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Molten Salts: Volume 4, Part I, Fluorides and Mixtures

Electrical Conductance, Density, Viscosity, and Surface Tension Data

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Data on the electrical conductance, density, viscosity, and surface tension of fluoride mixtures have been systematically collected and evaluated. Results are given for 44 binary mixtures over a range of compositions and temperatures. Values of the above properties for the single salts have been updated in accord with previously advanced recommendations.

Key words: Data compilation; density; electrical conductance; molten salt mixtures; fluorides; standard reference data; surface tension; viscosity.

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1. Introduction

This series of compilations includes thermodynamic, transport, and physical properties of selected inorganic salts in the molten state. The early sections covered single-salt melts, i.e., one-component systems in the classical phase-rule sense. Evaluated data on electrical conductance, viscosity, and density of single-salt melts were published in *Molten Salts, Vol. 1* (NSRDS–NBS–15 [1],[1] and surface tension was covered in Vol. 2 (NSRDS–NBS–28) [2]. Following the completion of that work, evaluation of data on the same four properties of binary molten salt mixtures was undertaken. The following classification was adopted from the many possible binary mixtures of inorganic compounds:

- nitrates-nitrates, nitrites-nitrites, and nitrates-nitrites
- halides-halides
  fluorides-fluorides; chlorides-chlorides; bromides-bromides and iodides-iodides; mixed halides
- additional binary systems
  carbonates-carbonates, sulfates-sulfates, . . . and mixed systems.

The recommendations for the nitrates-nitrates, nitrites-nitrites, and nitrates-nitrites, together with a Vol. 1 [1] update for the relevant single-salts melt data were reported in *Molten Salts, Vol. 3* [3]. The recommendations for the halides-halides, and for the additional binary systems are being prepared as Vols. 4 and 5 of this series. The results for the binary mixtures of halides, i.e., *Molten Salts, Vol. 4*, will be reported in four parts: Part 1, fluorides-fluorides; Part 2, chlorides-chlorides; Part 3, bromides-bromides and iodides-iodides; and Part 4, mixed halide systems. An

[1] Numbers in brackets refer to literature references in section 7.

update of the recommendations of Vol. 1 [1] for the relevant single-salts melt data is given in each of these parts. The results for some 44 fluoride-fluoride mixtures, and the single-salts melts update are reported herewith as Vol. 4, Part 1. The study includes published results up to approximately 31 December, 1972.

In this volume the discussion has been limited to essential observations concerning experimental procedures and melt preparation and purification. A tabular style is used wherever possible to display the important published results, recommended values, percent departures, and temperature and composition ranges.

As in Vol. 3 the limits imposed by the statistical analysis of the data required the comparisons for conductance and viscosity data to be made at the same compositions as in the original experimental studies; the recommendations are advanced accordingly, but at rounded temperatures. For density and surface tension, it was possible in some cases to report the properties at rounded values of temperature and composition.

Tables of numerical values follow immediately after the tabular presentations of the data sources and other comments. A temperature-liquidus phase diagram has been included wherever possible, to delineate to the lower limits of the liquidus ranges for the binary mixtures; however it should be understood that phase diagrams in this work are present for illustrative purposes and are not advanced as critically evaluated recommendations.

The fluoride mixtures are arranged in alphabetical order by cations according to chemical symbol. A system index is also given in the contents.

2. Symbols and Units

The symbols and units[2] for the four physical properties in this compilation are:

κ = specific conductance ($ohm^{-1}cm^{-1}$)
ρ = density (gcm^{-3})
η = viscosity (cp)
γ = surface tension (dyn cm^{-1})[3]

In addition:

E = activation energy (cal mol^{-1})
Λ = equivalent conductance (ohm^{-1} cm^2 $equiv^{-1}$)
C = concentration (mol %)
R = gas constant = 1.9817 cal $mol^{-1}deg^{-1}$
T = temperature in kelvin, defined on the thermodynamic scale by assigning 273.16 K to the triple point of water (freezing point, 273.15 K = 0 °C).

[2] For conversion to SI units:

1 ohm^{-1} cm = $1\times10^{2}\Omega^{-1}m^{-1}$
1 gcm^{-3} = 1×10^{3} Kg m^{-3}
1 cp = 1×10^{-3} N s m^{-2}
1 dyn cm^{-1} = 1×10^{-3} N m^{-1}
1 cal mol^{-1} = 4.184 J mol^{-1}

[3] When γ is treated as a free energy per unit area, it is given the unit, erg cm^{-2}; this is dimensionally identical to dyn cm^{-1}.

3. Experimental Methods

Authoritative reviews discussing experimental methods for studying transport properties of molten salts have been given elsewhere [3, 11, 21, 38, 53, 99]. Robbins [101] has reviewed the electrical conductance measurements on molten fluorides, with respect to the effects of cell design, materials for fabrication, and bridge methods for precise resistance measurements. The following section will highlight and reference certain experimental aspects that are generally restricted to the study of fluoride melts. Further information for specific fluoride systems has been included in the discussion sections (5.3 and 6.1) for single and binary melts, respectively.

3.1. Techniques

In the measurement of the electrical conductance of fluoride melts suitable materials for the construction of cells are extremely difficult to find [63] since most substances, if not rapidly attacked, are sufficiently porous to allow liquid penetration. Conductivity measurements have been made in cells constructed primarily from platinum [46, 45, 111], but boron nitride in graphite [24, 87, 119], single crystal beryllium oxide [54] and magnesium oxide [23, 34, 39] have also been found useful. Silica glass has been used for capillary cells [22, 30] but in general has not been suitable due to fluoride attack at high temperatures [45]. Electrodes of platinum [45, 46], inconel [120], molybdenum [87], and molten aluminum [39, 96] have been used. The low cell constants normally obtained using these materials in conjunction with the high conductivity of molten fluorides has necessitated the use of accurate bridge methods for precise resistance measurements and these have recently received attention by Robbins [101]. Additional comments regarding the measurements of electrical conductance for specific fluoride systems have been included under the discussion sections (5.3 and 6.1).

Viscosity measurements on fluoride melts have been made using the capillary, oscillating sphere, oscillating hollow cylinder and rotational cylinder methods. Little reported experimental information was available regarding the capillary technique. Oscillating bodies were constructed of platinum [5, 107] and palladium [108]; and rotational cylinders of bronze [117] and inconel [18, 19, 33] have been used. Platinum [5], graphite [117], nickel [33] and inconel [18, 19] melt containers were used. Recently reported viscosity measurements by Grjotheim et al. [44] on several molten chloride melts using the oscillational technique showed large differences (10 to 50%) for NaCl and KCl when compared to results of earlier investigations using the same method. Experimental problems associated with the method included consideration of wire diameter for the suspension system and proper pretreatment of the torsion wire. The stability of the measured torsional constant appeared to be strongly dependent upon these factors. In light of these conflicting results,

data on viscosity of fluoride melts obtained using the oscillating technique should be viewed with caution until further information becomes available on the reliability of this method.

The Archimedean method for density determination has been found very reliable for molten salts and specifically for fluoride melts. Bobs of platinum [7, 25, 33, 75, 95, 107], molybdenum [87, 98], and Pt–10 percent Rh [49] have been most commonly used with melt containers of platinum, nickel and graphite. A nickel dilatometer has been successfully used [28, 30]. Calibration procedures and corrections for thermal expansion and melt condensation have been discussed under sections 5.3 and 6.1.

The maximum bubble pressure method has been most widely used for surface tension measurements on molten fluorides. Capillaries of Pt–10 percent Rh [20, 43] and molybdenum [67] have been used. Experimental methods have been reviewed by White [113] and Janz [64].

The preparation, handling and transfer procedures for molten fluorides during experimental measurements are discussed in sections, 5.3 and 6.1, for specific and binary fluoride melts, respectively.

3.2. Percent Application of Methods

Experimental methods for studying transport properties of molten fluoride melts were cited in section 3.1. The following summaries indicate the frequency of use of these techniques. The Percent Application is defined as the number of investigations employing a particular method relative to the total number of reported studies for that transport property.

Specific conductance

Method	Percent Application
Classical ac	97.8
Potentiometric ac	2.2

Density

Method	Percent Application
Archimedean	96.7
Dilatometric	3.3

Viscosity

Method	Percent Application
Capillary	30
Oscillating sphere	15
Oscillating hollow cylinder	2.5
Rotational cyclinder	52.5

Surface tension

Method	Percent Application
Maximum bubble pressure	92.9
Wilhelmy slide plate	7.1

3.3. Melt Preparation and Purification

Most fluorides are commercially available, either in technical or analytical pure grades, so that synthetic procedures are avoided. Emphasis is given here to details of salt purification.

The following procedures have been adopted: recrystallization, sublimation, vacuum distillation, fusion under HF gas and heating with NH_4HF_2 in the case of UF_4. The salts are mostly dehydrated in a Pt-crucible under vacuum at elevated temperatures with an inert atmosphere.

Mixtures are prepared by fusion of the required amounts of the pure components under an inert gas atmosphere. The composition and purity are usually checked using standard spectrochemical and gravimetric procedures.

Detailed procedures, including handling and transfer, for each salt or mixture are discussed in sections 5.1 and 6.1, respectively.

4. Treatment of Data

4.1. Statistical Analysis

The statistical analysis was performed on the computer facilities (IBM 360, PDP15 and G.E. Mark II Time-Sharing Unit) at Rensselaer Polytechnic Institute.

The density, specific conductance, viscosity, and surface tension values were recalculated by a one-dimensional analysis, using the method of least squares to establish equations indicating the variations of the physical quantities with temperature at the experimental composition. For density and surface tension results, where five or more experimental compositions and temperatures or temperature-dependent equations were reported, the values were recalculated by a two-dimensional analysis, using a stepwise multiple regression routine. In this way a physical property-temperature-composition matrix was developed. Tabulated values given in brackets are less reliable because of a statistically insufficient number of data points.

a. One-Dimensional Analysis

The criterion for choosing the equation of best fit in the one-dimensional analysis is the standard error of estimate computed from the residuals and defined by

$$s=\sqrt{\frac{\sum^{n}(\gamma_e-\gamma_c)^2}{n-q}}$$

where γ_e = the experimental value at each temperature, γ_c = the value calculated from the least squares equation at the same temperature as γ_e, n = the number of experimental data points, and q = the number of coefficients in the least squares equation (2 for linear, 3 for quadratic). The standard error of estimate is also expressed as a percentage.

b. Two-Dimensional Analysis

Computer Programs Used

Programs from the IBM Scientific Subroutine Package[4] were used with the IBM 360/50 computer facility at Rensselaer. The routines consist of STPRG, CORRE, LOC, and MSTR, the latter two being storage routines which have no effect on the accuracy of the results. In addition the subroutine STOUT is used to print the results of each regression step and the subroutine MATRIX is used for printing a matrix of the final equation.

Statistical Procedures

The abbreviated Doolittle method [5] was used to select the variables entering the regression and for calculation of coefficients. The independent variable included in each step of the analysis was selected by computing the reduction of sums of squares of each variable. The variable causing the largest reduction was added to the equation and deleted from the table of sums of squares. The coefficients, intercept and statistical parameters for the new equation were computed and printed. This procedure was repeated until the maximum proportion of sums of squares to the total reduced was less than a limit set by the programmer. The independent variables used in the initial selection were chosen from a generalized procedure, which generated 30 combinations of the input variables using powers, reciprocals, logarithmic and exponential quantities. It was found that the procedure consistently selected the equation $(T + C)^3$, so that the working program used nine independent variables. After the final equation has been produced, it is transferred to the MATRIX routine, which recalculates values at rounded compositions and temperatures, within specified boundary conditions. In the presentation of the matrix, due cognizance is taken of the experimental range of the investigation and of the phase relationships for the system so that values are always "interpolated" rather than "extrapolated". The final step in the procedure involves the residual analysis, where the deviations of the original values from those computed from the "best" equations are given.

Statistical Parameters

For each step in the regression analysis a summary of significant statistical parameters is given. First the sums of squares reduced (S_i), the proportions of S_i/D, where D is defined below, given by P, the cumulative S_i given by S_{cum} and the cumulative proportion given by (P_{cum}) are listed. These quantities give an indication of the effect of each variable in the final equation. The programmers limit on P was always in the range $0.0001 \leq P \leq 0.001$.

Standard Error of Estimate

The standard error in the estimated y values adjusted for degrees of freedom is given by:

$$\text{s.e.} = \sqrt{\frac{D - S_{cum}}{n - q - 1}}$$

where

$$D = \sum_{j=1}^{n} (y_j - \bar{y})^2$$

y_j — experimental values.
$\bar{y}$ = average of all experimental values.
q = the number of independent variables in the equation.

The standard error of estimate is also expressed as a percentage. As a general guide about 68 percent of the results lie within the standard error of estimate, 95 percent within twice this value, and approximately 99 percent within three times the value.[6]

F Value for Analysis of Variance

This value is used to determine if a particular model is acceptable.[7] Tables of F values indicate that values greater than 2.0 are acceptable for the routine used here. In all cases values of F were greater than 500 and in most cases greater than 1000. The F value is defined as:

$$F = \frac{S_{cum/q}}{(D - S_{cum})/(n - q - 1)}$$

where S_{cum}, q, D, and n were defined earlier.

4.2. Percent Departure

The percent departure has been used to compare the results of different investigations with either previous [1, 2] or current recommendations and has been later considered when evaluating a study for possible recommendation.

The percent departure is defined by:

$$\text{Percent departure} = \frac{\text{"compared value"} - \text{"recommended value"}}{\text{"recommended value"}} \cdot 100$$

The "compared values" refer to the numerical data given in the discussed study and are compared to the "recom-

[4] System 360 Scientific Subroutine Package Programmers Manual; IBM 820-0205-3, 1969.

[5] C. A. Bennet and N. L. Franklin, Statistical Analysis in Chemistry and the Chemical Industry (John Wiley and Sons, 1954).

[6] T. D. Sterling and S. V. Pollack. Introduction to Statistical Data Processing (Prentice-Hall, 1968).

[7] H. Smith and N.R. Draper, Applied Regression Analysis (John Wiley and Sons, 1968).

mended values" given in NSRDS–NBS–15 [1] or NSRDS–NBS–28 [2], or the present work.

The experimental values, when available, were used as the "compared values", otherwise the "compared values" and the "recommended values" were calculated from statistically derived equations at common temperatures and compositions.

The percent departure is given in the discussion sections 5.3 for single salts and 6.1 for binary mixtures.

4.3. Value Judgments

The recommendations advanced in this work are based on three criteria: (a) type and quantity of experimental data available, (b) experimental method used, and (c) an error analysis of the reported results. The principles followed in selecting the most reliable data are, briefly, as follows:

(a) Studies reporting either numerical data, results derived from statistically generated equations or data in the form of temperature dependent equations were preferred over graphical results. Where investigations reporting numerical results and temperature dependent equations were of equal merit, normally the former was selected. For the case where two sets of results were reported for the same system, one graphical and the other numerical, the graphical results could be preferred if these were based on a more extensive composition and temperature range, when other criteria were of equal merit.

(b) The experimental aspects as discussed in section 3 were examined for each system when a recommendation has been advanced. Of primary importance was the cognizance of an investigator with respect to improvements and limitations on standard measuring techniques together with an examination of the errors leading to uncertainties in the measured transport properties. Attention was given to the preparation, purification, stability and analysis of single and mixed fluoride melts as discussed in section 3.3. The reliability of the measuring technique and melt preparation and purification procedures as determined from results on standard calibration materials was considered important in the ultimate value of the data reported.

(c) The statistical parameters and percent departures as discussed in section 4.1 and 4.2, respectively, were considered. For systems where investigations had similar quantity and quality of data, the results with superior statistical parameters were selected.

For some systems more than one reference has been advanced; this normally occurred when equally good data covered different composition and/or temperature ranges.

4.4. Discussion Tables

Transport properties of molten fluorides and their mixtures have been analyzed and summarized in tabular form with respect to: experimental methods employed, composition and temperature ranges studied, melt preparation and purification procedures and percent departures of numerical data from current or previous recommendations.

For each system the discussion table has been preceded by a brief introductory paragraph giving the recommended reference and experimental technique used, followed by three summary tables (where information exists), which contain respectively:

- the number of references critically re-examined
- the calculated percent departures

and

- the summary of cell materials and calibration methods.

Table A summarizes all investigations carried out for the relevant physical property with corresponding composition and temperature ranges. Data have been reported in numerical or equation form except where graphical results have been indicated.

Table B gives, when available, the minimum and maximum percent departures of the different investigations at comparable compositions and temperatures, in relation to previous recommendations [1, 2] or the present work. Experimental details such as cell materials and calibrations are presented, when available, in Table C for all investigations. Remarks concerning the accuracy, the reproducibility, and the form of numerical data are included. Additional comments may follow to highlight information of unusual importance (technique, experimental uncertainty, etc.) with respect to the particular property and system studied. Finally remarks on the salt preparation and purification are given.

The recommended investigation is always indicated by a bold-faced reference number in square brackets.

For certain systems more than one reference has been recommended where studies of comparable value have been reported covering different temperature and/or composition ranges.

A summary on melt preparation and purification is given for each system, when available.

4.5. Numerical Tables

The specific conductance, density, viscosity, and surface tension values were computed for each system for the experimental compositions at rounded temperatures using the corresponding "best" equation for the same temperature range for which the investigation was carried out. The temperature-dependent equations, the standard errors of estimate, the literature source and the form of the original data are given in each table. For density and surface tension the results were also recalculated using a two-dimensional statistical analysis in cases where sufficient data (more than five compositions and tempera-

tures) were given.

The matrices produced by the two-dimensional analysis are reported in tabular form at rounded temperatures and compositions; in addition the two-dimensional equation, maximum percent departure, standard error of estimate and literature reference are included in the table. Original values are given in cases where investigations reported only limited data or the one- or two-dimensional statistical analysis was unsuccessful. Numerical tables are presented only for the recommended studies and are given immediately after the discussions.

