 + BaO glass system	ρ: not given Deformation temp: by maximum on thermal expansion curve, ΔL/L: Fizeau type interferometer	Made from reagent grade materials. Melted at 1300°C, cast, annealed 3 hr, at 590°C, cooled at 3°C/hr. to 500°C, furnace cooled 2°C/min. rise for ΔL/L test
□	Ibid.	56-157	528 1676-1690	B_2O_3 + CaO glass system	Same as above	Same as above
△	Ibid.	56-157	528 1597-1660	B_2O_3 + SrO glass system	Same as above	Same as above
◇	Ibid.	56-157	528	Fused B_2O_3	Same as above	Same as above

Symbol	Material Composition, mol %			Density		Softening Temperature	
	Na_2O	B_2O_3	Al_2O_3	lb_m/ft^3	g/cm^3	°R	°K
○	15	75	10	131.7	2.109		
	22.5	67.5	10	136.4	2.185		
	25	65	10	138.4	2.217		
	30	60	10	143.3	2.295		
□	20	65	15	137	2.19		
	22.5	65	12.5	139	2.22		
	25	65	10	139	2.23		
	27.5	65	7.5	144	2.300		
	30	65	5	146	2.34		
	32.5	65	2.5	149	2.38		
	35	65	0	150	2.400		
△	20	65	15			1455	808
	22.5	65	12.5			1449	805
	25	65	10			1439	799
	27.5	65	7.5			1433	796
	30	65	5			1429	794
	32.5	65	2.5			1426	792

PROPERTIES OF SODIUM BOROALUMINATE GLASS

PROPERTIES OF SODIUM BOROALUMINATE GLASS

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Moore, H. and McMillan, P. W.	56-158	Room	$Na_2O + B_2O_3 + Al_2O_3$ series	ρ: weight in air and in xylene	
□	Chandappa, N. and Simpson, H. E.	51-83	499	$Na_2O + B_2O_3 + Al_2O_3$ series	ρ: weight in air and in $C Cl_4$	Corrected for loss in weight of wire immersed and for buoyancy of air
△	Ibid.	51-83	1426-1455	Same as above	Softening temp.: not described here, refers to others	

Symbol	Material Composition, Wt% Li_2O	B_2O_3	Al_2O_3	BeO	MgO	Density lb_m/ft^3	g/cm^3
○	0.0	100.0				116.0	1.859
	1.1	98.9				117.3	1.880
	2.8	97.2				120.5	1.931
	4.5	95.5				127.7	1.983
	6.5	93.5				126.6	2.029
	8.0	92.0				130.0	2.084
	10.6	89.4				133.2	2.135
	12.9	87.1				136.9	2.194
	14.8	85.2				139.2	2.231
□	4.34	80.87	14.79			129.4	2.073
	6.45	67.15	26.40			136.5	2.187
	6.54	71.15	22.31			134.5	2.155
	6.70	78.07	15.23			131.3	2.103
	7.04	92.96				129.4	2.072
	9.21	75.09	15.70			134.0	2.147
	10.51	73.55	15.94			135.2	2.165
	11.87	71.94	16.19			136.7	2.190
	14.71	68.57	16.72			140.1	2.244
	17.74	64.97	17.29			142.2	2.278
	20.98	61.13	17.89			143.4	2.297
△	10.41	84.89		4.70		134.9	2.161
	13.47	81.66		4.87		138.1	2.212
	16.77	78.18		5.05		140.1	2.244
◇	4.66	92.20			3.14	129.1	2.068
	4.77	88.81			6.42	132.2	2.117
	4.88	85.25			9.87	141.8	2.271
	7.38	85.99			6.63	137.0	2.195
	10.18	82.96			6.86	142.2	2.278
	10.71	74.85			14.44	148.5	2.378

DENSITY -- LITHIUM BORATE GLASS

DENSITY -- LITHIUM BORATE GLASS

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Charteis, L., Capps, W. and Spinner, S.	55-139	537	$Li_2O + B_2O_3$ series	Weight in air and in kerosene	
□	Moore, H. and McMillan, P. W.	56-158	Room	$Li_2O + B_2O_3 + Al_2O_3$ series	Weight in air and in xylene	
△	Ibid.	56-155	Room	$Li_2O + B_2O_3 + BeO$ series	Same as above	
◇	Ibid.	56-158	Room	$Li_2O + B_2O_3 + MgO$ series	Same as above	

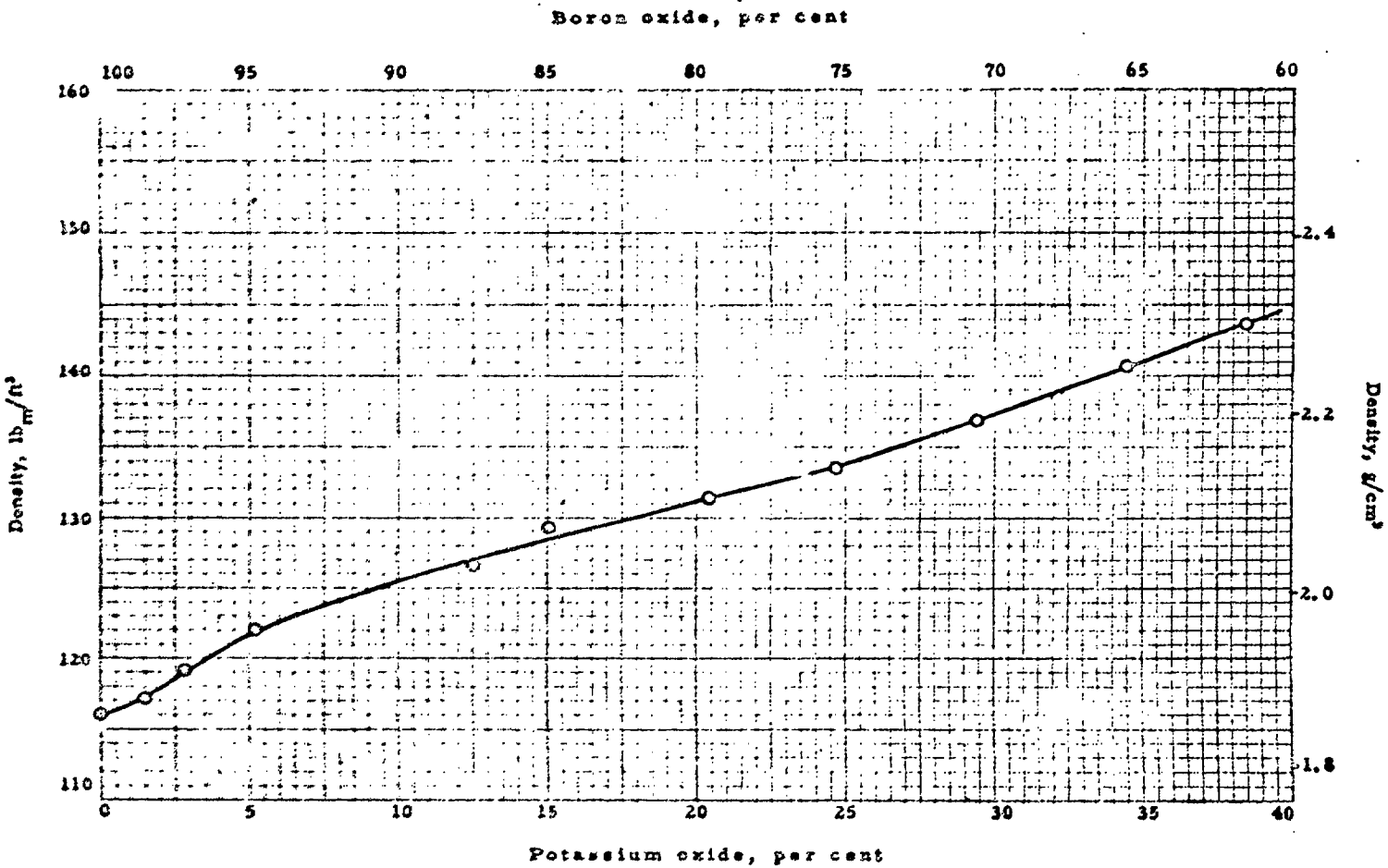
Symbol	Material Composition, Wt%				Density	
	MgO	B_2O_3	Al_2O_3	BeO	lb_m/ft^3	g/cm^3
○	22.54	61.18	16.28		154.1	2.469
	25.70	49.94	24.36		155.6	2.492
	26.38	56.95	16.67		155.0	2.483
	28.54	54.50	16.96		155.7	2.494
	29.60	45.45	24.95		157.6	2.525
	31.24	59.98	8.78		155.9	2.497
□	27.8	61.6		10.6	150.1	2.405
	31.3	60.8		7.9	152.4	2.441
	32.7	56.4		10.9	153.1	2.452

DENSITY -- MAGNESIUM BORATE GLASS

DENSITY -- MAGNESIUM BORATE GLASS

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Moore, H. and McMillan, P. W.	56-158	Room	$MgO + B_2O_3 + Al_2O_3$ glass series	Weight in air and in xylene	
□	Ibid.	56-158	Room	$MgO + B_2O_3 + BeO$ glass series	Same as above	



DENSITY -- POTASSIUM BORATE GLASS

DENSITY -- POTASSIUM BORATE GLASS

REFERENCE INFORMATION

Ref. No.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Shartsis, L., Capps, W. and Spinner, S.	53-13[illegible]	537	$K_2O + B_2O_3$ glasses	Weight in air and in kerosene	

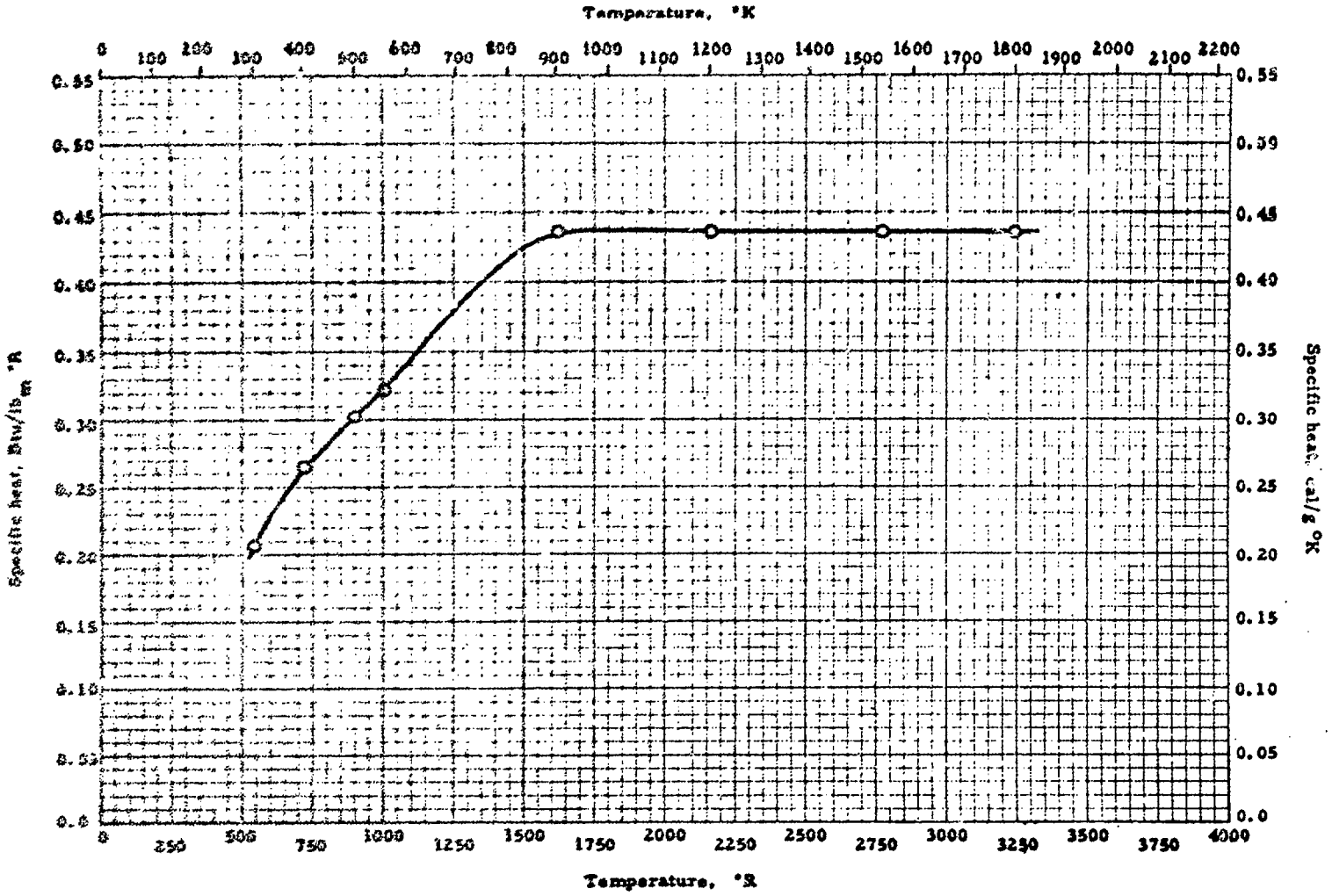
Symbol	Material Composition, Wt%				Density	
	Na_2O	B_2O_3	BeO	MgO	lb_m/ft^3	g/cm^3
O	0.0	100.0			116.0	1.859
	0.9	99.1			117.4	1.881
	2.7	97.3			119.6	1.916
	5.6	94.4			123.3	1.976
	9.0	91.0			127.8	2.048
	14.2	85.8			132.4	2.122
	17.8	82.2			135.5	2.172
	22.4	77.6			140.9	2.258
	26.4	73.6			144.1	2.309
	30.8	69.2			147.2	2.359
	31.8	68.2			148.4	2.378
□	14.48	81.32	4.20		136.0	2.178
	19.42	76.35	4.23		137.0	2.194
	24.42	71.33	4.25		139.3	2.231
	29.49	66.23	4.28		143.5	2.298
	34.61	61.08	4.31		146.3	2.344
Δ	4.67	89.25		6.08	130.4	2.089
	9.20	87.80		3.00	130.1	2.084
	9.40	84.49		6.11	134.3	2.152
	9.62	81.00		9.38	138.2	2.213
	9.84	77.37		12.79	142.4	2.281
	10.07	73.55		16.38	145.8	2.336
	14.19	79.67		6.14	139.5	2.235
	19.02	74.79		6.19	143.2	2.293
	28.88	64.87		6.25	149.6	2.396

DENSITY -- SODIUM BORATE GLASS

DENSITY -- SODIUM BORATE GLASS

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Smyrtsis, L., Carpa, W. and Spinner, S.	53-139	537	$Na_2O + B_2O_3$ glass series	Weight in air and in kerosene	
□	Moore, H. and McMillan, P. W.	56-158	Room	$Na_2O + B_2O_3 + BeO$ glass series	Weight in air and in xylene	
△	Ibid.	56-158	Room	$Na_2O + B_2O_3 + MgO$ glass series	Same as above	



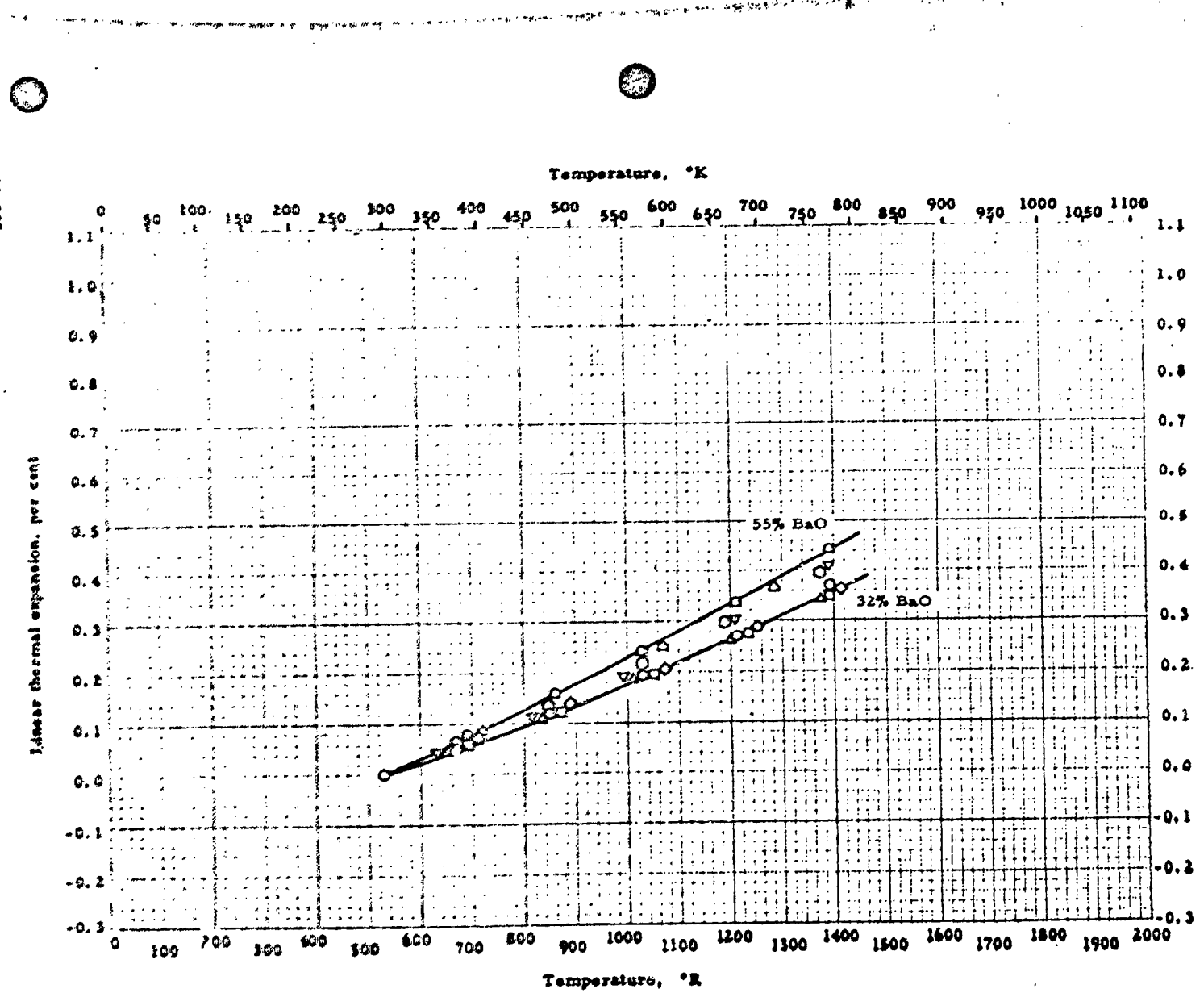
SPECIFIC HEAT -- BORON OXIDE GLASS

60-724
WADC TR 58-476
825

SPECIFIC HEAT -- BORON OXIDE GLASS

REFERENCE INFORMATION

Curve	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Southard, J. C.	41-25	687-3200	2 samples boron sesquioxide glass 99.30 - 99.79% B_2O_3, 0.06 - 0.55% H_2O	Drop method, copper block calorimeter	

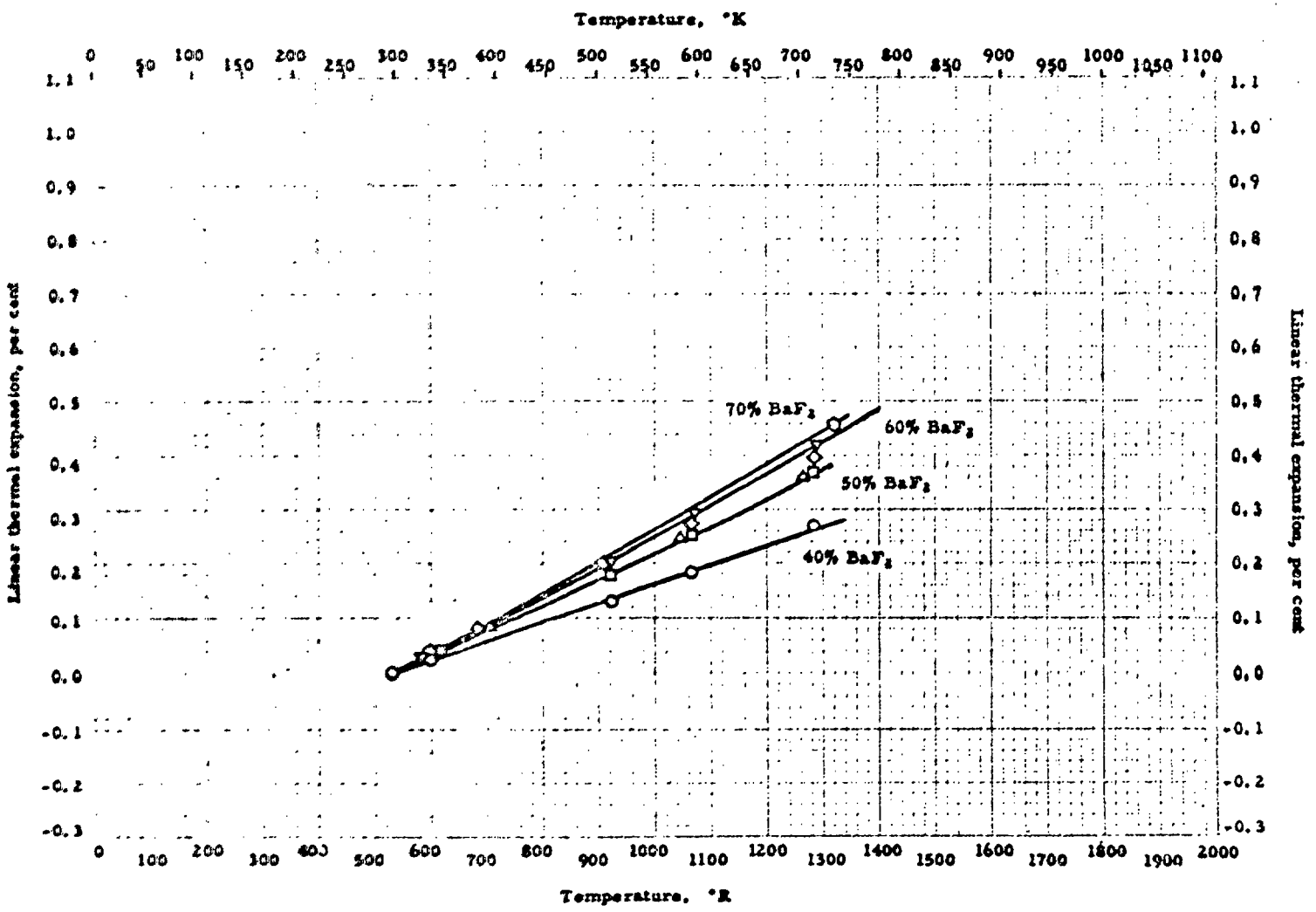


LINEAR THERMAL EXPANSION -- BARIUM BORATE GLASS

LINEAR THERMAL EXPANSION -- BARIUM BORATE GLASS

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Shermer, H. F.	56-157	528-1392	68.4% B_2O_3; 31.6% BaO	Interferometer, photographic recording	Melted from reagent grade materials at 1300°C, cast, annealed 3 hr. at 590°C, cooled at 3°C/hr to 500°C, furnace cooled
□	Ibid.	56-157	528-1392	64.2% B_2O_3; 35.8% BaO	Same as above	Same as above
△	Ibid.	56-157	528-1392	59.4% B_2O_3; 40.6% BaO	Same as above	Same as above
◇	Ibid.	56-157	528-1392	54.9% B_2O_3; 45.1% BaO	Same as above	Same as above
▽	Ibid.	56-157	528-1392	52.5% B_2O_3; 47.5% BaO	Same as above	Same as above
○	Ibid.	56-157	528-1392	50.6% B_2O_3; 49.4% BaO	Same as above	Same as above
□	Ibid.	56-157	528-1392	44.6% B_2O_3; 55.4% BaO	Same as above	Same as above
◇	Imamiami, T. and Terai, R.	52-135	528-1284	60% BaO; 40% B_2O_3	Not given	Melted in alumina crucible at 1100°C from chemically pure BaF_2 (from Marita Chemical Co.) and pure B_2O_3 made by dehydrating H_3BO_3 at 200-300°C.

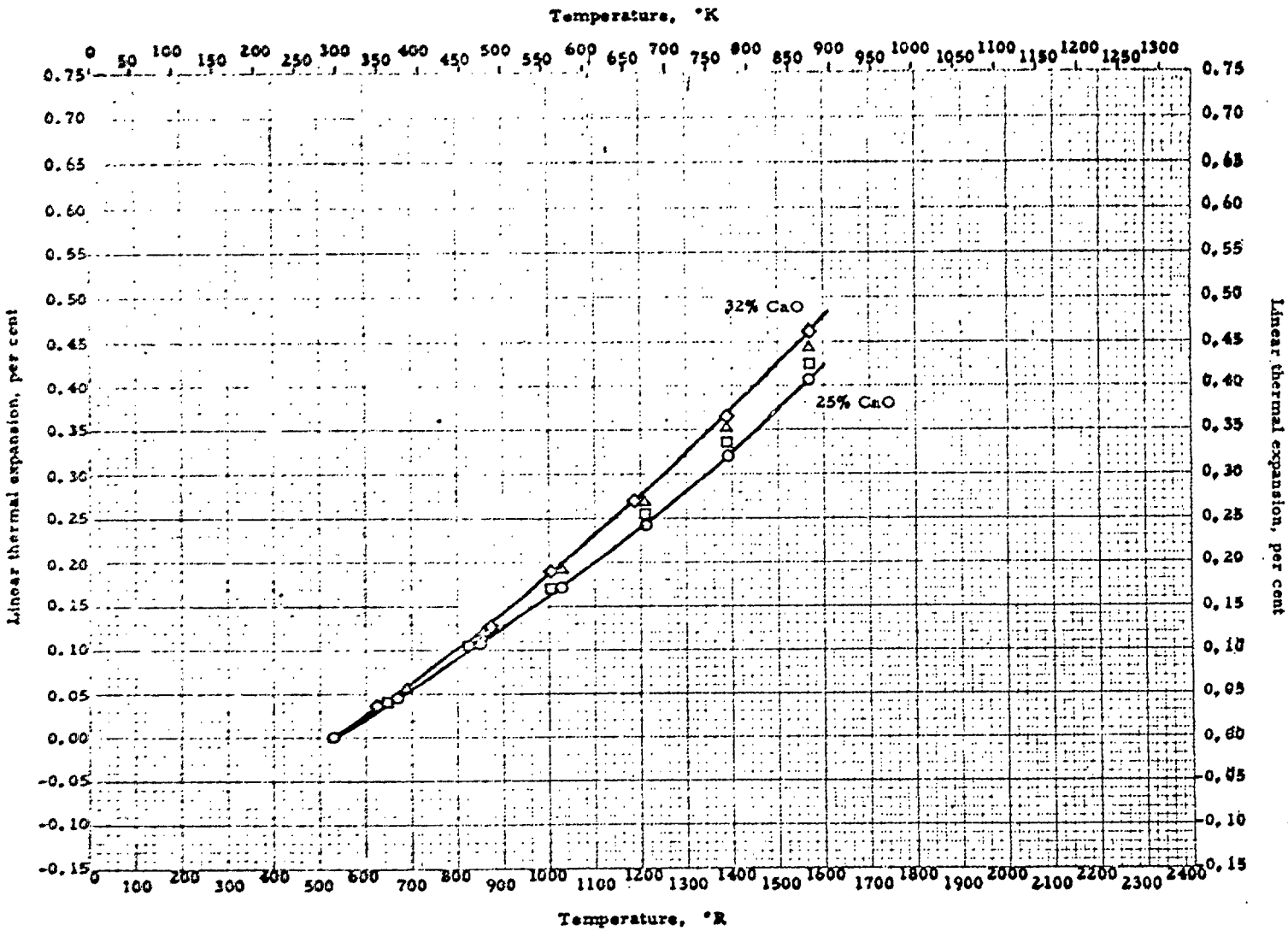


LINEAR THERMAL EXPANSION -- BARIUM FLUOBORATE GLASS

LINEAR THERMAL EXPANSION -- BARIUM FLUOBORATE GLASS

REFERENCE INFORMATION

Plot	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Inamitani, T. and Terai, R.	52-	528-1284	60% B_2O_3; 40% BaF_2. ρ = 176 lb_m/ft^3	Dilatometer	B_2O_3 from dehydrating H_3BO_3 at 200-300 °C. BaF_2 chemically pure. Melted in alumina crucible at 1100°C
□	Ibid.	52-	528-1284	50% B_2O_3; 50% BaF_2. ρ = 190 lb_m/ft^3	Same as above	Same as above
△	Ibid.	52-	528-1284	60% BaO; 40% B_2O_3. ρ = 235 lb_m/ft^3	Same as above	Same as above
◇	Ibid.	52-	528-1284	40% B_2O_3; 40% BaF_2; 20% BaO. ρ = 217 lb_m/ft^3	Same as above	Same as above
▽	Ibid.	52-	528-1284	60% BaF_2; 40% B_2O_3. ρ = 208 lb_m/ft^3	Same as above	Same as above
○	Ibid.	52-	528-1320	70% BaF_2; 30% B_2O_3. ρ = 227 lb_m/ft^3	Same as above	Same as above

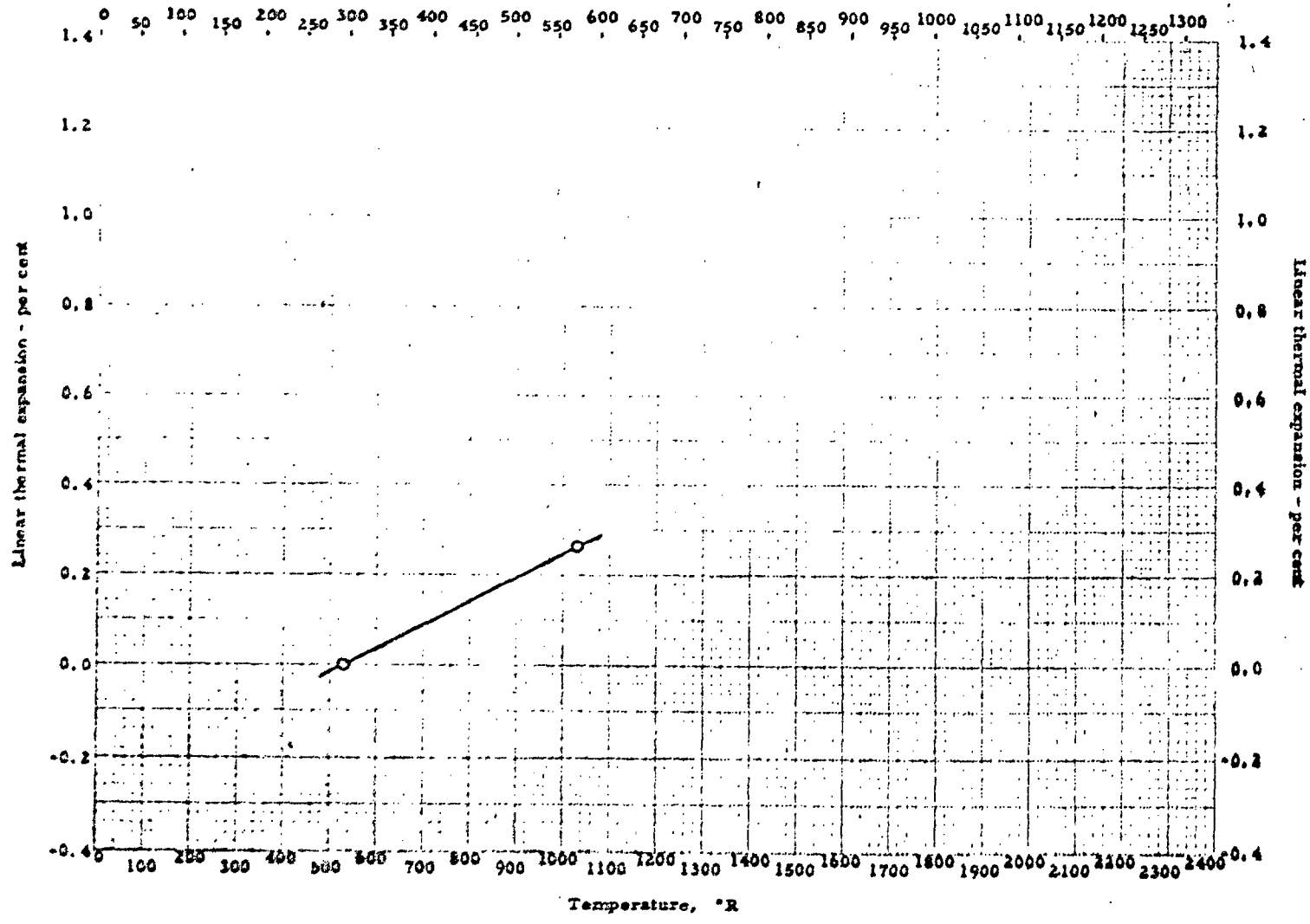


LINEAR THERMAL EXPANSION -- CALCIUM BORATE GLASS

LINEAR THERMAL EXPANSION -- CALCIUM BORATE GLASS

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Shermer, H. F.	56-157	528-1572	75% B_2O_3; 25% CaO	Interferometer, photographic recording	Melted from reagent grade materials at 1300°C, cast, annealed 3 hr. at 590°C, cooled at 3° C/hr. to 500°C, furnace cooled
□	Ibid.	56-157	528-1572	73% B_2O_3; 27% CaO	Same as above	Same as above
△	Ibid.	56-157	528-1572	69.8% B_2O_3; 30.2% CaO	Same as above	Same as above
◇	Ibid.	56-157	528-1572	67.7% B_2O_3; 32.3% CaO	Same as above	Same as above



LINEAR THERMAL EXPANSION --LEAD BORATE GLASS

LINEAR THERMAL EXPANSION -- LEAD BORATE GLASS

REFERENCE INFORMATION

Curve No.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Bischoff, F.	55-26	528-1932	76.2 %PbO; 23.8 P_2O_3	Not given	PbO • B_2O_3

Symbol	Material Composition						Average coefficient of linear expansion x 10^6	
	B_2O_3		Al_2O_3		Li_2O			
	Mol %	Wt %	Mol %	Wt %	Mol %	Wt %	582-762°R	323-423°K
O	85	93.0			15	7.0	3.99	7.18
	80	85.3	5	7.8	15	6.9	3.70	6.67
	80	80.9	10	14.8	10	4.3	3.92	7.06
	75	78.1	10	15.2	15	6.7	3.83	6.89
	65	76.3	5	8.6	30	15.1	4.44	7.99
	70	75.1	10	15.7	20	9.2	4.01	7.22
	72.5	74.6	12.5	18.8	15	6.6	3.65	6.57
	67.5	73.6	10	15.9	22.5	10.5	4.17	7.50
	65	71.9	10	16.2	25	11.9	4.31	7.75
	70	71.2	15	22.3	15	6.5	3.74	6.73
	62.5	70.3	10	16.4	27.5	13.3	4.28	7.71
	60	68.6	10	16.7	30	14.7	4.47	8.04
	67	67.1	18	26.4	15	6.5	3.83	6.90
	57.5	66.8	10	17.0	32.5	16.2	4.77	8.58
	55	65	10	17.3	35	17.7	4.90	8.82
	55	61.2	15	24.5	30	14.3	4.58	8.24
	50	61.1	10	17.9	40	21.0	5.51	9.92
	50	54.2	20	31.8	30	14.0	4.56	8.21

LINEAR THERMAL EXPANSION -- LITHIUM ALUMINUM BORATE GLASS

60-754
WADC TR 58-476 836

LINEAR THERMAL EXPANSION -- LITHIUM ALUMINUM BORATE GLASS

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Moore, H. and McMillan, P. W.	56-158	582-762	$Li_2O - Al_2O_3 - B_2O_3$ glasses	Not given	Annealed

Symbol	Material Composition						Average coefficient of of linear expansion x 10^6	
	B_2O_3		Li_2O		BeO			
	Mol %	Wt %	Mol %	Wt %	Mol %	Wt %	582-762°R	323-423°K
○	75	87.9	15	7.5	10	4.5	3.64	6.56
	70	84.9	20	10.4	10	4.7	3.78	6.81
	65	81.7	25	13.5	10	4.9	4.21	7.57
	60	78.2	30	16.8	10	5.0	4.78	8.61
							492-1032°R	273-578°K
□		70.23		17.82		11.95	5.5	9.9

LINEAR THERMAL EXPANSION -- LITHIUM BERYLLIUM BORATE GLASS

LINEAR THERMAL EXPANSION -- LITHIUM BERYLLIUM BORATE GLASS

REFERENCE INFORMATION

Ref. No.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Moore, H. and McMillan, P. W.	56-156	562-762	Li_2O - BeO - B_2O_3 glasses	Not given	Annealed
□	Dale, A. E., Pegg, E. F. and Stanworth, J. E.	51-81	492-1032	Lindemann x-ray transmitting glass. 70.23% B_2O_3; 17.82% Li_2O; 11.95% BeO	Quartz differential dilatometer	

Symbol	Material Composition, %						Average coefficient of linear expansion x 10^6	
	B_2O_3		Li_2O		MgO		582-762°R	323-423°K
	Wt.	Mol.	Wt.	Mol.	Wt.	Mol.	$°R^{-1}$	$°K^{-1}$
O	95.4	90	4.6	10			5.18	9.32
	92.2	85	4.7	10	3.1	5	4.04	7.28
	90.5	82.5	4.7	10	4.8	7.5	3.67	6.60
	90.3	80	9.7	20			4.06	7.31
	88.8	80	4.8	10	6.4	10	3.53	6.35
	86.7	75	9.9	20	3.4	5	3.82	6.88
	86.0	75	7.4	15	6.6	10	3.73	6.72
	85.2	75	4.9	10	9.9	15	3.50	6.30
	83.0	70	10.2	20	6.9	10	3.76	6.78
	81.5	70	5.0	10	13.5	20	3.40	6.12
	81.4	67.5	11.6	22.5	7.0	10	3.97	7.05
	79.0	65	10.4	20	10.6	15	3.89	7.00
	74.9	60	10.7	20	14.4	20	3.93	7.08
	70.5	55	11.0	20	18.5	25	4.06	7.31

LINEAR THERMAL EXPANSION -- LITHIUM MAGNESIUM BORATE GLASS

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Moore, H. and McMillan, P. W.	56-158	542-762	Li_2O - MgO - B_2O_3 Series	Not given	Annealed

Symbol	Material Composition, %						Average coefficient of linear expansion x 10^6	
	B_2O_3		MgO		Al_2O_3		582-762°R	323-423°K
	Wt.	Mol.	Wt.	Mol.	Wt.	Mol.	$°R^{-1}$	$°K^{-1}$
O	61.2	55	22.5	35	16.3	10	2.84	5.11
	60.0	50	31.2	45	8.8	5	3.06	5.50
	59.1	52.5	24.4	37.5	16.5	10	2.82	5.08
	56.9	50	26.4	40	16.7	10	2.79	5.02
	54.5	47.5	28.5	42.5	17.0	10	2.78	5.00
	52.5	45	30.4	45	17.1	10	2.69	4.85

60-550
WADC TR 58-476 042

LINEAR THERMAL EXPANSION -- MAGNESIUM ALUMINUM BORATE GLASS

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Moore, H. and McMillan, P. W.	56-158	582-762	$MgO - Al_2O_3 - B_2O_3$ Series	Not given	Annealed

Symbol	Material Composition						Average coefficient of linear expansion x 10^6	
	B_2O_3		MgO		BeO		582-762°R	323-423°K
	Mol%	Wt %	Mol %	Wt %	Mol %	Wt %	°R-1	°K-1
O	45	61.6	35	27.8	20	10.6	2.92	5.26
	45	60.8	40	31.3	15	7.9	2.53	4.56
	40	57.2	35	29.0	25	13.9	3.09	5.57
	40	56.4	40	32.7	20	10.9	3.06	5.50

LINEAR THERMAL EXPANSION -- MAGNESIUM BERYLLIUM BORATE GLASS

LINEAR THERMAL EXPANSION -- MAGNESIUM BERYLLIUM BORATE GLASS

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Moore, H. and McMillan, P. W.	56-170	582-762	MgO - BeO - B_2O_3 series	Not given	Annealed

Symbol	Material Composition, mol %			Average coefficient of linear expansion x 10^6	
	B_2O_3	Na_2O	Al_2O_3	582-762°R	323-423°K
○	80	20		5.33	9.59
	75	20	5	5.51	9.92
	75	15	10	5.19	9.34
	70	30		5.99	10.78
	70	20	10	5.66	10.18
	67.5	22.5	10	5.89	10.60
	65	30	5	6.28	11.30
	65	25	10	6.37	11.46
	65	20	15	5.99	10.79
	60	30	10	6.62	11.92
	55	30	15	6.65	11.97
	50	30	20	6.73	12.12
	40	40	20	8.02	14.44
□	65	35		5.8	10.4
	65	32.5	2.5	5.2	9.4
	65	30	5	5.0	9.0
	65	27.5	7.5	4.9	8.8
	65	25	10	4.4	7.9
	65	22.5	12.5	3.8	6.9
	65	20	15	4.0	7.2

LINEAR THERMAL EXPANSION -- SODIUM ALUMINUM BORATE GLASS

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Moore, H. and McMillan, P. W.	56-158	582-762	Na_2O - Al_2O_3 - B_2O_3 glasses	Not given	Annealed
□	Chandappa, N. and Simpson, H. E.	51-83	582-672	Na_2O - Al_2O_3 - B_2O_3 glasses	Quartz tube dilatometer	

Symbol	Material Composition						Average coefficient of linear expansion x 10^6	
	B_2O_3		Na_2O		BeO			
	Mol %	Wt %	Mol %	Wt%	Mol %	Wt %	582-762°R	323-423°K
O	85	88.7	10	9.3	5	2.0	5.31	9.56
	75	81.3	15	14.5	10	4.2	5.44	9.80
	70	76.4	20	19.4	10	4.2	5.28	9.51
	65	71.3	25	24.4	10	4.3	5.49	9.89
	60	66.2	30	29.5	10	4.3	6.55	11.79
	55	61.1	35	34.6	10	4.3	6.32	11.37

LINEAR THERMAL EXPANSION -- SODIUM BERYLLIUM BORATE GLASS

LINEAR THERMAL EXPANSION -- SODIUM BERYLLIUM BORATE GLASS

REFERENCE INFORMATION

Curve No.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Moore, H. and McMillan, P. W.	56-158	582-762	Na_2O - BeO - B_2O_3 glasses	Not given	Annealed

Symbol	Material Composition, %						Average coefficient of linear expansion x 10^6	
	B_2O_3		Na_2O		MgO		582-762°R	323-423°K
	Wt.	Mol.	Wt.	Mol.	Wt.	Mol.	per °R	per °K
O	91.0	90	9.0	10			5.73	10.31
	89.2	85	4.7	5	6.1	10	4.12	7.41
	87.8	85	9.2	10	3.0	5	5.06	9.10
	86.2	82.5	9.3	10	4.5	7.5	4.42	7.95
	84.5	80	9.4	10	6.1	10	4.19	7.55
	81.0	75	9.6	10	9.4	15	4.14	7.45
	79.7	75	14.2	15	6.1	10	4.48	8.07
	78.9	75	16.9	18	4.2	7	4.82	8.68
	78.4	75	18.6	20	3.0	5	5.14	9.25
	77.4	70	9.8	10	12.8	20	4.09	7.37
	77.1	75	22.9	25			5.60	10.08
	74.8	70	19.0	20	6.2	10	4.93	8.88
	73.6	65	10.1	10	16.4	25	4.11	7.39
	71.0	65	19.5	20	9.5	15	5.09	9.17
	70.5	65	21.7	22.5	7.8	12.5	5.42	9.75
	69.9	65	23.9	25	6.2	10	5.81	10.45
	64.9	60	28.9	30	6.2	10	6.69	12.05
	56.6	50	30.3	30	13.1	20	6.17	11.10

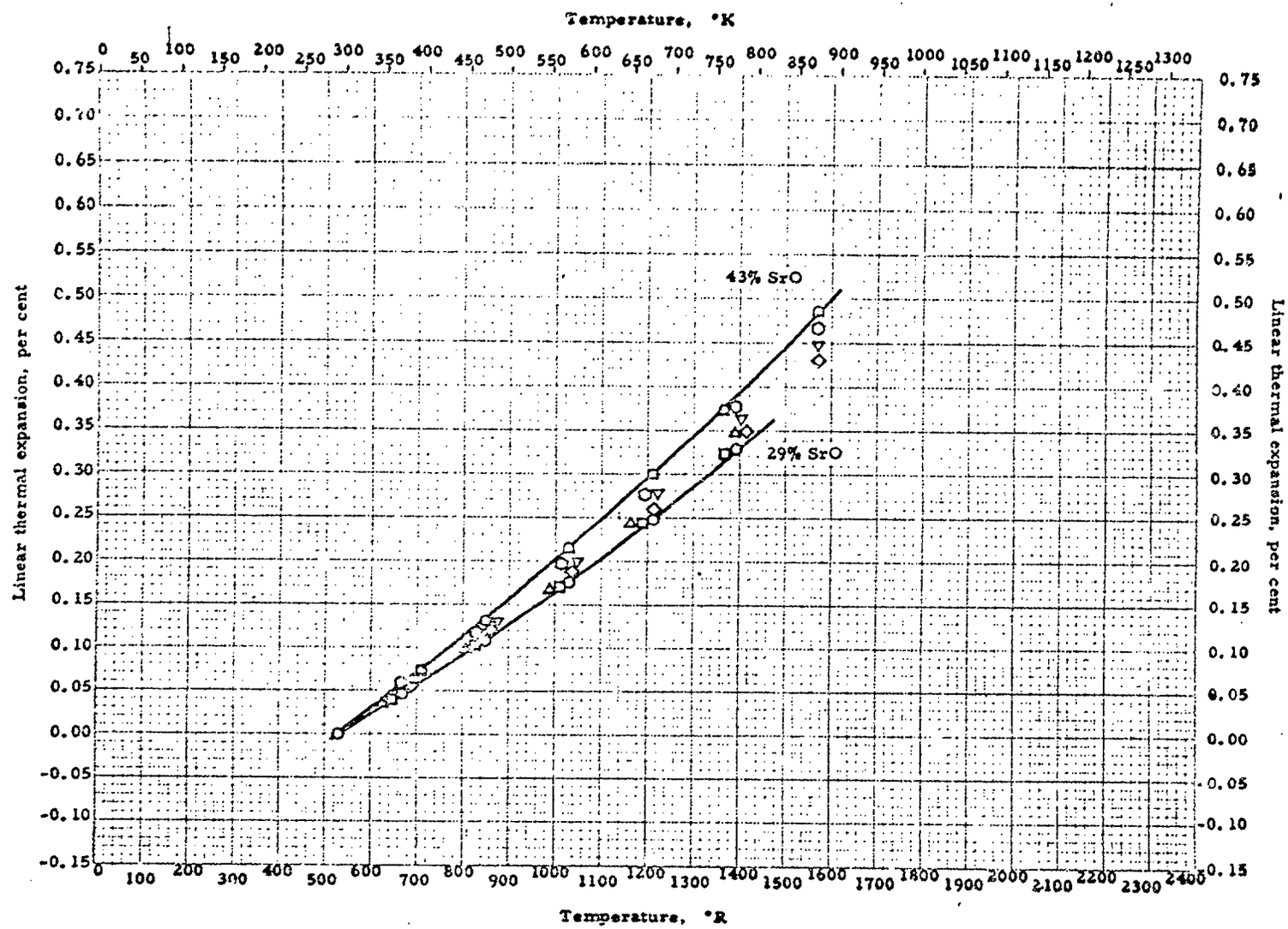
LINEAR THERMAL EXPANSION -- SODIUM MAGNESIUM BORATE GLASS

CINDAS TPRC 55-474 959

LINEAR THERMAL EXPANSION -- SODIUM MAGNESIUM BORATE GLASS

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Moore, H. and McMillan, P. W.	56-158	562-762	Na_2O - MgO - B_2O_3 glasses	Not given	Annealed

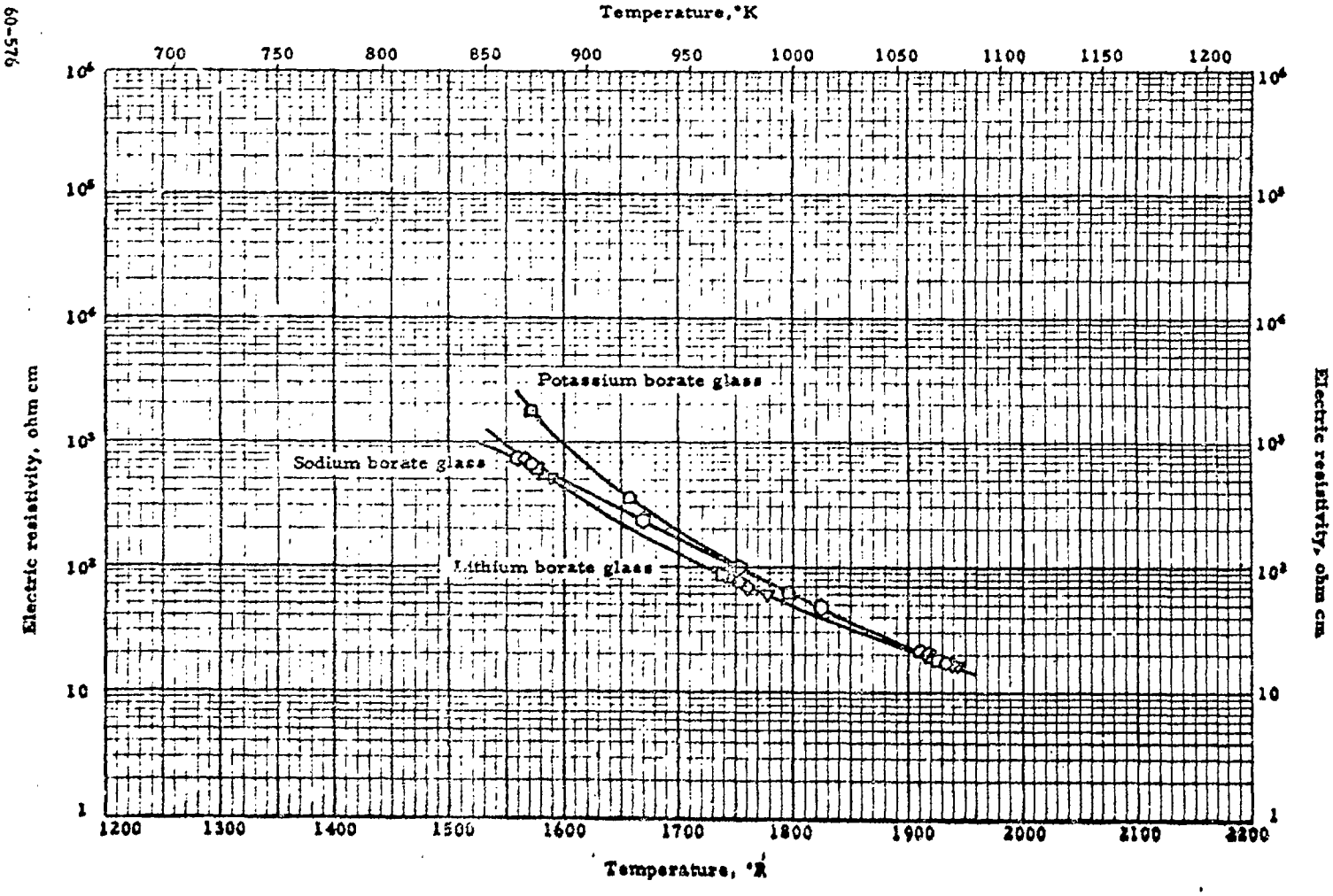


LINEAR THERMAL EXPANSION -- STRONTIUM BORATE GLASS

LINEAR THERMAL EXPANSION -- STRONTIUM BORATE GLASS

REFERENCE INFORMATION

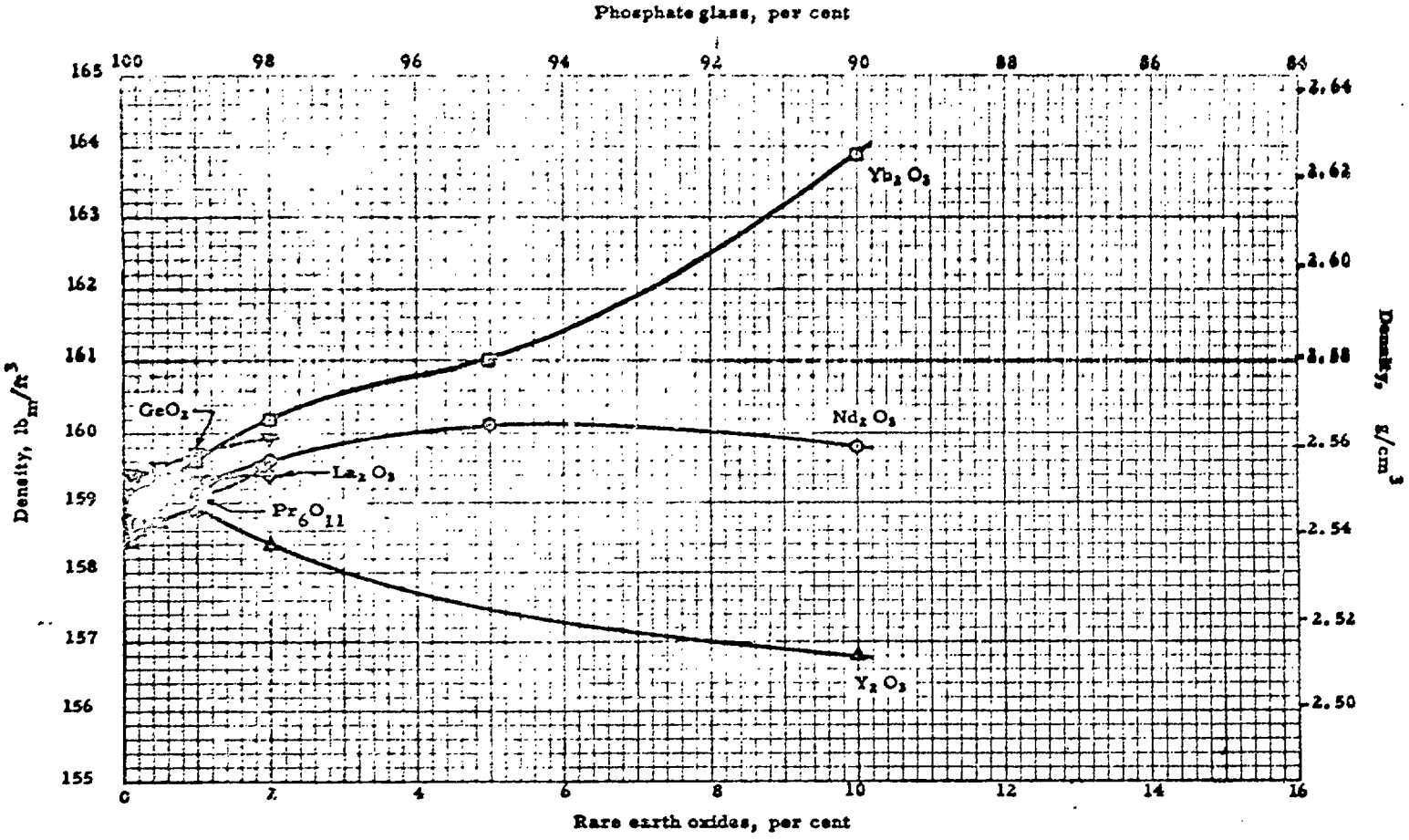
Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Shermer, H. F.	56-157	528-1572	71% B_2O_3; 29% SrO	Interferometer, photographic recording 2°C/min	Melted from reagent grade materials at 1300°C, cast, annealed 3 hr at 590°C, cooled to 540°C at 3°C/hr, furnace cooled
□	Ibid.	56-157	528-1572	70.6% B_2O_3; 29.4% SrO	Same as above	Same as above
△	Ibid.	56-157	528-1392	65.6% B_2O_3; 34.4% SrO	Same as above	Same as above
◇	Ibid.	56-157	528-1572	64.5% B_2O_3; 35.5% SrO	Same as above	Same as above
▽	Ibid.	56-157	528-1572	62.7% B_2O_3; 37.3% SrO	Same as above	Same as above
○	Ibid.	56-157	528-1572	60.4% B_2O_3; 39.6% SrO	Same as above	Same as above
⌂	Ibid.	56-157	528-1572	57.4% B_2O_3; 42.6% SrO	Same as above	Same as above


Temperature, °K
700
750
800
850
900
950
1000
1050
1100
1150
1200
Electric resistivity, ohm cm
10^6
10^5
10^4
10^3
10^2
10
1
Potassium borate glass
Sodium borate glass
Lithium borate glass
1200
1300
1400
1500
1600
1700
1800
1900
2000
2100
2200
Temperature, °R
Electric resistivity, ohm cm

ELECTRIC RESISTIVITY -- BORATE GLASS

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Laurent, B.	53-144	1572-1932	85.18% B_2O_3; 10.80% Li_2O; 4.02% BeO	AC impedance bridge, at 1000 cycles	
□	Ibid.	53-144	1572-1932	85.18% B_2O_3; 10.80% Li_2O; 4.02% MgO	Same as above	
△	Ibid.	53-144	1572-1932	85.18% B_2O_3; 10.80% Li_2O; 4.02% CaO	Same as above	
◇	Ibid.	53-144	1572-1932	85.18% B_2O_3; 10.80% Li_2O; 4.02% BaO	Same as above	
▽	Ibid.	53-144	1572-1932	85.18% B_2O_3; 10.80% Li_2O; 4.02% SrO	Same as above	
○	Ibid.	53-144	1572-1932	85.18% B_2O_3; 10.80% Na_2O; 4.02% BeO	Same as above	
⌂	Ibid.	53-144	1572-1932	85.18% B_2O_3; 10.80% K_2O; 4.02% BeO	Same as above	



DENSITY -- PHOSPHATE GLASS

DENSITY -- PHOSPHATE GLASS

REFERENCE INFORMATION

Sym.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Vickery, R. C. and Sedlack, R.	57-187	530-537	Basic phosphate glass + Nd_2O_3. 77.6% P_2O_5; 8.26% B_2O_3; 5.07% CaO; 3.98% Al_2O_3; 2.52% Fe_2O_3; 0.91% MgO; with various % Nd_2O_3	Pycnometer	Measured with CO_2 - free water; temp. meas. to 0.1°C
□	Ibid.	57-187	530-537	Basic phosphate glass + Yb_2O_3	Same as above	Same as above
△	Ibid.	57-187	530-537	Basic phosphate glass + Y_2O_3	Same as above	Same as above
◇	Ibid.	57-187	530-537	Basic phosphate glass + La_2O_3	Same as above	Same as above
▽	Ibid.	57-187	530-537	Basic phosphate glass + CeO_2	Same as above	Same as above
○	Ibid.	57-187	530-537	Basic phosphate glass + Pr_6O_{11}	Same as above	Same as above; auth. also report additional density data for additives of up to 2% of other rare earth oxides

Symbol	Material Composition, Mol %								Density	
	SiO_2	B_2O_3	ZnO	BaO	ZrO_2	TiO_2	MgO	Li_2O	lb_m/ft^3	g/cm^3
O	20	30	15	20	5	5	5		237	3.79
	20	30	20	25	5				245	3.93
	25	25	15	20	5	5	5		237	3.80
	30	20	15	20	5	5	5		239	3.83
	38	12	15	10	5	5	5	10	218	3.49
	38	12	15	15	5	5	5	5	214	3.43

DENSITY -- BARIUM ZINC BOROSILICATE GLASS

DENSITY -- BARIUM ZINC BOROSILICATE GLASS

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	National Bureau of Standards	57-179	Room	Barium-Zinc-Titanium Borosilicate glasses	Weight and volume from measured dimensions	

Symbol	Material Composition, mol, %									Density	
	SiO_2	B_2O_3	MgO	Al_2O_3	CaO	Na_2O	ZnO	SrO	Li_2O	lb_{Zn}/ft^3	g/cm^3
O	25	22.5	13.3	8.35	3.35		27.5			195	3.12
	25	22.5	13.3	8.4			30.8			197	3.15
	26.5	24	10.7	10.7		0.5	27.5			189	3.02
	40	10	20	16			6	4	4	174	2.79
	40	10	20	16			6	8		180	2.88
	40	10	23	17			10			177	2.83
	40	10	24	16			6	4		177	2.83
	40	10	26	14			6		4	169	2.71
	40	10	26	16			6		2	170	2.73
	40	10	26.6	16.7	6.7					192	3.08

DENSITY -- ZINC MAGNESIUM ALUMINUM BOROSILICATE GLASS

TPRC DATA SERIES
Vol. 1

DENSITY -- ZINC MAGNESIUM ALUMINUM BOROSILICATE GLASS

REFERENCE INFORMATION

	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	National Bureau of Standards	57-179	Room	Zinc-magnesium-aluminum boro-silicate glass	Weight and volume from measured dimensions	

Symbol	Material Compositon, Mol %							Density	
	SiO_2	B_2O_3	ZnO	MgO	Li_2O	Al_2O_3	ZrO_2	lb_m/ft^3	g/cm^3
O	10.5	36.9	31.6	10.5	10.5			196	3.14
	10	35	40	10	5			208	3.33
	10	35	40	10		5		206	3.30
	17	18	30	25	4	4	2	211	3.38
	17	18	32	25	2	4	2	213	3.41
	17	18	34	21	4	4	2	216	3.46
	17	18	34	23	2	4	2	217	3.47
	17	18	30	30		5		208	3.33
	17	18	31	30		4		211	3.38
	17	18	33	30		2		215	3.44
	17	18	36	21	4	4		214	3.43
	17	18	36	23	2	4		216	3.46

DENSITY -- ZINC MAGNESIUM BOROSILICATE GLASS

59-119

WADC TR 58-476 282

DENSITY -- ZINC MAGNESIUM BOROSILICATE GLASS

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	National Bureau of Standards	57-17	Room	Zinc-Magnesium Borosilicate glasses	Weight and volume from measured dimensions	

PROPERTIES OF BOROSILICATE GLASS

MOST PROBABLE VALUES

Property	Brit. Engineering Units	C. G. S. Units
Density.	157 lb_m/ft^3*	2.52 g/cm^3*
Annealing Point.	1491 °R*	828 °K*
Heat of Fusion		
Heat of Vaporization. . .		
Heat of Sublimation . . .		

*Value for borosilicate crown glass

REPORTED VALUES

Density:		lb_m/ft^3	g/cm^3
	O	138.64	2.2208
	◇	138.66	2.2210
	O	157.74	2.5271
		157.25	2.5193
		157.09	2.5167
		156.74	2.5110

Annealing Point:		°R	°K
	▽	1491	828

Heat of Fusion: Btu/lb_m cal/g

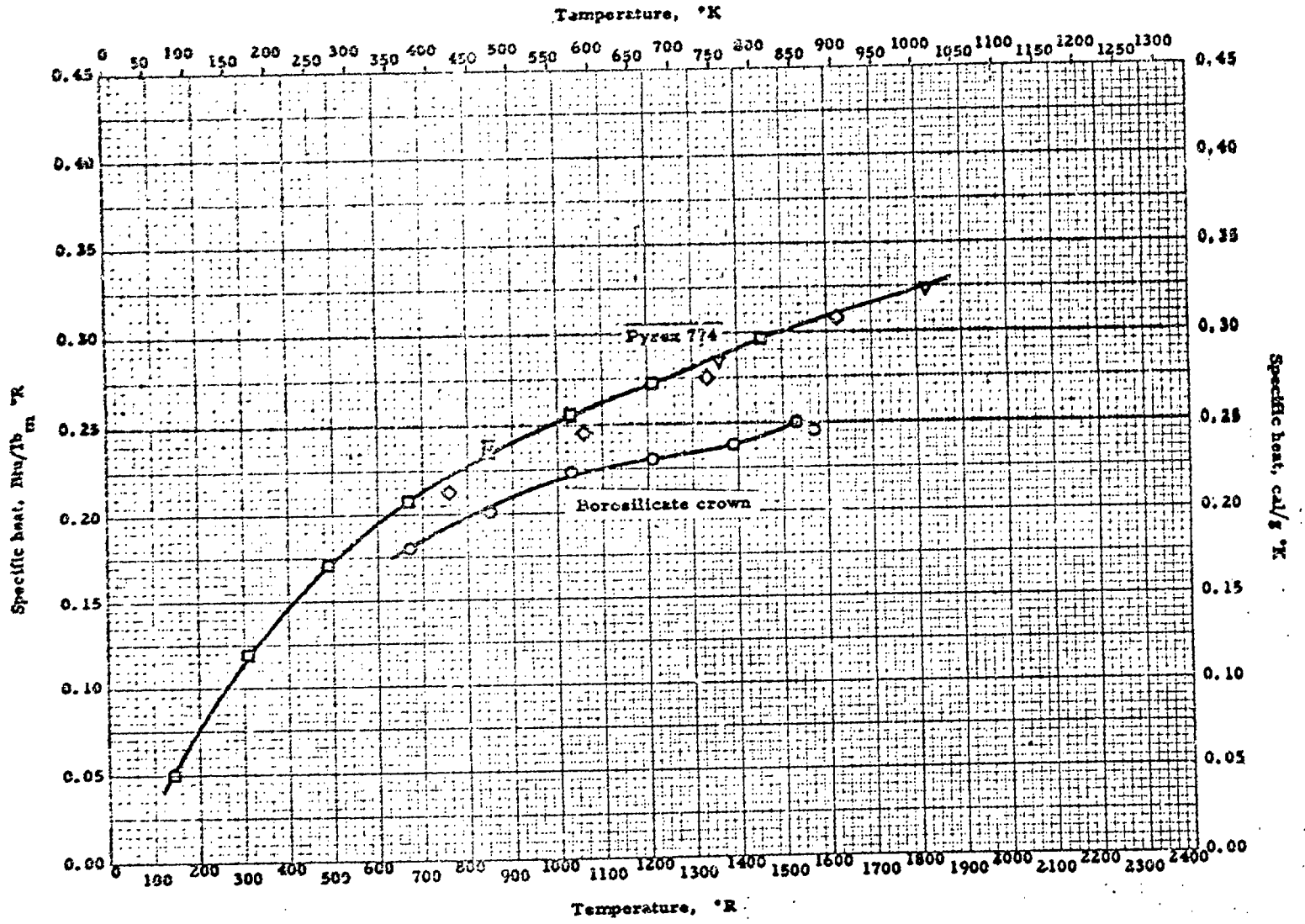
Heat of Vaporization: Btu/lb_m cal/g

Heat of Sublimation: Btu/lb_m cal/g

PROPERTIES OF BOROSILICATE GLASS

REFERENCE INFORMATION

	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Locke, C. F. and Blaz, G. F.	33-35	528	Pyrex clear chemical glass No. 774	ρ: not given	Made by Cincinnati Gasket and Packing Co.
◇	Locke, C. F., Thompson, H. B., et al.	34-65	Room	Pyrex clear chemical glass No. 774	ρ: weight in air and in water	Made by Cincinnati Gasket and Packing Co.
▽	Nagy, E. E. and Ahmad, M. N.	57-184	1491	Borosilicate crown glass. Nominal: 70% SiO_2; 11% B_2O_3; 9% Na_2O; 7% K_2O; 3% BaO	Annealing point: by thermal expansion. Quartz tube dilatometer with dial gauges with 100° C /hr rise	
□	Ibid.	57-184	Room	Same as above	ρ: computed by Newton-Drude equation $\frac{n^2 - 1}{\rho}$ = const. Index of refraction: Graney V-block refractometer	4 samples

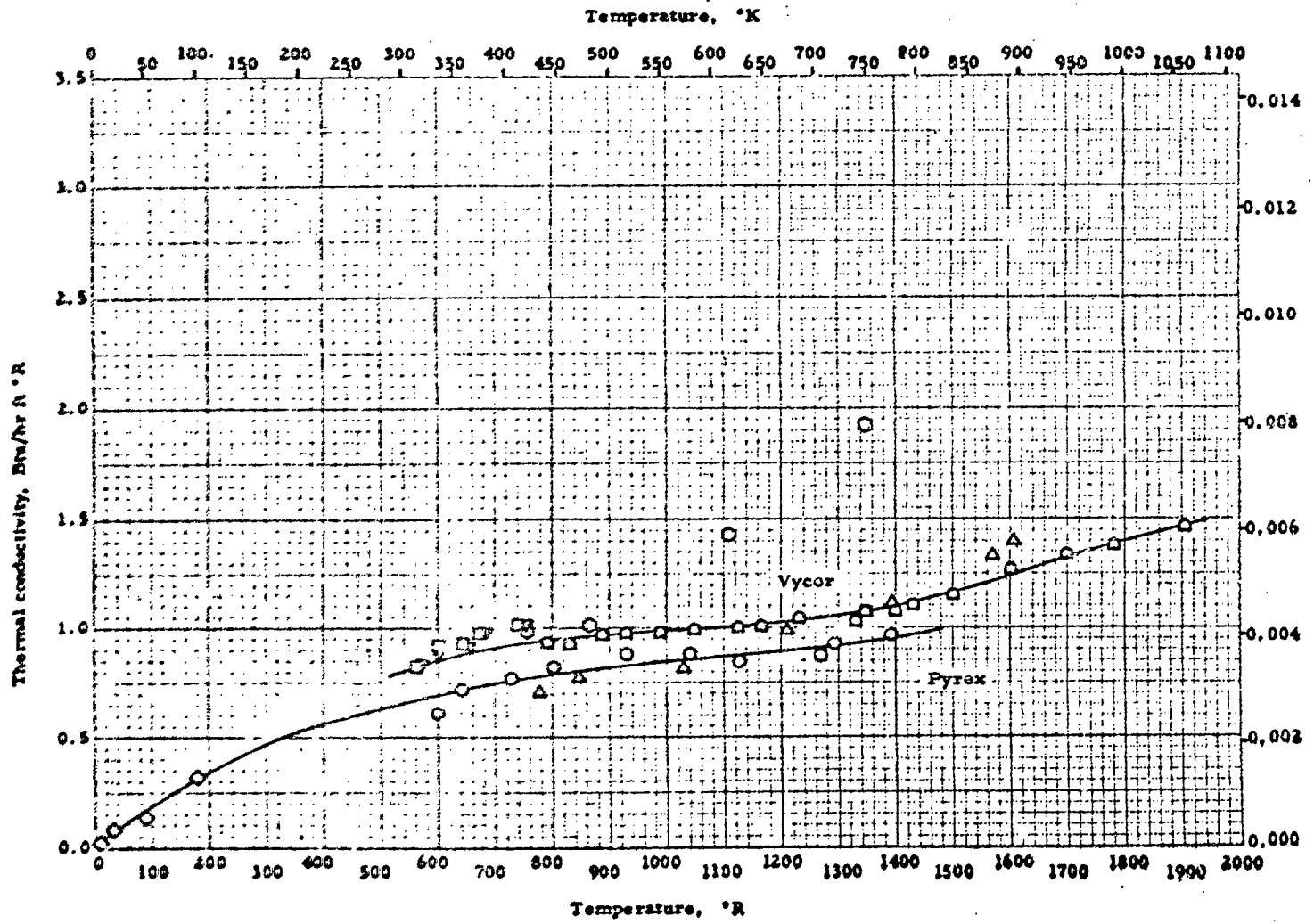


SPECIFIC HEAT -- BOROSILICATE GLASS

SPECIFIC HEAT -- BOROSILICATE GLASS

REFERENCE INFORMATION

	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Prud'homme, M.	55-43	672-1572	Borosilicate crown glass	Comparative, rate of temperature rise in sample compared with standard (silica) under same conditions	Auth. believes second-order transformation at 575°C
□	Lucks, C. F., Matolich, J. and Van Valzor, J. A.	54-27	140-1460	Pyrex Type 774	Drop method; ice calorimeter	
◇	Kubaschewski, O. and Wittig, F. E.	41-24	532-1626	Supremax glass	Drop method	Calculated from auth's eq.; avg. c_p $(\frac{cal}{g°C}) = 0.1882 + 9.49 \times 10^{-5}$ $(T - 22°C)$, c_p calc. as $c_p = \text{avg. } c_p + \Delta T \frac{d \text{ avg. } c_p}{dT}$
▽	Kubaschewski, O.	43-13	392-1824	Supremax glass	Not described here, refers to others	Calculated from equation fitted to author's enthalpy data by least mean square routine at ARF. Auth. est. accuracy ± 1%



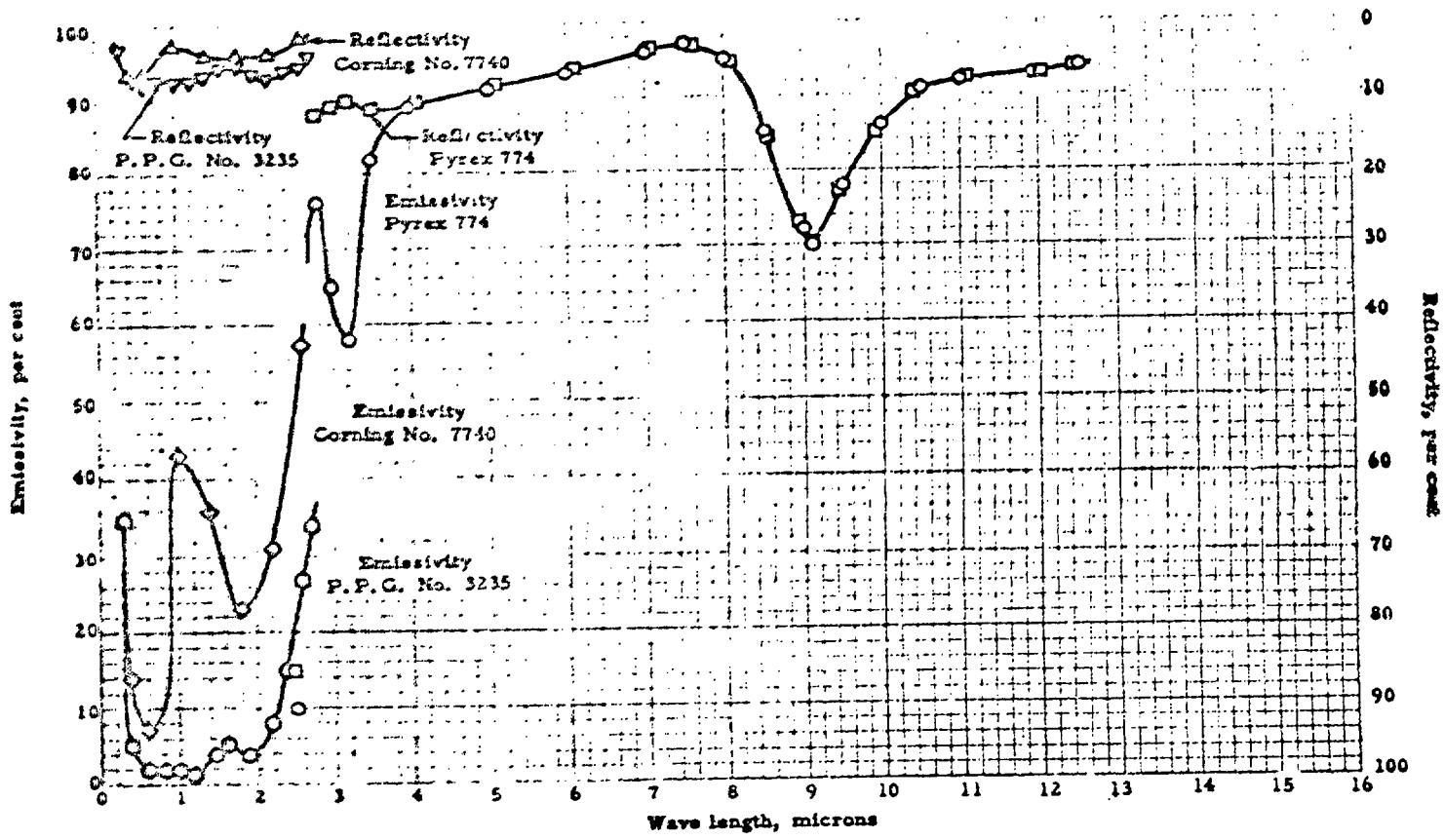
THERMAL CONDUCTIVITY -- BOROSILICATE GLASS

WADC TR 58-476 Pt 5 548

THERMAL CONDUCTIVITY -- BOROSILICATE GLASS

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Lucks, C.F. and Deem, G.F.	52-33	595-1383	Pyrex Glass No. 774 (clear chemical glass)	Comparative; rods (Armco Iron standard)	
□	Koenig, J.H., New Jersey Ceramic Research Station	53-43	560-750	Pyrex Glass. $\rho = 139$ lb_m/ft^3	Comparative; rods; Cu primary standard; Inconel working standard	Tested in vacuum
▽	Ibid.	53-43	570-760	Borosilicate Glass. (Am. Ceram. Soc. standard glass) $\rho = 147$ lb_m/ft^3	Same as above	Same as above
△	Kingery, W.D. and Norton, F.H.	54-64	780-1603	Pyrex Glass	Probably comparative	
◇	Berman, R.	51-14	5-180	Phoenix Glass (Pyrex Type)	Temp. distribution in rod heated at one end	
○	Knapp, W.J.	43-11	700-1355	Pyrex Glass: 80.5% SiO_2; 12.9% B_2O_3; 3.8% Na_2O; 2.2% Al_2O_3; 0.4% K_2O	Comparative; 1 cm cubes, Stainless steel standard	
○	Lucks, C.F., Matolich, J. and Van Valzor, J.A.	54-27	796-1907	Vycor Glass	Comparative, (Armco Iron standard)	

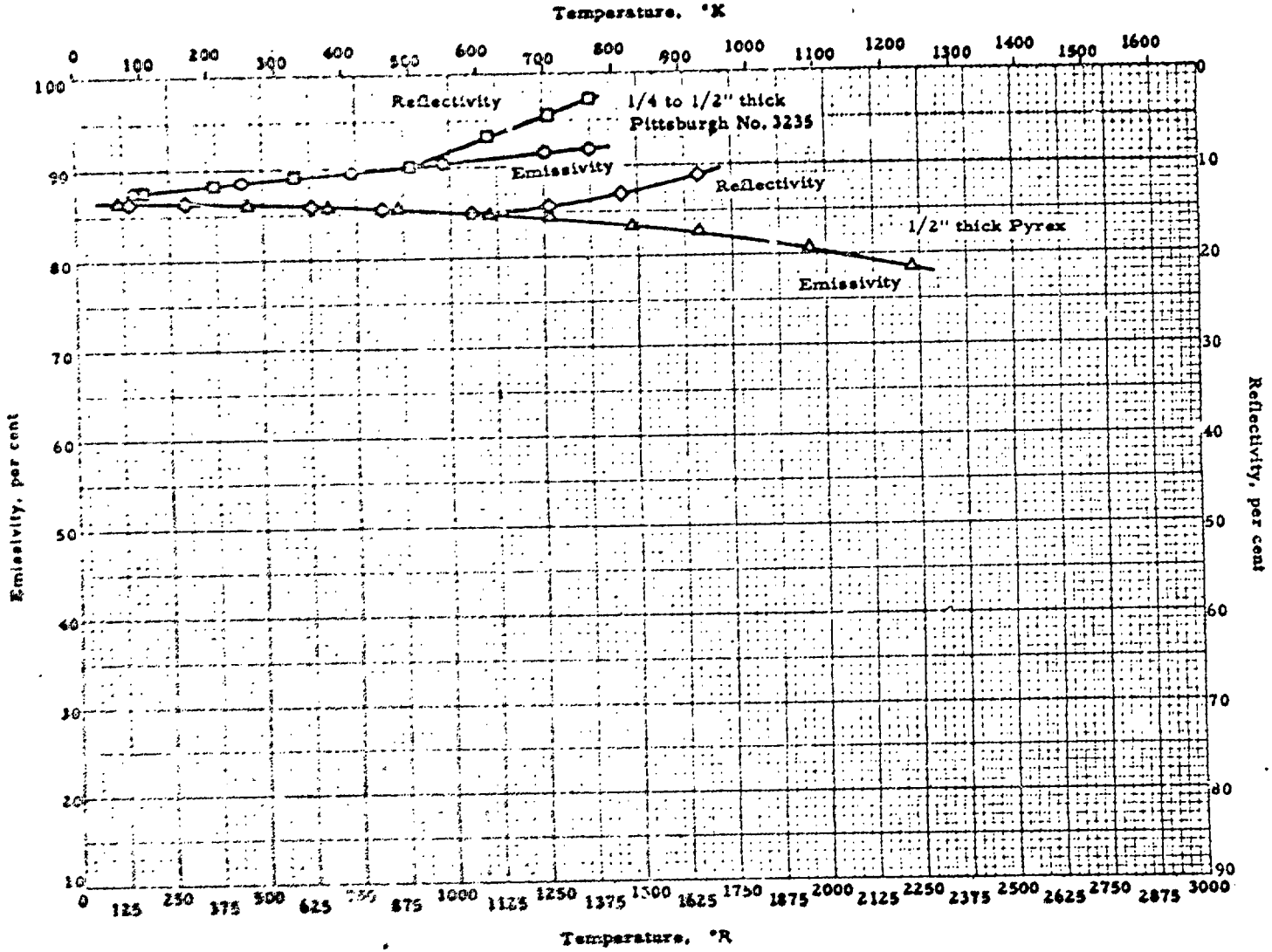


SPECTRAL EMISSIVITY -- BOROSILICATE GLASS

SPECTRAL EMISSIVITY -- BOROSILICATE GLASS

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	McMahon, H.	51-60	1460	Pyrex 774. 81% SiO_2 ; 13% B_2O_3 ; 3.8% Na_2O-K_2O; 2.2% R_2O_3	Spectral emissivity: Parkin-Elmer spectrometer	Sample 1/8 in. thick at 1000 °F
□	Ibid.	51-60	1460	Same as above	Spectral emissivity: computed from emissivity and transmissivity. Transmission of black body radiation	Same as above. Reflectivity = 1 - transmissivity - emissivity
△	Glaca, O.H. and Morris, J.C.	59-1	Room	Glass - Corning No. 7740, Pyrex	Spectral reflectivity at 9°: sample compared with $MgCO_3$ standard in MgO integrating sphere, quartz lens, PbS detector	Sample 1/2 in. thick
◇	Ibid.	59-1	Room	Same as above	Spectral emissivity: meas. spectral reflectivity as above, and spectral transmissivity: comparative; radiation through sample compared with incident radiation by integrating sphere	Same as above. Emissivity = 1 - reflectivity - transmissivity
▽	Ibid.	59-1	Room	Glass - borosilicate, Pittsburgh No. 3235	Spectral reflectivity at 9°: sample compared with $MgCO_3$ standard in MgO integrating sphere, quartz lens, PbS detector	
○	Ibid.	59-1	Room	Same as above	Spectral emissivity: meas. spectral reflectivity as above, and spectral transmissivity: comparative; radiation through sample compared with incident radiation by integrating sphere	Emissivity = 1 - reflectivity - transmissivity