4.6. Phase Diagrams

Phase diagrams for each system are included in section 6.1 when available. It should be understood that the temperature-liquidus phase diagrams included in this work are not advanced as critically evaluated recommendations, but serve the useful purpose of reporting values for a eutectic composition. The liquidus curves were also used as guidelines for imposing the boundary conditions for generating the matrix, in order to avoid producing values in the solid phase. References for each phase diagram are given with the diagram.

4.7. General Summary Tables

Summary tables are given in section 5.4 (single salts) and section 6.2 (binary mixtures) to summarize specific information such as total number of investigations, recommended references, experimental techniques used, and literature references.

5. Single Salts

The sections 5.1 and 5.2 update the recommendations for single salt melts given in NSRDS–NBS–15 [1] and NSRDS–NBS–28 [2]. The discussions for each single salt recommendation and the numerical values together with the temperature dependent equations are given in section 5.3. References for single fluoride salts not included in NSRDS–NBS–15 [1] and NSRDS–NBS–28 [2] are listed in section 5.4.

5.1. New Recommendations

Single fluoride salts which do not appear in NSRDS–NBS–15 [1] and NSRDS–NBS–28 [2] are listed below. The discussions, numerical values and temperature-dependent equations for the new recommendations are given in section 5.3.

Compound	Number of investigations	
	Density	Viscosity
BeF_2	3	
KF		1
LiF		2
NaF		1
RbF	2	
UF_4		1

5.2 Revised Recommendations

The recommendations for single fluoride melts given in NSRDS–NBS–15 [1] have been updated relative to new investigations and in the case of NaF a revised recommendation is given in this volume. The recommendations given in NSRDS–NBS–28 [2] are still accepted.

The discussions, numerical values, and temperature-dependent equations for the revised recommendations are given in section 5.3.

Compound	Number of investigations Density	NSRDS–NBS–15 [1] recommendation
NaF	17	p. 3

5.3. Discussions and Numerical Values

Single fluoride salts for which a new or revised recommendation is reported are discussed in this section with respect to experimental techniques, references, temperature ranges, percent departure values and melt preparation and purification. Numerical values are given for each property at rounded temperatures together with the temperature-dependent equations.

BeF_2

Density

The recommended values in table 2 are based on the work of Mackenzie and Cantor et al. (Archimedean method) [73] and [33], respectively.

TABLE 1 A. Investigations critically re-examined

Ref.	Temp. Range (T)
73	1073
33	1123
32	1073

Comment: The result reported in [33] is an upper limit of the actual BeF_2 density value. In reference [73] a surface tension of 200 dyn cm^{-1} was assumed which yielded a corrected density value of 1.947 ± 0.010 gcm^{-3} at 800 ° C.

Melt Preparation and Purification

Mackenzie [73] used 99 percent pure BeF_2 contained in a Pt–20 percent Rh crucible and placed overnight in the apparatus under a stream of dry N_2. The apparatus was then evacuated to a pressure of about 10 mm Hg and the temperature was raised slowly to 200 °C to remove the water present. When the temperature was increased to 700 °C, dry N_2 was admitted. The melt was kept at 900 °C for 1 hr before measurements. In reference [33] BeF_2 was purified by vacuum distillation.

TABLE 2. BeF_2

T	ρ (gcm^{-3})
1073.2	1.947 ± 0.010 [1]
1123.2	1.96 [2]

Density: [1] [73]
[2] [33]

KF

Viscosity

The recommended value in table 4 is based on the work of Sheiko (oscillating sphere method) [107].

TABLE 3 A. Investigations critically re-examined

Ref.	Temp. Range (T)
107	1246

Comment: Sheiko [107] used a platinum sphere as the oscillating bob.

TABLE 4. KF

T	η (cp)
1246.2	1.59

Viscosity: [107].

LiF

Viscosity

The recommended values in table 6 are based on the work of Vetyukov and Sipriya (oscillating sphere method) [108].

TABLE 5 A. Investigations critically re-examined

Ref.	Temp. range (T)
18	1073
108	1140–1348

TABLE 5 B. Cell materials and calibration

Cell materials	Calibration
Pd-ball and Mo-suspension wire [108]	Sodium cryolite was used to check the method [108]

Melt Preparation and Purification

Vetyukov and Sipriya [108] used analytically pure LiF, heated at 600 °C for 3 h before using.

TABLE 6. LiF

$\eta = 1.8549 \cdot 10^{-1} \cdot \exp(5610/RT)$ (cp)

Stand. error of est.: $0.0157 = 0.86\%$

T	η
1140	2.21
1160	2.11
1180	2.03
1200	1.95
1220	1.88
1240	1.81
1260	1.74
1280	1.68
1300	1.63
1320	1.57
1340	1.53

Viscosity: [18, 108].

NaF

Density

The recommended values in table 9 are based on the work of Paucirova, Matiasovsky, and Malinovsky (Archimedean method) [95] and supersede the recommendation given in NSRDS–NBS–15 (Molten Salts: Vol. 1) [1].

TABLE 7 A. Additional investigations* critically re-examined

Ref.	Temp. range (T)
106	1290, 1392, 1487
115	1273 (graphical)
96**	1273, 1373 (graphical)
45	1273–1349
7	1283–1393
26	1573
75	1273, 1323, 1373
24	1303–1363
97	1273
5	1288–1473
94	1273
95	1273–1373
49***	1283–1403
87	1273 (graphical)
98	1273–1353
103	1273–1373 (graphical)

*Refer to reference [1] for previous work
**Data taken from references [5, 7].
***Data taken from references [62, 10].

TABLE 7 B. Comparison with previous recommendations

Ref.	Recommended Value		% Departure			
	Vol.	Page	% (min)	(T)	% (max)	(T)
106	1	3	−0.03	(1290–1392)		
7	1	3	0.56	(1383)	0.95	(1283)
75	1	3	−0.04	(1323)	−0.24	(1373)
24	1	3	0.06	(1320)	−0.50	(1360)
97	1	3	−0.51	(1273)		
5	1	3	0.42	(1398)	0.84	(1288)
94	1	3	0.16	(1273)		
95	1	3	−0.02	(1320)	−0.18	(1360)
98	1	3	−2.23	(1280)	−2.47	(1350)
45	1	3	0.63	(1340)	0.75	(1280)

TABLE 7 C. Cell materials and calibration

Cell materials	Calibration
Pt-sinker and suspension wire [106, 45]	Volume calculated using coefficient of expansion of Pt [106, 45]
Pt spherical bob [5, 7, 97], Pt-ball [26]	Volume of ball determined from measurements on substances of known density [26]
Mo plummet connected to a quartz spring by a Mo wire, melt contained in a graphite crucible [24, 98]	Molten KCl [24, 98]
Pt sinker and suspension wire, melt in Pt crucible [75, 94, **95**]	Molten NaCl and KCl [75, 94, **95**]

Comment: Details concerning the density measurements by Paucirova et al. [95] are discussed under the system AlF_3–NaF.

Viscosity

The recommended values in table 9 are based on the work of Abramov (oscillating sphere method) [5].

TABLE 8 A. Investigations critically re-examined

Ref.	Temp. range (T)
5	1288–1473

TABLE 8 B. Cell materials and calibration

Cell material	Calibration
Pt sphere and Mo suspension wire, melt contained in a Pt cup [5]	Water, aniline and sulfuric acid [5]

Comment: Abramov [5] reported a standard deviation of ±2 percent.

Melt Preparation and Purification

The melt preparation and purification described in the following references are discussed under the binary systems given in section 6.1.

Ref.	Systems
45	AlF_3–NaF
75	AlF_3–NaF
5	AlF_3–NaF
94	AlF_3–NaF
95	AlF_3–NaF
98	CaF_2–LiF
24	LiF–ThF_4

TABLE 9. NaF

$\rho = 2.7550 - 6.36 \cdot 10^{-4} T$ (gcm^{-3})

$\eta = 3.970 \cdot 10^{-2} \cdot \exp(9831/RT)$ (cp)

Stand. error of est. for η: 0.0190 = 1.33%

T	ρ	η
1280	1.941	
1290	1.935	1.04
1300	1.928	1.79
1310	1.922	1.73
1320	1.915	1.69
1330	1.909	1.64
1340	1.903	1.59
1350	1.896	1.55
1360	1.890	1.51
1370	1.884	1.47
1380		1.43
1390		1.40
1400		1.36
1410		1.33
1420		1.29
1430		1.26
1440		1.23
1450		1.20
1460		1.18
1470		1.15

Density: [5, 7, 24, 26, 45, 49, 75, 87, 94, 95, 96, 97, 98, 103, 106, 115].

Viscosity: [5].

RbF

Density

The recommended values in table 11 are based on the work of Jaeger et al. (Archimedean method [62] and [106], respectively.

TABLE 10 A. Investigations critically re-examined

Ref.	Temp. Range
62	1076–1359
106	1093–1279

TABLE 10 B. Cell materials and calibration

Cell Materials	Calibration
Pt-sinker and Pt-suspension wire [62, 106]	Volume calculated using coefficient of expansion of Pt [62, 106]

Comment: The melting point of RbF in reference [62] was found to be 760 ° C and at 1000 ° C a markable evaporation was observed.

TABLE 11. RbF

$\rho = 3.9953 - 1.0211 \cdot 10^{-3} T$ (gcm^{-3})

Stand. error of est.: 0.0019 = 0.07%

T	ρ
1080	2.893
1100	2.872
1120	2.852
1140	2.831
1160	2.811
1180	2.790
1200	2.770
1220	2.750
1240	2.729
1260	2.709
1280	2.688
1320	2.668
1340	2.647

Density: [62, 106]

UF_4

Viscosity

The recommended values in table 13 are based on the work of Kulifeev et al. (oscillating hollow cylinder method) [69].

TABLE 12 A. Investigations critically re-examined

Ref.	Temp. Range (T)
69	1338–1618

TABLE 12 B. Cell material and calibration

Cell material
Graphite crucible, W-suspension wire [69]

Comment: Kulifeev [69] applied a closed crucible with an Argon atmosphere of 100 mm Hg-pressure to prevent evaporation of UF_4. An accuracy of ±10 percent was reported.

Melt Preparation and Purification

Kulifeev and Panchisnyi [69] purified UF_4 by heating the salt with NH_4HF_2 at 800 to 900 K. The oxide impurities did not exceed 0.08 wt. percent.

TABLE 13. UF_4

T	η^* (cp)
1338	2.460
1348	2.010
1398	1.606
1433	1.348
1448	1.308
1488	1.272
1618	1.122

*The one-dimensional statistical analysis resulted in a Stand. Error of Est. of about 10 percent, therefore the experimental values are given.

Viscosity: [69].

5.4. General Summary Tables

TABLE 13 a. Total and recommended investigations [a]

Compound	κ		ρ		η		γ	
	No. of Invest.	Rec. Ref.	No. of Invest.	Rec. Ref.	No. of Invest.	Rec. Ref.	No. of Invest.	Rec. Ref.
AgF	1	[1]						
BaF_2			5	[1]				
BeF_2	1	[1]	3	[33, 73]	5	[1]		
CaF_2			2	[1]				
CeF_3			1	[1]				
CsF	2	[1]	4	[1]			3	[2]
CuF_2	1	[1]						
KF	14	[1]	10	[1]	1	[107]	4	[2]
LaF_3			1	[1]				
LiF	15	[1]	17	[1]	2	[108]	4	[2]
MgF_2			1	[1]				
MnF_2	1	[1]						
NaF	21	[1]	17	[95]	1	[5]	6	[2]
PbF_2	1	[1]						
RbF			2	[62, 106]			2	[2]
SrF_2			1	[1]				
ThF_4			4	[1]			1	[2]
UF_4			4	[1]	1	[69]	2	[2]
UF_6							1	[2]
ZnF_2	1	[1]						

[a] Total number of investigations and recommended references for specific conductance, density, viscosity, and surface tension of single fluoride melts.

TABLE 13 b. References.[a]

Specific conductance

Single salts	No. of invest.	Literature references
KF	14	**1**, 13, 14, 15, 89, **107**, 120
LiF	15	**1**, 13, 16, 24, 40, 76, 78, 79, 80, 84, 87, 120
NaF	21	**1**, 5, 8, 13, 24, 41, 50, 59, 66, 70, 76, 78, 79, 80, 87, 110, 120

[a] The total number of investigations evaluated and literature references that were not given in NSRDS–NBS–15 [1] and NSRDS–NBS–28 [2].

Table 13 c. References [a]

Density

Single salts	No of invest.	Literature references
BaF_2	5	**1**, 9, 26, 27, 118
BeF_2	3	**32**, **33**, 73
CsF	4	**1**, 26, 106
KF	10	**1**, 26, 27, 87, 89, 98, 106, 107
LiF	17	**1**, 16, 18, 24, 26, 32, 60, 75, 84, 87, 89, 95, 98, 106, 108
NaF	17	**1**, 5, 7, 24, 26, 45, 49, 75, 87, 94, **95**, 96, 97, 98, 103, 106
RbF	2	**62**, 106
ThF_4	4	**1**, 31, 60, 98
UF_4	4	**1**, 69, 87, 98

[a] The total number of investigations evaluated and literature references that were not given in NSRDS–NBS–15 [1] and NSRDS–NBS–28 [2].

TABLE 13 d. References [a]

Viscosity

Single salts	No. of invest.	Literature references
BeF_2	5	**1**, 32, 33, 91
KF	1	**107**
LiF	2	18, **108**
NaF	1	**5**
UF_4	1	**69**

[a] The total number of investigations evaluated and literature references that were not given in NSRDS–NBS–15 [1] and NSRDS–NBS–28 [2].

TABLE 13 e. References.[a]

Surface tension

Single salt	No. of invest.	Literature references
CsF	3	**2**, 68
KF	4	**2**, 61, 89, 106
LiF	4	**2**, 61, 89
NaF	6	**2**, 5, 43, 61
RbF	3	**2**, 61
UF_4	2	**2**, 69

[a] The total number of investigations evaluated and literature references that were not given in NSRDS–NBS–15 [1] and NSRDS–NBS–28 [2].

6. Binary Mixtures

6.1. Discussions and Numerical Data

This section comprises a discussion of the investigated transport properties featuring references, composition and temperature ranges, percent departure values, and experimental techniques. The melt preparation and purification section summarizes the procedures used in each investigation. Numerical tables of physical properties at rounded or experimental compositions and temperatures, together with temperature and composition-dependent equations are given for the recommended studies. Phase diagrams for each binary mixture are reported as an aid to the user.

AlF_3-CsF

Density

The recommended values in table 15 are based on the work of Mal'tsev and Bukhalova (Archimedean method) [25].

TABLE 14 A. Investigations critically re-examined

Ref.	CsF (mol %)	Temp. range (T)
25	75	1123–1273
74	75	1123–1223

TABLE 14 B. Cell materials and calibration

Cell material	Calibration
Pt ball and suspension wire [25, 74]	Molten NaF, NaCl, KCl [25, 74]

Melt Preparation and Purification

Mal'tsev and Bukhalova [25, 74] for the preparation of Cs_3AlF_6 reported only that the synthesis was carried out by fusion of analytical grade CsF and AlF_6.

TABLE 15 a. AlF_3-CsF: Density

Numerical Values (gcm^{-3})

T	75 Mol % CsF
1130	3.046
1140	3.031
1150	3.015
1160	3.000
1170	2.985
1180	2.969
1190	2.954
1200	2.939
1210	2.923
1220	2.908
1230	2.893
1240	2.877
1250	2.862
1260	2.846
1270	2.831

TABLE 15 b. Temperature-dependent equations

$\rho = a + bT$ (gcm^{-3})

Comp. (mol % CsF)	a	$b \cdot 10^3$	Stand. error of est.
75	4.7793	−1.5340	0.0003

Reference: [25]. Data reported in numerical form.

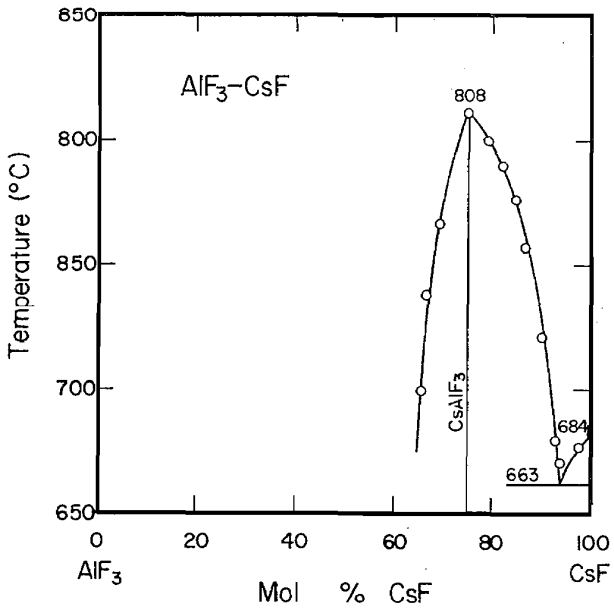

FIGURE 1. Temperature-composition phase diagram for AlF_3-CsF. E. P. Dergunov, Dan S.S.S.R., **60**, 1185 (1948).

AlF_3-KF

Electrical Conductance

The recommended values in figure 2 are based on the work of Yim and Feinleib (classical ac technique) [**120**].

TABLE 16 A. Investigations critically re-examined

Ref.	KF (mol %)	Temp. range (T)
120	75, 100 (graphical except for 100% at 1173 K)	1153–1343
15	60–100	1133–1323
100*	75	1273, 1333
14	75	1273, 1298, 1322

*Values from reference [**120**].

TABLE 16 B. Comparisons with previous recommendations

Ref.	Recommended value		KF (mol %)	% Departure			
	Vol.	Page		% (min)	(T)	% (max)	(T)
120	1	3	100	3.3	(1173)		
15	1	3	100	14.1	(1153)	22.5	(1248)

TABLE 16 C. Cell materials and calibration

Cell Material	Electrodes	Frequency Range (Hz)	Calibration
Boron nitride cell inside graphite crucible [**120**]	Inconel [**120**]	1,000–20,000 measurements at 2000 [**120**]	Calculated from dimensions of electrodes or/ molten KCl [**120**]
Pt crucible [14]	Pt [14]		KCl solution [14]

Comment: Yim and Feinleib [**120**] corrected for the conductance of the boron nitride cell body by measuring both the combined conductance of the electroyte and cell body and then the conductance of the empty cell. Since boron nitride is rapidly oxidized at about 1000 ° C, all measurements were made in an argon atmosphere. Polarization was not considered a problem since resistance readings did not vary appreciably between 1,000 and 20,000 hertz.

Measurements were reported to be reproducible to about 1–2 percent.

Density

The recommended values in table 18 are based on the work of Mal'tsev and Bukhalova (Archimedean method) [**74**].

TABLE 17 A. Investigations critically re-examined

Ref.	KF (mol %)	Temp. range (T)
25	75	1073
74	75	1273, 1323

TABLE 17 B. Cell materials and calibration

Cell material	Calibration
Pt ball and wire [25, 74]	Molten NaF, KCl, NaCl [25, 74]

Comment: No correction for surface tension was applied in references [25, 74].

Melt Preparation and Purification

Yim and Feinlieb [**120**] used Baker's reagent grade KF. The preparation of pure AlF_3 is described under the system AlF_3-LiF. The preparation of pure AlF_3 and KF (similar to NaF) by Batashev [14, 15] is given under the AlF_3-NaF system.

Mal'tsev and Bukhalova [25, **74**] synthesized K_3AlF_6 by fusion of KF with AlF_3. Salts of analytical grade were used for synthesis.

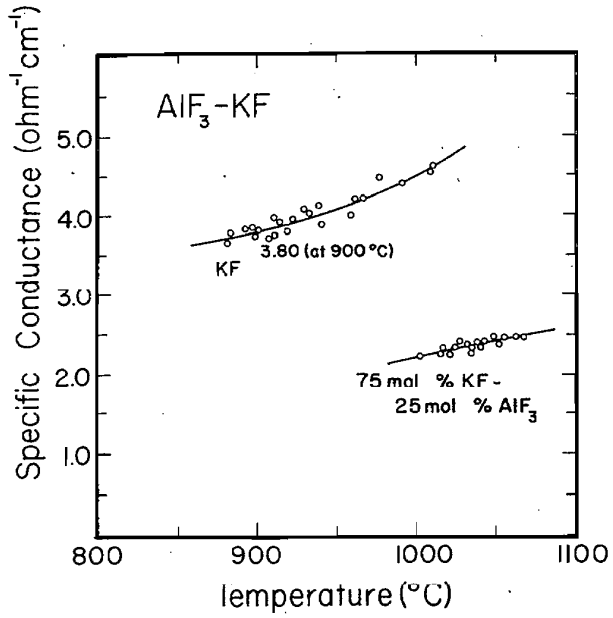

FIGURE 2. Plots [120] of specific conductance against temperature for the system AlF_3-KF.

TABLE 18. AlF_3-KF: Density

Numerical Values (gcm^{-3})

T	75 Mol % KF
1273.2	1.828
1323.2	1.791

Reference: [74].
Due to limited data the experimental values are given.

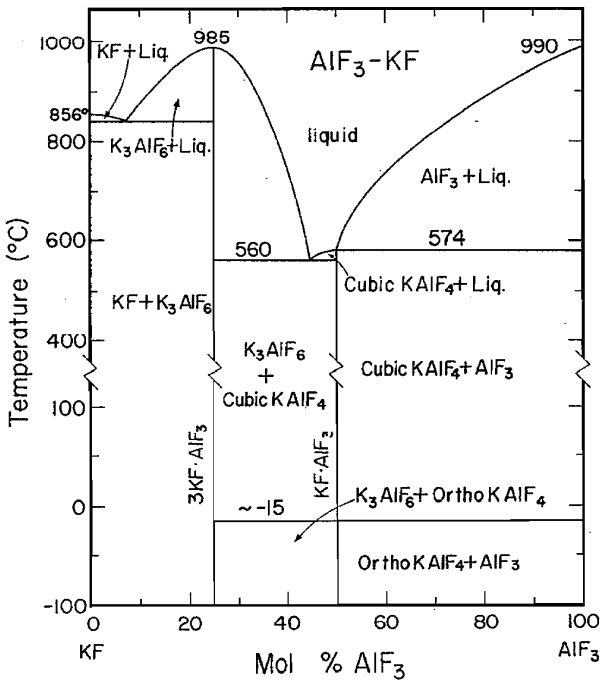

FIGURE 3. Temperature-composition phase diagram for AlF_3-KF. Bert Phillip, C. M. Warsaw, and I. Mockrin, J. Am. Ceram. Soc., 49 [12] 633 (1966).

AlF_3-LiF

Electrical Conductance

The recommended values in table 22 and figure 4 are based on the work of Matiasovsky et al.[8] (Classical ac technique) [80].

TABLE 19 A. Investigations critically re-examined

Ref.	LiF (mol %)	Temp. Range (T)
120	75, 100 (graphical for 75 mol % LiF)	1063–1248
80	55–100 (numerical for 75 and 100 mol % LiF)	1123–1323
40	25–100 (graphical)	1073–1348
6	75	1098–1348
79	25–100 (graphical)	1173, 1273, 1373
86	75	1073–1273
100*	75	1073–1193
41	75	1153–1348
84	25–100 (graphical)	1073, 1173, 1273
42	75 (graphical)	1273, 1323, 1373
77	75 (graphical)	1273, 1323

* Data from reference [120].

TABLE 19 B. Comparison with previous recommendations

Ref.	Recommended value		LiF (mol %)	% Departure			
	Vol.	Page		% (min)	(T)	% (max)	(T)
120	1	2	100	−4.2	(1173)		
80	1	2	100	0.04	(1260)	−3.7	(1140)
120	4.1	15	100	−1.2	(1173)		
6	4.1	15	75	−2.0	(1173)	−4.0	(1323)
86	4.1	15	75	12.4	(1273)		

[8] These result have been further discussed recently. See K. Matiasovsky and V. Danek, J. Electrochem. Soc. 120, 919 (1973).

TABLE 19 C. Cell materials and calibration

Cell material	Electrodes	Frequency range (Hz)	Calibration
Boron nitride cell inside a graphite crucible [120]	Inconel [120]	1,000–70,000 (measurements at 2,000) [120]	Measurements of cell dimensions and molten KCl [120]
Pt crucible [6, 40, 41, 79, **80**]	Pt [6, 40, 41, 79, **80**, 86]	4,000–20,000 (measurements at 18,000) [6, 40, 41, 79, **80**]	Molten Na_3AlF_6 [6, 40, 41, 79, **80**]
Pt crucible [86]	Mo [84]	5,500 [86]	0.1 N KCl solution at 18 ° C [86]
Boron nitride cell inside graphite holder [84]		1,000–20,000 [84]	

Comments: The conductance of the boron nitride cell body used in reference [119, 120] was corrected by measuring the combined conductance of the electroyte and the cell, and then lifting the cell out of the melt and determining the "empty cell conductance." Yim and Feinleib [119, 120] reported that reproducibility between runs was usually 2 percent or better.

Matiasovsky et al reported an overall error of less than ±2 percent for conductivity measurements. Mashovets and Petrov [86] estimated their accuracy at ±3 percent.

Density

The recommended values in table 23 are based on the work of Matiasovsky et al. (Archimedean method) [**75, 95**].

TABLE 20 A. Investigations critically re-examined

Ref.	LiF (mol %)	Temp. range (T)
75	55 –100	1123–1323
86	75	1061–1302
108	65 –100	1140–1398
94	55 –100	1273
95	55 –100	1123–1323
84	37.5–100	1073, 1273
74	75	1073–1273
83	75	1283–1348

Two references from the same laboratory were weighted equally. Reference [95] is based on the numerical results received as a private communication [75]; in [95] numerical values are not reported, but rather the results are presented as a set of smoothed equations. The recommended values advanced herewith are based on the numerical results (ref. 75).

TABLE 20 B. Comparison with Previous Recommendations

Ref.	Recommended value		LiF (mol %)	% Departure			
	Vol.	Page		% (min)	(T)	% (max)	(T)
75	1	2	100	−0.11	(1273)	−0.17	(1173)
94	1	2	100	−0.11	(1273)		
95	1	2	100	−0.36	(1140)	−0.18	(1300)
108	1	2	100	−0.64	(1348)	−1.2	(1188)
84	1	2	100	−2.8	(1273)		
108	4.1	16	100	−0.53	(1348)	−0.90	(1188)
84	4.1	16	100	−2.8	(1273)		
84	4.1	16	95	3.6	(1273)		
108	4.1	16	90	−0.90	(1276)	−0.94	(1238)
84	4.1	16	90	3.7	(1273)		
84	4.1	16	80	−0.20	(1273)		
86	4.1	16	75	2.7	(1273)		
108	4.1	16	75	−0.90	(1241)	−0.94	(1340)
84	4.1	16	75	−0.97	(1273)		
74	4.1	16	75	−0.48		−2.5	
108	4.1	16	70	−0.77	(1289)	−0.80	(1236)
108	4.1	16	65	−0.69	(1277)	−1.07	(1207)
84	4.1	16	60	6.4	(1273)		

TABLE 20 C. Cell materials and calibration

Cell material	Calibration
Pt sinker and suspension wire [74, **75**, 83, 94, **95**]	Molten KCl, NaCl [74, **75**, 83, 94, **95**]

Comment: Matiasovsky et al. [74, **75**, 83, 94, **95**] found that volumes of the Pt sinker determined from molten KCl and NaCl differed by less than 0.2 percent. The reproducibility of measurements was reported to be better than 0.1 percent.

Viscosity

The recommended values in table 25 are based on the work of Vetyukov and Sipriya (oscillating sphere method) [**108**].

TABLE 21 A. Investigations critically re-examined

Ref.	LiF (mol %)	Temp. range (T)
108	65–100	1140–1398

Melt Preparation and Purification

Yim and Feinleib [119, 120] used Baker's reagent grade LiF. Aluminium fluoride was Alcoa X–2A grade powder containing approximately 97 percent AlF_3, 1.2 percent NaF and 1.5 percent Al_2O_3. The material was not sublimed. Mixtures were prepared by mixing the melt constituents in the dry state followed by fusion in a graphite crucible. The melt was cooled, pulverized, thoroughly mixed, and sampled.

Abramov et al. [6] used sublimation techniques to purify technical grade AlF_3. The LiF was heated to 1100 °C to remove moisture.

Lithium cryolite, used in reference [86] was synthetically prepared from chemically-pure lithium and aluminium fluoride. The composition was checked by chemical analysis and optical crystallography.

Vetyukov and Sipriya [108] used analytically pure LiF and c.p. AlF_3. Before using, LiF was heated at 600 °C for 3 h and AlF_3 was heated at 300 °C for 3 h.

TABLE 22a. AlF_3–LiF: Electrical Conductance

Specific Conductance: Numerical Values (ohm^{-1} cm^{-1})

	Mol percent LiF	
T	100	75
1130	8.20	
1140	8.28	
1150	8.35	
1160	8.42	
1170	8.50	
1180	8.57	4.02
1190	8.64	4.04
1200	8.71	4.06
1210	8.78	4.08
1220	8.85	4.10
1230	8.91	4.12
1240	8.98	4.14
1250	9.04	4.15
1260	9.11	4.17
1270	9.17	4.18
1280	9.23	4.20
1290	9.29	4.21
1300	9.35	4.23
1310	9.41	4.24
1320	9.46	4.25

TABLE 22 b. Temperature-dependent equations

$\kappa = a + bT + cT^2$ (ohm^{-1} cm^{-1})

Comp. (mol % LiF)	a	$b \cdot 10^3$	$c \cdot 10^6$
75	−3.3489	10.3337	−3.4658
100	−7.6069	20.2557	−5.5475

Reference: [80]. Data reported in equation form. Additional data are reported graphically in figure 4.

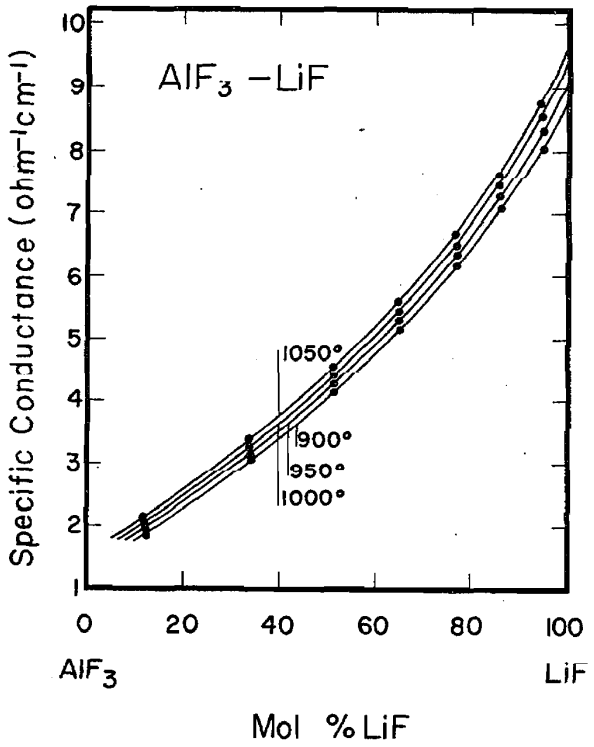

FIGURE 4. Isotherms [80] (°C) of specific conductance against molar composition for the system AlF_3-LiF.

TABLE 23. AlF_3-LiF: Density

Numerical values (gcm^{-3})

Mol percent LiF

T	100	95	90	85	80	75	70	65	60	55
1130	1.800	1.885	1.972	2.037	2.073	2.098	2.088	2.041	1.962	1.861
1140	1.795	1.880	1.966	2.030	2.065	2.089	2.079	2.031	1.952	1.851
1150	1.791	1.875	1.960	2.023	2.058	2.081	2.069	2.021	1.942	1.842
1160	1.786	1.870	1.953	2.016	2.051	2.073	2.060	2.010	1.931	1.832
1170	1.781	1.866	1.947	2.010	2.044	2.064	2.051	2.000	1.921	1.823
1180	1.777	1.861	1.941	2.003	2.037	2.056	2.041	1.990	1.911	1.814
1190	1.772	1.856	1.935	1.996	2.030	2.048	2.032	1.979	1.901	1.805
1200	1.767	1.851	1.929	1.990	2.023	2.039	2.022	1.969	1.891	1.795
1210	1.763	1.846	1.923	1.983	2.016	2.031	2.013	1.959	1.880	1.786
1220	1.758	1.842	1.917	1.976	2.009	2.022	2.004	1.948	1.870	1.776
1230	1.753	1.837	1.910	1.970	2.002	2.014	1.994	1.938	1.860	1.767
1240	1.748	1.832	1.904	1.963	1.994	2.006	1.985	1.928	1.850	1.758
1250	1.744	1.827	1.898	1.956	1.987	1.997	1.976	1.918	1.840	1.748
1260	1.739	1.822	1.892	1.950	1.980	1.989	1.966	1.907	1.829	1.739
1270	1.734	1.817	1.886	1.943	1.973	1.981	1.957	1.897	1.819	1.729
1280	1.730	1.813	1.880	1.936	1.966	1.972	1.948	1.887	1.809	1.720
1290	1.725	1.808	1.874	1.929	1.959	1.964	1.938	1.876	1.799	1.711
1300	1.720	1.803	1.867	1.923	1.952	1.956	1.929	1.866	1.789	1.701
1310	1.716	1.798	1.861	1.916	1.945	1.947	1.920	1.856	1.778	1.692
1320	1.711	1.793	1.855	1.909	1.938	1.939	1.910	1.845	1.768	1.682

TABLE 24. Temperature-dependent equations

$\rho = a + bT$ (gcm^{-3})

Comp. (mol % LiF)	a	$b \cdot 10^4$	Stand. error of est.
55	2.9235	−9.4019	0.0006
60	3.1147	−10.2009	0.0000
65	3.2050	−10.2998	0.0003
70	3.1456	−9.3597	0.0003
75	3.0422	−8.3590	0.0003
80	2.8751	−7.1021	0.0004
85	2.7935	−6.6981	0.0003
90	2.6660	−6.1429	0.0003
95	2.4298	−4.8222	0.0007
100	2.3283	−4.6757	0.0000

Reference: [75]. Data reported in numerical form.

TABLE 25 a. AlF_3-LiF: Viscosity

Numerical values (cp)

Mol percent LiF

T	100.0	90.0	77.5	75.0	70.0	65.0
1150	2.16					
1160	2.11					
1170	2.07					
1180	2.03		[2.81]	3.01		
1190	1.99		[2.72]	2.89		
1200	1.95		[2.64]	2.78		
1210	1.91		[2.55]	2.67		[2.01]
1220	1.88		[2.47]	2.56		[1.93]
1230	1.84		[2.40]	2.47		[1.86]
1240	1.81	[1.90]	[2.32]	2.38	2.15	[1.79]
1250	1.77	[1.88]	[2.24]	2.29	2.06	[1.73]
1260	1.74	[1.85]	[2.16]	2.21	1.99	[1.68]
1270	1.71	[1.82]	[2.09]	2.13	1.91	[1.62]
1280	1.68	[1.79]	[2.01]	2.05	1.84	[1.58]
1290	1.65	[1.75]	[1.93]	1.98	1.78	[1.53]
1300	1.63	[1.72]	[1.84]	1.92	1.72	[1.49]
1310	1.60	[1.68]	[1.76]	1.85	1.66	[1.45]
1320	1.57	[1.64]	[1.67]	1.79	1.60	[1.41]
1330	1.55	[1.60]	[1.58]	1.73	1.55	[1.37]
1340	1.53	[1.56]	[1.48]	1.68	1.50	
1350		[1.52]	[1.38]		1.45	
1360		[1.49]			1.40	
1370		[1.46]			1.36	
1380		[1.43]			1.31	
1390		[1.40]				

TABLE 25 b. Temperature-dependent equations

$\eta = a + bT + cT^2 + dT^3$ (cp)

$\eta = A \cdot \exp(E/RT)$ (cp)

Comp. (mol % LiF)	$a \cdot 10^{-1}$	$b \cdot 10^2$	$c \cdot 10^4$	$d \cdot 10^7$	$A \cdot 10^2$	E (cal mol^{-1})	Stand. error of est.
65.0	[22.0537]	[−48.3987]	[3.5890]	[−0.8940]			0.0000
70.0					1.691	11934	0.0235
75.0					2.240	11491	0.0551
77.5	[16.0675]	[−36.5688]	[2.8710]	[−0.7676]			0.0000
90.0	[−22.7452]	[52.8134]	[−4.0281]	[1.0166]			0.0000
100.0					18.549	5610	0.0157

Reference: [108]. Data reported in numerical form.