EMISSIVITY -- BOROSILICATE GLASS

60-745
WADC TR 59-676
822

EMISSIVITY -- BOROSILICATE GLASS

REFERENCE INFORMATION

	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Olsen, O. H. and Morris, J. C.	59-1	160-1360	Pittsburgh No. 3235	Total normal emissivity: comparative: surface brightness compared with that of a black body hole. Sample temp by thermocouple, accuracy = ± 3%	Sample is $\frac{1}{2}$ in. thick
□	Ibid.	59-1	160-1360	Same as above	Total normal reflectivity: meas. emissivity as above, and apparent trasmissivity of radiation from black body at sample temp.	Same as above. Reflectivity = 1-emissivity-transmissivity Auth. also report data for 1/4 in. and 3/16 in. thick samples, within ± 2% of values for 1/2 in. thick sample.
△	Ibid.	59-1	160-1960	Corning No. 7740, pyrex	Total normal emissivity: comparative: surface brightness compared with that of a black body hole	$\frac{1}{2}$ in. thick sample in air
◇	Ibid.	59-1	160-1960	Same as above	Total normal reflectivity: emissivity as above, and transmissivity of radiation from black body at sample temp.	Same as above. Reflectivity = 1-emissivity-transmissivity

Symbol	Material Composition, Wt %							Average coefficient of linear expansion x 10^6	
	SiO_2	B_2O_3	Al_2O_3	Li_2O	K_2O	CaO	Na_2O	492-1032°R	273-573°K
								$°R^{-1}$	$°K^{-1}$
O	49.5	20.8	9.0	10.1	10.6			5.1	9.1
	46.2	19.4	8.4	6.3	19.7			5.6	10.0
	43.4	18.2	17.9	2.9	27.8			6.0	10.8
	40.7	17.1	7.4		34.8			6.5	11.7
	50.2	14.9	18.3	10.3		6.3		4.0	7.2
	48.8	14.4	17.7	6.7		12.4		3.7	6.7
	47.5	14.0	17.2	3.4		18.0		3.4	6.1
	46.2	13.6	16.8			23.4		3.1	5.5
	51.4	21.6	9.3	10.5			7.2	5.4	9.7
	49.6	20.8	9.0	6.7			13.9	5.8	10.4
	47.9	20.8	8.7	3.2			20.2	6.1	11.0
	46.2	19.4	8.4				26.0	6.4	11.5

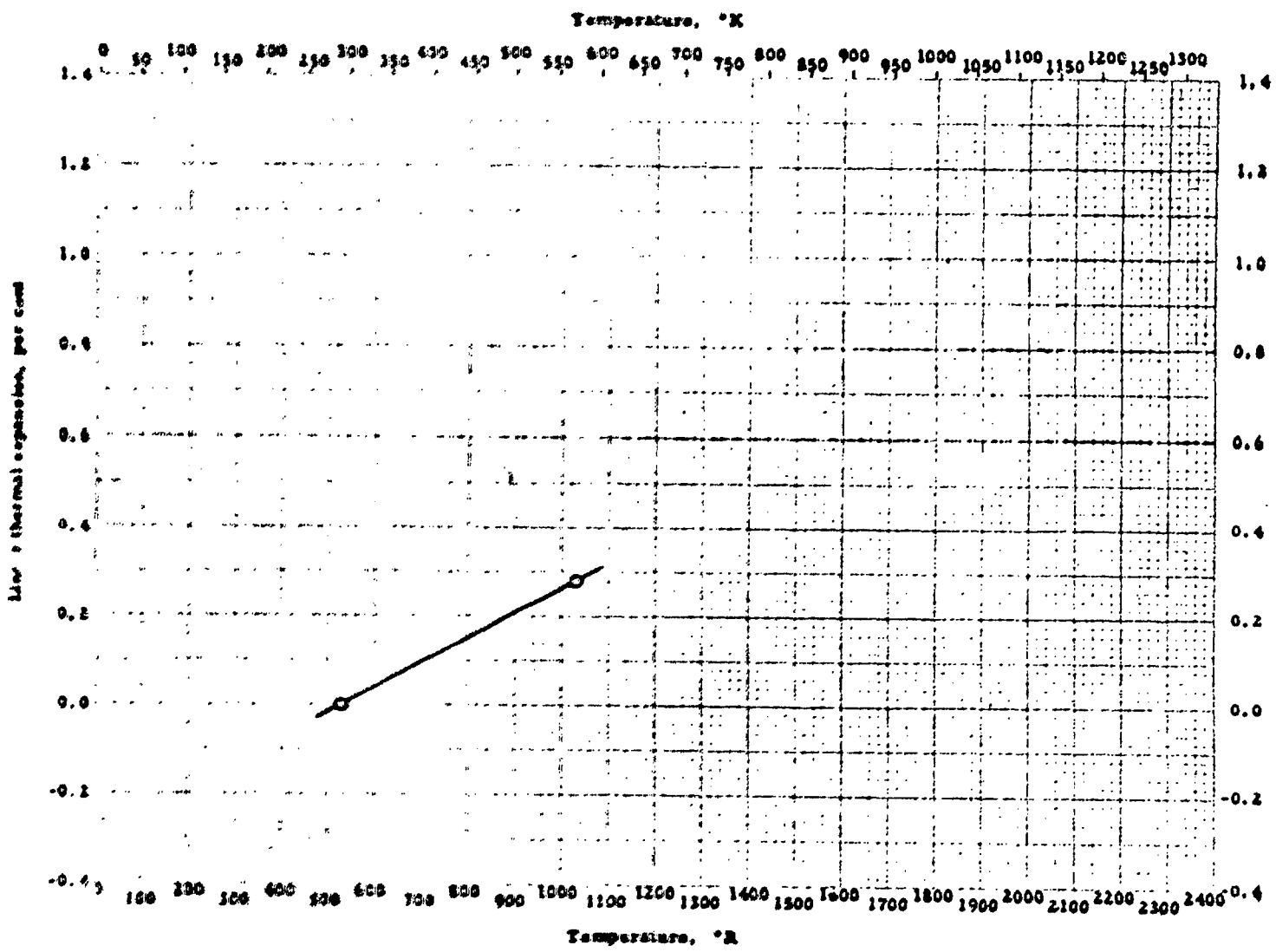
Also see graphs of $\Delta L/L$ vs T

LINEAR THERMAL EXPANSION -- ALKALI AND ALKALINE EARTH ALUMINUM BOROSILICATE GLASS

LINEAR THERMAL EXPANSION -- ALKALI AND ALKALINE EARTH ALUMINUM BOROSILICATE GLASS

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Dale, A. E., Pegg, E. F. and Stanworth, J. E.	21-61	492-1632	Series of glasses	Differential dilatometer with 10 cm x 3 mm dia. fused silica rods	



LINEAR THERMAL EXPANSION--LEAD BOROSILICATE GLASS

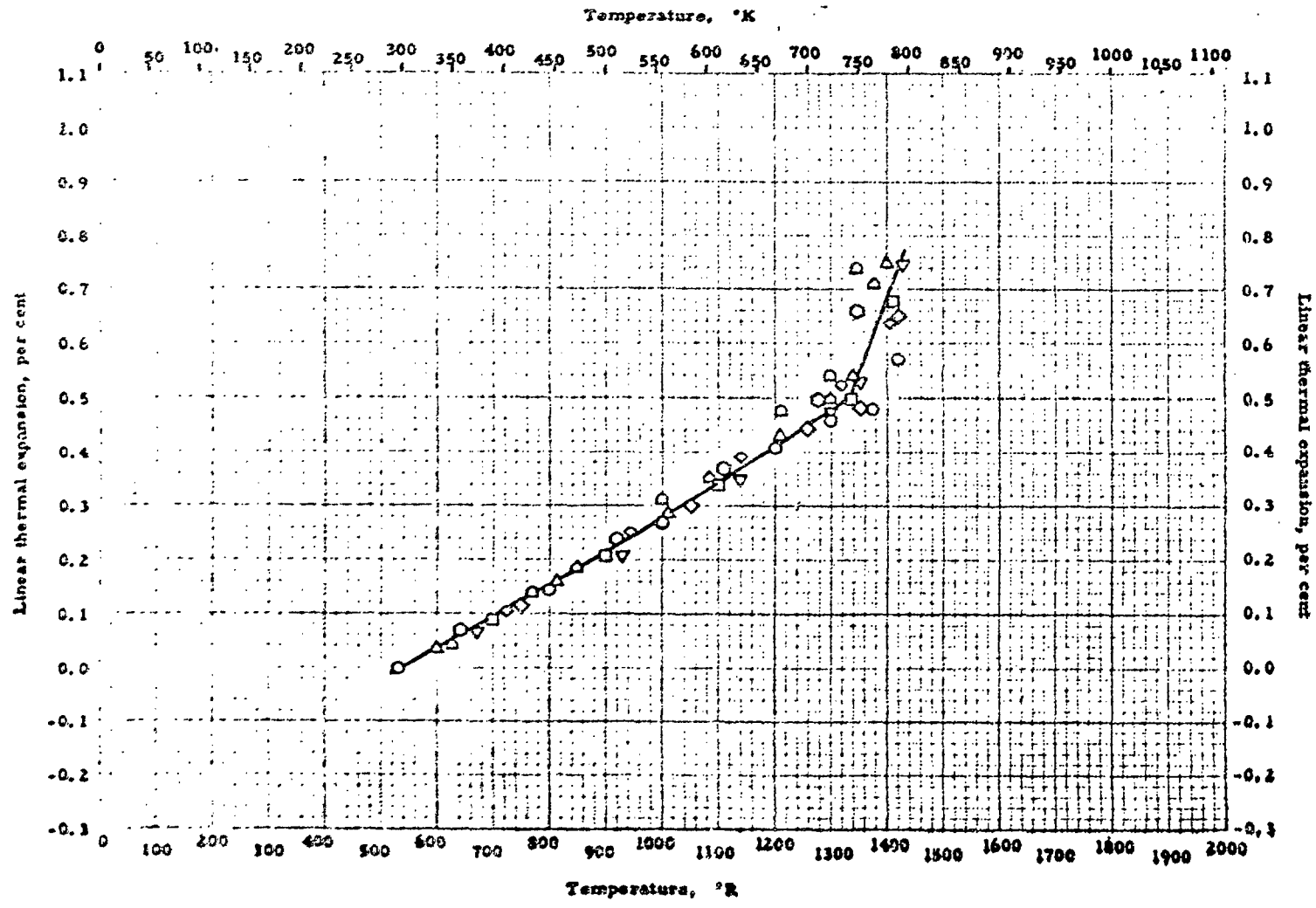
WADC TR 59-595

816

LINEAR THERMAL EXPANSION -- LEAD BOROSILICATE GLASS

REFERENCE INFORMATION

Point Ref.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Bischoff, F.	55-26	528-1032	78.5% PbO; 19.0% SiO_2; 2.5% B_2O_3 (50 mol % PbO; 45 mol % SiO_2; 5 mol % B_2O_3) ρ = 381 lb_m/ft^3	Not given	

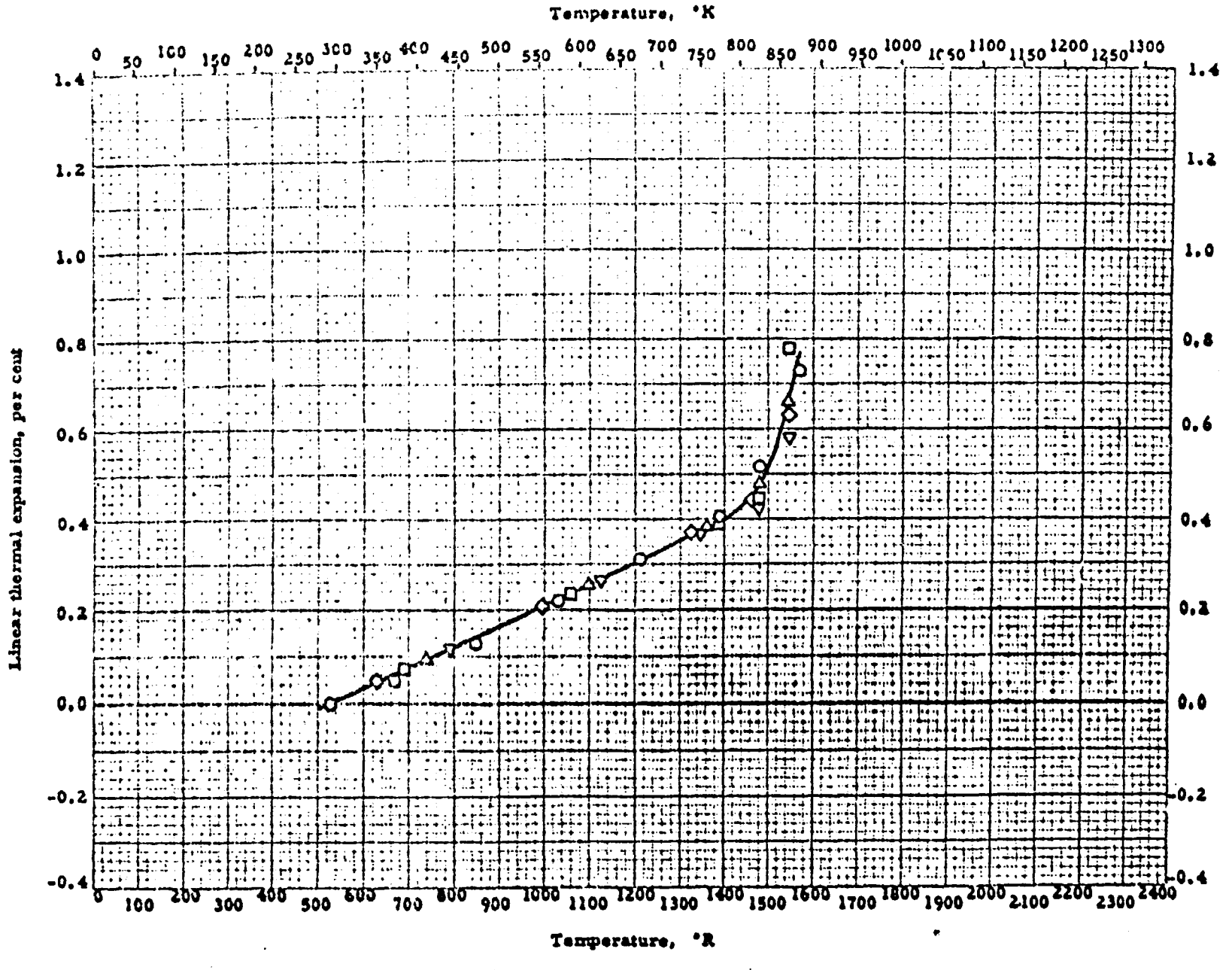


LINEAR THERMAL EXPANSION -- LITHIUM BOROSILICATE GLASS

LINEAR THERMAL EXPANSION -- LITHIUM BOROSILICATE GLASS

REFERENCE INFORMATION

	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
C	Hardwark, J. H. and McVay, T. N.	54-148	528-1420	70.37% SiO_2; 16.95% Li_2O; 10.85% B_2O_3; 0.40% oxides of the form R_2O_3	Gaertner interferometer	Made from chemically pure materials melted and crushed 3 times, cast in 300°C mold, annealed 4 hr at 300°C, furnace cooled
D	Ibid.	54-148	528-1410	65.80% SiO_2; 17.13% Li_2O; 15.54% B_2O_3; 0.33% oxides of the form R_2O_3	Same as above	Same as above
E	Ibid.	54-148	528-1400	60.75% SiO_2; 20.23% B_2O_3; 17.58% Li_2O; 0.30% oxides of the form R_2O_3	Same as above	Same as above
F	Ibid.	54-148	528-1420	55.54% SiO_2; 25.55% B_2O_3; 17.31% Li_2O; 0.26% oxides of the form R_2O_3	Same as above	Same as above
G	Ibid.	54-148	528-1430	51.35% SiO_2; 30.58% B_2O_3; 17.95% Li_2O; 0.29% oxides of the form R_2O_3	Same as above	Same as above
H	Ibid.	54-148	528-1367	61.28% SiO_2; 21.39% Li_2O; 16.03% B_2O_3; 0.30% oxides of the form R_2O_3	Same as above	Same as above
I	Ibid.	54-148	528-1367	55.73% SiO_2; 22.09% Li_2O; 20.69% B_2O_3; 0.32% oxides of the form R_2O_3	Same as above	Same as above
J	Ibid.	54-148	528-1378	50.75% SiO_2; 25.50% B_2O_3; 21.71% Li_2O; 0.39% oxides of the form R_2O_3	Same as above	Same as above
K	Ibid.	54-148	522-1410	65.55% SiO_2; 19.51% CaO; 13.36% Li_2O; 1.02% B_2O_3; 0.26% oxides of the form R_2O_3	Same as above	Same as above



LINEAR THERMAL EXPANSION -- SODIUM POTASSIUM BOROSILICATE GLASS

CINDAS 68-6 (REV. 3-68)

LINEAR THERMAL EXPANSION -- SODIUM POTASSIUM BOROSILICATE GLASS

REFERENCE INFORMATION

	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Hagy, H. E. and Hiland, H. M.	57-184	525-1572	Borosilicate Crown Glass. Nominal: 70% SiO_2; 11% B_2O_3; 9% Na_2O; 7% K_2O; 3% BaO	Cooling data meas. with micrometer microscope sighting on wires suspended from sample	
□	Ibid.	57-184	525-1545	Same as above, ρ = 137.8 lb_m/ft^3	Heating data meas. with differential silica dilatometer	This sample and the following three were subjected to 4 different heat treatments which were not described
△	Ibid.	57-184	525-1545	Same as above except ρ = 157.2 lb_m/ft^3	Same as above	
◇	Ibid.	57-184	525-1545	Same as above except ρ = 157.1 lb_m/ft^3	Same as above	
▽	Ibid.	57-184	525-1545	Same as above except ρ = 156.8 lb_m/ft^3	Same as above	

Symbol	Material Composition, Wt %							Average coefficient of linear expansion x 10^6	
	SiO_2	B_2O_3	Na_2O	ZnO	Al_2O_3	CaO	K_2O	528-672°R	293-373°K
○	68.2	11.0	6.9	6.4	3.2	2.7	1.5	3.62	6.52
□	64.2	15.3	6.8	6.4	3.2	2.6	1.5	3.23	5.81
△	62.2				14.6	23.2		3.00	5.4
◇	60.0	19.6	6.8	6.4	3.2	2.6	1.5	3.39	6.1

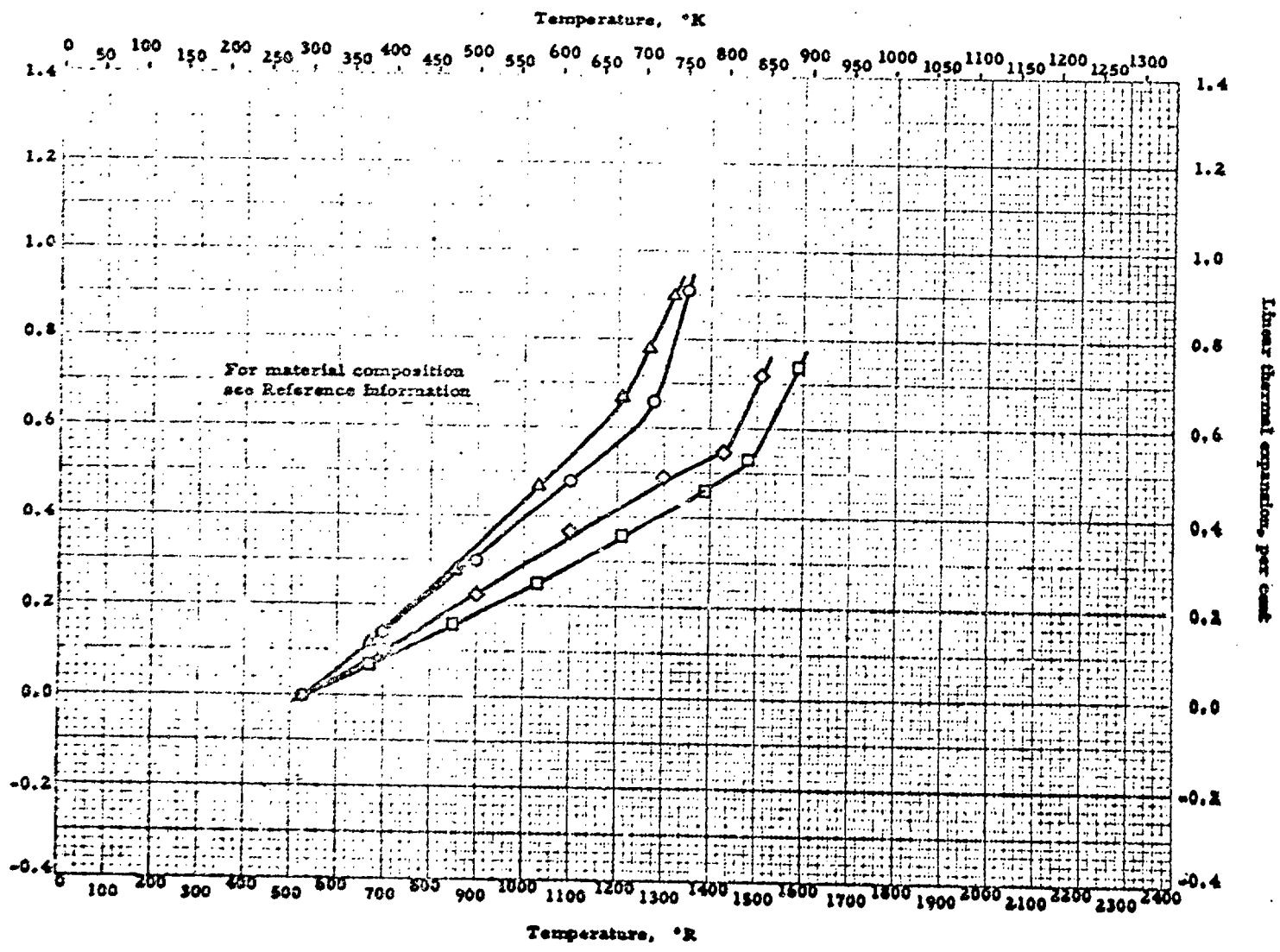
LINEAR THERMAL EXPANSION -- SODIUM ZINC BOROSILICATE GLASS

WADC TR 59-676 69-151 002

LINEAR THERMAL EXPANSION -- SODIUM ZINC BOROSILICATE GLASS

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Napolitano, A., Waxler, R. and Olvert Jr., J. M.	56-169	Room	72% SiO_2 ; 10% B_2O_3 ; 7% Na_2O; 5% ZnO; 3% CaO; 2% Al_2O_3 ; 1% K_2O (mol %)	Not given	
□	Ibid.	56-169	Room	68% SiO_2 ; 14% B_2O_3 ; 7% Na_2O; 5% ZnO; 3% CaO; 2% Al_2O_3 ; 1% K_2O (mol %)	Not given	
△	Ibid.	56-169	Room	64% SiO_2 ; 18% B_2O_3 ; 7% Na_2O; 5% ZnO; 3% CaO; 2% Al_2O_3 ; 1% K_2O (mol %)	Not given	
◇	Ibid.	56-169	Room	62.2% SiO_2 ; 23.2% CaO; 14.6% Al_2O_3 (weight %)	Not given	



LINEAR THERMAL EXPANSION -- SODIUM BOROSILICATE GLASS

LINEAR THERMAL EXPANSION -- SODIUM BOROSILICATE GLASS

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Hamlwark, J. H. and McVay, T. N.	54-148	528-1356	57.83% SiO_2; 32.32% Na_2O; 8.50% B_2O_3; 0.25% metal oxides of the form R_2O_3	Gaertner interferometer	Made from chemically pure materials melted and crushed 3 times, cast in 300 C mold and annealed 4 hr. at 300 C, furnace cooled
□	Ibid.	54-148	528-1590	71.15% SiO_2; 17.28% Na_2O; 10.20% B_2O_3; 0.35% metal oxides of the form R_2O_3	Same as above	Same as above
△	Ibid.	54-148	528-1320	51.72% SiO_2; 37.40% Na_2O; 8.61% B_2O_3; 0.24% metal oxides of the form R_2O_3	Same as above	Same as above
◇	Ibid.	54-148	528-1510	64.93% SiO_2; 22.85% Na_2O; 10.78% B_2O_3; 0.27% metal oxides of the form R_2O_3	Same as above	Same as above

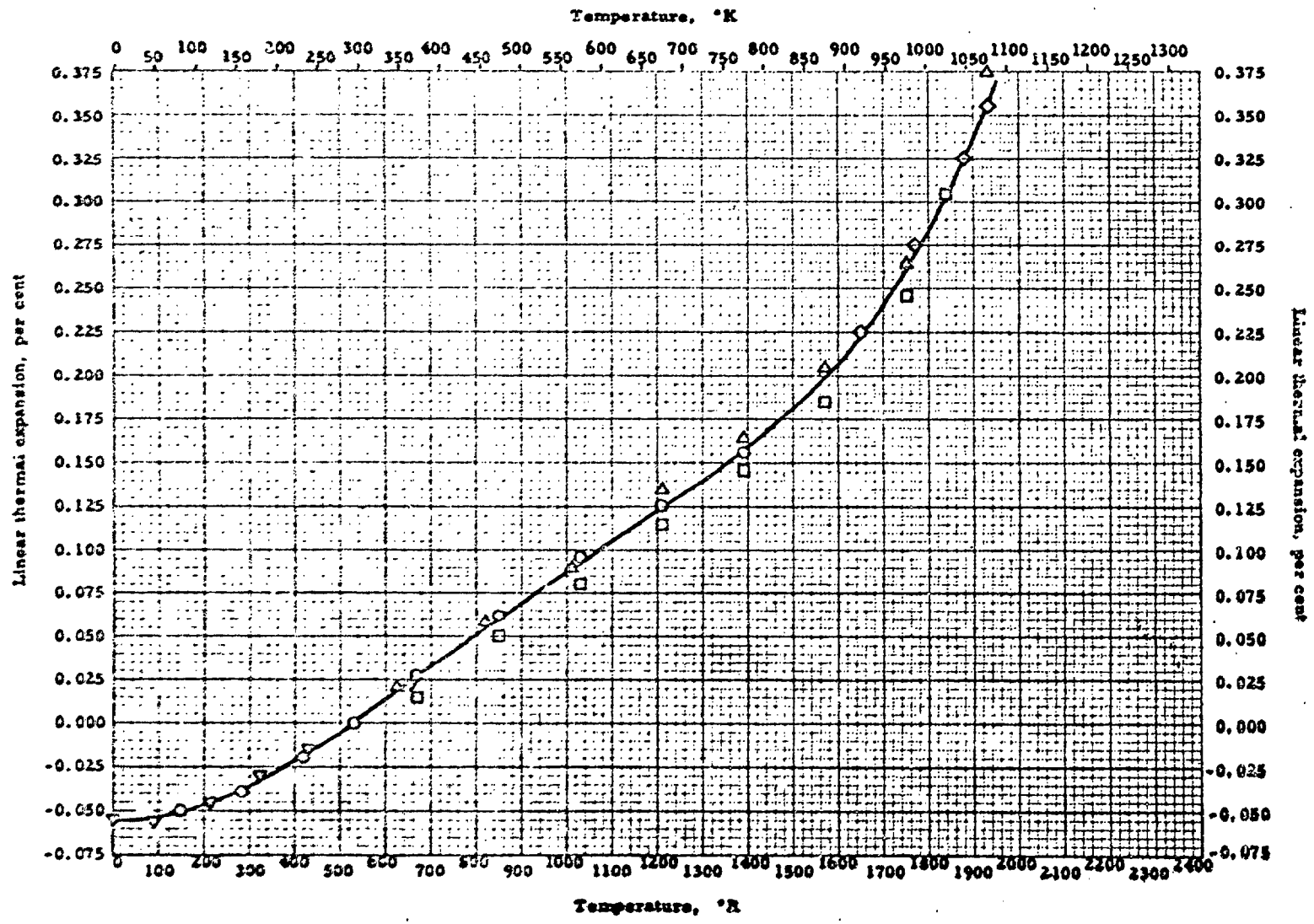
Symbol	Material Composition, Mol %						Average coefficient of linear expansion × 10^6	
	SiO_2	B_2O_3	MgO	Al_2O_3	ZnO	Others	672-1212°R	373-673°K
O	42.9	13	21.5	21.5		1.1% Na_2O	2.4	4.3
	40	10	26	14	6	4% Li_2O	3.3	5.9
	40	10	26.6	16.7		6.7% CaO	2.6	4.7
	40	10	20	16	6	4% ea. SrO, Li_2O	3.1	5.6
	40	10	23	17	10		2.6	4.6
	40	10	24	16	6	4% SrO	3.1	5.6
	40	10	20	16	6	8% SrO	3.0	5.4
	26.5	24	10.7	10.7	27.5	0.5% Na_2O	2.7	4.8
	25	22.5	13.3	8.35	27.5	3.35% CaO	2.8	5.1
	25	22.5	13.3	8.4	30.8		2.9	5.2
	17	18	30		35		3.4	6.2
	17	18	30	5	30		3.7	6.6
	17	18	25	4	36		3.4	6.1
	17	18	25	4	34	2% ZrO	3.5	6.3
	10.5	36.9	10.5		31.6	10.5% Li_2O	4.4	7.9
	10	35	10		45		3.1	5.5
	10	35	10	5	40		3.0	5.4

LINEAR THERMAL EXPANSION -- ZINC MAGNESIUM ALUMINUM BOROSILICATE GLASS

LINEAR THERMAL EXPANSION -- ZINC MAGNESIUM ALUMINUM BOROSILICATE GLASS

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	National Bureau of Standards	57-179	672-1212	Series of glasses	Not given	

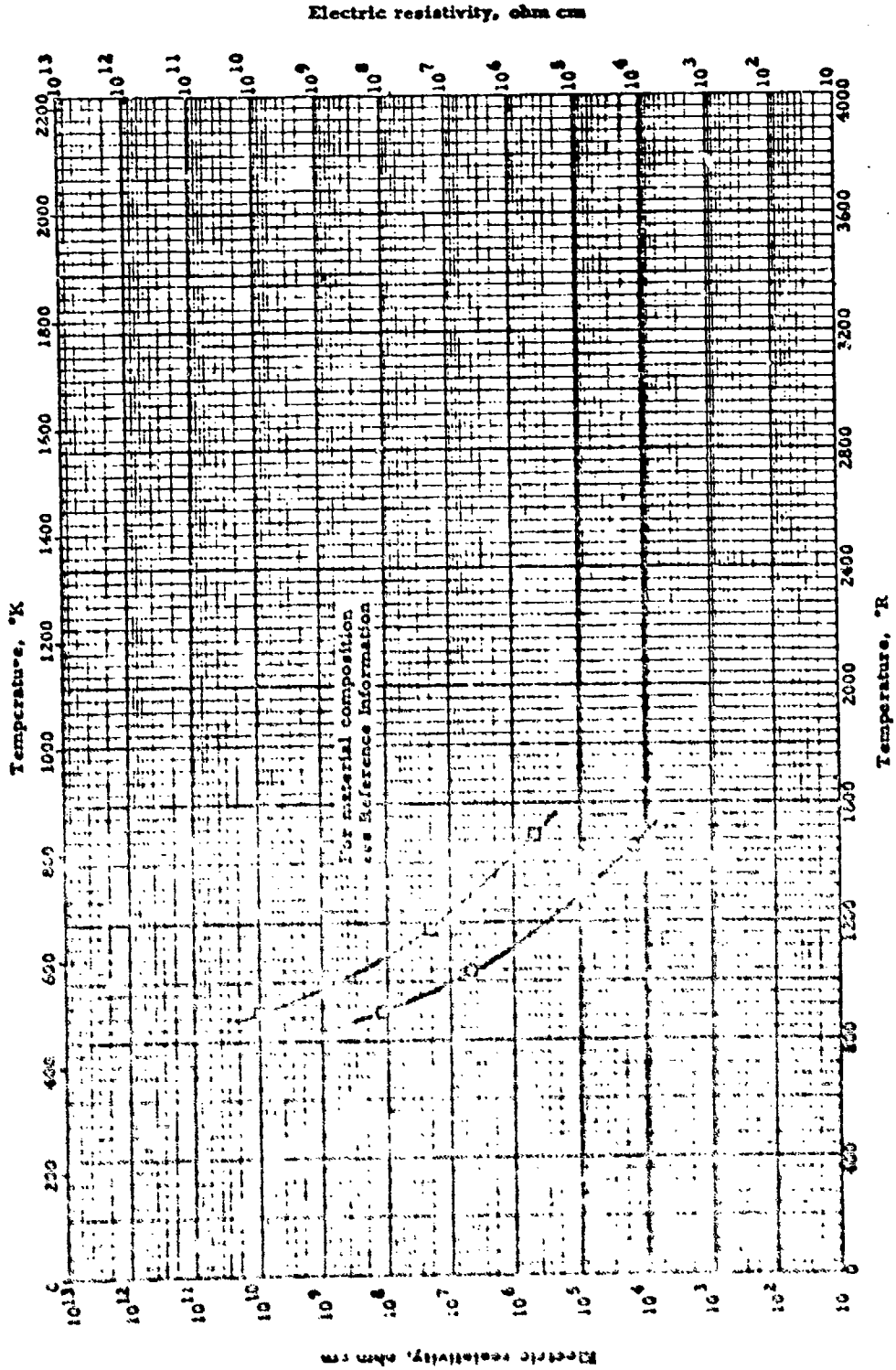


LINEAR THERMAL EXPANSION -- BOROSILICATE GLASS

LINEAR THERMAL EXPANSION -- BOROSILICATE GLASS

REFERENCE INFORMATION

	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Locke, C. F., Berg, G. F. et al.	52-33	150-1400	Pyrex Glass No. 774, clear chemical glass	Interferometer	Made by Cincinnati Gasket and Packing Co.
□	Cox, S. M., Conting, J. F. and Kirby, P. L.	51-26	580-1850	Pyrex Borosilicate Glass, 80% SiO_2	Measured sample expansion by rotation of cylindrical sample support with other sample end held fixed. Temp. by Chromel-Alumel thermocouple	Data taken during cooling from 750°C
△	Ibid.	51-26	550-1930	Same as above	Same as above	Data taken during second cooling and heating
◇	Ibid.	51-26	1650-1930	Same as above	Same as above	Data taken at high temp.
▽	Laquer, H. L.	52-39	0-650	Pyrex 774	Quartz dilatometer with dial gauges	



ELECTRIC RESISTIVITY -- BOROSILICATE GLASS

ELECTRIC RESISTIVITY -- BOROSILICATE GLASS

REFERENCE INFORMATION

Sym.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Joyner, B. L. and Bell, W. C.	53-105	900-1464	Borosilicate glass; 38.7% SiO_2; 37.3% B_2O_3; 16.6% Na_2O; 7.2% TiO_2	Wheatstone bridge	Glassy phase
□	Ibid.	53-105	900-1499	36.7% SiO_2; 25% TiO_2; 17.6% B_2O_3; 14.9% CaO; 7.8% Na_2O	Same as above	Glassy phase

PROPERTIES OF SILICA GLASS

PROBABLE VALUES

Property	Brit. Engineering Units	C. G. S. Units
Density.	137.6 lb_m/ft^3	2.204 g/cm^3
Softening Point, Vycor . .	3190 °R	1770 °K
Heat of Fusion		
Heat of Vaporization. . .		
Heat of Sublimation . . .		

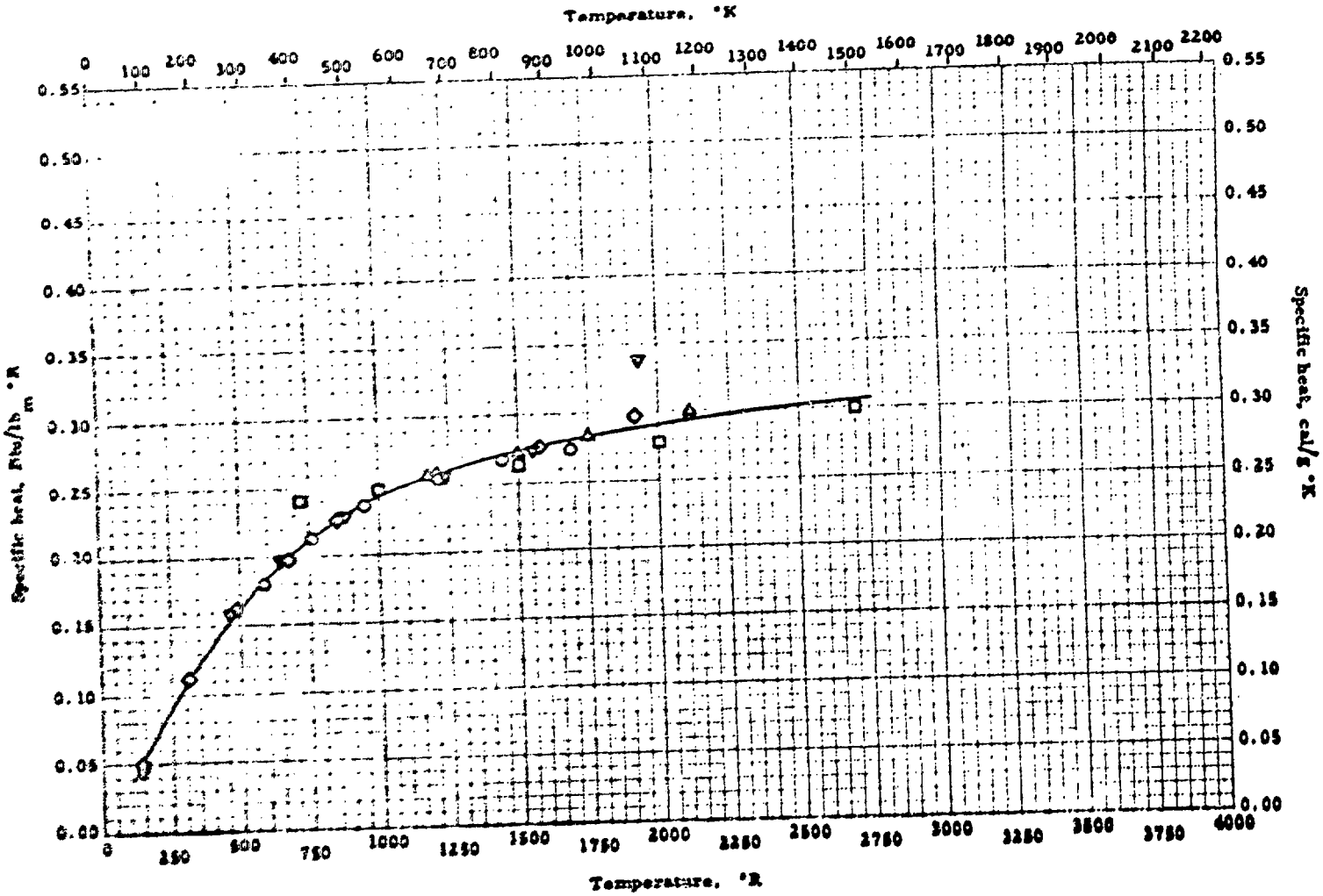
REPORTED VALUES

Density:		lb_m/ft^3	g/cm^3
	○	137.59	2.2040
	□	137.53	2.2030
	△	137.6 ± 0.06	2.204 ± 0.001
	◇	137.53	2.2030
	○	136.62	2.1883
Softening Point:		°R	°K
	▽	3192	1773
Heat of Fusion:		Btu/lb_m	cal/g
Heat of Vaporization:		Btu/lb_m	cal/g
Heat of Sublimation:		Btu/lb_m	cal/g

PROPERTIES OF SILICA GLASS

REFERENCE INFORMATION

	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
C	Frost, D. and Kinser, F.	52-82	Room	Not given	ρ: weight and volume by displacement in liquid	Auth. states accuracy $\pm 10^{-4}$ g/cm^3
□	Locke, C. F. and Ding, G. F.	52-33	528 (492-582)	Clear fused quartz	ρ: weight and volume by water displacement	From Hanovia Chem. Co.
△	Oak Ridge National Lab.	57-150	537	Silica glass	ρ: weight in air and in kerosene	Measured by O. Sisman, C. D. Bopp, R. L. Towns
◇	Locke, C. F., Thompson, H. B. et al.	51-65	Room	Clear fused silica	ρ: weight in air and in water	From Hanovia Chemical Co.
▽	Nordberg, M. E.	44-11	3192	Silica glass, Vycor No. 790. 96% SiO_2 : 3% B_2O_3 0.4% R_2O_3 + RO_2 (chiefly Al_2O_3, traces of Na_2O and As_2O_3)	Softening point; not described here, refers to others	Melted, formed, heat treated above annealing point separating it into two phases. The unstable glass was leached out in hot dilute acid. Then the sample was washed and dried
○	Locke, C. F. and Ding, G. F.	52-33 also 51-65	528	Vycor	ρ: not given	Made by Corning Glass Works



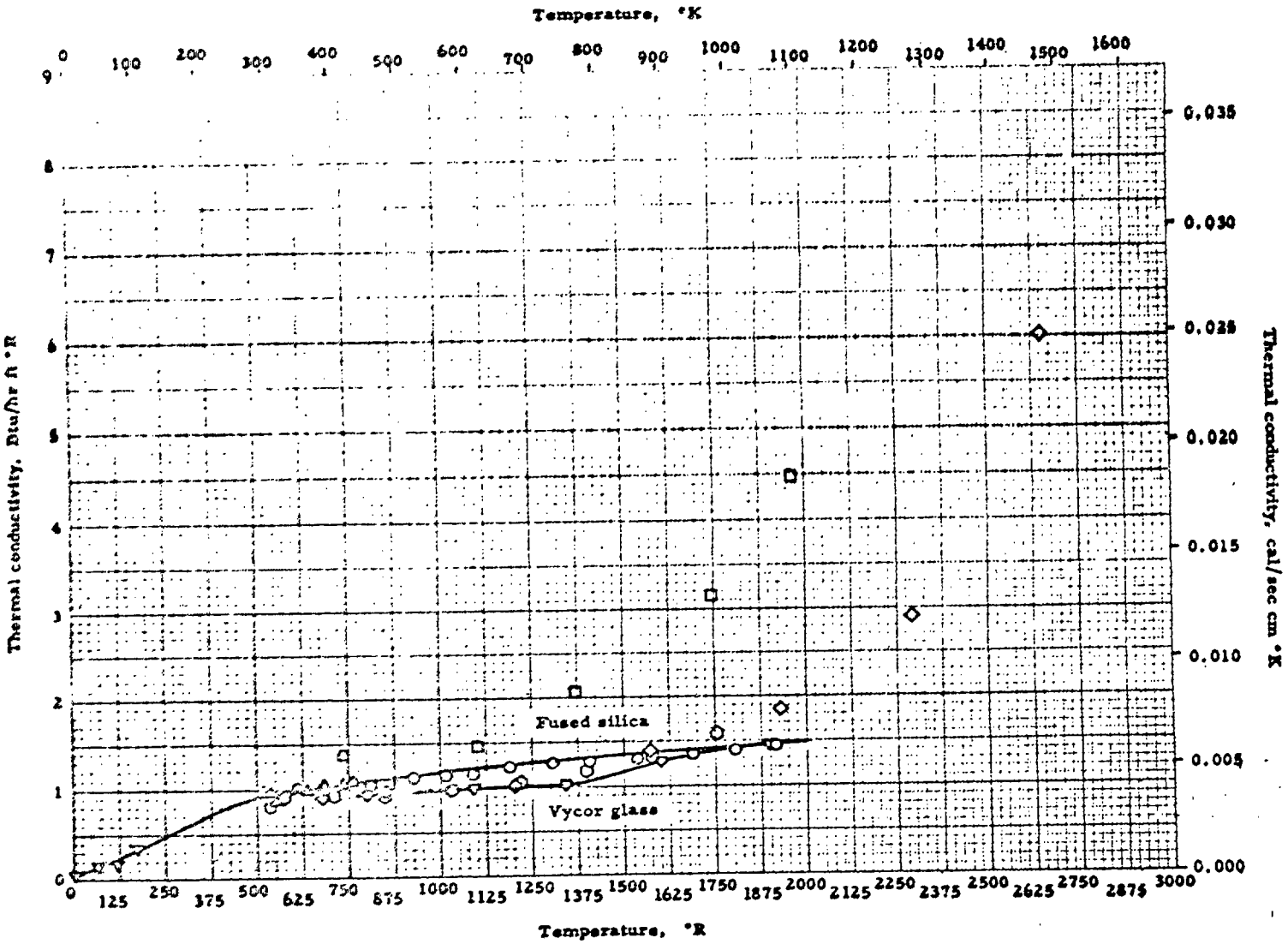
SPECIFIC HEAT -- SILICA GLASS

AMPC TR 64-816 694 64-65

SPECIFIC HEAT -- SILICA GLASS

REFERENCE INFORMATION

Curve No.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Moser, H.	41-13	582-1665	Quartz glass	Guarded cmple	Heated in argon at low pressure
□	Kelley, K. K., Naylor, B. F. and Stormate, C. H.	46-1	720-2700	Silica glass	Drop method; copper block calorimeter	Enthalpy data of auth. fitted with quadratic eq. by ARF
△	Kubaschewski, O.	43-13	1176-2112	Quartz glass	Drop method; copper block calorimeter	Same as above
◇	Lucks, C. F., Matolich, J. and Van Valzer, J. A.	54-27	140-1921	Clear	Drop method; ice calorimeter	
▽	Ibid.	54-27	140-1934	Vycor	Same as above	



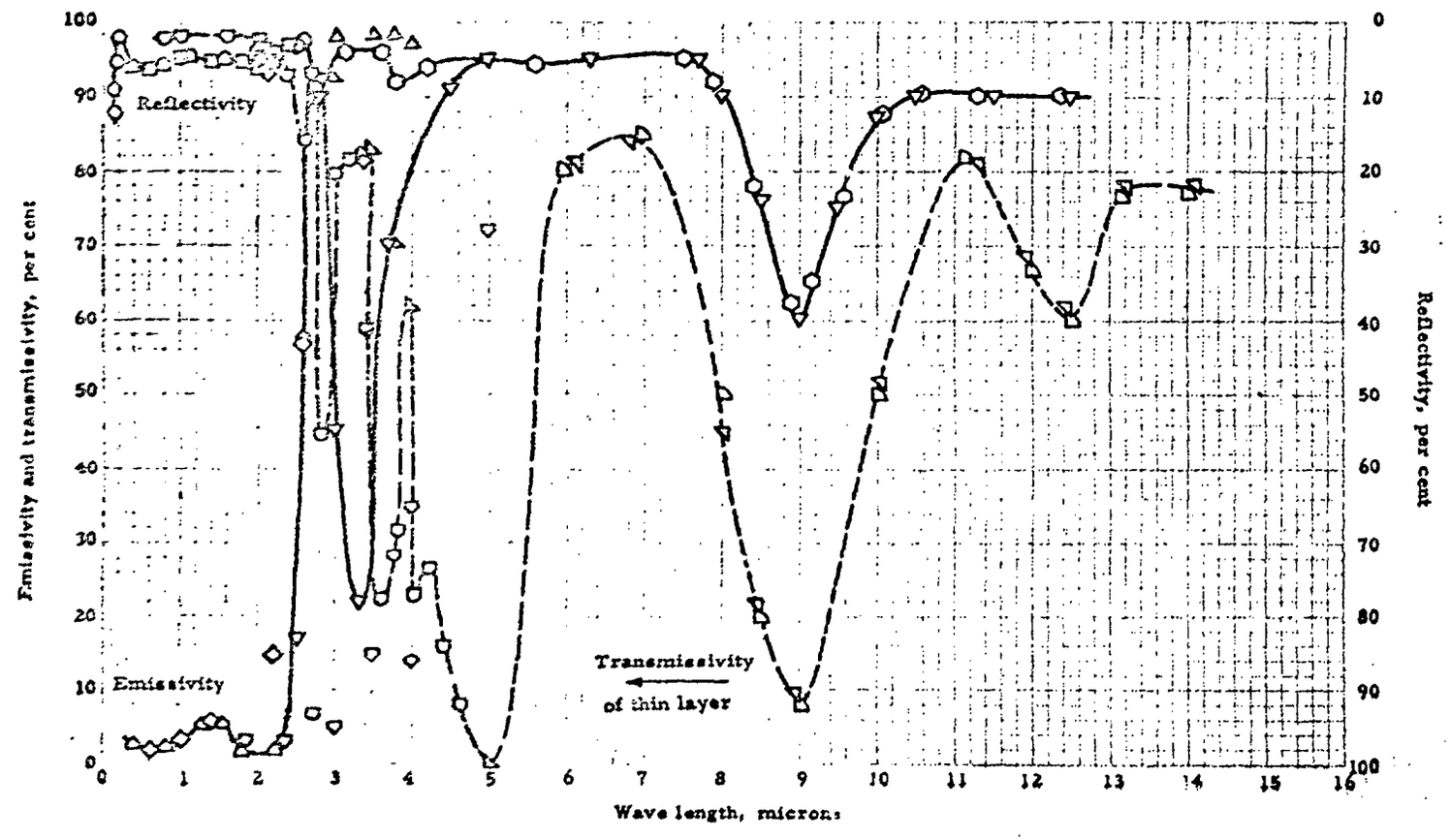
THERMAL CONDUCTIVITY -- SILICA GLASS

WADC TR 58-476 659

THERMAL CONDUCTIVITY -- SILICA GLASS

REFERENCE INFORMATION

	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Lucks, C.F., Matolich, J. and Van Valzor, J.A.	54-27	802-1918	Fused silica (quartz)	Comparative. Armco Iron standard	Low emissivity foil on both sides of sample
□	Knapp, W. J.	43-11	680-1970	Fused silica glass (pure)	Comparative; 1 cm cubes; *stainless steel standard*	
△	Koenig, J.H., Snyder, N.H. et al.	53-3	560-742	Vitreous silica (silky fused silica)	Comparative; rods Cu standard	Two samples. One with silky lines parallel to heat flow, the other perpendicular
◇	Kingery, W.D. and Norton, F. H.	55-57	672-2652	Clear fused silica	Comparative; rods	
▽	Berman, R.	51-14	6-180	Quartz glass	Temp. distribution in rod heated at one end	
○	Kingery, W. D.	55-75 also 53-68 54-137	582-1752	Fused silica (transparent)	Comparative and prolate spheroid	Samples ground from blocks of clear fused silica
△	Weeks, J.L. and Seifert, R.L.	52-1 also 51-39	623-735	Fused quartz	Temp. distribution in rod heated at one end	
△	Colosky, B.P.	52-80	560-735	Vitreous silica	Comparative; rods	2 clear samples; 1 smoky
□	Oak Ridge National Laboratory	57-150	546	Silica glass	Not described here, refers to others	
▽	Lucks, C.F., Matolich, J. and Van Valzor, J.A.	54-27	796-1907	Vycor glass	Comparative. Armco Iron standard	



SPECTRAL EMISSIVITY -- SILICA GLASS

SPECTRAL EMISSIVITY -- SILICA GLASS

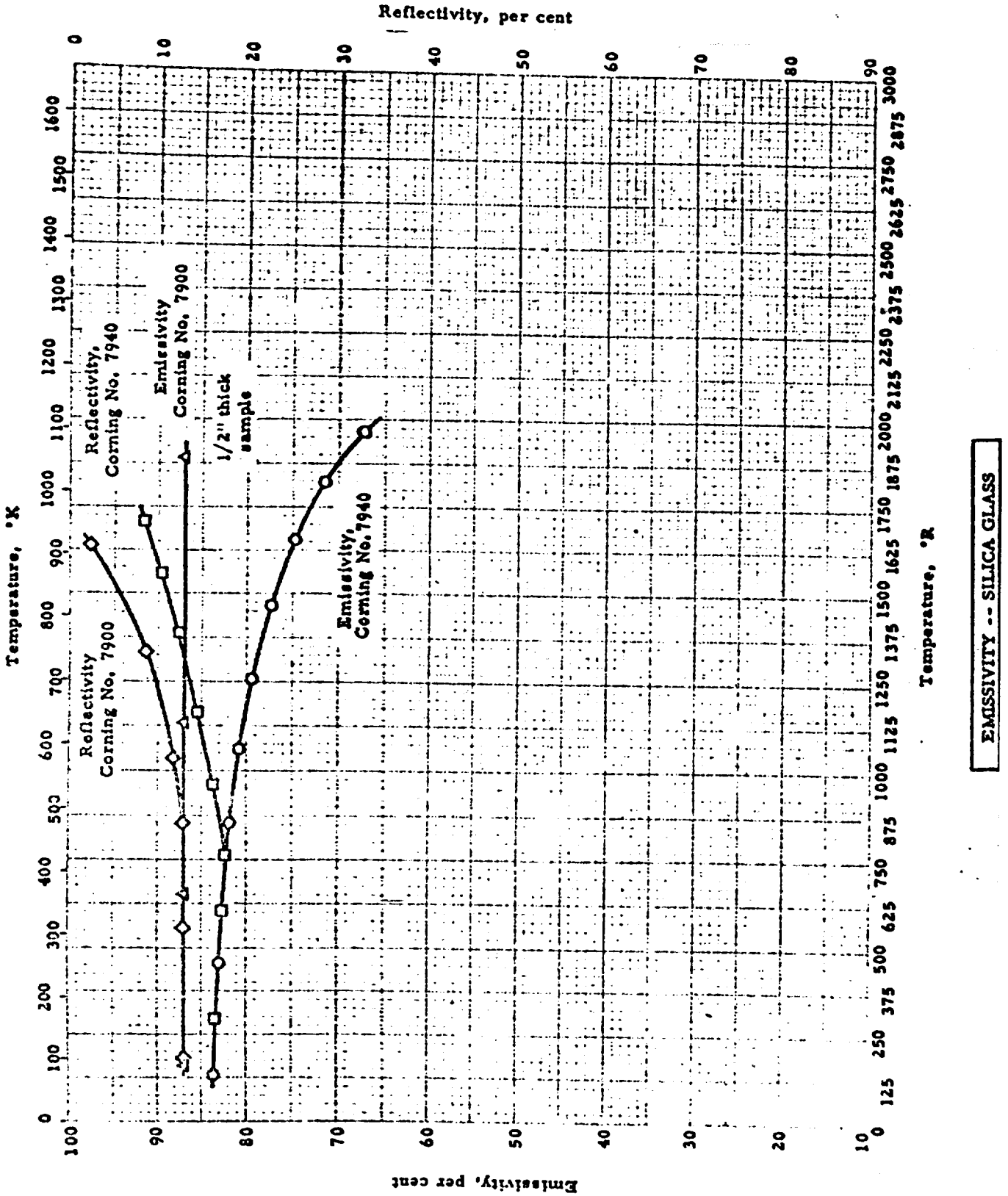
REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Johnson, B.K.	41-20	Room	Not given	Spectral reflectivity: intensity of direct and reflected spectral lines compared on photographic plate	Polished front surface. Back surface ground
△	Mingery, W.D. and Norton, F.H.	55-47	537	Not given	Spectral reflectivity: not given	2mm thick sample
□	Olsen, O.H. and Morris, J.C.	59-1	Room	Glass - Corning No. 7940 (fused silica)	Spectral reflectivity at 9°: Sample compared with $MgCO_3$ standard in MgO integrating sphere, quartz lens, PbS detector	1/2 in. thick sample
◇	Ibid.	59-1	Room	Same as above	Spectral emissivity: spectral reflectivity meas. as above, and transmissivity: comparative: radiation through sample compared with incident radiation by integrating sphere	Same as above; emissivity = 1-reflectivity-transmissivity
▽	McMahon, H.	51-80	1460	Vycor glass. 96.3% SiO_2; 2.9% B_2O_3; <0.04% $Na_2O + K_2O$; 0.4% R_2O_3	Perkin-Elmer spectrometer and thermocouple	1/16 in. thick at 1000°F
○	Ibid.	51-80	1460	Same as above	Spectral reflectivity: computed from spectral emissivity and spectral transmissivity. Spectral emissivity: same as above. Spectral transmissivity: meas. radiation through sample from black body at sample temp.	Same as above. Reflectivity = 1-transmissivity-emissivity
□	Olsen, O.H. and Morris, J.C.	59-1	Room	Vycor glass (Corning No. 7900) 1/2 in. thick	Spectral reflectivity at 9°: compared with $MgCO_3$ std. in MgO-coated Al integrating sphere with quartz lens and PbS detector	
◇	Ibid.	59-1	Room	Same as above	Spectral emissivity: computed from spectral reflectivity and spectral transmissivity. Spectral reflectivity: same as above. Spectral transmissivity: compared radiation thru sample with incident radiation by integrating sphere	Reflectivity = 1-transmissivity-emissivity

SPECTRAL EMISSIVITY -- SILICA GLASS (Cont'd)

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
□	Nordberg, M.E.	44-11	Room	Vycor No. 790 glass. 96% SiO_2; 3% B_2O_3; 0.4% R_2O_3 + RO_2 (chiefly Al_2O_3); traces of Na_2O and As_2O_3	Spectral transmissivity: not given	Alkali borosilicate glass, melted, formed, heat treated above annealing point, separated into 2 phases, of which the unstable was leached out in hot dilute acid. Washed and dried
○	Kingery, W.D. and Norton, F.H.	55-47	537	Not given	Spectral transmissivity: by Beckman infrared spectrometer. Data corrected for reflectivity loss	2mm thick sample. Plotted emissivity = 1-reflectivity - transmissivity
△	Ibid.	55-47	537	Same as above	Same as above	Plotted transmissivity
◇	Ibid.	55-47	2652	Same as above	Same as above	Same as above
▷	Moore, H. and McMillan, P.W.	56-79	Room	100% pure SiO_2 powder	Spectral transmissivity by Grubb-Parson infrared and ultra-violet non-recording spectrophotometer	Plotted transmissivity, thin layer of powdered sample on rock salt plates
▽	Ibid.	56-79	Room	Vitreous silica	Same as above	Same as above

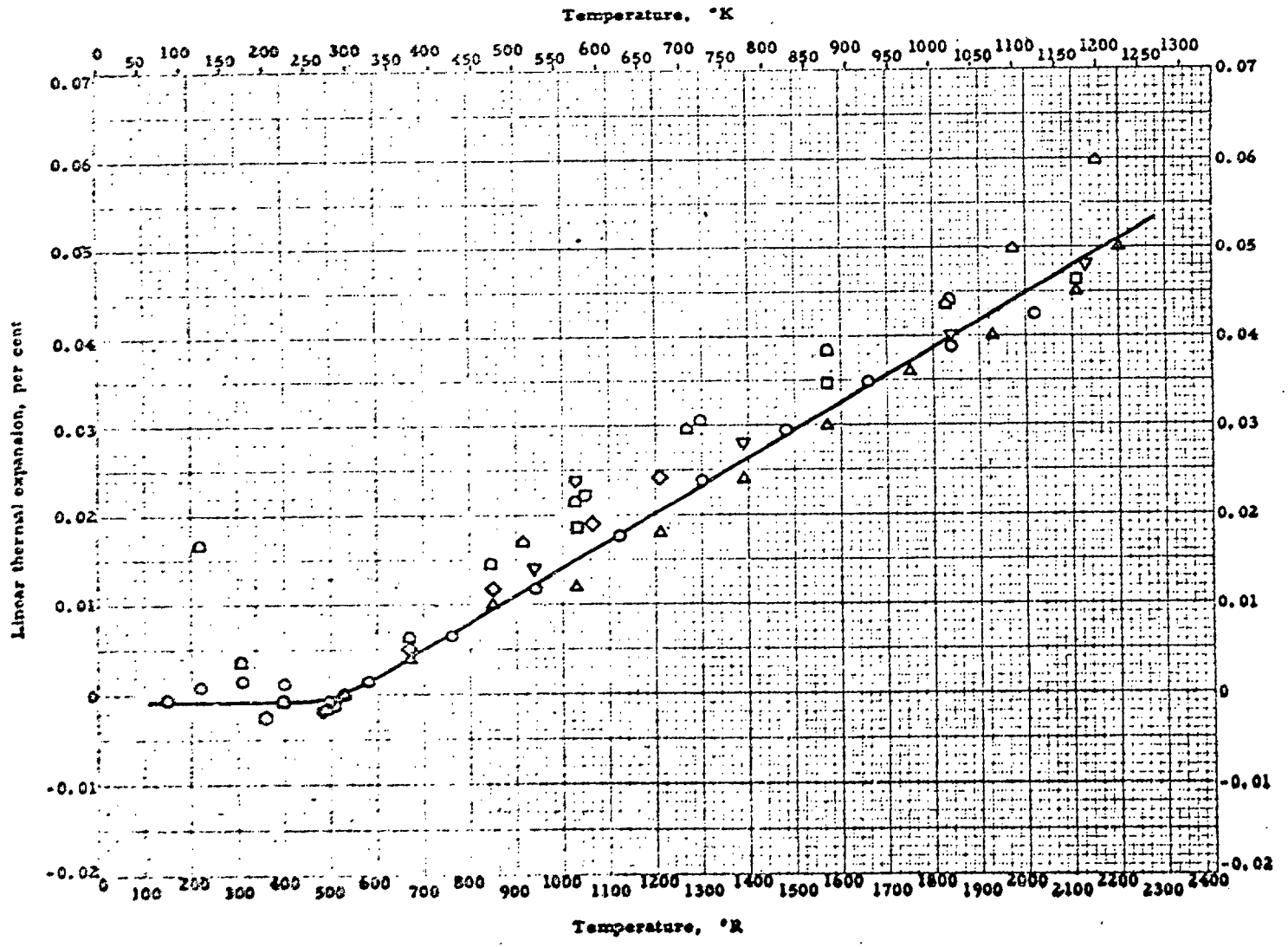


EMISSIVITY -- SILICA GLASS

EMISSIVITY -- SILICA GLASS

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Olson, O. H. and Morris, J. C.	59-1	160-1960	Glass - Corning No. 7940 fused silica	Total normal emissivity: comparative: surface brightness compared with that of a black body hole, using thermopile. Sample temp. by thermocouple	1/2 in. sample in air. Accuracy ± 3%
□	Ibid.	59-1	160-1960	Same as above	Total normal reflectivity: meas. emissivity as above, and apparent transmissivity of radiation from black body at sample temp.	Same as above; reflectivity = 1-emissivity-transmissivity
△	Ibid.	59-1	160-1960	Glass - Corning No. 7900, Vycor	Total normal emissivity: compared: surface brightness compared with that of a black body hole	1/2 in. thick sample in air, in furnace. Data from authors' smoothed curve
◇	Ibid.	59-1	160-1960	Same as above	Total normal reflectivity: emissivity as above and transmissivity of radiation from black body at sample temp.	Same as above. Reflectivity = 1 - transmissivity - emissivity

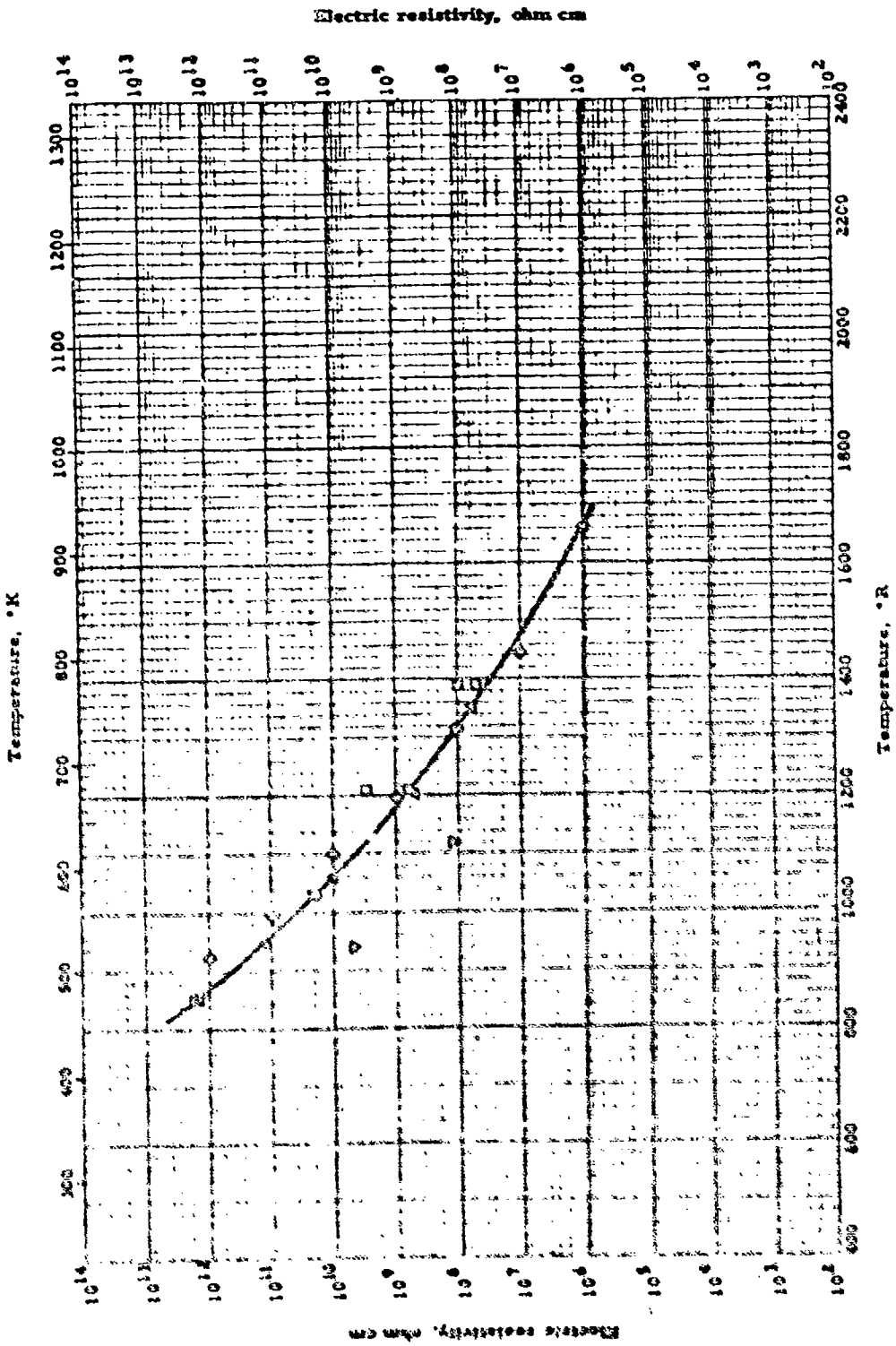


LINEAR THERMAL EXPANSION -- SILICA GLASS

LINEAR THERMAL EXPANSION -- SILICA GLASS

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Lucks, C. F. and Deem, G. F.	52-33	150-2072	Clear fused silica, $\rho = 138\ lb_m/ft^3$	Interferometer	From Hanovia Chemical Co.
□	Whitemore, O. J. and Auld, N. M.	56-7	1032-2112	Fused SiO_2	Alumina tube dilatometer, temp. by thermocouple	
△	Durbin, R. A. and Harman, C. G.	52-31	528-2202	Vitreous silica	Interferometer	
◇	Sherman, H. F.	56-466	530-1210	Fused silica, $\rho = 135\ lb_m/ft^3$	Interferometer	
▽	Nordberg, M. E.	44-11	530-2150	Fused silica	Interferometer	
○	Perry, S.	45-6	530-360	Fused quartz	Dilatometer with dial indicator	Auth. est. accuracy ± 3.4%
□	Lucks, C. F., Deem, G. F. et al.	52-33	222-1842	Vycor	Interferometer	From Corning Glass Works
△	Nordberg, M. E. and Lillie, H. R.	44-11	528-2157	Vycor No. 790 Silica glass. 96% SiO_2; 3% B_2O_3; 0.4% R_2O_2 + RO_3 (chiefly Al_2O_3); traces Na_2O, As_2O_3	Interferometer	Melted, formed, heat treated above annealing pt. to separate it into 2 phases of which the unstable glass is leached out in hot dilute acid, washed, dried
□	Ibid.	44-11	492-1032	Same as above	Dilatometer	Same as above
▽	Ibid.	44-11	492-1032	Same as above	Same as above	Pulverized vycor, refined same as above



ELECTRIC RESISTIVITY -- SILICA GLASS

ELECTRIC RESISTIVITY -- SILICA GLASS

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	National Bureau of Standards	53-96	252-1392	Fused quartz	Not described here, refers to others	
□	Hauth, W.E.	56-75	1032-1392	Fused silica	Bridge method; thermocouple	
△	Strauss, E.W., Moore, D.G. et al.	56-69	857-1353	Silica glass; 0.001-0.01% ea. Al, Na; 0.0001-0.01% Fe; 0.001% Mg; 0.0001-0.001% Ca; 0.0001% Cu	Potential drop, DC reversal; Fe-Const thermocouple	Prepared from reagent grade chemicals, ground, melted, cast, annealed overnight, ground flat
◇	Russel Jr., R. and Berberich, L.J.	44-6	924-1662	Transparent fused quartz	Potential drop	
▽	Norberg, M. E.	44-11	942-1122	Vycor No. 790 silica glass. 96% SiO_2; 3% B_2O_3; 0.4% R_2O_3 + RO_2 (chiefly Al_2O_3); traces of Na_2O and As_2O_3	Wheatstone bridge	Melted, formed, heat treated above the annealing point, separating into two phases. The unstable glass is leached out in hot dilute acid, washed and dried. Author reports same values for porous and multiform types.

Symbol	Density		Melting Point	
	lb_m/ft^3	g/cm^3	°R	°K
○	227	3.63	1428	793
□	208	3.33	1428	793
△	190	3.04	1442	801
◇	176	2.82	1410	783
▽	217	3.48	1450	805
○	235	3.76	1554	863

PROPERTIES OF FLUOBORATE GLASS

PROPERTIES OF FLUOBORATE GLASS

REFERENCE INFORMATION

Item	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Inomistani, T. and Terai, R.	52-135	Room 1428-1554	70% BaF_2; 30% B_2O_3	ρ: not given MP: not given	B_2O_3 prepared by dehydrating H_3BO_3 at 200-300°C. Chemically pure BaF_2. Material melted in alumina crucible at 1100°C
□	Ibid.	52-135	Room 1428-1554	60% BaF_2; 40% B_2O_3	ρ: same as above MP: same as above	Same as above
△	Ibid.	52-135	Room 1428-1554	50% BaF_2; 50% B_2O_3	ρ: same as above MP: same as above	Same as above
◇	Ibid.	52-135	Room 1428-1554	60% B_2O_3; 40% BaF_2	ρ: same as above MP: same as above	Same as above
▽	Ibid.	52-135	Room 1428-1554	40% B_2O_3; 40% BaF_2; 20% B_2O	ρ: same as above MP: same as above	Same as above
○	Ibid.	52-135	Room 1428-1554	20% B_2O; 40% B_2O_3	ρ: same as above MP: same as above	Same as above

60-634
WADC TR 59-476
300

PROPERTIES OF GERMANIUM OXIDE GLASS

MOST PROBABLE VALUES

Property	Brit. Engineering Units	C. G. S. Units
Density.	229 lb_m/ft^3*	3.67 g/cm^3*
Melting Point		
Heat of Fusion		
Heat of Vaporization . . .		
Heat of Sublimation . . .		

*Average for engineering purposes

REPORTED VALUES

		lb_m/ft^3	g/cm^3
Density:	○	230	3.68
	□	229	3.67
	△	228	3.66
	◇	228	3.65
	▽	227	3.64

	°R	°K
Melting Point:		

	Btu/lb_m	cal/g
Heat of Fusion:		
Heat of Vaporization:		
Heat of Sublimation:		

PROPERTIES OF GERMANIUM OXIDE GLASS

REFERENCE INFORMATION

	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Parikh, N. M. and Simpson, H. E.	52-143	Room	79.4% GeO_2; 14.1% Na_2O; 6.5% CaO	ρ; weight and volume by displacement in liquid	
□	Ibid.	52-143	Room	79.35% GeO_2; 15.4% Na_2O; 5.35% CaO	ρ; same as above	
△	Ibid.	52-143	Room	79.3% GeO_2; 16.6% Na_2O; 4.28% CaO	ρ; same as above	
◇	Ibid.	52-143	Room	79.2% GeO_2; 17.75% Na_2O; 3.22% CaO	ρ; same as above	
▽	Ibid.	52-143	Room	79.0% GeO_2; 18.9% Na_2O; 2.15% CaO	ρ; same as above	

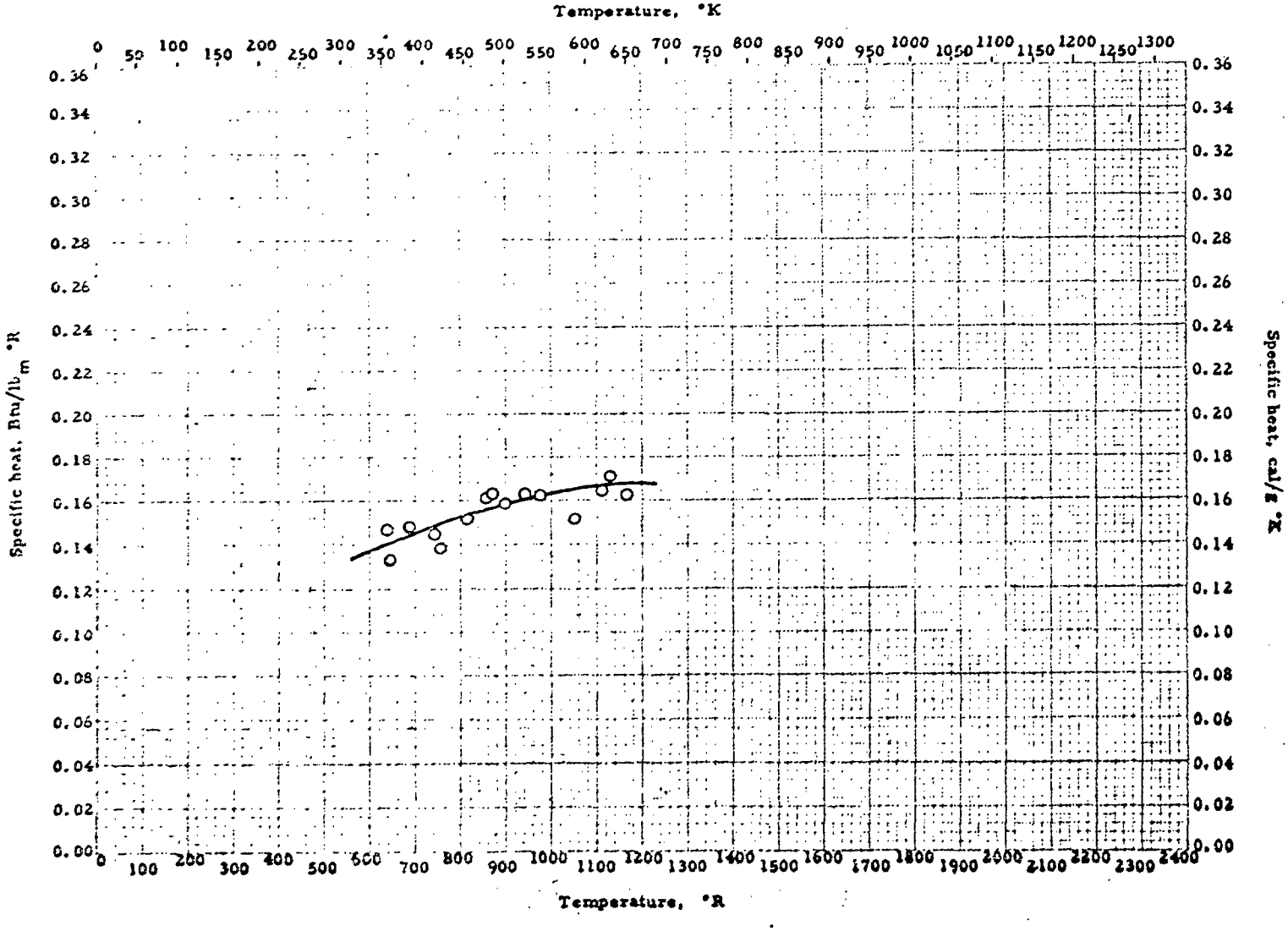
Symbol	Nominal Composition, % TeO_2	MoO_3	WO_3	Density lb_m/ft^3	g/cm^3
○	69	31	----	314	5.03
□	83.3	--	16.7	365	5.84
	82.3	--	17.7	366	5.86
	79.1	--	20.9	368	5.90
	77.5	--	22.5	370	5.92
	75.6	--	24.4	371	5.94
	65.5	--	34.5	379	6.07

DENSITY -- TELLURIUM OXIDE GLASS

DENSITY -- TELLURIUM OXIDE GLASS

REFERENCE INFORMATION

	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
C	Dietz, A. E., Pegg, E. F. and Stanworth, J. E.	54-140	Room	TeO_2 + MoO_3 glass 69% TeO_2; 31% MoO_3	Not given	Melted in Al_2O_3 crucible
D	Ibid.	54-140	Room	TeO_2 + WO_3 glasses	Same as above	Same as above

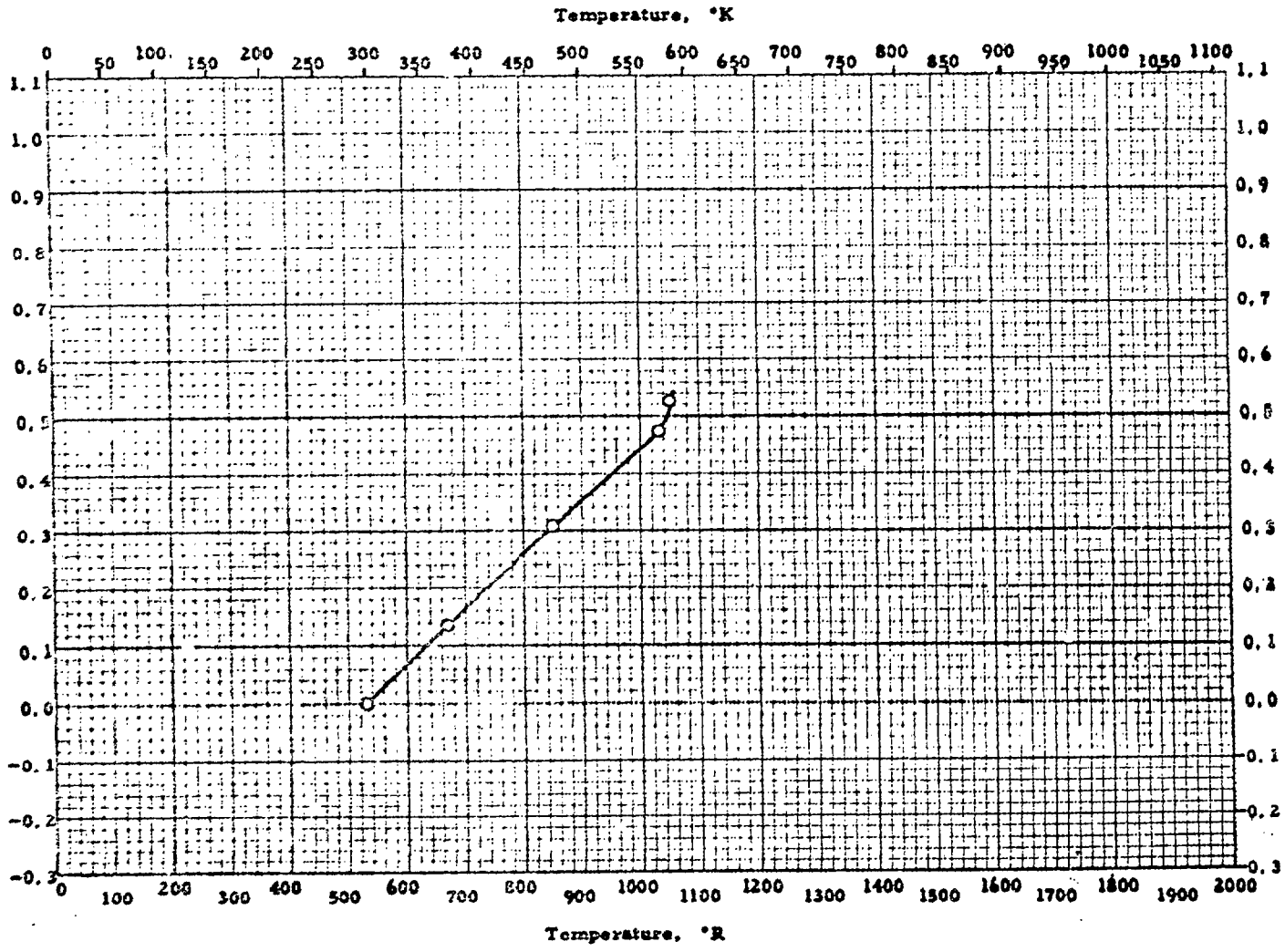


SPECIFIC HEAT -- GERMANIUM OXIDE GLASS

SPECIFIC HEAT -- GERMANIUM OXIDE GLASS

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Skogen, H. S.	55-39	642.5 - 1165	Germanium oxide glass	Spherical calorimeter with 2 concentric shells around spherical sample. Heat input to sample meas. with precision wattmeter. Temp. by Fe-const. thermocouple	Fused in Pt 8 hr at 1400°C, furnace cooled, crushed, screened. Powder between 40 and 60 mesh. Auth. est. accuracy ± 8%

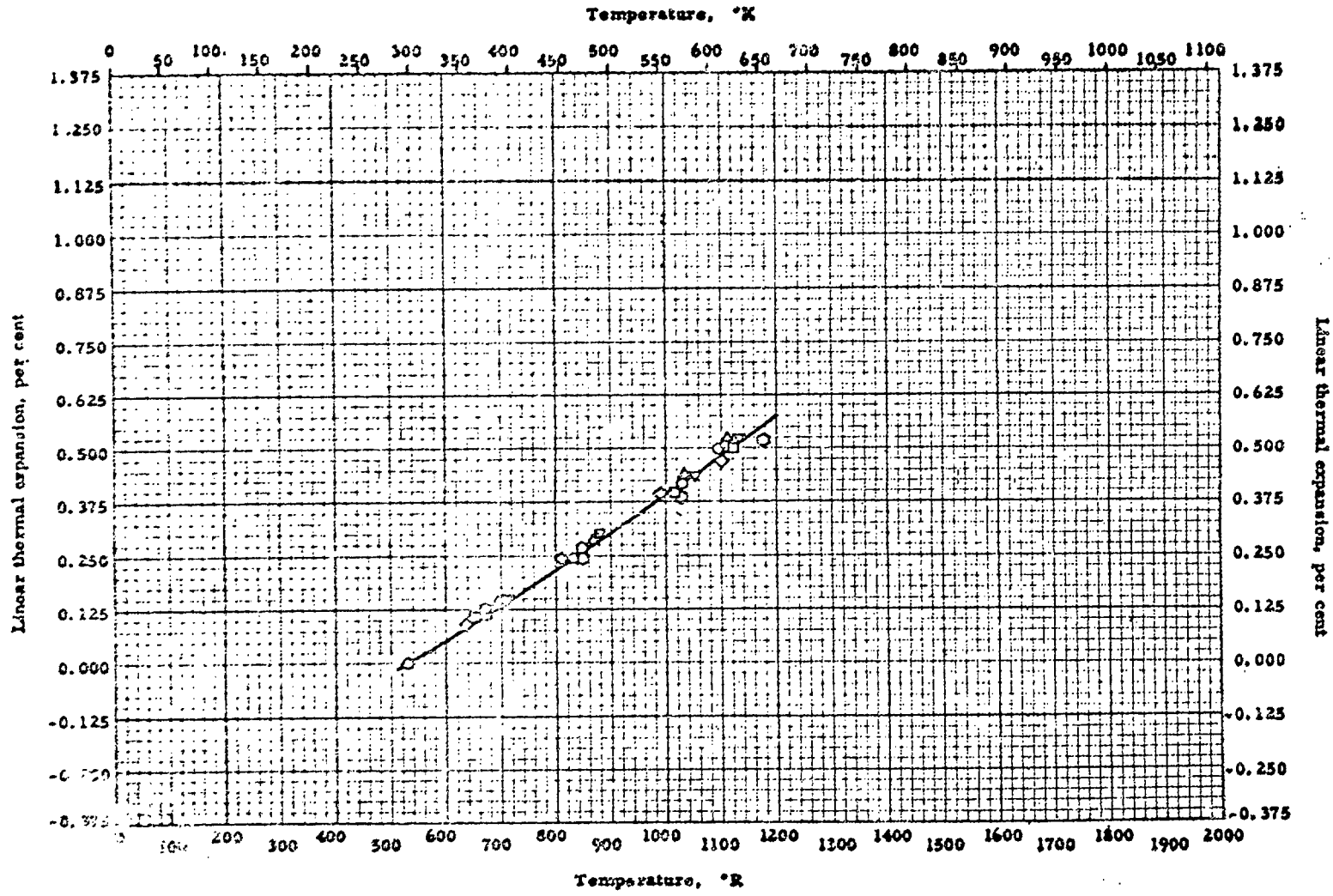


LINEAR THERMAL EXPANSION -- TELLURIUM OXIDE - MOLYBDENUM OXIDE GLASS

LINEAR THERMAL EXPANSION -- TELLURIUM OXIDE - MOLYBDENUM OXIDE GLASS

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Dale, A. E., Pegg, E. F. and Stanworth, J. E.	54-140	672-1050	65% TeO_2 ; 31% MoO_3. ρ = 314 lb_m/ft^3	Not described here, refers to others	Melted in Al_2O_3 crucible



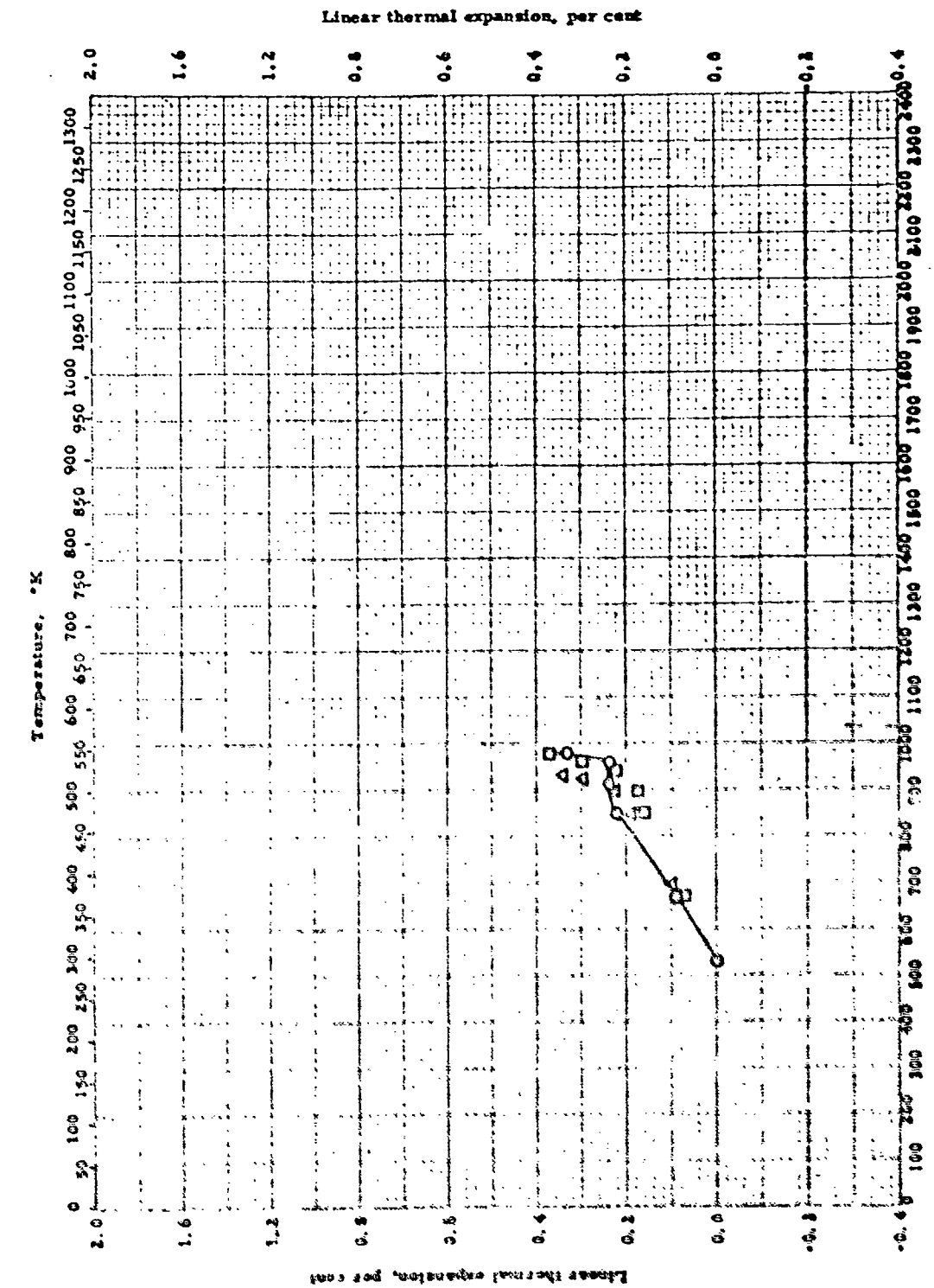
LINEAR THERMAL EXPANSION -- TELLURIUM OXIDE-TUNGSTEN OXIDE GLASS

AAC TN 58-916 60-731

LINEAR THERMAL EXPANSION -- TELLURIUM OXIDE-TUNGSTEN OXIDE GLASS

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Dale, A. E., Pegg, E. F. and Sunderth, J. E.	54-140	672-1095	83.3% TeO_2 ; 16.7% WO_3. ρ = 364 lb_m/ft^3	Not described here, refers to others	Melted in Al_2O_3 crucible
□	Ibid.	54-140	672-1122	82.3% TeO_2 ; 17.7% WO_3. ρ = 366 lb_m/ft^3	Same as above	Same as above
△	Ibid.	54-140	672-1104	79.1% TeO_2 ; 20.9% WO_3. ρ = 368 lb_m/ft^3	Same as above	Same as above
◇	Ibid.	54-140	672-1104	77.5% TeO_2 ; 22.5% WO_3. ρ = 370 lb_m/ft^3	Same as above	Same as above
▽	Ibid.	54-140	672-1122	75.6% TeO_2 ; 24.4% WO_3. ρ = 371 lb_m/ft^3	Same as above	Same as above
○	Ibid.	54-140	672-1176	65.5% TeO_2 ; 34.5% WO_3. ρ = 379 lb_m/ft^3	Same as above	Same as above

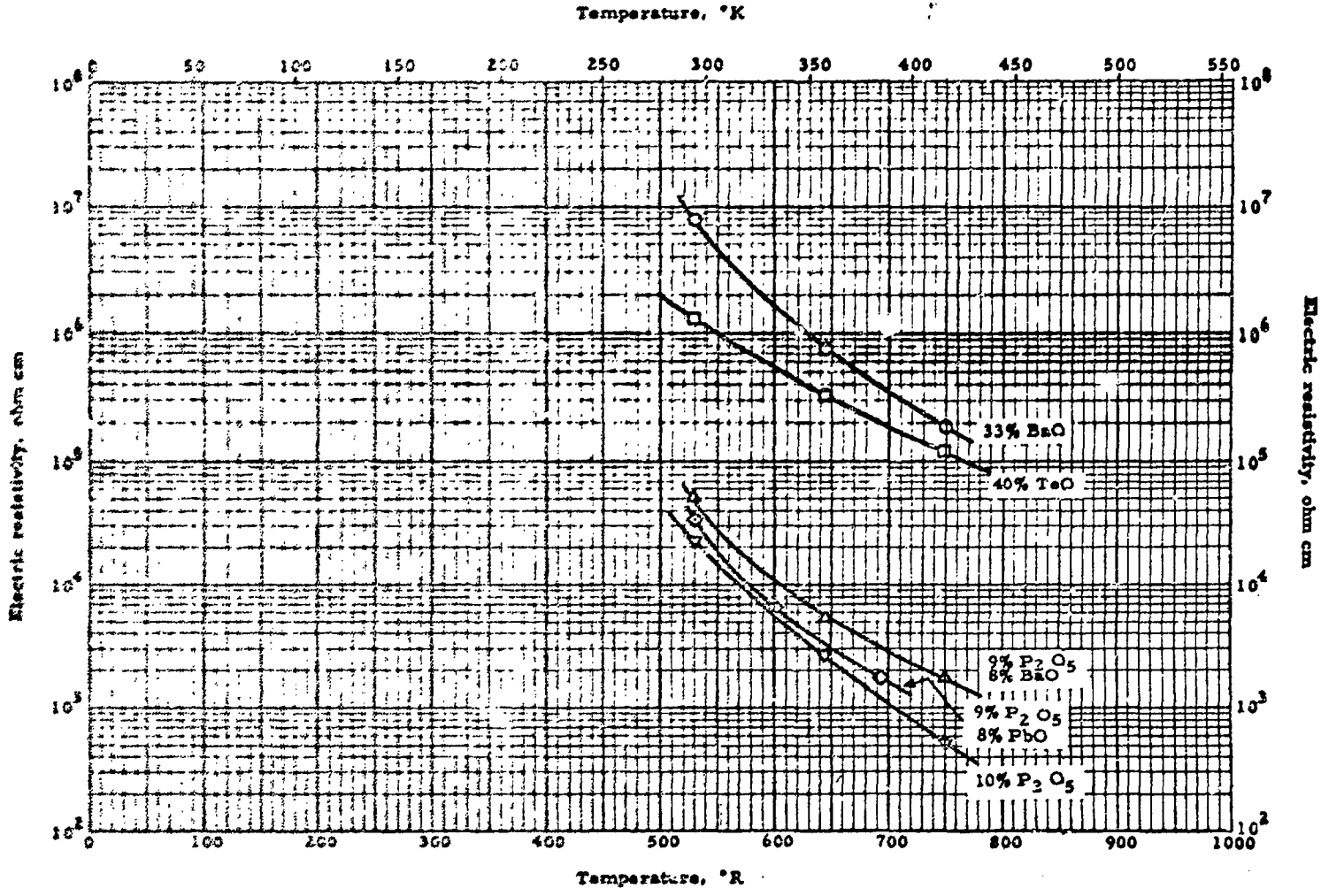


LINEAR THERMAL EXPANSION -- VANADATE GLASS

LINEAR THERMAL EXPANSION -- VANADATE GLASS

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	King, E. W. and Sober, L. L.	55-17	537-978	SrO + 2 V_2O_5; 98-99 vol % glass 1 - 2 vol % V_2O_5 inclusions	Interferometer	Heated to 700 °C
□	Weston, E. P., Rawson, H. and Stanworth, J. E.	54-139	528-978	67% V_2O_5; 33% BaO	Not given	
△	Ibid.	54-139	528-933	83% V_2O_5; 9% P_2O_5; 8% PbO	Not given	



ELECTRIC RESISTIVITY -- VANADATE GLASS

ELECTRIC RESISTIVITY -- VANADATE GLASS

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °K	Material Composition	Test Method	Remarks
○	Denton, E. P., Rawson, H. and Seddon, J. E.	54-139	530-750	67% V_2O_5; 33% BaO	Not given	
□	Ibid.	54-139	530-750	60% V_2O_5; 40% TeO_2	Same as above	
△	Ibid.	54-139	530-750	83% V_2O_5; 9% P_2O_5; 8% BaO	Same as above	
◇	Ibid.	54-139	530-750	83% V_2O_5; 9% P_2O_5; 8% PbO	Same as above	
▽	Ibid.	54-139	530-750	90% V_2O_5; 10% P_2O_5	Same as above	

PROPERTIES OF SILICON CARBIDE

MOST PROBABLE VALUES

Property	Brit. Engineering Units	C. G. S. Units
Density.	185 lb_m/ft^3	2.96 g/cm^3
Melting Point(decomposes)	5350°R *	2970°K *
Heat of Fusion		
Heat of Vaporization. . .		
Heat of Sublimation . . .		

* Constitution of Binary Alloys (Ref. 58-11)

REPORTED VALUES

		Density: lb_m/ft^3	Density: g/cm^3
	○	185	2.96
	□	184	2.95
	△	200.4	3.210
	◇	300.3	3.708

Melting Point:	°R	°K

Heat of Fusion:	Btu/lb_m	cal/g

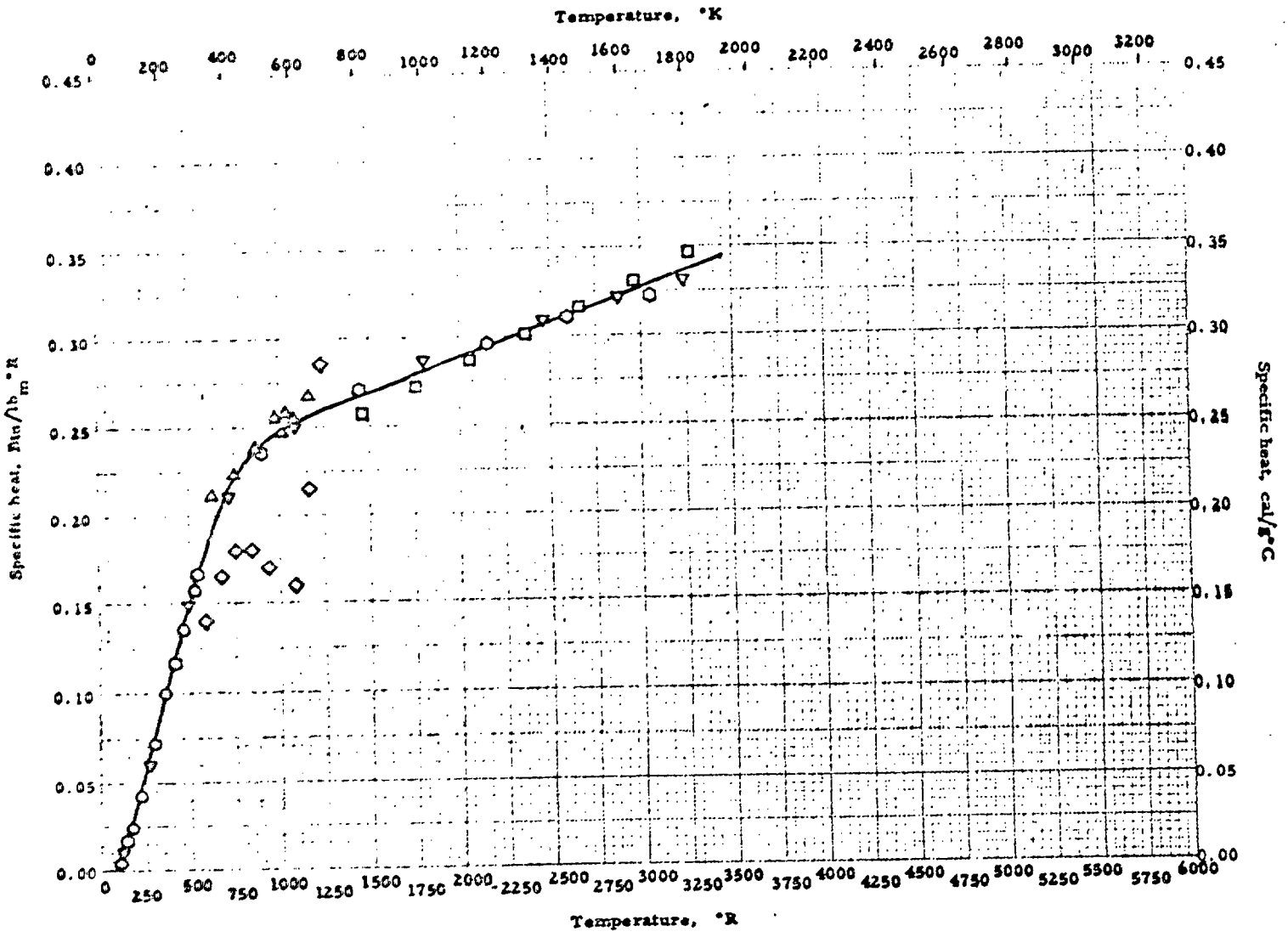
Heat of Vaporization:	Btu/lb_m	cal/g

Heat of Sublimation:	Btu/lb_m	cal/g

PROPERTIES OF SILICON CARBIDE

REFERENCE INFORMATION

Item No.	Investigator	Ref.	Range, °F	Material Composition	Test Method	Remarks
○	Alliegro, R.A., Coffin, L.B. and Tinklepaugh, J.R.	53-18	Room	SiC. 25% 1200 mesh; 40% 240 mesh; 35% 100 mesh	ρ: not given	Prepressed at 25,000 psi and hot pressed at 10,000 psi; heated 10 min. to 4645°F
□	Ibid.	53-18	Room	Same as above	ρ: same as above	Prepressed at 2500 psi and hot pressed at 10,000 psi; heated 15 min. to 4600°F. Auth. quotes theor. ρ = 3.217 g/cm^3
△	Taylor, A. and Laidler, D. S.	50-68	Room	SiC	ρ: computed from X-ray measurements of lattice	β phase, cubic form
◇	Ibid.	50-68	Room	Same as above	ρ: same as above	Hexagonal form, modification II. Auth. prepared many samples, containing the 2 forms in various amounts.

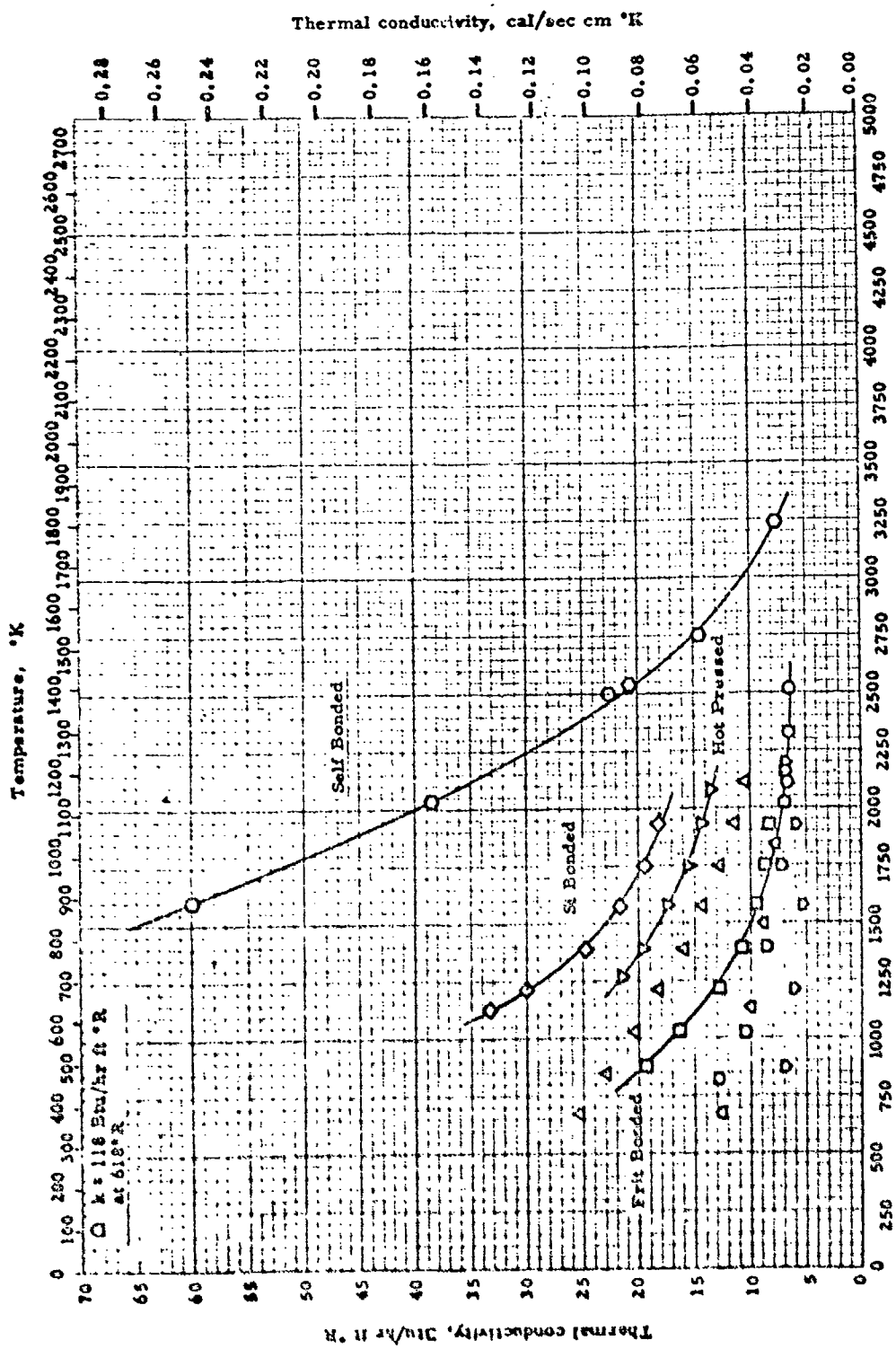


SPECIFIC HEAT -- SILICON CARBIDE

SPECIFIC HEAT -- SILICON CARBIDE

REFERENCE INFORMATION

	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Kelley, K. K.	41-2	98-531	99% SiC; 0.6% SiO_2	Comparative; rate of temp. rise in sample compared with standard under same heating conditions	Corrected for SiO_2 impurity (assumed to be quarts). Auth. est. accuracy ± 0.5%
□	Fieldhouse, I. B., Hedge, J. C. et al.	58-4	1460-3260	Before test: 67.46% Si; 28.58% C; 0.73% Al; 0.58% Fe; 0.48% CaO. After test: 68.12% Si; 27.29% C; 1.47% Al; 0.32% Fe; 0.44% CaO. ρ = 511.2 lb_m/ft^3	Drop method; water calorimeter	Tested in He atmos.
△	Skogen, H. S.	55-39	636-1212	"Exolon" type, common black variety; powder between 40 and 60 mesh	Guarded sample	Auth. est. accuracy ± 8%
◇	Kondo, K.	50-26	582-1302	SiC; powdered sample	Comparative; Cu standard	Tested in coal gas atmos.
▽	Humphrey, G. L.	52-134	90-3240	99.73% pure hexagonal type II SiC: 69.84% Si; 29.89% C; 0.18% Fe; 0.03% Al; <0.01% Ca	Drop method	For 298 to 1800°K, c_p calc. from author's eq., $c_p \left(\frac{cal}{g\ mole\ °C}\right) = 9.93 + 0.00192\ T\ (°K) - 366,000\ T\ (°K)^{-2}$
○	Ibid.	52-134	90-3060	Cubic type SiC: <1% hexagonal SiC; 0.34% free C; 0.17% SiO_2; 0.06% Al; 0.013% free Si; 0.004% Fe	Same as above	For 298 to 1800°K, c_p calc. from author's eq., $c_p \left(\frac{cal}{g\ mole\ °C}\right) = 9.97 + 0.00182\ T\ (°K) - 364,000\ T\ (°K)^{-2}$

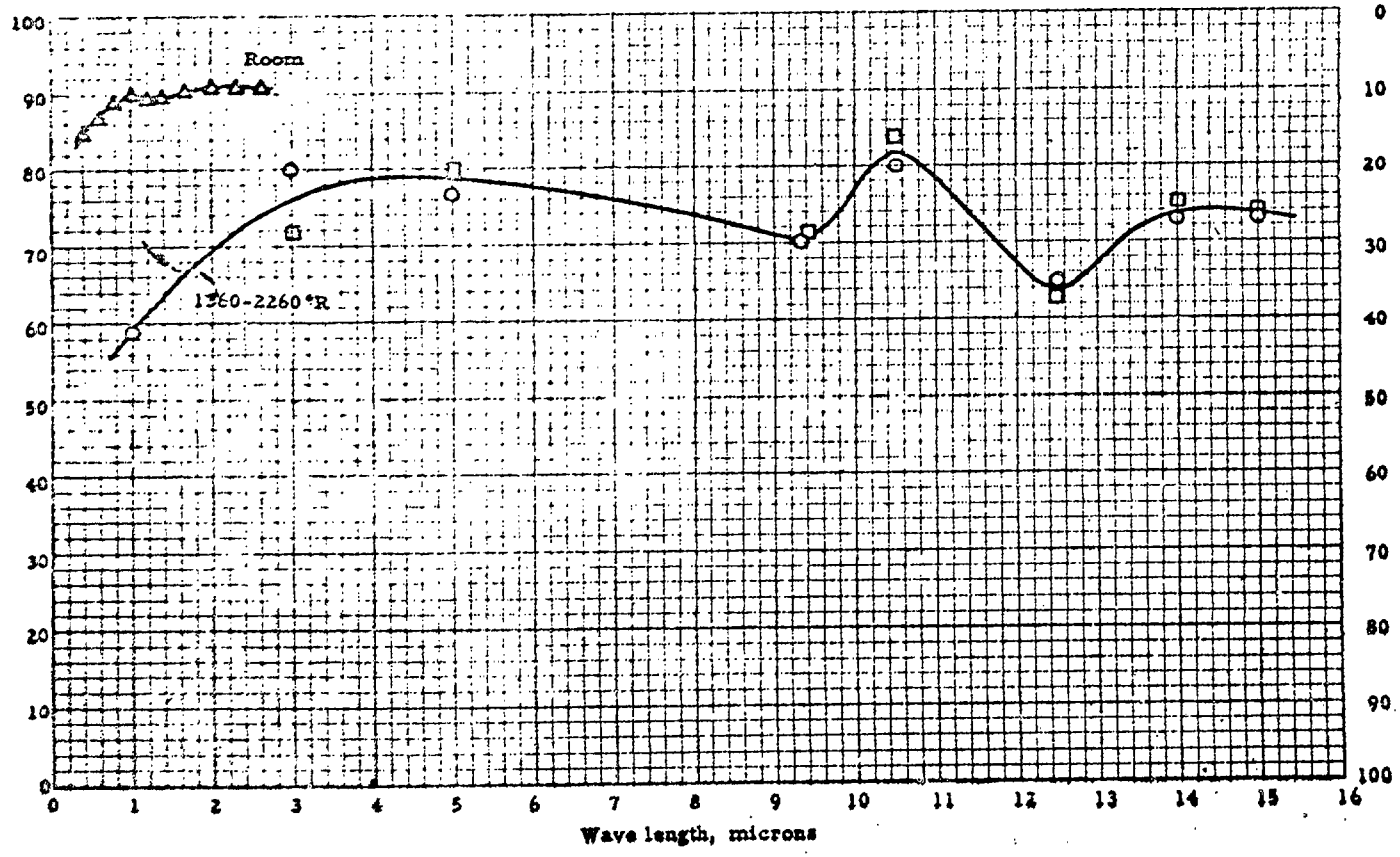


THERMAL CONDUCTIVITY -- SILICON CARBIDE

THERMAL CONDUCTIVITY -- SILICON CARBIDE

REFERENCE INFORMATION

Sym-bol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Clements, J. F. and Vyse, J.	57-26	2022-2517	Silicon carbide brick; 1.71% Al_2O_3; SiO_2, TiO_2, Fe_2O_3, CaO, MgO, K_2O, Na_2O not detected. ρ = 157 lb_m/ft^3. Apparent porosity = 17.8%	Not adequately described	Auth. est. accuracy ± 5%
□	Norton, F. H. and Kingery, W. D.	55-25	888-1932	Commercial frit bonded	Comparative; rods	
△	Vasilos, T. and Kingery, W. D.	54-24 also 53-40 also 53-41	672-2112	Cut from ingot	Comparative; rods	Run in vacuum
◇	Norton, F. H. and Kingery, W. D.	55-25	1122-1932	Silicon bonded (consists of continuous Si phase and cubic SiC)	Comparative; rods	
▽	Ibid.	55-25	1266-2076	Hot pressed	Same as above	
○	Fieldhouse, I. B., Hedge, J. C. et al.	58-4	1600-3242	Self bonded. Before test: 67.46% Si; 28.58% C; 0.73% Al; 0.58% Fe; 0.48% CaO. After test: 68.12% Si; 27.29% C; 1.47% Al; 0.32% Fe; 0.44% CaO. ρ = 193 lb_m/ft^3	Single flat plate; boiling liq. calorimeter	Run in He atmos.
□	Weeks, J. L. and Seifert, R. A.	53-17 also 52-49	618	Polycrystalline; ρ = 175 lb_m/ft^3	Comparative; rods	Run in vacuum
△	Suzuki, H., Kuwayama, M. and Yamauchi, T.	56-166	672-1862	Carbofrax; 89% SiC; 16.52% porosity	Calorimetric method of steady state heat flow	Carbofrax made by Carborundum Co.
○	Norton, F. H. and Kingery, W. D.	54-142	816-2160	SiC, frit bonded, commercial sample	"Linear flow tester"	Sample 1
▽	Ibid.	54-142	870-2202	Same as above	Same as above	Sample 2

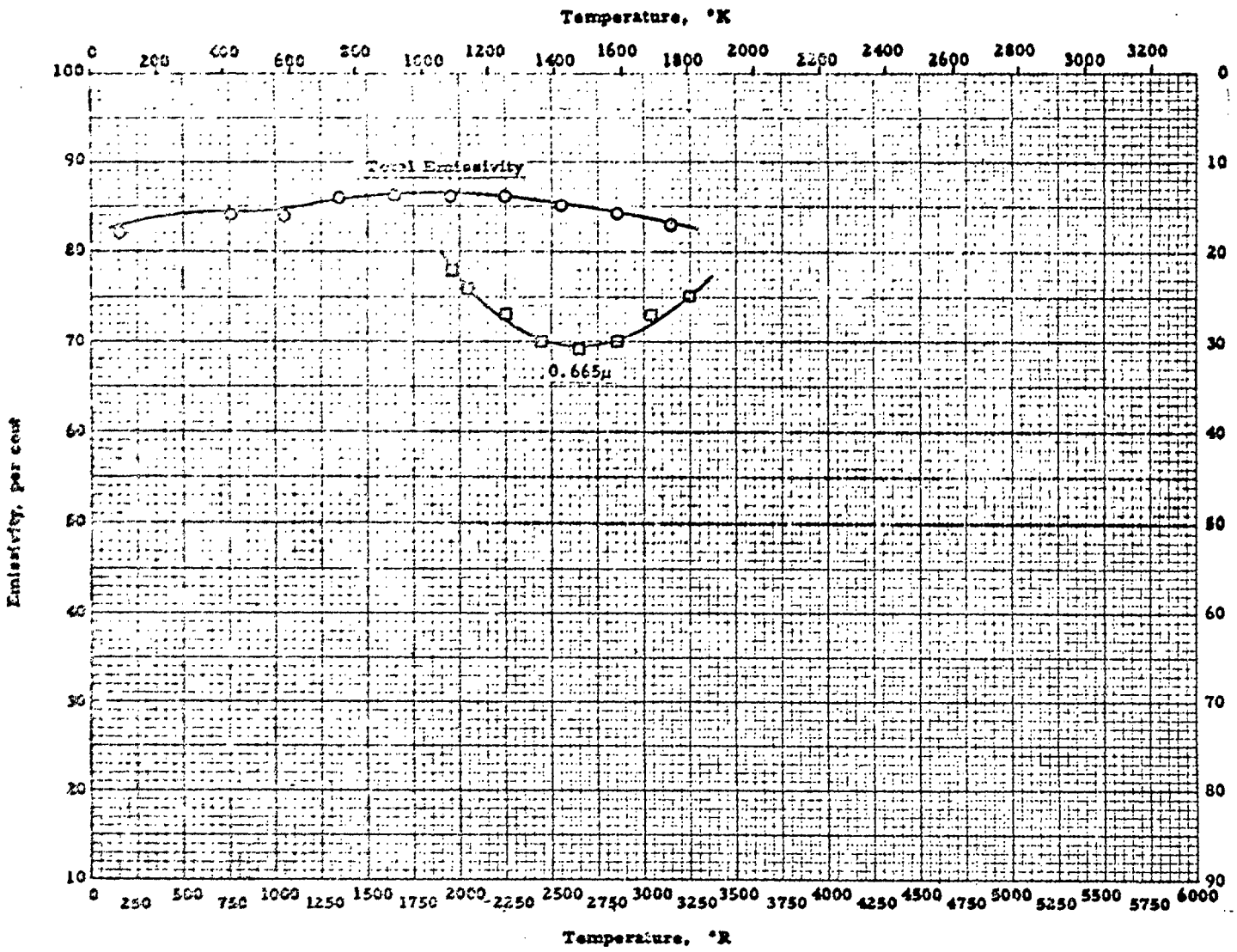


SPECTRAL EMISSIVITY -- SILICON CARBIDE

SPECTRAL EMISSIVITY -- SILICON CARBIDE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Stewart, J. E. and Richmond, J. C.	57-186	2260	Silicon carbide, Globar (recrystallized silicon carbide)	Spectral emissivity: Comparative: surface brightness compared with that of a standard meas. against black body	
□	Ibid.	57-186	1360	Same as above	Same as above	
△	Olsen, O. H. and Morris, J. C.	59-1	Room	Silicon carbide	Spectral reflectivity at 9°: Sample compared with $MgCO_3$ standard in MgO integrating sphere, quartz lens, PbS detector	



EMISSIVITY -- SILICON CARBIDE

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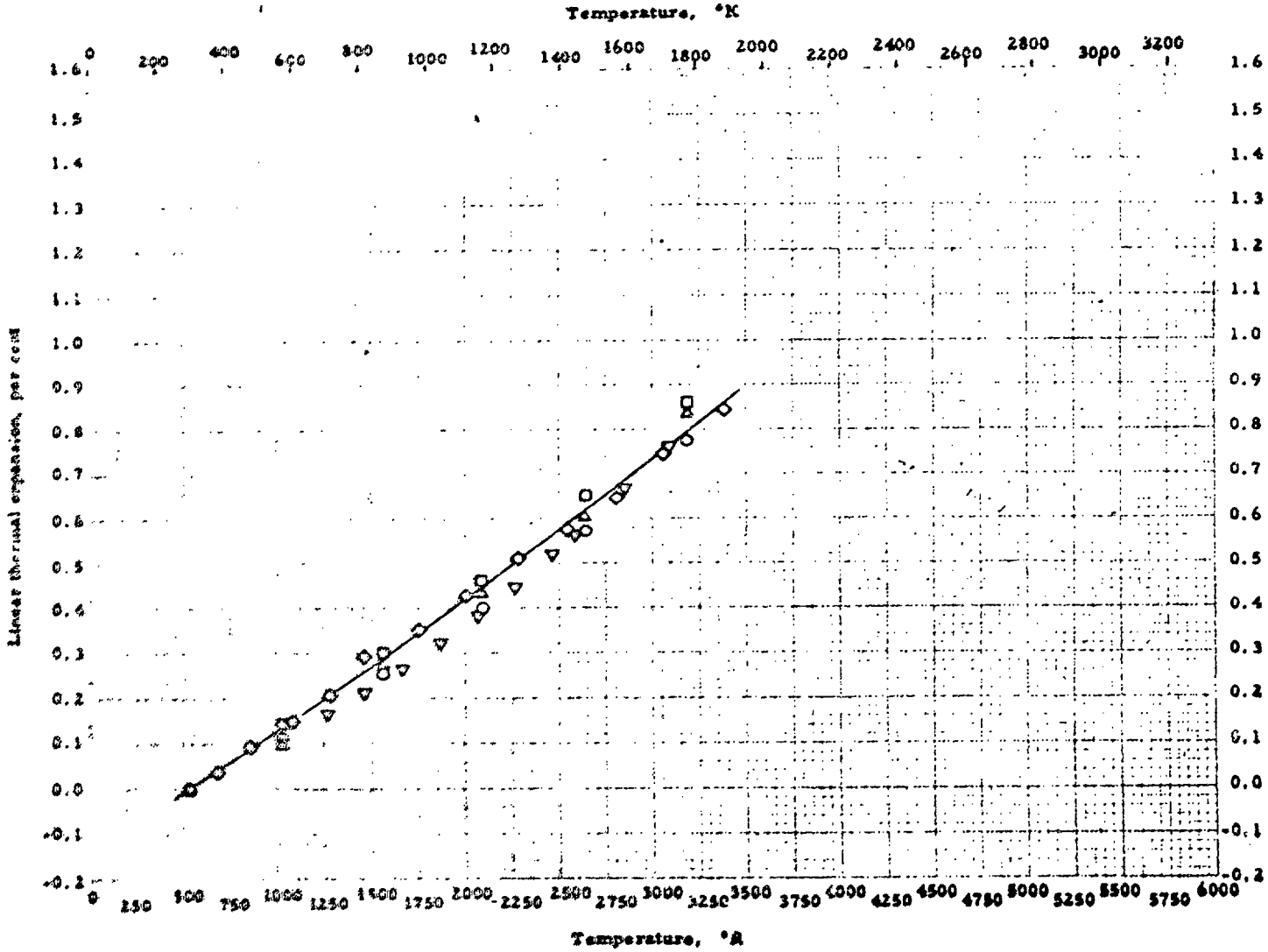
EMISSIVITY -- SILICON CARBIDE

REFERENCE INFORMATION

Sym.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Citron, O.H. and Morris, J.C.	59-1	160-2700	Not given	Total normal emissivity: comparative: radiant heat flow compared with that of a black body, thermopile; sample temp. by thermocouple	Sample in air
□	Ibid.	59-1	1960-3260	Not given	Spectral normal emissivity at 0.665μ: comparative: surface brightness compared with that of a black body hole, disappearing filament optical pyrometer; sample temp. by thermocouple	



LINEAR THERMAL EXPANSION -- SILICON CARBIDE

LINEAR THERMAL EXPANSION -- SILICON CARBIDE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Whittemore, O. J. and Ault, N. N.	56-7	1032-3192	Silicon carbide (recrystallized)	Telemicroscopes sighting on pointed ends of sample	
△	Ibid.	56-7	1032-3192	Silicon carbide (clay-bonded)	Same as above	
□	Ibid.	56-7	1032-3192	Silicon carbide (bonded glazed brick)	Same as above	
◇	Fieldhouse, I. B., Hedge, J. C. et al.	58-4	540-3383	Before test: 67.46% Si; 28.58% C; 0.73% Al; 0.58% Fe; 0.48% CaO After test: 68.12% Si; 27.29% C; 1.47% Al; 0.32% Fe; 0.44% CaO	Telemicroscopes sighting on samples	
▽	Seibel, R. D. and Mason, G. L.	57-156	1260-3060	Silicon Carbide	Alumina tube dilatometer with differential transformer pick-up	In vacuum of 10^{-6} - 10^{-9} mm Hg

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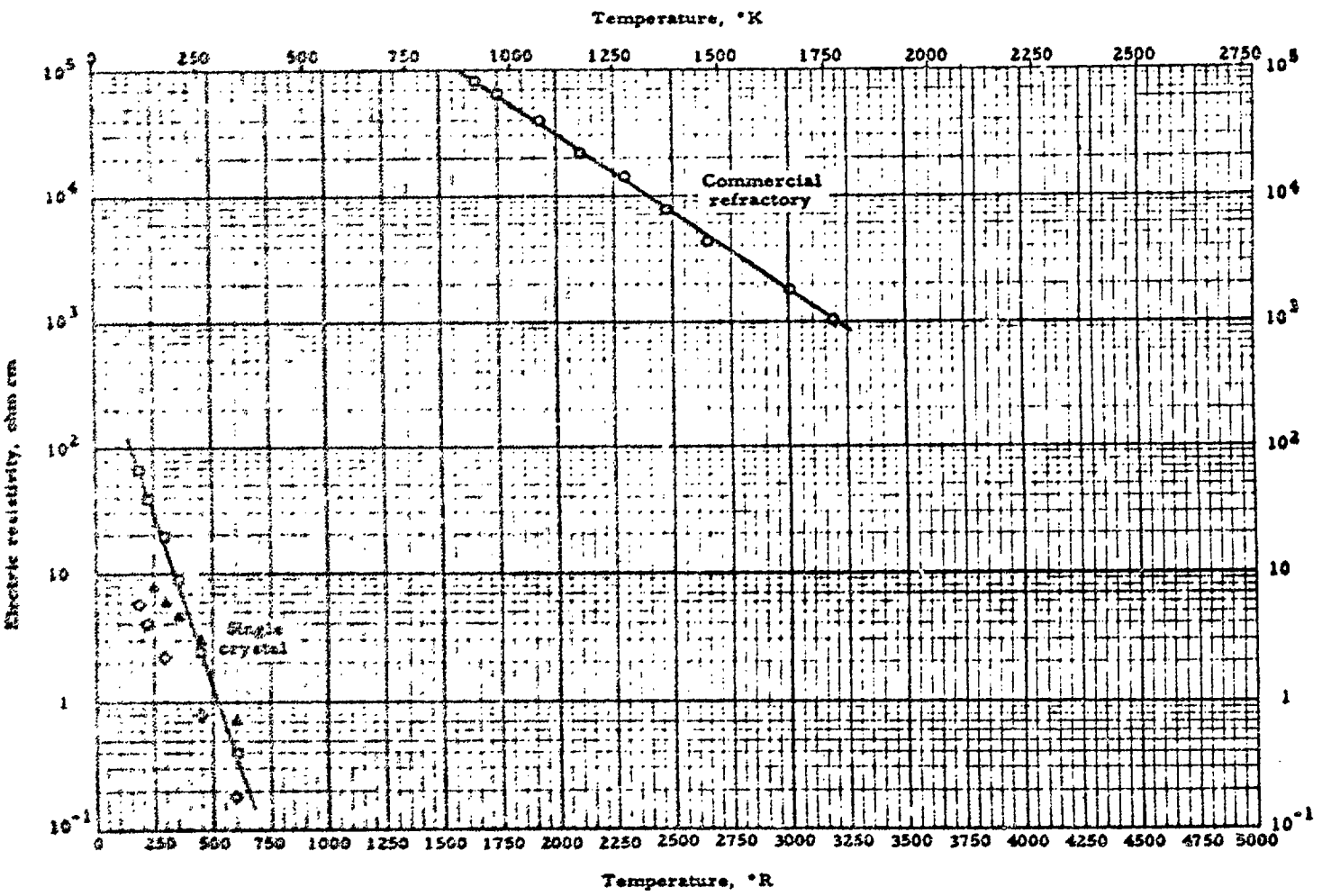


ELECTRIC RESISTIVITY -- SILICON CARBIDE

VIII - D - 1 - a

ELECTRIC RESISTIVITY -- SILICON CARBIDE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Chiochetti, V. E. J. and Henry, E. G.	53-94	1662-3192	Commercial refractory. Comp. not given	Wheatstone bridge at 965 cycles	Apparent porosity 12%
□	Loeb, W.	52-98	180-600	Cut from single crystal	Not given	Black sample No. 1
△	Ibid.	52-98	180-600	Same as above	Same as above	Green sample
◇	Ibid.	52-98	180-600	Same as above	Same as above	Black sample No. 2

PROPERTIES OF SILICON CARBIDE + BORON CARBIDE

MOST PROBABLE VALUES

Property	Engr. Engineering Units	C. G. S. Units
Density.	187 lb_m/ft^3 *	3.00 g/cm^3 *
Melting Point		
Heat of Fusion		
Heat of Vaporization. . .		
Heat of Sublimation . . .		

* For 15% B_4C

REPORTED VALUES

		lb_m/ft^3	g/cm^3
Density:	O	187	3.00

Melting Point: °R °K

Heat of Fusion: Btu/lb_m cal/g

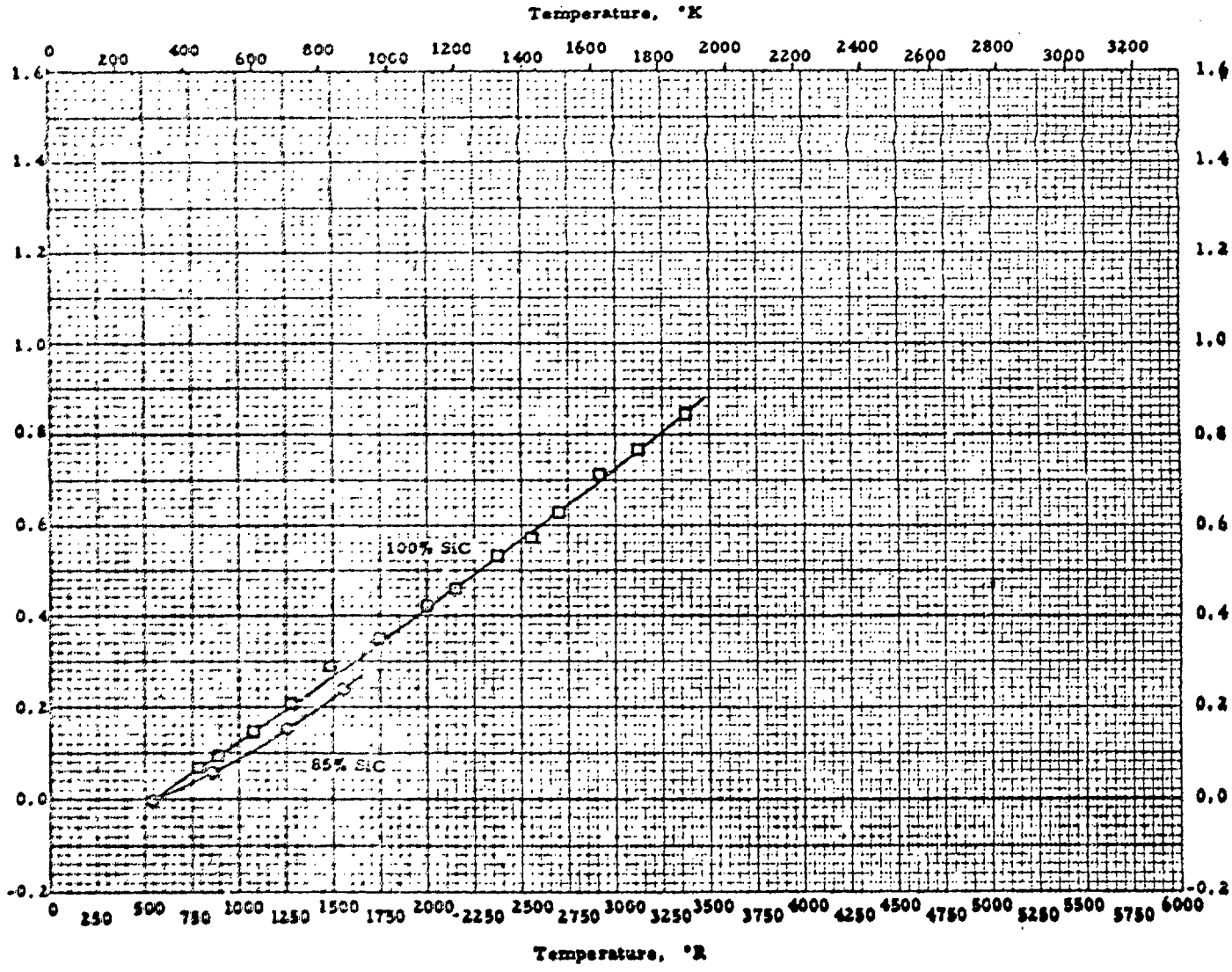
Heat of Vaporization: Btu/lb_m cal/g

Heat of Sublimation: Btu/lb_m cal/g

PROPERTIES OF SILICON CARBIDE + BORON CARBIDE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Gangler, J.J.	50-10	Room	85% silicon carbide; 15% boron carbide; 59.89% Si; 14.36% B; 22.21% combined C; 3.02% free C	ρ: weight in air and in distilled water	Samples fabricated by hot pressing in graphite mold

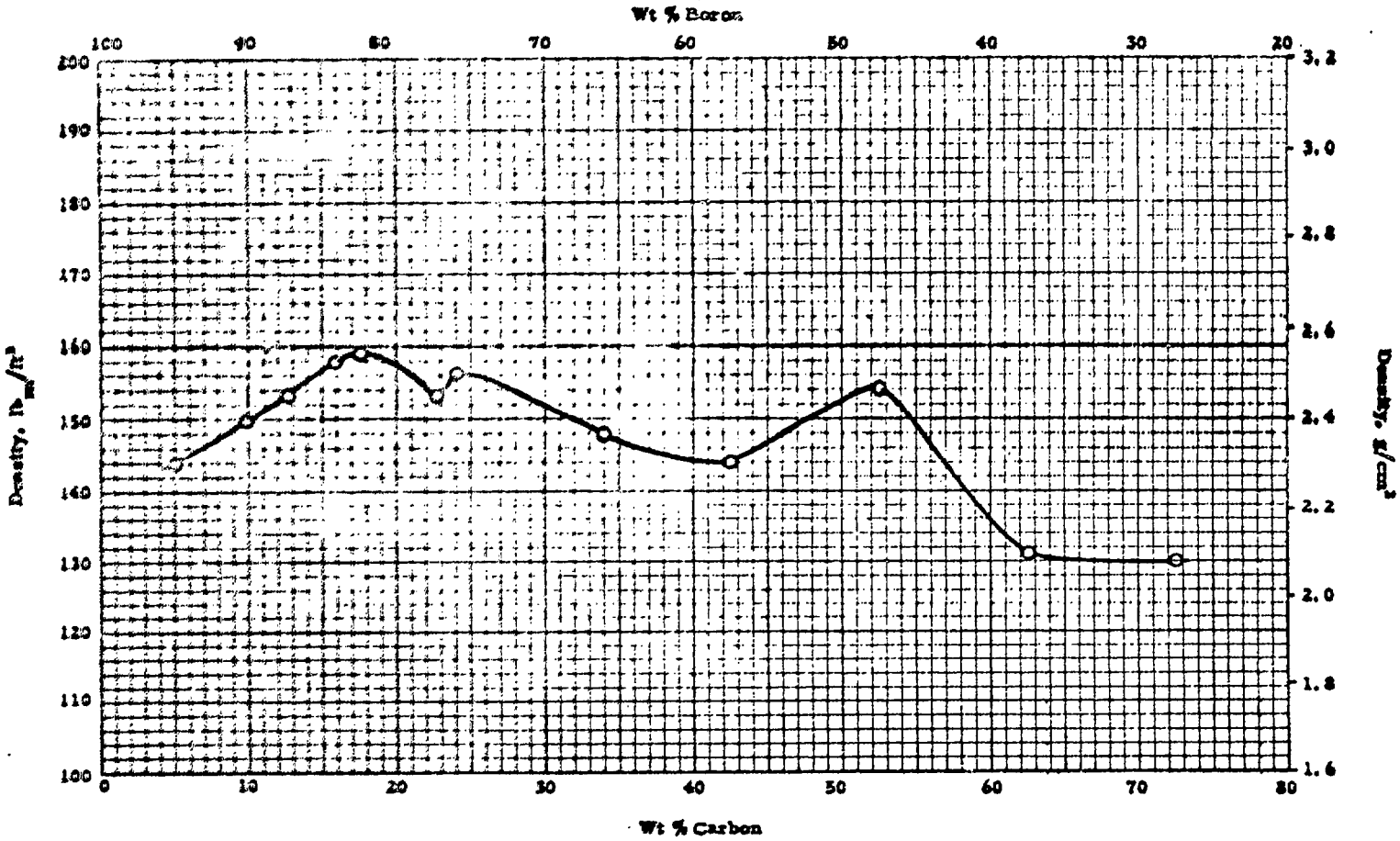


LINEAR THERMAL EXPANSION -- SILICON CARBIDE + BORON CARBIDE

LINEAR THERMAL EXPANSION -- SILICON CARBIDE + BORON CARBIDE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Gangler, J. J.	50-10	540-1560	Approx. 85% SiC; 15% B_4C; analyzed as 59.89% Si; 22.21% combined C; 14.36% B; 3.02% free C; ρ = 187.2 lb_m/ft^3	Interferometer	Hot pressed in graphite mold; tested at 4°C/min, rise
□	Fieldhouse, I.B., Hedge, J.C. et al.,	58-4	540-3383	Silicon carbide; before test: 67.46% Si; 28.58% C; 0.73% Al; 0.58% Fe; 0.48% CaO; after test: 68.12% Si; 27.29% C; 1.97% Al; 0.32% Fe; 0.44% CaO	Telemicroscopes sighting on samples	



DENSITY -- BORON CARBIDE

DENSITY -- BORON CARBIDE

REFERENCE INFORMATION

Key	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Samsonov, G.V. Zhuravlev, N.N. and Amanai, L.G.	56-151	Room	5.11-72.5% C. Prepared from 99.5% pure B and 99.8% pure lampblack	Pycnometric weighing in xylene	Hot pressed; stress relieved and homogenized in vacuum furnace; slowly cooled

PROPERTIES OF BORON CARBIDE

MOST PROBABLE VALUES

Property	Brit. Engineering Units	C. G. S. Units
Density.	156 lb_m/ft^3	2.5 g/cm^3
Melting Point	4860+ °R*	2700+ °K *
Heat of Fusion		
Heat of Vaporization. . .		
Heat of Sublimation . . .		

* High Temp. Technology by Campbell (Ref. 56-54)

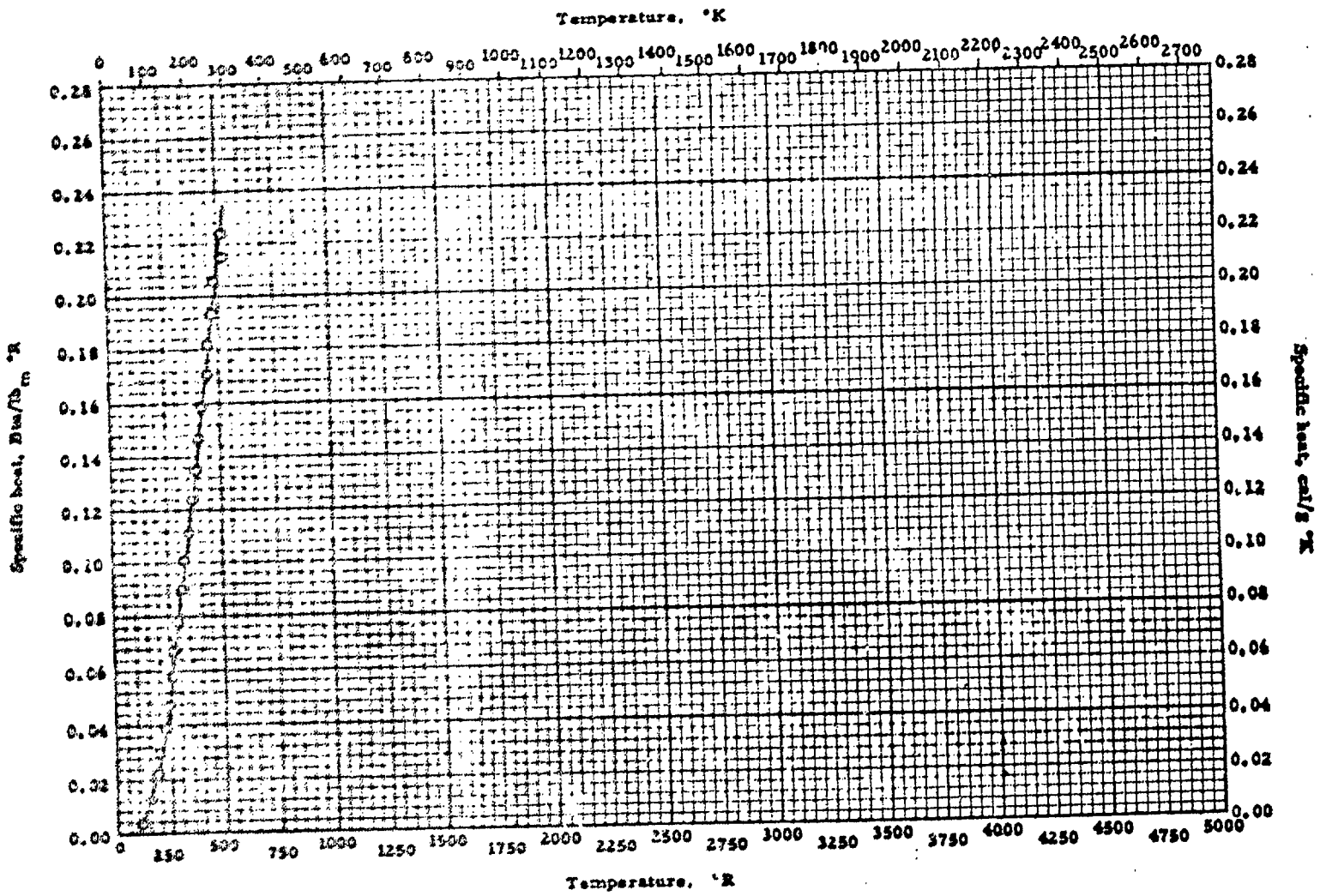
REPORTED VALUES

Density:		lb_m/ft^3	g/cm^3
	O	156	2.50
	□	156	2.50
Melting Point:		°R	°K
Heat of Fusion:		Btu/lb_m	cal/g
Heat of Vaporization:		Btu/lb_m	cal/g
Heat of Sublimation:		Btu/lb_m	cal/g

PROPERTIES OF BORON CARBIDE

REFERENCE INFORMATION

Curve No.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Gangler, J. J.	50-10	Room	79.08% B; 10.79% combined C; 3.65% free C	ρ: weight in air and in distilled water	Fabricated by hot pressing in graphite mold. Auth. gives theor. ρ = 2.52 g/cm^3
□	Hamjian, H. J. and Lidman, W. G.	52-78	Room	76.6% B; 23.54% C; 0.06% Fe	ρ: not given	



SPECIFIC HEAT - BORON CARBIDE

SPECIFIC HEAT -- BORON CARBIDE

REFERENCE INFORMATION

	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Kelley, K. K.	41-2	98-520	96% B_4C, 4% free and included graphite	Comparative: rate of temp. rise in sample compared with that in standard under same heating conditions	Corrected for graphite; auth. est. accuracy within 0.5%

THERMAL CONDUCTIVITY -- BORON CARBIDE

THERMAL CONDUCTIVITY -- BORON CARBIDE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Doem, H. W. and Lucks, C. F.	51-46	672° to 1932°	Boron carbide (No. D11,798-1) $\rho = 119\ lb_m/ft^3$	Comparative; rods. (Armco iron standard)	Tested in vacuum
□	Doem, H. W. and Lucks, C. F.		672° to 1932°	Boron carbide (Norton No. D11 776-2) $\rho = 145\ lb_m/ft^3$	Same as above	Same as above
△	Doem, H. W. and Lucks, C. F.		672° to 1932°	Boron carbide 77.1% B; 22.2% C; ($B_{3.46}C$) $\rho = 156\ lb_m/ft^3$	Same as above	Hot pressed; tested in vacuum
◇	McCreight, L. R.	57-143	654-1932	Boron carbide, 2 samples: a. $\rho = 156\ lb_m/ft^3$ b. $\rho = 145\ lb_m/ft^3$	Two methods: a. comparative, rods b. axial heat flow in rod	Plotted avg. of two samples, agreeing within ± 1%
▽	Ibid.	57-143	591-1977	Boron carbide, $\rho = 119\ lb_m/ft^3$	Same as above	Rammed and sintered
⬡	Ibid.	57-143	645-1770	Boron carbide, $\rho = 118\ lb_m/ft^3$	Same as above	Same as above
⊏	Ibid.	57-143	960-1374	Boron carbide with 1.85% sodium silicate binder $\rho = 127\ lb_m/ft^3$	Same as above	Rammed with sodium silicate binder
⌂	Ibid.	57-143	960-1329	Boron carbide with 2.15% sodium silicate binder $\rho = 129\ lb_m/ft^3$	Same as above	Same as above

LINEAR THERMAL EXPANSION -- BORON CARBIDE

LINEAR THERMAL EXPANSION -- BORON CARBIDE

REFERENCE INFORMATION

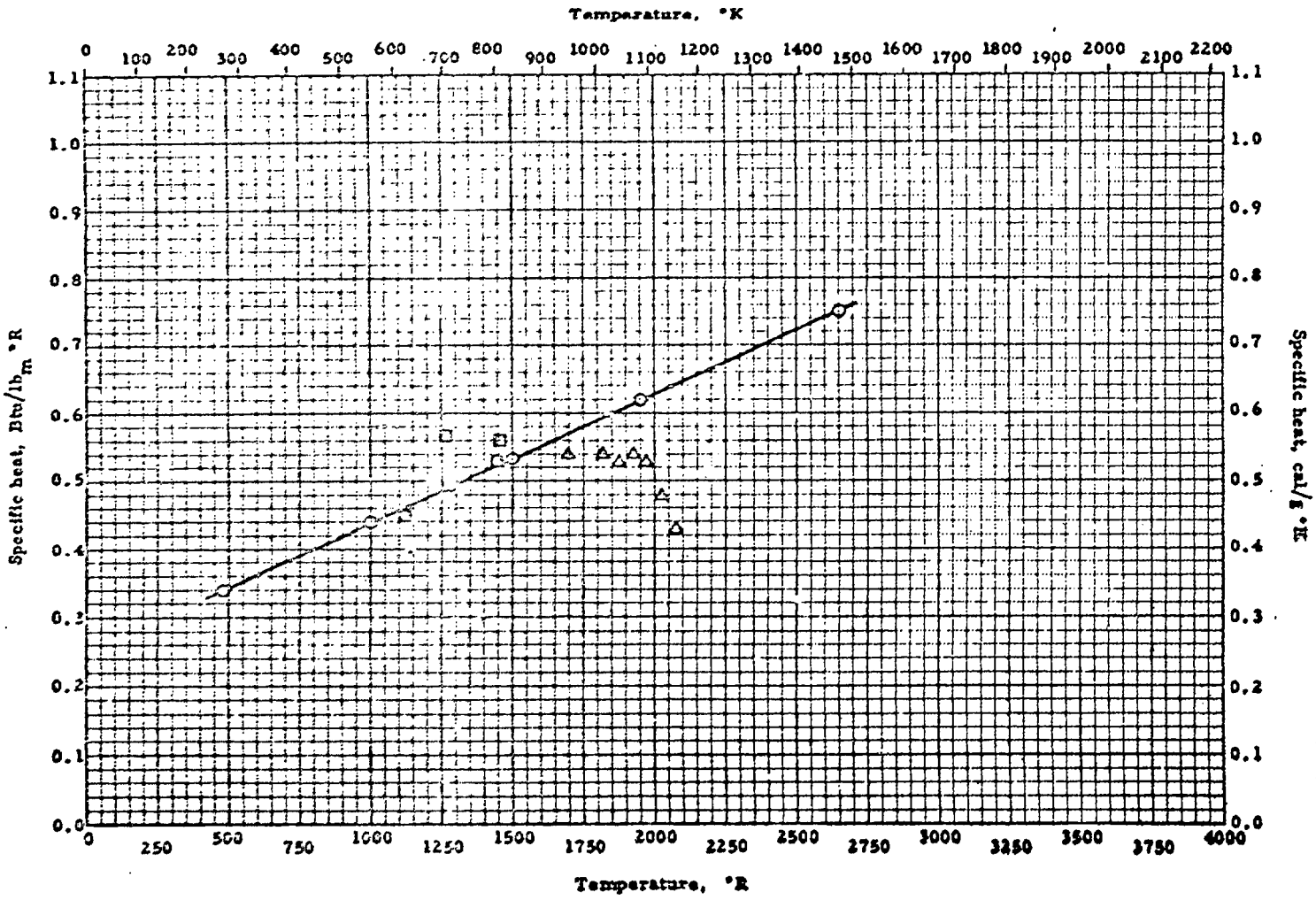
Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Whittemore, O. J. and Ault, N. N.	56-7	1032-2112	Not given	Telemicroscopes sighting on pointed ends of sample	Hot molded
□	Gangler, J. J.	50-10	540-1560	79.08% B; 10.79% combined C; 3.85% free C; ρ = 156 lb_m/ft^3	Interferometer	Hot pressed in graphite mold; tested at 4°C/min. rise

VAPOR PRESSURE -- BORON CARBIDE

VAPOR PRESSURE -- BORON CARBIDE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Gilles, P. W. and Robson, H. E.	56-154	4340	B_4C. 77.50% B; 22.20% C; 0.07% Fe	Langmuir effusion method	Auth. believe $B_4 \rightarrow 4B_{(g)}+C_{(s)}$ with little $B_4 \rightarrow 4B_{(g)}+C_{(g)}$. Calc. based only on $B_{(g)}$ in vapor

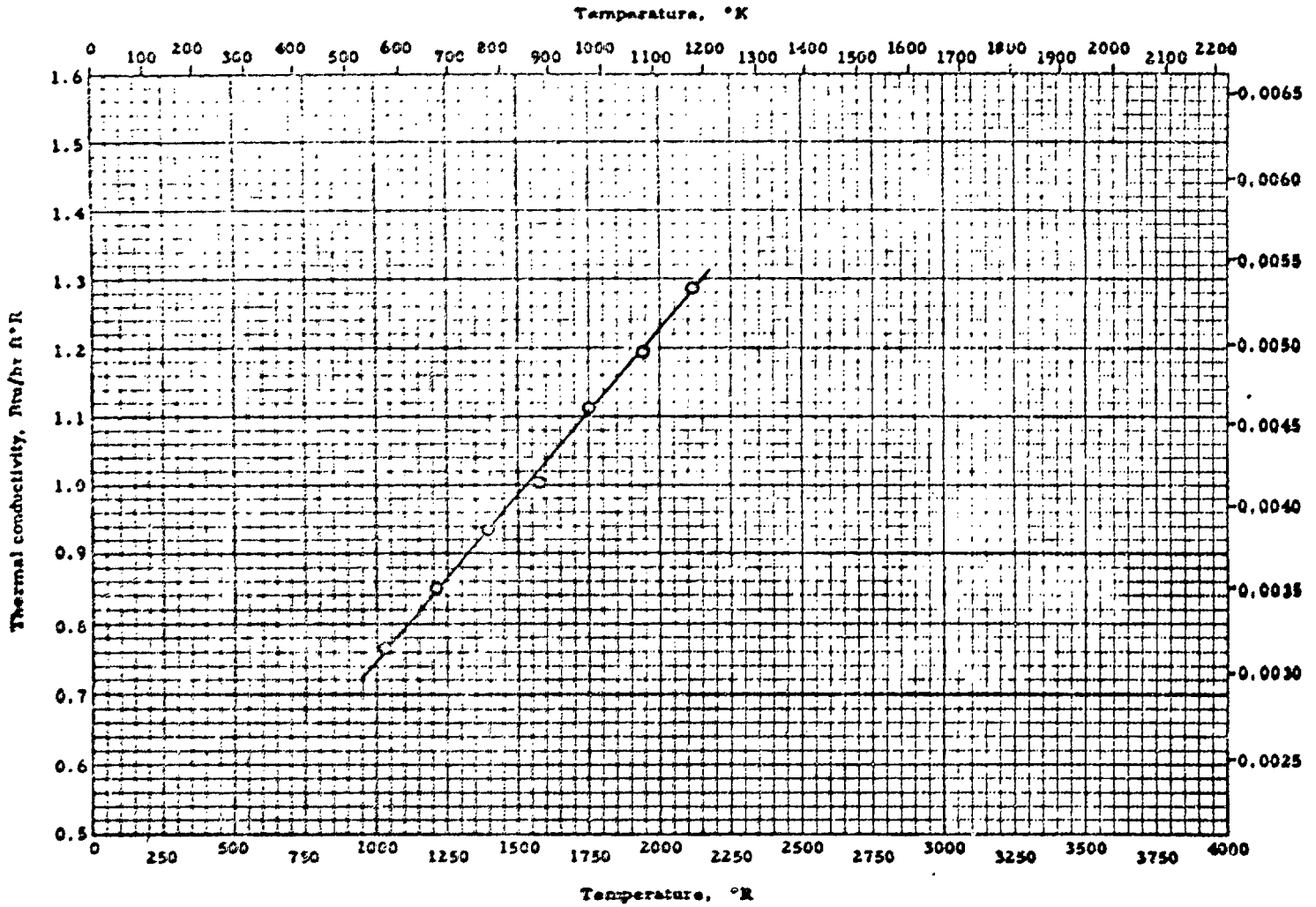


SPECIFIC HEAT -- BERYLLIUM CARBIDE

SPECIFIC HEAT -- BERYLLIUM CARBIDE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Neely, J. J., Teeter, C. E. and Trice, J. B.	50-19 also 48-16	492-2652	Be_2C. Before test: 80% pure, most of impurities were oxide and nitride. After test: 74% Be_2C	Drop method; copper block calorimeter	Auth. est. accuracy ± 10 - 15%. Not corrected for impurities
□	Trice, J. B., Neely, J. J. and Teeter Jr, C. E.	48-33	1125-1455	Be_2C: 56.5% Be; 3.14% free C; 0.005% free Fe. Powdered sample	Drop method, copper block inside water calorimeter	Auth. est. accuracy ± 15%. Auth. recommends $c_p = 0.5 \pm 0.1$ Btu/lb_m °R
△	Trice, J. B., Neely, J. J. and Teeter Jr., C. E.	48-34	1700-2075	Be_2C. Left end: 52.45% Be; 1.94% free C Middle: 48.65% Be; 3.39% free C Right end: 50.24% Be; 1.96% free C (theoretical 60.05% Be)	Measuring the rate of temp. drop during cooling	Hot pressed hollow cylinder made by Norton. Auth. est. accuracy ± 25%. Auth. recommends $c_p = 0.5 \pm 0.1$ Btu/lb_m °R

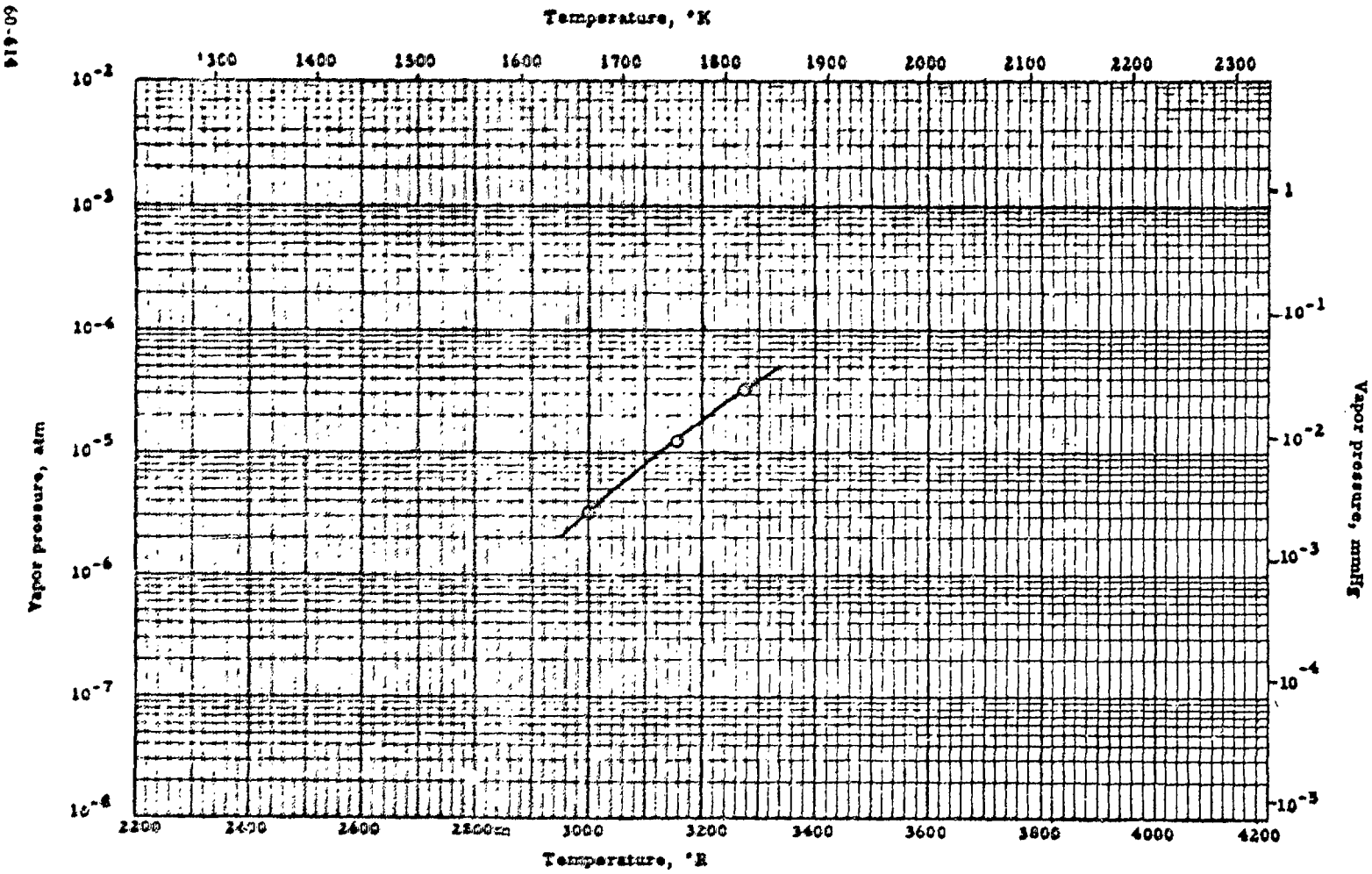


THERMAL CONDUCTIVITY -- BERYLLIUM CARBIDE

THERMAL CONDUCTIVITY -- BERYLLIUM CARBIDE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Neely, J.J. Teeter, C.E. and Trice, J.E.	50-19 also 48-16	1032-2112	80% Be_2C; impurities mostly BeO and Be_3N_2	Radial heat flow in cylinder	Auth. est. accuracy ± 200%

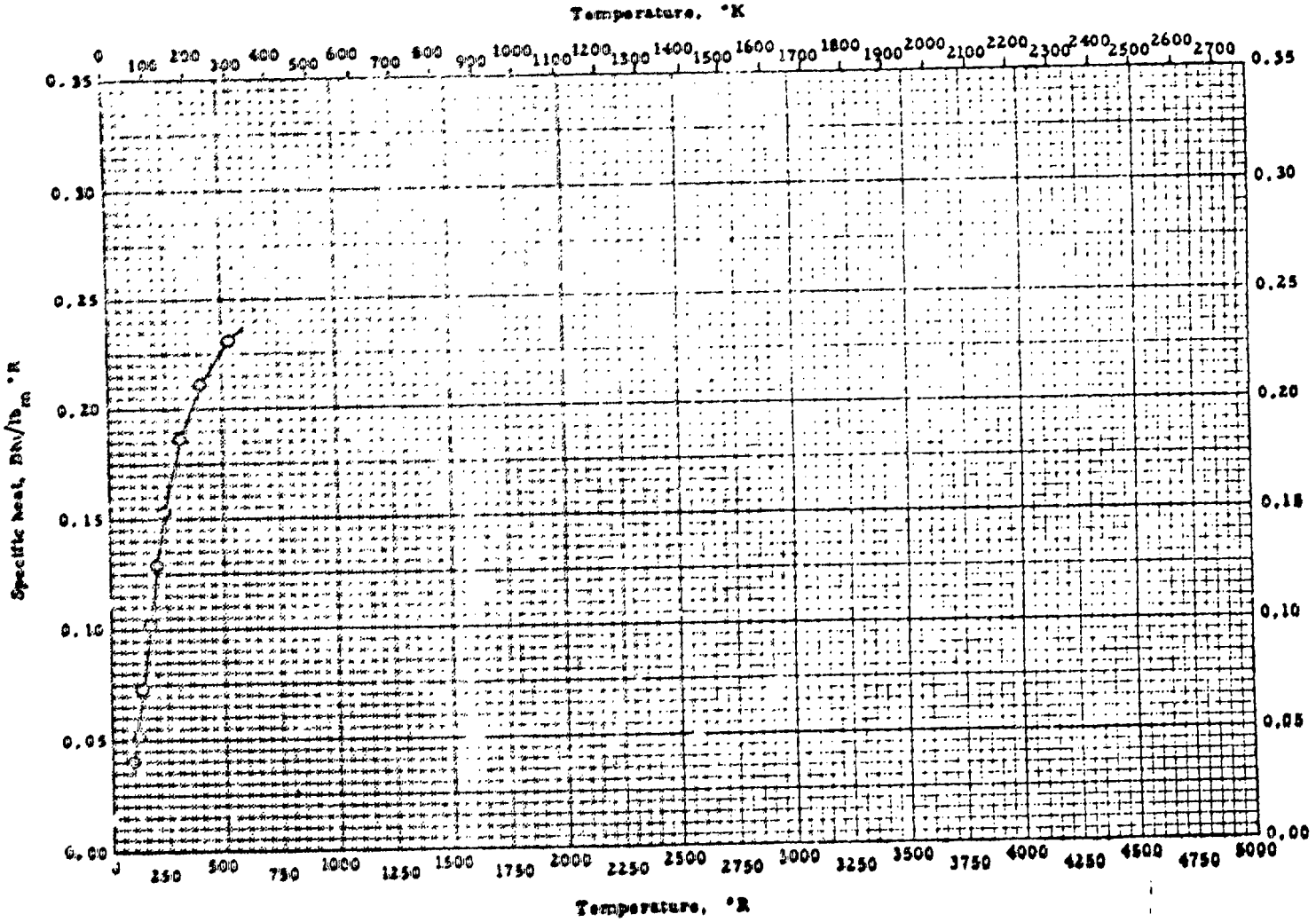


VAPOR PRESSURE--BERYLLIUM CARBIDE

VAPOR PRESSURE -- BERYLLIUM CARBIDE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Yosim, S. J. and Milne, T. A.	57-145	3000-3273	Be_2C. Plotted Be(g) from the equation $1/2\ Be_2C(s) \longrightarrow Be(g) + 1/2\ C(g)$	Knudsen method in graphite crucible	