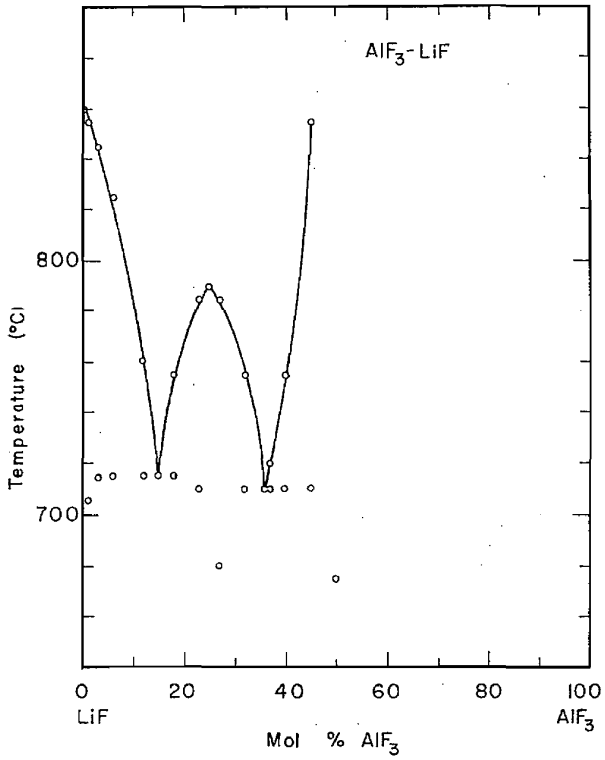

FIGURE 5. Temperature-composition phase diagram for AlF_3-LiF. P. P. Fedotjeff and K. Timofeeff, Z. Anorg. Allg. Chem., **206**, 263 (1932).

AlF_3-NaF
Electrical Conductance

The recommended values in table 30 are based on the work of Edwards et al. (classical ac technique) [**45, 46**].

TABLE 26 A. Investigations critically re-examined

Ref.	NaF (mol %)	Temp. Range (*T*)
96	40–100 (graphical)	1273
14	53.4–100	1023–1323
45	67.6–100	1273, 1313, 1353
85	75	1273
39	75	1293
116	75	1273, 1297, 1323
10	75	1253–1313
80	75, 100 (graphical for 75 mol %)	1273–1373
40	75 (graphical)	1273–1323
6	75	1273–1423
79	75, 100 (graphical for 75 mol %)	1273, 1323
86	75 (graphical except for 1273 K)	1273–1423
120	70.9–100 (graphical)	1173–1333
77	75 (graphical)	1273, 1323
12	75	1273–1353
41	75, 100 (graphical)	1273–1390
5	48.5–100	1003–1439
70	75, 100 (graphical)	940–1523
82	75 (graphical)	1273–1353
110*	75 (graphical)	1273
51**	71.1–100	1273
46	75	1273–1353
104***	20–100 (graphical except for 75 mol %)	1273–1353
114	63.5–100 (graphical for mixtures)	1193–1411
81	75 (graphical)	1273

*Values from reference [120].

**Values from references [45, 114, 120].

***Values from references [14, 45, 86, 114, 116, 120]. and see also K. Matiasovsky and V. Danek, J. Electrochem. Soc. **120**, 919 (1973).

TABLE 26 B. Comparisons with previous recommendations

Ref.	Recommended value		NaF (mol %)	% Departure			
	Vol.	Page		% (min)	(T)	% (max)	(T)
14	1	3	100	−8.8	(1323)	−18.8	(1273)
45	1	3	100	11.7	(1273)	15.1	(1353)
80	1	3	100	0.0	(1370)	−1.9	(1280)
79	1	3	100	0.0	(1370)	−1.9	(1280)
5	1	3	100	−7.9	(1390)	−9.4	(1287)
14	4.1	20	100	−21.4	(1313)	−27.4	(1273)
80	4.1	20	100	−9.3	(1313)	−15.7	(1273)
51	4.1	20	100	−5.9	(1273)		
14	4.1	20	75	−15.4	(1273)	−20.0	(1313)
85	4.1	20	75	−21.4	(1273)		
116	4.1	20	75	−13.0	(1323)	−15.7	(1273)
10	4.1	20	75	18.3	(1313)	−20.4	(1273)
6	4.1	20	75	−10.0	(1273)	−11.4	(1348)
86	4.1	20	75	−9.6	(1273)		
5	4.1	20	75	−5.2	(1313)	−8.2	(1283)
14	4.1	20	70	13.8	(1273)		

TABLE 26 C. Cell materials and calibration

Cell Material	Electrodes	Frequency range (Hz)	Calibration
Pt crucible [10, 14]	Pt [6, 10, 12, 14, 40, 41, 45, 46, 70, 77, 79, 80, 82, 86]	500–4000 [45, 46]	KCl solution (18 ° C) [14]
Pt cell with cylindrical sides and hemispherical top and bottom, melt contained in Pt crucible [45, 46]	Inconel [120]	1,000–20,000 (measurements at 2,000) [120]	31.1% H_2SO_4 and 0.01 N KCl [45, 46], Molten KCl [120]
Boron nitride cell inside graphite crucible [120]		4,000–20,000 (measurements at 18,000) [6, 40, 77, 79, 80]	Molten Na_3AlF_6 [6, 40, 77, 79, 80]
Pt crucible with Pt disc electrodes [6, 12, 40, 41, 79, 80, 82]		5,000 [12, 82]	30% H_2SO_4 [12]
Pt crucible with two hemispherical Pt electrodes [86]		5,500 [86]	Molten KNO_3, NaCl, Na_2SO_4 [82]
Pt crucible with inner cylindrical Pt electrode [70]			0.1 N KCl (25 ° C) [10]
			0.1 N KCl, 1 N KCl and 30% H_2SO_4 [86]
			KCl solution [70]

Comment: Resistance readings in reference [45 and 46] were extrapolated to infinite frequency using plots of resistance versus frequency$^{-1/2}$. Attempts at determining the cell constant in molten NaCl and KCl were unsuccessful.

Comments concerning reference [120] are given under the system AlF_3–LiF.

Matiasovsky et al. [6, 40, 41, 79, 80, 82] used as a cell a platinum crucible with two Pt disc electrodes. The electrodes were positioned in the melt with the aid of a micrometer screw to an accuracy of ±0.01 mm. An overall error of ±2 percent for conductivity measurements was reported.

Mashovets and Petrov [86] estimated their measurements to be accurate to ±3 percent.

Density

The recommended values in table 31 are based on the work of Matiasovsky et al. (Archimedean method) [75, 95].

TABLE 27 A. Investigations critically re-examined

Ref.	NaF (mol %)	Temp. range (T)
115	75–100 (graphical except for 75%)	1273–1303
4	75	1293–1403
96	66–100 (graphical)	1273, 1373
45	67.6–100	1220–1367
85	75	1273
65	75	1308, 1352, 1395
7	60–100	1128–1413
93	58.7–75.0	1303, 1323, 1343
75	55–100	1273, 1323, 1373
25	75	1273, 1323
86	75	1273
52*	75–100 (graphical)	1273–1373
5	62.01, 66.7, 75.0, 83.3, 100	1196–1396
108**	75	1313, 1347, 1378, 1449
94	55–100	1273
95	50–100	1273–1373
103	70.0–100 (graphical)	1213–1373
84	75	1273–1373
83	75	1273–1373
46	75	1273–1353
92***	75	1303–1424

*Values from reference [45].
**Values from reference [86].
***Values from reference [5].

TABLE 27 B. Comparisons with previous recommendations

Ref.	Recommended Value		NaF (mol %)	% Departure			
	Vol.	Page		% (min)	(T)	% (max)	(T)
45	1	3	100	0.63	(1340)	0.75	(1280)
7	1	3	100	−0.56	(1383)	0.95	(1283)
75	1	3	100	−0.04	(1323)	−0.24	(1373)
5	1	3	100	0.42	(1398)	0.84	(1288)
45	4.1	22	80	1.07	(1283)	1.16	(1353)
7	4.1	22	80	1.3	(1373)	1.8	(1333)
115	4.1	22	75	0.38	(1273)	0.43	(1303)
4	4.1	22	75	0.15	(1363)	0.29	(1293)
45	4.1	22	75	−0.33	(1273)	−0.88	(1353)
85	4.1	22	75	−1.05	(1273)		
65	4.1	22	75	−0.98	(1352)	−1.4	(1308)
7	4.1	22	75	−0.05	(1323)	0.29	(1293)
93	4.1	22	75	−0.34	(1303)	−0.39	(1343)
25	4.1	22	75	−4.3	(1273)		
86	4.1	22	75	0.00	(1357)	−0.04	(1307)
5	4.1	22	75	0.43	(1303)	0.54	(1366)
108	4.1	22	75	0.05	(1313)	−0.49	(1347)
84	4.1	22	75	−0.45	(1373)	−0.90	(1273)
46	4.1	22	75	−0.33	(1273)	−0.88	(1353
45	4.1	22	70	1.07	(1283)	1.16	(1353
93	4.1	22	70	−0.15	(1303)	−0.20	(1343
7	4.1	22	60	0.66	(1323)	0.73	(1373

TABLE 27 C. Cell materials and calibration

Cell Material	Calibration
Pt spherical bob [4, 5, 7]	Volume calculated using coefficient of expansion of Pt [45, 86]
Pt sinker and suspension wire [45]	Water and molten KCl [65]
Pt sinker and suspension wire, melt in Pt crucible [65, 75, 83, 94, 95]	Molten KCl, NaCl, NaF [25]
Pt sphere and suspension wire [25]	Molten NaCl and KCl [75, 83, 94, 95]
Pt float and melt in Pt crucible [86]	
Pt ball and crucible [84]	

Comment: Matiasovsky et al. [75, 83, 94, 95], using the hydrostatic weighting method, calibrated their platinum sinker using the density data of Bruner (Molten Salts: Vol. 1, reference 3) for NaCl and KCl. The volumes determined using these two salts differed by less than 0.2 percent. The accuracy reported for density values was ±0.2 percent.

Viscosity

The recommended values in table 32 are based on the work of Abramov (oscillating sphere method) [5].

TABLE 28 A. Investigations critically re-examined

Ref.	NaF (mol %)	Temp. range (T)
117	68–80 (graphical)	1243–1323
93	70–75	1303, 1323, 1343
5	62.0–100	1168–1473
108	75	1313–1449
92	75	1303–1424

TABLE 28 B. Comparisons with previous recommendations

Ref.	Recommended value		NaF (mol %)	% Departure			
	Vol.	Page		% (min)	(T)	% (max)	(T)
117	4.1	22	75	204	(1323)		
93	4.1	22	75	−47	(1323)	−51	(130
108	4.1	22	75	−5.1	(1443)	−6.6	(131
92	4.1	22	75	−0.8	(1313)	2.5	(142

TABLE 28 C. Cell materials and calibration

Cell material	Calibration
Rotating cylinder made of bronze, cryolite in graphite container [117]	Glycerine solution [117]
Pt sphere and Mo suspension wire, melt contained in a Pt cup [5]	Water, aniline and sulfuric acid [5]
Pd ball and rod, Mo suspension wire [108]	Cryolite was used to check method [108]
Pt bob and suspension wire [92]	

Comment: Abramov [5] reported a standard deviation of ±2 percent.

Surface Tension

The recommended values in table 33 are based on the work of Bloom and Burrows (maximum bubble pressure method) [**20**].

TABLE 29 A. Investigations critically re-examined

Ref.	NaF (mol %)	Temp. range (T)
20	72.6–100	1273–1353
5	50 –100	1273

TABLE 29 B. Comparisons with previous recommendations

Ref.	Recommended value		NaF (mol %)	% Departure			
	Vol.	Page		% (min)	(T)	% (max)	(T)
5	2	57	100	7.75	(1273)		
5	4.1	23	86.4	8.9	(1273)		
5	4.1	23	78	6.1	(1273)		
5	4.1	23	75	8.5	(1273)		

Comment: The apparatus used by Bloom and Burrows [**20**] was essentially the same as that described by Peake and Bothwell (J. S. Peake and M. R. Bothwell, J. Am. Chem. Soc., **76**, 2653 (1954)). Reproducibility of surface tension values was reported to be ±1.5 percent.

Melt Preparation and Purification

Batashev [14] dehydrated NaF (Kahlbaum) by gradually heating the material in a platinum cup to melting. Analysis showed 54.63 percent Na and 44.99 percent F (theoretical: 54.76% Na, 45.24% F). Chemically pure and dehydrated AlF_3 was prepared by sublimation. The product was ground up and subjected to magnetic separation of ferrous impurities. Mixtures were prepared by fusing cryolite with NaF and AlF_3. Mixtures which were analyzed following experiments showed compositional changes of less than 0.5 percent.

Edwards et al. [**45**, 46] used crystals of pure Greenland cryolite which were crushed to 20 mesh and associated particles of galena were removed. Sodium fluoride was Baker's c.p. powder and aluminium fluoride was sublimed. The above materials were ignited at 600 °C in a platinum crucible before weighing. Spectrographic analysis of cryolite showed only K and Li as impurities at 0.1 to 0.01 percent. Analysis gave the results: 54.34 percent F (theoretical—54.30%, 32.76 percent Na (32.86%), 13.01 percent Al (12.84%).

Aluminium fluoride, sodium fluoride and cryolite used by Yim and Feinleib [120] were Alcoa X–2A grade powder, Baker's reagent grade and natural hand-picked crystals (Pennsylvania Salt Mfg. Company) respectively. Pure salts and mixtures were fused at a temperature of about 50 °C above the melting point. Melts were cooled, crushed and sampled with analysis showing little or no compositional changes.

Matiasovsky et al. [40, 41, **75**, 77, 79, 80, 83, 94, **95**] used NaF of a purity "for monocrystals" and hand-picked Greenland natural cryolite. Pure AlF_3 (99.5 wt. % AlF_3) was prepared by sublimation of the technical product in a platinum apparatus.

Abramov [4, **5**, 6] used natural cryolite. The NaF was fused and ground to a powder. Technical AlF_3 was sublimed resulting in colorless transparent crystals.

Bukhalova and Mal'tsev used "analytical reagent" grade fluoride salts.

Sodium cryolite was synthetically prepared by Mashovets and Petrov [86] from the "chemically-pure" fluorides.

Vetyukov and Sipriya [108] used "analytically pure" NaF and c.p. grade AlF_3. Sodium fluoride was heated at 600 °C for 3 h while the aluminium fluride was dehydrated at 300 °C for 3 h.

Landon and Ubbelohde [70] used natural hand-picked crystals of cryolite (Kryolitselskabet 'Oresund', Kobenhavn, Denmark).

Bloom and Burrows [**20**] used natural cryolite (99.6% Na_3AlF_6), analytical reagent NaF (98% NaF) and reagent grade AlF_3 (93% AlF_3). Mixtures containing up to 2 mol percent AlF_3 were prepared by adding dry NaF to cryolite. Mixtures of compositions greater than 25 mol percent AlF_3 were made by adding AlF_3 to cryolite.

TABLE 30. AlF_3-NaF: Electrical conductance

Specific conductance: Numerical values (ohm^{-1} cm^{-1})

Mol percent NaF

T	100	86.2	80.0	78.1	75.0	70.3	67.7
1273.2	5.518	3.856	3.189	3.122	2.799	2.677	2.600
1313.2	5.744	3.998	3.301	3.233	2.901	2.773	2.684
1353.2	5.953	4.135	3.408	3.333	2.997	2.856	2.762

Reference: [45]. Due to limited data the experimental values are given.

TABLE 31 a. AlF_3-NaF: Density

Numerical values (gcm^{-3})

Mol percent NaF

T	100	90	85	80	77	75	70	65	60	55	50
1275	1.944	2.042	2.078	2.097	2.098	2.100	2.053	1.976	1.857	1.723	1.615
1280	1.941	2.039	2.074	2.092	2.094	2.096	2.048	1.971	1.853	1.719	1.612
1285	1.938	2.035	2.070	2.088	2.089	2.091	2.044	1.966	1.848	1.715	1.608
1290	1.935	2.032	2.067	2.083	2.085	2.087	2.039	1.962	1.844	1.711	1.605
1295	1.931	2.029	2.063	2.079	2.080	2.082	2.034	1.957	1.840	1.707	1.601
1300	1.928	2.026	2.059	2.074	2.076	2.077	2.030	1.952	1.835	1.703	1.598
1305	1.925	2.022	2.055	2.070	2.071	2.073	2.025	1.948	1.831	1.699	1.595
1310	1.922	2.019	2.051	2.065	2.066	2.068	2.021	1.943	1.826	1.695	1.591
1315	1.919	2.016	2.048	2.061	2.062	2.064	2.016	1.938	1.822	1.691	1.588
1320	1.915	2.013	2.044	2.056	2.057	2.059	2.011	1.934	1.817	1.688	1.584
1325	1.912	2.009	2.040	2.052	2.053	2.054	2.007	1.929	1.813	1.684	1.581
1330	1.909	2.006	2.036	2.047	2.048	2.050	2.002	1.924	1.808	1.680	1.577
1335	1.906	2.003	2.032	2.043	2.044	2.045	1.998	1.920	1.804	1.676	1.574
1340	1.903	2.000	2.028	2.038	2.039	2.040	1.993	1.915	1.800	1.672	1.570
1345	1.900	1.996	2.025	2.034	2.035	2.036	1.988	1.910	1.795	1.668	1.567
1350	1.896	1.993	2.021	2.029	2.030	2.031	1.984	1.906	1.791	1.664	1.563
1355	1.893	1.990	2.017	2.025	2.025	2.027	1.979	1.901	1.786	1.660	1.560
1360	1.890	1.987	2.013	2.020	2.021	2.022	1.975	1.896	1.782	1.656	1.557
1365	1.887	1.983	2.009	2.016	2.016	2.017	1.970	1.892	1.777	1.652	1.553
1370	1.884	1.980	2.005	2.011	2.012	2.013	1.965	1.887	1.773	1.648	1.550

TABLE 31 b. Temperature-dependent equations

$\rho = a + bT$ (gcm^{-3})

Comp. (mol % NaF)	a	$b \cdot 10^4$
50	2.4950	−6.90
55	2.7198	−7.82
60	2.9921	−8.90
65	3.1679	−9.35
70	3.2258	−9.20
75	3.2733	−9.20
77	3.2612	−9.12
80	3.2415	−8.98
85	3.0535	−7.65
90	2.8680	−6.48
100	2.7550	−6.36

Reference: [95]. Data reported in numerical form.