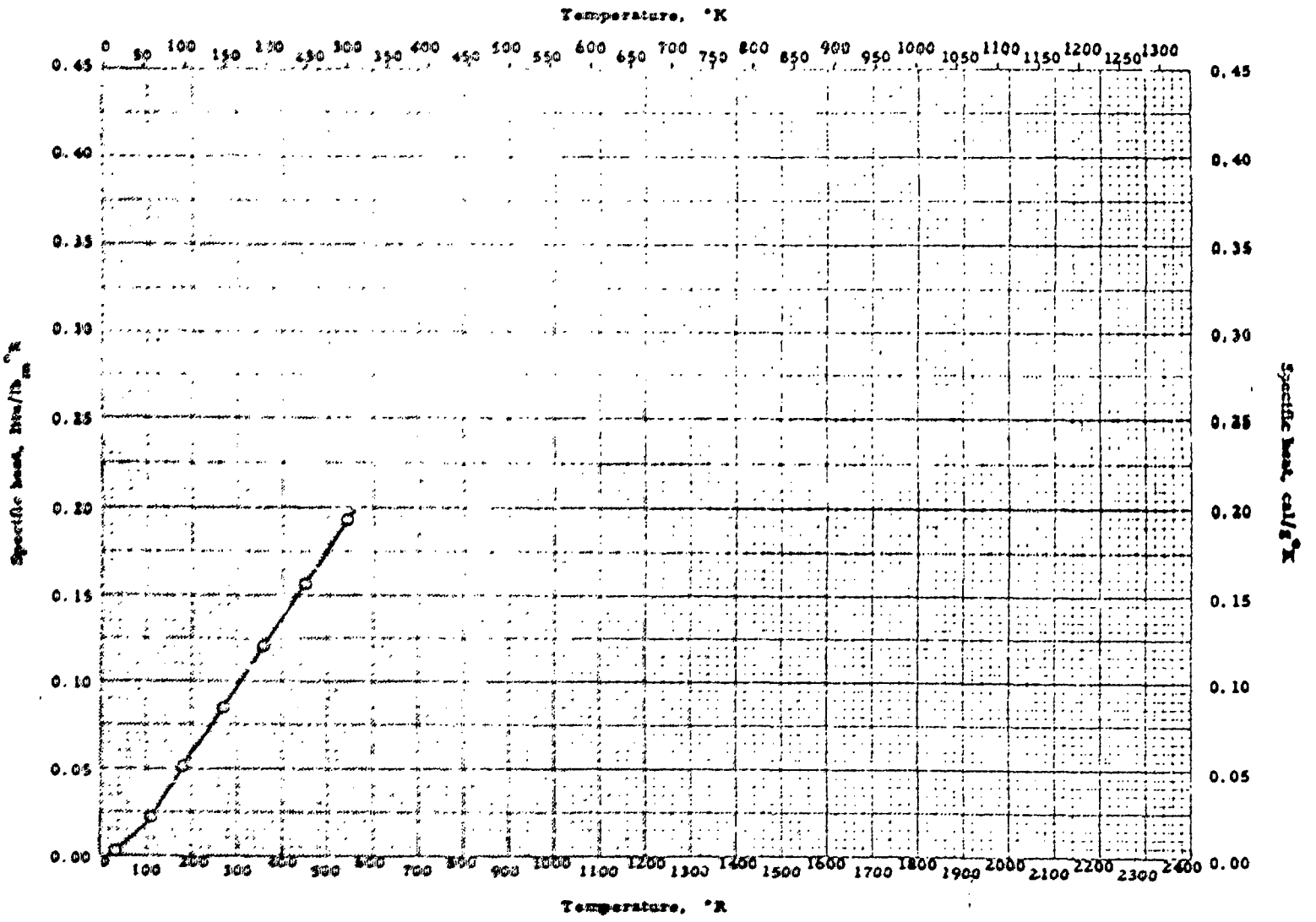


SPECIFIC HEAT -- CALCIUM CARBIDE

SPECIFIC HEAT -- CALCIUM CARBIDE

REFERENCE INFORMATION

System No.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Kelley, K. K.	41-16	96-532	91.0% CaC_2; 6.47% CaO; 1.15% SiO_2; 0.77% Al_2O_3; 0.2% C; 0.08% MgO; 0.29% FeS	Guarded sample	

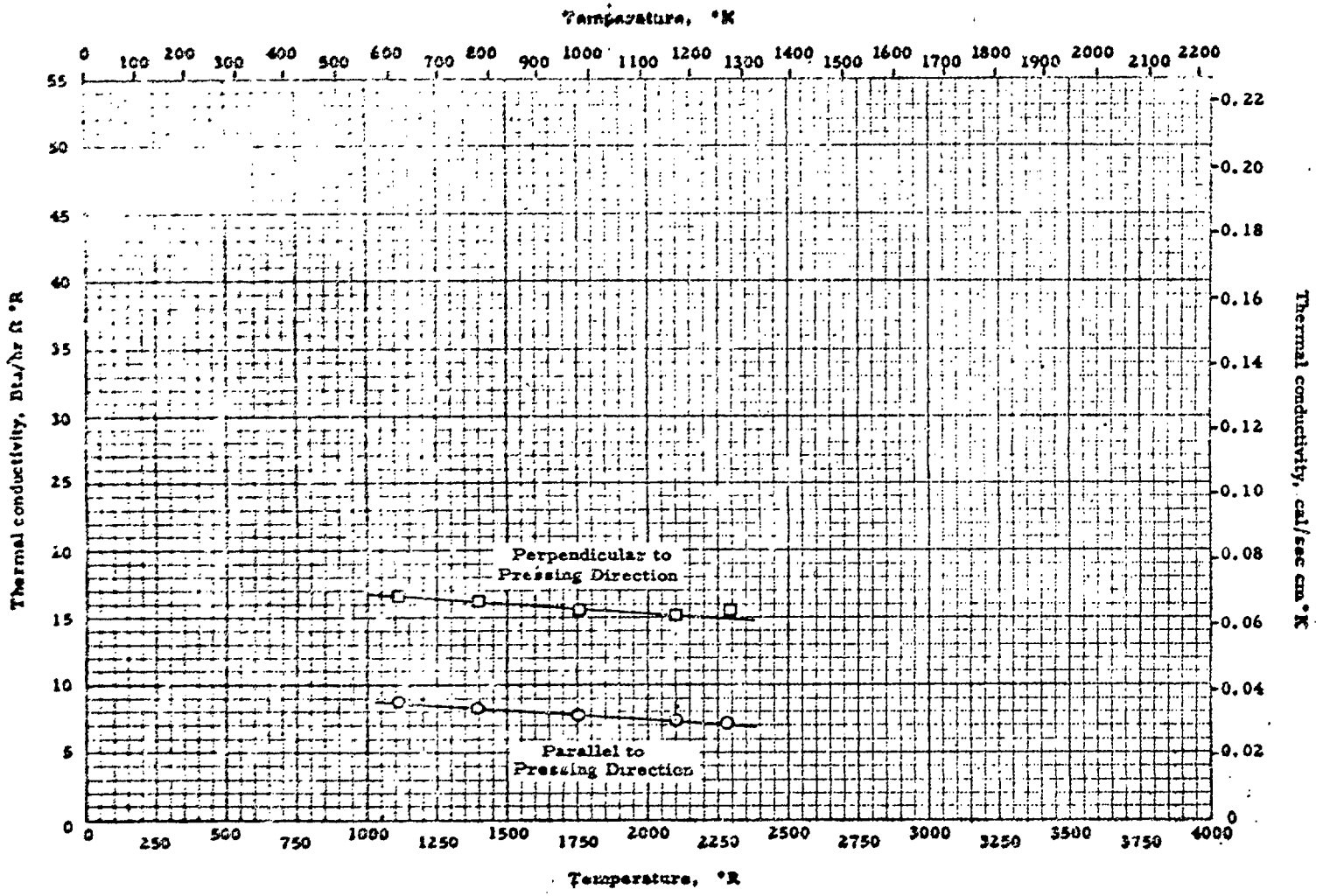


SPECIFIC HEAT -- BORON NITRIDE

SPECIFIC HEAT -- BORON NITRIDE

REFERENCE INFORMATION

Key	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Deerkin, A. S., Zaccor, D. J. and Van Artsdalen, E. R.	34-136	36-540	BN 1.5% Fe as Fe_3O_4.	Adiabatic calorimeter for direct measurement of C_p	

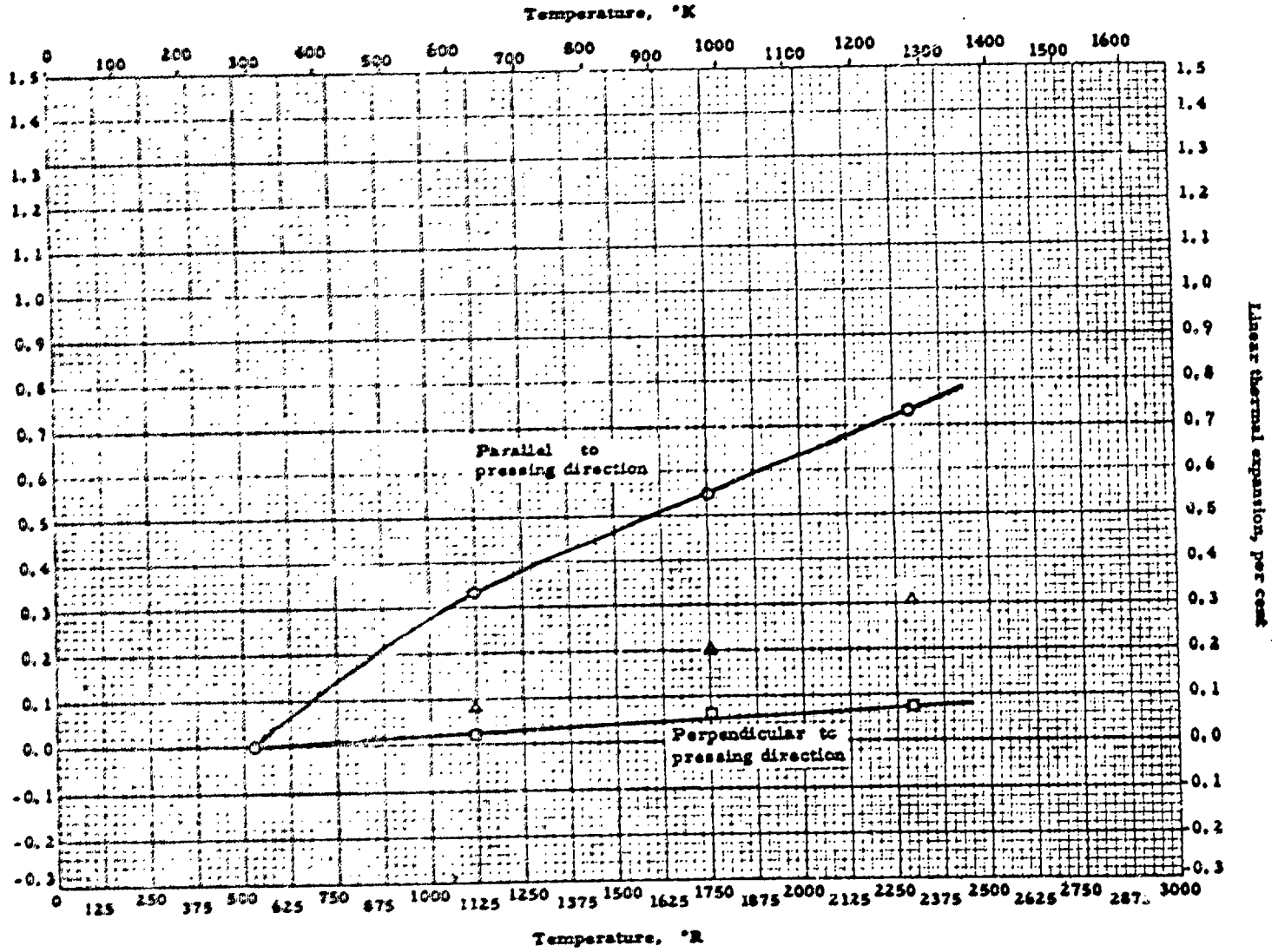


THERMAL CONDUCTIVITY -- BORON NITRIDE

THERMAL CONDUCTIVITY -- BORON NITRIDE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Taylor, K. M.	55-69	1212-2292	97% BN; 2.04% B_2O_3; 0.25% SiO_2; 0.15% Al_2O_3; 0.08% C; ρ = 131 lb_m/ft^3	Not given	Hot pressed; parallel to pressing direction
□	Ibid.	55-69	1212-2292	Same as above	Same as above	Hot pressed; perpendicular to pressing direction


Temperature, °K
0 100 200 300 400 500 600 700 800 900 1000 1100 1200 1300 1400 1500 1600
Linear thermal expansion, per cent
1.5 1.4 1.3 1.2 1.1 1.0 0.9 0.8 0.7 0.6 0.5 0.4 0.3 0.2 0.1 0.0 -0.1 -0.2 -0.3
Parallel to pressing direction
Perpendicular to pressing direction
0 125 250 375 500 625 750 875 1000 1125 1250 1375 1500 1625 1750 1875 2000 2125 2250 2375 2500 2625 2750 2875 3000
Temperature, °R
Linear thermal expansion, per cent

VII - D -

LINEAR THERMAL EXPANSION -- BORON NITRIDE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Taylor, K. M.	55-69	528-2292	97%BN; 2.04% B_2O_3; 0.25% SiO_2; 0.15% Al_2O_3; 0.08%C. ρ = 132 lb_m/ft^3	Not given	Hot pressed. Meas. parallel to pressing direction
□	Ibid.	55-69	528-2292	Same as above	Same as above	Hot pressed. Meas. perpendicular to pressing direction
△	Ibid.	55-69	528-2292	BN. ρ = 107 lb_m/ft^3	Same as above	

ELECTRIC RESISTIVITY -- BORON NITRIDE

ELECTRIC RESISTIVITY -- BORON NITRIDE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Taylor, R. M.	55-69	537-3192	97% BN; 2.04% B_2O_3; 0.25% SiO_2; 0.15% Al_2O_3; 0.08% C. Apparent ρ = 131 lb_m/ft^3	Not given	Meas. with electric field parallel to pressing direction

PROPERTIES OF ALKALI METAL FLUORIDES

MOST PROBABLE VALUES

Property	Brit. Engineering Units	C. G. S. Units
Density.		
Melting Point, LiF . . .	1928 °R	1071 °K
Heat of Fusion		
Heat of Vaporization, RbF	$3622_{2484-2860\,°R}$ Btu/lb$_m$	$2012_{1124-1333\,°K}$ cal/g
Heat of Sublimation . . .		

REPORTED VALUES

Density: lb_m/ft^3 g/cm^3

Melting Point:

	°R	°K	
O	1928	1071	LiF

Heat of Fusion: Btu/lb$_m$ cal/g

Heat of Vaporization:

	Btu/lb$_m$	cal/g	
O	$3622_{2484-2860\,°R}$	$2012_{1124-1333\,°K}$	RbF

Heat of Sublimation: Btu/lb$_m$ cal/g

PROPERTIES OF ALKALI METAL FLUORIDES

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Sense, K. A., Stone, R. W. and Filbert Jr., R. B.	57-174	2024-2400	"Pure" LiF	Δh_v from vapor press. measurements	Supplied by Oak Ridge National Lab.
□	Ibid.	57-174	1928	RbF	MP; by thermal analysis	

PROPERTIES OF AMERICIUM FLUORIDE

MOST PROBABLE VALUES

Property	Brit. Engineering Units	C. G. S. Units
Density.		
Melting Point		
Heat of Fusion		
Heat of Vaporization. . .	$362_{4540°R}$ Btu/lb_m	$269_{2690°K}$ cal/g
Heat of Sublimation . . .	$680_{0°R}$ Btu/lb_m	$378_{0°K}$ cal/g

REPORTED VALUES

Density: lb_m/ft^3 g/cm^3

Melting Point: °R °K

Heat of Fusion: Btu/lb_m cal/g

Heat of Vaporization: Btu/lb_m cal/g

□ $362_{4543°A}$ $269_{2660°K}$

Heat of Sublimation: Btu/lb_m cal/g

○ $674_{2291°R}$ $419_{1273°K}$

△ $680.2 \pm 0.68_{0°R}$ $377.9 \pm 0.490_{0°K}$

PROPERTIES OF AMERICIUM FLUORIDE

REFERENCE INFORMATION

Symbol	Investigator	Ref	Range, °R	Material Composition	Test Method	Remarks
O	Carniglia, S. C.	53-73	1291	99.8% pure AmF_3	Δh_s: from vapor pressure measured by Knudsen cell with radioactive counting	Precipitated from re-purified Am by aqueous HF; washed with dil HF and H_2O then acetone; air dried. Vapor pressure measured at 2016-2646°R
□	Ibid.	53-73	4641	Same as above	Δh_v: from extrapolated vapor pressure data obtained by Knudsen cell with radioactive counting	Auth. assumed Δh_f = 13 kcal/mole
△	Carniglia, S. C.	55-72	0	AmF_3: 0.01% Al; 0.05% Fe	Δh_s: not given	

PROPERTIES OF BERYLLIUM FLUORIDE

MOST PROBABLE VALUES

Property	Brit. Engineering Units	C. G. S. Units
Density.		
Melting Point	1937°R	1076°K
Heat of Fusion	414 1937°R Btu/lb_m	230 1076°K cal/g
Heat of Vaporization. . .	3660 1937°R Btu/lb_m	2033 1076°K cal/g
Heat of Sublimation . . .	4074 1937°R Btu/lb_m	2263 1076°K cal/g

REPORTED VALUES

Density:		lb_m/ft^3	g/cm^3
Melting Point:		°R	°K
	O	1937	1076
Heat of Fusion:		Btu/lb_m	cal/g
	O	414 1937°R	230 1076°K
Heat of Vaporization:		Btu/lb_m	cal/g
	O	3660 1937°R	2033 1076°K
Heat of Sublimation:		Btu/lb_m	cal/g
	O	4074 1937°R	2263 1076°K

PROPERTIES OF BERYLLIUM FLUORIDE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Sense, K. A., Snyder, M. J. and Gregg, J. W.	53-141	1937 1820-1937 1934-2090 1937	Beryllium fluoride, BeF_2	MP: not given Δh_v: from vapor pressure measurement Δh_s: same as above $\Delta h_f = \Delta h_s - \Delta h_v$	

PROPERTIES OF PLUTONIUM FLUORIDE

MOST PROBABLE VALUES

Property	Brit. Engineering Units	C. G. S. Units
Density.		
Melting Point	3024°R	1680°K
Heat of Fusion	78.3 Btu/lb_m	43.5 cal/g
Heat of Vaporization. . .	$461_{4430°R(B.P.)}$ Btu/lb_m	223_{2460} (B.P.) cal/g
Heat of Sublimation . . .	$695_{0°R}$ Btu/lb_m	$386_{0°K}$ cal/g

REPORTED VALUES

Density:		lb_m/ft^3	g/cm^3
Melting Point:		°R	°K
	□	3824 ± 36	1680 ± 20
Heat of Fusion:		Btu/lb_m	cal/g
	○	$78.3_{3824 \pm 36°R}$	$43.5_{1680 \pm 20°K}$
Heat of Vaporization:		Btu/lb_m	cal/g
	○	$637.5_{0°R}$	$354.2_{0°K}$
	○	$460.9_{4428°R\ (B.P.)}$	$222.7_{2460°K\ (B.P.)}$
	□	$377_{4590°R}$	$209_{2550°K}$
Heat of Sublimation:		Btu/lb_m	cal/g
	○	$695.3_{0°R}$	$386.3_{0°K}$
	□	$371_{2400°R}$	$317_{1333°K}$ ∞
	△	$468.624 \pm 0.954_{0°R}$	$382.216 \pm 0.530_{0°K}$

PROPERTIES OF PLUTONIUM FLUORIDE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Brewer, L., Bromley, L. et al.	49-65	0-3968	PuF_3	MP: not described here, refers to others Δh_f: not described here, refers to others Δh_v: not described here, refers to others Δh_s: not described here refers to others	
□	Carnigila, S. C.	53-73	2196-4590	PuF_3. 99.9 + % pure 0.02% ea. Al, Mg; 0.01% La	Δh_v: from vapor pressure measured by Knudsen cell with radioactive counting Δh_s: from vapor pressure measured by Knudsen cell with radioactive counting	Precipitated with H_2 from purified Pu (IV) stock solution after reduction to Pu (III) with SO_2. Washed, air dried, vacuum dried, vapor press. meas. 1220-1450°K
△	Carnigila, S. C. and Cunningham, B. B.	55-77	0	PuF_3. 0.02% ea. Al, Mg; 0.01% La	Δh_v: from vapor pressure measurements by Knudsen method	

PROPERTIES OF THORIUM FLUORIDE

MOST PROBABLE VALUES

Property	Brit. Engineering Units	C. G. S. Units
Density.		
Melting Point	2490°R	1380°K
Heat of Fusion	16 Btu/lb_m	9 cal/g
Heat of Vaporization. . .	$408_{2730°R}$ Btu/lb_m	$226_{1520°K}$ cal/g
Heat of Sublimation . . .	$450_{2120°R}$ Btu/lb_m	$250_{1180°K}$ cal/g

REPORTED VALUES

Density:

	lb_m/ft^3	g/cm^3

Melting Point:

	°R	°K
O	2489	1383

Heat of Fusion:

	Btu/lb_m	cal/g
O	$16_{2489°R}$	$9.1_{1383°K}$

Heat of Vaporization:

	Btu/lb_m	cal/g
O	$408 \pm 0.9_{2729°R}$	$226 \pm 0.5_{1516°K}$
O	$370_{3479°R}$	$205_{1933°K}$

Heat of Sublimation:

	Btu/lb_m	cal/g
O	$450 \pm 0.5_{2117°R}$	$250 \pm 0.3_{1176°K}$
O	$447_{2489°R}$	$249_{1383°K}$

PROPERTIES OF THORIUM FLUORIDE

REFERENCE INFORMATION

Sym.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Yosim, S. J. and Milne, T. A.	57-145	2489 2117-2489 2729-3679 2489	ThF_4	MP: thermal analysis Δh_s : from vapor press. meas. by Knudsen effusion cell, Δh_v : from vapor press. meas. by Rodebush cell measuring total pressure $\Delta h_f = \Delta h_s - \Delta h_v$	

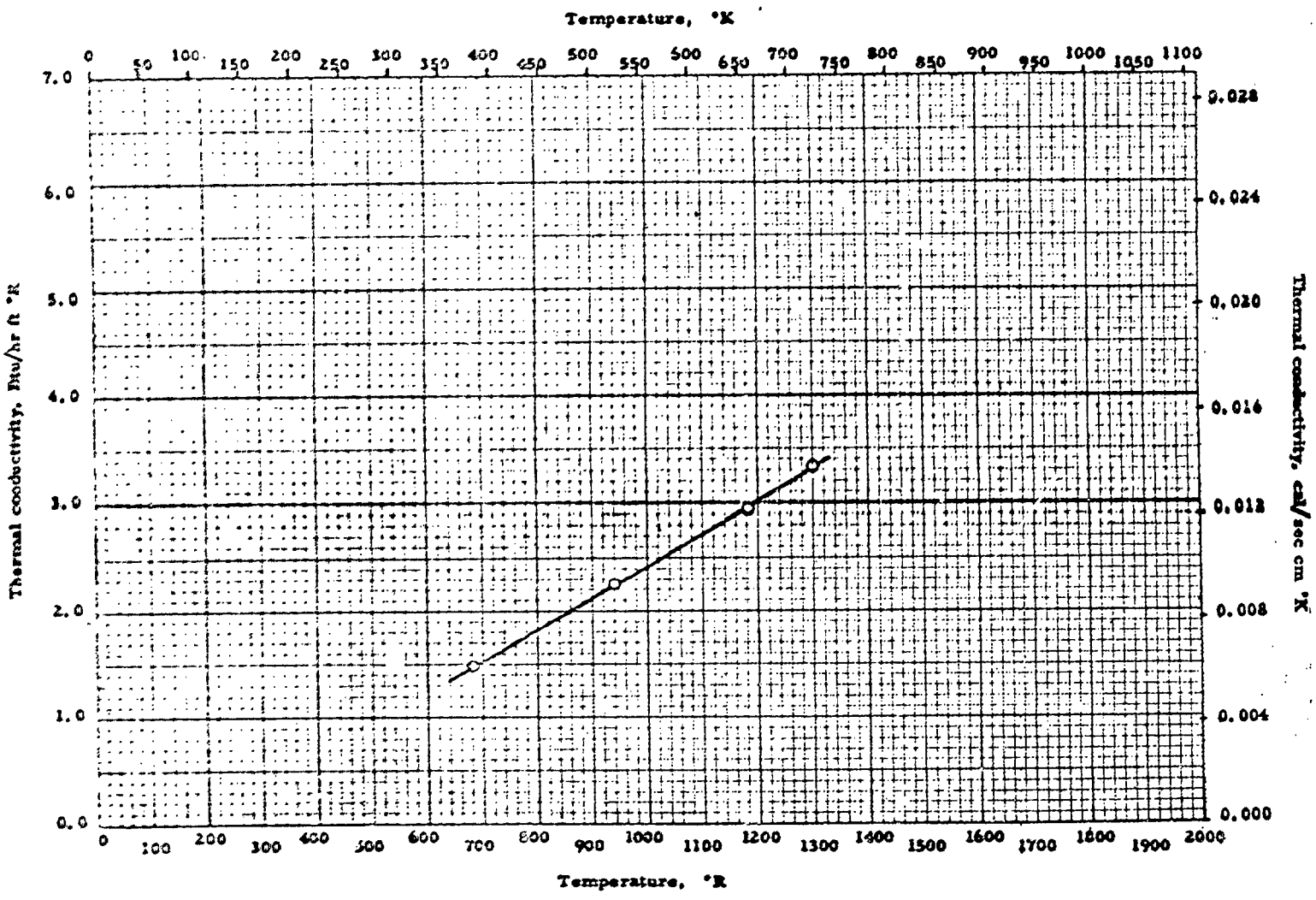
Symbol	Material Composition, % ZrF_4 Mol	ZrF_4 Wt	NaF Mol	NaF Wt	RbF Mol	RbF Wt	LiF Mol	LiF Wt	Melting Point °R	Melting Point °K
O	100	100							2148	1193
	90.0	97.28	10	2.72					2094	1163
	80.0	94.09	20	5.91					2015	1119
	70.0	90.29	30	9.71					1896	1053
	66.5	88.77	33.5	11.23					1572	873
	62.3	86.81	37.7	13.19					1752	973
	55.0	82.96	45	17.04					1482	823
□	94.5	96.5			5.5	3.5			2112	1173
	84.0	89.37			16.0	10.63			2022	1123
	77.0	84.3			23.0	15.7			1932	1073
	68.6	77.8			31.4	22.2			1752	973
	64.5	74.4			35.5	25.6			1572	873
△	90.0	98.31					10.0	1.69	2101	1167
	80.0	96.26					20.0	3.74	2031	1128
	70.6	93.94					29.4	6.06	1932	1073
	60.0	91.48					40.0	8.52	1752	973
	58.8	90.20					41.2	9.80	1716	953

MELTING POINT -- ZIRCONIUM FLUORIDE + ALKALI METAL FLUORIDE

MELTING POINT -- ZIRCONIUM FLUORIDE + ALKALI METAL FLUORIDE

REFERENCE INFORMATION

Sym	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Sense, K. A. Stone, R. W. and Filbert Jr., R. B.	57-174	1482-2148	ZrF_4 + NaF (82.96-100% ZrF_4)	MP: from varpor press. meas. and thermal analysis	
□	Ibid.	57-174	1572-2148	ZrF_4 + RbF (74.4-96.5% ZrF_4)	MP: same as above	
△	Ibid.	57-174	1716-2148	ZrF_4 + LiF (90.20-98.31% ZrF_4)	MP: same as above	
◇	Ibid.	57-174	2148	100% ZrF_4	MP: same as above	



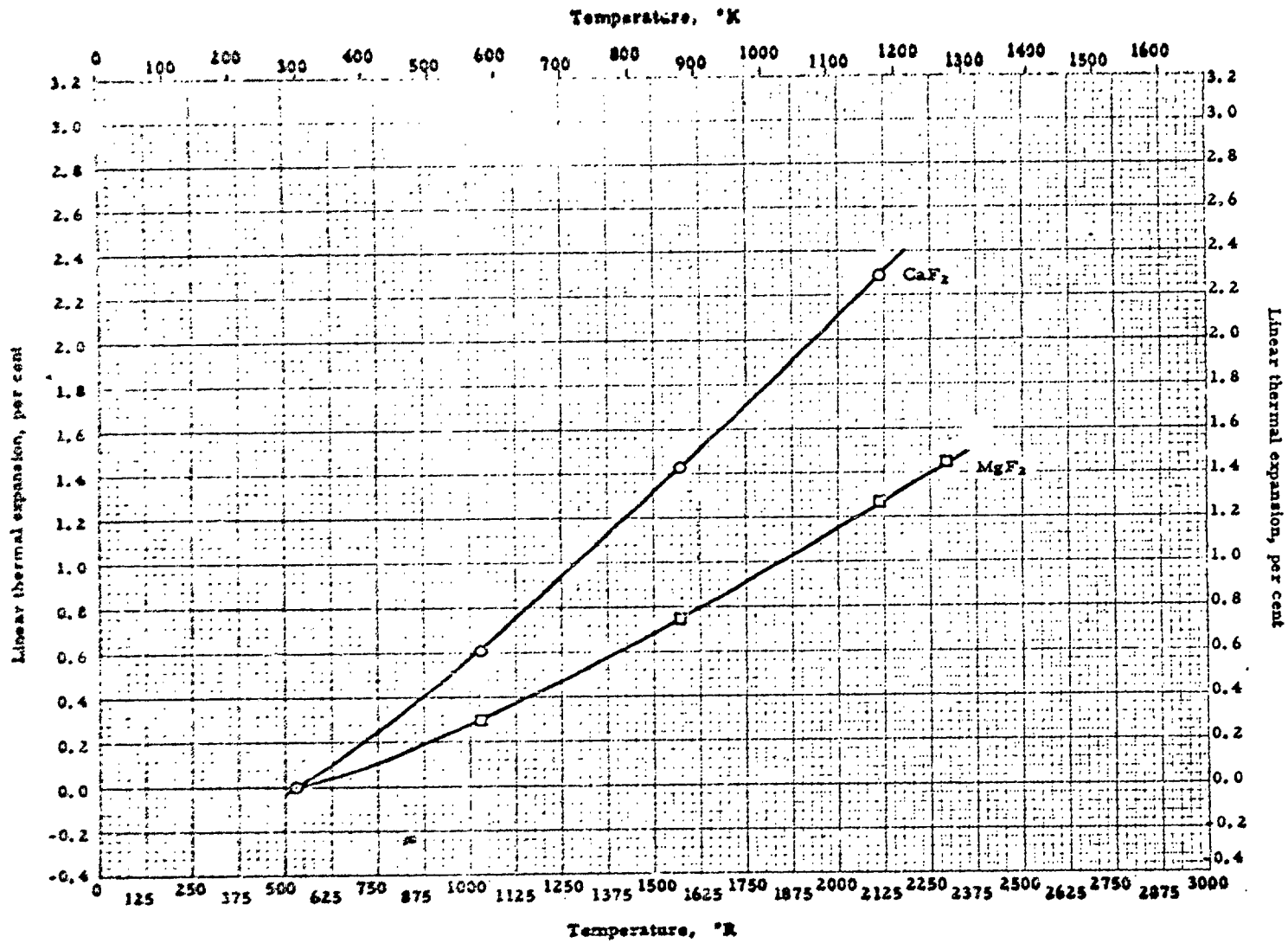
THERMAL CONDUCTIVITY -- LITHIUM FLUORIDE

WADC TR 58-476 186 60-620

THERMAL CONDUCTIVITY -- LITHIUM FLUORIDE

REFERENCE INFORMATION

Curve Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Knapp, W. J.	43-11	681-1300	Lithium fluoride	Axial heat flow in rod, guarded heat source and sample. Temp. by Chromel-Const. thermocouples	Synthetic material

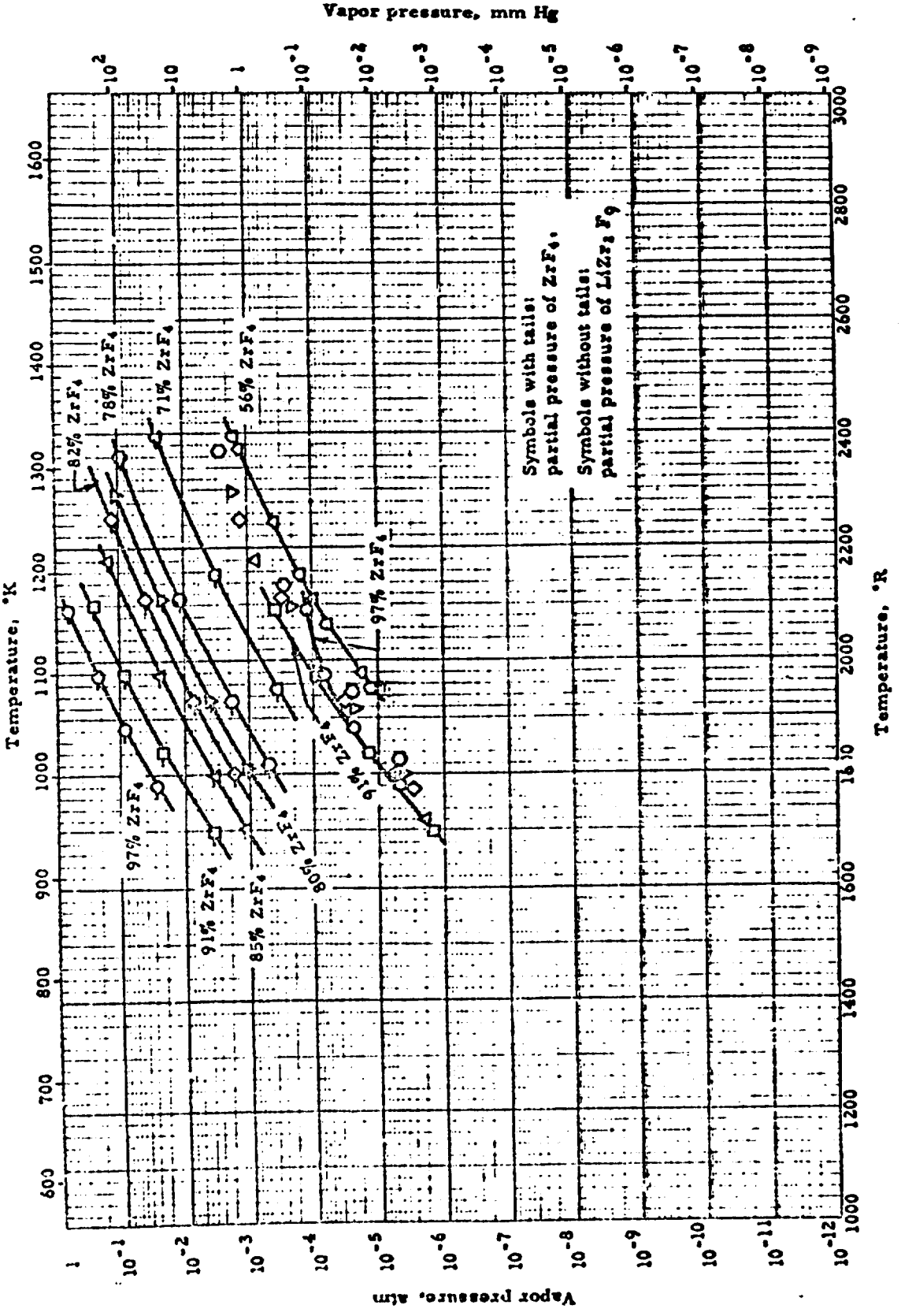


LINEAR THERMAL EXPANSION -- FLUORIDES

LINEAR THERMAL EXPANSION -- FLUORIDES

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Whittemore, O. J. and Ault, N. N.	56-7	1032-2112	CaF_2	Dilatometer. Temp. by Pt thermocouple	Sintered, high density
□	Ibid.	56-7	1032-2292	MgF_2	Same as above	Fine grain

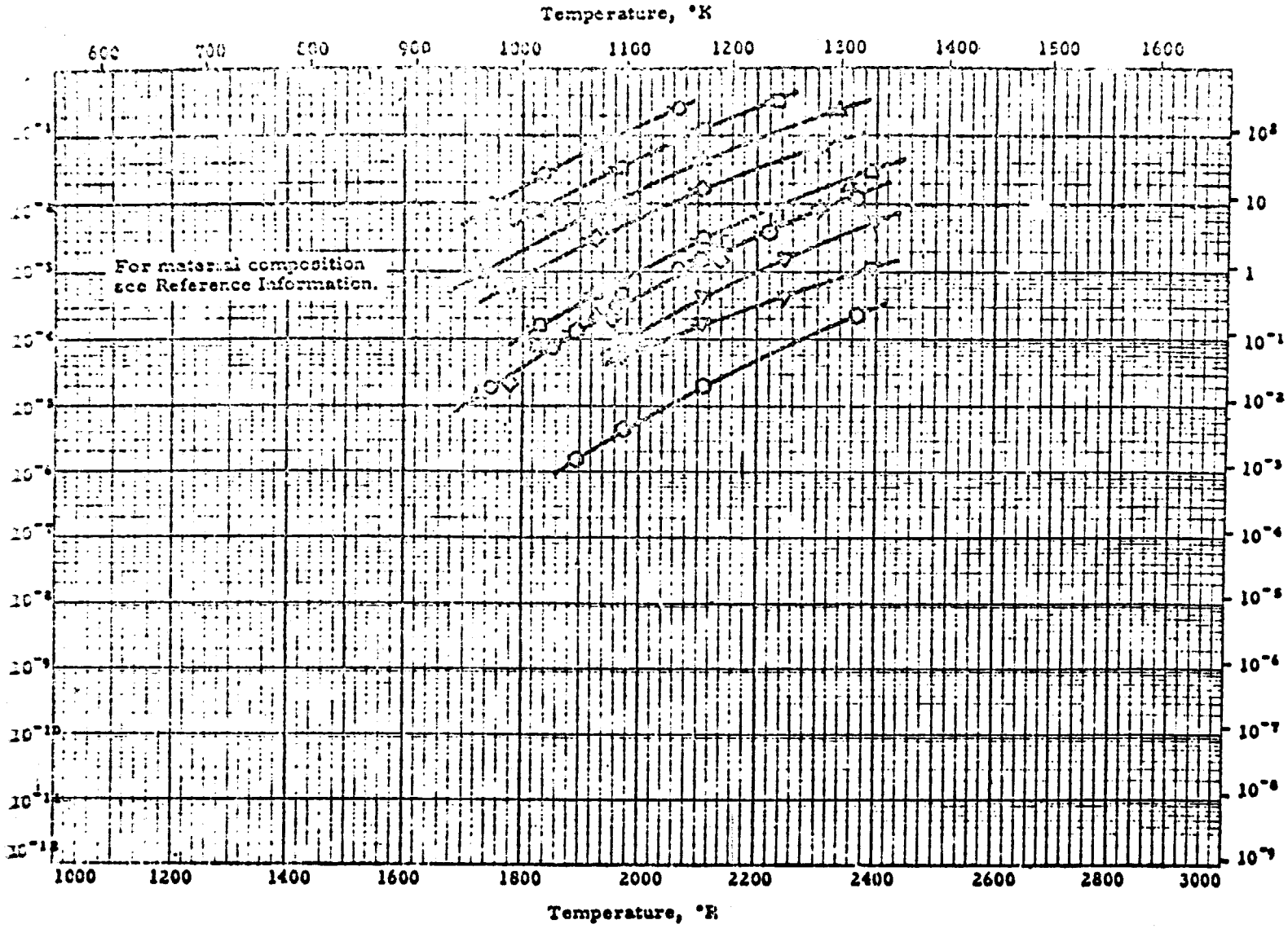


VAPOR PRESSURE -- ZIRCONIUM FLUORIDE + LITHIUM FLUORIDE

VAPOR PRESSURE -- ZIRCONIUM FLUORIDE + LITHIUM FLUORIDE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Sense, K. A., Stone, R. W. and Filbert Jr., R. B.	57-174	1782-2093	96.7% ZrF_4 (82 mol%)	Rate of weight loss to inert gas stream over sample	Data from least - square Eqn. Auth. est. accuracy ± 8%. Auth. believe vapor consists of LiF, ZrF_4 and $LiZr_2F_9$ Symbol with tail: partial pressure of ZrF_4 Symbol without tail: partial pressure of $LiZr_2F_9$
□	Ibid.	57-174	1697-2097	91.3% ZrF_4 (61.8 mol%)	Same as above	Same as above
△	Ibid.	57-174	1706-2182	85.4% ZrF_4 (47.5 mol%)	Same as above	Same as above
◇	Ibid.	57-174	1800-2250	82.4% ZrF_4 (42.1 mol%)	Same as above	Same as above
▽	Ibid.	57-174	1859-2295	80.4% ZrF_4 (38.8 mol%)	Same as above	Same as above
⬡	Ibid.	57-174	1818-2369	77.8% ZrF_4 (35.2 mol%)	Same as above	Same as above
⊡	Ibid.	57-174	1957-2396	70.8% ZrF_4 (27.3 mol%)	Same as above	Same as above
⊙	Ibid.	57-174	1980-2399	55.7% ZrF_4 (16.3 mol%)	Same as above	Same as above



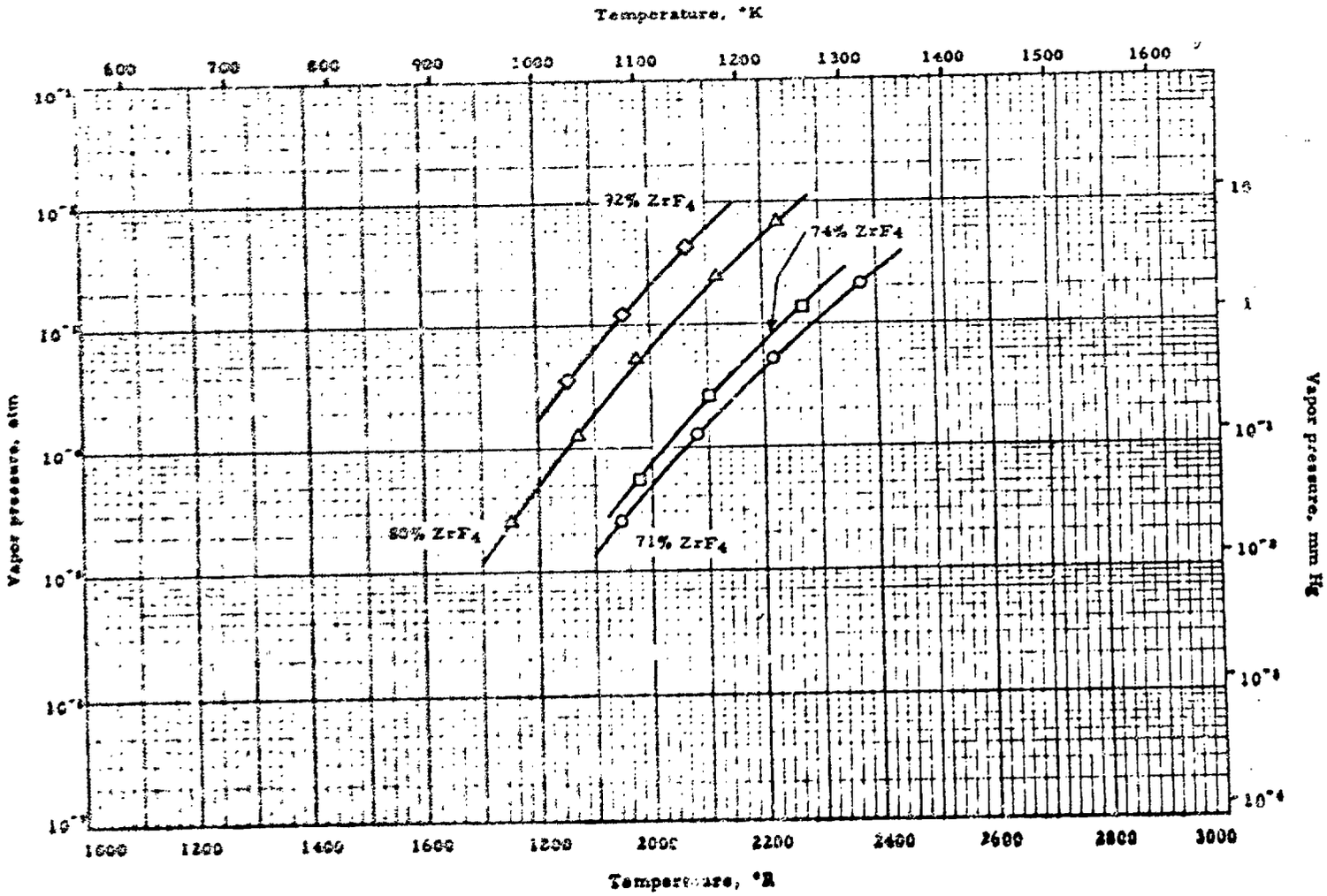
VAPOR PRESSURE -- ZIRCONIUM FLUORIDE + RUBIDIUM FLUORIDE

WADC TR 58-476 Pt 3 680 60-549

VAPOR PRESSURE -- ZIRCONIUM FLUORIDE - RUBIDIUM FLUORIDE

REFERENCE INFORMATION

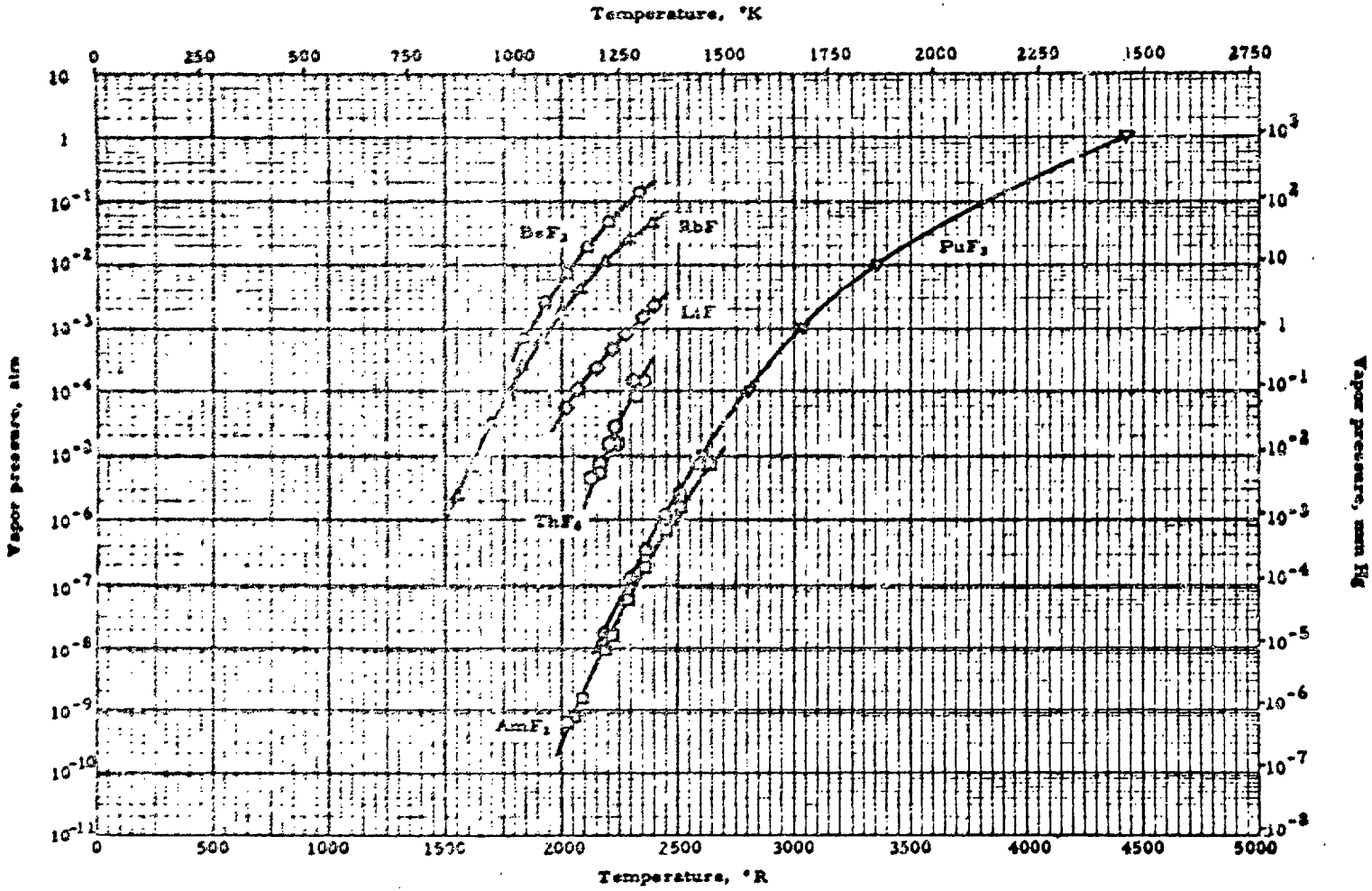
Item	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Brasc, K. A., Stone, R. W. and Gilbert Jr., R. B.	57-174	1746-2068	81.2% ZrF_4. Made from "pure salts"	Rate of weight loss to inert gas stream over sample	Data from least square eqn. Auth. believe vapor consists of RbF, ZrF_4 and $RbZr_2F_9$. Symbol with tail: partial pressure of ZrF_4. Symbol without tail: partial pressure of $RbZr_2F_9$
□	Ibid.	57-174	1832-2236	75.0% ZrF_4	Same as above	Same as above
△	Ibid.	57-174	1733-2338	66.9% ZrF_4	Same as above	Same as above
◇	Ibid.	57-174	1780-2303	60.6% ZrF_4	Same as above	Same as above
▽	Ibid.	57-174	1778-2400	51.1% ZrF_4	Same as above	Same as above
○	Ibid.	57-174	1894-2369	34.2% ZrF_4	Same as above	Same as above except symbol with tail: partial pressure of RbF
⌂	Ibid.	57-174	1836-2400	22.1% ZrF_4	Same as above	Same as above


Temperature, °K
600
700
800
900
1000
1100
1200
1300
1400
1500
1600
92% ZrF4
74% ZrF4
80% ZrF4
71% ZrF4
Vapor pressure, atm
Vapor pressure, mm Hg
1
10⁻¹
10⁻²
10⁻³
10⁻⁴
1000
1200
1400
1600
1800
2000
2200
2400
2600
2800
3000
Temperature, °R

VAPOR PRESSURE -- ZIRCONIUM FLUORIDE + SODIUM FLUORIDE

REFERENCE INFORMATION

Key	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Sense, K. A., Stone, R. W. and Filbert Jr., R. B.	57-174	1946-2349	70.9% ZrF_4 (38.0 mol %)	Rate of weight loss to inert gas stream over sample.	From least-squares eq. fitted by auth. with max. deviation of 8% at lowest temp; partial press. of NaF derived on basis that vapor consists only of NaF and ZrF_4
□	Ibid.	57-174	1978-2264	74.2% ZrF_4 (41.9 mol %)	Same as above	Same as above
△	Ibid.	57-174	1751-2223	79.9% ZrF_4 (50.0 mol %)	Same as above	Same as above
◇	Ibid.	57-174	1856-2061	91.9% ZrF_4 (74.0 mol %)	Same as above	Same as above



VAPOR PRESSURE -- FLUORIDES

VAPOR PRESSURE -- FLUORIDES

REFERENCE INFORMATION

Sym	Investigator	Ref.	Range, °K	Material Composition	Test Method	Remarks
○	Cunniglia, S. C. and Cunningham, B. B.	55-77 also 53-73	2185-2559	PuF_3 + 0.02% ea. Al, Mg; 0.01% La	Knudsen effusion cell of tantalum. Temp. meas. by Pt, Pt-Rh thermocouple	Thermocouple calibrated against MP of Au, Ag, Sn, Al. Auth. est. accuracy ± 6%
□	Ibid.	55-77 53-73	2027-2644	AmF_3. 0.05% Fe; 0.01% Al	Same as above	Same as above
△	Sense, K. A., Stone, R. W. and Filbert Jr., R. B.	57-174	1552-2398	RbF "pure salt"	Meas. rate of deposit of salt from inert gas flow over sample	By Oak Ridge National Laboratory. Least-square eq. was fitted to experimental data by authors with ±8% deviation at the lowest temperatures
◇	Ibid.	57-174	2023-2400	LiF "pure salt"	Same as above	Same as above
▽	Brewer, L., Bromley, L., et al	49-65	2484-4428	PuF_3	Not described here, refers to others	
○	Yosim, S. J. and Milne, T. A.	57-194	2030-2360	ThF_4. <0.2% ea. O_2 or H_2O; 74.8% Th (compared with 75.1% theoretical)	Knudsen effusion cell of nickel. Temp. meas. by calibrated Pt, Pt-Rh thermocouple	Auth. state data are tentative. Auth. report: $\log_{10} p\ (atm) = 10.51 - \frac{18740}{°K}$
□	Sense, K. A., Snyder, M. J. and Clegg, J. W.	53-141 also 57-77	1842-2337	Beryllium fluoride	Meas. rate of condensation of vapor	Corrected for diffusion

Symbol	Material Composition	Density	
		lb_m/ft^3	g/cm^3
○	$CeBr_3$	323	5.18
□	$LaBr_3$	254	4.07
△	$PrBr_3$	328	5.26

DENSITY -- RARE EARTH BROMIDES

DENSITY -- RARE EARTH BROMIDES

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Zachariasen, W. H.	49-66	Room	$CeBr_3$	ρ: computed from x-ray measurements of lattice	
□	Ibid.	49-66	Room	$LaBr_3$	Same as above	
△	[illegible]	49-66	Room	$PrBr_3$	Same as above	

PROPERTIES OF BROMIDES OF URANIUM AND TRANSURANIC ELEMENTS

MOST PROBABLE VALUES*

Property	Brit. Engineering Units	C. G. S. Units
Density.		
Melting Point	1717 °R	954 °K
Heat of Fusion	50.1 Btu/lb_m	27.8 cal/g
Heat of Vaporization. . .	$160_{3213\,°R(B.P.)}$ Btu/lb_m	$91_{1785\,°K(B.P.)}$ cal/g
Heat of Sublimation . . .	$307_{\,°R}$ Btu/lb_m	$170_{0\,°K}$ cal/g

*Values for $PuBr_3$; for others see Reported Values below.

REPORTED VALUES

				Material
Density:		lb_m/ft^3	g/cm^3	
	O	413	6.61	$Np\,Br_3$
	□	408	6.53	$U\,Br_3$
Melting Point:		°R	°K	
	Δ	1717	954	$Pu\,Br_3$
Heat of Fusion:		Btu/lb_m	cal/g	
	Δ	$50.1_{1717\,°R}$	$27.8_{954\,°K}$	$Pu\,Br_3$
Heat of Vaporization:		Btu/lb_m	cal/g	
	Δ	$271_{0\,°R}$	$151_{0\,°R}$	$Pu\,Br_3$
	Δ	$160_{3213\,°R}$	$91_{1785\,°K}$	
Heat of Sublimation:		Btu/lb_m	cal/g	
	Δ	$307_{0\,°R}$	$170_{0\,°K}$	$Pu\,Br_3$

PROPERTIES OF BROMIDES OF URANIUM AND TRANSURANIC ELEMENTS

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °K	Material Composition	Test Method	Remarks
○	Zachariasen, W. H.	49-66		$NpBr_3$	ρ: computed from x-ray measurements of lattice	
□	Ibid.	49-66		UBr_3	ρ: same as above	
△	Brewer, L., Bromley, L. and Lofgren, N. L.	49-65	1717	$PuBr_3$	MP: not described here, refers to others	
			1717		Δh_f: not described here, refers to others	
			0 and 321		Δh_{sub}: not described here, refers to others	
			0		Δh_s: not described here, refers to others	

Symbol	Material Composition	Density	
		lb_m/ft^3	g/cm^3
○	$CeCl_3$	247	3.95
□	$LaCl_3$	240	3.84
△	$NdCl_3$	258	4.14
◇	$PrCl_3$	251	4.02

DENSITY -- RARE EARTH CHLORIDES

669.619
NBS TN 384-416

DENSITY -- RARE EARTH CHLORIDES

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Zachariasen, W. H.	49-66	Room	$CeCl_3$	ρ: computed from x-ray measurements of lattice	
□	Ibid.	49-66	Room	$LaCl_3$	ρ: same as above	
△	Ibid.	49-66	Room	$NdCl_3$	ρ: same as above	
◇	Ibid.	49-66	Room	$PrCl_3$	ρ: same as above	

PROPERTIES OF THORIUM CHLORIDE

MOST PROBABLE VALUES

Property	Brit. Engineering Units	C. G. S. Units
Density.	287 lb_m/ft^3	4.60 g/cm^3
Melting Point	1967°R*	1093°K*
Heat of Fusion		
Heat of Vaporization. . .		
Heat of Sublimation . . .		

*Handbook of Chemistry and Physics, Ref. 59-2

REPORTED VALUES

Density:		lb_m/ft^3	g/cm^3
	○	287	4.60
Melting Point:		°R	°K
Heat of Fusion:		Btu/lb_m	cal/g
Heat of Vaporization:		Btu/lb_m	cal/g
Heat of Sublimation:		Btu/lb_m	cal/g

PROPERTIES OF THORIUM CHLORIDE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Zachariasen, W. H.	49-66		$ThCl_4$	ρ: computed from x-ray meas. of lattice	

PROPERTIES OF CHLORIDES OF URANIUM AND TRANSURANIC ELEMENTS

MOST PROBABLE VALUES*

Property	Brit. Engineering Units	C. G. S. Units
Density.	356 lb_m/ft^3	5.70 g/cm^3
Melting Point	1860°R	1033°K
Heat of Fusion	78.5 Btu/lb_m	43.6 cal/g
Heat of Vaporization. . .	241.5 Btu/lb_m	134.2 cal/g
Heat of Sublimation . . .	435.8 $_{0°R}$ Btu/lb_m	242.1 $_{0°K}$ cal/g

* Values for $PuCl_3$; for others see Reported Values below

REPORTED VALUES

		lb_m/ft^3	g/cm^3	Material
Density:	○	344	5.51	UCl_3
	□	304	4.87	UCl_4
	△	348	5.58	$NpCl_3$
	◇	307	4.92	$NpCl_4$
	▽	356	5.70	$PuCl_3$
		°R	°K	
Melting Point:	○	1860 ± 9	1033 ± 5	$PuCl_3$
		Btu/lb_m	cal/g	
Heat of Fusion:	○	78.5	43.6	$PuCl_3$
		Btu/lb_m	cal/g	
Heat of Vaporization:	○	368.0 $_{0°R}$	204.4 $_{0°K}$	$PuCl_3$
	○	241.5 $_{3672°R\ (B.P.)}$	134.2 $_{2040°K\ (B.P.)}$	$PuCl_4$
		Btu/lb_m	cal/g	
Heat of Sublimation:	○	435.8 $_{0°R}$	242.1 $_{0°K}$	$PuCl_3$

PROPERTIES OF CHLORIDES OF URANIUM AND TRANSURANIC ELEMENTS

REFERENCE INFORMATION

	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Zachariasen, W. H.	49-66	Room	UCl_3	ρ: computed from x-ray measurements of lattice	
□	Ibid.	49-66	Room	UCl_4	ρ: same as above	
△	Ibid.	49-66	Room	$NpCl_3$	ρ: same as above	
◇	Ibid.	49-66	Room	$NpCl_4$	ρ: same as above	
▽	Ibid.	49-66	Room	$PuCl_3$	ρ: same as above	
○	Brewer, L., Bromley, L. et al	49-65	0-3672	$PuCl_3$	MP: not given; refers to others Δh_f: not given; refers to others Δh_v: not given; refers to others Δh_s: not given; refers to others	

PROPERTIES OF PLUTONIUM IODIDE

MOST PROBABLE VALUES

Property	Brit. Engineering Units	C. G. S. Units
Density.		
Melting Point	1890°R	1050°K
Heat of Fusion	34.7 Btu/lb_m	19.3 cal/g
Heat of Vaporization. . .	$115_{2970°R\ (B.P.)}$ Btu/lb_m	$63.8_{1650°K\ (B.P.)}$ cal/g
Heat of Sublimation . . .	$201_{0°R}$	$111_{0°K}$

REPORTED VALUES

Density:

	lb_m/ft^3	g/cm^3

Melting Point:

	°R	°K
O	1890	1050

Heat of Fusion:

	Btu/lb_m	cal/g
O	$34.7_{1890°R}$	$19.3_{1050°K}$

Heat of Vaporization:

	Btu/lb_m	cal/g
O	$172.0_{0°R}$	$95.5_{0°K}$
O	$114.8_{2970°R}$	$63.8_{1650°K}$

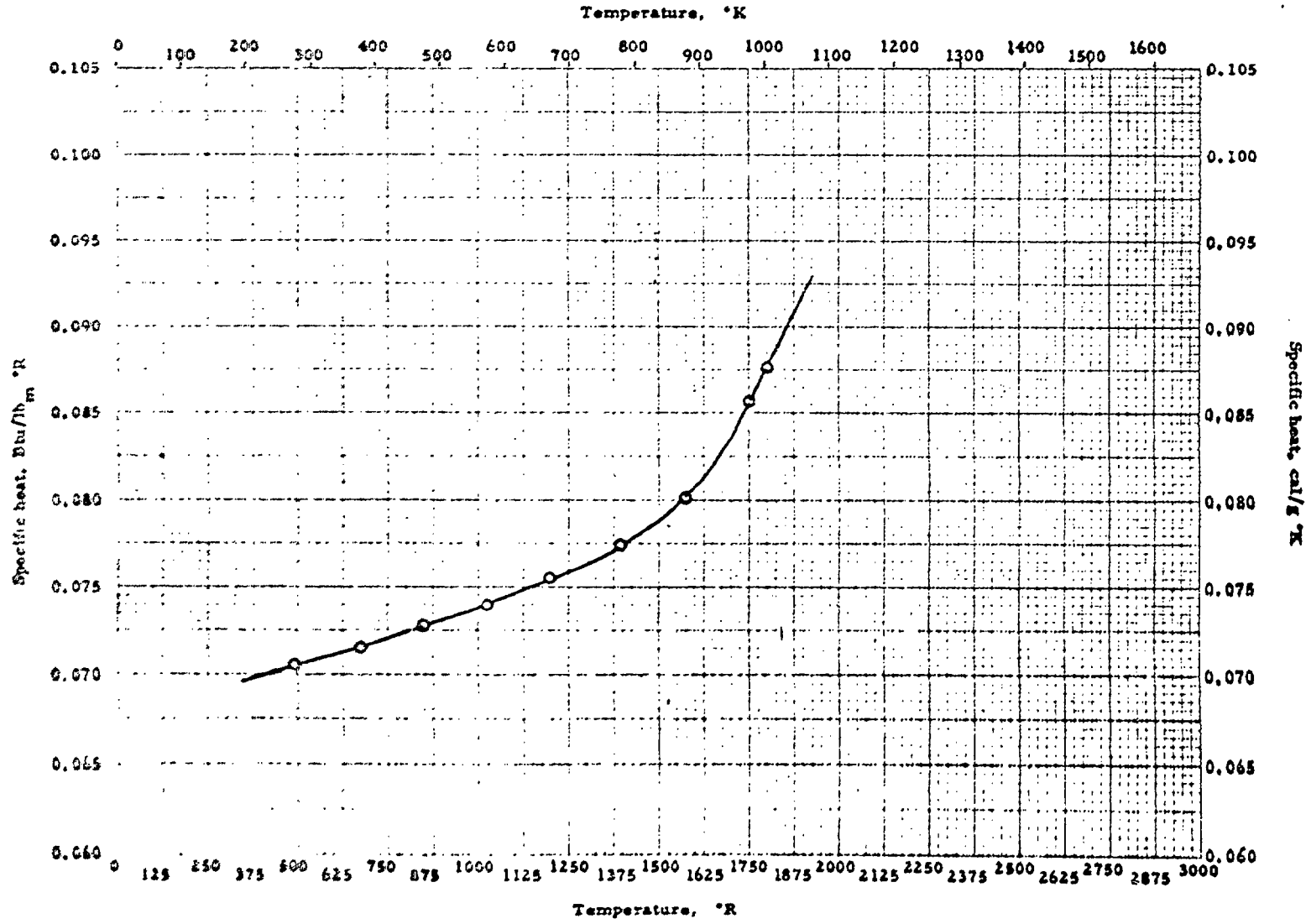
Heat of Sublimation:

	Btu/lb_m	cal/g
O	$200.4_{0°R}$	$111_{0°K}$

PROPERTIES OF PLUTONIUM IODIDE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Brewer, L., Bromley, L. et al	49-65	0-2970	PuI_3	MP: not given; refers to other ref. Δh_f: not given; refers to other ref. Δh_v: not given; refers to other ref. Δh_s: not given; refers to other ref.	



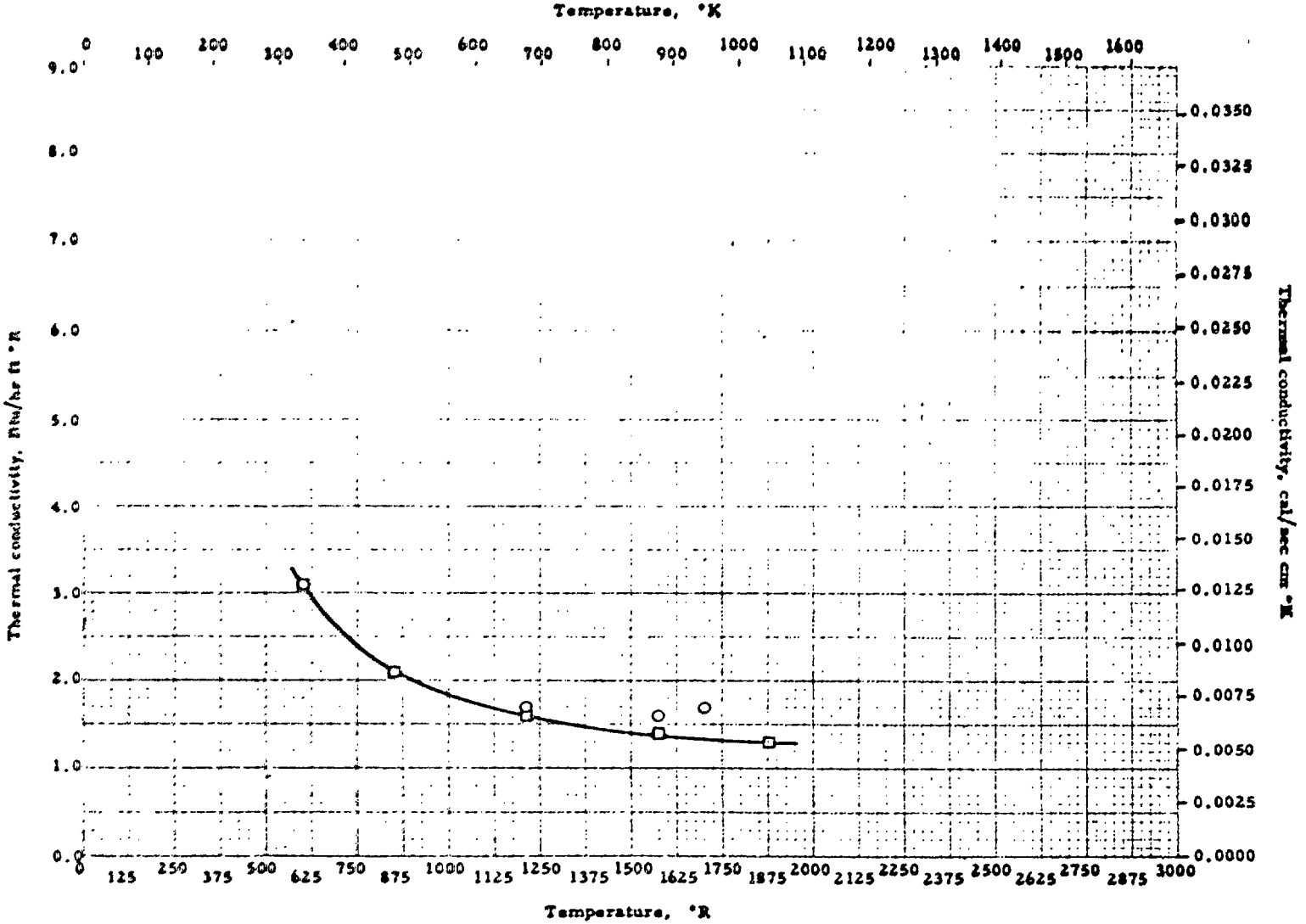
SPECIFIC HEAT -- URANIUM CHLORIDE

WADC TR 58-476 (pt. 4) 1961

SPECIFIC HEAT -- URANIUM CHLORIDE

REFERENCE INFORMATION

Curve Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Cinnings, D. C. and Corruccini, R. J.	47-1	492-1792	99.5% UCl_3, 0.02% Na, 0.013% Fe, 0.01% Ca, 0.01% Mg, 0.006% Si; balance U (probably as oxide)	Drop method; ice calorimeter	

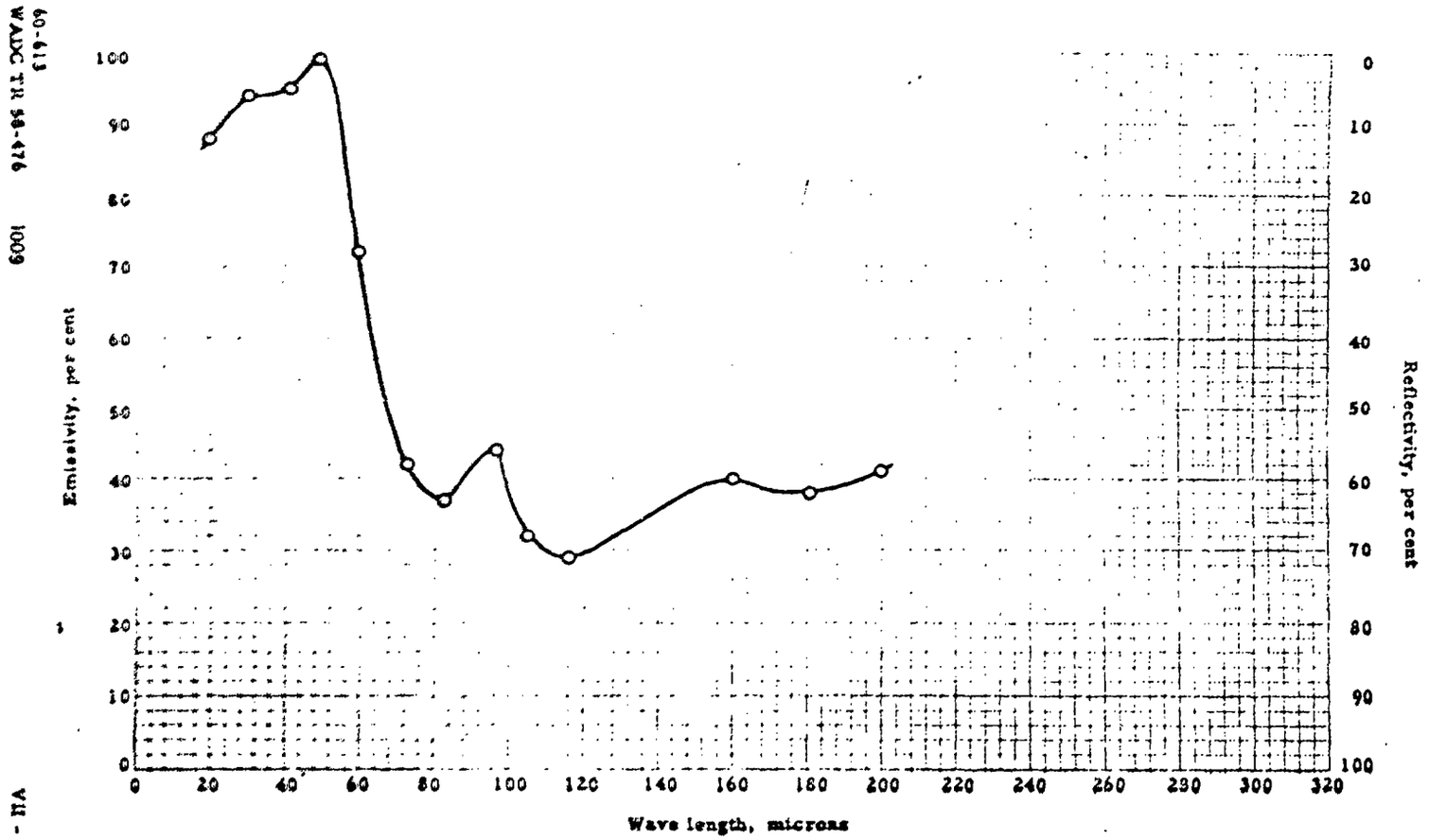


THERMAL CONDUCTIVITY -- FLUORITE

THERMAL CONDUCTIVITY -- FLUORITE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Charvat, F. R. and Kingery, W. D.	57-53	582-1932	Single crystal CaF_2	Comparative; rods	
□	Ibid.	57-53	582-1932	Polycrystalline CaF_2	Same as above	Data corrected to zero porosity. Porosity is 8.17% based on density and 10.9% based on microstructure



SPECTRAL EMISSIVITY -- THALLIUM CHLORIDE

WADC TR 58-476 60-613
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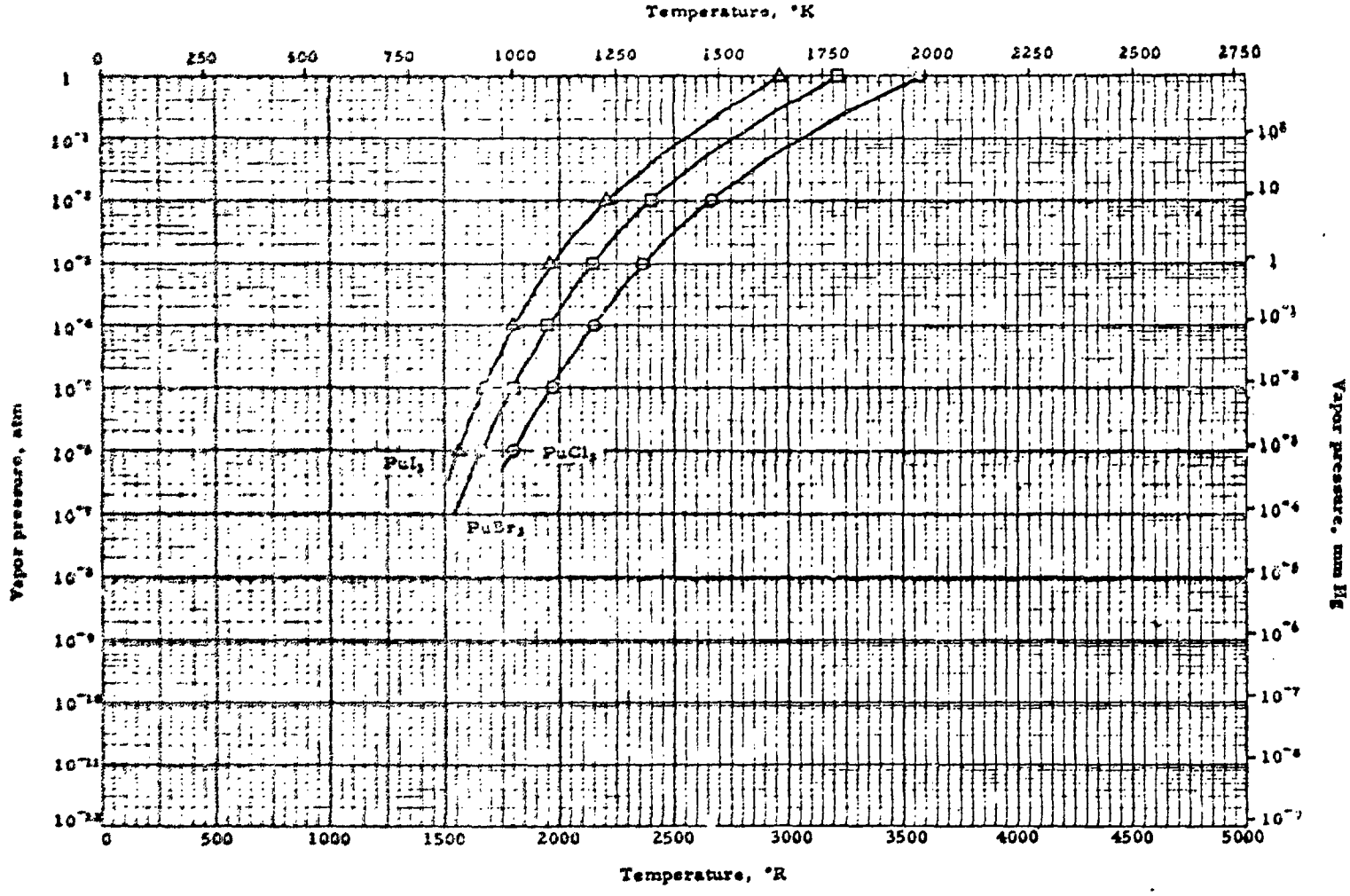
SPECTRAL EMISSIVITY -- THALLIUM CHLORIDE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Yoshimaga, H.	55-98	533	TlCl	Spectral normal reflectivity: far infrared spectrograph	Probably fairly pure crystals



VAPOR PRESSURE -- PLUTONIUM HALIDES

VAPOR PRESSURE -- PLUTONIUM HALIDES

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Brewer, L., Bromley, L. et al.	49-65	1800-3572	$PuCl_3$	Not given here, refers to others	
□	Ibid.	49-65	1665-3213	$PuBr_3$	Same as above	
△	Ibid.	49-65	1557-2970	PuI_3	Same as above	Estimated from corresponding uranium compound

PROPERTIES OI BERYLLIUM SULFIDE

MOST PROBABLE VALUES

Property	Brit. Engineering Units	C. G. S. Units
Density.	260 lb_m/ft^3	4.2 g/cm^3
Melting Point	4452°R	2473°K
Heat of Fusion		
Heat of Vaporization. . .		
Heat of Sublimation . . .		

REPORTED VALUES

Density:		lb_m/ft^3	g/cm^3
	O	260	4.2
Melting Point:		°R	°K
	O	4452 +	2473 +
Heat of Fusion:		Btu/lb_m	cal/g
Heat of Vaporization:		Btu/lb_m	cal/g
Heat of Sublimation:		Btu/lb_m	cal/g

60-720
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PROPERTIES OF BERYLLIUM SULFIDE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Brewer, L., Bromley, L. et al.	48-51	Room 4452	BeS. "Pure"	ρ: not described here, refers to others MP: not described here, refers to others	White sample

PROPERTIES OF CERIUM SULFIDE

MOST PROBABLE VALUES

Property	Brit. Engineering Units	C. G. S. Units
Density.	370 lb_m/ft^3 *	5.93 g/cm^3 *
Melting Point	4900°R *	2725°K *
Heat of Fusion		
Heat of Vaporization. . .		
Heat of Sublimation . . .		

*Value for CeS_2 for others see Reported Values below

REPORTED VALUES

Density:		lb_m/ft^3	g/cm^3	Material
	○	370	5.93	CeS
	△	331	5.3	Ce_3S_4
	◇	325	5.2	Ce_2S_3

Melting Point:		°R	°K	
	○	4902 ± 180	2723 ± 100	CeS
	□	4091 ± 135	2273 ± 75	$CeS_{1.15}$
	△	4182 ± 135	2323 ± 75	Ce_3S_4
	◇	3894 ± 90	2163 ± 50	Ce_2S_3

Heat of Fusion:		Btu/lb_m	cal/g
Heat of Vaporization:		Btu/lb_m	cal/g
Heat of Sublimation:		Btu/lb_m	cal/g

PROPERTIES OF CERIUM SULFIDE

REFERENCE INFORMATION

Sym bol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Eastman, E. D., Brewer, L., et al.	50-27 also 48-31	4722-5082	CeS	MP: visual observation; optical pyrometer ρ: not given	ρ measured by Zachariasen at ANL
□	Ibid.	50-27 also 48-31	3956-4226	$CeS_{1.15}$ (Eutectic)	MP: same as above	
△	Ibid.	50-27 also 48-31	4047-4317	Ce_3S_4	MP: same as above ρ: not given	Same as above
◇	Ibid.	50-27 also 48-31	3804-3984	Ce_2S_3	MP: same as above ρ: same as above	Same as above

PROPERTIES OF MOLYBDENUM SULFIDE

MOST PROBABLE VALUES

Property	Brit. Engineering Units	C. G. S. Units
Density.		
Melting Point	3500°R	1920°K
Heat of Fusion		
Heat of Vaporization. . .		
Heat of Sublimation . . .		

REPORTED VALUES

Density:		lb_m/ft^3	g/cm^3
Melting Point:		°R	°K
	O	3507 ± 45	1923 ± 25
Heat of Fusion:		Btu/lb_m	cal/g
Heat of Vaporization:		Btu/lb_m	cal/g
Heat of Sublimation:		Btu/lb_m	cal/g

69-611
WADC TR 58-476 1018

PROPERTIES OF MOLYBDENUM SULFIDE

REFERENCE INFORMATION

Sym-bol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Zelikman, A. N. and Belyaevskaya, L. V.	56-151	3462-3552	MoS_2 (Molybdenite). Initial compos. of MoS_2: 58.45% Mo; 39.02% S At 1650°C: 60.43% Mo; 37.7% S At 1700°C: 76.24% Mo; 31.8%	MP: not given	Heated in press to 1600-1900°C. Products studied microscopically, chemically, and by x-ray analysis. Melts with decomposition at 1650-1700°C

PROPERTIES OF THORIUM SULFIDE

MOST PROBABLE VALUES*

Property	Brit. Engineering Units	C. G. S. Units
Density.	460 lb_m/ft^3	7.36 g/cm^3
Melting Point	3921°R	2178°K
Heat of Fusion		
Heat of Vaporization. . .		
Heat of Sublimation . . .		

*Values for ThS_2; for others see Reported Values below.

REPORTED VALUES

Density:		lb_m/ft^3	g/cm^3	Material
	○	597	9.56	ThS
	◇	486	7.78	Th_4S_7 or Th_7S_{12}
	○	460	7.36	ThS_2
Melting Point:		°R	°K	
	○	4452 +	2473 +	ThS
	□	3732 +	2073 +	ThS-Th_2S_3 eutectic
	△	4002 ± 90	2223 ± 50	Th_2S_3
	◇	3678	2043	Th_4S_7 or Th_7S_{12}
	▽	3670 ± 45	2038 ± 25	Th_7S_{12}-ThS_2 eutectic
	○	3921	2178	ThS_2
Heat of Fusion:		Btu/lb_m	cal/g	
Heat of Vaporization:		Btu/lb_m	cal/g	
Heat of Sublimation:		Btu/lb_m	cal/g	

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PROPERTIES OF THORIUM SULFIDE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Brewer, L., Bromley, L., et al.	48-31	4452	ThS	ρ: not described here, refers to others MP: not described here, refers to others	Silvery metallic lustre
□	Ibid.	48-31	3732	Eutectic between ThS and Th_2S_3	MP; same as above	
△	Ibid.	48-31	3912-4092	Th_2S_3	MP; same as above	Brown
◇	Ibid.	48-31	3678	"Th_6S_7 or Th_7S_{10}"	ρ: same as above MP; same as above	
▽	Ibid.	48-31	3628-3715	Eutectic between "Th_6S_7 or Th_7S_{10}" and ThS_2	MP; same as above	
○	Ibid.	48-31	3421	ThS_2	ρ: same as above MP; same as above	Purple

PROPERTIES OF URANIUM SULFIDE

MOST PROBABLE VALUES

Property	Brit. Engineering Units	C. G. S. Units
Density.	493 lb_m/ft^3*	7.90 g/cm^3*
Melting Point.		
Heat of Fusion		
Heat of Vaporization. . .		
Heat of Sublimation . . .		

*Value for US_2; for others see Reported Values below.

REPORTED VALUES

Density:		lb_m/ft^3	g/cm^3	Material
	O	678.6	10.87	US
	□	493	7.90	US_2

Melting Point: °R °K

Heat of Fusion: Btu/lb_m cal/g

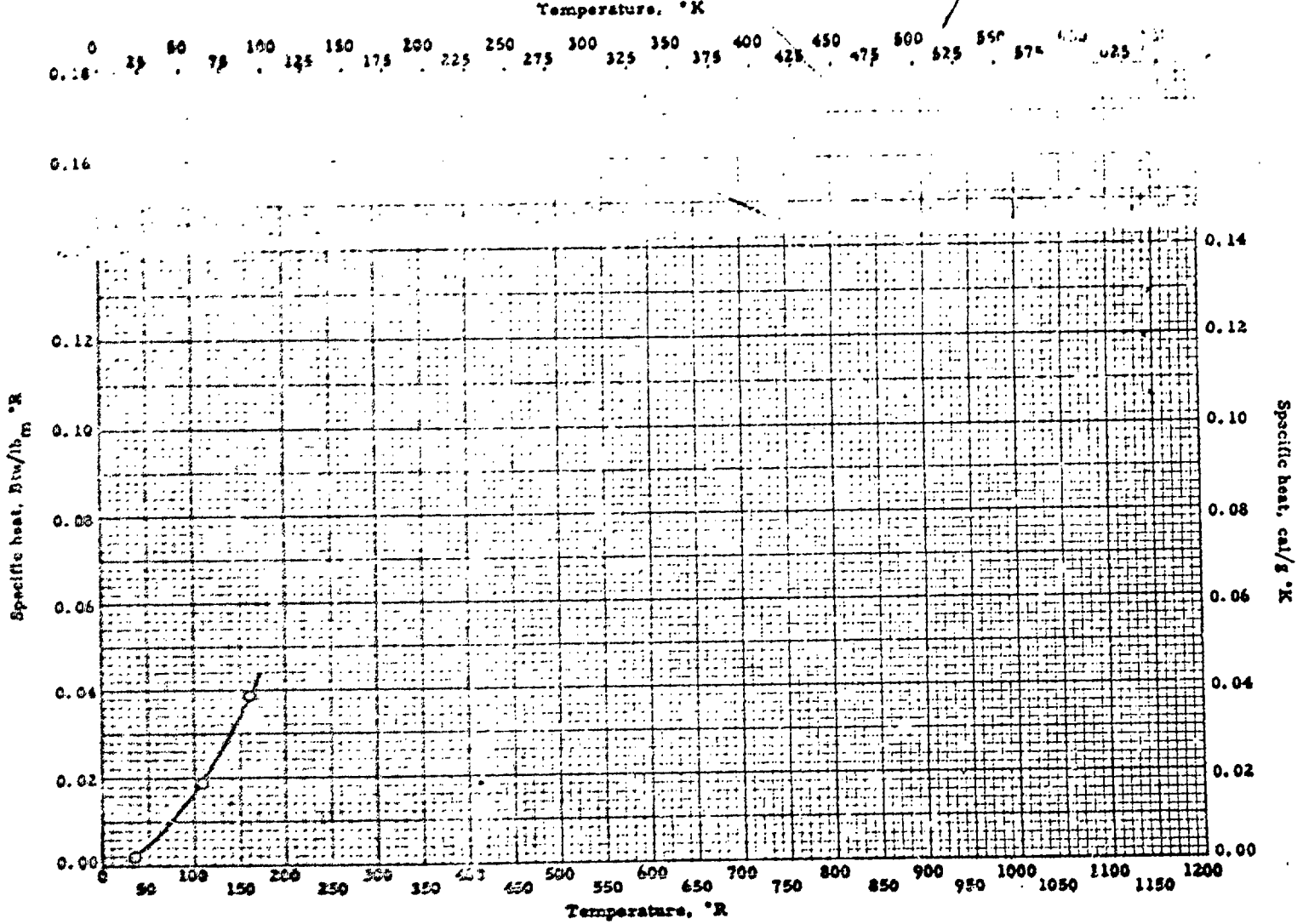
Heat of Vaporization: Btu/lb_m cal/g

Heat of Sublimation: Btu/lb_m cal/g

PROPERTIES OF URANIUM SULFIDE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °K	Material Composition	Test Method	Remarks
○	Brewer, L., Bromley, L., et al.	48-31	Room	US	ρ: not described here, refers to others	
□	Ibid.	48-31	Room	US_2	ρ: same as above	US_2 is black

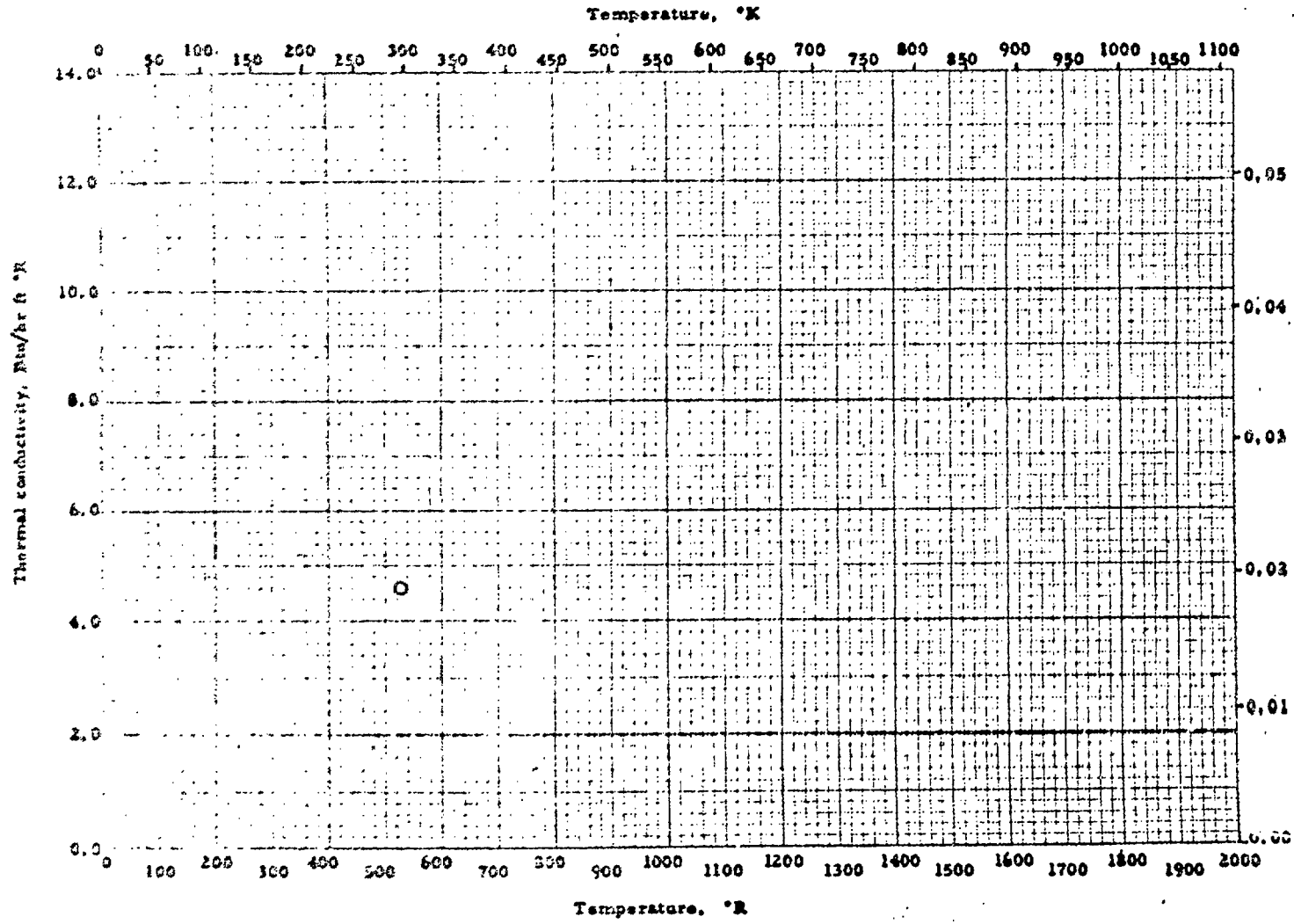


SPECIFIC HEAT -- MOLYBDENUM SULFIDE

SPECIFIC HEAT -- MOLYBDENUM SULFIDE

REFERENCE INFORMATION

Curve	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Smith, D. F., Brown, D. et al.	56-150	36-162	MoS_2	Low temperature adiabatic calorimeter	Contains some free carbon and oil

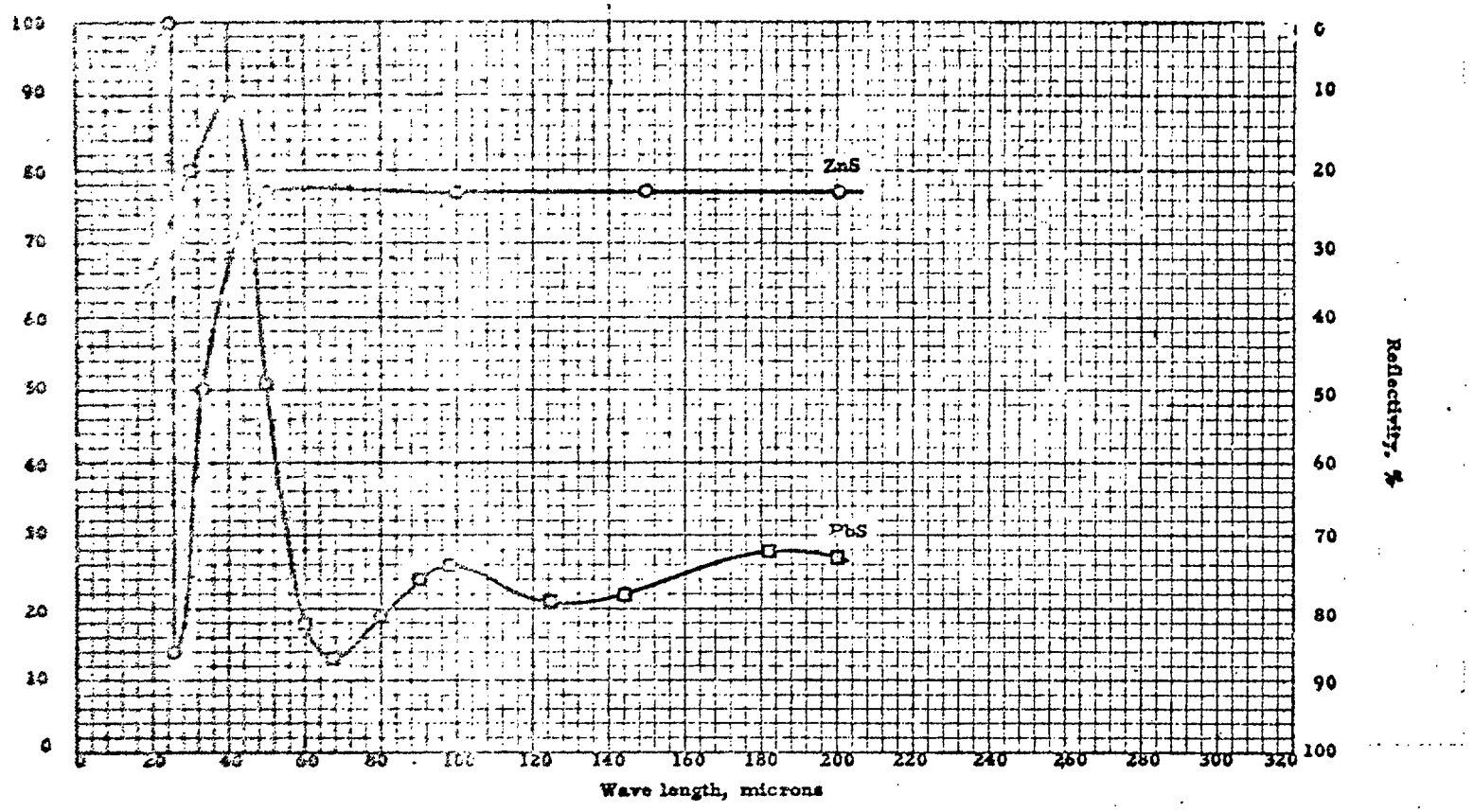


THERMAL CONDUCTIVITY -- CERIUM SULFIDE

THERMAL CONDUCTIVITY -- CERIUM SULFIDE

REFERENCE INFORMATION

	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Edwards, R. K.	52-12	Room	CeS	Comparative, disks with Bi Standard	Auth. assumes uncertainty of factor of 2

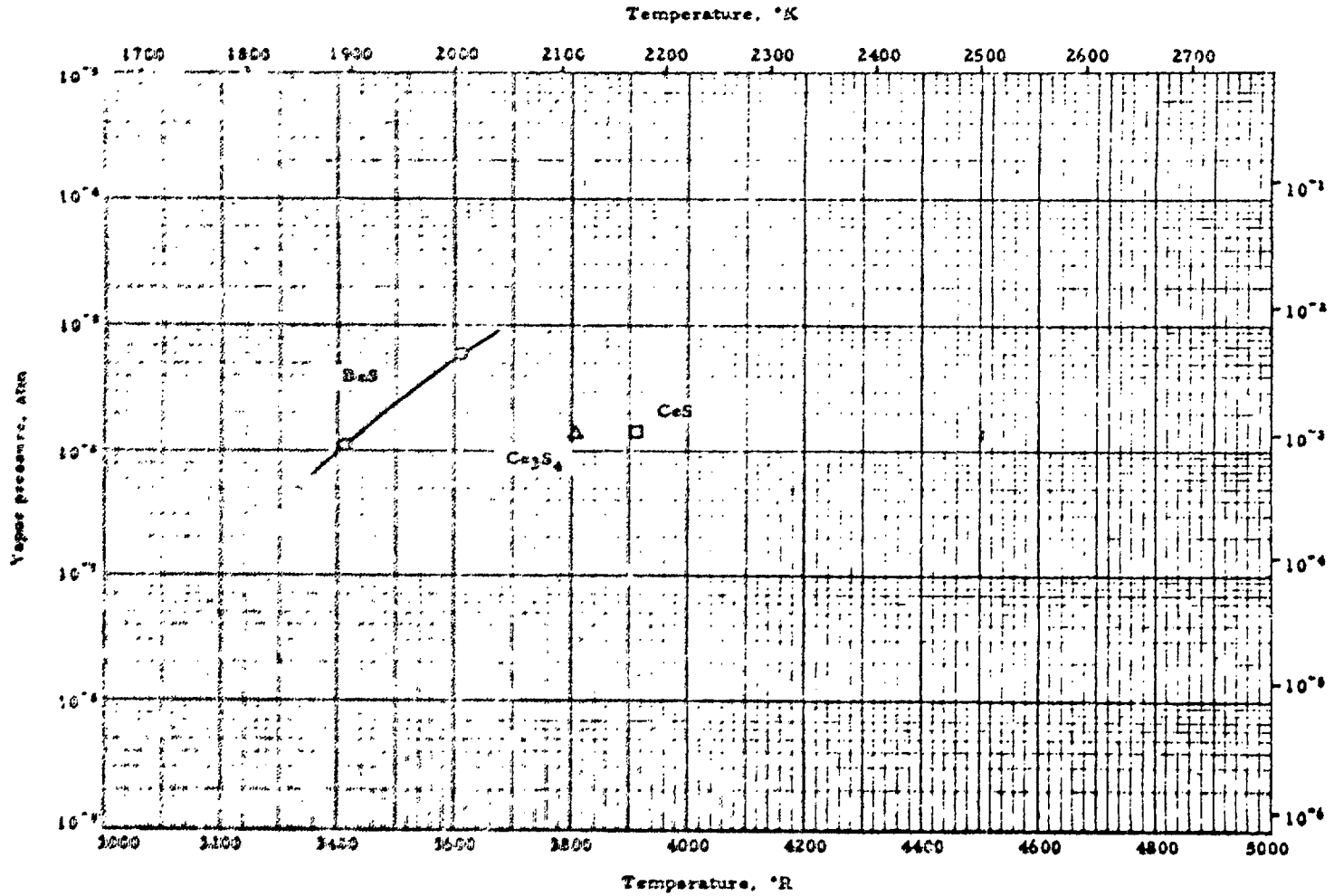


SPECTRAL EMISSIVITY -- SULFIDES

SPECTRAL EMISSIVITY -- SULFIDES

REFERENCE INFORMATION

	Investigator	Ref.	Range, °K	Material Composition	Test Method	Remarks
C	Yoshinaga, H.	55-98	533	ZnS	Spectral reflectivity: far infrared spectrograph	Probably fairly pure crystals
□	Reid.	55-98	537	PbS	Same as above	Same as above



VAPOR PRESSURE -- SULFIDES

69-779
WADC TR 58-476 1029

VAPOR PRESSURE -- SULFIDES

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Brewer, L., Bromley, L. et al.	48-31	3408-3606	BeS "pure". $\rho = 4.2$ g/cm^3	Not described here, refers to others	Approximate measurement. Authors also report some data for ThS
□	Eastman, E. F., Brewer, L. et al.	50-27 also 48-31	3408-3912	CaS crystal. $\rho = 5.93$ g/cm^3	Weight loss, assuming vaporis Ca and S atoms	
△	Ibid.	50-27 also 48-31	3408-3912	Ca_3S_4. $\rho = 5.3$ g/cm^3	Same as above	

PROPERTIES OF BARIUM SELENIDE

MOST PROBABLE VALUES

Property	Brit. Engineering Units	C. G. S. Units
Density.		
Melting Point	3860° R	2140° K
Heat of Fusion		
Heat of Vaporization. . .		
Heat of Sublimation. . .		

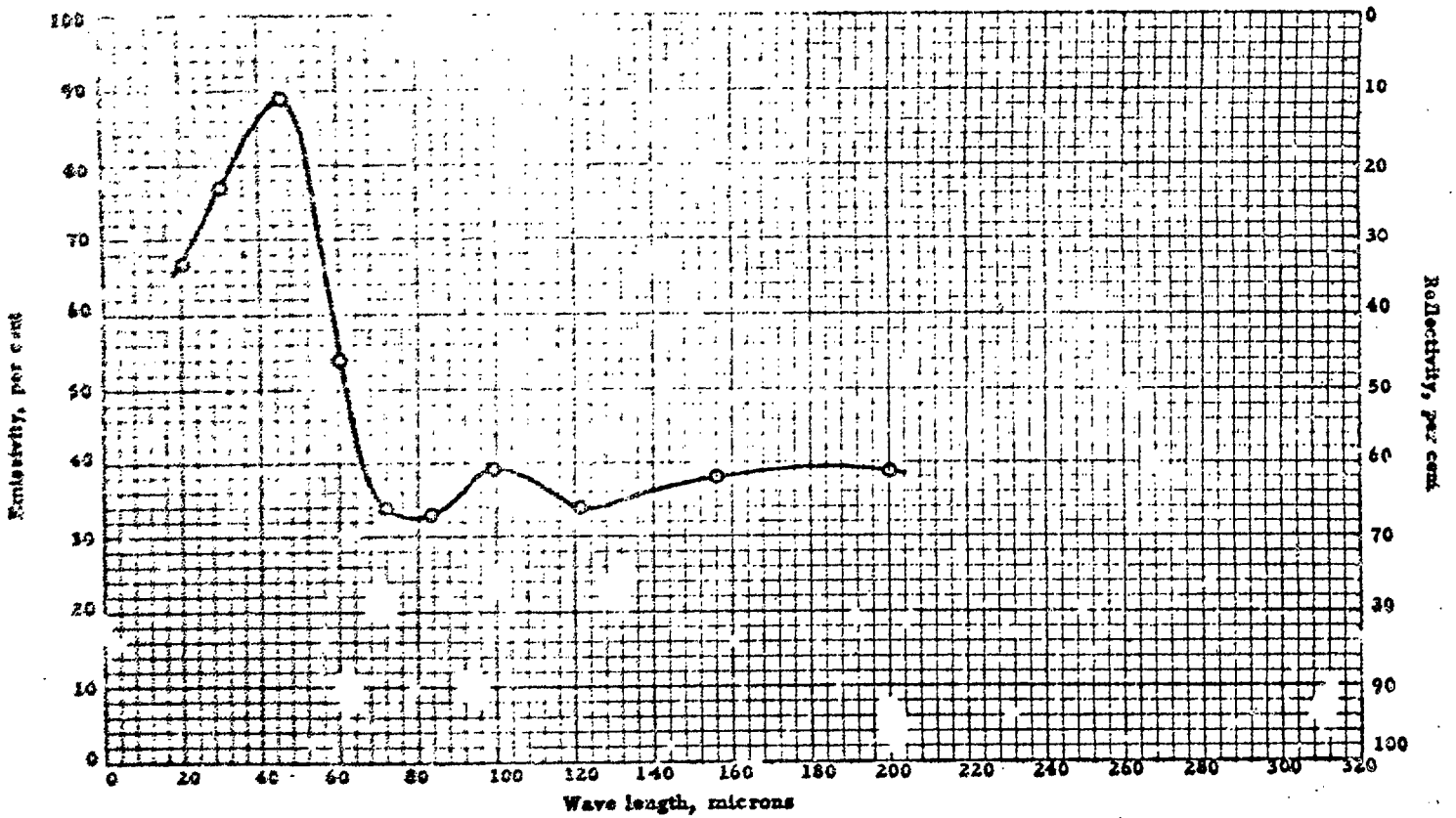
REPORTED VALUES

Density:	lb_m/in^3	g/cm^3
Melting Point:	°R	°K
	3858 ± 36	2143 ± 20
Heat of Fusion:	Btu/lb_m	cal/g
Heat of Vaporization:	Btu/lb_m	cal/g
Heat of Sublimation:	Btu/lb_m	cal/g

PROPERTIES OF BARIUM SELENIDE

REFERENCE INFORMATION

	Investigator	Ref.	Temp, °R	Material Composition	Test Method	Remarks
O	Cedrone, L.E., Miller, E. and Komarek, K.	58-13	3222-3894	BaSe	MP: visual observation of order of melting of sample and standards	



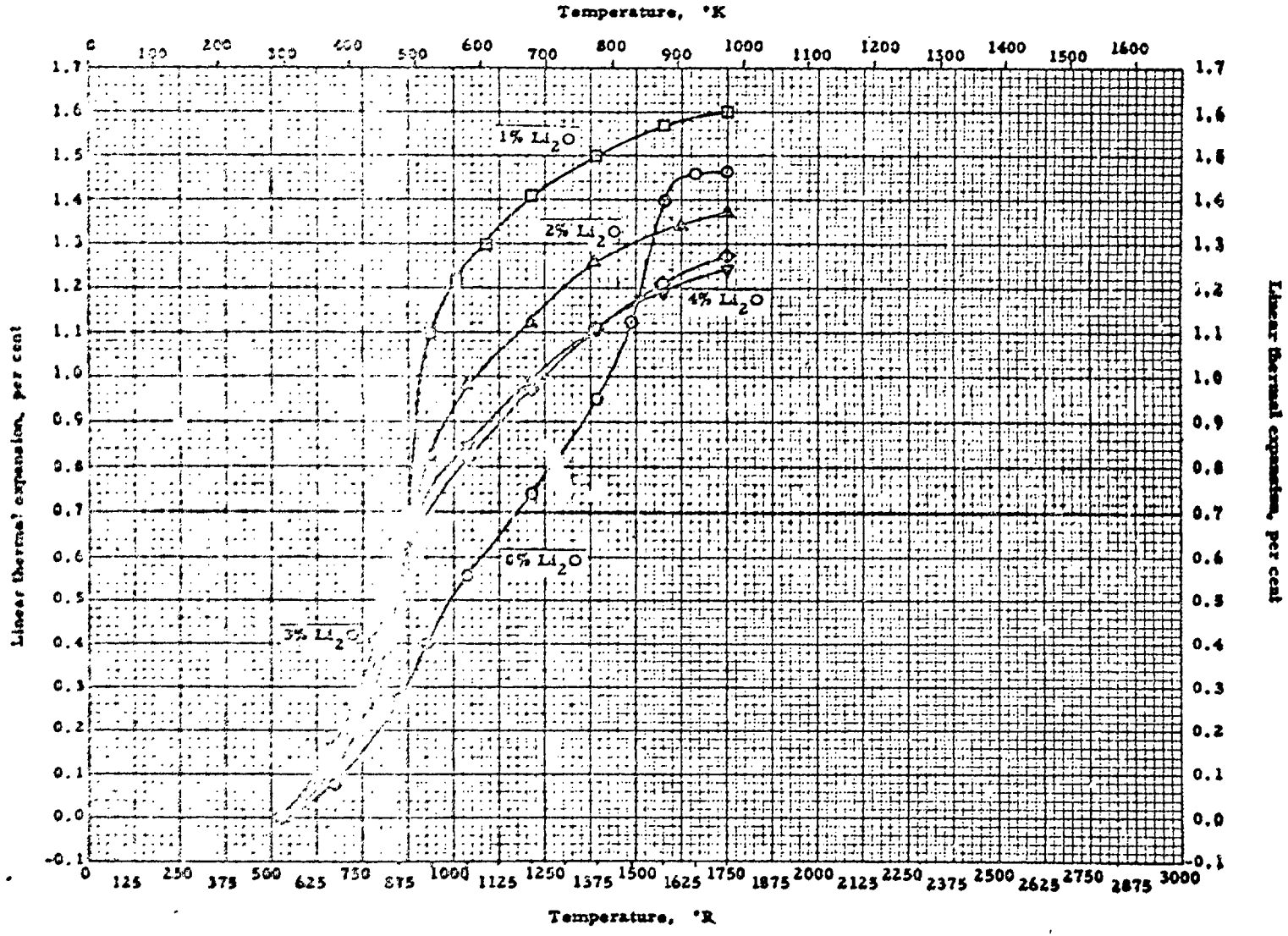
SPECTRAL EMISSIVITY -- LEAD SELENIDE

60-621
WADC TR 58-476 1034

SPECTRAL EMISSIVITY -- LEAD SELENIDE

REFERENCE INFORMATION

Curve No.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Yoshinaga, H.	55-98	533	PbSe	Spectral normal reflectivity: far infrared spectrograph	Probably fairly pure crystals

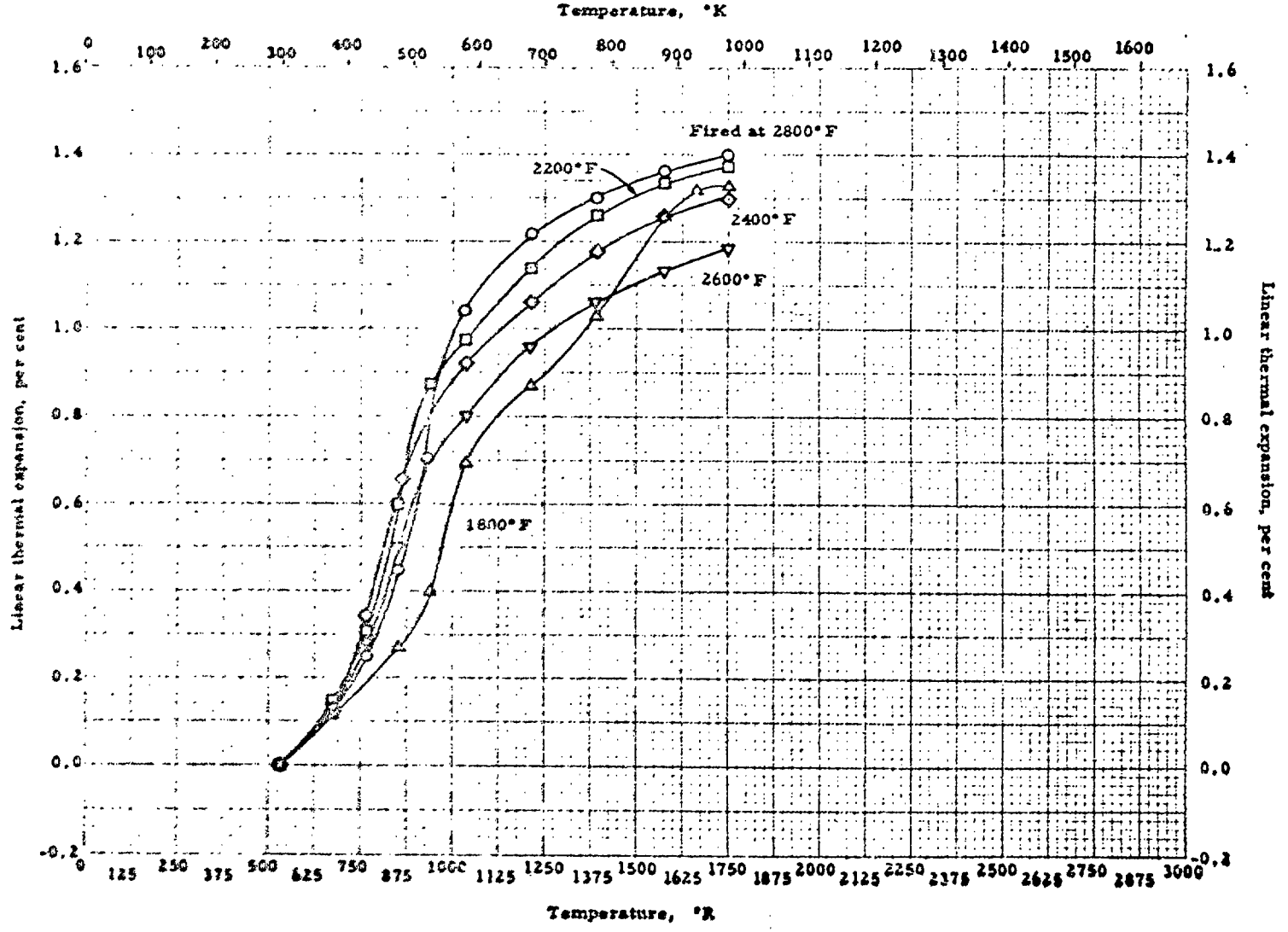


LINEAR THERMAL EXPANSION -- LITHIUM SILICATE - QUARTZ BODY
(Effect of composition)

LINEAR THERMAL EXPANSION -- LITHIUM SILICATE - QUARTZ BODY
(Effect of composition)

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °F.	Material Composition	Test Method	Remarks
○	Smoke, E. J.	54-43	528-1752	100% SiO_2 (flint)	Fused silica tube dilatometer	Fired 5 hr. to 2200°F, soaked 1 hr., tested at 2-3°C/min. rise
□	Ibid.	54-43	528-1752	99% SiO_2; 1% Li_2O; prepared from flint and Li_2CO_3	Same as above	Same as above
△	Ibid.	54-43	528-1752	98% SiO_2; 2% Li_2O; raw materials same as above	Same as above	Same as above
◇	Ibid.	54-43	528-1752	97% SiO_2; 3% Li_2O; raw materials same as above	Same as above	Same as above
▽	Ibid.	54-43	528-1752	96% SiO_2; 4% Li_2O; raw materials same as above	Same as above	Same as above

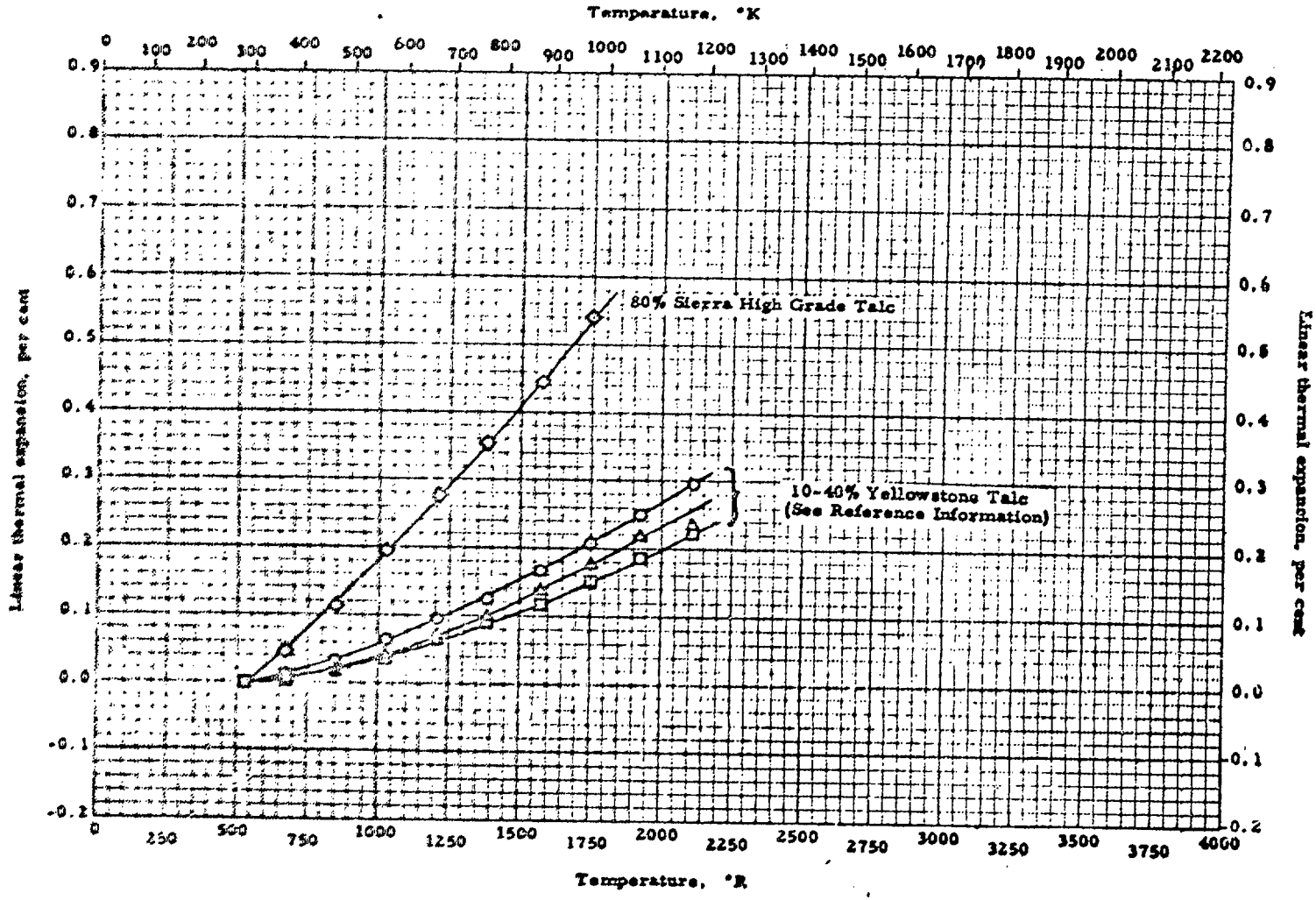


LINEAR THERMAL EXPANSION -- LITHIUM SILICATE - QUARTZ BODY,
(Effect of firing temperature)

LINEAR THERMAL EXPANSION -- LITHIUM SILICATE - QUARTZ BODY,
(*Effect of firing temperature*)

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Smoke, E. J.	54-43	528-1752	98% SiO_2; 2% Li_2O. Made from potter's flint and Li_2CO_3. Flint composition: 99.4% SiO_2; 0.18% Al_2O_3; 0.13% CaO; 0.06% ea. MgO, Fe_2O_3; 0.03% TiO_2. Li_2CO_3 contained 0.80% alkalies; 0.2% LiCl; 0.01% Fe_2O_3	Fused silica tube dilatometer	Fired to 2800°F in 5 hrs. and soaked for 1 hr. Heating rate during test: 2-3 °C/min.
□	Ibid.	54-43	528-1752	Same as above	Same as above	Same as above except fired at 2200°F.
△	Ibid.	54-43	528-1752	Same as above	Same as above	Same as above except fired at 1800°F
◇	Ibid.	54-43	528-1752	Same as above	Same as above	Same as above except fired at 2400°F.
▽	Ibid.	54-43	528-1752	Same as above	Same as above	Same as above except fired at 2600°F.

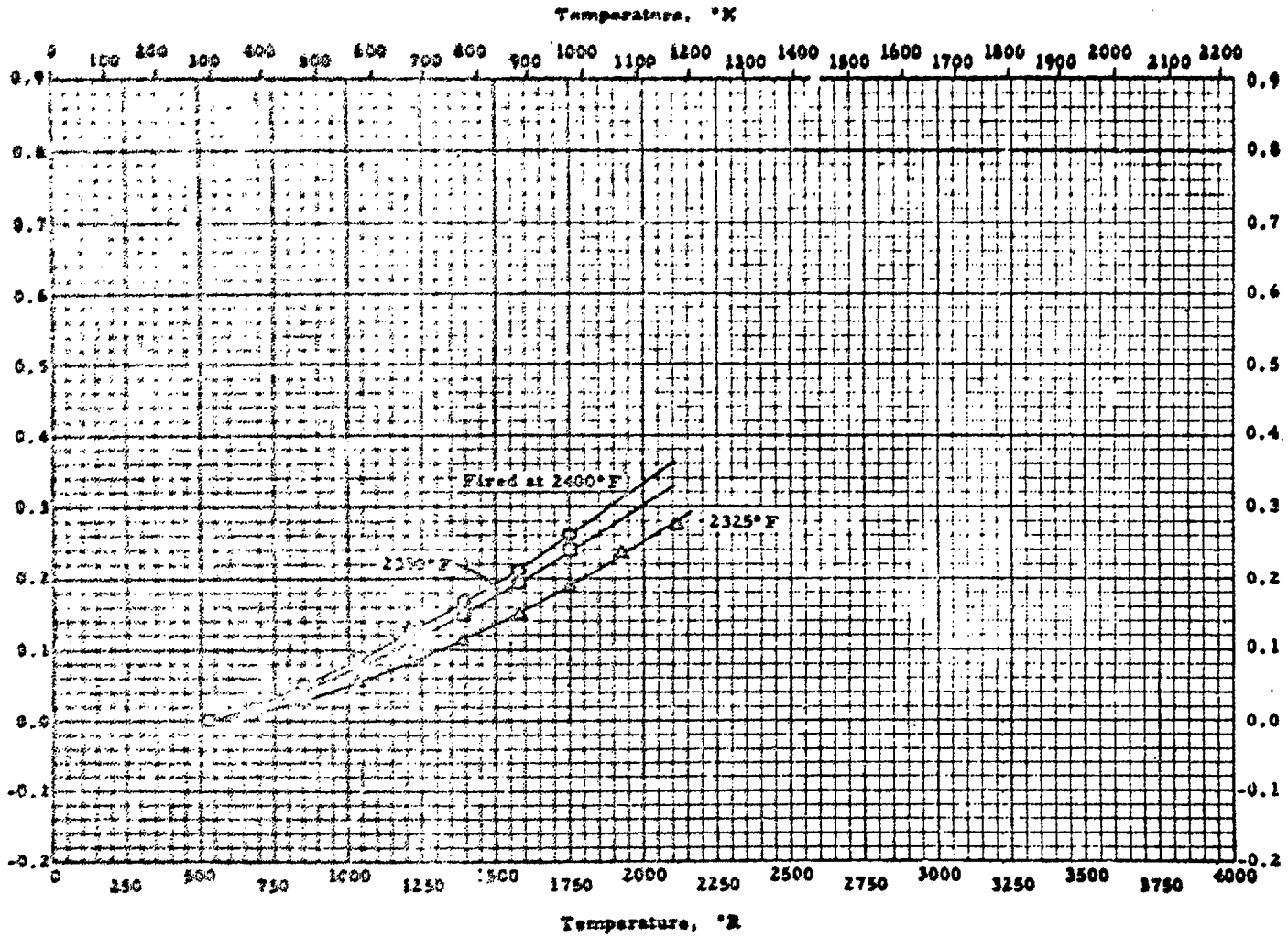


LINEAR THERMAL EXPANSION -- LOW DENSITY BARIUM CORDIERITE

LINEAR THERMAL EXPANSION -- LOW DENSITY BARIUM CORDIERITE

REFERENCE INFORMATION

	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Lamar, H. E., and Warner, N. F.	54-47	672-2112	40% Yellowstone talc; 37.3% E.P.K.; 13.6% Al_2O_3; 9.1% $BaCO_3$	Quartz tube dilatometer	Fired at 1275°C; absorption 6.3%
□	Ibid.	54-49	672-2112	61.7% E.P.K.; 15.8% $MgCO_3$; 13.4% Yellowstone talc; 9.1% $BaCO_3$	Same as above	Fired at 1288°C; absorption 7.8%
△	Ibid.	54-49	672-2112	56.6% E.P.K.; 14.5% $MgCO_3$; 13.3% Yellowstone talc; 8.3% ea. $BaCO_3$, $PbSiO_3$	Same as above	Fired at 1260°C; absorption 15.8%
◇	New Jersey Ceramic Research Station	55-22	672-1752	80% Sierra high grade talc; 10% ea. $BaCO_3$, E.P.K. clay	Fused silica tube dilatometer	Tested at 3-3°C/min. rise

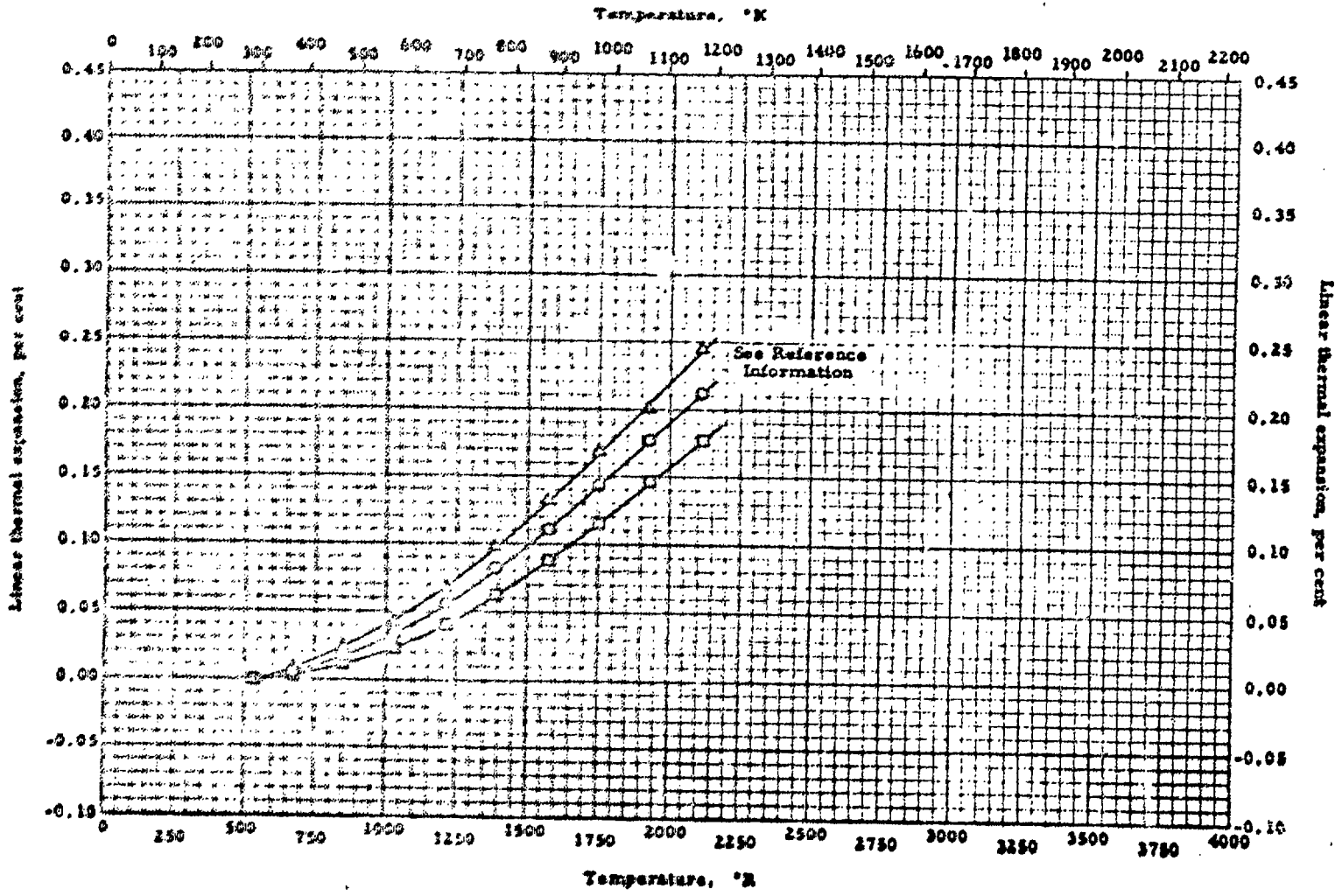


LINEAR THERMAL EXPANSION -- MEDIUM DENSITY BARIUM CORDIERITE

LINEAR THERMAL EXPANSION -- MEDIUM DENSITY BARIUM CORDIERITE

REFERENCE INFORMATION

	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	New Jersey Ceramic Research Station	53-65	528-1752	32% E.P.K.; 32% Sparks North Carolina kaolin; 17% $BaCO_3$; 11% potter's flint; 6% Sierra high grade talc	Silica tube dilatometer	Fired at 2400°F; ($3BaO \cdot 2MgO \cdot 8Al_2O_3 \cdot 26SiO_2$)
□	RMI.	53-65	528-1752	Same as above	Same as above	Fired at 2350°F; ($3BaO \cdot 2MgO \cdot 8Al_2O_3 \cdot 26SiO_2$)
△	Lamar, M. S. and Warner, M. F.	54-69	672-2112	45.4% E.P.K.; 45.4% Sierralite; 9.1% $BaCO_3$	Quartz tube dilatometer	Fired at 2327°F; absorption 3.2%

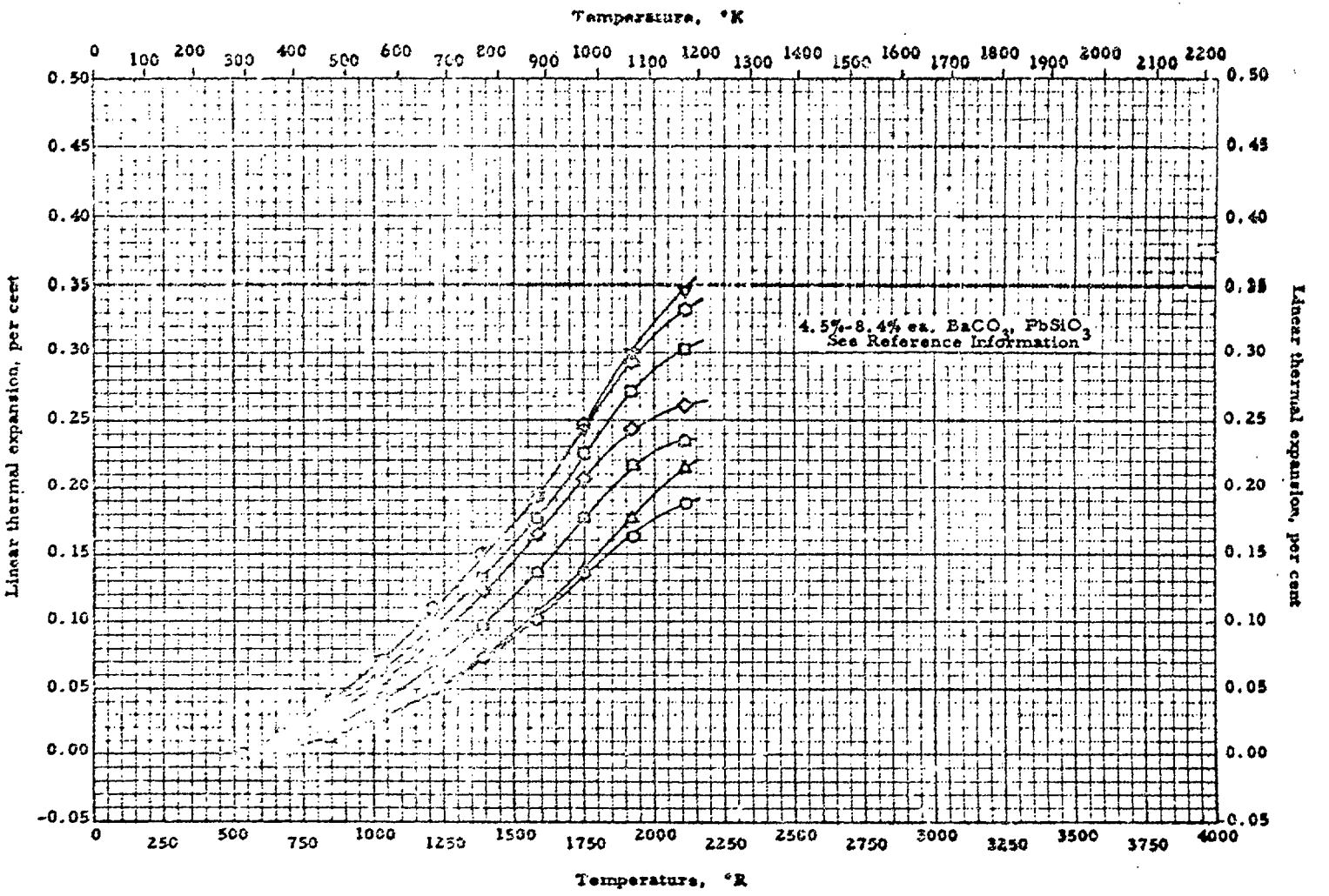


LINEAR THERMAL EXPANSION -- DENSE BARIUM CORDIERITE

LINEAR THERMAL EXPANSION -- DENSE BARIUM CORDIERITE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Lamar, E. S. and Warner, N. F.	54-49	672-2112	68.2% E.P.K.; 22.7% Yellowstone talc; 9.1% $BaCO_3$	Quartz tube dilatometer	Fired at 1288°C; absorption 0.3%
□	Ibid.	54-49	672-2112	65.9% E.P.K.; 20.0% Yellowstone talc; 9.1% $BaCO_3$; 5% $MgCO_3$	Same as above	Fired at 1300°C; absorption 0.5%
△	Ibid.	54-49	672-2112	45.4% E.P.K.; 37.1% Sierralite; 9.1% $BaCO_3$; 8.4% Yellowstone talc	Same as above	Fired at 1288°C; absorption 0.7%

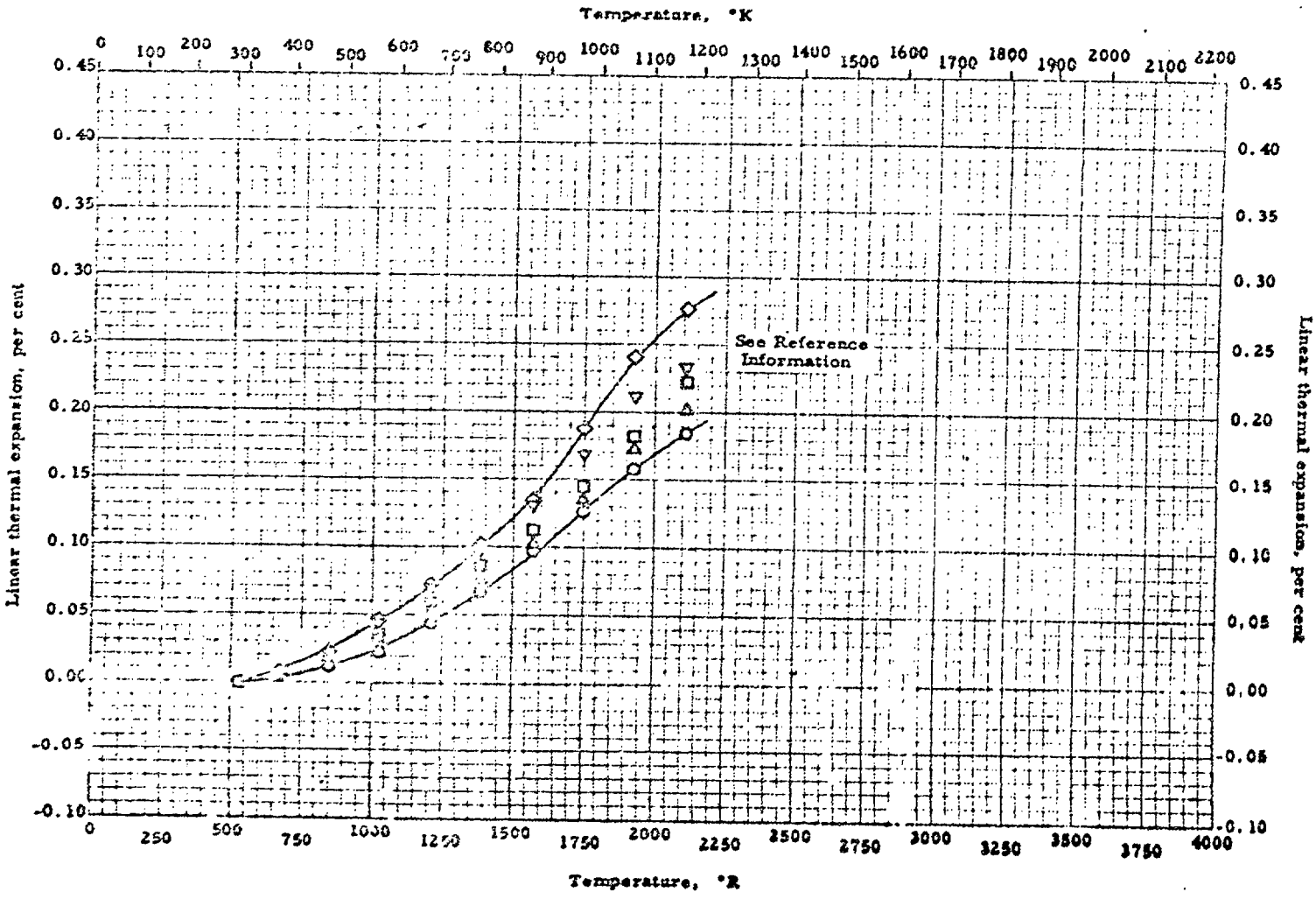


LINEAR THERMAL EXPANSION -- LOW DENSITY LEAD-BARIUM CORDIERITE

LINEAR THERMAL EXPANSION -- LOW DENSITY LEAD-BARIUM CORDIERITE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Lamar, H. S. and Warner, N. F.	54-49	672-2112	60.4% E.P.K.; 18.3% Yellowstone talc; 8.4% ea. $BaCO_3$, $PbSiO_3$; 4.6% $MgCO_3$	Quartz tube dilatometer	Fired at 1275°C; absorption 7.3%
□	Ibid.	54-49	672-2112	41.7% E.P.K.; 41.7% Sierralite; 8.3% ea. $BaCO_3$, $PbSiO_3$	Same as above	Fired at 1232°C; absorption 10.8%
△	Ibid.	54-49	672-2112	61.7% E.P.K.; 15.8% $MgCO_3$; 13.4% Yellowstone talc; 4.5% ea. $BaCO_3$, $PbSiO_3$	Same as above	Fired at 1316°C; absorption 10.9%
◇	Ibid.	54-49	672-2112	41.7% E.P.K.; 3% Sierralite; 8.3% ea. $BaCO_3$, $PbSiO_3$; 7.7% Yellowstone talc	Same as above	Fired at 1219°C; absorption 6.7%
▽	Ibid.	54-49	672-2112	40% Yellowstone talc; 37.3% E.P.K.; 13.6% Al_2O_3; 4.5% ea. $BaCO_3$, $PbSiO_3$	Same as above	Fired at 1260°C; absorption 9.6%
⬡	Ibid.	54-49	672-2112	36.7% Yellowstone talc; 34.2% E.P.K.; 12.5% Al_2O_3; 8.3% ea. $BaCO_3$, $PbSiO_3$	Same as above	Fired at 1246°C; absorption 11.5%
⌂	Ibid.	54-49	672-2112	56.6% E.P.K.; 14.5% $MgCO_3$; 12.3% Yellowstone talc; 8.3% ea. $BaCO_3$, $PbSiO_3$	Same as above	Fired at 1260°C; absorption 13.8%



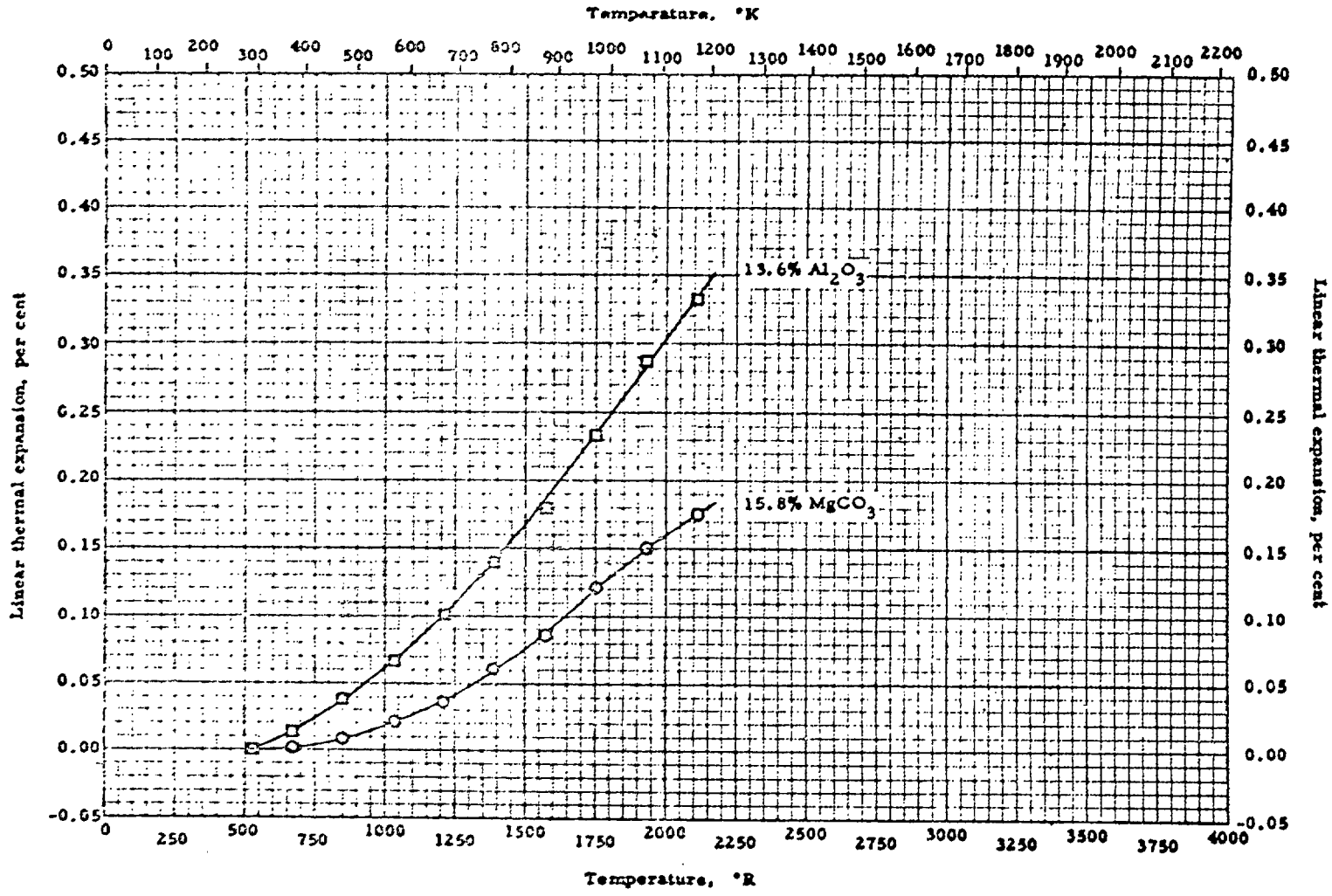
LINEAR THERMAL EXPANSION -- HIGH DENSITY LEAD-BARIUM CORDIERITE

WADC TR 59-494 1048

LINEAR THERMAL EXPANSION -- HIGH DENSITY LEAD-BARIUM CORDIERITE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R.	Material Composition	Test Method	Remarks
○	Lawrence, H. S. and Warner, N. F.	54-49	672-2112	62.5% E.P.K.; 20.8% Yellowstone talc; 8.3% ea. $BaCO_3$, $PbSiO_3$	Quartz tube dilatometer	Fired at 1260°C; absorption 0.3%
□	Ibid.	54-49	672-2112	68.2% E.P.K.; 22.7% Yellowstone talc; 4.5% ea. $BaCO_3$, $PbSiO_3$	Same as above	Fired at 1260°C; absorption 0.6%
△	Ibid.	54-49	672-2112	65.9% E.P.K.; 20.0% Yellowstone talc; 5% $MgCO_3$; 4.5% ea. $BaCO_3$, $PbSiO_3$	Same as above	Fired at 1275°C; absorption 0.7%
◇	Ibid.	54-49	672-2112	45.5% ea. E.P.K., Sierralite; 4.5% ea. $BaCO_3$, $PbSiO_3$	Same as above	Fired at 1246°C; absorption 0.7%
▽	Ibid.	54-49	672-2112	45.6% E.P.K.; 37.1% Sierralite; 8.4% Yellowstone talc; 4.5% ea. $BaCO_3$, $PbSiO_3$	Same as above	Fired at 1204°C; absorption 0.8%

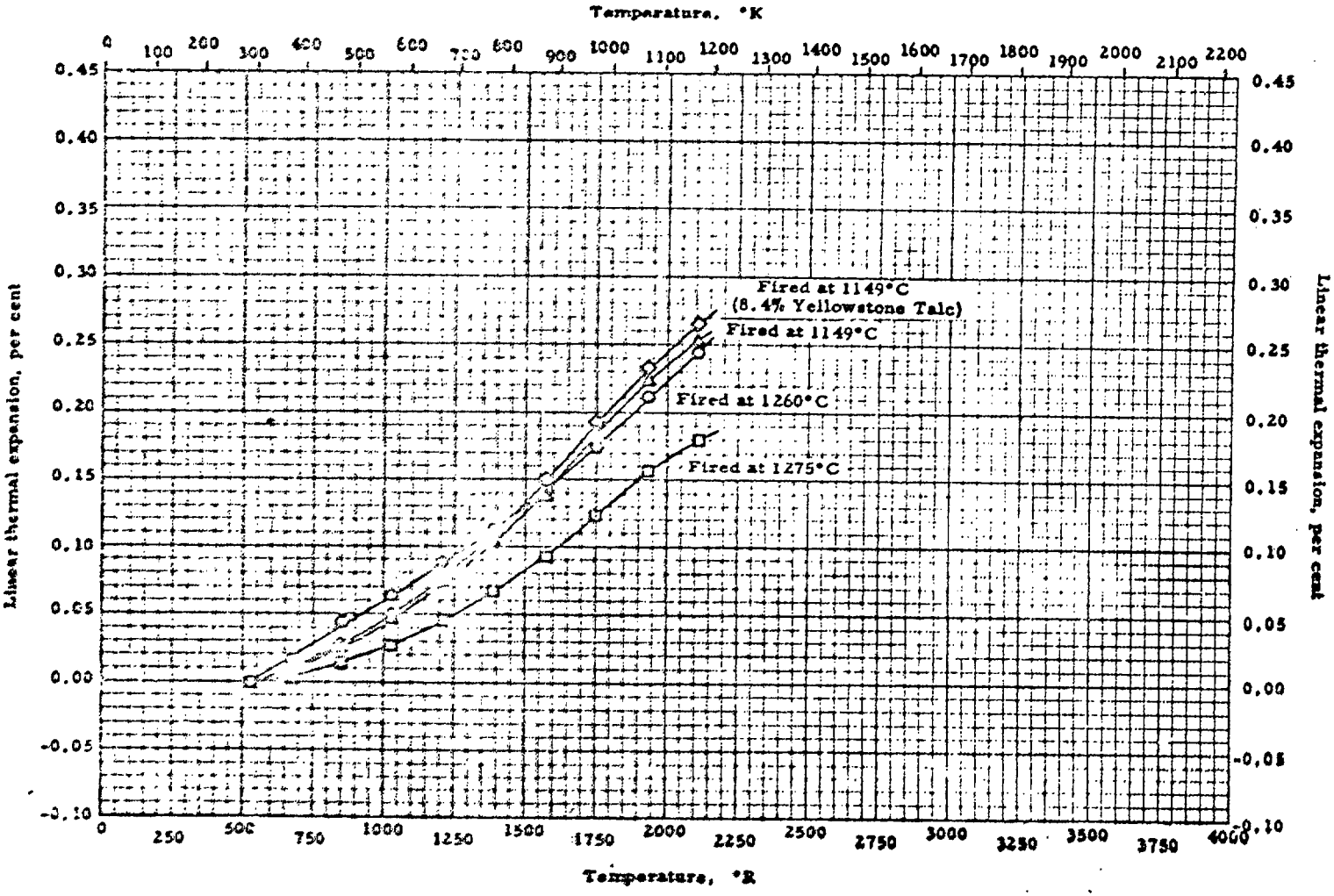


LINEAR THERMAL EXPANSION -- LOW DENSITY LEAD CORDIERITE

LINEAR THERMAL EXPANSION -- LOW DENSITY LEAD CORDIERITE

REFERENCE INFORMATION

	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Lamar, H. S. and Warner, N. F.	54-49	672-2112	61.7% E.P.K.; 15.8% $MgCO_3$; 13.4% Yellowstone talc; 9.1% $PbSiO_3$	Quartz tube dilatometer	Fired at 1316°C; absorption 8.9%
□	Ibid.	54-49	672-2112	40% Yellowstone talc; 37.3% E.P.K.; 13.6% Al_2O_3; 9.1% $PbSiO_3$	Same as above	Fired at 1260°C; absorption 8.6%



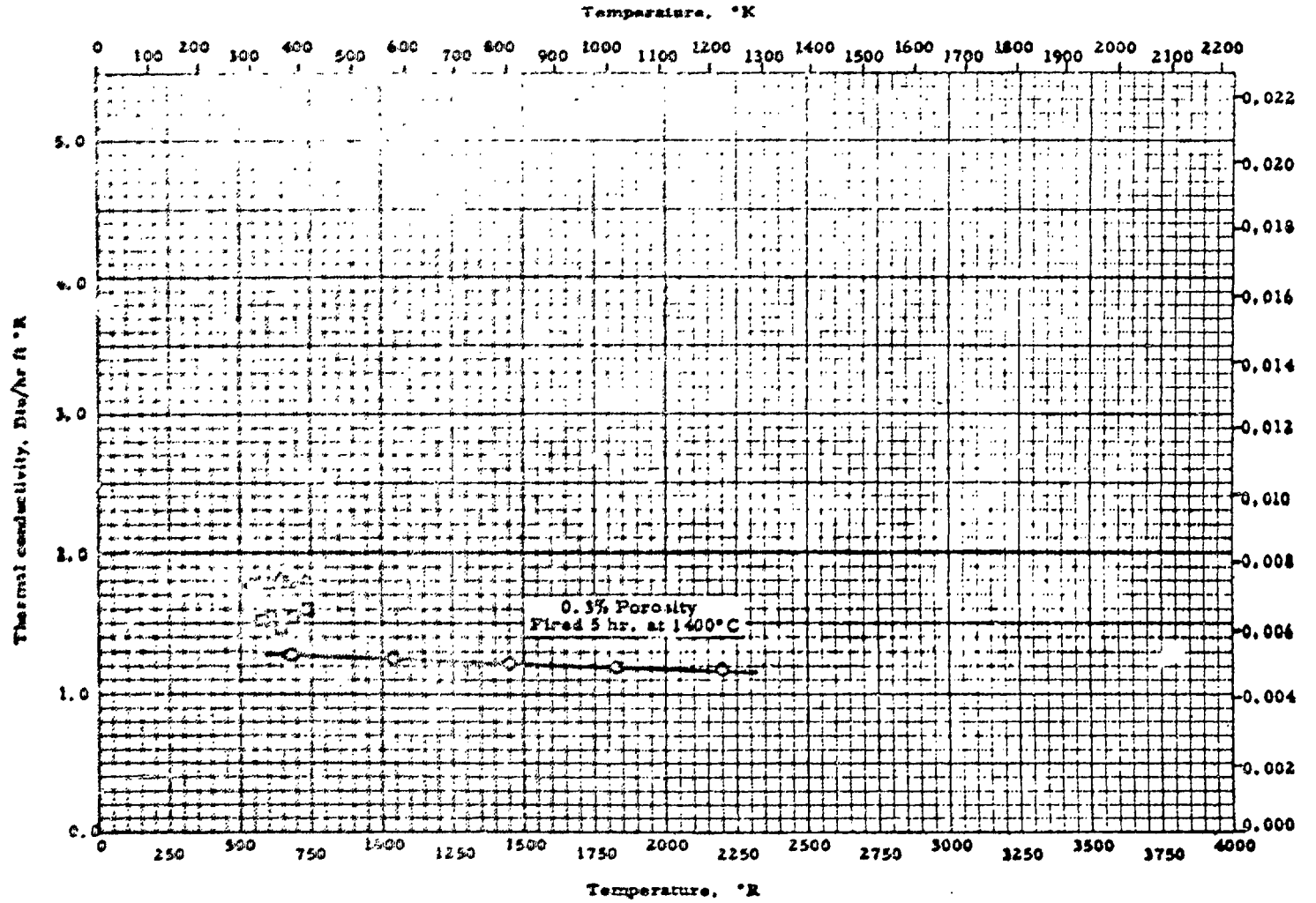
LINEAR THERMAL EXPANSION -- DENSE LEAD CORDIERITE

59-054
WADC TR 58-476
1958

LINEAR THERMAL EXPANSION -- DENSE LEAD CORDIERITE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Lamar, H. S. and Warner, N. F.	54-49	672-2112	68.2% E.P.K.; 22.7% Yellowstone Talc; 9.1% $PbSiO_3$	Quartz tube dilatometer	Fired at 1260°C; 0.6% absorption.
□	Ibid.	54-49	672-2112	66.2% E.P.K.; 20.6% Yellowstone Talc; 9.2% $PbSiO_3$; 4.6% $MgCO_3$	Same as above	Fired at 1275°C; 0.8% absorption.
△	Ibid.	54-49	672-2112	45.4% E.P.K.; 45.4% Sierralite; 9.1% $PbSiO_3$	Same as above	Fired at 1149°C; 0.1% absorption
◇	Ibid.	54-49	672-2112	45.4% E.P.K.; 37.1% Sierralite; 9.1% $PbSiO_3$; 8.4% Yellowstone Talc	Same as above	Fired at 1149°C; 0.1% absorption

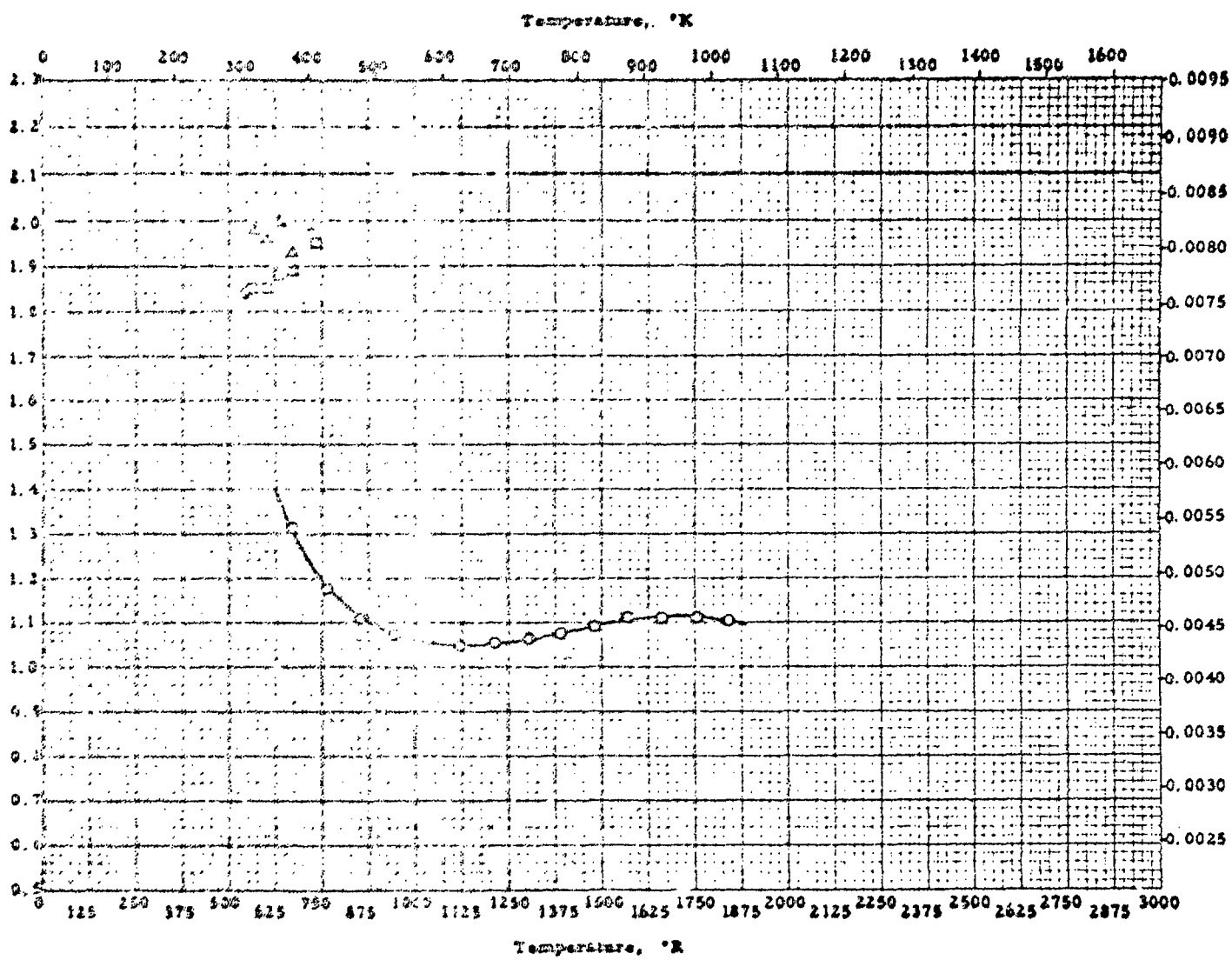


THERMAL CONDUCTIVITY -- CORDIERITE

THERMAL CONDUCTIVITY -- CORDIERITE

REFERENCE INFORMATION

	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Hoffman, W. R. and Lenoe, E. A.	55-10	672-1202	52.1% Florida kaolin (EPK); 34.6% C and C ball clay; 7.3% MgO Westvaco FN722; 6% Sierra talc. ρ = 132 lb_m/ft^3; porosity = 0.3%	Radial heat flow in cylinder	Fired 5 hr. at 1400°C
□	New Jersey Ceramic Research Station	54-69	576-735	35.95% calcine 23D; 29.57% ea. Edgar Plastic kaolin and N. Carolina kaolin, 10% Old Mine No. 4 ball clay	Comparative; rods	Tested in vacuum
△	" "	54-69	576-735	59.15% Edgar Plastic kaolin; 35.95% calcine 23D; 10.90% Old Mine No. 4 ball clay	Same as above	Same as above
◇	Oak Ridge National Lab.	57-150	546	Cordierite 202	Not described here; refers to others	Measured by O. Sisman, C. D. Bopp and R. L. Towns

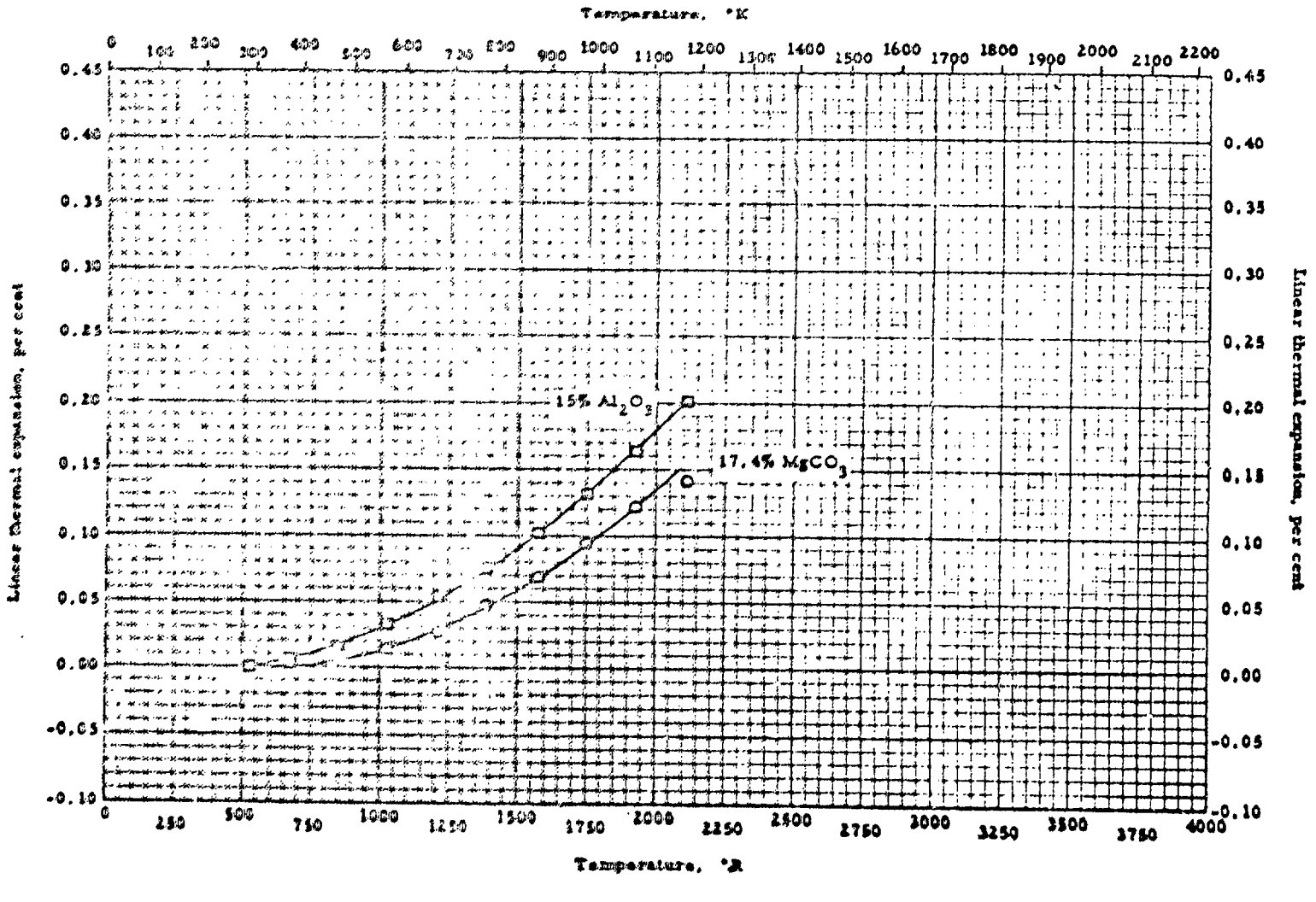


THERMAL CONDUCTIVITY -- FIRED STEATITE

THERMAL CONDUCTIVITY -- FIRED STEATITE

REFERENCE INFORMATION

	Investigator	Ref.	Temps, °F	Material Composition	Test Method	Remarks
	[illegible], W. R. and [illegible], E. A.	11-10	672-1642	Steatite: 22% Manchurian talc; 10% Tenn. ball clay; 2% [illegible] feldspar; 1% binder Porosity: 0.1%, ρ: 2.56 g/cm^3	Stacked disc method	Axial heat flow minimized during tests. Fired 1 hr. at 1305°C on pottery flint
	[illegible] Corning Ceramic [illegible] Research Station	14-69	164-735	Commercial Steatite #12C-2	Comparative, rods, in vacuum. Redetermined with vacuum method	
	[illegible]	14-65	570-727	Steatite #1CB-2	Same as above	
	[illegible] Ridge National [illegible].	57-154	248	Steatite	Not described here, refers to others	