TABLE 32 a. AlF_3–NaF: Viscosity

Numerical values (cp)

Mol percent NaF

T	100.00	95.46	90.00	83.33	78.58	75.00	71.04	62.01
1170								1.79
1180								1.75
1190								1.70
1200								1.66
1210								1.62
1220								1.58
1230								1.54
1240			2.32					1.50
1250			2.26					1.46
1260			2.20	2.55				1.42
1270			2.14	2.48				1.38
1280		1.76	2.08	2.41				1.34
1290	1.84	1.72	2.03	2.34	2.50			1.30
1300	1.79	1.68	1.97	2.27	2.43		2.18	1.26
1310	1.73	1.64	1.92	2.21	2.36	2.46	2.10	1.22
1320	1.69	1.60	1.87	2.14	2.29	2.37	2.03	1.18
1330	1.64	1.57	1.82	2.08	2.22	2.28	1.95	1.15
1340	1.59	1.53	1.77	2.02	2.15	2.20	1.89	1.11
1350	1.55	1.50	1.72	1.96	2.08	2.12	1.82	1.07
1360	1.51	1.46	1.67	1.90	2.01	2.05	1.76	1.04
1370	1.47	1.43	1.63	1.84	1.95	1.98	1.70	1.00
1380	1.43	1.40	1.58	1.78	1.88	1.91	1.65	
1390	1.39	1.37	1.54	1.73	1.82	1.85	1.60	
1400	1.36	1.34	1.50	1.68	1.75	1.79	1.56	
1410	1.33	1.31	1.46	1.62	1.69	1.73	1.52	
1420	1.29	1.29	1.42		1.63	1.68	1.48	
1430	1.26	1.26	1.39		1.57	1.62	1.45	
1440	1.23	1.24	1.36		1.52	1.57	1.43	
1450	1.20	1.21	1.32		1.46		1.40	
1460	1.18	1.19	1.29		1.40			
1470	1.15							

TABLE 32 b. Temperature-dependent equations

$\eta = a + bT + cT^2 + dT^3$ (cp)

$\eta = A \cdot \exp(E/RT)$ (cp)

Comp. (mol % NaF)	a	$b \cdot 10^2$	$c \cdot 10^5$	$d \cdot 10^9$	$A \cdot 10^2$	E (cal mol^{-1})	Stand. error of est.
62.01	9.7513	−0.9247	0.2088	0			0.0362
71.04	6.3419	2.9098	−4.5892	16.1901			0.0236
75.00					1.736	12893	0.0209
78.58	14.0023	−0.5917	−0.5863	2.7430			0.0121
83.33	21.6190	−2.3163	0.6369	0			0.0152
90.00	11.1065	−0.1768	−0.9437	4.0773			0.0097
95.46	10.7245	−0.6870	−0.2522	1.8864			0.0072
100.00					3.970	9831	0.0190

Reference: [5]. Data reported in numerical form..

TABLE 33 a. AlF_3-NaF: Surface tension
Numerical values (dyn cm^{-1})
Mol percent NaF

T	100	86.4	81.0	78.1	75.0	72.6
1275	185.0	160.4	150.4	143.6	133.8	127.3
1280	184.6	159.8	149.6	142.9	133.1	126.8
1285	184.2	159.3	149.0	142.3	132.5	126.2
1290	183.8	158.7	148.2	141.6	131.8	125.7
1295	183.4	158.1	147.6	141.0	131.2	125.2
1300	183.0	157.6	146.8	140.3	130.6	124.7
1305	182.6	157.0	146.2	139.7	130.0	124.1
1310	182.2	156.4	145.4	139.0	129.3	123.6
1315	181.8	155.9	144.8	138.4	128.6	123.1
1320	181.4	155.3	144.0	137.7	128.0	122.5
1325	181.0	154.8	143.4	137.1	127.4	122.0
1330	180.5	154.2	142.6	136.4	126.7	121.5
1335	180.1	153.6	142.0	135.8	126.1	121.0
1340	179.7	153.0	141.2	135.1	125.4	120.4
1345	179.3	152.5	140.6	134.5	124.8	119.9
1350	178.9	151.9	139.8	133.8	124.2	119.4

TABLE 33 b. Temperature-dependent equations
$\gamma = a + bT$ (dyn cm^{-1})

Comp. (mol % NaF)	a	$b \cdot 10^2$
72.6	262.5	−10.6
75.0	297.0	−12.8
78.1	309.3	−13.0
81.0	328.8	−14.0
86.4	304.5	−11.3
100	289.6	−8.2

Reference: [20]. Data reported in equation form.

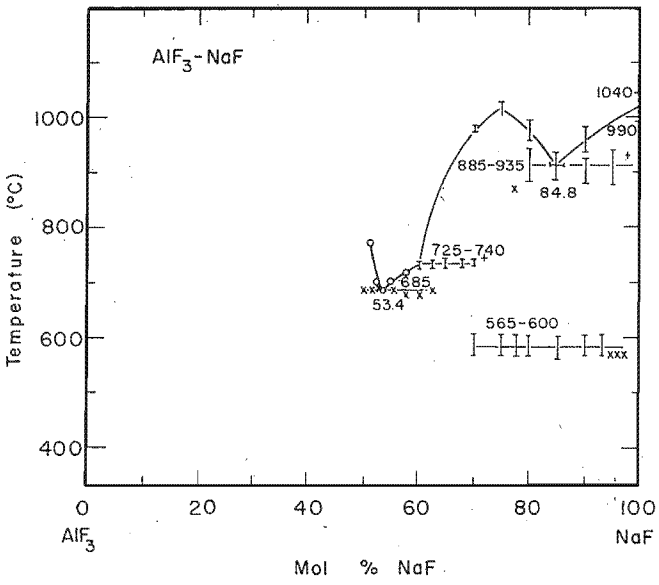

FIGURE 6. Temperature-composition phase diagram for AlF_3-NaF.
N. A. Pushkin and A. V. Baskov, J. Russ. Chem. Soc., **45**, 82–101 (1913).
P. P. Fedotiev and V. L. Iljinsky, Z. Anorg. Allg. Chem., **80**, 113–54 (1912).

AlF_3-RbF

Density

The recommended values in table 35 are based on the work of Mal'tsev and Bukhalova (Archimedean method) **[25, 74]**.

TABLE 34 A. Investigations critically re-examined

Ref.	RbF (mol %)	Temp. range (T)
25	75	1273, 1323
74	75	1223, 1273

TABLE 34 B. Cell materials and calibration

Cell material	Calibration
Pt ball and suspension wire **[25, 74]**	Molten NaF, NaCl, KCl **[25, 74]**

Melt Preparation and Purification

The preparation of Rb_3AlF_6 in reference **[25, 74]** was accomplished by the fusion of analytical grade RbF and AlF_3.

TABLE 35. AlF_3–RbF: Density
Numerical values (gcm^{-3})

T	75 Mol % RbF
1223.2	2.515*
1273.2	2.453
1323.2	2.385

References: [25] and [74*]. Due to limited data the experimental values are given.

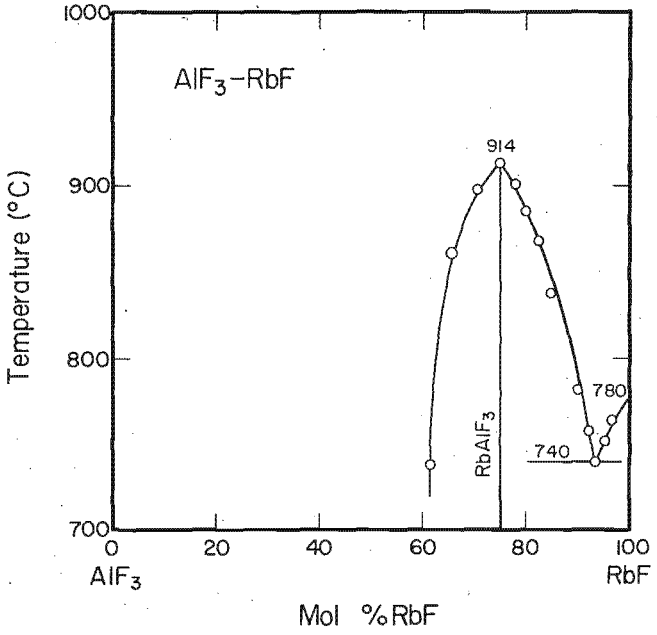

FIGURE 7. Temperature-composition phase digaram for AlF_3-RbF. E. P. Dergunov, DAN S.S.S.R., **60**, 1185 (1948).

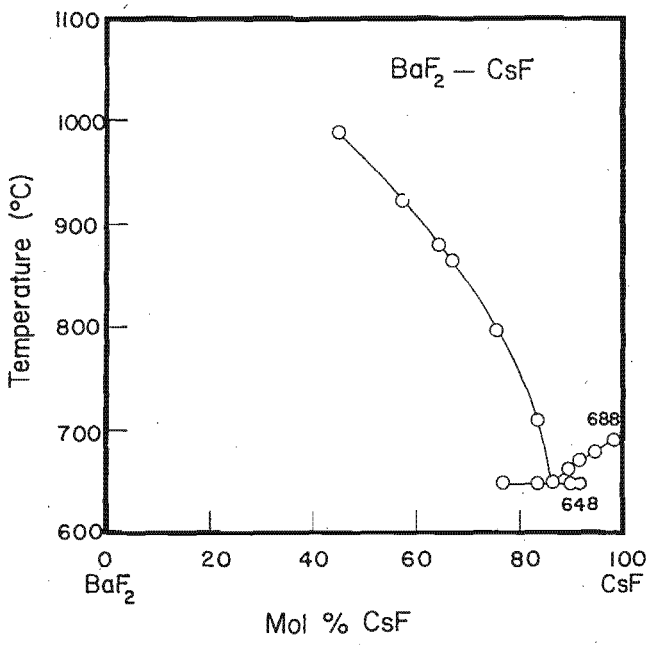

FIGURE 9. Temperature-composition phase diagram for BaF_2-CsF. G. A. Bukhalova and E. S. Yagubyan, Izv. Akad. Nauk S.S.S.R., **3**, 1096 (1967).

BaF_2-CsF

Density

The recommended values in figure 8 are based on the work of Bukhalova and Yagub'yan (Archimedean method) [**26**].

TABLE 36 A. Investigations critically re-examined

Ref.	CsF (mol %)	Temp. range (*T*)
26	0–100 (graphical)	1573

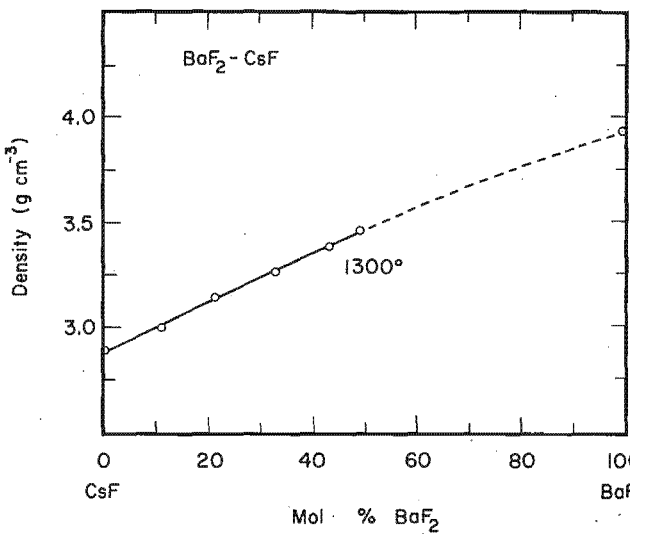

FIGURE 8. Isotherms [26] (°C) of density against molar composition for the system BaF_2-CsF.

BaF_2-KF

Density

The recommended values in figure 10 are based on the work of Bukhalova and Yagub'yan (Archimedean method) [**26**].

TABLE 37 A. Investigations critically re-examined

Ref.	KF (mol %)	Temp. range (*T*)
26	0–100 (graphical)	1473, 1573

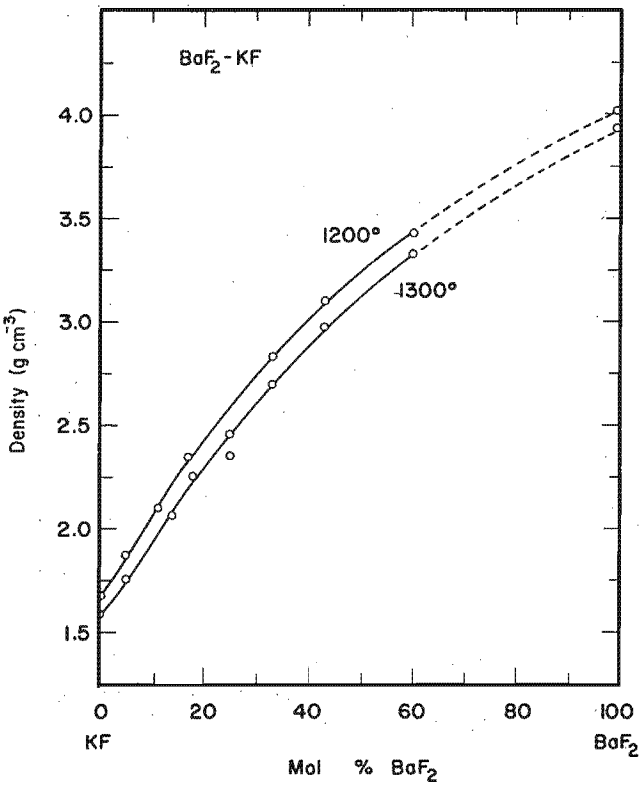

FIGURE 10. Isotherms [26] (°C) of density against molar composition for the system BaF_2-KF.

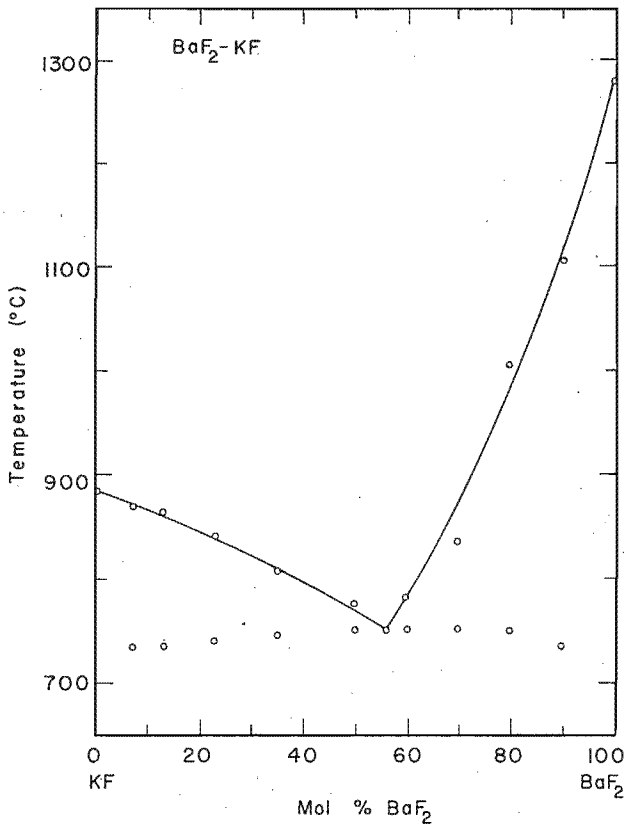

FIGURE 11. Temperature-composition phase diagram for BaF_2-KF. N. A. Poschin and A. Baskov, Z. Anorg. Allg. Chem., **81**, 347 (1913).

BaF_2-LiF

Density

The recommended values in figure 12 are based on the work of Bukhalova and Yagub'yan (Archimedean method) [**26**].

TABLE 38 A. Investigations critically re-examined

Ref.	LiF (mol %)	Temp. range (T)
26	0–100 (graphical)	1573

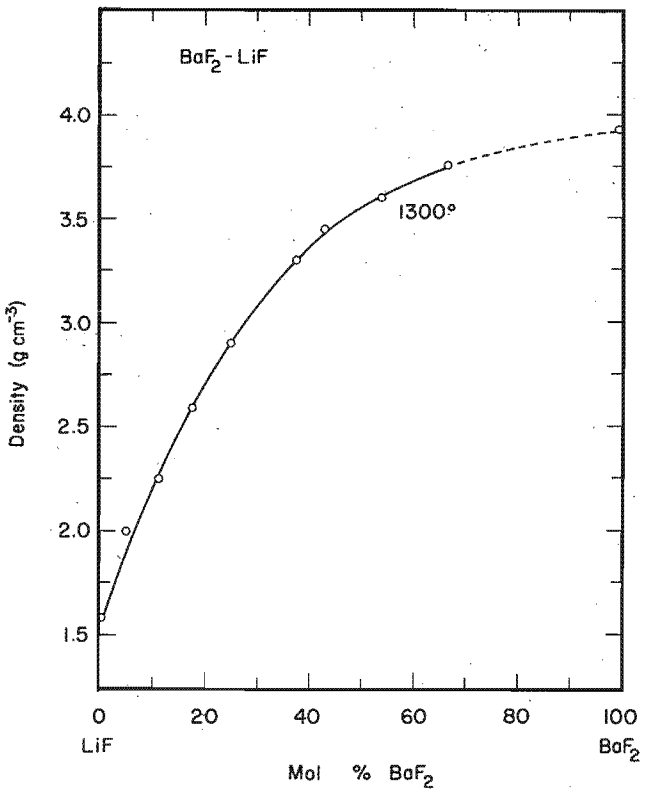

FIGURE 12. Isotherms [**26**] (°C) of density against molar composition for the system BaF_2-LiF.