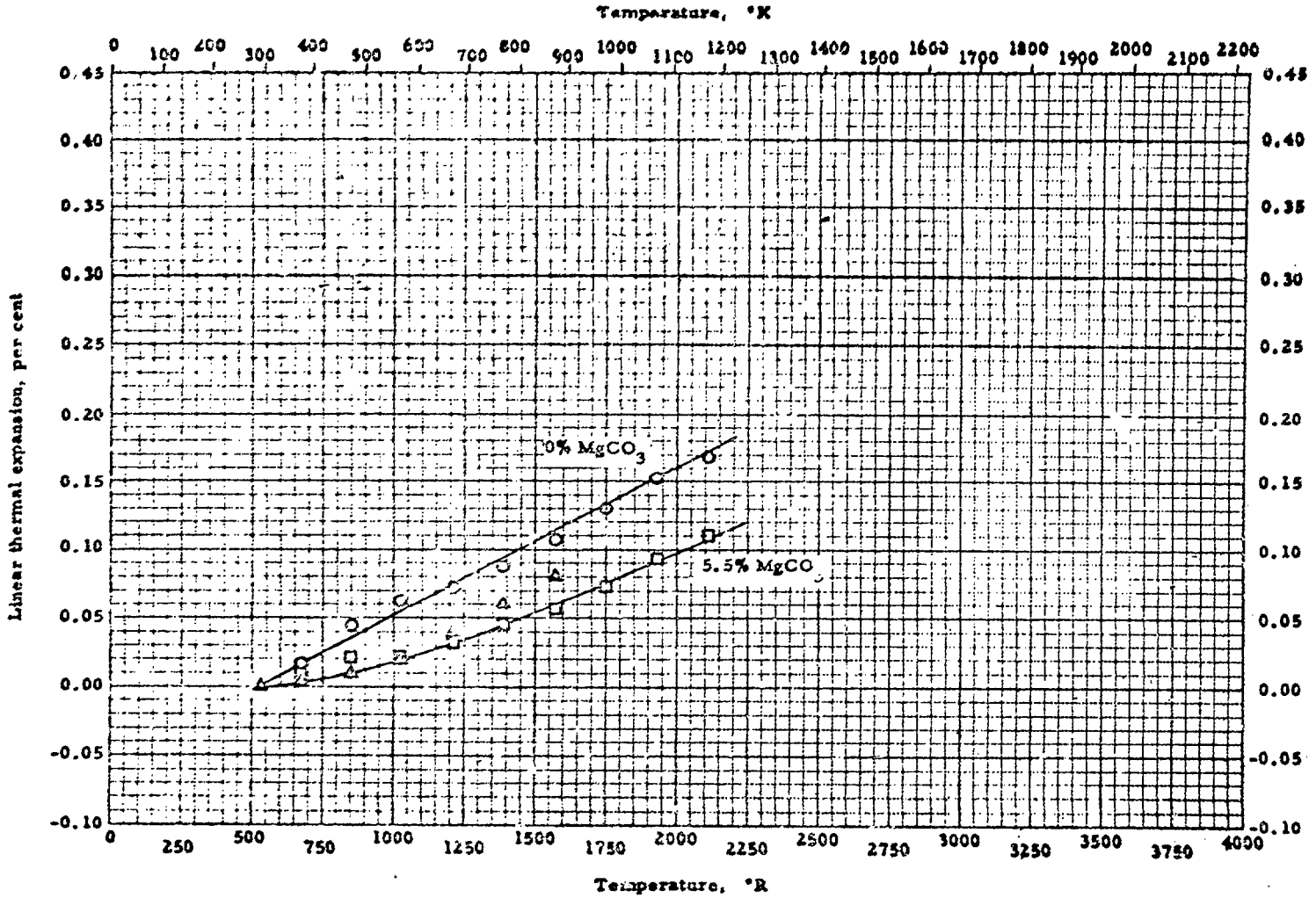
LINEAR THERMAL EXPANSION -- LOW DENSITY CORDIERITE

WADC TR 54-476 1057

LINEAR THERMAL EXPANSION -- LOW LENSITY CORDIERITE

REFERENCE INFORMATION

Curve No.	Investigator	Ref.	Range, °F	Material Composition	Test Method	Remarks
○	Lamar, R. S. and Warner, N. F.	54-49	672-2112	67.9% E.P.K.; 17.4% $MgCO_3$; 14.7% Yellowstone talc	Quartz tube dilatometer	Fired at 1316°C; absorption 13.5%
□	Ibid.	54-49	672-2112	44% Yellowstone talc; 41% E.P.K.; 15% Al_2O_3	Same as above	Fired at 1300°C; absorption 9.8%

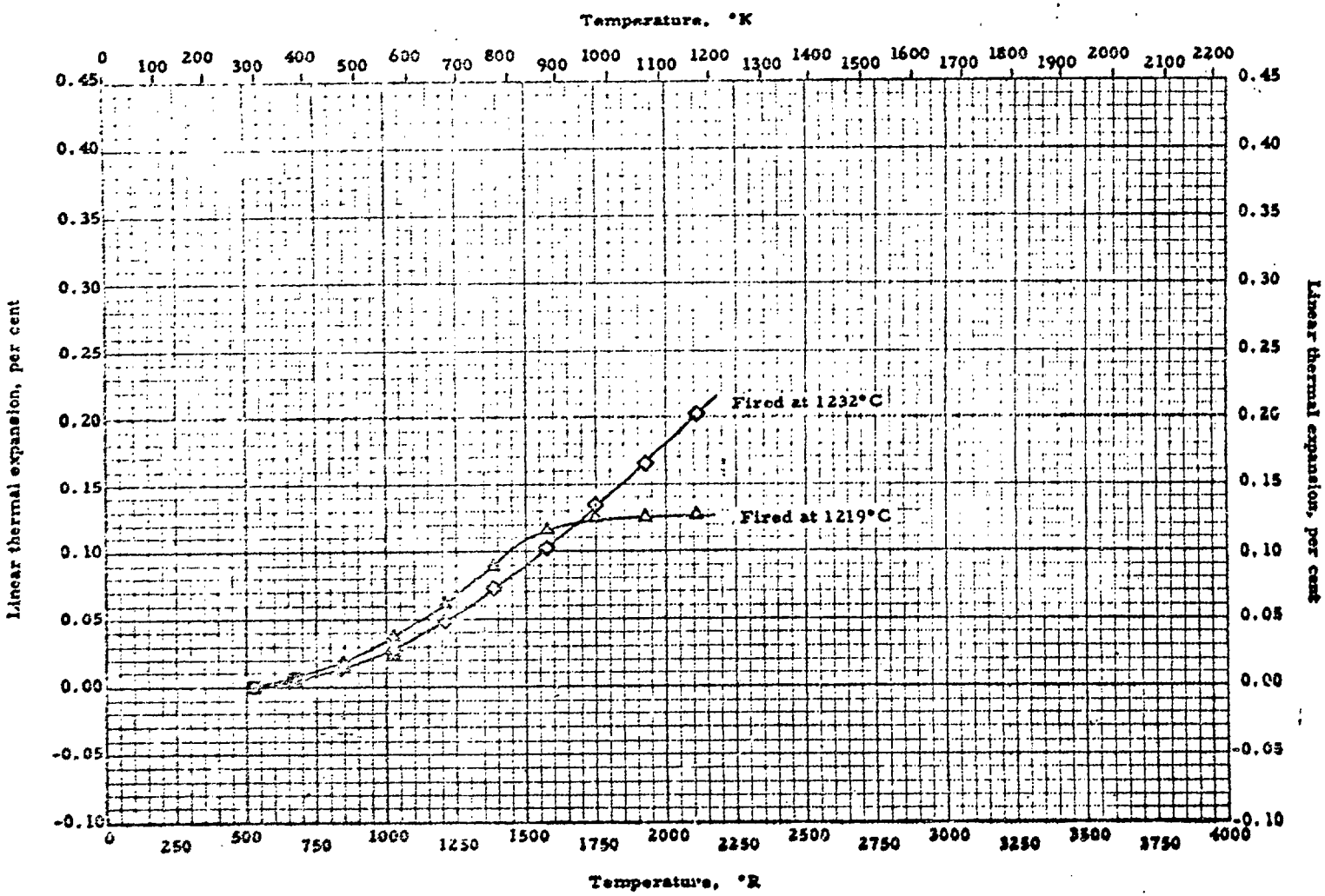


LINEAR THERMAL EXPANSION -- MEDIUM DENSITY CORDIERITE

LINEAR THERMAL EXPANSION -- MEDIUM DENSITY CORDIERITE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Lamar, H. S. and Warner, N. F.	54-49	672-2112	75% E.P.K.; 25% Yellowstone talc	Quartz tube dilatometer	Fired at 1316°C; absorption 1.5%
□	Ibid.	54-49	672-2112	72.3% E.P.K.; 21.9% Yellowstone talc; 5.5% $MgCO_3$	Same as above	Fired at 1343°C; absorption 2.2%
Δ	Durbin, E. A. and Harman, C. G.	52-31	528-1572	Not given	Interferometer	Fired 16 hr. at 1350°C

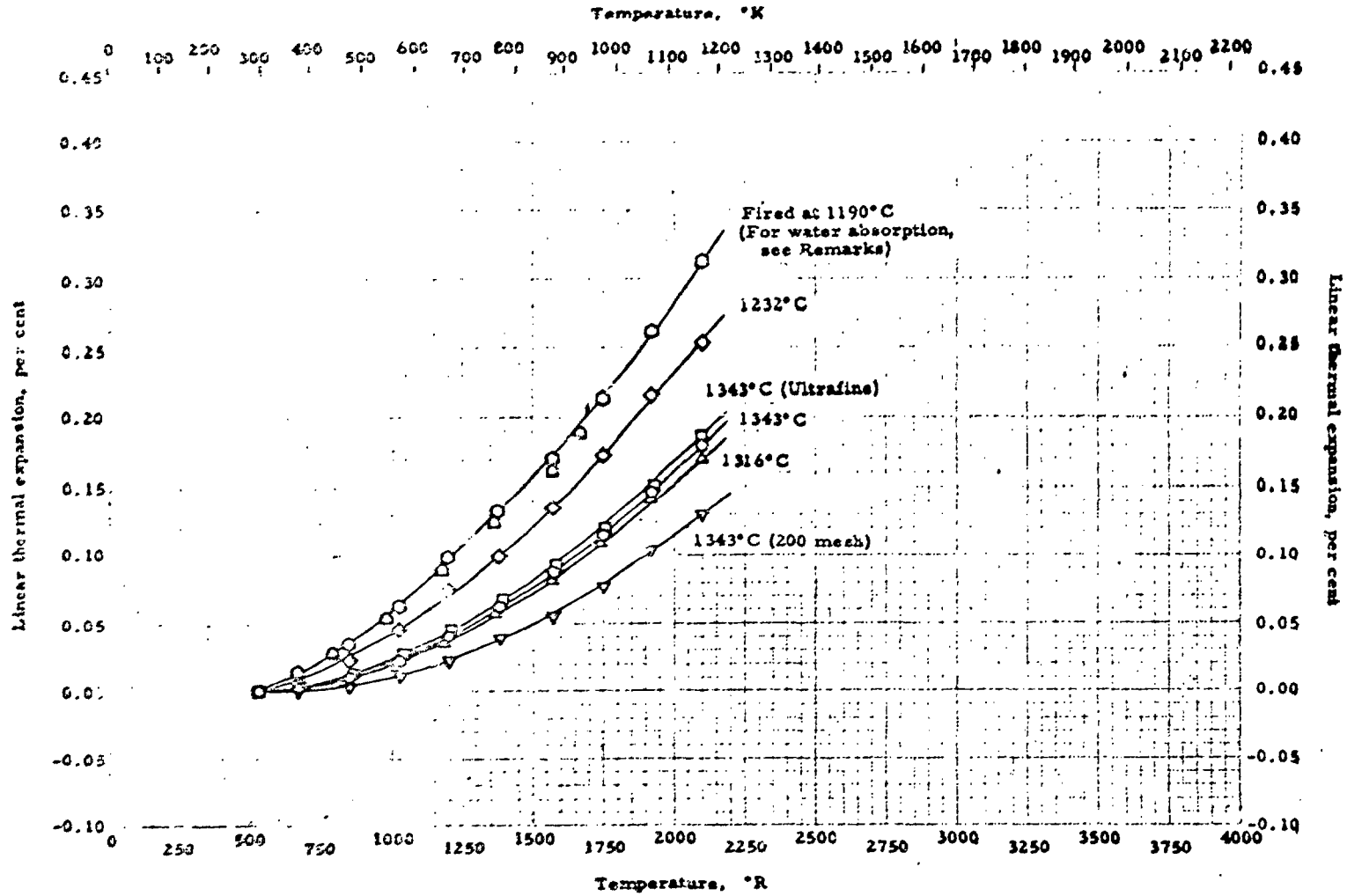


LINEAR THERMAL EXPANSION -- DENSE CORDIERITE

LINEAR THERMAL EXPANSION -- DENSE CORDIERITE

REFERENCE INFORMATION

	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Gebler, K. A. and Wisely, H. R.	49-19	528-1032	69% Ball clay; 17.55% $MgCO_3$; 7.1% talc; 6.35% $Al(OH)_3$; apparent ρ = 145 lb_m/ft^3; true ρ = 162 lb_m/ft^3	Not given	
□	Ibid.	49-19	528-1032	48.1% Kaolin; 32% Ball clay; 14.2% $MgCO_3$; 5.7% talc; apparent ρ = 140 lb_m/ft^3; true ρ = 155 lb_m/ft^3	Same as above	
△	Larman, H. S. and Warner, N. F.	54-49	672-2112	50% E.P.K.; 40.8% Sierralite; 9.2% Yellowstone talc	Quartz tube dilatometer	Fired at 1219°C; absorption 0.6%
◇	Ibid.	54-49	672-2112	Same as above	Same as above	Fired at 1232°C; absorption 0.5%



LINEAR THERMAL EXPANSION -- CORDIERITE BODIES

LINEAR THERMAL EXPANSION -- CORDIERITE BODIES

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Lamar, H. S. and Warner, N. F.	54-49	672-2112	50% EPK; 50% Sierralite	Quartz tube dilatometer	Fired at 1343°C Absorbtion not given
□	Ibid.	54-49	672-2112	Same as above (ultrafine)	Same as above	Fired at 1343°C Absorption 1.6%
△	Ibid.	54-49	672-2112	Same as above	Same as above	Fired at 1316°C Absorbtion 0.9%
◇	Ibid.	54-49	672-2112	Same as above	Same as above	Fired at 1232°C Absorption 0.0%
▽	Ibid.	54-49	672-2112	Same as above (200 mesh)	Same as above	Fired at 1343°C Absorption 7.5%
○	Ibid.	54-49	672-2112	Same as above	Same as above	Fired at 1190°C Absorbtion 6.4%
⌂	Durbin, E. A. and Harman, C. G.	52-31	528-1662	Commercial cordierite body	Interferometer	

ELECTRIC RESISTIVITY -- CORDIERITE

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ELECTRIC RESISTIVITY -- CORDIERITE

REFERENCE INFORMATION

Curve	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Wisely, H. R.	57-98	1460-2460	Magnesium aluminosilicate (Cordierite) approx. 51% SiO_2; 35 % Al_2O_3; 14% MgO	AC impedance bridge; sample temp. by Chromel-Alumel thermocouple	

ELECTRIC RESISTIVITY -- FIRED STEATITE

ELECTRIC RESISTIVITY -- FIRED STEATITE

REFERENCE INFORMATION

	Investigator	Ref.	Range, °K	Material Composition	Test Method	Remarks
○	Clavenstura, J. E. and Plumb, R. A.	54-95	652-1302	Steatite, grade L-4, Al Silicate	High resistance DC bridge	
□	Ibid.	54-95	652-1302	Steatite; grade L-5, Frenn and Seymour E-211-M	Same as above	
△	Ibid.	54-95	652-1302	Cordierite; grade L-2A	Same as above	
◇	Ibid.	54-95	652-1302	Ceralerite, Al Silicate	Same as above	
▽	Kinzel Jr., E. and Herbstrith, L. F.	44-6	672-1372	Commercial steatite; average grade	Potential drop	
○	Ibid.	44-6	922-1422	Commercial ultra-steatite; low loss type	Same as above	

PROPERTIES OF PORCELAIN

MOST PROBABLE VALUES

Property	Brit. Engineering Units	C. G. S. Units
Density.	210 lb_m/ft^3 *	3.4 g/cm^3 *
Melting Point		
Heat of Fusion		
Heat of Vaporization. . .		
Heat of Sublimation . . .		

*Average value for engineering purposes

REPORTED VALUES

Density:		lb_m/ft^3	g/cm^3
	○	212.9 ± 0.6	3.41 ± 0.01
	□	181	2.90
	△	179	2.87
	◇	244	3.91
	▽	233	3.68
	○	239	3.76
	△	230	3.68

Melting Point:	°R	°K
Heat of Fusion:	Btu/lb_m	cal/g
Heat of Vaporization:	Btu/lb_m	cal/g
Heat of Sublimation:	Btu/lb_m	cal/g

PROPERTIES OF PORCELAIN

REFERENCE INFORMATION

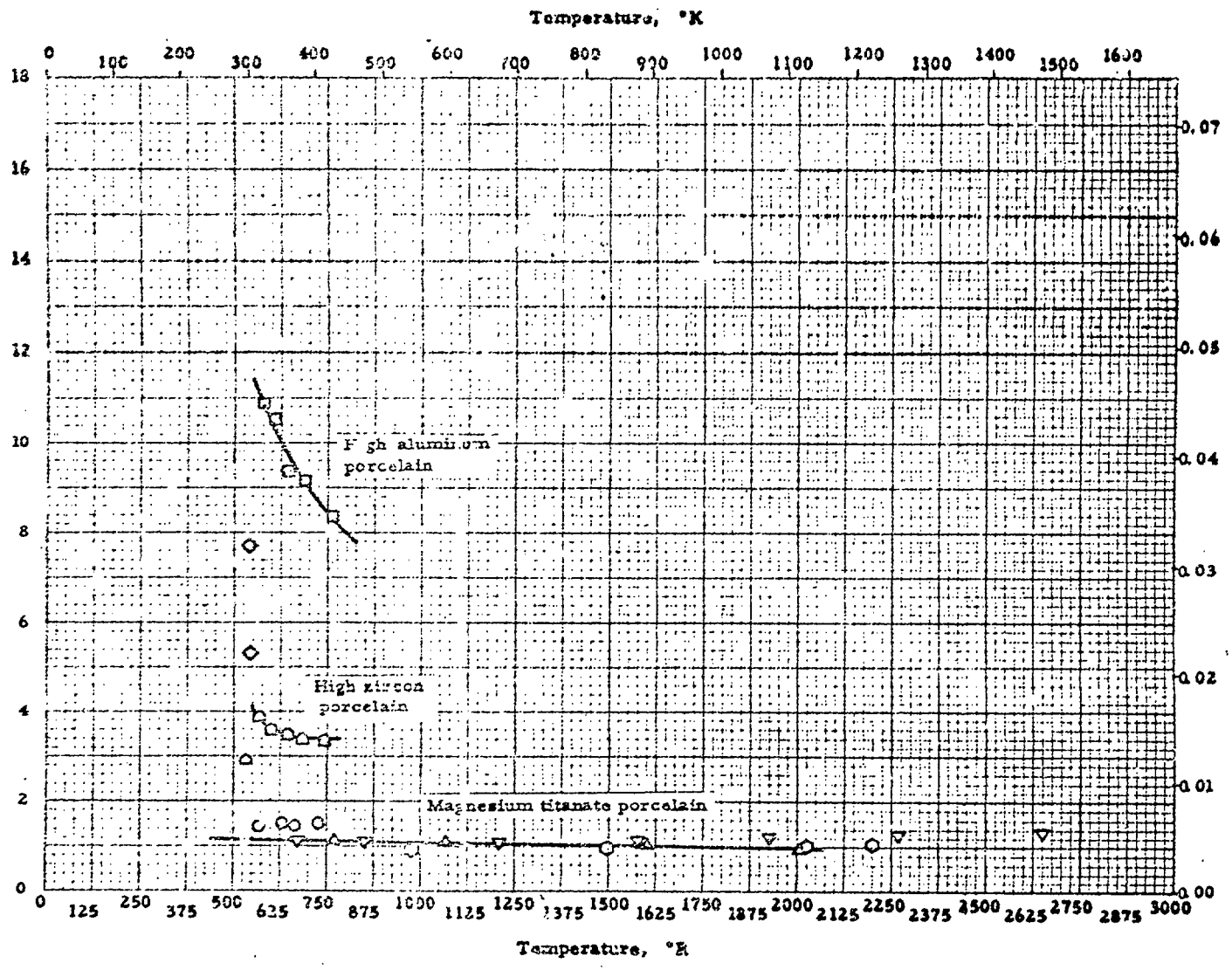
Sym	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Oak Ridge National Laboratory	57-150	537	Porcelain 576	ρ: weight in air and in kerosene	
□	Koenig, J. H.	53-43	Room	Type 4811 commercial BeO porcelain by Coors; water absorption = 0.09%	Not given	
△	McCreight, L. R.	57-148	Room	Mg titanate porcelain	Not given	
◇	Koenig, J. H.	53-43	Room	High zircon porcelain. 62.5% zircon G; 25% calcium zirconium silicate; 12.5% Old Mine No. 4 ball clay. Water absorption = 0.03%	Not given	
▽	Russell Jr., R. and Mohr, W. C.	47-11	Room	Westinghouse zircon porcelain	Not given	
○	Russell Jr., R. and Berberich, L.J.	44-6	Room	Low loss zircon porcelain (above avg. grade)	Not given	
⌂	Ibid.	44-6	Room	Commercial low loss porcelain (avg. grade)	Not given	

THERMAL CONDUCTIVITY -- COMMERCIAL BERYLLIUM OXIDE PORCELAIN

THERMAL CONDUCTIVITY -- COMMERCIAL BERYLLIUM OXIDE PORCELAIN

REFERENCE INFORMATION

	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Koenig, J. H.	53-43	570-790	Type 4611 commercial BeO porcelain by Coors. ρ = 181 lb_m/ft^3; water absorption = 0.09%	Comparative; rods (copper standard)	

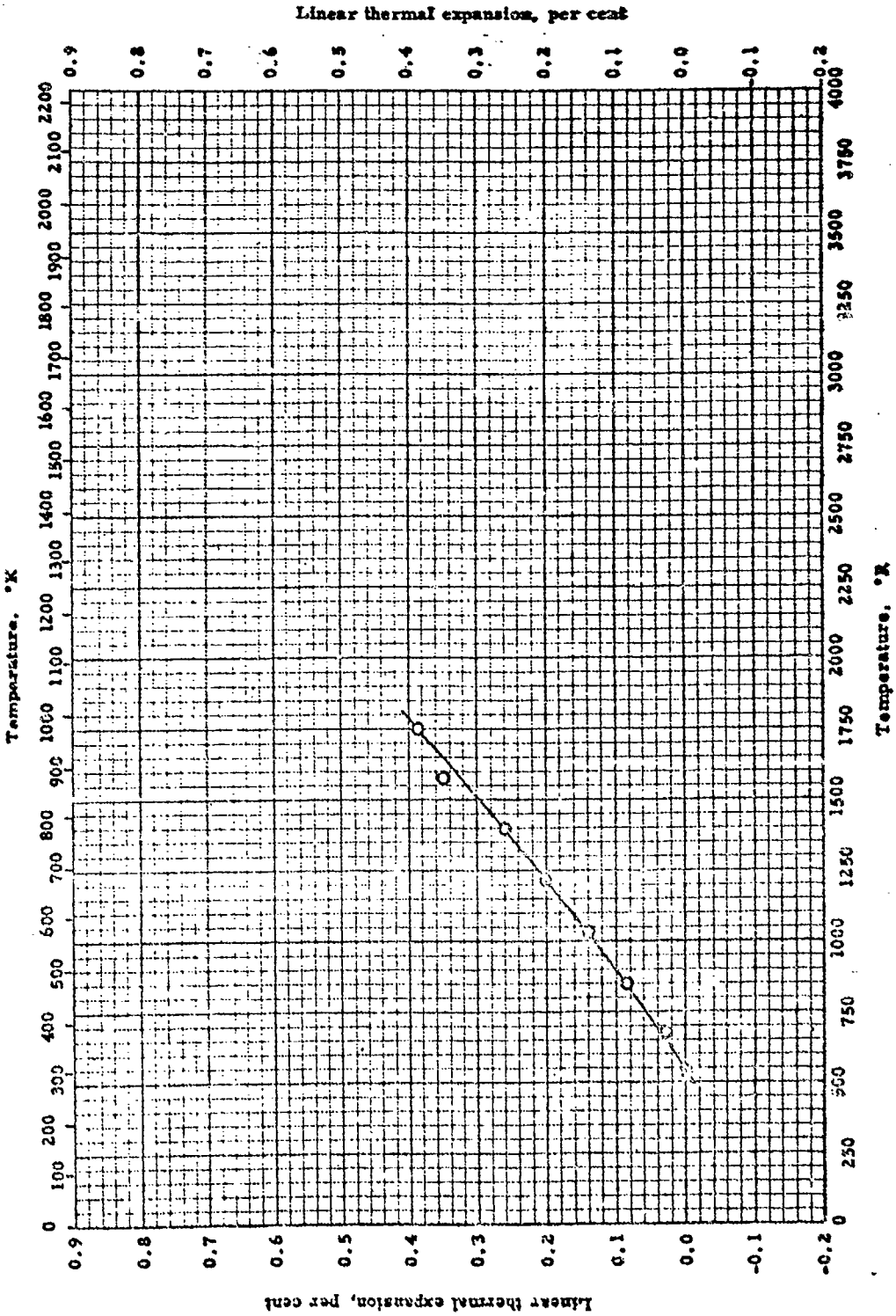


THERMAL CONDUCTIVITY -- VARIOUS PORCELAINS

THERMAL CONDUCTIVITY -- VARIOUS PORCELAINS

REFERENCE INFORMATION

	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	New Jersey Ceramic Research Station	54-69	572-727	Wet process porcelain No. 7A2	Comparative, rods in vacuum	
□	New Jersey Ceramic Research Station and Koenig, J. H.	53-43	120-305	High alumina porcelain	Comparative, rods in vacuum; inconel standard	Pt alloy glaze for ceramic-to-metal bond
△	McCreight, L. R.	57-142	771-2004	Mg titanate porcelain $\rho = 2.87$ g/cm^3	Two methods: a. comparative, rods b. axial heat flow in rod; guarded heat source and sample	
◇	Oak Ridge National Laboratory	57-150	546	Porcelain 576	Not described here, refers to others	Measured by C. Sisman, C. D. Bopp and R. L. Towns
▽	Kingery, W.D. and Francl, J.	54-1	472-2652	Electrical porcelain: 37.0% Oxford feldspar; 22.0% Edgar Nocarb clay; 19.0% flint; 15.0% Kentucky Old Mine No. 4 ball clay; 7.0% Edgar plastic kaolin	Ellipsoidal envelope	Ball milled 15 hr., slip cast, fired at 1250 °C to zero apparent porosity
○	Klasse, F., Heinz, A. and Hein, J.	57-181	987-2157	Electrical porcelain	Comparative, disks, with guard cylinder. Temp. by thermocouple	Data of low accuracy
◇	Koenig, J.H.	53-43	560-740	High zircon porcelain. 62.5% zircon G; 25% calcium zirconium silicate; 12.5% Old Mine No. 4 ball clay. $\rho = 244$ lb$_m$/ft^3. Water absorption = 0.03%	Comparative; rods (copper standard)	
△	Russell Jr., R. and Mohr, W.C.	47-11	Room	Westinghouse zircon porcelain. $\rho = 230$ lb$_m$/ft^3	Not given	

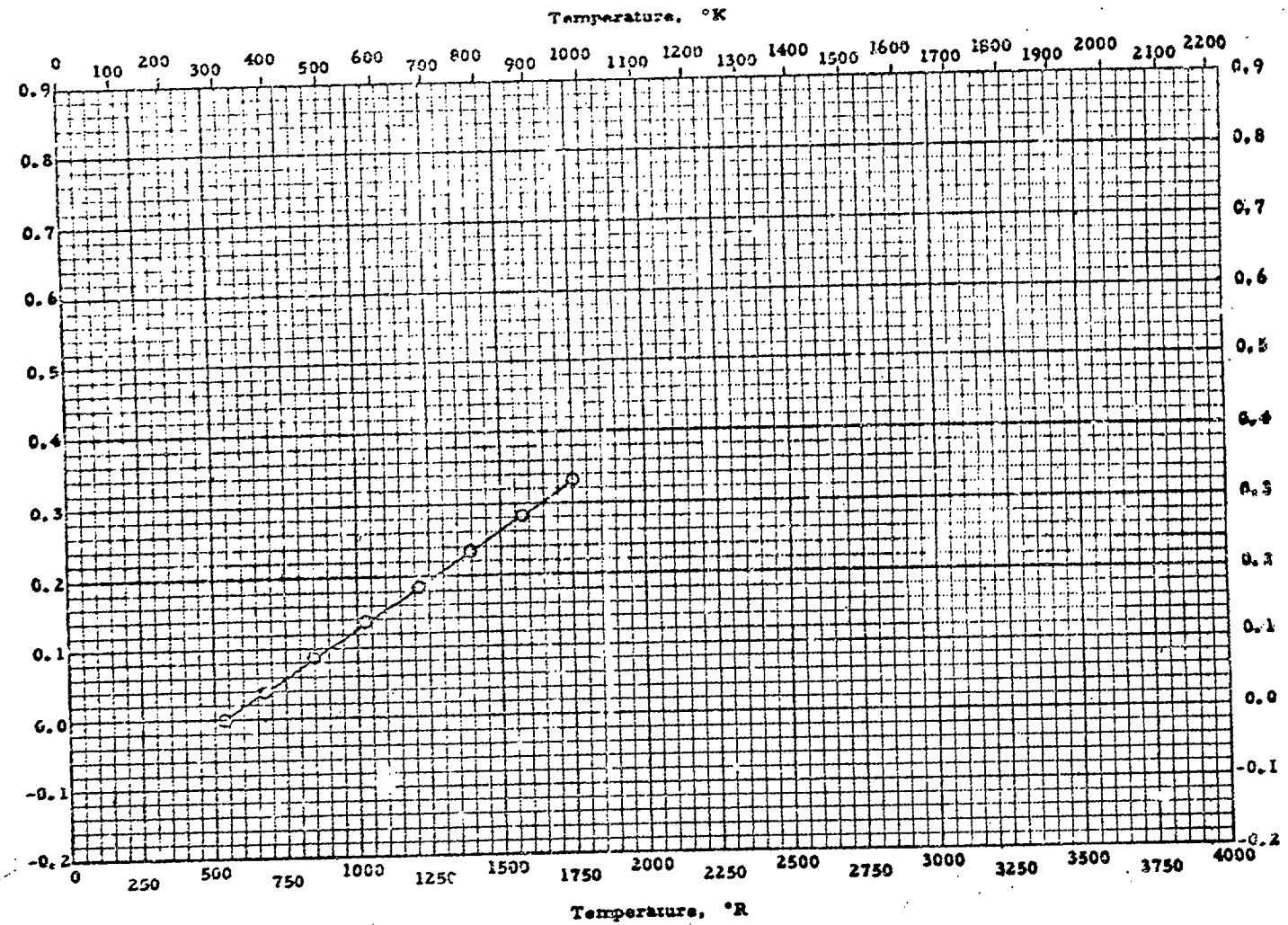


LINEAR THERMAL EXPANSION -- ELECTRICAL PORCELAIN

LINEAR THERMAL EXPANSION -- ELECTRICAL PORCELAIN

REFERENCE INFORMATION

Curve Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Durbin, E. A. and Herman, C. G.	52-31	528-1752	Not given	Interferometer	

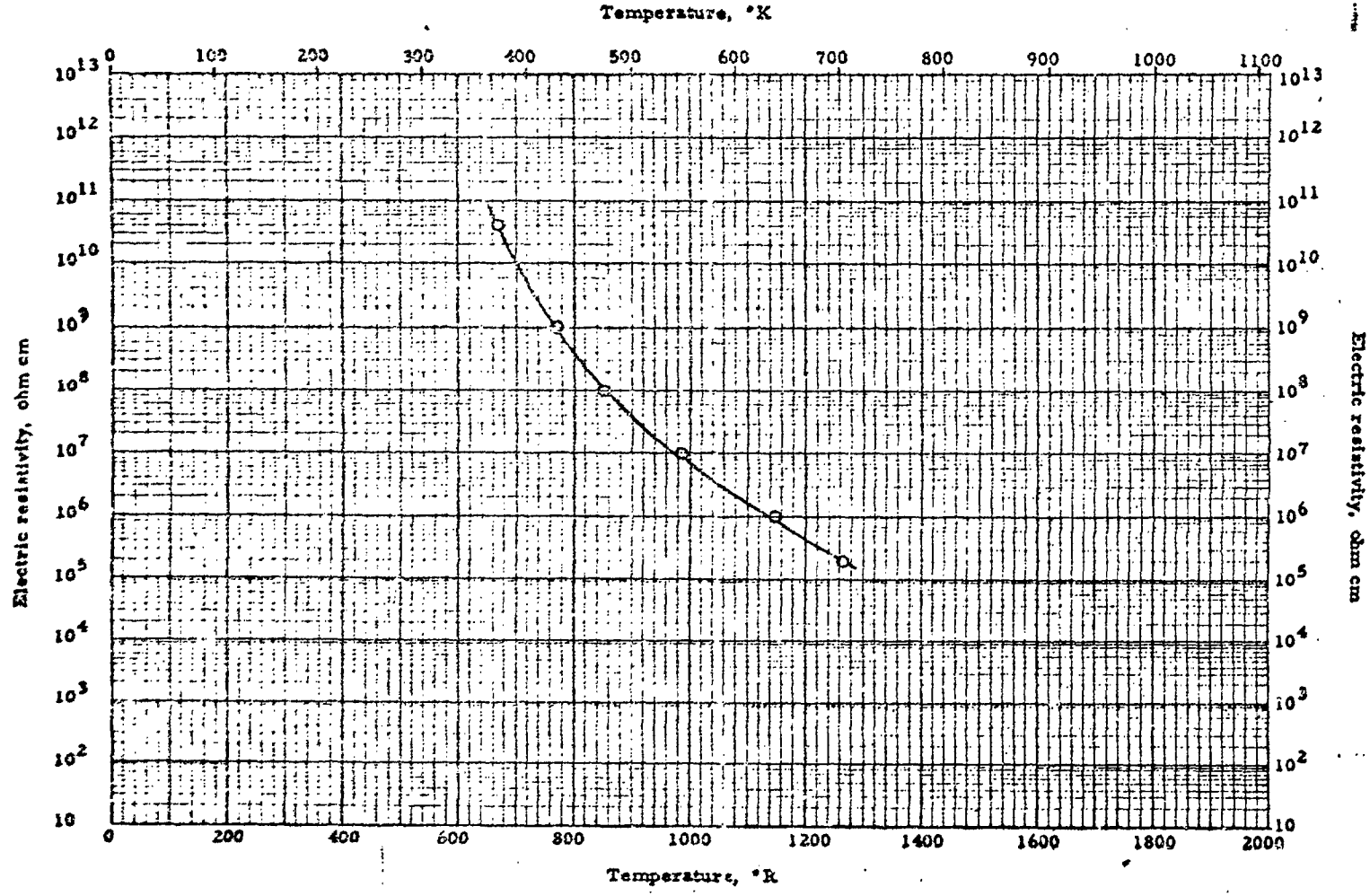


LINEAR THERMAL EXPANSION -- ZIRCON PORCELAIN

LINEAR THERMAL EXPANSION -- ZIRCON PORCELAIN

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Russell, Jr., R. and Mohr, W. C.	47-11	528-1752	Westinghouse Zircon Porcelain; ρ = 230 lb_m/ft^3	Not given	

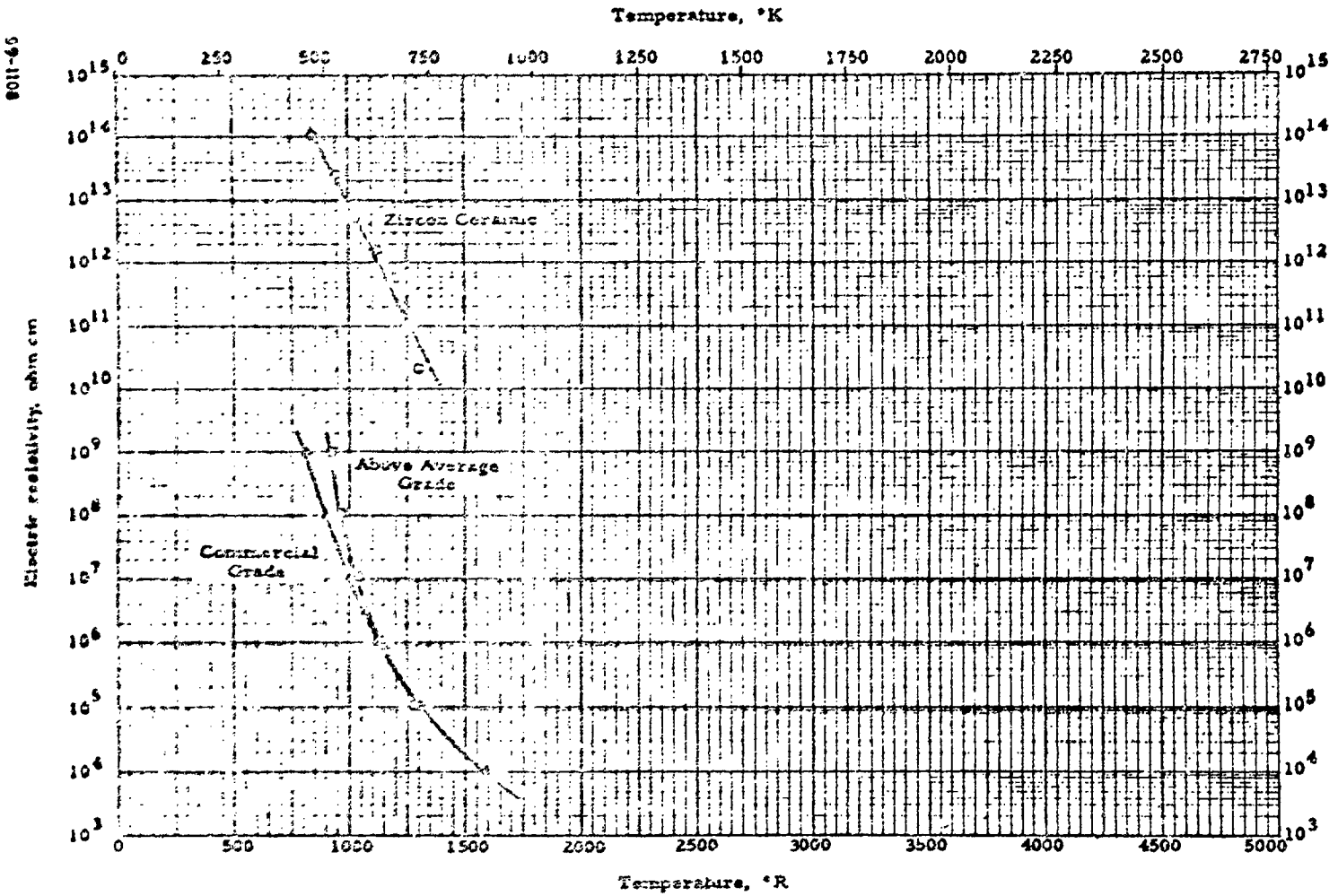


ELECTRIC RESISTIVITY -- ELECTRICAL PORCELAIN, HIGH TENSION

ELECTRIC RESISTIVITY -- ELECTRICAL PORCELAIN, HIGH TENSION

REFERENCE INFORMATION

Symb.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Russel Jr., R. and Berberich, L. J.	44-6	672-1266	Commercial high-tension electrical porcelain	AC impedance bridge	Density 150 lb_m/ft^3

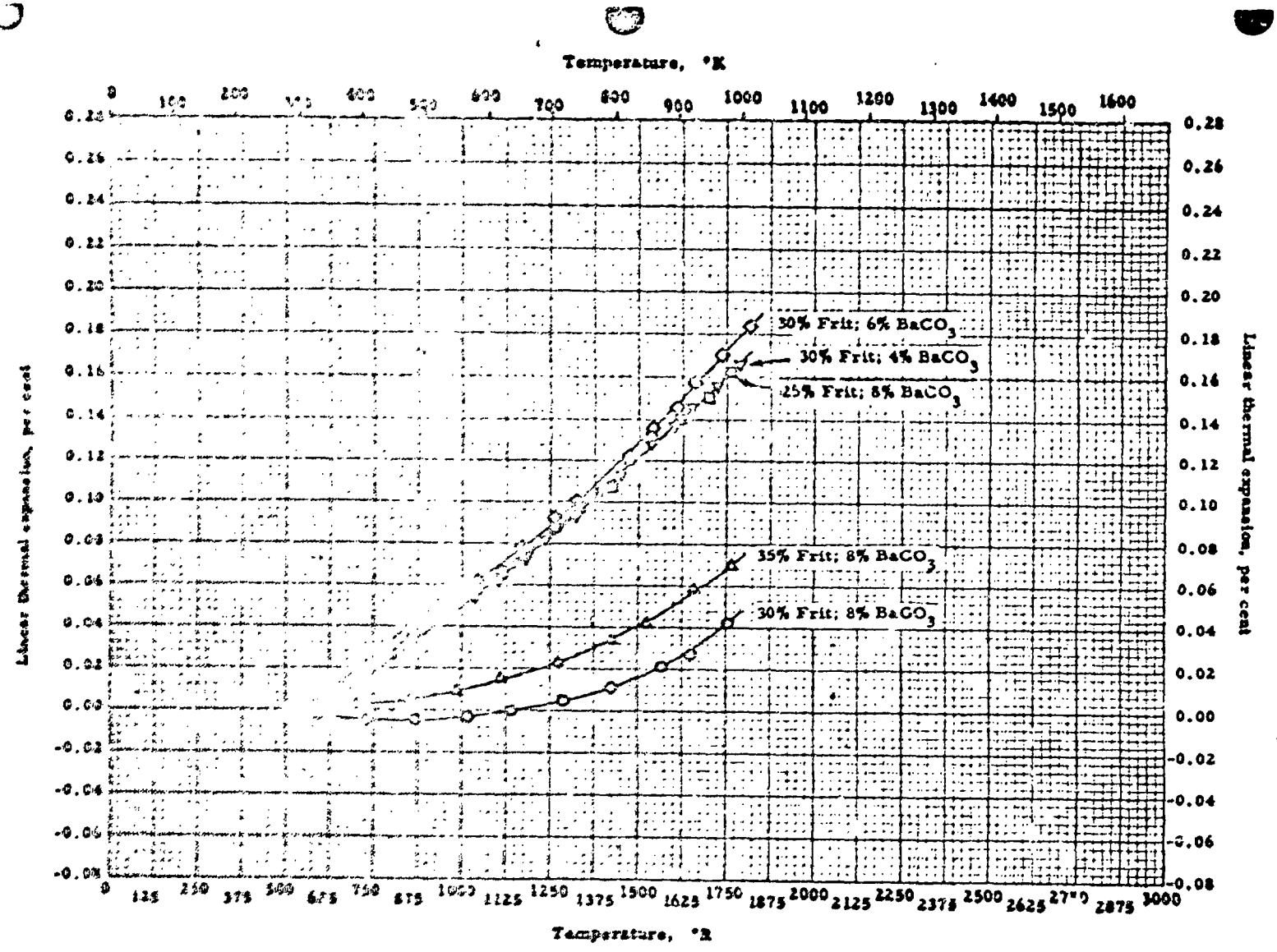


ELECTRIC RESISTIVITY -- ZIRCON PORCELAIN

ELECTRIC RESISTIVITY -- ZIRCON PORCELAIN

REFERENCE INFORMATION

	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Camahort, J. E. and Smith, R. A.	54-95	852-1302	12.52% zircon; 30.0% CaZr silicate; 12.5% BaZr silicate; 7.5% MgZr silicate; 20% Old Mine No. 4 clay; 17.5% EPK	DC reversal	
□	Russell Jr., R. and Harbaugh, L. J.	44-6	924-1662	Low loss zircon porcelain (above avg. grade)	Bridge method and potential drop at lower resistivities	ρ = 235 lb_m/ft^3
△	Ibid.	46-6	816-1590	Commercial low loss porcelain, avg. grade	Same as above	ρ = 230 lb_m/ft^3

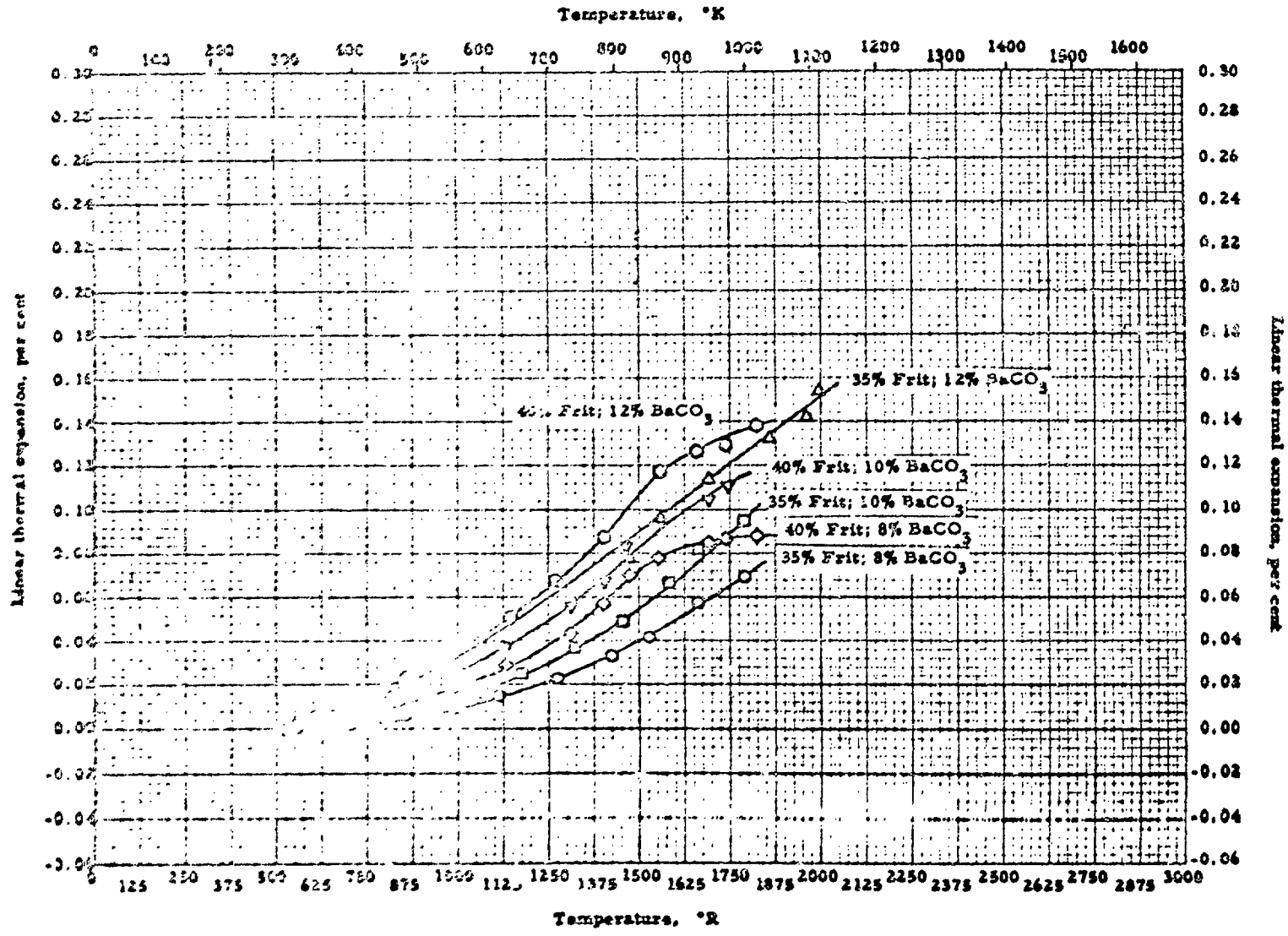


LINEAR THERMAL EXPANSION -- LITHIUM ALUMINOSILICATE BODIES, BARIUM MODIFIED
(25 - 35% Frit Level)

LINEAR THERMAL EXPANSION -- LITHIUM ALUMINOSILICATE BODIES, BARIUM MODIFIED
(25 - 35% Frit Level)

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Koenig, J. H.	53-43	528-1757	62% E.P.K. clay; 30% QC6 frit; 8% $BaCO_3$	Fused silica tube dilatometer	Tested at 2-3°C/min. rise. QC6 frit has an oxide analysis of: 80% SiO_2; 12% Li_2O; 8% Al_2O_3 and is made from Li_2C . T.P.K. clay, and flint
□	Ibid.	53-43	528-1764	67% E.P.K. clay; 25% QC6 frit; 8% $BaCO_3$	Same as above	Same as above
△	Ibid.	53-43 also 53-9	528-1793	57% E.P.K. clay; 35% QC6 frit; 8% $BaCO_3$	Same as above	Same as above
◇	Ibid.	53-43	528-1822	64% E.P.K. clay; 30% QC6 frit; 6% $BaCO_3$	Same as above	Same as above
▽	Ibid.	53-43	528-1730	66% E.P.K. clay; 30% QC6 frit; 4% $BaCO_3$	Same as above	Same as above

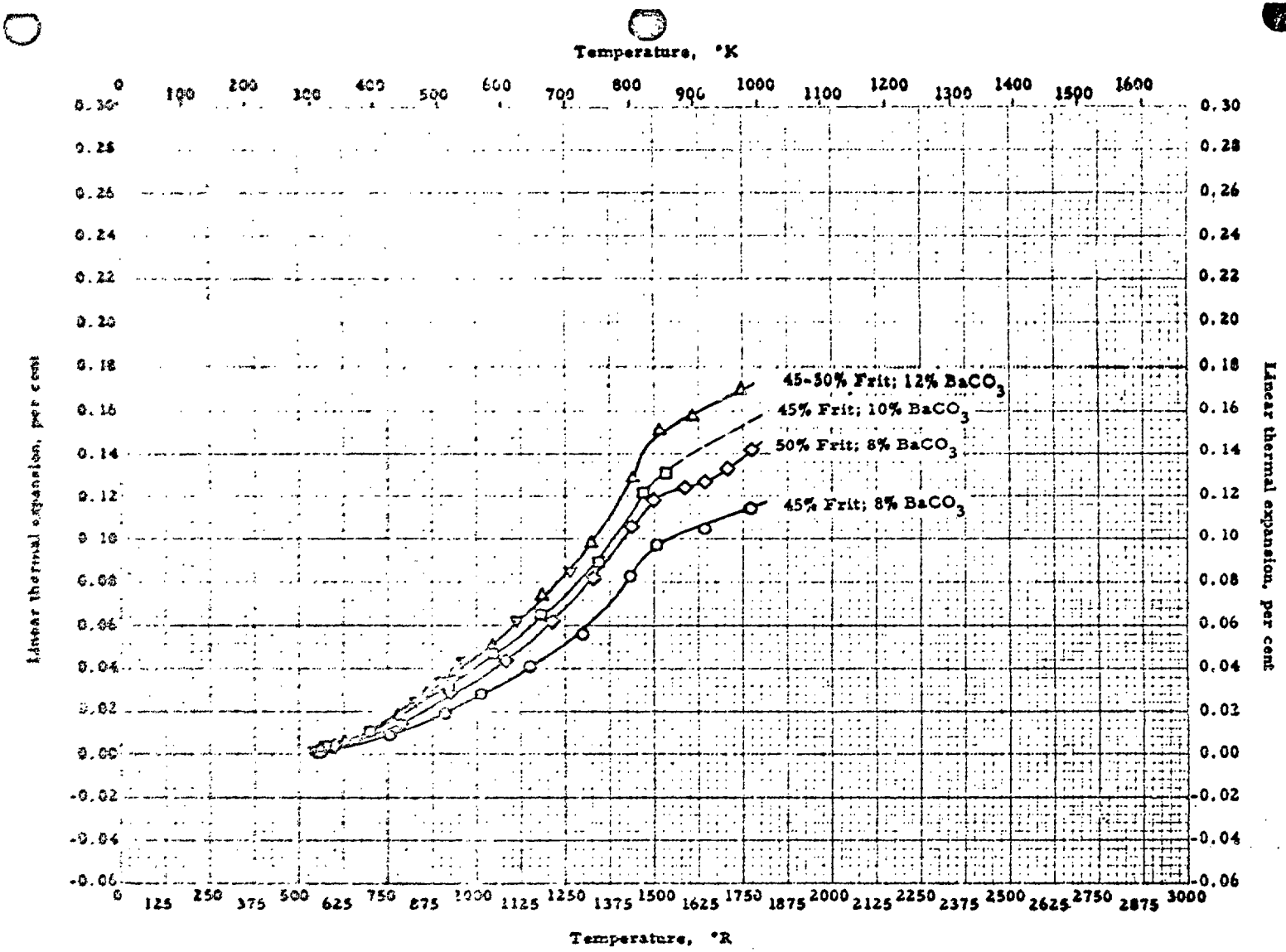


LINEAR THERMAL EXPANSION -- LITHIUM ALUMINOSILICATE BODIES, BARIUM MODIFIED
(35 - 40% Frit Level)

LINEAR THERMAL EXPANSION -- LITHIUM ALUMINOSILICATE BODIES, BARIUM MODIFIED
(35 - 40% Frit Level)

REFERENCE INFORMATION

	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	New Jersey Ceramic Research Station	53-5 Also 53-43	562-1793	57% clay (No. 4 Blend); 35% QC6 frit; 8% $BaCO_3$	Fused silica tube dilatometer	Matured at 2200°F. Frit has an oxide analysis of 80% SiO_2; 12% Li_2O; 8% Al_2O_3 and is prepared from Li_2CO_3, E.P.K. clay and flint. No. 4 Blend clay is from United Clay Mines Corp.
□	Ibid.	53-5	564-1781	55% clay (No. 4 Blend); 35% QC6 frit; 10% $BaCO_3$	Same as above	Same as above
△	Ibid.	53-5	550-1491	53% clay (No. 4 Blend); 35% QC6 frit; 12% $BaCO_3$	Same as above	Matured at 1480°F; rest same as above
◇	Ibid.	53-5	566-1828	52% clay (No. 4 Blend); 40% QC6 frit; 8% $BaCO_3$	Same as above	Matured at 2000°F; rest same as above
▽	Ibid.	53-5	562-1743	50% clay (No. 4 Blend); 40% QC6 frit; 10% $BaCO_3$	Same as above	Matured at 1940°F; rest same as above
○	Ibid.	53-5	566-1824	48% clay (No. 4 Blend); 40% QC6 frit; 12% $BaCO_3$	Same as above	Matured at 1800°F; rest same as above



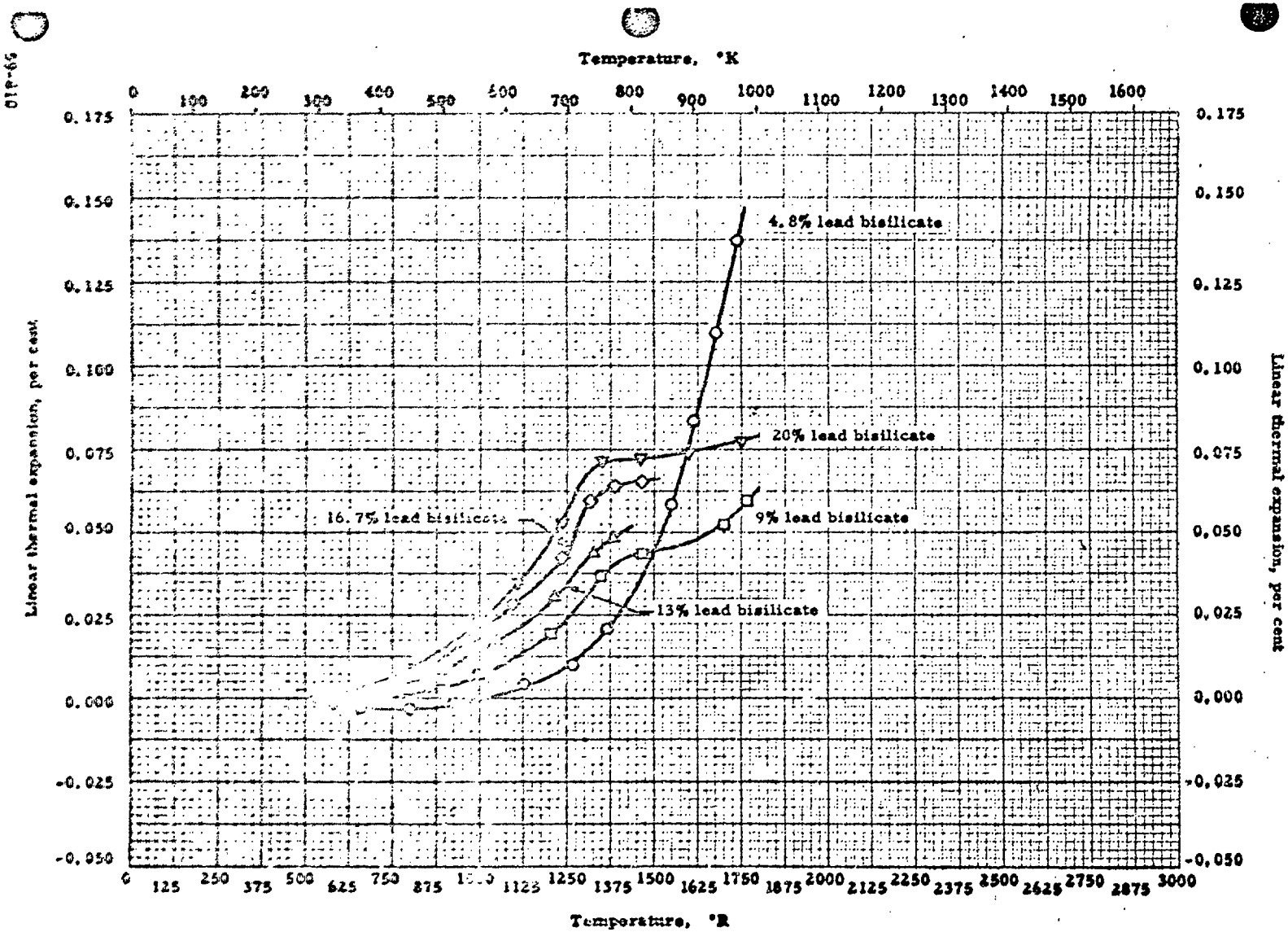
LINEAR THERMAL EXPANSION -- LITHIUM ALUMINOSILICATE BODIES, BARIUM MODIFIED
(45 - 50% Frit Level)

MANCHESTER 5-4474 10M2

LINEAR THERMAL EXPANSION -- LITHIUM ALUMINOSILICATE BODIES. BARIUM MODIFIED
(45 - 50% Frit Level)

REFERENCE INFORMATION

	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	New Jersey Ceramic Research Station	53-5	564-1772	47% clay (No. 4 Blend); 45% QC6 frit; 8% $BaCO_3$	Fused silica tube dilatometer	Matured at 1880°F. QC6 frit has an oxide analysis of 80% SiO_2; 12% Li_2O; 8% Al_2O_3 and is prepared from Li_2CO_3; E.P.K. clay; and flint. No. 4 Blend clay is from United Clay Mines Corp.
□	Ibid.	53-5	573-1534	45% clay (No. 4 Blend); 45% QC6 frit; 10% $BaCO_3$	Same as above	Matured at 1780°F; rest same as above
△	Ibid.	53-5	566-1747	45% QC6 frit; 43% clay (No. 4 Blend); 12% $BaCO_3$	Same as above	Same as above
◇	Ibid.	53-5	566-1777	50% QC6 frit; 42% clay (No. 4 Blend); 8% $BaCO_3$	Same as above	Matured at 1880°F; rest same as above
▽	Ibid.	53-5	566-1268	50% QC6 frit; 38% clay (No. 4 Blend); 12% $BaCO_3$	Same as above	Matured at 1780°F; rest same as above

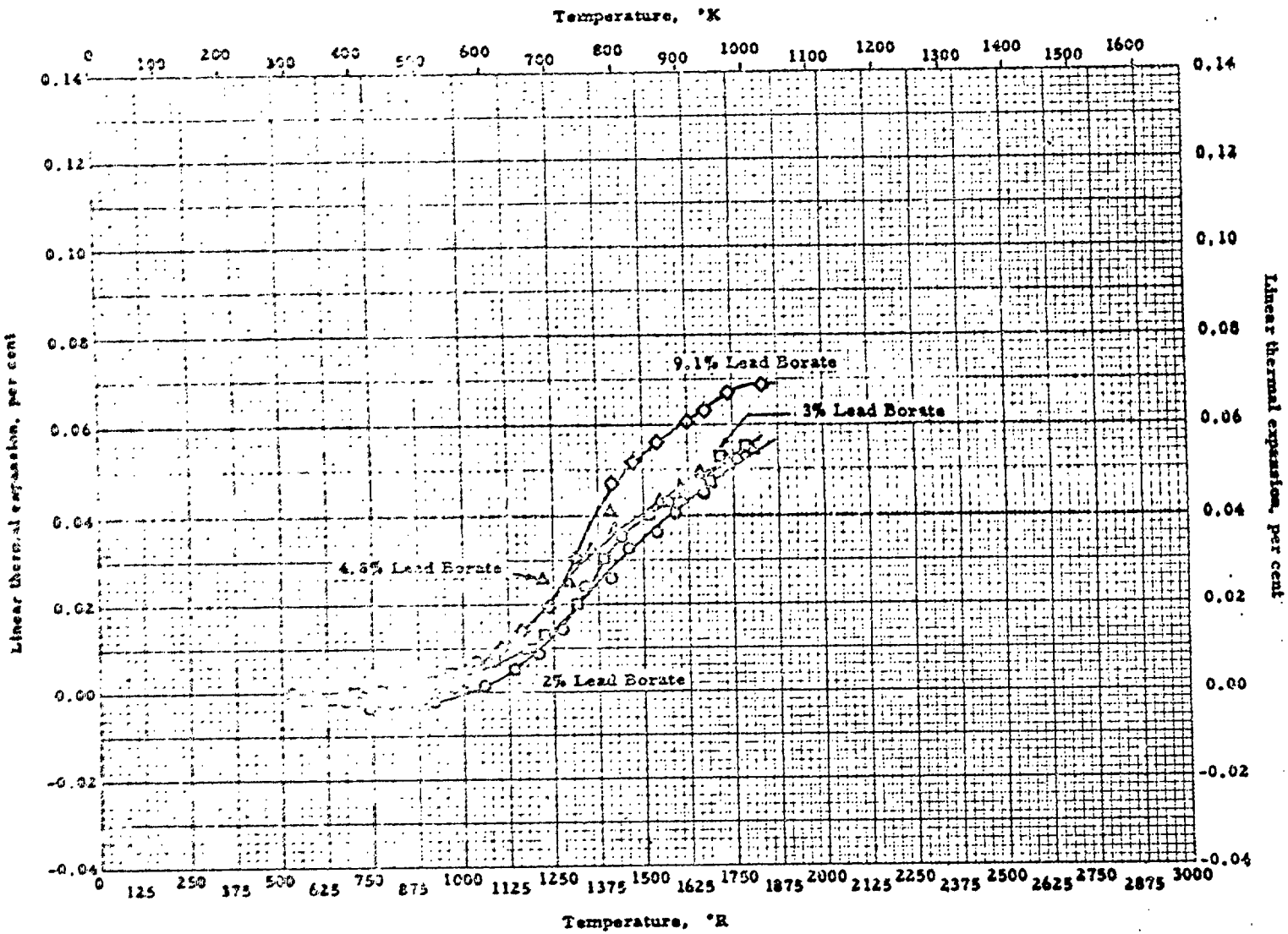


LINEAR THERMAL EXPANSION -- LITHIUM ALUMINOSILICATE WITH LEAD BISILICATE

LINEAR THERMAL EXPANSION -- LITHIUM ALUMINOSILICATE WITH LEAD BISILICATE

REFERENCE INFORMATION

	Investigator	Ref.	Range, °F.	Material Composition	Test Method	Remarks
○	Corning G. R.	53-43	528-1743	56.1% QC6 frit; 37.1% E.P.K. clay; 4.8% lead bisilicate	Fused silica tube dilatometer	Tested at 2-3°C/min. rise. QC6 frit has an oxide analysis of: 80% SiO_2; 12% Li_2O; 8% Al_2O_3 and is made from Li_2CO_3, E.P.K. clay, and flint
□	Ibid.	53-43	528-1766	55.5% QC6 frit; 35.5% E.P.K. clay; 9% lead bisilicate	Same as above	Same as above
△	Ibid.	53-43	528-1384	53.0% QC6 frit; 33.9% E.P.K. clay; 13% lead bisilicate	Same as above	Same as above
◇	Ibid.	53-43	528-1460	50.8% QC6 frit; 32.5% E.P.K. clay; 16.7% lead bisilicate	Same as above	Same as above
▽	Ibid.	53-43	528-1750	48.8% QC6 frit; 31.2% E.P.K. clay; 20% lead bisilicate	Same as above	Same as above



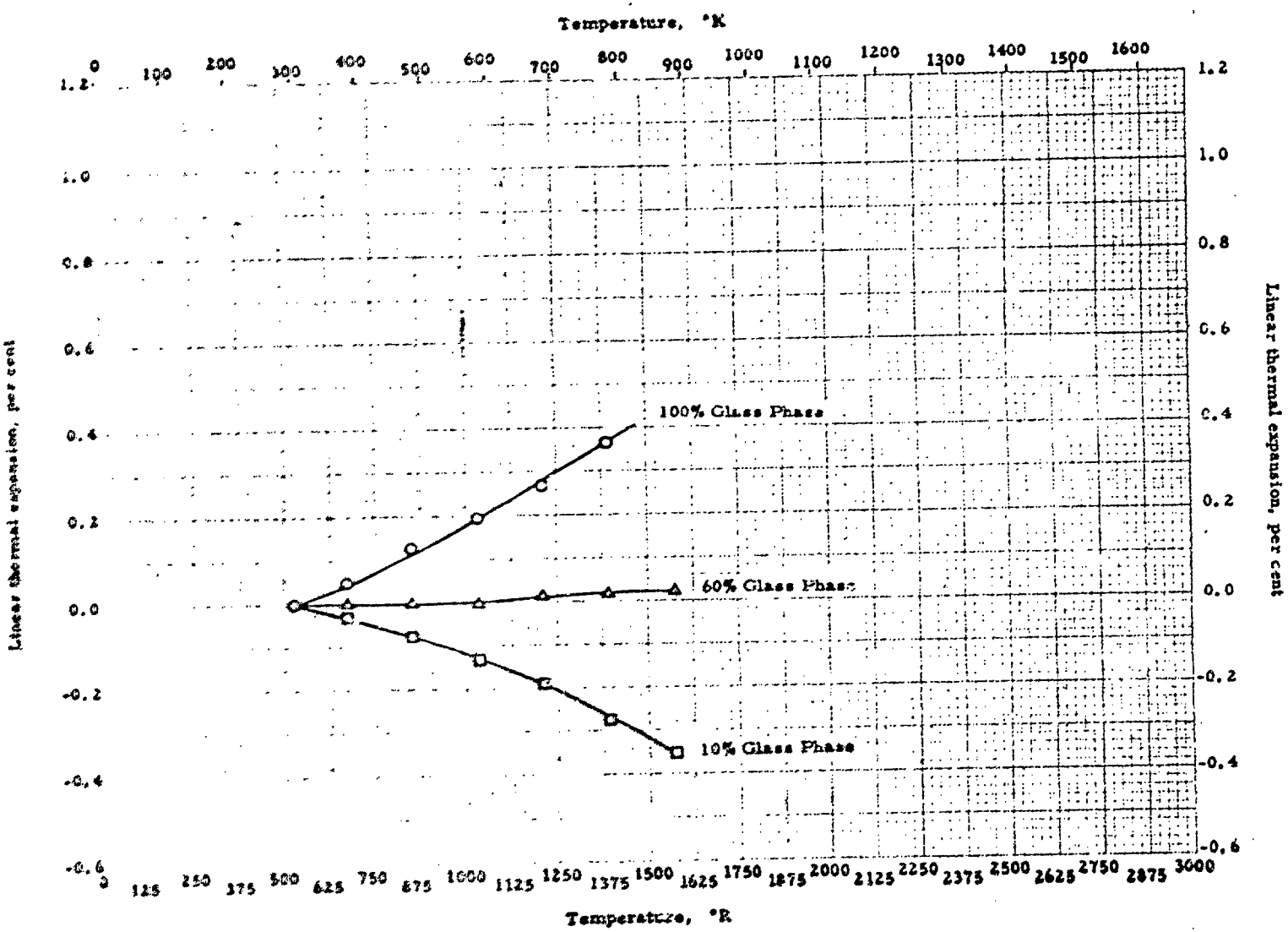
LINEAR THERMAL EXPANSION -- LITHIUM ALUMINOSILICATE WITH LEAD BORATE

WADC TR 58-476 Pt 5 1092

LINEAR THERMAL EXPANSION -- LITHIUM ALUMINOSILICATE WITH LEAD BORATE

REFERENCE INFORMATION

Fig. No.	Investigator	Ref.	Range, °F.	Material Composition	Test Method	Remarks
○	Koenig, J. H.	53-43	528-1759	59.8% QC6 frit; 38.2% E.P.K. clay; 2% lead borate	Fused silica tube dilatometer	Tested at 2-3°C/min. rise. QC6 frit has an oxide analysis of: 80% SiO_2; 12% Li_2O; 8% Al_2O_3 and is made from Li_2CO_3, E.P.K. clay, and flint
□	Ibid.	53-43	528-1784	59.2% QC6 frit; 37.9% E.P.K. clay; 3% lead borate	Same as above	Same as above
△	Ibid.	53-43	526-1809	58.1% QC6 frit; 37.1% E.P.K. clay; 4.8% lead borate	Same as above	Same as above
◇	Ibid.	53-43	528-1834	55.5% QC6 frit; 35.4% E.P.K. clay; 9.1% lead borate	Same as above	Same as above



LINEAR THERMAL EXPANSION -- LITHIUM ALUMINOSILICATE (1 : 1 : 2)

LINEAR THERMAL EXPANSION -- LITHIUM ALUMINOSILICATE (1: 1: 2)

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Avgustinik, A. and Vasilev, E. I.	55-27	528-1392	$Li_2O \cdot Al_2O_3 \cdot 2SiO_2$; 100% glass phase	Dilatometer	Fired 1 hr. at 1450°C
△	Ibid.	55-27	528-1392	Same as above; 40% crystals of eucryptite; 60% glass	Same as above	Fired 1 hr. at 1150°C
□	Ibid.	55-27	528-1392	Same as above; 90% crystals of eucryptite; 10% glass	Same as above	Fired 1/2 hr. at 1150°C

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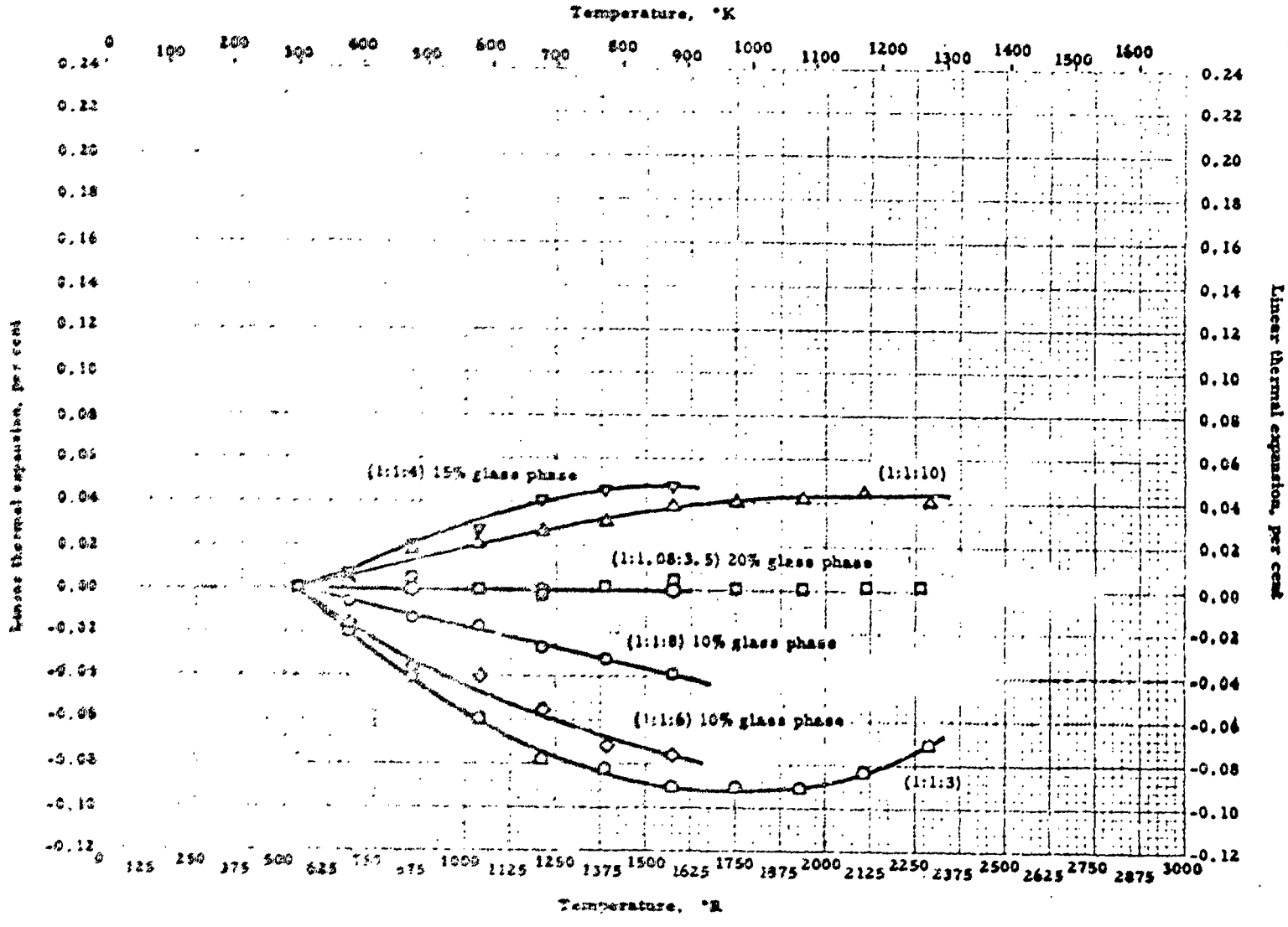
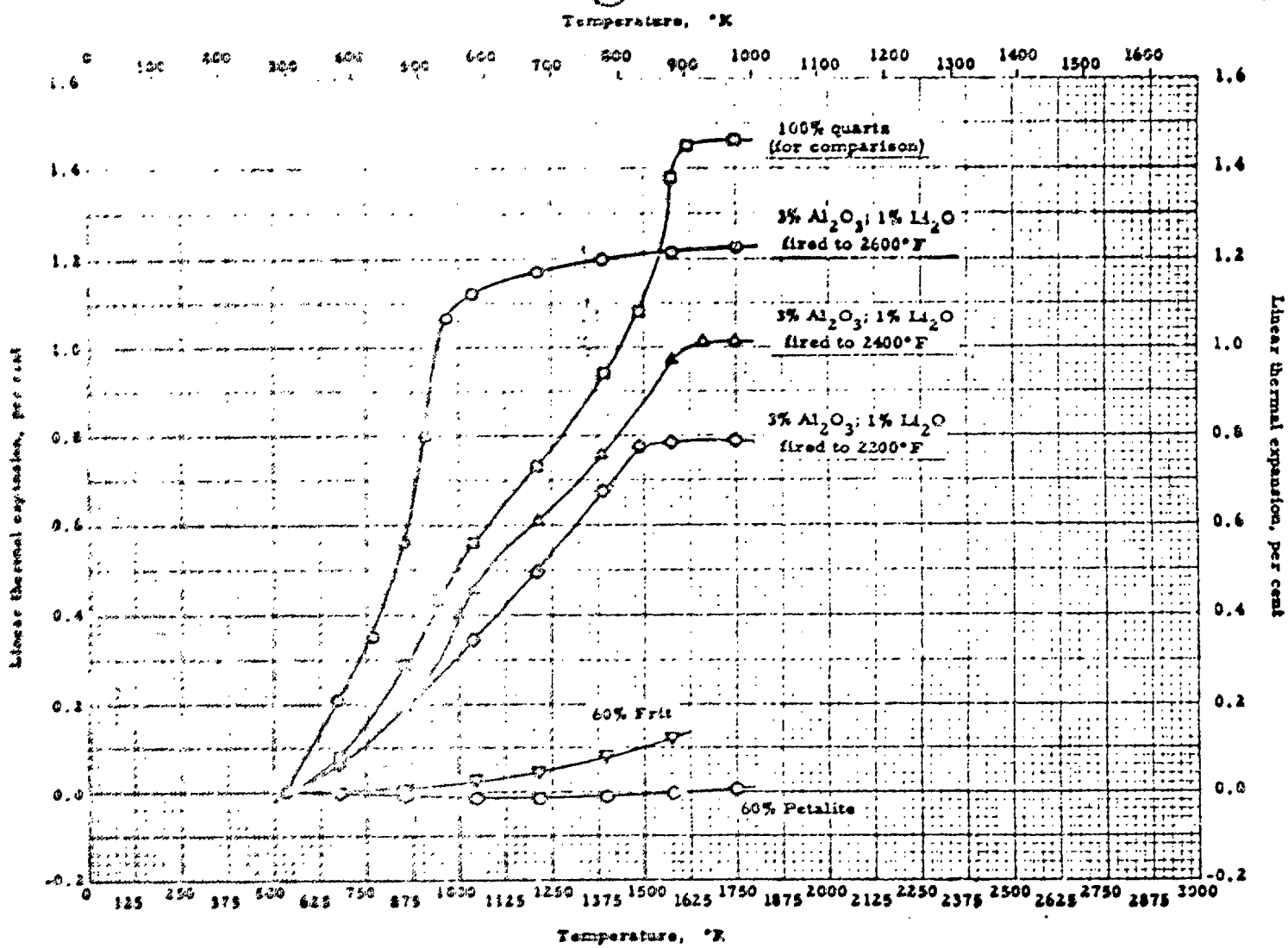


LINEAR THERMAL EXPANSION -- LITHIUM ALUMINOSILICATE (1:1:3 to 10

LINEAR THERMAL EXPANSION -- LITHIUM ALUMINOSILICATE (1:1:3 to 10

REFERENCE INFORMATION

	Investigator	Ref.	Range, °F	Material Composition	Test Method	Remarks
○	Avgustinik, A. and Vasil'ev, E. I.	55-27	528-1572	$Li_2O \cdot Al_2O_3 \cdot 8SiO_2$; 85% petalite; 5% α-$Al_2O_3$; 10% glass phase	Dilatometer	Fired 1/2 hr. at 1150°C
□	Hummel, F. A.	51-21	528-2292	$Li_2O \cdot Al_2O_3 \cdot 8SiO_2$; petalite prepared from c.p. Li_2CO_3; c.p. Al_2O_3; potter's flint	Dilatometer	Pressed 100 mesh calcined material at 1000 lb/in.^{2} with binder
△	Ibid.	51-21	528-2292	$Li_2O \cdot Al_2O_3 \cdot 10SiO_2$; prepared from c.p. Li_2CO_3; c.p. Al_2O_3; potters flint	Dilatometer	Pressed 100 mesh calcined material at 1000 lb/in.^{2} with binder
◇	Avgustinik, A. and Vasil'ev, E. I.	55-27	528-1572	$Li_2O \cdot Al_2O_3 \cdot 6SiO_2$; 90% crystals; 10% glass phase	Dilatometer	Fired 1/2 hr. at 1150°C
▽	Ibid.	55-27	528-1572	$Li_2O \cdot Al_2O_3 \cdot 4SiO_2$; 80% crystals of β-eucryptite; 15% glass; 5% not given	Dilatometer	Fired 1/2 hr. at 1150°C
○	Ibid.	55-27	528-1572	$Li_2O \cdot 1.05Al_2O_3 \cdot 3.5SiO_2$; 80% crystals of eucryptite; 20% glass	Same as above	Same as above
○	Hummel, F. A.	51-21	528-2292	$Li_2O_3 \cdot Al_2O_3 \cdot 3SiO_2$; prepared from c.p. Li_2CO_3; c.p. Al_2O_3; potter's flint	Dilatometer	Pressed from 100 mesh calcined material at 1000 lb/in.^{2} with binder

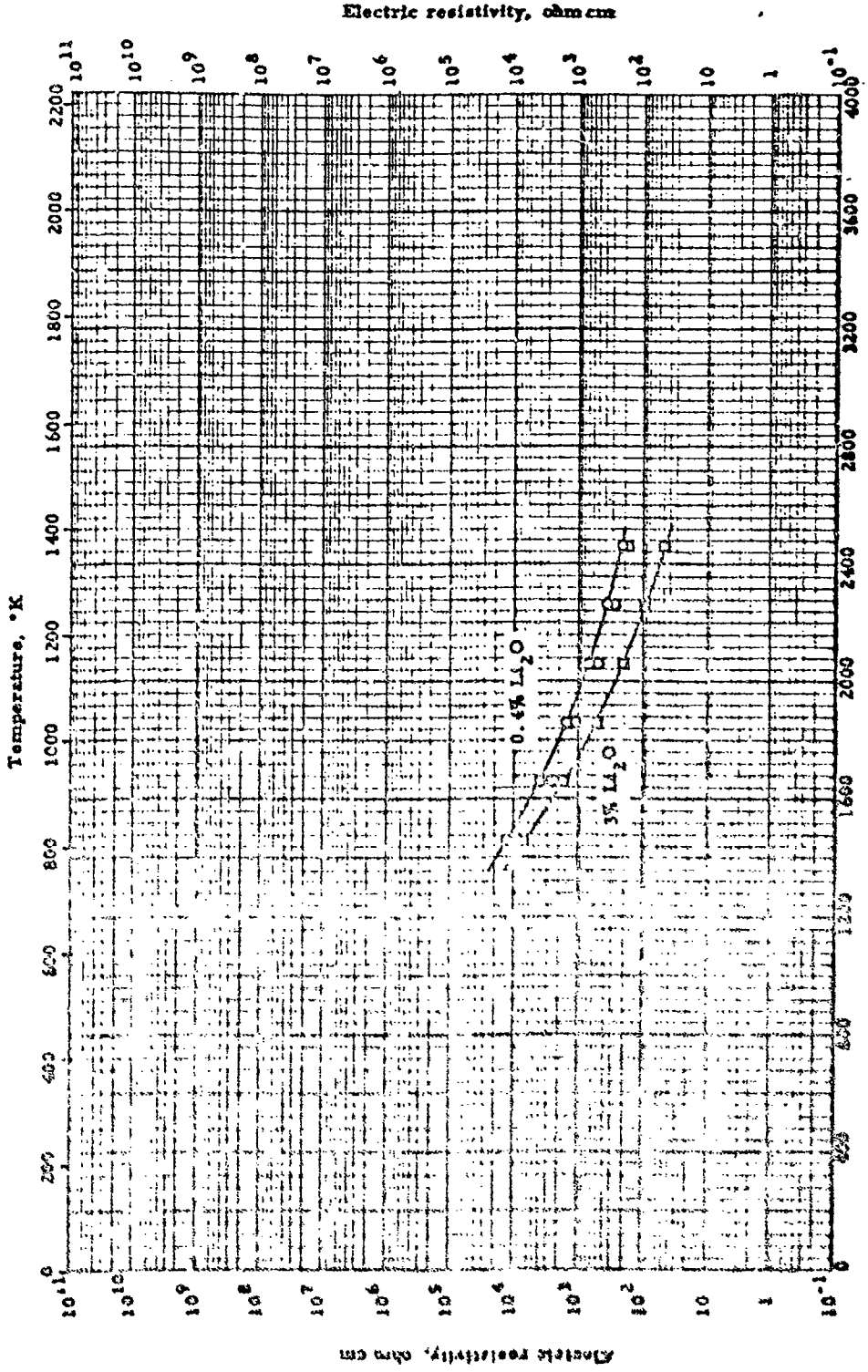


LINEAR THERMAL EXPANSION -- LITHIUM ALUMINOSILICATE

LINEAR THERMAL EXPANSION -- LITHIUM ALUMINOSILICATE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Smoke, E. J.	54-43	528-1752	96% SiO_2; 3% Al_2O_3; 1% Li_2O; prepared from E.P.K. clay, flint, Li_2CO_3	Fused silica tube dilatometer	Fired in 5 hr. to 2500°F, soaked 1 hr.
△	Ibid.	54-43	528-1752	Same as above	Same as above	Fired in 5 hr. to 2400°F, soaked 1 hr.
◇	Ibid.	54-43	528-1752	Same as above	Same as above	Fired in 5 hr. to 2200°F, soaked 1 hr.
□	Ibid.	54-43	528-1752	100% SiO_2 quartz (for comparison purposes)	Same as above	Same as above
▽	New Jersey Ceramic Research Station	53-44	528-1572	59.8% QC6 frit; 38.2% E.P.K. clay; 2% $MgCO_3$	Fused silica tube dilatometer	QC6 frit has oxide composition of 80% SiO_2; 12% Li_2O; 8% Al_2O_3 and is prepared from Li_2CO_3, E.P.K. clay and flint
○	Ibid.	53-44	528-1752	60% Petalite; 24.4% QC6 frit; 15.6% E.P.K. clay	Same as above	Same as above



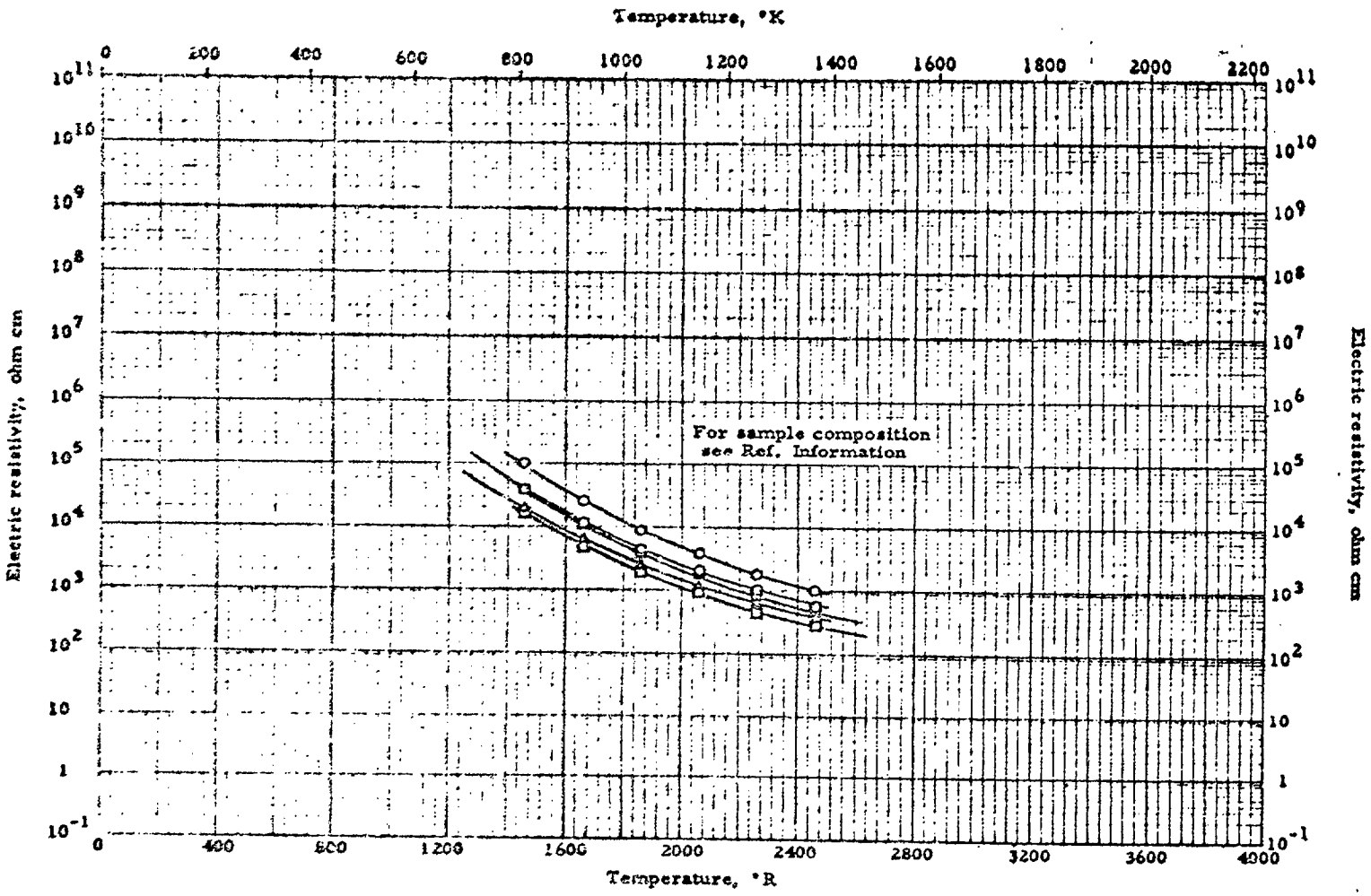
ELECTRIC RESISTIVITY -- ELECTRICAL PORCELAIN, LITHIUM MODIFIED

59-1134
WADC TR 58-476
0011

ELECTRIC RESISTIVITY -- ELECTRICAL PORCELAIN, LITHIUM MODIFIED

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Wisely, H.R.	57-98	1460-2460	Li-K body series: 1, 2a, 2b, 2c, 2d, 2e; nominal range: 62.2-75.5% SiO_2, 21.6-35.5% Al_2O_3, 1.8-2.8% $(K, Na)_2O$; 0.4-0.7% Li_2O	AC impdeance bridge; Chromel-Alumel thermocouple	Fired at 2200-2550°F
□	Ibid.	57-98	1460-2460	Petalite body; nominal: 76.0% SiO_2; 21.0% Al_2O_3; 3.0% Li_2O	Same as above	Fired at 2400°F. Formed from 30% petalite and 50% clay



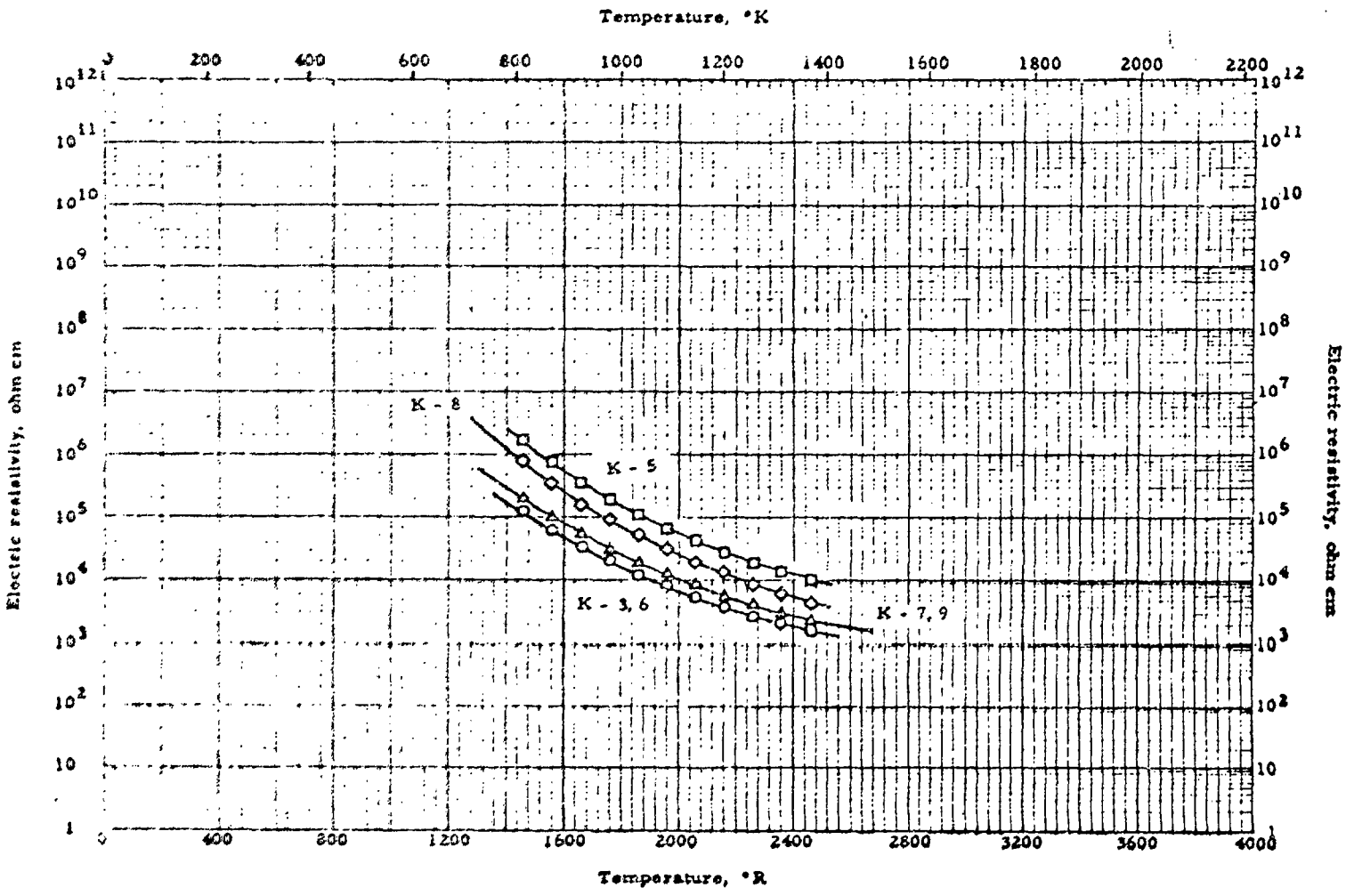
ELECTRIC RESISTIVITY -- ELECTRICAL PORCELAIN, LOW TENSION

19-1126
9211-176 PN 56-176
1102

ELECTRIC RESISTIVITY -- ELECTRICAL PORCELAIN, LOW TENSION

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Wisely, H.R.	57-98	1460-2460	Feldspar Porcelain: Dinnerware Cone 12-14. Nominal: 73-76% SiO_2; 20-24% Al_2O_3; 2-4% $(K, Na)_2O$; balance (Ca, Mg) O	AC impedance bridge; Chromel-Alumel thermocouple	Auth. reports range of values
□	Ibid.	57-98	1460-2460	Feldspar Porcelain; low tension electrical grade: nominal: 68-70% SiO_2; 23-27% Al_2O_3; 5-6% $(K, Na)_2O$; balance (Ca, Mg) O	Same as above	Auth. reports range of values
△	Ibid.	57-98	1460-2460	Porcelain, Cone 14. Nominal: 76% SiO_2; 21% Al_2O_3; 3% $(K, Na)_2O$	Same as above	Fired at 2535° F

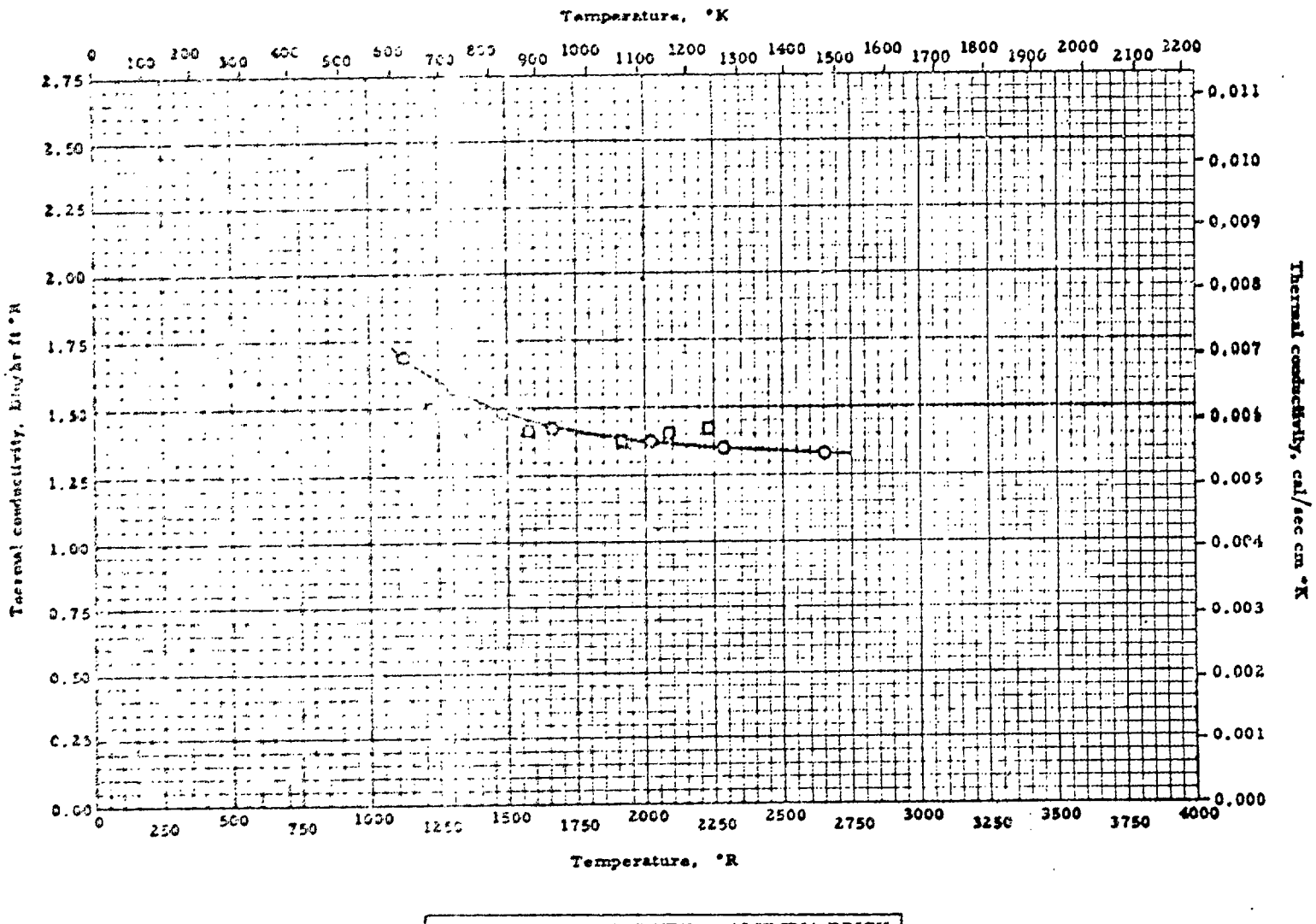


ELECTRIC RESISTIVITY -- ELECTRICAL PORCELAIN

ELECTRIC RESISTIVITY -- ELECTRICAL PORCELAIN

REFERENCE INFORMATION

	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Wisely, H. R.	57-93	1460-2460	K-3 body; nominal: 60% Al_2O_3; 30% SiO_2; 10% K_2O; also:	AC impedance bridge; Chromel-Alumel thermocouple	Fired at 2450°F
				K-6 body; nominal: 45% SiO_2; 40% Al_2O_3; 15% K_2O		Fired at 2400°F. Same resistivity as K-3 body
□	Ibid.	57-93	1460-2460	K-5 body; nominal: 75% Al_2O_3; 20% SiO_2; 5% K_2O	Same as above	Fired at 2600°F
△	Ibid.	57-93	1460-2460	K-7 body; nominal: 48% SiO_2; 40% Al_2O_3; 12% K_2O; also:	Same as above	Fired at 2400°F
				K-9 body; nominal: 45% Al_2O_3; 45% SiO_2; 10% K_2O		Fired at 2400°F. Same resistivity as K-7 body
◇	Ibid.	57-93	1460-2460	K-8 body; nominal: 53% Al_2O_3; 40% SiO_2; 7% K_2O	Same as above	Fired at 2450°F

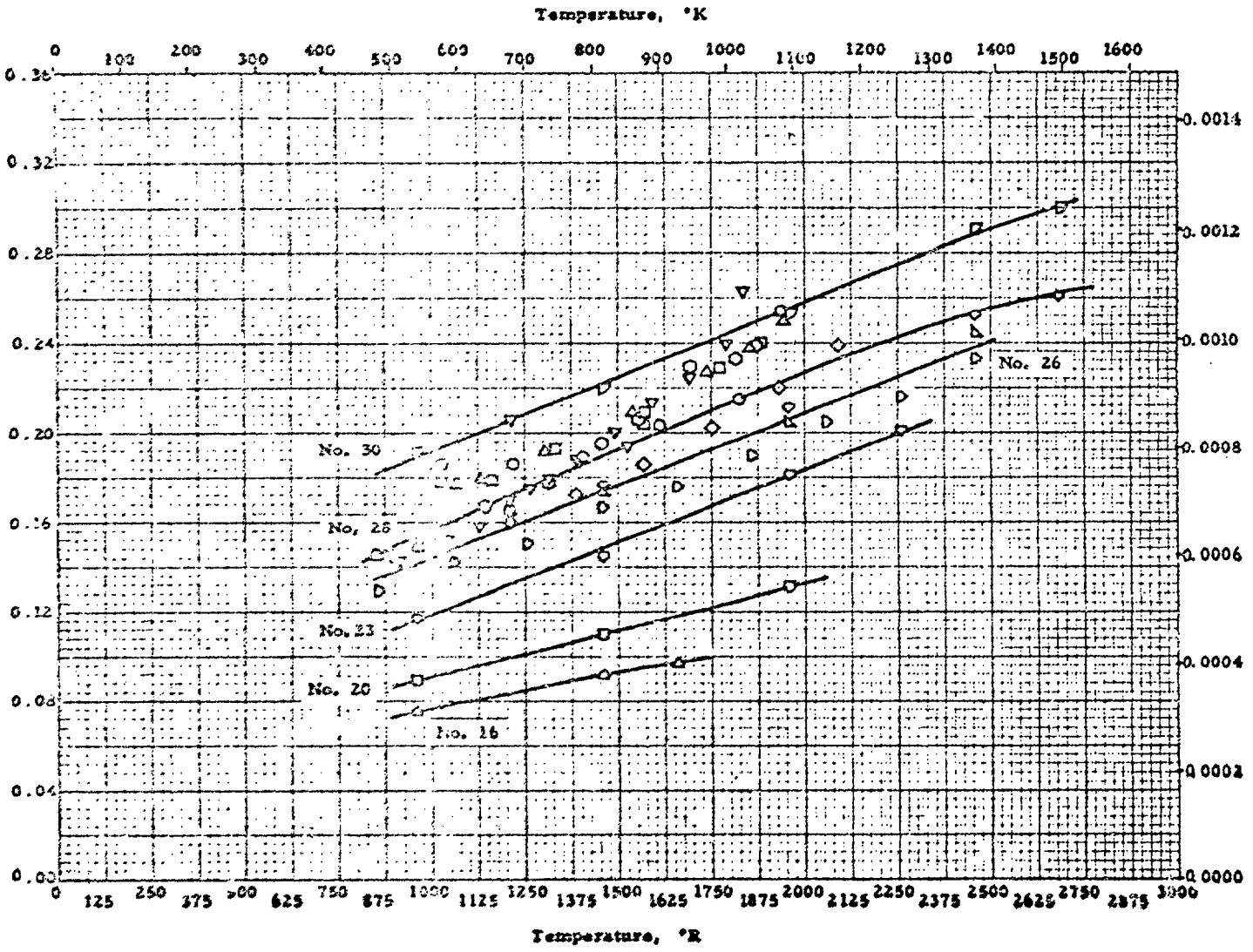


THERMAL CONDUCTIVITY -- ALUMINA BRICK

THERMAL CONDUCTIVITY -- ALUMINA BRICK

REFERENCE INFORMATION

	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Clements, J. F. and Vyse, J.	37-26	1122-2652	86.9% Al_2O_3; 10.08% SiO_2; 2.08% TiO_2; 0.66% Fe_2O_3; 0.35% K_2O; 0.26% CaO; 0.10% Na_2O; 0.08% loss on ignition. Bulk ρ = 178 lb_m/ft^3 (Theor. ρ = 228.7); apparent porosity = 22.1%	Not given (method of Brit.Ceramic Research Assoc.)	Auth. est. accuracy ±5%
□	Masse, F., Heinz, A. and Heim, J.	57-181	1220-2230	Mullite brick	Comparative: discs; heated guard cylinder	

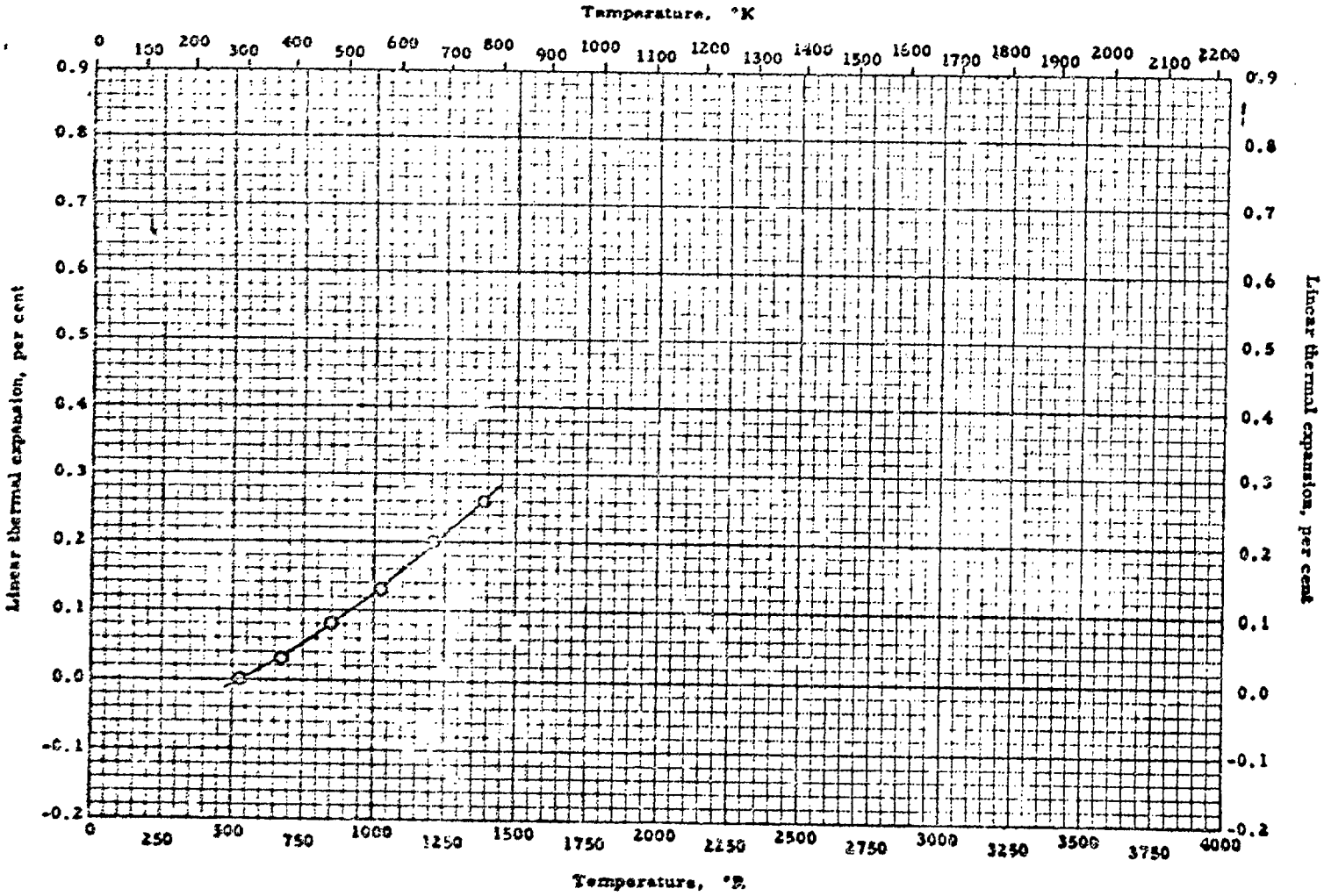


THERMAL CONDUCTIVITY -- INSULATING FIREBRICK

THERMAL CONDUCTIVITY -- INSULATING FIREBRICK

REFERENCE INFORMATION

	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Norton, F.H., Fellows, D.M. et al.	49-62	1028-1825	Insulating firebrick K-28	Cylindrical envelope, hemispherical end. Temp by chromel-alumel thermocouple	Made by Babcock and Wilcox 2.5 lb per standard brick
□	Norton, F.H., Fellows, D.M.	50-64	1031-1853	Insulating firebrick K-28	Prolate ellipsoid with heavy insulating cover	Made by Babcock and Wilcox, Run no. 1
△	Ibid.	50-64	1037-1943	Same as above	Same as above	Same as above, but run no. 2
◇	Ibid.	50-64	895-2094	Same as above	Same as above	Same as above, but run no. 3
▽	Norton, F.H., and Kingery, W.D. et al.	51-76	919-1838	Insulating firebrick K-28	Ellipsoidal sample	Made by Babcock and Wilcox, Run no. 2
○	Ibid.	51-76	996-1873	Same as above	Same as above	Same as above, but run no. 3
□	Norton, F.H.	51-77	852-1932	Insulating firebrick, K-28	Ellipsoidal envelope method	Auth. est. accuracy ± 20%
△	Brady, J.C. and Matthews, S.	56-E5	960-1660	Insulating firebrick, ASTM group no. 16	Single flat plate, circulating water calorimeter. ASTM methods C 182-47 and C 201-47	
○	Ibid.	56-E5	960-1960	Insulating firebrick, ASTM group no. 20	Same as above	
▽	Ibid.	56-E5	960-2260	Insulating firebrick, ASTM group no. 23	Same as above	
L	Ibid.	56-E5	960-2460	Insulating firebrick, ASTM group no. 26	Same as above	
○	Ibid.	56-E5	960-2560	Insulating firebrick, ASTM group no. 28	Same as above	
▽	Ibid.	56-E5	960-2560	Insulating firebrick, ASTM group no. 30	Same as above	
▷	Brady, J. G.	54-B3	860-2460	Insulating firebrick ASTM group no. 26	Single flat plate, circulating water calorimeter. ASTM methods C 182-47 and C 201-47	Main purpose was to describe method and equipment.



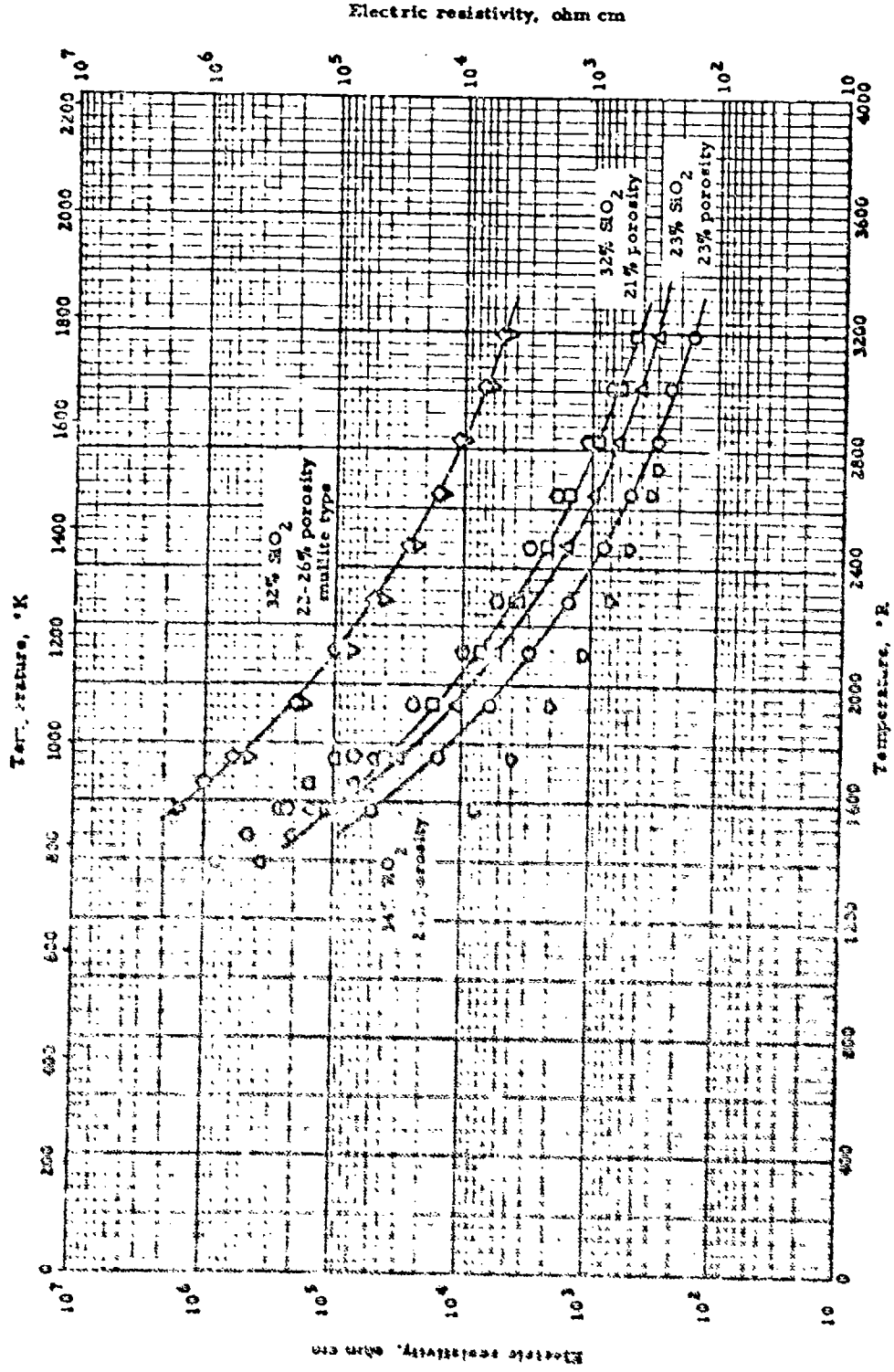
LINEAR THERMAL EXPANSION -- K-30 INSULATING BRICK

59-R40
NASA TR 56-476
110

LINEAR THERMAL EXPANSION -- K-30 INSULATING BRICK

REFERENCE INFORMATION

	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Zimmerman, W. F., Plankenhorn, W. J. and Bennett, D.G.	53-42	528-1392	Not given	Interferometer	

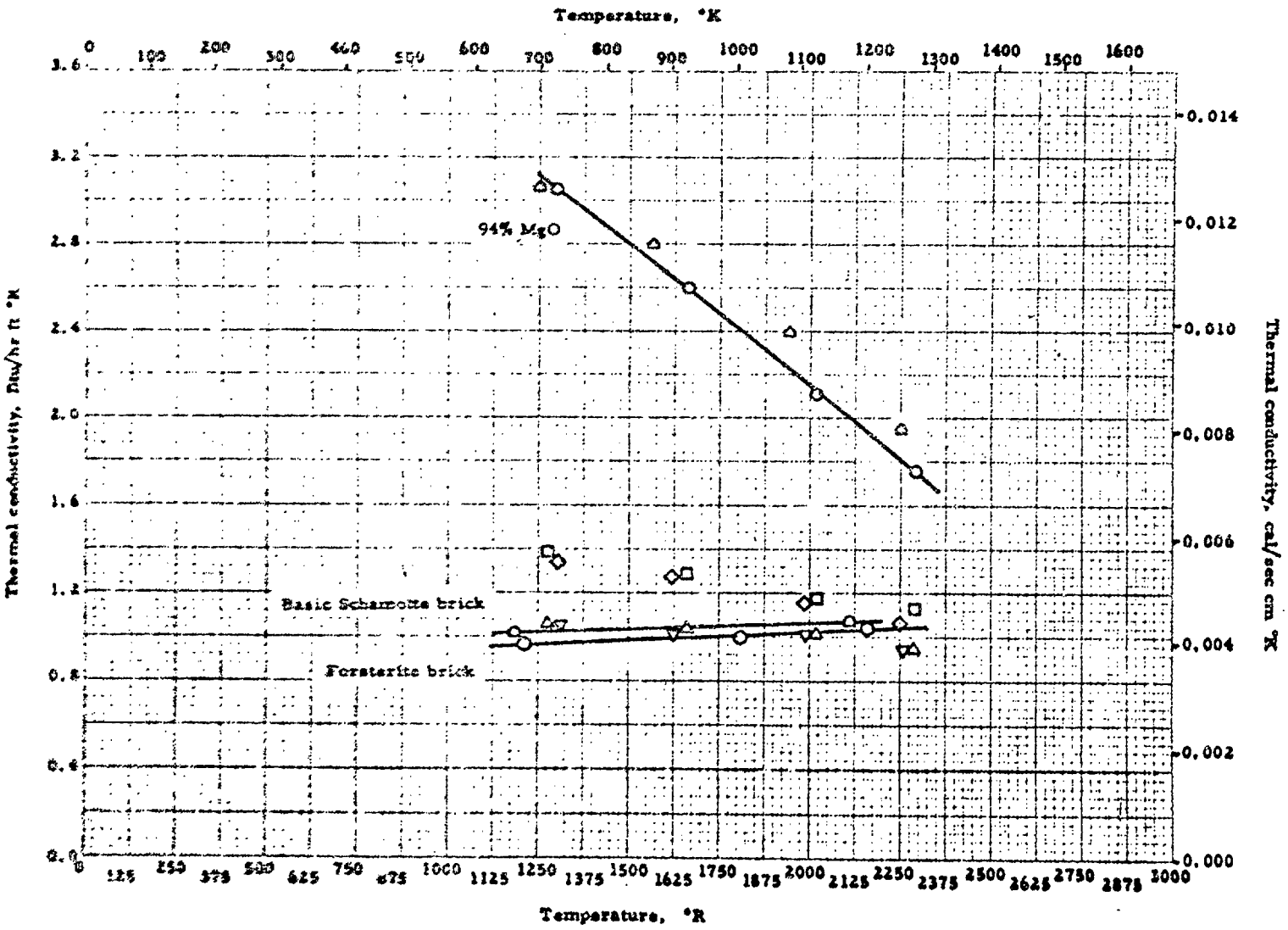


ELECTRIC RESISTIVITY -- ALUMINA FIREBRICK
Commercial Brick

ELECTRIC RESISTIVITY -- ALUMINA FIREBRICK
Commercial Brick

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Caicchetti, V. E. J. and Harry, E. C.	53-94	1572-3192	34% SiO_2; 60% Al_2O_3; 24% porosity	Wheatstone bridge at 965 cycles	35-37 pyrometric cone equivalent
□	Ibid.	53-94	1572-3192	32% SiO_2; 62% Al_2O_3; 21% porosity	Same as above	36-37 pyrometric cone equivalent
△	Ibid.	53-94	1572-3192	23% SiO_2; 69% Al_2O_3; 23% porosity	Same as above	37-38 pyrometric cone equivalent
◇	Ibid.	53-94	1572-3192	32% SiO_2; 64% Al_2O_3; 26% porosity; mullite type	Same as above	38 + pyrometric cone equivalent
▽	Ibid.	53-94	1572-3192	32% SiO_2; 64% Al_2O_3; 22% porosity; mullite type	Same as above	37-8 pyrometric cone equivalent
⬡	Ibid.	53-94	1572-3192	Not given. Fused; mullite type	Same as above	37-8 pyrometric cone equivalent
▽	Ibid.	53-94	1572-2742	80% Al_2O_3; 20% chromite; 2.9% porosity	Same as above	
○	Budnikov, P. P. and Tresvyatskii, S. G.	55-142	1392-1752	95% white corundum; 5% clay. White corundum: 95.55% Al_2O_3; 2.50% SiO_2; 0.30% CaO; 0.25% Fe_2O_3; 0.16% MgO 0.56% residue. Clay: 53.17% SiO_2; 31.6% Al_2O_3; 0.90% Fe_2O_3; 0.54% CaO; 0.30% MgO; 12.96% residue.	AC bridge at 50 cycles/sec.	Fired 2 hr. at 1400°C. Plotted data avg. of 3 samples within ± 10%
⬡	Ibid.	55-142	1392-1752	50% white corundum; 50% clay Raw materials: same as above	Same as above	Same as above. Auth. also gives data for 10, 20, 30, and 40% clay which lie between the ○ and ⬡



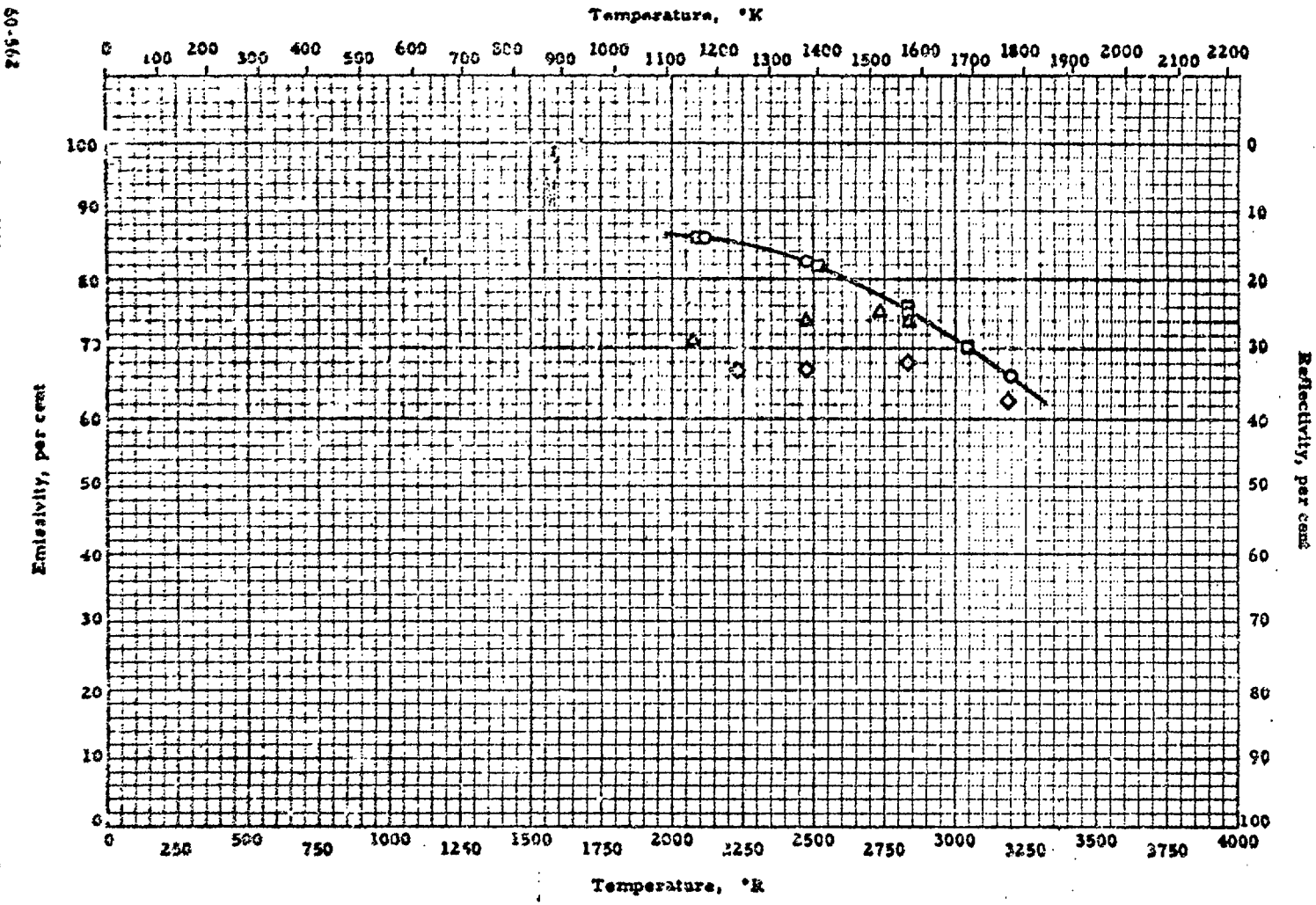
THERMAL CONDUCTIVITY -- BASIC REFRACTORY

WADC TR 54-476 1115 60-934

THERMAL CONDUCTIVITY -- BASIC REFRACTORY

REFERENCE INFORMATION

	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Kolechkova, A. F. and Goncharov, V. V.	55-142	1302-2292	93.68% MgO; 2.08% SiO_2; 1.62% Fe_2O_3; 1.24% CaO; 0.83% Al_2O_3; 0.05% TiO_2. Porosity = 22% ρ = 175 lb_m/ft^3	Axial heat flow in bar with calorimeter	Auth. est. accuracy ± 8.0%
□	Ibid.	55-142	1302-2292	64.85% MgO; 12.23% Cr_2O_3; 8.57% Al_2O_3; 5.80% Fe_2O_3; 4.28% SiO_2; 1.67% FeO; 1.44% CaO. Porosity = 19.1%, ρ = 190 lb_m/ft^3	Same as above	Same as above
△	Ibid.	55-142	1302-2292	49.46% MgO; 20.48% Cr_2O_3; 12.59% Al_2O_3; 9.15% Fe_2O_3; 5.24% SiO_2; 1.90 FeO; 1.26% CaO. Porosity = 22.8%, ρ = 184 lb_m/ft^3	Same as above	Same as above
◇	Ibid.	55-142	1302-2292	42.87% MgO; 22.34% Cr_2O_3; 13.04% Fe_2O_3; 11.45% Al_2O_3; 5.42% SiO_2; 2.88% FeO; 1.76% CaO. Porosity = 25.6%, ρ = 184 lb_m/ft^3	Same as above	Same as above
▽	Ibid.	55-142	1302-2292	42.31% MgO; 24.35% Cr_2O_3; 12.34% Al_2O_3; 11.64% Fe_2O_3; 6.14% SiO_2; 1.71% FeO; 1.65% CaO. Porosity = 23.5%, ρ = 189 lb_m/ft^3	Same as above	Same as above
○	Klasse, F., Matos, A. and Mats, J.	57-181	1212-2157	Forsterite brick	Comparative, discs. Simple guard heater reduced but did not eliminate heat leakage. Temp. by thermocouples	
□	Ibid.	57-181	1188-2121	Basic Schamotte brick	Same as above	
◇	Ibid.	57-181	1248-2247	Magnesite brick "hü"	Same as above	



EMISSIVITY -- CHROME MAGNESITE

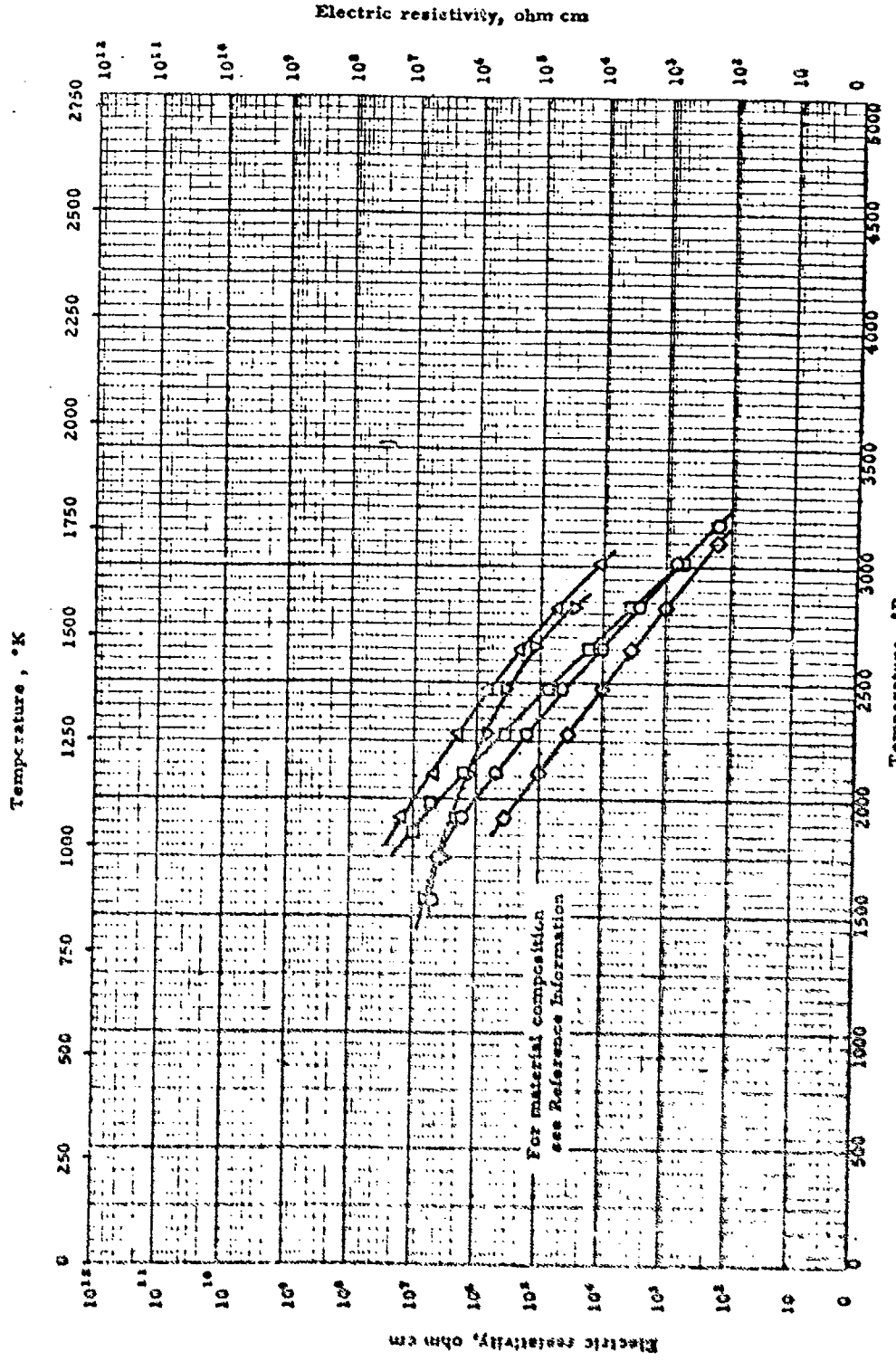
60-562
WADC TR 59-476 III S
VE - E - 10

WADC TR 59-676 116

EMISSIVITY -- CHROME MAGNESITE

REFERENCE INFORMATION

	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Pattison, J. R.	55-86	2112-3192	Chrome magnesite basic firebrick	Total normal emissivity: Hilger thermopile. *Temp. by optical pyrometer* focused on black body hole	Rib block
□	Ibid.	55-86	2094-3048	Same as above	Same as above	Used brick
△	Ibid.	55-86	2076-2742	Same as above	Same as above	1st sample contaminated with iron oxide
◇	Ibid.	55-86	2238-3192	Same as above	Same as above	2nd sample contaminated with iron oxide



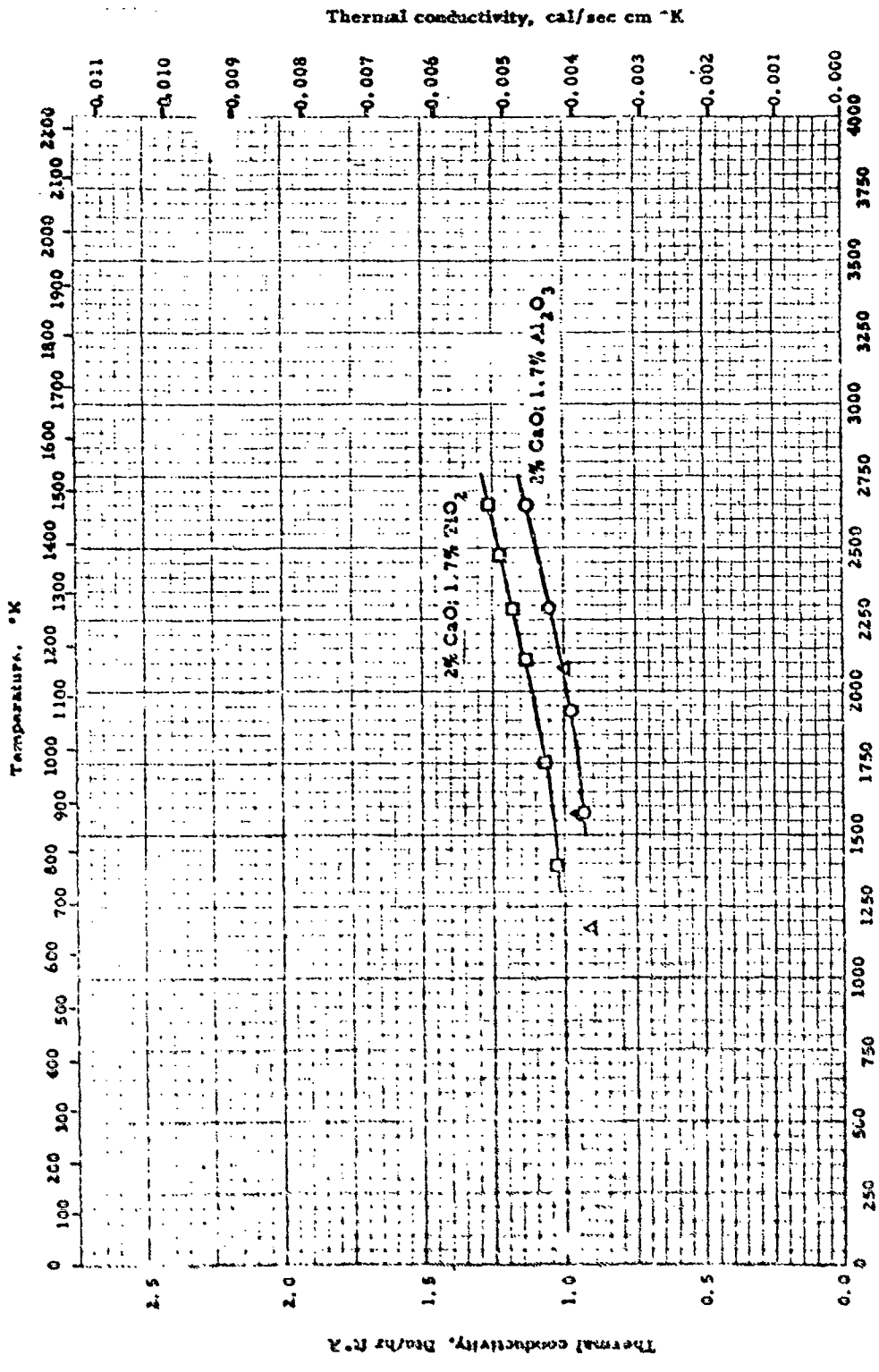
ELECTRIC RESISTIVITY -- BASIC BRICK

AEDC-TR-60-176
AD 315 114

ELECTRIC RESISTIVITY -- BASIC BRICK

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Chlorbath, V. E. J. and Henry, E. C.	53-94	1572-3192	Basic brick (Forsterite) commercial material; composition not given; apparent porosity 21%	Wheatstone bridge at 965 cycles	Auth. est. error ± 10% at 10^4 ohm-cm ± 4% at 50,000 ohm-cm ± 0.3% at 100 ohm-cm
□	Ibid.	53-94	1860-3010	82% MgO; porosity = 18%	Same as above	Same as above
△	Ibid.	53-94	1930-3010	90-95% MgO; porosity = 17%	Same as above	Same as above
◇	Ibid.	53-94	1930-3100	Magnesite-chrome; porosity = 19%	Same as above	Same as above
▽	Ibid.	53-94	1570-2830	Chrome-magnesite; porosity = 14%	Same as above	Same as above

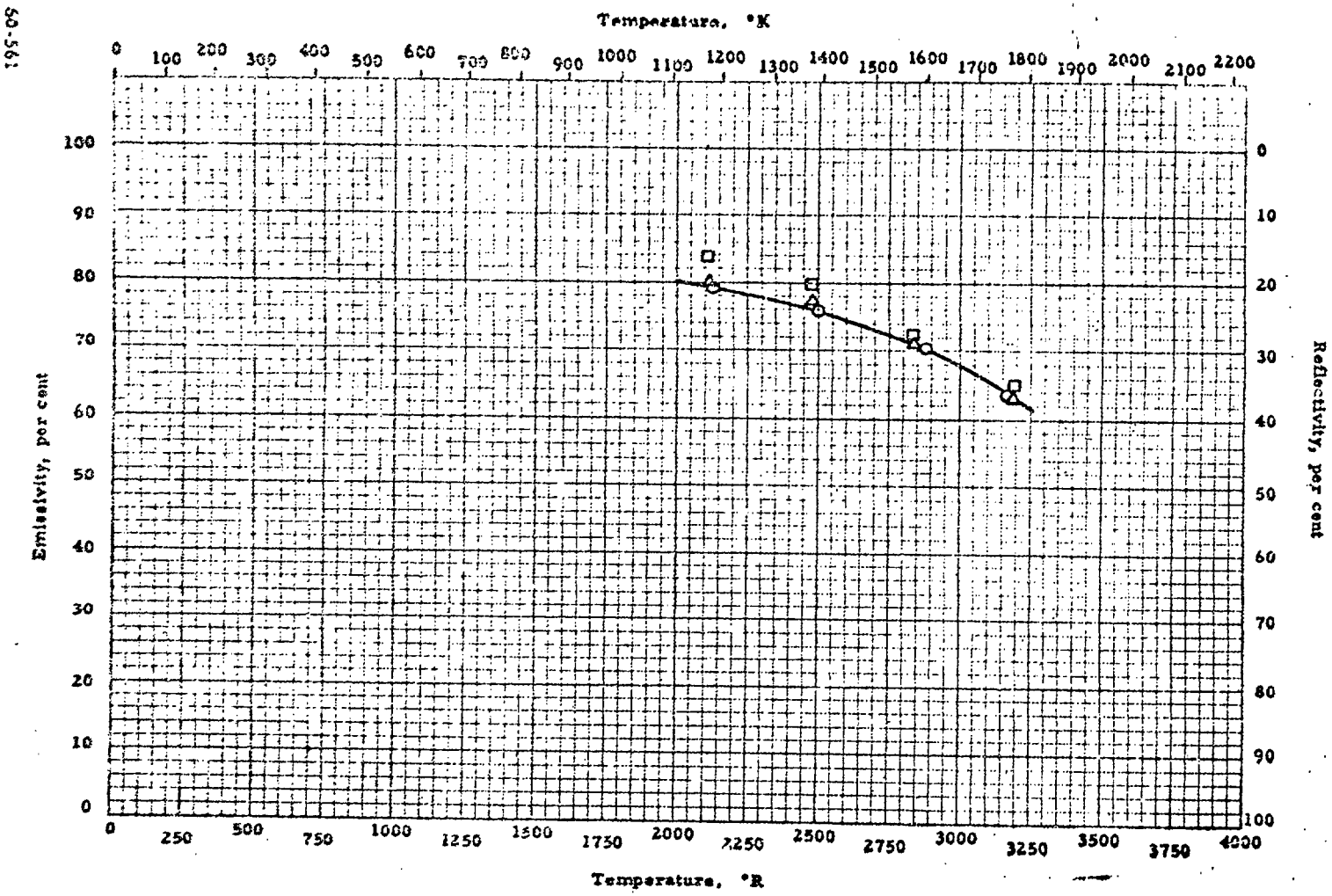


THERMAL CONDUCTIVITY -- SILICA BRICK

THERMAL CONDUCTIVITY -- SILICA BRICK

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Clements, J. F. and Vyse, J.	57-26	1572-2652	95.33% SiO_2; 2.07% CaO; 1.71% Al_2O_3; 0.53% Fe_2O_3; 0.25% Na_2O; 0.13% K_2O; 0.12% TiO_2; 0.12% loss on ignition. Bulk ρ = 107 lb_m/ft^3 (cf. theor. ρ = 146) apparent porosity = 26.4%	Not described; used apparatus of Brit. Ceramic Research Assn.	Auth. est. accuracy ± 5%
□	Ibid.	57-26	1392-2652	94.20% SiO_2; 2.01% CaO; 1.72% TiO_2; 0.76% Fe_2O_3; 0.29% Al_2O_3; 0.22% MnO, trace of MgO; no K_2O, Na_2O or loss on ignition. Bulk ρ = 119 lb_m/ft^3 (cf. theor. ρ = 146) apparent porosity = 18.7%	Same as above	Made from South African silcrete rock. Auth. est. accuracy ± 5%
Δ	Klasse, F., Heinz, A. and Hein, J.	57-191	1170-2090	Coke oven silica brick	Comparative, disks with heated guard cylinder	



EMISSIVITY -- SILICA BRICK

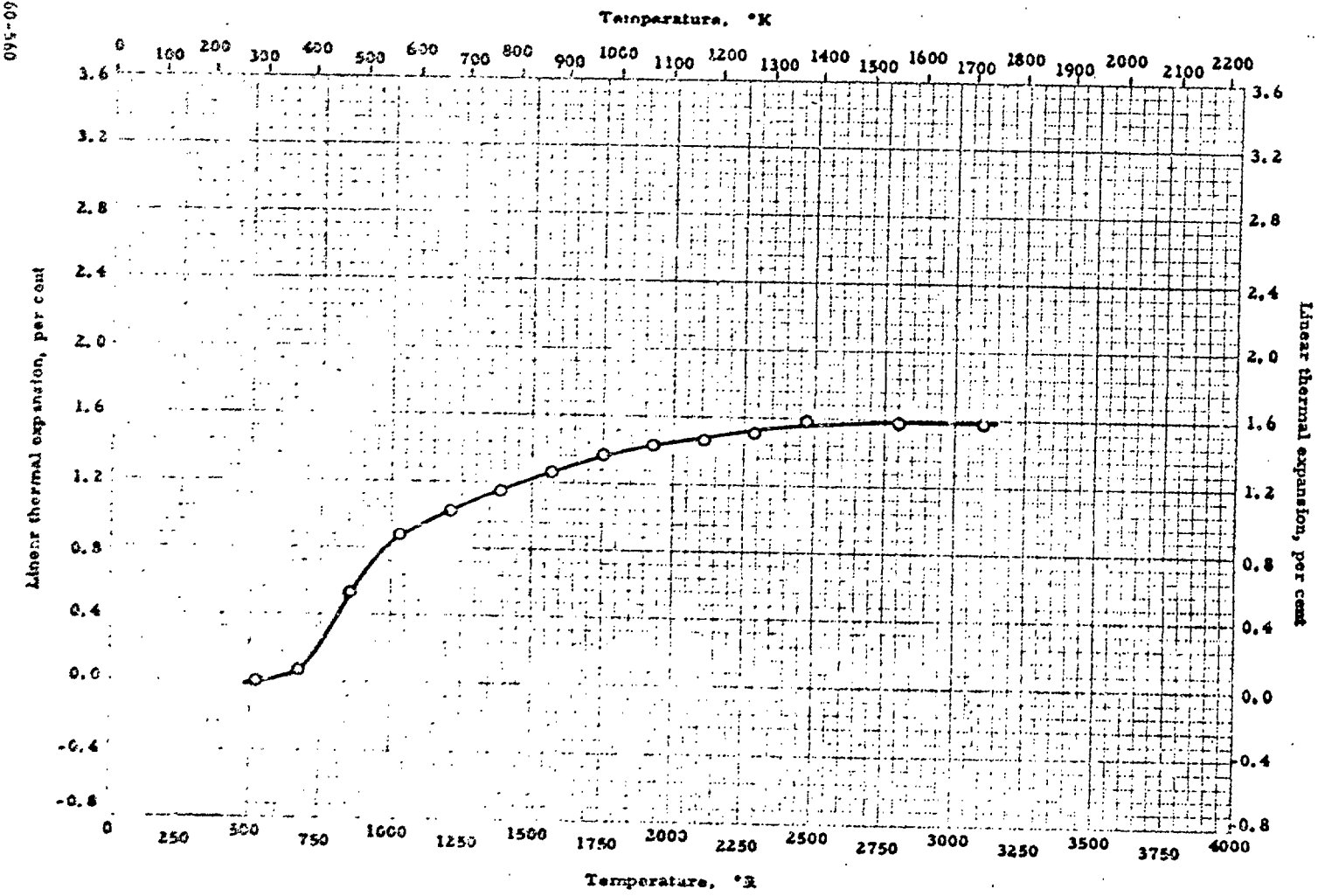
60-561

1122

EMISSIVITY -- SILICA BRICK

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Pattison, J. R.	55-35	2112-3192	Silica firebrick	Total normal emissivity: Hilger thermopile. Temp. by optical pyrometer focused on black body hole	
□	Ibid.	55-86	2112-3192	Silicrete quality silica brick	Same as above	
△	Ibid.	55-86	2112-3192	Standard roof quality silica brick	Same as above	



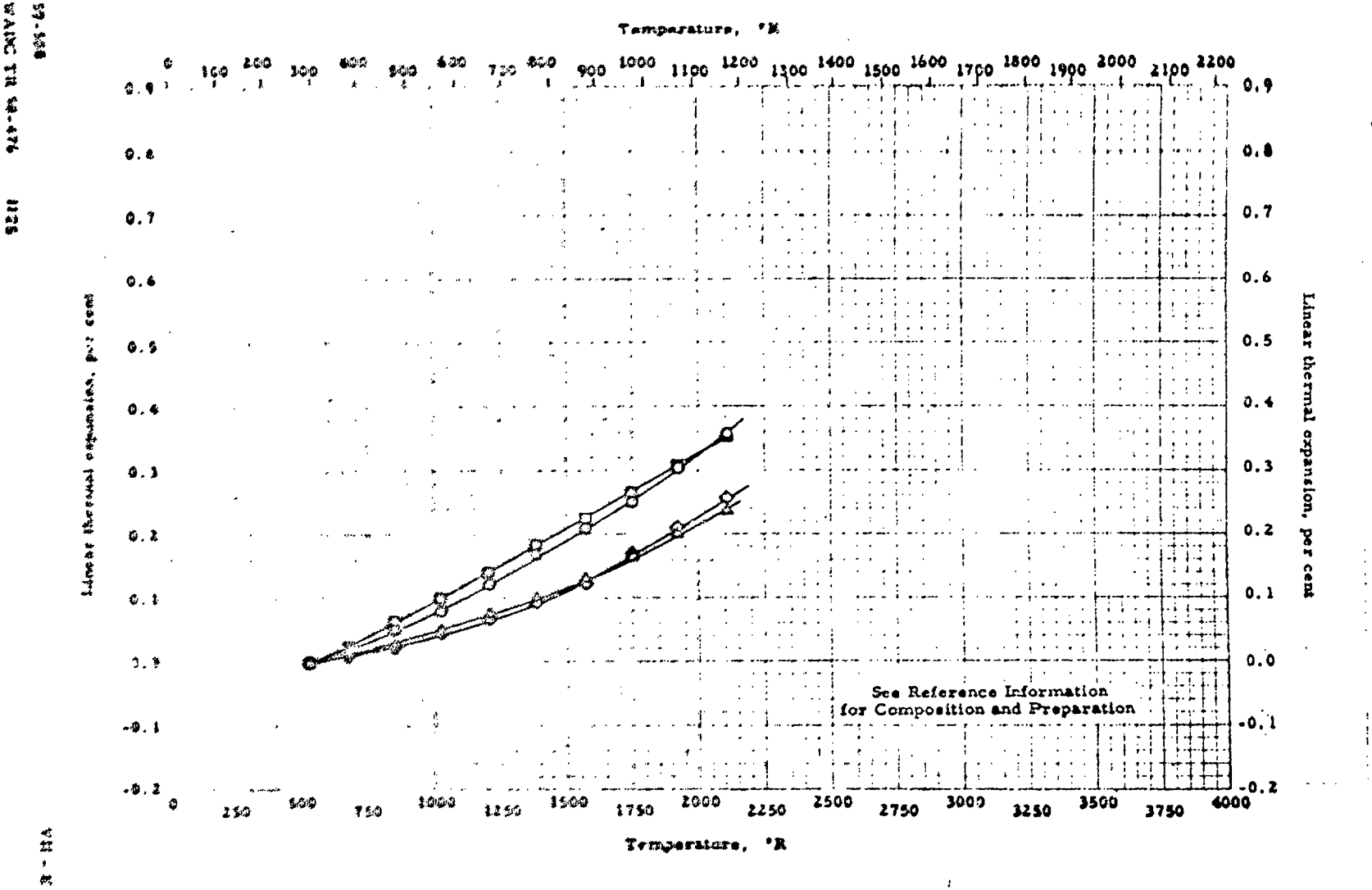
LINEAR THERMAL EXPANSION -- SILICA BRICK

LINEAR THERMAL EXPANSION -- SILICA BRICK

WADC TR 54-476 1124

REFERENCE INFORMATION

Fig. No.	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Pawlowski, S.	57-183	672-3103	Silica Refractory. 97.43 - 98.36% SiO_2; 1.2 - 1.8% R_2O_3; 0.25 - 0.49% CaO. ρ = 141 lb_m/ft^3	Not given	Made from 70-79% Cristobolite; 12-18% trydemite; 9-12% quartz; Material III-H. Mixed 15 min., hydraulically pressed 5 times at 800 kg/cm^2, dried, fired

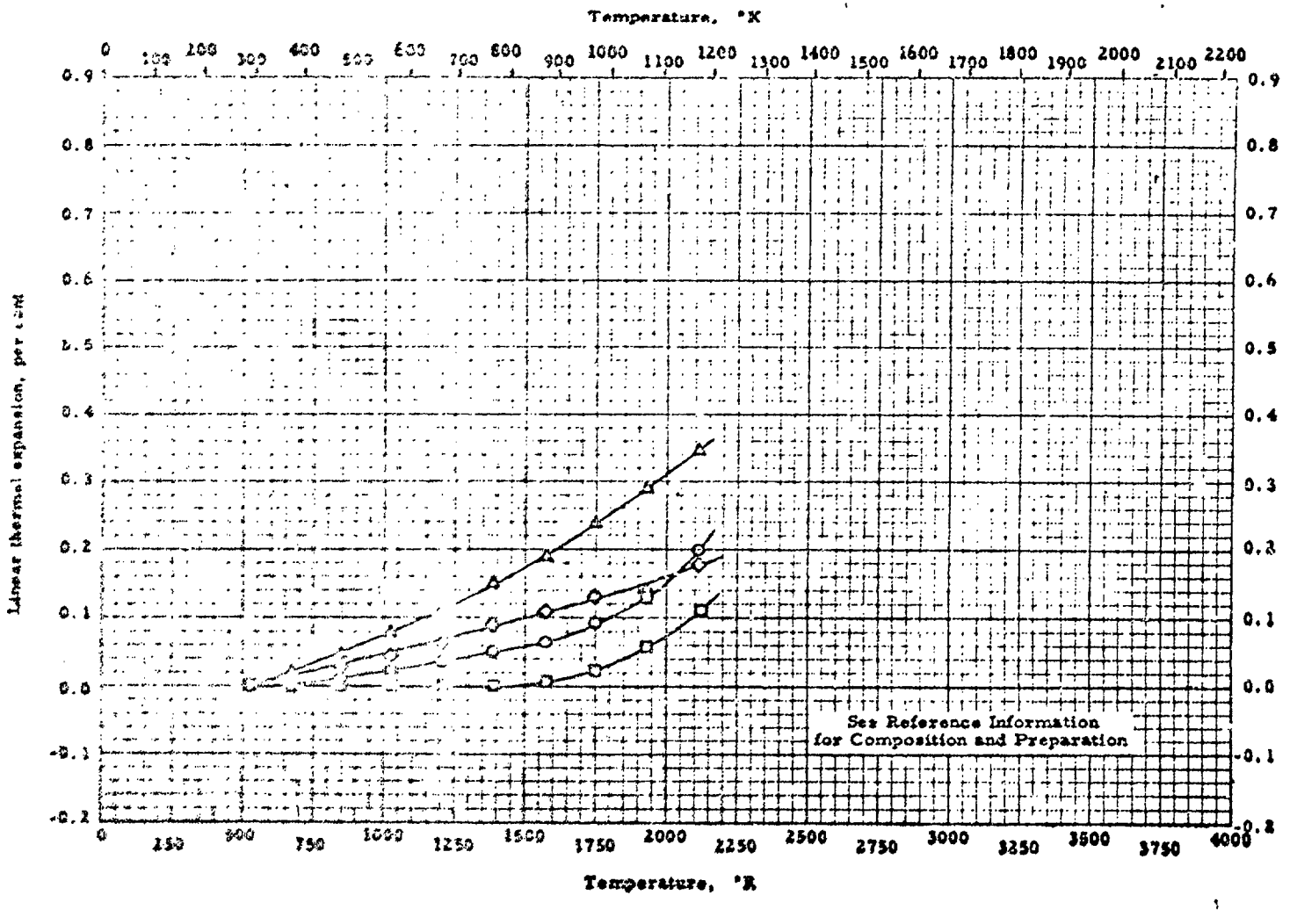


LINEAR THERMAL EXPANSION -- VITREOUS BONDED ALUMINUM TITANATE
(58 - 68 vol % Al_2O_3 . TiO_2: 21 - 39 vol % α - Al_2O_3 Inclusions; 0 - 10 vol % Mullite)

LINEAR THERMAL EXPANSION -- VITREOUS BONDED ALUMINUM TITANATE
(58 - 68 vol % $Al_2O_3 \cdot TiO_2$; 21 - 39 vol % $\alpha - Al_2O_3$ Inclusions; 0 - 10 vol % Mullite)

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Koch, W.J. and Harman, C.G.	50-12	528-2112	67.5 vol % $Al_2O_3 \cdot TiO_2$ crystals; 21.6 vol % $\alpha - Al_2O_3$ inclusions; 10.0 vol % mullite crystals; 1.0 vol % isotropic glass, apparent porosity 7.80%	Not given	Equimolar mix of fused Al_2O_3 (6μ) and c.p. TiO_2 wet milled, dried, temporary wax binder added screened (50 mesh), pressed (10,000 lb/in.^{2}), fired in 8 hr. to 650°C, fired in 24 hr. to 1820°C, held 1 hr. furnace cooled, powdered, mixed with more fused Al_2O_3, fired to 1650°C
□	Ibid.	50-12	528-2112	61.0 vol % $Al_2O_3 \cdot TiO_2$ crystals; 38.7 vol % $\alpha - Al_2O_3$ inclusions; 0.3 vol % mineral impurities, apparent porosity 22.6%	Same as above	Ignited $\gamma - Al_2O_3$ (1μ) treated as above
△	Ibid.	50-12	528-2112	60.0 vol % $Al_2O_3 \cdot TiO_2$ crystals; 33.8 vol % $\alpha - Al_2O_3$ inclusions; 5.2 vol % mullite; 1.0 vol % isotropic glass, apparent porosity 5.55%	Same as above	Same as above
◇	Ibid.	50-12	528-2112	58.1 vol % $Al_2O_3 \cdot TiO_2$ crystals; 37.9 vol % $\alpha - Al_2O_3$ inclusions; 3.5 vol % mullite; 0.5 vol % isotropic glass, apparent porosity 6.06%	Same as above	Same as above



LINEAR THERMAL EXPANSION -- VITREOUS BONDED ALUMINUM TITANATE
(74 - 78 vol % $Al_2O_3 \cdot TiO_2$; 12 - 20 vol % $\alpha - Al_2O_3$ Inclusions; 6 - 11 vol % Mullite)

LINEAR THERMAL EXPANSION -- VITREOUS BONDED ALUMINUM TITANATE
(74 - 78 vol % $Al_2O_3 \cdot TiO_2$; 12 - 20 vol % $\alpha - Al_2O_3$ Inclusions; 6 - 11 vol % Mullite)

REFERENCE INFORMATION

Sym	Investigator	Ref.	Range, °F	Material Composition	Test Method	Remarks
○	Koch, W. J. and Harman, C. G.	50-12	528-2112	78 vol % $Al_2O_3 \cdot TiO_2$ crystals; 11 vol % mullite crystals; 11 vol % isotropic glass, apparent porosity 7.05%	Not given	Equimolar mix of fused Al_2O_3 (6μ) and c.p. TiO_2 wet milled, dried, temporary wax binder added, screened (50 mesh), pressed (10,000 lb/in.^{2}), fired in 8 hr to 650 C, fired in 26 hr to 1820 C, held 1 hr, furnace cooled, powdered, mixed with more fused Al_2O_3, fired to 1650 C
□	Ibid.	50-12	528-2112	77 vol % $Al_2O_3 \cdot TiO_2$ crystals; 15 vol % isotropic glass; 8.0 vol % mullite crystals, apparent porosity 6.5%	Same as above	Same as above
△	Ibid.	50-12	528-2112	75.2 vol % $Al_2O_3 \cdot TiO_2$ crystals; 12.8 vol % $\alpha - Al_2O_3$ inclusions; 11 vol % mullite crystals; 1.0 vol % isotropic glass, apparent porosity 6.12%	Same as above	Same as above
◇	Ibid.	50-12	528-2112	74.0 vol % $Al_2O_3 \cdot TiO_2$ crystals; 19.1 vol % $\alpha - Al_2O_3$ inclusions; 6.4 vol % mullite crystals; 0.5 vol % isotropic glass, apparent porosity 5.81%	Same as above	Ignited $\gamma - Al_2O_3$ (1μ) treated as above

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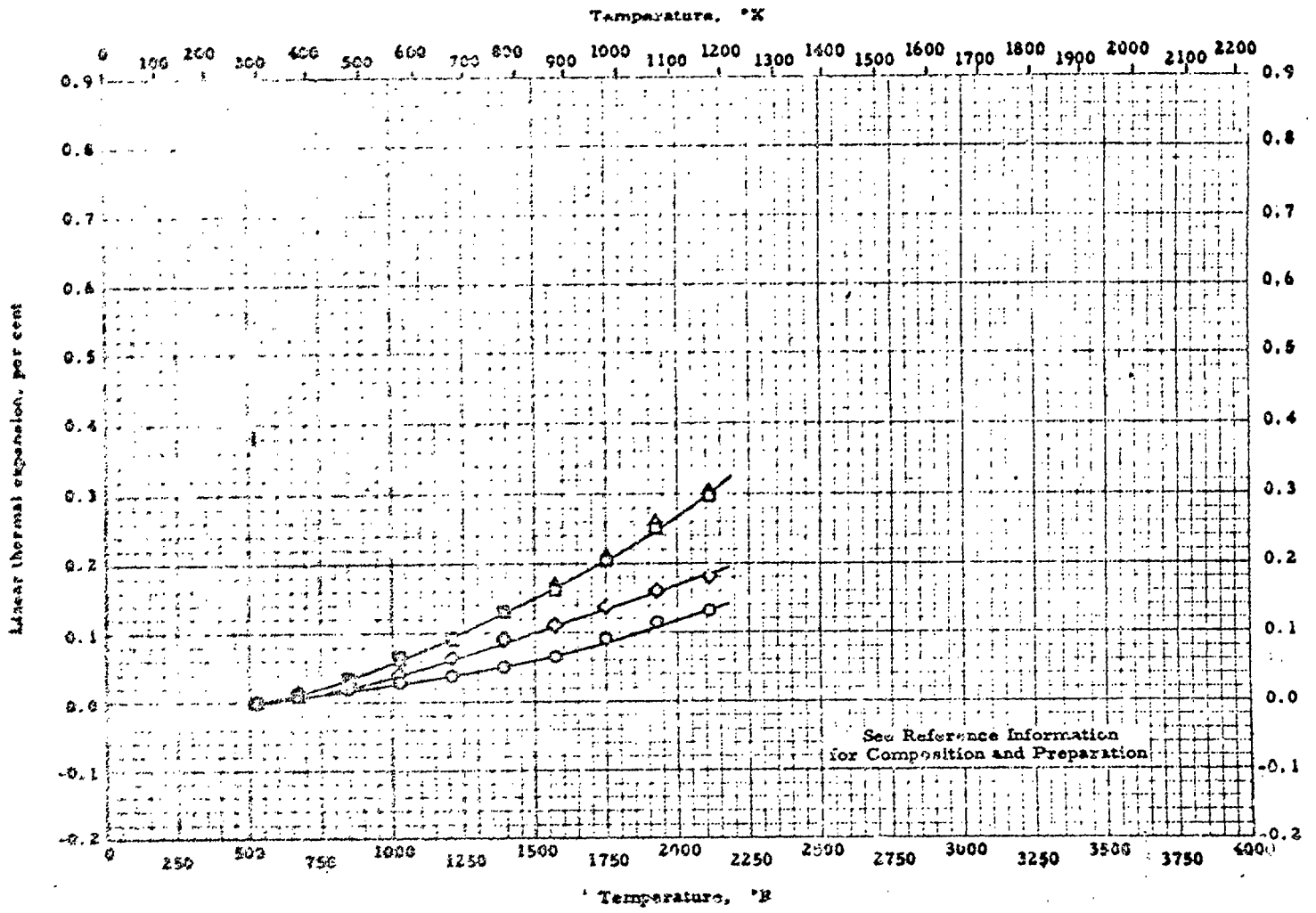
59-585