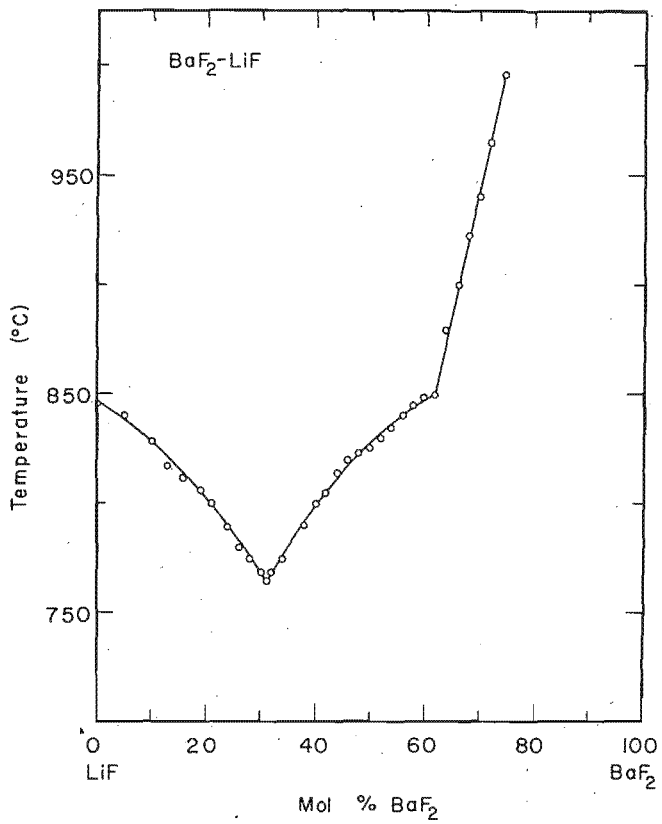

FIGURE 13. Temperature-composition phase diagram for BaF_2-LiF. A. G. Bergman and E. I. Banachek, Izv. Sekt. Fiz. Khim. A., **23**, 201 (1953).

BaF_2-NaF

Electrical Conductance

The recommended values in table 41 are based on the work of Thompson and Kaye (classical ac technique) [**111**].

TABLE 39 A. Investigations critically re-examined

Ref.	NaF (mol %)	Temp. range (T)
111	67.6	1173–1373
100*	67.6	1173, 1273, 1373
110	67.6–100 (graphical except for 67.6 mol %)	1123–1273

*Values from reference [**111**].

TABLE 39 B. Comparisons with previous recommendations

Ref.	Recommended value		NaF (mol %)	% Departure			
	Vol.	Page		% (min)	(T)	% (max)	(T)
110	4.1	29	67.6	0.34	(1223)	0.61	(1273)

TABLE 39 C. Cell materials and calibration

Cell material	Electrodes	Frequency range (Hz)	Calibration
Pt crucible [110, **111**]	Pt [110, **111**]	2500, 5000, 10000 [110]	Molten KNO_3 [**111**]
		1000 [**111**]	0.01 N KCl solution [110]

Comment: Thompson and Kaye [**111**] used molten KNO_3 to determine the cell constant in the temperature range 350–500 ° C. A 50 weight percent mixture of $CaCl_2$–NaCl (values of Ryscheivitsch) was used in the temperature range 500–670 ° C. The value of the cell constant at 1100 ° C was found by extrapolation.

Density

The recommended values in table 42 are based on the work of Abramov and Kozunov (Archimedean method) [**7**].

TABLE 40 A. Investigation critically re-examined

Ref.	NaF (mol %)	Temp. range (T)
7	50.0, 66.8, 83.5, 100	1228–1453
26	0–100 (graphical)	1473, 1573

TABLE 40 B. Comparisons with previous recommendations

Ref.	Recommended value		NaF (mol %)	% Departure			
	Vol.	Page		% (min)	(T)	% (max)	(T)
7	1	3	100	0.56	(1383)	0.95	(1283)

TABLE 40 C. Cell materials and calibration

Cell material	Calibration
Pt ball [26]	Volume of ball determined from measurements c substances of known density [26].

Melt Preparation and Purification

Sodium fluoride in reference [7] was purified by sublimation.

Thompson and Kaye [111] used analyzed chemical reagents (J. T. Baker Chemical Co.) without further purification.

Taniuchi [110] used first grade commercial reagents (Morita Chem. Ind. Co.) which were dried at 100 °C and kept dessicated until use.

TABLE 41 a. BaF_2–NaF: Electrical conductance

Specific conductance: Numerical values (ohm^{-1} cm^{-1})

T	67.6 Mol % NaF
1180	4.052
1190	4.118
1200	4.184
1210	4.250
1220	4.316
1230	4.382
1240	4.448
1250	4.514
1260	4.580
1270	4.646
1280	4.712
1290	4.778
1300	4.844
1310	4.910
1320	4.976
1330	5.042
1340	5.108
1350	5.174
1360	5.240
1370	5.306

TABLE 41 b. Temperature-dependent equation

$\kappa = a + bT$ (ohm^{-1} cm^{-1})

Comp. (mol % NaF)	a	$b \cdot 10^3$	Stand. error of est.
67.6	−3.7363	6.6000	0.0436

Reference: [111]. Data reported in numerical form.

TABLE 42 a. BaF_2-NaF: Density

Numerical values (gcm^{-3})

T	Mol percent NaF 100.0	83.5	66.8	50.0
1230		2.685		3.598
1240		2.679		3.592
1250		2.673	3.153	3.585
12(		2.668	3.147	3.579
12'		2.662	3.141	3.573
12!		2.656	3.135	3.567
12!	1.951	2.650	3.129	3.560
13(	1.944	2.645	3.123	3.554
1310	1.938	2.639	3.117	3.548
1320	1.932	2.633	3.111	3.542
1330	1.926	2.627	3.105	3.536
1340	1.919	2.622	3.099	3.529
1350	1.913	2.616	3.093	3.523
1360	1.907	2.610	3.087	3.517
1370	1.901	2.604	3.081	3.511
1380	1.894	2.599	3.075	3.504
1390	1.888	2.593	3.069	3.498
1400		2.587	3.063	3.492
1410		2.581	3.057	3.486
1420		2.575	3.051	3.479
1430		2.570	3.045	3.473
1440				3.467
1450				3.461

TABLE 42 b. Temperature-dependent equations

$\rho = a + bT$ (gcm^{-3})

Comp. (mol % NaF)	a	$b \cdot 10^4$	Stand. error of est.
50.0	4.3643	−6.2311	0.0043
66.8	3.9022	−5.9959	0.0087
83.5	3.3934	−5.7600	0.0073
100.0	2.7571	−6.2513	0.0016

Reference: [7]. Data reported in numerical form.

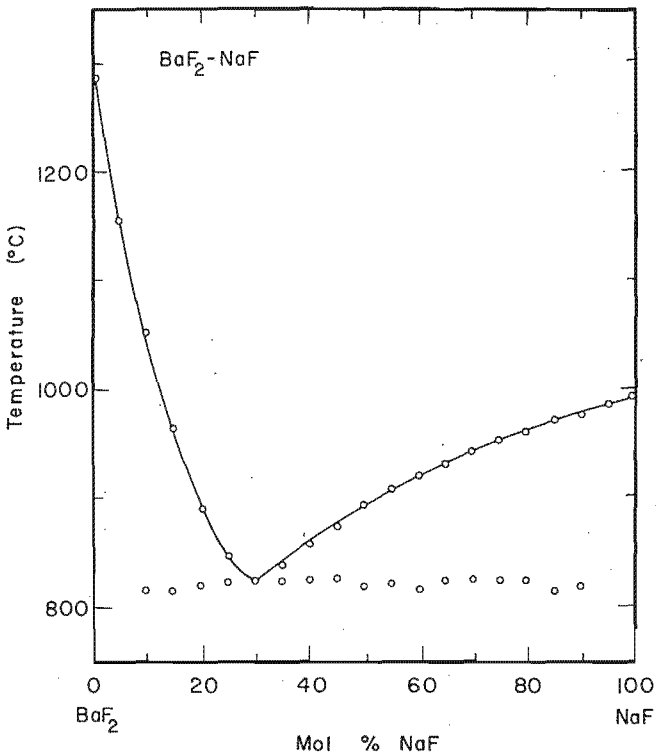

FIGURE 14. Temperature-composition phase diagram for BaF_2-NaF. G. Z. Grube, Z. Elekroch., **33**, 481 (1827).

BeF_2-KF

Viscosity

The recommended values in table 44 are based on the work of Cohen et al. (capillary method) [**35**].

TABLE 43 A. Investigations critically re-examined

Ref,	KF (mol %)	Temp. range (*T*)
36	79	1023–1123
35	50, 79	873–1073
37	50	843–1073

Comment: Cohen et al. [**35**, 36, 37] measured viscosities using a capillary viscometer as well as a modified Brookfield rotational device. Error limits for the experimental measurements were ±10 percent

TABLE 44. BeF_2-KF: Viscosity

Numerical values (cp)

Mol percent KF

T	79	50
873.2		15.3
973.2		6.7
1073.2	2.2	3.45

Reference: [35]. Due to limited data the experimental values are given.

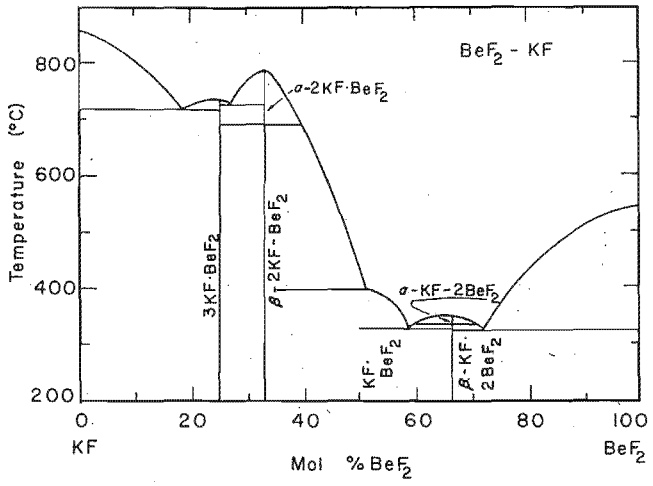

FIGURE 15. Temperature-composition phase diagram for BeF_2-KF. M. P. Borzenkova, A. V. Novoselova, Yu. P. Simanov, V. I. Chernikh, and E. I. Yarembash, Zh. Neorg. Khim. **1**, 2071–82 (1956).

BeF_2-LiF

Electrical Conductance

The recommended values in table 49 are based on the work of Robbins and Braunstein (classical ac technique) [**102**].

TABLE 45 A. Investigations critically re-examined

Ref.	LiF (mol %)	Temp. Range (*T*)
22	48, 53, 58, 62	671.9–806.4
29	66	741 –920
30	66	741 –920
58	48, 53, 58, 62 (graphical)	671.9–806.4
102	30.0–66.0	643 –920
57	30.0–66.0	643 –920
55	66	743, 758, 773

TABLE 45 B. Cell materials and calibration

Cell material	Electrodes	Frequency range (cps)	Calibration
Silica dip cell [22, 29, 30, 55, 58, **102**]	L shaped Pt [22, 29, 30, 55, 58, **102**]	1,000–10,000 [22, 29, 30, 55, 58, **102**]	0.1 demal KCl [22, 29, 30, 55, 58, **102**]

Comment: Robbins and Braunstein [22, 29, 30, 55, 58, **102**] found the measured resistance of their fluoride melts to vary less than 0.5 percent over the frequency range 1–10 kHz. Values of the measured resistance extrapolated to infinite frequency were less than 0.3 percent of the 10 kHz values. Measurements in molten KNO_3 reproduced the cell constant to within 0.7 percent. The overall accuracy was reported to be ±2 percent.

Density

The recommended values in tables 50, 51 are based on the work of Cantor, Ward, and Moynihan (Archimedean and dilatometric methods) [**30, 33**]

TABLE 46 A. Investigations critically re-examined

Ref.	LiF (mol %)	Temp. Range (T)
121	50, 69	
35	50, 69	
33	0, 10.8, 25.1, 49.8	854–1135
32	0, 10.8, 25.1, 49.8, 100 (0, 100-extrapolated)	1073
18	45–100	873, 973, 1073
29	66	788–1093
30	66	788–1093
57	66	788–1093

TABLE 46 B. Comparisons with previous recommendations

Ref.	Recommended value		LiF (mol %)	% Departure			
	Vol.	Page		% (min)	(T)	% (max)	(T)
18	4.1	32	66	−1.3	(1073)	−2.3	(873)
18	4.1	32	50	−0.57	(973)	−0.58	(1073)

TABLE 46 C. Cell materials and calibration

Cell material	Calibration
Pt bob, Pt-10% Rh suspension wire, melt contained in cylindrical nickel vessel [32, **33**]	Water [**30**, 32, **33**, 57]
Pt cylinder, Pt suspension wire, melt contained in an Inconel crucible [18]	Dilatometer performance checked using molten $NaNO_3$ [**30**, 57]
Metal dilatometer (cylindrical cup for lower section and conical top with long neck for upper section) [**30**, 57]	

Comment: The liquid level in the dilatometer used by Cantor et al. [**30**, 57] was detected electrically using a metal probe. Corrections were made for thermal expansion of the vessel and the probe. The volume measurements were reproducible to ±0.1 percent. The Archimedean apparatus used by Cantor et al. [32, **33**] gave results which were reported to be accurate to within 0.4 percent, the two major sources of error were corrections for the surface tension of the melt and the weight of the immersed bob.

Blanke et al. [18] reported an overall error of ±1 percent for their density results.

Viscosity

The recommended values in table 52 are based on the work of Cantor, Ward, and Moynihan (rotating cylinder method) [**33**].

TABLE 47 A. Investigations critically re-examined

Ref.	LiF (mol %)	Temp. range (T)
121	50, 69	873
68	2.24, 4.39, 6.71	813–1123
30	50, 69	873, 973, 1073
33	0–64	649–1252
18	45–100	873, 973, 1073
29	66	
37	50	843–1073

TABLE 47 B. Comparisons with previous recommendations

Ref.	Recommended value		LiF (mol %)	% Departure			
	Vol.	Page		% (min)	(T)	% (max)	(T)
18	4.1	32	55	−19.5	(873)		
18	4.1	32	50	−14.8	(873)		

TABLE 47 C. Cell materials and calibration

Cell material	Calibration
Inconel rotating spindle and melt contained in a nickel metal cylinder [**33**, 68];	NBS standard oils J and L [**33**, 68]
Two concentric Inconel cylinders (outer one containing fused salt), nickel shaft connected to inner cylinder, Mo torsion wire [18]	

Comment: Cantor, Ward and Moynihan [**33**] reported their viscosity results in the form of Arrhenius equations with mean standard deviations of about 0.026 in $\Delta\eta/\eta$. They estimated an experimental error of ±3 percent.

Blanke et al. [18], using a rotational cylinder method, reported an overall error of ±5 percent.

Surface Tension

The recommended values in table 53 are based on the work of Sturm (Ring method) [**109**].

TABLE 48 A. Investigations critically re-examined

Ref.	LiF (mol %)	Temp. range (T)
109	63	753
68	66	
29	66	

TABLE 49 a. BeF_2-LiF: Electrical Conductance

Specific conductance: Numerical values (ohm^{-1} cm^{-1})

Mol percent LiF

T	66.0	62.0	58.0	53.0	50.0	48.0	46.0	42.5	40.0	35.0	30.0
650					0.256						
660					0.288		0.197				
670					0.321		0.222				
680					0.354	0.294	0.248				
690					0.388	0.324	0.274				
700				0.506	0.423	0.355	0.301				
710				0.548	0.458	0.387	0.329				
720				0.591	0.494	0.420	0.357	0.270			
730			0.852	0.635	0.531	0.453	0.385	0.294			
740		1.109	0.908	0.679	0.568	0.487	0.414	0.318	0.253		
750	1.397	1.169	0.964	0.724	0.606	0.522	0.444	0.343	0.274		
760	1.463	1.228	1.018	0.770	0.645	0.558	0.474	0.369	0.296	[0.178]	
770	1.530	1.288	1.072	0.816	0.684	0.595	0.505	0.395	0.319	[0.193]	
780	1.596	1.347	1.126	0.863	0.724	0.633	0.536	0.422	0.342	[0.208]	[0.118]
790	1.662	1.407	1.179	0.911	0.765	0.671	0.568	0.449	0.366	[0.224]	[0.128]
800	1.728	1.466	1.232		0.806	0.710	0.600	0.477	0.390	[0.239]	[0.138]
810	1.793				0.848		0.633	0.506	0.416	[0.254]	[0.148]
820	1.859				0.891		0.667		0.441	[0.269]	[0.158]
830	1.925										
840	1.990										
850	2.056										
860	2.121										
870	2.186										
880	2.251										
890	2.316										
900	2.381										
910	2.445										
920	2.510										

TABLE 49 b. Temperature-dependent equations

$\kappa = a + bT + cT^2$ (ohm^{-1} cm^{-1})

Comp. (mol % LiF)	a	$b \cdot 10^3$	$c \cdot 10^6$	Stand. error of est.
30.0	[−0.2950]	[0.0991]	[0.5525]	0.0000
35.0	[−0.9074]	[1.3537]	[0.0985]	0.0000
40.0	0.4133	−2.5360	3.1343	0.0012
42.5	0.1501	−2.0133	3.0275	0.0007
46.0	−0.2437	−1.1552	2.7625	0.0021
48.0	0.1895	−2.6619	4.1409	0.0014
50.0	−0.4247	−1.0833	3.2773	0.0023
53.0	−0.9034	−0.1872	3.1434	0.0013
58.0	−4.7115	9.6348	−2.7575	0.0001
62.0	−3.2970	5.9539	0	0.0015
66.0	−3.9067	7.4990	−0.5702	0.0039

Reference: [102]. Data reported in numerical form.

TABLE 50 a. BeF_2-LiF: Density

Numerical values (gcm^{-3})

T	66.0 Mol % LiF
800	2.023
820	2.013
840	2.003
860	1.993
880	1.984
900	1.974
920	1.964
940	1.954
960	1.945
980	1.935
1000	1.925
1020	1.915
1040	1.905
1060	1.896
1080	1.886

TABLE 50 b. Temperature-dependent equations

$\rho = a + bT$ (gcm^{-3})

Comp. (mol % LiF)	a	$b \cdot 10^4$	Stand. dev. [30]
66.0	2.413	−4.88	0.00046

Reference: [30]. Data reported in equation form.

TABLE 51 a. BeF_2-LiF: Density

Numerical values (gcm^{-3})

T	Mol percent LiF			
	49.8	25.1	10.8	0*
860		1.952		
870		1.950		
880		1.948		
890		1.945		
900		1.943		
910		1.941		
920		1.938		
930	1.955	1.936		
940	1.950	1.933		
950	1.946	1.931		
960	1.942	1.929		
970	1.938	1.926		
980	1.933	1.924		
990	1.929	1.921		
1000	1.925	1.919		
1010	1.921	1.917		
1020	1.917	1.914	1.924	
1030	1.912	1.912	1.923	
1040	1.908	1.909	1.921	
1050	1.904	1.907	1.920	
1060	1.900	1.905	1.918	
1070	1.895	1.902	1.917	
1080	1.891	1.900	1.915	
1090	1.887	1.897	1.914	
1100	1.883	1.895	1.912	
1110	1.878	1.893	1.911	
1120	1.874	1.890	1.909	
1130	1.870	1.888	1.908	
1123.2				1.96

*The only experimental value reported.

TABLE 51 (b). Temperature-dependent equations

$\rho = a + bT$ (gcm^{-3})

Comp. (mol % LiF)	a	$b \cdot 10^4$	Stand. dev. [33]
10.8	2.075	−1.48	0.00037
25.1	2.158	−2.39	0.0022
49.8	2.349	−4.24	0.00078

Reference: [33]. Data reported in equation form.

TABLE 52 a. BeF_2-LiF: Viscosity

Numerical values (cp)

Mol percent LiF																
.00	55.0	50.00	44.99	40.00	35.00	30.00	25.00	20.01	15.00	9.98	8.98	6.99	5.	1.99	0.99	0
		374														
		273	584													
	104	203	421													
.4	81.9	153	309	762												
.8	65.5	118	231	549	1470											
.1	53.0	91.6	175	403	1040	3040										
.7	43.3	72.2	135	300	751	2110	6880									
.4	35.8	57.5	105	227	551	1490	4630									
	8	46.4	82.8	174	410	1070	3180		44800		414000					
		37.8	66.1	135	310	784	2220	7960	28900		249000		140			
					237	581	1580	5440	19000		153000	358000	80			129000000
					184	437	1140	3780	12800	61600	95900	218000	17			58600000
					144	333	834	2670	8720	39700	61500	13500	29			27600000
					114	256	619	1910	6060	26100	40200	85600	18	1210000		13500000
					91.1	199	465	1390	4270	17500	26800	55300	11	695000		6790000
					73.5	157	354	1020	3060	11900	18100	36400	73200	410000		3530000
					59.9			764	2220	8250	12500	24400	48000	247000	596000	1880000
								577	1630	5790	8710	16600	32100	152000	350000	1030000
									1210	4120	6170	11500	21700	95000	209000	581000
										2970	4430	8020	15000	60600	128000	334000
										2170	3220	5700	10400	39300	79600	197000
										1600	2370	4100	7390	25900	50400	118000
										1200	1760	2980	5290	17300	32400	72200
										904				11800	21200	45000
										689				8100	14100	28500
														5650	9480	18400
														3990	6470	12000
															4470	8010
															3130	5390
															2210	3680

TABLE 52 (b). Temperature-dependent equations

$\eta = A \cdot \exp(E/RT)$ (cp)

Comp. (mol % LiF)	A	E (cal mol^{-1})
0*		
0.99	$1.53 \cdot 10^{-6}$	51970
1.99	$6.62 \cdot 10^{-6}$	47400
3.00	$2.31 \cdot 10^{-5}$	43870
3.99	$6.05 \cdot 10^{-5}$	40850
5.09	$7.96 \cdot 10^{-5}$	39370
6.99	$1.05 \cdot 10^{-4}$	37510
8.98	$1.99 \cdot 10^{-4}$	34960
9.98	$1.71 \cdot 10^{-4}$	34450
15.00	$4.57 \cdot 10^{-4}$	29980
20.01	$5.98 \cdot 10^{-4}$	27380
25.00	$9.20 \cdot 10^{-4}$	24530
30.00	$2.02 \cdot 10^{-3}$	21480
35.00	$3.11 \cdot 10^{-3}$	19210
40.00	$4.21 \cdot 10^{-3}$	17320
44.99	$6.27 \cdot 10^{-3}$	15460
50.00	$8.45 \cdot 10^{-3}$	14030
55.00	$2.07 \cdot 10^{-2}$	11850
60.00	$4.30 \cdot 10^{-2}$	10080
64.00	$5.94 \cdot 10^{-2}$	9150

*The equation for pure BeF_2 is:

$$\eta = 7.603 \cdot 10^{-7} \exp\left[(52590/RT) + (1471 \cdot 10^6/T^2)\right]$$

Reference: [33]. Data reported in equation form.

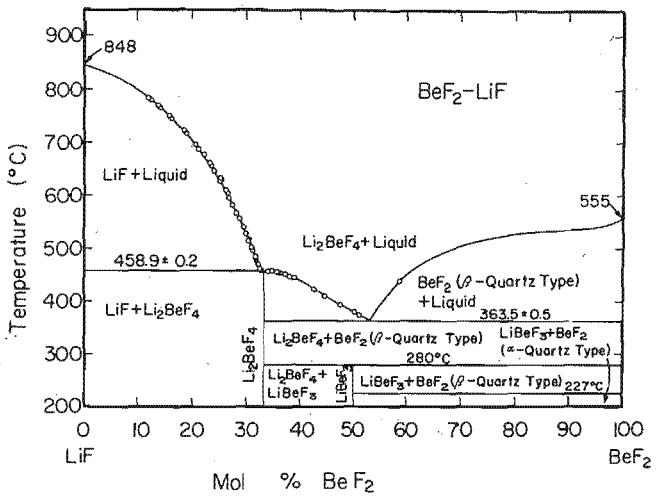

FIGURE 16. Temperature-composition phase diagram for BeF_2-LiF. K. A. Romberger, J. Braunstein, and R. E. Thoma, J. Phys. Chem., **76**, 1159 (1972).

TABLE 53. BeF_2–LiF: Surface tension

Numerical values (dyn cm^{-1})

T	63 Mol % LiF
753.2	196

Reference: [109]. The only experimental value is given.

BeF_2-NaF

Electrical Conductance

The recommended values in table 58 are based on the work of Robbins and Braunstein (classical ac technique) **[30]**.

TABLE 54 A. Investigations critically re-examined

Ref.	NaF (mol %)	Temp. range (T)
30	45, 50, 57	624–833

TABLE 54 B. Cell materials and calibration

Cell material	Electrodes	Frequency range (Hz)	Calibration
Silica glass cells [30]	Pt [30]	5000–50,000 [30]	Molten KNO_3 [30]

Comment: Robbins and Braunstein [30] reported that the measur resistance was independent of frequency over the range 5,000 50,000 Hz, within the accuracy limits of the bridge (±0.2%).

Density

The recommended values in table 59 are based on the work of Blanke et al. (Archimedean method) [17].

TABLE 55 A. Investigations critically re-examined

Ref.	NaF (mol %)	Temp. range (T)
35	50, 57, 70	
30*	45, 50, 57	
19	21.9–81.2	873, 973, 1073
17**	20–80	650–1170

*Data from [17].

**Numerical values at 873, 1073; graphical results for temp. range indicated.

TABLE 54 B. Cell materials and calibration

Cell material
Pt cylinder and suspension wire, In crucible [17, 19]

Comment: Blanke et al. [17] reported an overall error for density results of ±0.27 percent.

Viscosity

The recommended values in tables 60, 61 are based on the work of Cohen et al. (capillary and rotating cylinder methods) [35] and Blanke et al. (rotating cylinder method) [19].

TABLE 56 A. Investigations critically re-examined

Ref.	NaF (mol %)	Temp. range (T)
121*	57	873
35	50, 57, 70	873, 973, 1073
56	57	727
19	21.9–81.7	873, 973, 1073

*Data from reference [35].

TABLE 56 B. Cell materials and calibration

Cell material
Inner and outer cylinder of Inconel, Ni shaft and Mo torsion wire [19].

Comment: Cohen et al. [35] measured viscosities using a capillary viscometer as well as a modified Brookfield rotational device. Error limits for the experimental measurements were ±10 percent.

Surface Tension

The recommended values in table 62 are based on the work of Mac Pherson (maximum bubble pressure method) [72].

TABLE 57 A. Investigations critically re-examined

Ref.	NaF (mol %)	Temp. range (T)
72	57.1–62.0	773–1073

Melt Preparation and Purification

Robbins and Braunstein [30] used hand picked, glass-clear crystals of recrystallized NaF and sublimed BeF_2 which were melted under an inert atmosphere into the conductance cell. Spectrographic analysis of the starting materials showed the major impurities to be (in ppm by weight) for BeF_2: 50 Li, 100 Na and for NaF: 2 Mg, 2 Fe, and 3 Ca.

Blanke et al. [17, 19] used analytical grade BeF_2 (Brush Beryllium Corporation) without further purification. NaF was analytical reagent grade and was dried at 200 to 230 °C for at least 24 hours before use. Salts were pulverized, weighed and mixed in a stainless steel drybox. Samples were melted in nickel crucibles and transferred into Inconel sample crucibles.

TABLE 58 a. BeF_2–NaF: Electrical conductance

Specific conductance: Numerical values (ohm^{-1} cm^{-1})

	Mol percent NaF		
T	57.0	50.0	45.0
630	0.1750		
640	0.2032		0.0915
650	0.2322		0.1069
660	0.2620		0.1232
670	0.2927	0.1867	0.1402
680	0.3243	0.2097	0.1581
690	0.3567	0.2337	0.1768
700	0.3899	0.2587	0.1964
710	0.4239	0.2845	0.2167
720	0.4588	0.3113	0.2379
730	0.4946	0.3391	0.2600
740	0.5312	0.3677	0.2828
750	0.5686	0.3973	0.3065
760	0.6068	0.4279	0.3310
770	0.6459	0.4593	0.3563
780	0.6859	0.4917	0.3825
790	0.7266	0.5251	0.4094
800	0.7682	0.5593	0.4372
810	0.8107	0.5946	0.4659
820	0.8540	0.6307	0.4953
830			0.5256

TABLE 58 b. Temperature-dependent equations

$\kappa = a + bT + cT^2$ (ohm^{-1} cm^{-1})

Comp. (mol % NaF)	$a \cdot 10^1$	$b \cdot 10^3$	$c \cdot 10^6$	Stand. error of est.
45.0	8.2320	−3.7865	4.1301	0.0011
50.0	7.6991	−4.0005	4.6716	0.0007
57.0	0.9115	−2.5105	4.1961	0.0038

Reference: [30]. Data reported in numerical form.

TABLE 59. BeF_2-NaF: Density

Numerical values (gcm^{-3})

Mol percent NaF

T	80	76	70	66.7	64	60	58	52.9	52	50	46	40	20
873.2			2.113	2.111	2.108	2.113	2.103	2.099	2.098	2.070	2.088	2.086	
1073.2	2.024	2.018	2.012	2.034	2.008	2.007	2.005	2.034	1.992	1.969	1.985	1.982	1.971

Reference [17]. Due to limited data the numerical interpolated values reported in rereference [17] are given.

TABLE 60. BeF_2-NaF: Viscosity

Numerical values (cp)

Mol percent NaF

T	81.7	75	72.96	70	69.83	66.67	60	55.59	50	47.8	42.7	35.89	21.93
873.2				4.98	5.03	9.04	9.59	9.92	14.58	17.19			
973.2			4.06	3.92	3.65	5.91		5.68		8.80	12.97	25.90	
1073.2	3.60	3.04	2.89	2.81	2.81	4.18	3.79	3.60	4.58	5.02	5.49	11.04	55.20

Reference: [19]. Due to limited data the numerical interpolated values reported in reference [19] are given.

TABLE 61. BeF_2-NaF: Viscosity

Numerical values (cp)

Mol percent NaF

T	70	57	50
873.2	5.0	12.8	15.3
973.2	3.9	7.0	8.4
1073.2	2.8	4.25	5.25

Reference: [35]. Due to limited data the experimental values are given.

TABLE 62. BeF_2-NaF: Surface tension

Numerical values (dyn cm^{-1})

Mol percent NaF

T	63.0	57.5	57.1
780	209.6	200.5	187.6
800	206.3	197.8	185.3
820	203.0	195.1	183.0
840	199.7	192.4	180.7
860	196.4	189.6	178.3
880	193.1	186.9	176.0
900	189.8	184.2	173.7
920	186.5	181.5	171.4
940	183.2	178.8	169.1
960	179.9	176.0	166.7
980	176.6	173.3	164.4
1000	173.3	170.6	162.1
1020	170.0	167.9	159.8
1040	166.7	165.2	157.5
1060	163.4	162.4	155.1

TABLE 62 b. Temperature-dependent equations

$\gamma = a + bT$ (dyn cm^{-1})

Comp. (mol % NaF)	a	b
57.1	278.1	−0.116
57.5	306.6	−0.136
63.0	338.3	−0.165

Reference: [72].
Data reported in equation form.

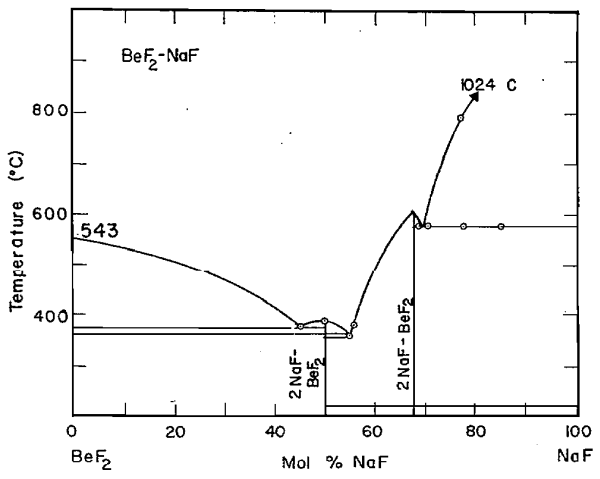

FIGURE 17. Temperature-composition phase diagram for BeF_2-NaF. R. E. Thoma, editor, Phase Diagrams for Nuclear Reactor Materials, Oak Ridge National Laboratory, ORNL 2540 (1959).

BeF_2-RbF

Density

The recommended values in table 65 are based on the work of Cohen et al. (Archimedean method) [35].

TABLE 63 A. Investigations critically re-examined

Ref.	RbF (mol %)	Temp. range (T)
35	50	873–1073

Viscosity

The recommended values in table 66 are based on the work of Cohen et al. (capillary and rotational-cylinder methods) [35].

TABLE 64 A. Investigations critically re-examined

Ref.	RbF (mol %)	Temp. range (T)
35	50	873, 973, 1073

Comment: Brief remarks concerning reference [35] are discussed under the system BeF_2-NaF.

TABLE 65 a. BeF_2-RbF: Density

Numerical values (gcm^{-3})

T	50 Mol % RbF
880	2.45
900	2.44
920	2.43
940	2.42
960	2.41
980	2.40
1000	2.39
1020	2.38
1040	2.37
1060	2.36

TABLE 65 b. Temperature-dependent equation

$\rho = a + bT$ (gcm^{-3})

Comp. (mol % RbF)	a	$b \cdot 10^4$
50	2.89	−5.00

Reference: [35]. Data reported in equation form. The temperature range was assumed to be the same as for viscosity measurements.

TABLE 66. BeF_2-RbF: Viscosity

Numerical values (cp)

T	50 Mol % RbF
873.2	11.5
973.2	5.2
1073.2	2.75

Reference: [35]. Due to limited data the experimental values are given.

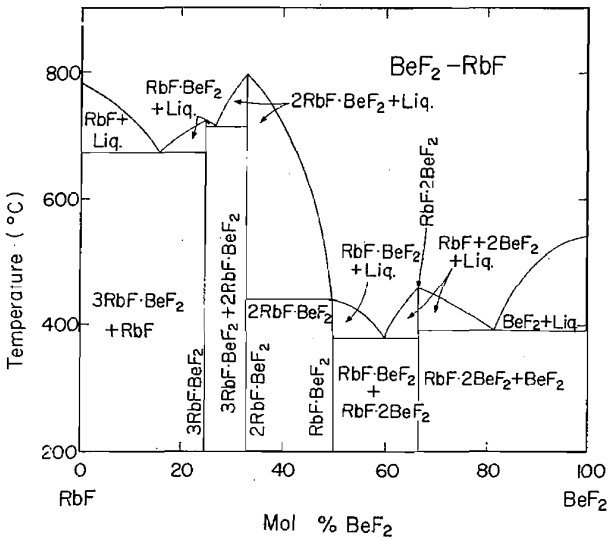

FIGURE 18. Temperature-composition phase diagram for BeF_2-RbF. R. E. Moore, C. J. Barton, L. M. Bratcher, T. N. McVay, G. D. White, R. J. Sheil, W. R. Grimes, and R. E. Meadows, Oak Ridge National Laboratory, Phase Diagrams of Nuclear Reactor Materials, R. E. Thoma, ed. ORNL-2548, 39 (1959).