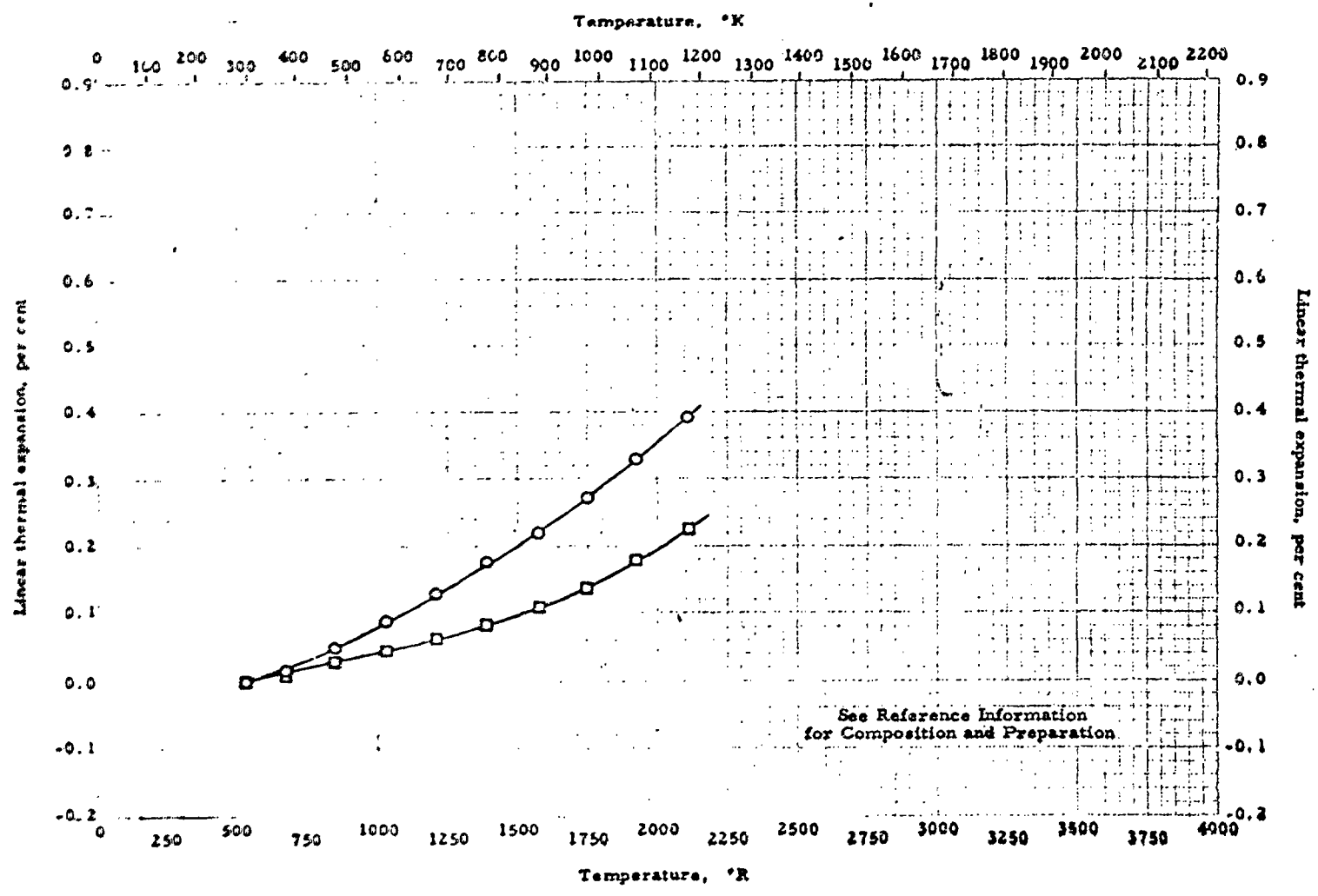
LINEAR THERMAL EXPANSION - VITREOUS BONDED ALUMINUM TITANATE
(83 - 87 vol % $Al_2O_3 \cdot TiO_2$; 0 - 10 vol % $\alpha - Al_2O_3$ Inclusions; 9 - 16 vol % Mullite)

VEL - 8

LINEAR THERMAL EXPANSION -- VITREOUS BONDED ALUMINUM TITANATE
(80 - 87 vol % $Al_2O_3 \cdot TiO_2$; 0 - 10 vol % $\alpha - Al_2O_3$ Inclusions; 9 - 16 vol % Mullite)

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Buch, W. J. and Harman, C. C.	59-12	528-2112	87.6 vol % $Al_2O_3 \cdot TiO_2$ crystals; 11 vol % mullite crystals; 1.0 vol % $\alpha - Al_2O_3$ inclusions; 1.0 vol % isotropic glass, apparent porosity 6.24%	Not given	Equimolar mix of ignited γ-Al_2O_3 (1μ) and c.p. TiO_2 wet milled, dried, temporary wax binder added screened (50 mesh), pressed (10,000 lb/in.^{2}), fired in 8 hr to 650°C, fired in 26 hr to 1820°C, held 1 hr, furnace cooled, powdered, mixed with more ignited γ Al_2O_3, fired to 1650°C
□	Ibid.	59-12	528-2112	83.9 vol % $Al_2O_3 \cdot TiO_2$ crystals; 9.2 vol % mullite crystals; 4.9 vol % $\alpha - Al_2O_3$ inclusions; 2.0 vol % isotropic glass, apparent porosity 5.57%	Same as above	Fused Al_2O_3 (6μ) treated as above
△	Ibid.	59-12	528-2112	81 vol % $Al_2O_3 \cdot TiO_2$ crystals; 16 vol % mullite crystals; 3 vol % isotropic glass, apparent porosity 7.08 %	Same as above	Same as above
◇	Ibid.	59-12	528-2112	80.6 vol % $Al_2O_3 \cdot TiO_2$ crystals; 10.0 vol % mullite crystals; 8.4 vol % $\alpha - Al_2O_3$ inclusions; 1.0 vol % isotropic glass, apparent porosity 5.67 %	Same as above	Ignited γ-Al_2O_3 treated as above

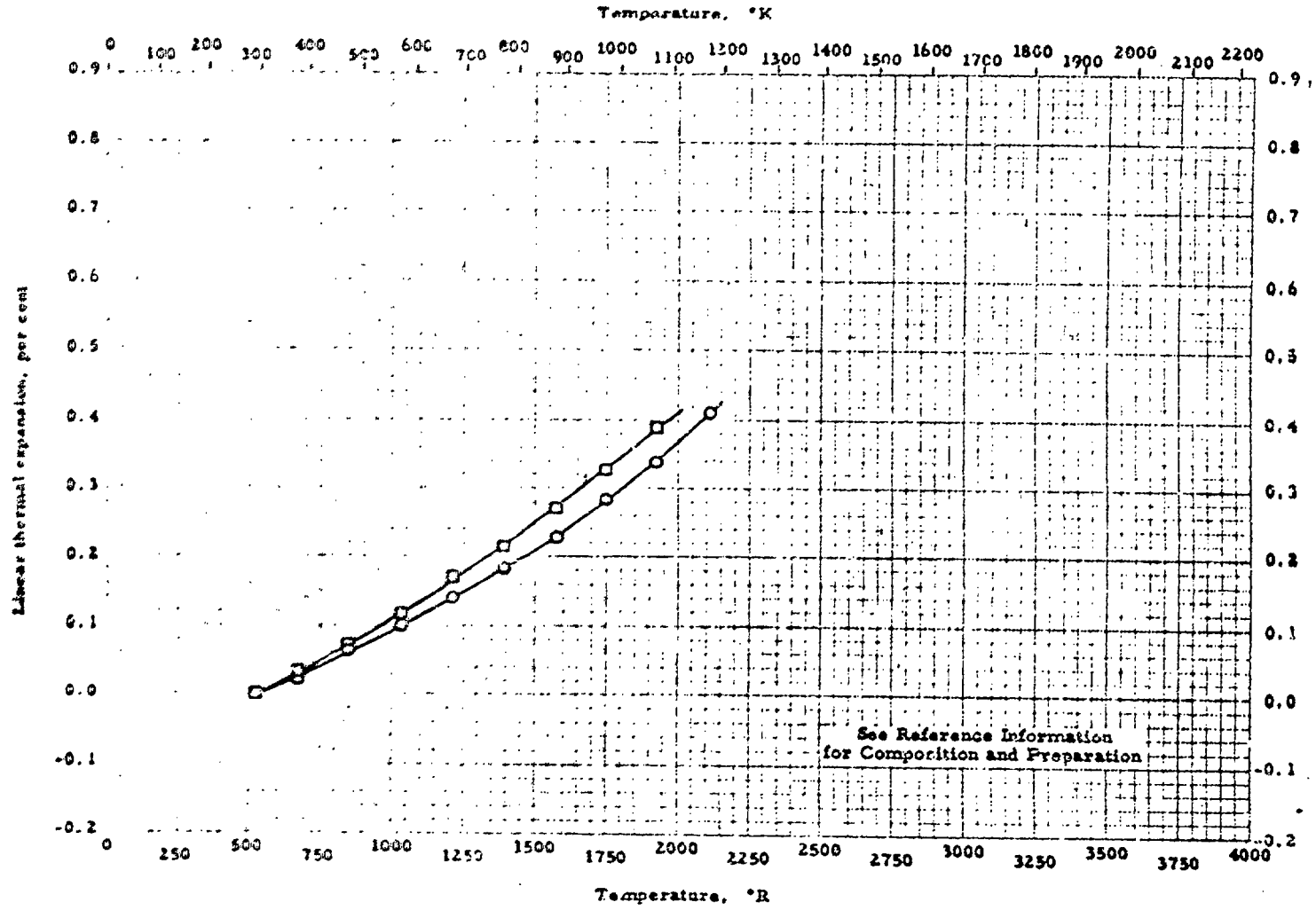


LINEAR THERMAL EXPANSION -- VITREOUS BONDED ALUMINUM TITANATE
(72 - 76 vol % $Al_2O_3 \cdot TiO_2$; 23 - 27 vol % α - Al_2O_3 Inclusions)

LINEAR THERMAL EXPANSION -- VITREOUS BONDED ALUMINUM TITANATE
(72 - 76 vol % $Al_2O_3 \cdot TiO_2$; 23 - 27 vol % α - Al_2O_3 Inclusions)

REFERENCE INFORMATION

	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Koch, W. J. and Norman, C. C.	50-12	528-2112	75.3 vol % $Al_2O_3 \cdot TiO_2$ crystals; 23.7% vol % α - Al_2O_3 inclusions; 1 vol % mineral impurities, apparent porosity 16.0%	Not given	Fused Al_2O_3(6 μ) and c.p. TiO_2 wet milled, dried, temporary wax binder added, screened (50 mesh), pressed (10,000 lb/in.^{2}), fired in 8 hr. to 630°C, fired in 26 hr. to 1820°C, held 1 hr., furnace cooled
□	Ibid.	50-12	528-2112	72.1% vol % $Al_2O_3 \cdot TiO_2$ crystals; 26.9 vol % α - Al_2O_3 inclusions; 1 vol % mineral impurities, apparent porosity 10.5%	Same as above	Same as above



LINEAR THERMAL EXPANSION -- VITREOUS BONDED ALUMINUM TITANATE
(80 - 84 vol % $Al_2O_3 \cdot TiO_2$; 16 - 20 vol % α - Al_2O_3 Inclusions)

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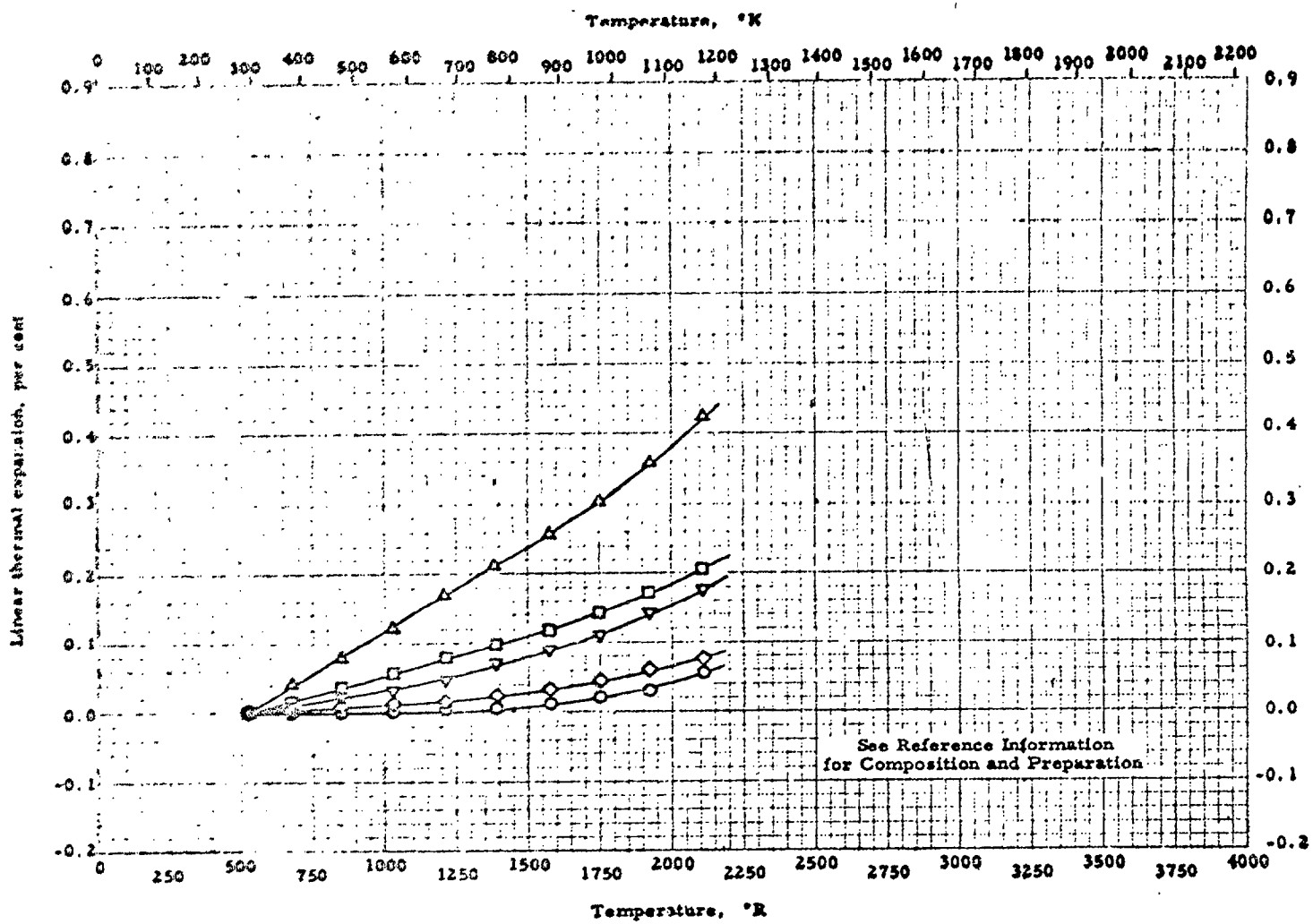
LINEAR THERMAL EXPANSION -- VITREOUS BONDED ALUMINUM TITANATE
(20 - 24 vol % $Al_2O_3 \cdot TiO_2$; 16 - 20 vol % $\alpha - Al_2O_3$ inclusions)

REFERENCE INFORMATION

	Investigator	Ref.	Range, °F	Material Composition	Test Method	Remarks
O	Hasselman, W. J. and Fulrath, C. C.	50-12	522-2512	81.5 vol % $Al_2O_3 \cdot TiO_2$ crystals, 16.2 vol % $\alpha - Al_2O_3$ inclusions; 0.3 vol % mineral impurities, apparent porosity 23.9%	Not given	Ignited γ-Al_2O_3 (1μ) and c.p. TiO_2 wet milled, dried, temporary wax binder added, screened (50 mesh), pressed (10,000 lb/in.^{2}), fired in 8 hr to 650°C, fired in 24 hr to 1820°C, held 1 hr, furnace cooled
□	Ibid.	50-12	522-1922	80.2 vol % $Al_2O_3 \cdot TiO_2$ crystals, 19.5 vol % $\alpha - Al_2O_3$ inclusions; 0.3 vol % mineral impurities, apparent porosity 27.0%	Same as above	Same as above

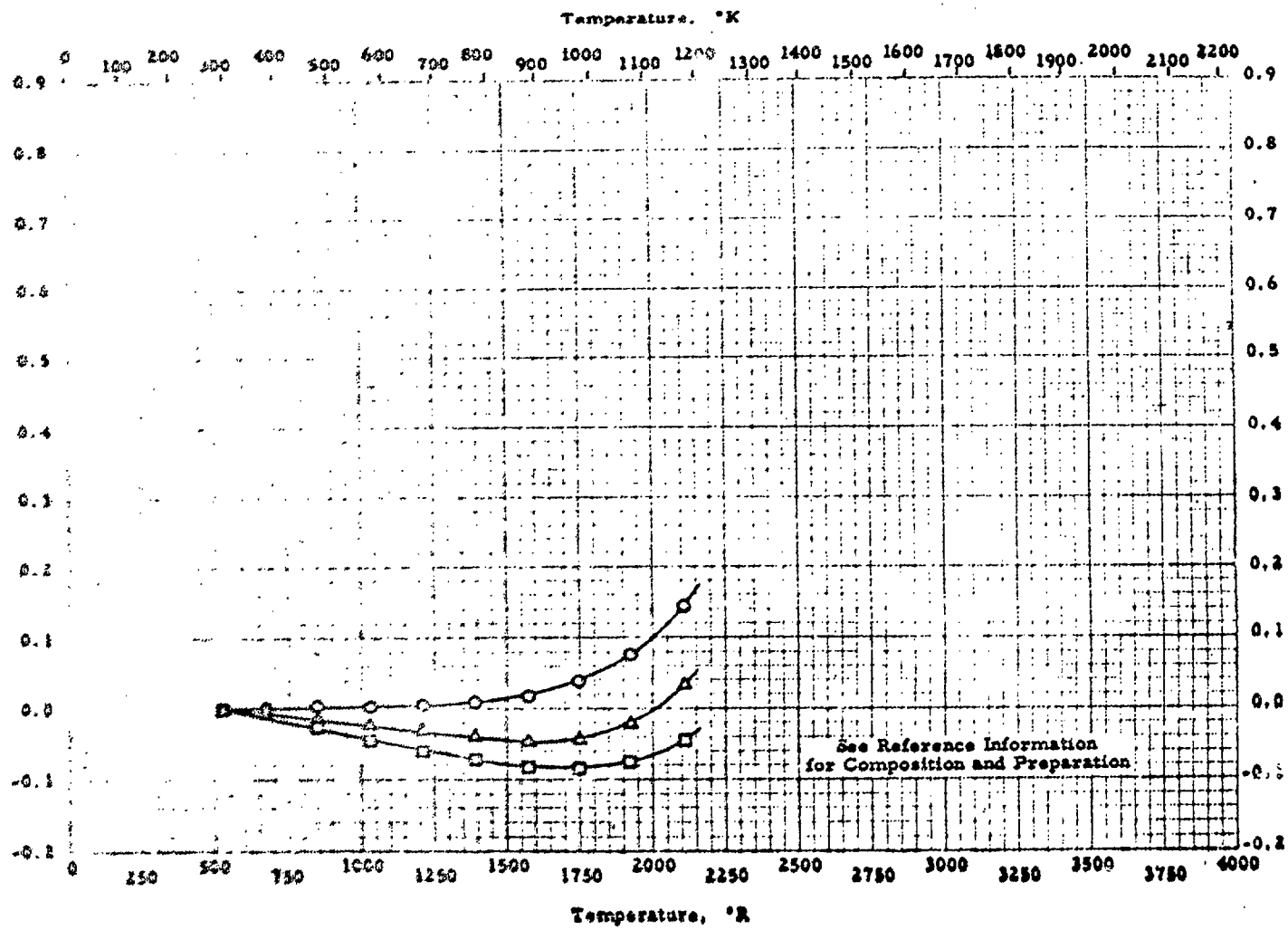


LINEAR THERMAL EXPANSION -- VITREOUS BONDED ALUMINUM TITANATE
(91 - 94 vol % $Al_2O_3 \cdot TiO_2$; 5 - 8 vol % α - Al_2O_3 Inclusions)

LINEAR THERMAL EXPANSION -- VITREOUS BONDED ALUMINUM TITANATE
(91 - 94 vol % $Al_2O_3 \cdot TiO_2$; 5 - 8 vol % α - Al_2O_3 Inclusions)

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Koch, W. J. and Harman, C. G.	50-12	528-2112	92.8 vol % $Al_2O_3 \cdot TiO_2$ crystals; 7.2 vol % α - Al_2O_3 inclusions apparent porosity 30.1%	Not given	Ignited γ Al_2O_3 (1μ) and c.p. TiO_2 wet milled, dried, temporary wax binder added, screened (50 mesh), pressed (10,000 lb/in.^{2}), fired in 8 hr to 650°C, fired in 26 hr to 1820°C, held 1 hr, furnace cooled
□	Ibid.	50-12	528-2112	92.0 vol % $Al_2O_3 \cdot TiO_2$ crystals; 8.0 vol % α-Al_2O_3 inclusions, apparent porosity 27.5%	Same as above	Same as above
△	Ibid.	50-12	528-2112	91.7 vol % $Al_2O_3 \cdot TiO_2$ crystals; 7.3 vol % α - Al_2O_3 inclusions, 1% mineral impurities, apparent porosity 26.8%	Same as above	Fused Al_2O_3 (6μ) and c.p. TiO_2 treated as above
◇	Ibid.	50-12	528-2112	93.7 vol % $Al_2O_3 \cdot TiO_2$ crystals; 5.3 vol % α - Al_2O_3 inclusions, 1% mineral impurities, apparent porosity 22.3%	Same as above	Same as above
▽	Ibid.	50-12	528-2112	91.1 vol % $Al_2O_3 \cdot TiO_2$ crystals; 7.9 vol % α - Al_2O_3 inclusions, 1.0% mineral impurities, apparent porosity 15.8 %	Same as above	Same as above

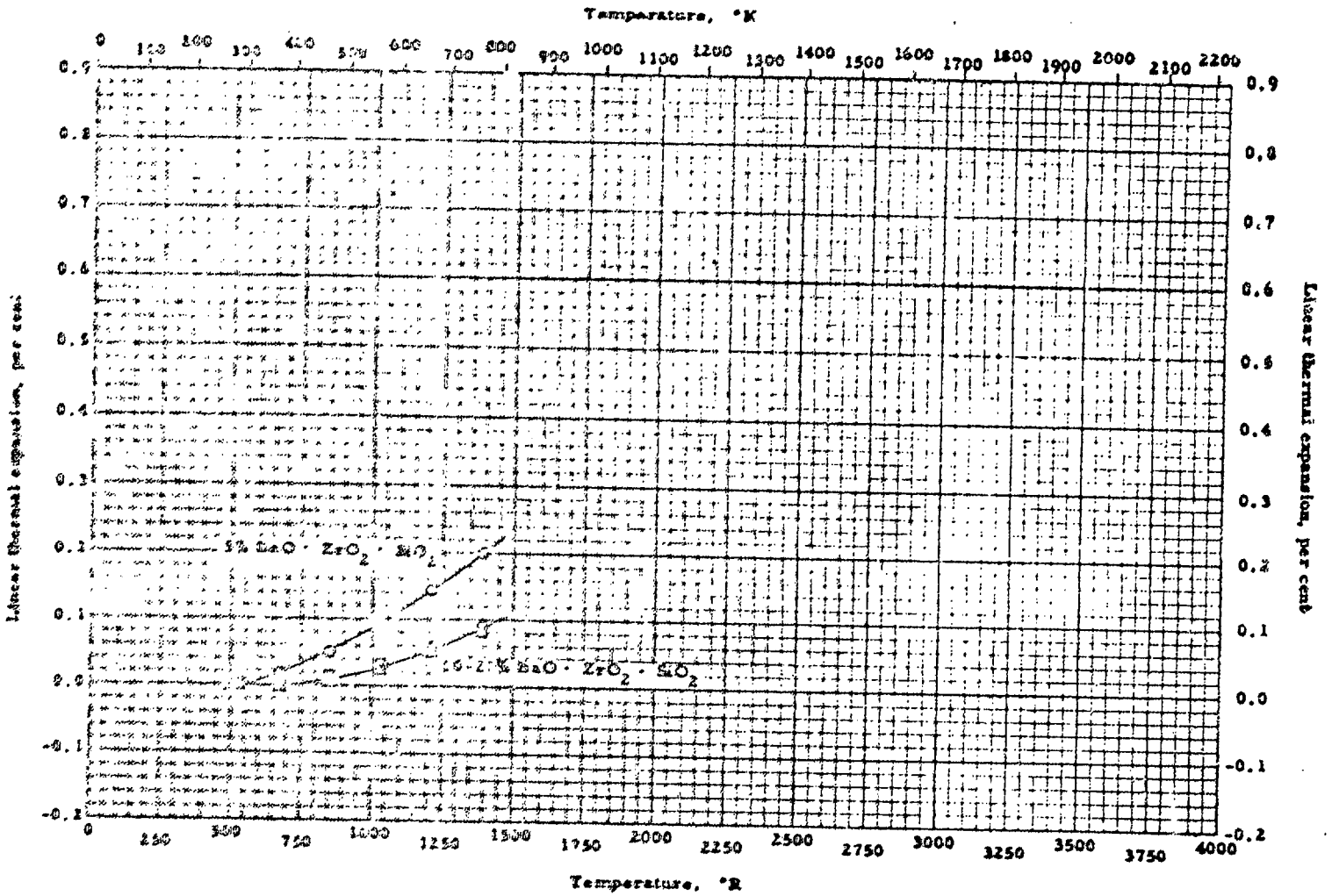


LINEAR THERMAL EXPANSION -- VITREOUS BONDED ALUMINUM TITANATE
(51 - 90 vol % $Al_2O_3 \cdot TiO_2$; 1 - 3 vol % Mullite)

LINEAR THERMAL EXPANSION -- VITREOUS BONDED ALUMINUM TITANATE
(91 - 99 vol % $Al_2O_3 \cdot TiO_2$; 1 - 3 vol % Mullite)

REFERENCE INFORMATION

	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Koch, W. J. and Harrman, C. G.	50-12	528-2112	89.3 vol % $Al_2O_3 \cdot TiO_2$ crystals; 9.7 vol % isotropic glass, 1.0 vol % mullite crystals, apparent porosity 8.4%	Not given	Equimolar mix of ignited γ-Al_2O_3 (1μ) and c.p. TiO_2 wet milled, dried, temporary wax binder added, screened (50 mesh), pressed (10,000 lb/in.^{2}), fired in 8 hr to 650°C, fired in 26 hr to 1820°C, held 1 hr, furnace cooled, reground, mixed with c.p. TiO_2, refired to 1650°C
□	Ibid.	50-12	528-2112	91.3 vol % $Al_2O_3 \cdot TiO_2$ crystals; 15.7 vol % isotropic glass, 3.0 vol % mullite crystals, apparent porosity 5.76 %	Same as above	Same as above
△	Ibid.	50-12	528-2112	91.3 vol % $Al_2O_3 \cdot TiO_2$ crystals; 17.7 vol % isotropic glass, 1.0 vol % mullite crystals, apparent porosity 5.33 %	Same as above	Same as above



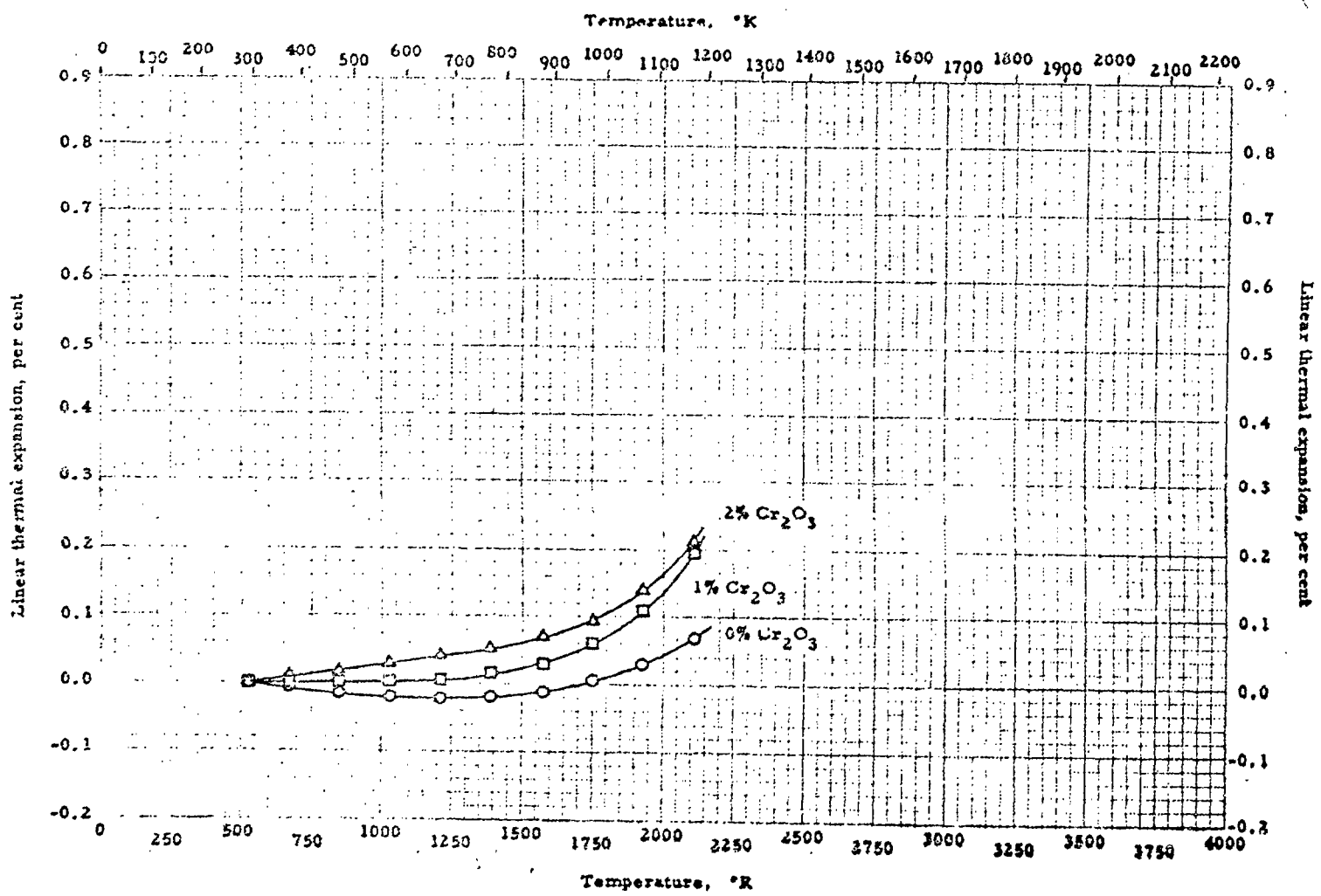
LINEAR THERMAL EXPANSION -- VITREOUS BONDED ALUMINUM TITANATE WITH $BaO-ZrO_2-SiO_2$

59-299
WADC TR 58-476
1140

LINEAR THERMAL EXPANSION -- VITREOUS BONDED ALUMINUM TITANATE WITH $BaO-ZrO_2-SiO_2$

REFERENCE INFORMATION

	Investigator	Ref.	Range, °F	Material Composition	Test Method	Remarks
○	Zimmerman, W. F. Plankerhorn, W. J. and Bennett, D. G.	53-42	528-1392	95% $Al_2O_3 \cdot TiO_2$ 5% $BaO \cdot ZrO_2 \cdot SiO_2$	Interferometer	
□	Ibid.	53-42	528-1392	90% $Al_2O_3 \cdot TiO_2$; 10% $BaO \cdot ZrO_2 \cdot SiO_2$	Same as above	
△	Ibid.	53-42	528-1392	80% $Al_2O_3 \cdot TiO_2$; 20% $BaO \cdot ZrO_2 \cdot SiO_2$	Same as above	

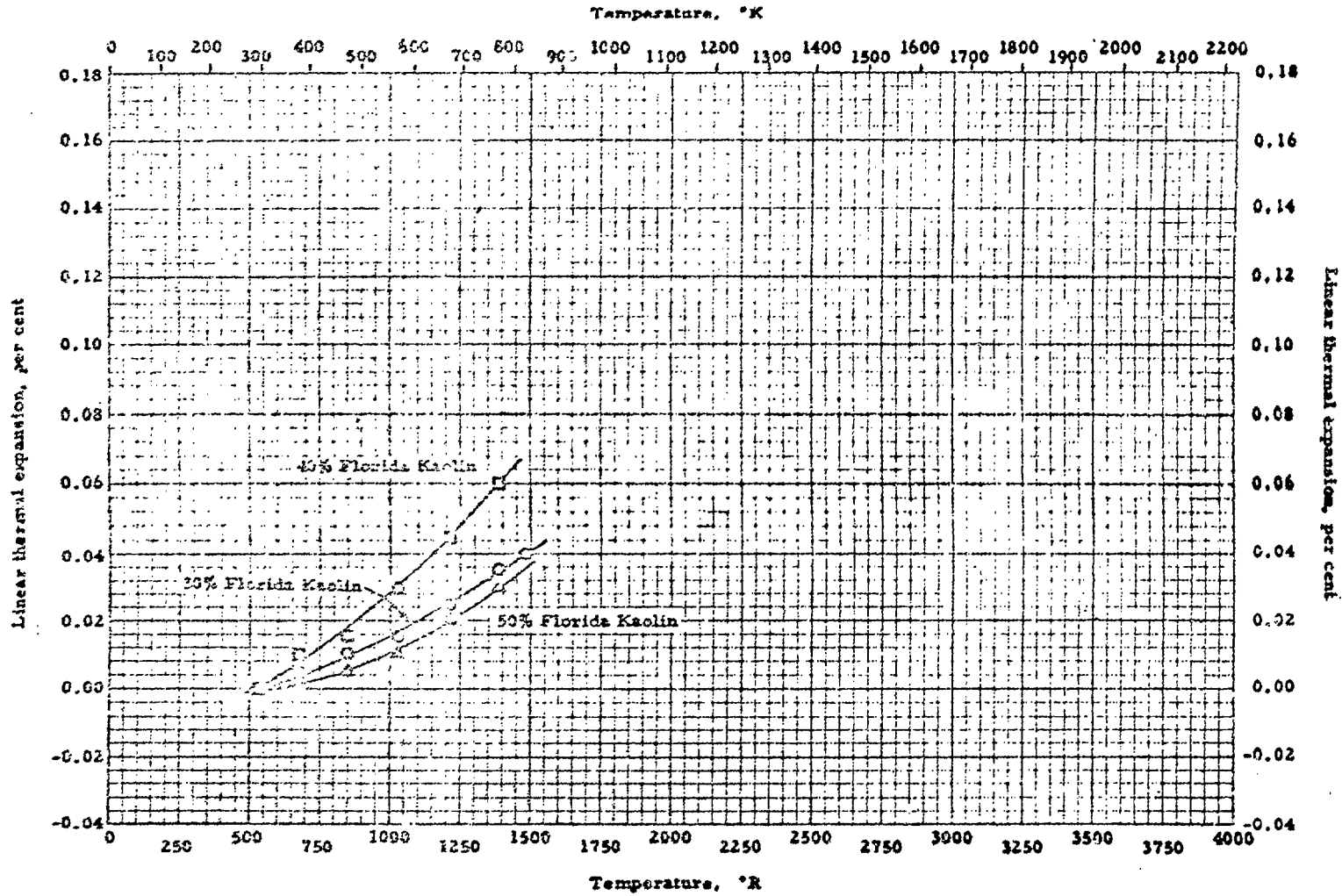


LINEAR THERMAL EXPANSION -- VITREOUS BONDED ALUMINUM TITANATE WITH Cr_2O_3

LINEAR THERMAL EXPANSION -- VITREOUS BONDED ALUMINUM TITANATE WITH Cr_2O_3

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °F	Material Composition	Test Method	Remarks
O	Koch, W. J. and Harman, C. G.	50-12	528-2112	100% $Al_2O_3 \cdot TiO_2$	Not given	Equimolar Al_2O_3 and TiO_2 wet milled, dried, temporary wax binder added, screened (50 mesh), pressed (10,000 lb/in^2), fired in 8 hr. to 650°C, fired in 26 hr. to 1820°C, held 1 hr., furnace cooled
□	Ibid.	50-12	528-2112	99% $Al_2O_3 \cdot TiO_2$; 1% Cr_2O_3	Same as above	Above material ground, Cr_2O_3 added, refired to 1650°C
Δ	Ibid.	50-12	528-2112	98% $Al_2O_3 \cdot TiO_2$; 2% Cr_2O_3	Same as above	Same as above

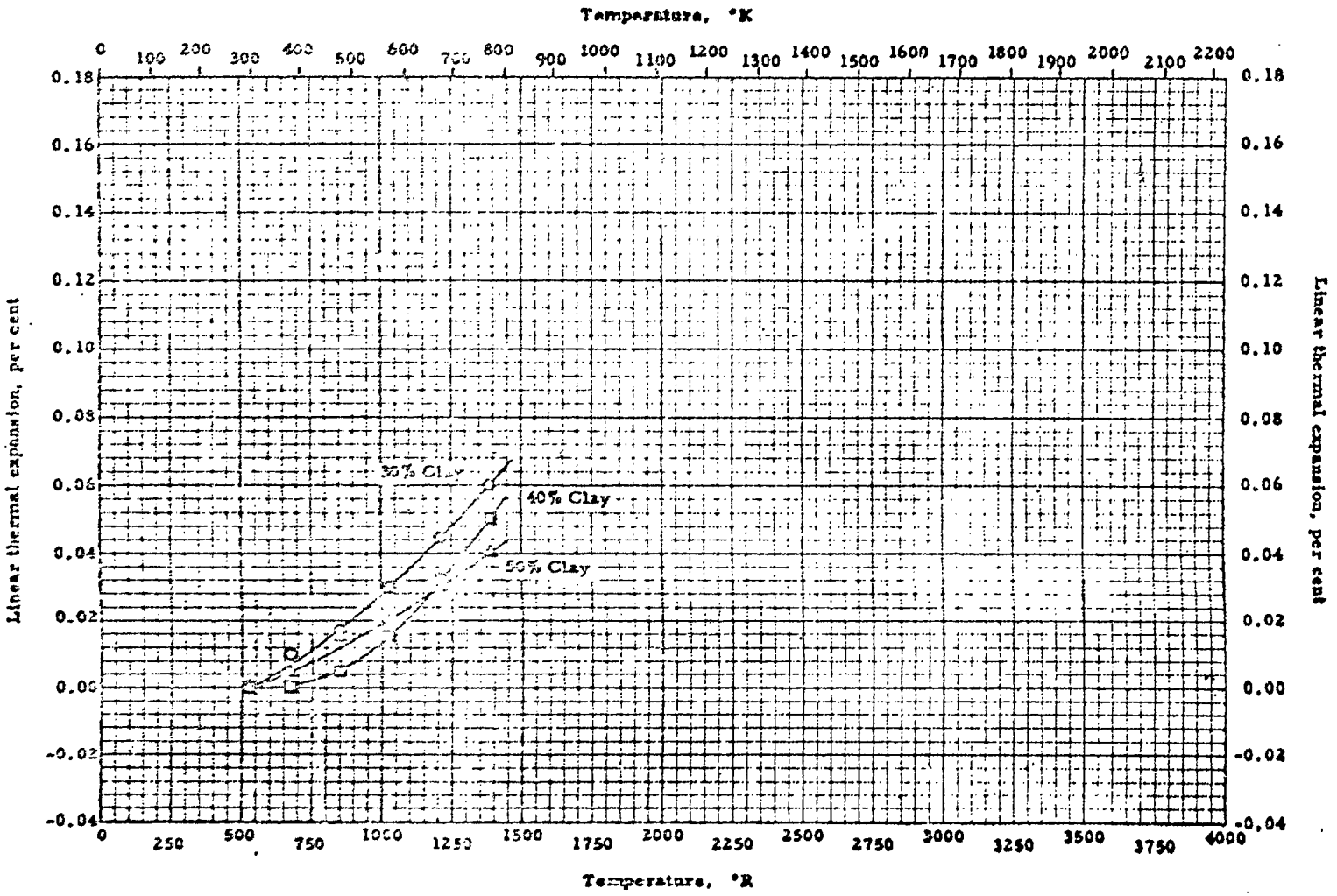


LINEAR THERMAL EXPANSION -- VITREOUS BONDED ALUMINUM TITANATE WITH FLORIDA KAOLIN

LINEAR THERMAL EXPANSION -- VITREOUS BONDED ALUMINUM TITANATE WITH FLORIDA KAOLIN

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Zimmerman, W. F., Plankenhorn, W. J. and Bennett, D. G.	53-42	528-1482	70% $Al_2O_3 \cdot TiO_2$; 30% Florida Kaolin	Interferometer	
□	Ibid.	53-42	528-1392	60% $Al_2O_3 \cdot TiO_2$; 40% Florida Kaolin	Same as above	
△	Ibid.	53-42	528-1392	50% $Al_2O_3 \cdot TiO_2$; 50% Florida Kaolin	Same as above	



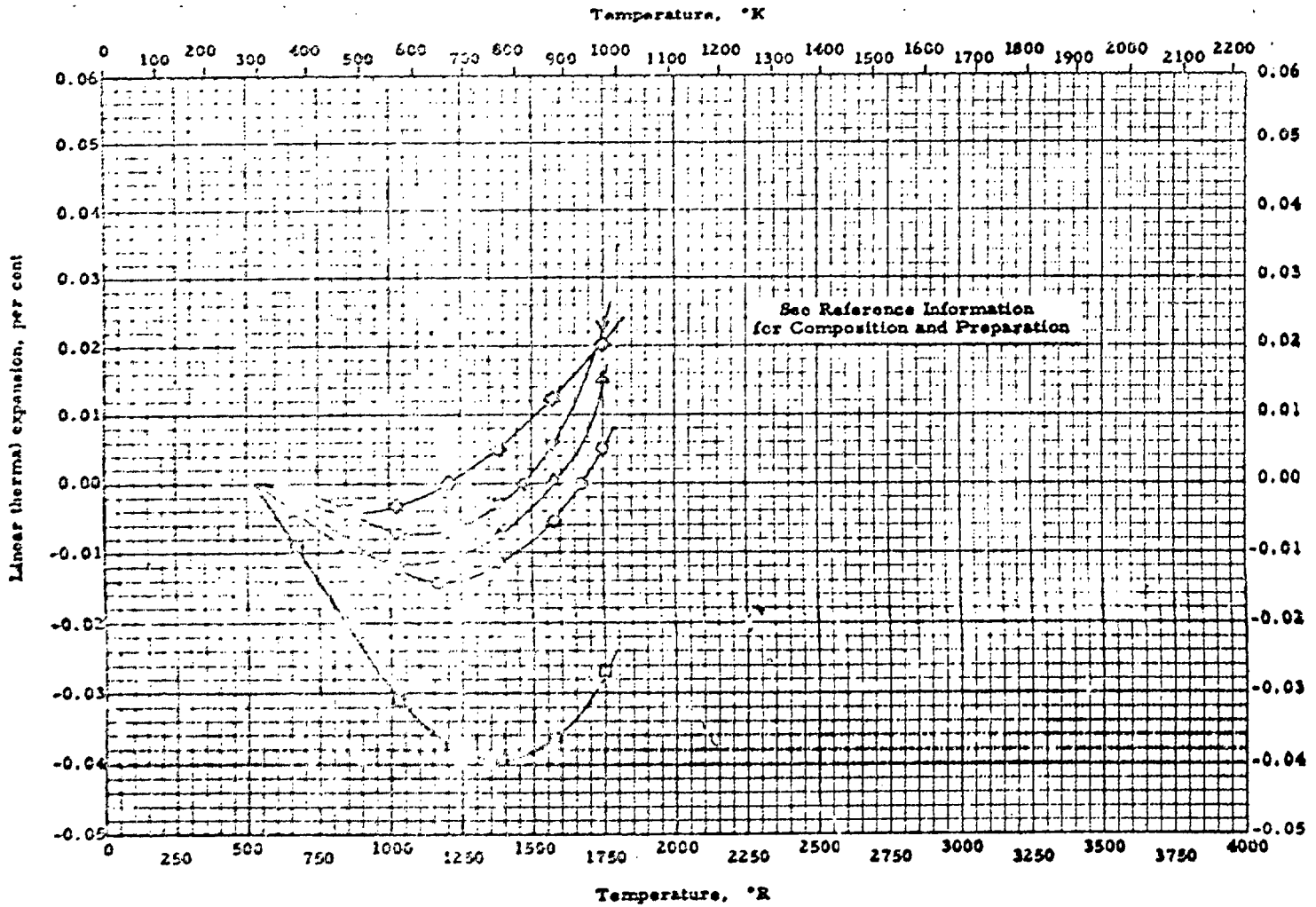
LINEAR THERMAL EXPANSION -- VITREOUS BONDED ALUMINUM TITANATE WITH FULTON PLASTIC CLAY

58-149
WADC TR 58-476
11440

LINEAR THERMAL EXPANSION -- VITREOUS BONDED ALUMINUM TITANATE WITH FULTON PLASTIC CLAY

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Zimmerman, W. F., Plankenhorn, W. J. and Bennett, D.G.	53-42	528-1392	70% $Al_2O_3 \cdot TiO_2$; 30% Fulton plastic clay	Interferometer	
□	Ibid.	53-42	528-1392	60% $Al_2O_3 \cdot TiO_2$; 40% Fulton plastic clay	Interferometer	
△	Ibid.	53-42	528-1392	50% $Al_2O_3 \cdot TiO_2$; 50% Fulton plastic clay	Interferometer	

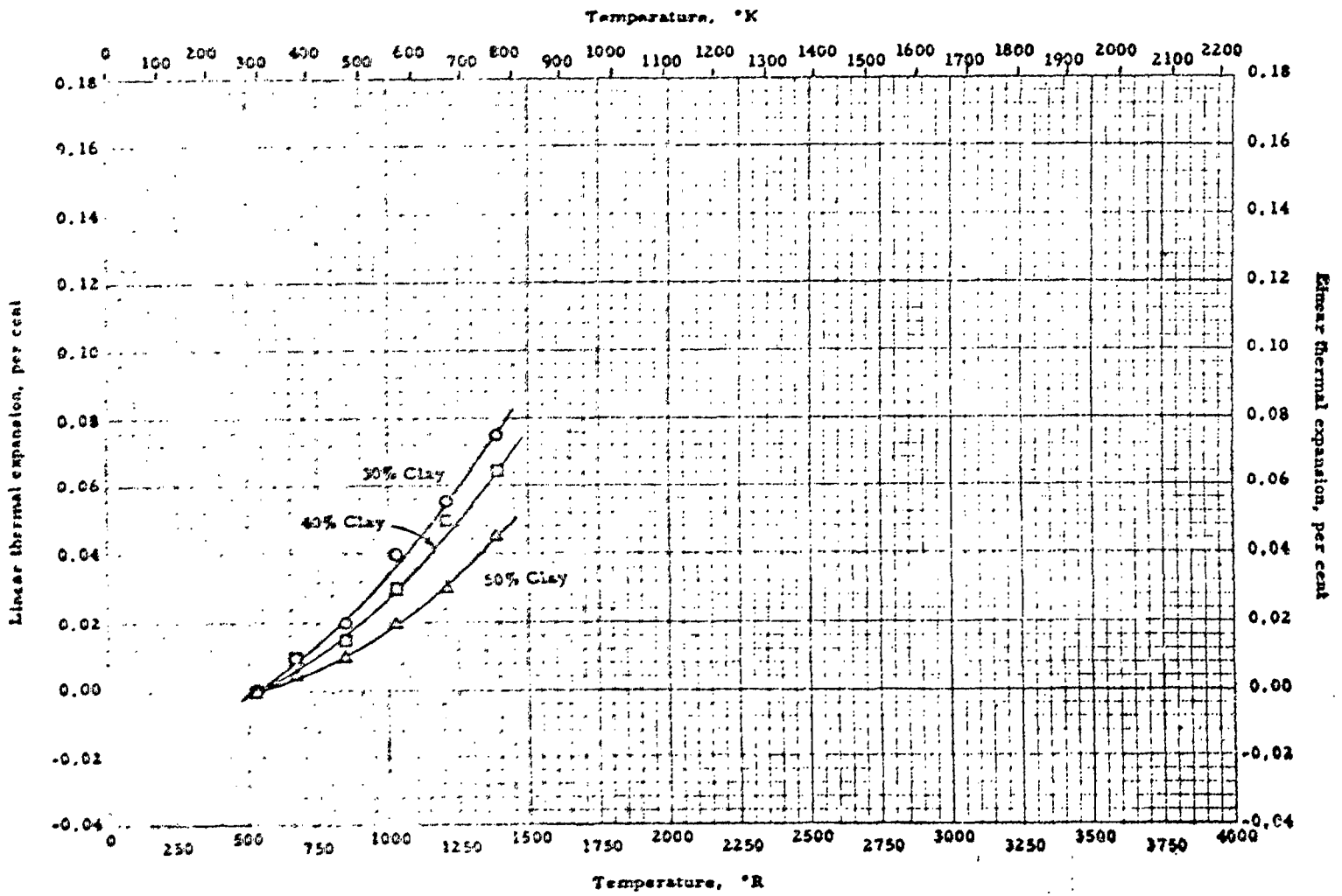


LINEAR THERMAL EXPANSION -- VITREOUS BONDED ALUMINUM TITANATE WITH PETALITE AND E.P.K. CLAY

LINEAR THERMAL EXPANSION -- VITREOUS BONDED ALUMINUM TITANATE WITH PETALITE AND E.P.K. CLAY

REFERENCE INFORMATION

	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	New Jersey Ceramic Research Station	55-22	672-1752	60% petalite; 40% $Al_2O_3 \cdot TiO_2$; prepared from petalite + Al_2O_3 + TiO_2 (equimolar mix)	Fused silica tube dilatometer	Tested at 2-3°C/min. rise
□	Ibid.	55-22	672-1752	Same as above; prepared from petalite + $Al_2O_3 \cdot TiO_2$	Same as above	Tested at 2-3°C/min. rise. $Al_2O_3 \cdot TiO_2$ formed by pressing, firing to 2800°F, crushing, grinding to 200 mesh
△	Ibid.	55-22	672-1752	50% petalite; 40% $Al_2O_3 \cdot TiO_2$; 10% E.P.K. clay	Same as above	Same as above
◇	Ibid.	55-22	672-1752	40% petalite; 40% $Al_2O_3 \cdot TiO_2$; 20% E.P.K. clay	Same as above	Same as above
▽	Ibid.	55-22	672-1752	45% petalite; 30% $Al_2O_3 \cdot TiO_2$; 7.5% E.P.K. clay; 7.5% feldspar (Buckingham)	Same as above	Same as above

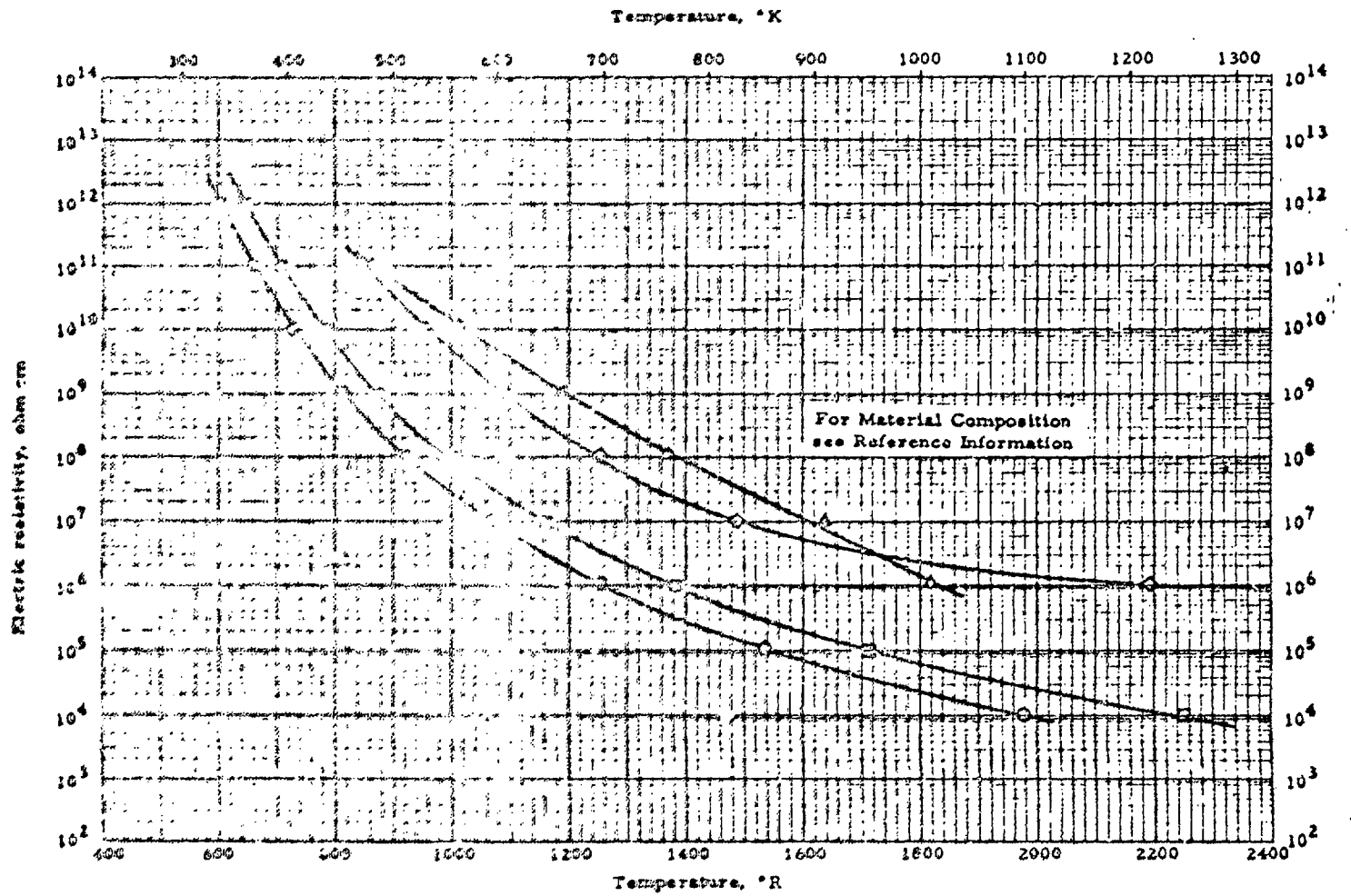


LINEAR THERMAL EXPANSION -- VITREOUS BONDED ALUMINUM TITANATE WITH TENNESSEE NO. 5 BALL CLAY

LINEAR THERMAL EXPANSION -- VITREOUS BONDED ALUMINUM TITANATE WITH TENNESSEE NO. 5 BALL CLAY

REFERENCE INFORMATION

Curve Symbol	Investigator	Ref.	Range, °K	Material Composition	Test Method	Remarks
O	Zimmerman, W. F., Plankenhorn, W. J. and Bennett, D. G.	53-42	528-1392	50% $Al_2O_3 \cdot TiO_2$: 50% Tennessee No. 5 Ball Clay	Interferometer	
□	Ibid.	53-42	528-1392	60% $Al_2O_3 \cdot TiO_2$: 40% Tennessee No. 5 Ball Clay	Same as above	
△	Ibid.	53-42	528-1392	70% $Al_2O_3 \cdot TiO_2$ 30% Tennessee No. 5 Ball Clay	Same as above	



ELECTRIC RESISTIVITY -- VITREOUS BONDED ALUMINUM TITANATE
(72-78 wt% $Al_2O_3 \cdot TiO_2$; 12-27 wt% α-Al_2O_3 Inclusions; 0-11 wt% Mullite)

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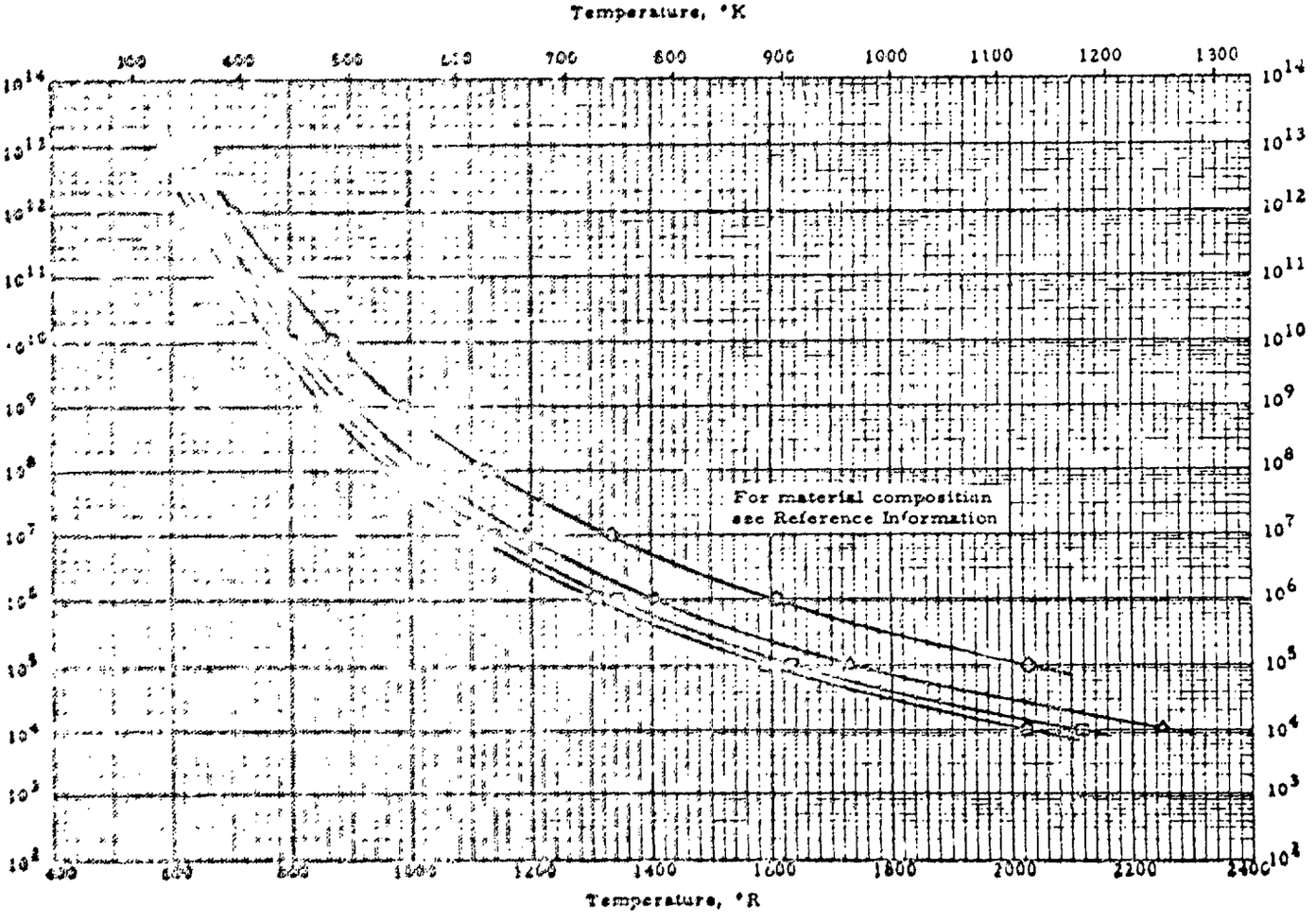
ELECTRIC RESISTIVITY -- VITREOUS BONDED ALUMINUM TITANATE
(72-78 wt% $Al_2O_3 \cdot TiO_2$; 12-27 wt% α-Al_2O_3 Inclusions; 0-11 wt% Mullite)

REFERENCE INFORMATION

	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Koch, W. J. and Norman, C. G.	50-12	601-1978	77.0 wt% $Al_2O_3 \cdot TiO_2$ crystals; 15.6 vol% isotropic glass, 7.5% mullite crystals. Apparent porosity = 6.50%. Interstitial material of mullite and glass with average crystal size of 23 μ	Not given	Equimolar mix of Al_2O_3 and TiO_2 fused, powdered, fired to 1650°C
□	Ibid.	50-12	543-1850	74.6 wt% $Al_2O_3 \cdot TiO_2$ crystals; 19.1 vol% α-Al_2O_3 inclusions; 6.4 vol% mullite crystals; 0.5% isotropic glass. Apparent porosity = 5.81%	Same as above	59.9% equimolar mix of ignited γ-Al_2O_3 and TiO_2 powdered, mixed with 40.1% Al_2O_3, fired to 1650°C
△	Ibid.	50-12	560-1818	75.3 wt% $Al_2O_3 \cdot TiO_2$ crystals; 23.7 vol% α-Al_2O_3 inclusions; 1.0 vol% mineral impurities. Apparent porosity = 16.0%	Same as above	69.6% fused Al_2O_3 and 30.4% c.p. TiO_2 ball-milled, dried at 110°C, 5% wax binder added, pressed at 10,000 lb/in², fired to 650°C in 8 hr. to remove binder, heated to 1820°C in 26 hr., held 1 hr., furnace cool to room temp.
◇	Ibid.	50-12	557-2196	72.1 wt% $Al_2O_3 \cdot TiO_2$ crystals; 26.9 vol% α-Al_2O_3 inclusions; 1.0 vol% mineral impurities. Apparent porosity = 10.5%	Same as above	Same as above, except 71.9% fused Al_2O_3 and 28.1% c.p. TiO_2 were milled.

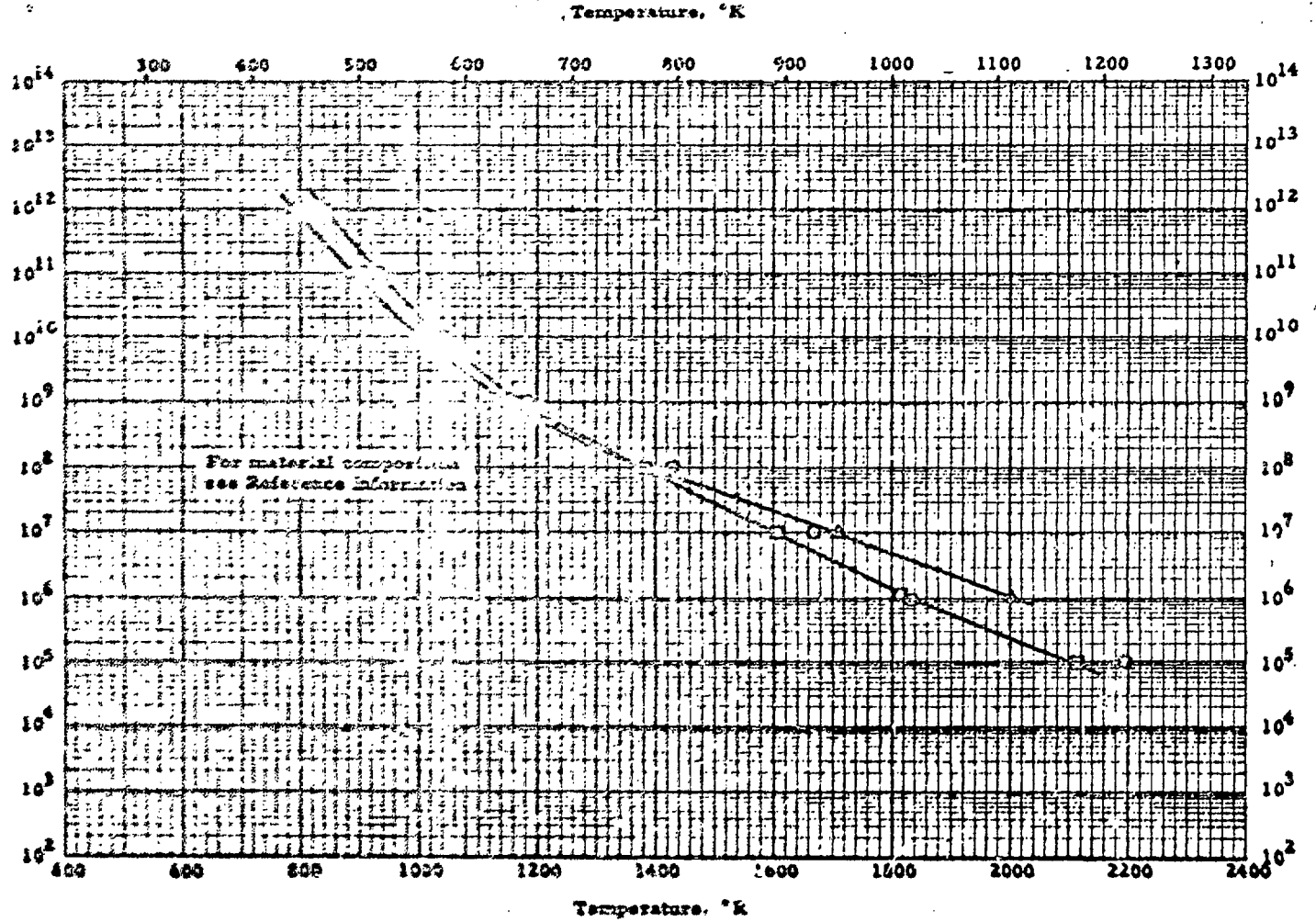


ELECTRIC RESISTIVITY -- VITREOUS BONDED ALUMINUM TITANATE
(80-93 vol% Al_2O_3 · TiO_2; 0-10 vol% α-Al_2O_3 Inclusions; 1-16 vol% Mullite)

ELECTRIC RESISTIVITY -- VITREOUS BONDED ALUMINUM TITANATE
(80-90 vol% $Al_2O_3 \cdot TiO_2$; 0-10 vol% α-Al_2O_3 Inclusions; 1-16 vol% Mullite)

REFERENCE INFORMATION

Ref.	Investigator	Ref.	Range, °F	Material Composition	Test Method	Remarks
C	Koch, W. J. and Hartman, C. G.	50-12	639-2023	81.3 vol. % $Al_2O_3 \cdot TiO_2$ crystals; 15.7 vol. % isotropic glass; 3.0 vol. % mullite crystals. Apparent porosity = 5.76%	Not given	Equimolar mix of ignited γ-Al_2O_3 and c.p. TiO_2 prepared, reground, mixed with c.p. TiO_2 as required, refired to 1650°C
□	Ibid.	50-12	648-2117	81.3 vol. % $Al_2O_3 \cdot TiO_2$ crystals; 17.7 vol. % isotropic glass; 1.0 vol. % mullite crystals. Apparent porosity = 5.33%	Same as above	Same as above
△	Ibid.	50-12	686-2253	89.3 vol. % $Al_2O_3 \cdot TiO_2$ crystals; 9.7 vol. % isotropic glass; 1.0 vol. % mullite crystals. Apparent porosity = 8.40%	Same as above	Same as above
◇	Ibid.	50-12	709-2023	83.9 vol. % $Al_2O_3 \cdot TiO_2$ crystals; 9.2 vol. % mullite crystals; 4.9 vol. % α-Al_2O_3 inclusions; 2.0 vol. % isotropic glass. Apparent porosity = 5.57%	Same as above	59.9% fused $Al_2O_3 \cdot TiO_2$ powdered, mixed with 40.1% fused Al_2O_3, fired to 1650°C

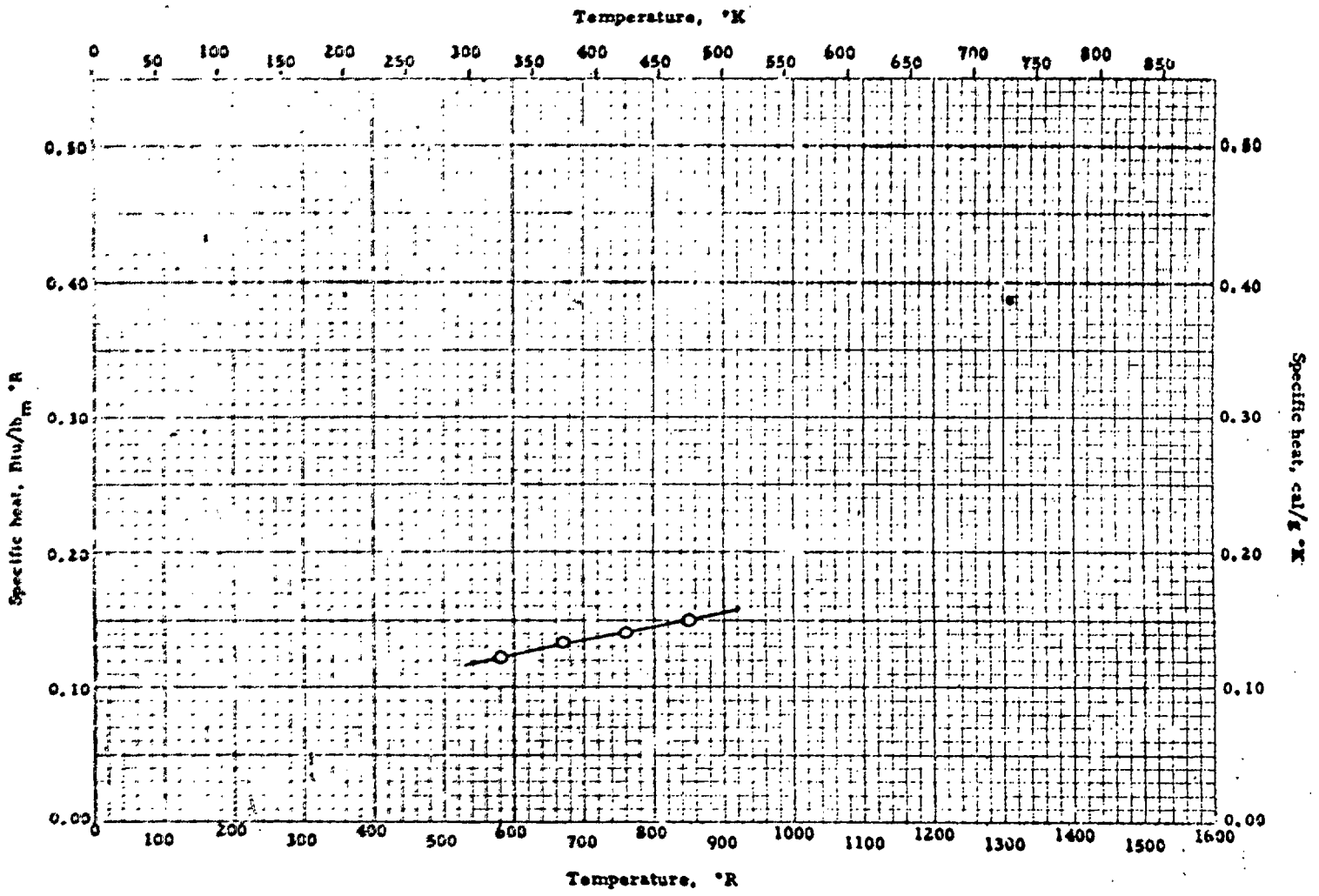


ELECTRIC RESISTIVITY -- VITREOUS BONDED ALUMINUM TITANATE
(91-94 vol% Al_2O_3 - TiO_2; 5-8 vol% α - Al_2O_3 Inclusions)

ELECTRIC RESISTIVITY -- VITREOUS BONDED ALUMINUM TITANATE
(91-96 vol% $Al_2O_3 \cdot TiO_2$; 5-8 vol% α - Al_2O_3 Inclusions)

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Koch, W. J. and Harman, C. G.	59-12	806-1176	91.7 Vol% $Al_2O_3 \cdot TiO_2$ crystals; 5.3 Vol% - Al_2O_3 inclusions; 1.0 Vol% mineral impurities. Porosity = 22.3%	Not given	Ball milled, dried at 110°C, wax added, pressed at 10,000 psi, fired 6 hr. at 650°C, raised to 1820°C in 26 hr., held 1 hr. at 1820°C. Furnace cooled to room temp.
□	Ibid.	59-12	841-1117	91.7 Vol% $Al_2O_3 \cdot TiO_2$ crystals; 7.3 Vol% - Al_2O_3 inclusions; 1.0 Vol% mineral impurities. Porosity = 26.8%	Same as above	Same as above
△	Ibid.	59-12	793-1000	91.1 Vol% $Al_2O_3 \cdot TiO_2$ crystals; 7.9 Vol % - Al_2O_3 inclusions; 1.0 Vol% mineral impurities. Porosity = 15.8%	Same as above	Same as above



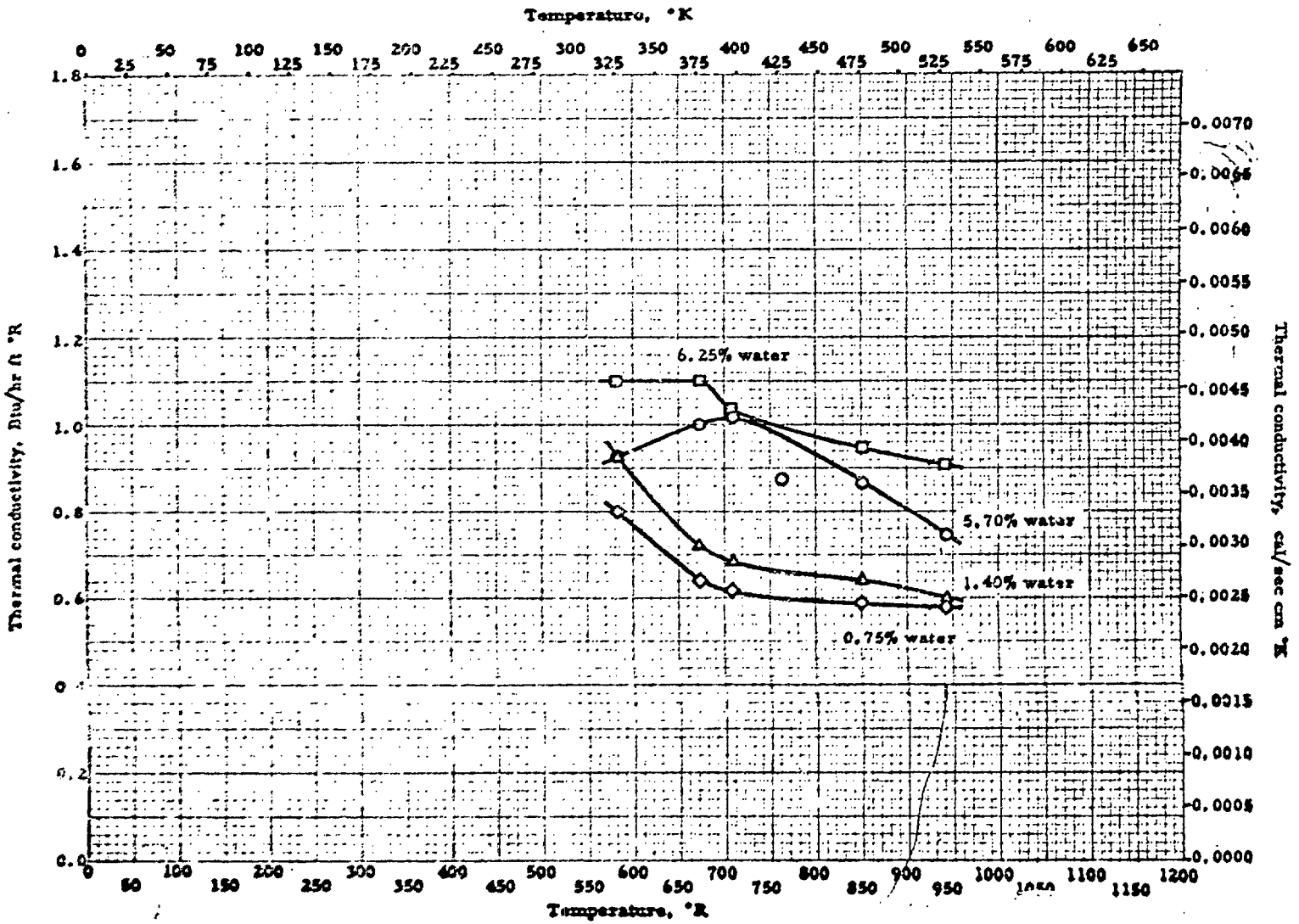
SPECIFIC HEAT -- PORTLAND CEMENT - BARYTES AGGREGATE

59-829
WADC TR 58-476 1188

SPECIFIC HEAT -- PORTLAND CEMENT - BARYTES AGGREGATE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
O	Gallaher, R.B. and Kitses, A.S.	53-63	582-852	48.1% of 1-in. Sweetwater barytes; 41.9% of 3/8-in. Sweetwater barytes; 10% Portland cement. (Sweetwater barytes contain 95.9% $BaSO_4$, 1.3% O_2; 1% Fe; 0.5% Ca). ρ = 218 lb_m/ft^3	Drop method; water calorimeter	



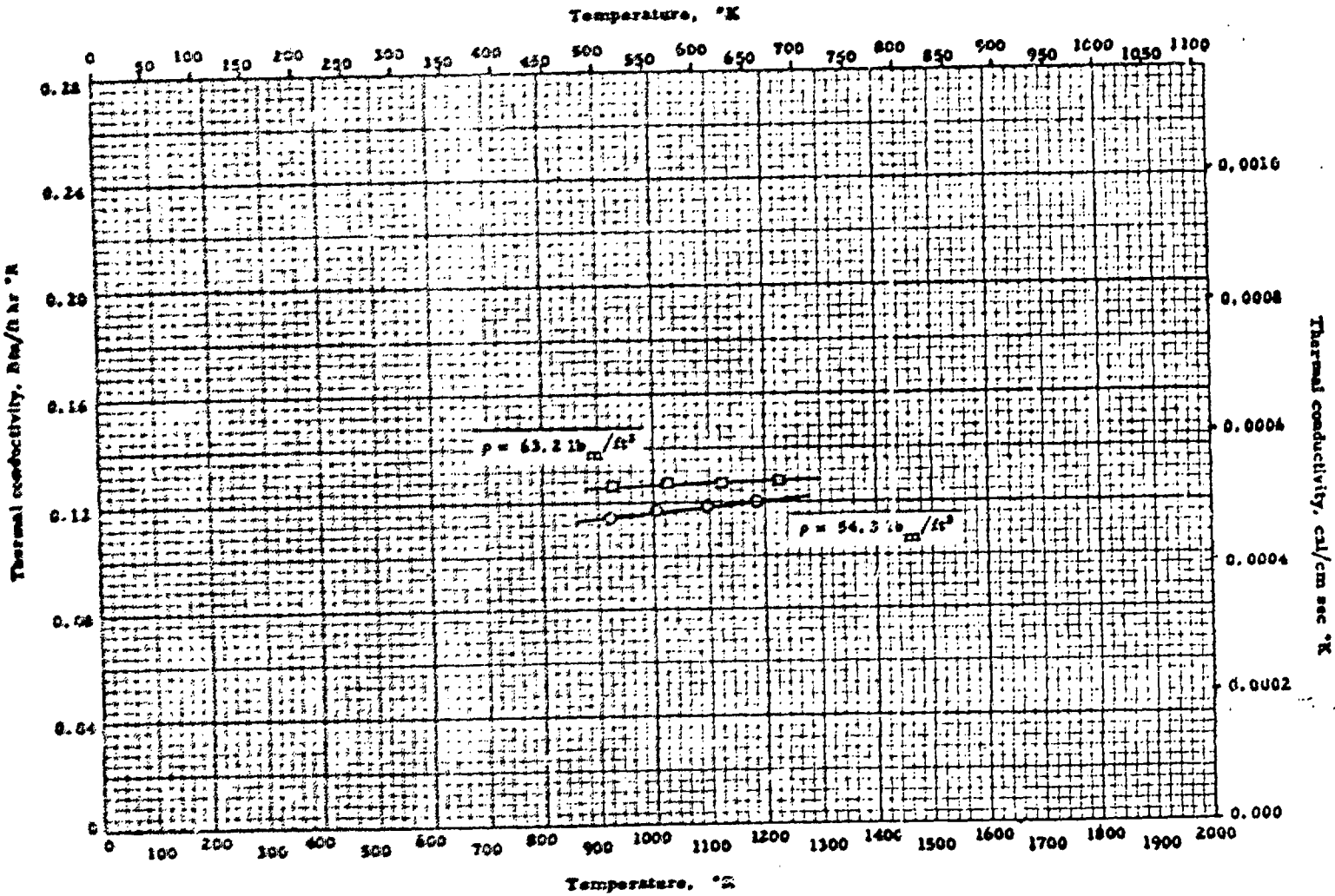
THERMAL CONDUCTIVITY -- PORTLAND CEMENT-BARYTES AGGREGATE

60-508 WADC TR 59-476 1160

THERMAL CONDUCTIVITY -- PORTLAND CEMENT-BARYTES AGGREGATE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °k	Material Composition	Test Method	Remarks
○	Callaher, R. B. and Kitzes, A. S.	53-63	582-942	Barytes concrete. Dry ingredients for pouring: 48.1% 1" sweetwater barytes; 41.9% 3/8" sweetwater barytes; 10% Portland cement (type I or II). Dry ingredients for blocks: 91.4% 1/2" sweetwater barytes; 8.6% Portland cement (type I or II). ρ = 220 lb_m/ft^3 1" barytes contain: 95.9% $BaSo_4$; 1% Fe; 1.3% O_2; 0.5% Ca. Bulk ρ = 162 lb_m/ft^3; 38% voids. 3/8" barytes contain: 81.6% $BaSO_4$; 9.8% Fe; 6.2% O_2; 0.9% Ca. Bulk ρ = 159 lb_m/ft^3; 35% voids. Sample with 5.76% water (normal)	Radial heat flow towards center of cylinder, ends guarded. Heat flow meas. by temp. rise of water passing through center	
□	Ibid.	53-63	582-942	Same as above except 6.25% water	Same as above	
△	Ibid.	53-63	582-942	Same as above except 1.40% water	Same as above	
◇	Ib.	53-63	582-942	Same as above except 0.75% water	Same as above	



THERMAL CONDUCTIVITY -- LIGHTWEIGHT CONCRETE

66-489
WADC TR 58-476 1962

THERMAL CONDUCTIVITY -- LIGHTWEIGHT CONCRETE

REFERENCE INFORMATION

Symbol	Investigator	Ref.	Range, °R	Material Composition	Test Method	Remarks
○	Bishui, B. M. and Prasad, J.	57-175	923-1185	Lightweight concrete. ρ = 54.3 lb_m/ft^3	Single flat plate; water calorimeter	
□	Ibid.	57-175	926-1228	Same as above. ρ = 6[illegible].2 lb_m/ft^3	Same as above	