BeF_2-UF_4

Density

The recommended values in table 68 are based on the work of Blanke et al. (Archimedean method) [18].

TABLE 67 A. Investigations critically re-examined

Ref.	UF_4 (mol %)	Temp. range (T)
18	35	1073

TABLE 67 B. Cell materials and calibration

Cell material
Pt cylinder and Pt suspension wire, melt contained in an Inconel crucible [18].

TABLE 68. BeF_2-UF_4: Density

Numerical values (gcm^{-3})

T	35 Mol % UF_4
1073.2	4.502

Reference: [18]. The only experimental value is given.

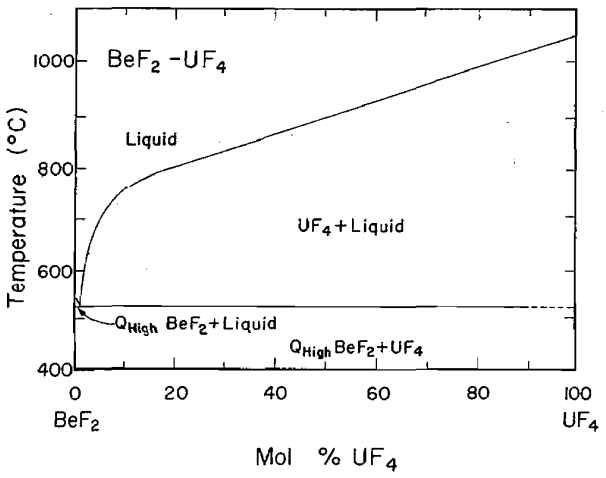

FIGURE 19. Temperature-composition phase diagram for BeF_2-UF_4. L. V. Jones, D. E. Etter, C. R. Hudgens, A. A. Huffman, T. B. Rhinehammer, N. E. Rogers, P. A. Tuker, and L. J. Wittenberg, J. Amer. Ceram. Soc., 45[2], 79 (1962).

CaF_2-LiF

Electrical Conductance

The recommended values in table 71 are based on the work of Meaker, Porter, and Kesterke (classical ac technique) [87].

TABLE 69 A. Investigations critically re-examined

Ref.	LiF (mol %)	Temp. range (T)
87	70, 80, 86, 93, 100	1083–1343

TABLE 69 B. Comparisons with previous recommendations

Ref.	Recommended value		LiF (mol %)	% Departure			
	Vol.	Page		% (min)	(T)	% (max)	(T)
87	1	2	100	5.1	(1150)	8.2	(1310)

TABLE 69 C. Cell materials and calibration

Cell material	Electrodes[F4]	Frequency range (Hz)
Capillary cell consisting of two boron nitride cylinders encased in a graphite jacket [87]	Mo [87]	20–20,000 measurements at 10,000 [87].

Comment: The specific conductance values measured in reference [87] were reported reproducible to ±1 percent. The precision of the measurements was ±3 percent. The measured resistance was found to be independent of frequency over the range 20 to 20,000 Hz.

Density

The recommended values in table 72 are based on the work of Porter and Meaker (Archimedean method) [98].

TABLE 70 A. Investigations critically re-examined

Ref.	LiF (mol %)	Temp. range (T)
87	70–100 (graphical)	1273
98	70–100	1073–1353

TABLE 70 B. Comparisons with previous recommendations

Ref.	Recommended value		LiF (mol %)	% Departure			
	Vol.	Page		%(min)	(T)	% (max)	(T)
98	1	2	100	−4.5	(1310)	−5.6	(1150)

TABLE 70 C. Cell materials and calibration

Cell material	Calibration
Mo plummet connected to a quartz spring by a Mo wire, melt contained in a graphite crucible [87, 98]	Molten KCl [87, 98]

Comment: Density values for molten KCl, determined by Porter and Meaker [98], agreed with those of Van Artsdalen and Yaffe (Molten Salts: Vol. 1, reference 79) [1] to within a standard deviation of ±0.3 percent.

Experimental density values in reference [98] were fitted to linear equations with standard deviations in the range: 7.00×10^{-3} gcm^{-3} (93 mol % LiF) to 19.0×10^{-3} gcm^{-3} (70 mol % LiF).

Melt Preparation and Purification

Reagent-grade chemicals were used in references [87] and [98]. After vacuum drying at 400 °C the salts were cooled and combined in the correct proportions. The salts were then placed in graphite crucibles and heated under vacuum (50 μm (Hg) to 600 °C. For density and conductance measurements the mixtures were melted in an atmosphere of helium in a controlled-atmosphere chamber. Melt compositions were confirmed by analyses after density measurements.

TABLE 71 a. CaF_2-LiF: Electrical conductance

Specific conductance: Numerical values (ohm^{-1} cm^{-1})

Mol percent LiF

T	100.0	93.0	86.0	80.0	70.0
1090			6.39	6.60	
1100			6.46	6.68	
1110			6.52	6.75	
1120			6.59	6.83	
1130		8.20	6.66	6.90	
1140		8.25	6.72	6.98	
1150	9.10	8.31	6.79	7.05	
1160	9.16	8.37	6.86	7.13	6.27
1170	9.22	8.42	6.92	7.20	6.32
1180	9.27	8.48	6.99	7.28	6.38
1190	9.33	8.54	7.06	7.35	6.44
1200	9.39	8.59	7.12	7.42	6.50
1210	9.45	8.65	7.19	7.50	6.55
1220	9.51	8.71	7.25	7.57	6.61
1230	9.57	8.76	7.32	7.65	6.67
1240	9.62	8.82	7.39	7.72	6.72
1250	9.68	8.88	7.45	7.80	6.78
1260	9.74	8.93	7.52	7.87	6.84
1270	9.80	8.99	7.59	7.95	6.90
1280	9.86	9.05	7.65	8.02	6.95
1290	9.92	9.10	7.72	8.09	7.01
1300	9.97	9.16	7.79	8.17	7.07
1310	10.03	9.22	7.85	8.24	7.12
1320	10.09	9.27	7.92	8.32	7.18
1330	10.15	9.33	7.98	8.39	7.24
1340	10.21	9.39	8.05	8.47	7.30

TABLE 71 b. Temperature-dependent equations

$\kappa = a + bT$ (ohm^{-1} cm^{-1})

Comp. (mol % LiF)	$a \cdot 10^1$	$b \cdot 10^3$	Stand. dev. [87]
70.0	−3.716	5.722	0.0470
80.0	−15.14	7.448	0.0478
86.0	−0.8412	6.636	0.0268
93.0	17.86	5.673	0.0290
100.0	23.95	5.830	0.0500

Reference: [87]. Data reported in equation form.

TABLE 72 a. CaF_2-LiF: Density

Numerical values (gcm^{-3})

Mol percent LiF

T	100.0	93.0	86.0	80.0	70.0
1080				2.053	
1095			1.937	2.047	
1110			1.932	2.042	
1125	1.700	1.825	1.926	2.036	
1140	1.695	1.821	1.921	2.031	
1155	1.690	1.817	1.916	2.025	2.144
1170	1.685	1.813	1.910	2.020	2.136
1185	1.680	1.809	1.905	2.014	2.127
1200	1.675	1.805	1.899	2.009	2.118
1215	1.670	1.802	1.894	2.003	2.110
1230	1.666	1.798	1.888	1.997	2.101
1245	1.661	1.794	1.883	1.992	2.093
1260	1.656	1.790	1.877	1.986	2.084
1275	1.651	1.786	1.872	1.981	2.075
1290	1.646	1.782	1.866	1.975	2.067
1305	1.641	1.778	1.861	1.970	2.058
1320	1.636	1.774	1.856	1.964	2.049
1335	1.631	1.770	1.850	1.959	2.041
1350	1.626	1.766	1.845	1.953	2.032

TABLE 72 b. Temperature-dependent equations

$\rho = a + bT$ (gcm^{-3})

Comp. (mol % LiF)	a	$b \cdot 10^4$	Stand. dev. [98]
70.0	2.809	−5.755	0.0190
80.0	2.453	−3.704	0.0113
86.0	2.336	−3.640	0.00750
93.0	2.120	−2.621	0.00700
100.0	2.074	−3.321	0.00705

Reference: [98]. Data reported in equation form.

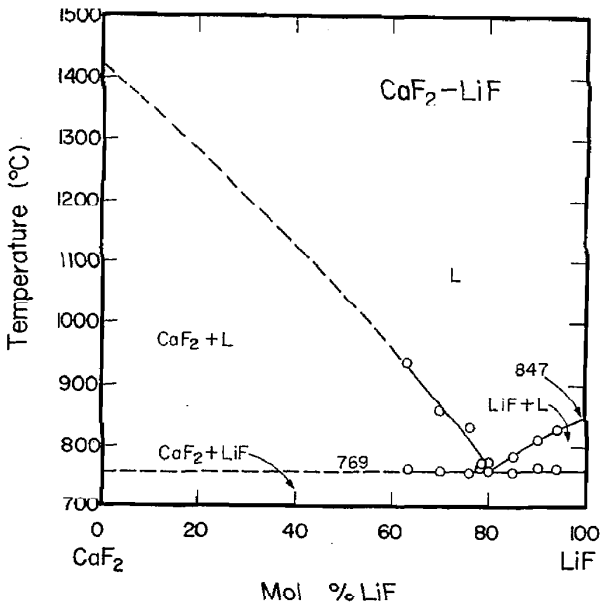

FIGURE 20. Temperature-composition phase diagram for CaF_2-LiF. W. E. Roake, J. Electrochem. Soc., **104**, 661 (1957).

CaF_2-NaF

Electrical Conductance

The recommended values in table 75 are based on the work of Thompson and Kaye (classical ac technique) [**111**].

TABLE 73 A. Investigations critically re-examined

Ref.	NaF (mol %)	Temp. range (T)
111	48.2	1173–1373
10	94.4	1253, 1273, 1293
100*	48.2	1173, 1273, 1373

*Data from reference [**111**].

TABLE 73 B. Cell materials and calibration

Cell material	Electrodes	Frequency range (Hz)	Calibration
Pt crucible [10, **111**]	Pt [10, **111**]	1000 [**111**]	Molten KNO_3 [**111**] 0.1 N KCl (25 °C) [10]

Density

The recommended values in table 76 are based on the work of Abramov and Kozunov (Archimedean method) [7].

TABLE 74 A. Investigations critically re-examined

Ref.	NaF (mol %)	Temp. range (T)
7	50.0, 66.8, 83.5, 100	1143–1443

TABLE 74 B. Comparisons with previous recommendations

Ref.	Recommended value		NaF (mol %)	% Departure			
	Vol.	Page		% (min)	(T)	% (max)	(T)
7	1	3	100	0.56	(1383)	0.95	(1283)

Melt Preparation and Purification

Thompson and Kaye [111] used analyzed chemical reagents (J. T. Baker Chemical Co.) without further purification.

Sodium fluoride, used by Abramov and Kozunov [7], was purified by sublimation.

TABLE 75 a. CaF_2-NaF: Electrical conductance

Specific conductance: Numerical values ($ohm^{-1}\ cm^{-1}$)

T	48.2 Mol % NaF
1180	4.859
1200	4.960
1220	5.062
1240	5.162
1260	5.264
1280	5.366
1300	5.467
1320	5.568
1340	5.670
1360	5.771

TABLE 75 b. Temperature-dependent equation

$\kappa = a + bT$ ($ohm^{-1}\ cm^{-1}$)

Comp. (mol % NaF)	a	$b \cdot 10^3$	Stand. error of est.
48.2	−1.1188	5.0660	0.050

Reference: [111]. Data reported in numerical form.

TABLE 76 a. CaF_2-NaF: Density

Numerical values (gcm^{-3})

Mol percent NaF

T	100.0	83.5	66.8	50.0
1150			2.299	
1160			2.294	
1170			2.288	
1180			2.283	
1190			2.277	
1200			2.272	
1210		2.150	2.266	
1220		2.144	2.261	
1230		2.138	2.256	
1240		2.132	2.250	
1250		2.126	2.245	
1260		2.119	2.239	
1270		2.113	2.234	
1280		2.107	2.228	
1290	1.951	2.101	2.223	
1300	1.944	2.095	2.217	
1310	1.938	2.089	2.212	
1320	1.932	2.083	2.207	
1330	1.926	2.077	2.201	2.357
1340	1.919	2.071	2.196	2.352
1350	1.913	2.065	2.190	2.347
1360	1.907	2.059	2.185	2.341
1370	1.901	2.053	2.179	2.336
1380	1.894	2.047	2.174	2.330
1390	1.888	2.041	2.168	2.325
1400		2.035	2.163	2.320
1410		2.029	2.157	2.314
1420		2.023	2.152	2.309
1430		2.017	2.147	2.303
1440		2.011		2.298

TABLE 76 b. Temperature-dependent equations

$\rho = a + bT$ (gcm^{-3})

Comp. (mol % NaF)	a	$b \cdot 10^4$	Stand. error of est.
50.0	3.0783	−5.4195	0.0018
66.8	2.9258	−5.4489	0.0054
83.5	2.8803	−6.0380	0.0043
100.0	2.7571	−6.2513	0.0016

Reference: [7]. Data reported in equation form.

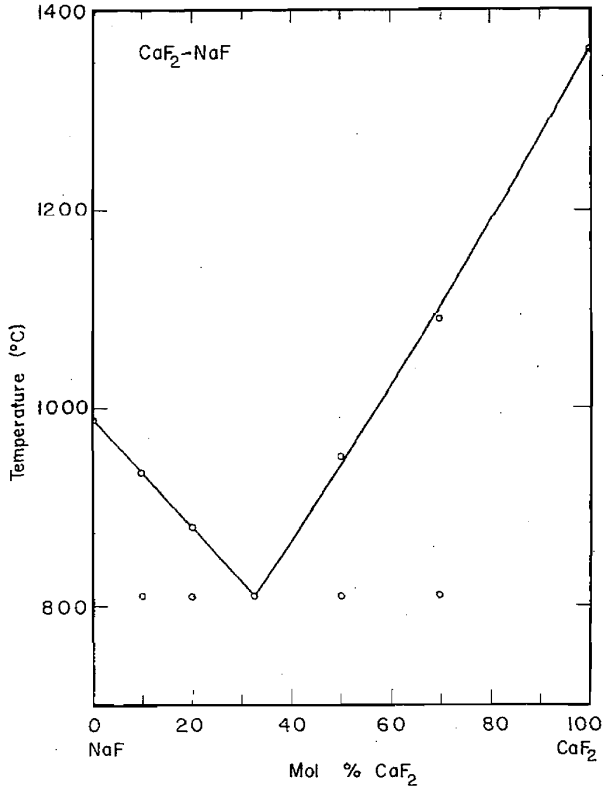

FIGURE 21. Temperature-composition phase diagram for CaF_2-NaF. P. P. Fedotyeff and W. P. Ilyinskiy, Z. Anorg. Allg. Chem., **129**, 93 (1923).

CeF_3-KF

Electrical Conductance

The recommended values in table 79 are based on the work of Meaker, Porter, and Kesterke (classical ac technique) [87].

TABLE 77 A. Investigations critically re-examined

Ref.	KF (mol %)	Temp. range (T)
87	60, 70, 80, 90, 100	1023–1343

TABLE 77 B. Comparisons with previous recommendations

Ref.	Recommended value		KF (mol %)	% Departure			
	Vol.	Page		% (min)	(T)	% (max)	(T)
87	1	3	100	3.5	(1280)	4.5	(1140)

TABLE 77 C. Cell materials and calibration

Cell material	Electrodes	Frequency range (Hz)
Capillary cell consisting of two boron nitride cylinders encased in a graphite jacket [87]	Mo [87]	20–20,000 measurements at 10,000 [87]

Comment: Brief remarks concerning reference [87] are discussed under the system CaF_2-LiF.

Density

The recommended values in tables 80, 81 are based on the work of Meaker and Porter (Archimedean method) [98].

TABLE 78 A. Investigations critically re-examined

Ref.	KF (mol %)	Temp. range (T)
87	60–100 (graphical)	1273
98	60, 70, 80, 90, 100	1043–1353

TABLE 78 B. Comparisons with previous recommendations

Ref.	Recommended value		KF (mol %)	% Departure			
	Vol.	Page		% (min)	(T)	% (max)	(T)
98	1	3	100	−3.1	(1140–1280)		

TABLE 78 C. Cell materials and calibration

Cell material	Calibration
Mo plummet connected to a quartz spring by a Mo wire, melt contained in a graphite crucible [87, 98]	Molten KCl [87, 98]

Comment: Brief remarks concerning reference [98] are discussed under the system CaF_2–LiF.

Density values [98] were reported in the form of linear temperature dependent equations with standard deviations in the range: 2.53×10^{-3} gcm^{-3} (90 mol % KF) to 11.9×10^{-3} gcm^{-3} (70 mol % KF).

Melt Preparation and Purification

The preparation of pure salts by Porter et al. [87, 98] is described under the system CaF_2-LiF. Cerium fluoride contained less than 0.1 weight-percent metallic impurities.

TABLE 79 a. CeF_3-KF: Electrical conductance

Specific conductance: Numerical values (ohm^{-1} cm^{-1})

Mol percent KF

T	100.0	90.0	80.0	70.0	60.0
1030				1.36	
1040			1.77	1.40	
1050			1.81	1.44	
1060			1.84	1.47	
1070			1.88	1.51	
1080			1.91	1.54	
1090			1.95	1.58	
1100			1.98	1.61	
1110		2.69	2.02	1.65	
1120		2.73	2.05	1.68	
1130		2.77	2.09	1.72	
1140	3.74	2.81	2.13	1.75	
1150	3.77	2.85	2.16	1.79	
1160	3.80	2.88	2.20	1.82	
1170	3.83	2.92	2.23	1.86	1.70
1180	3.86	2.96	2.27	1.89	1.74
1190	3.89	3.00	2.30	1.93	1.77
1200	3.92	3.04	2.34	1.96	1.81
1210	3.95	3.08	2.37	2.00	1.85
1220	3.98	3.12	2.41	2.03	1.88
1230	4.01	3.15	2.44	2.07	1.92
1240	4.03	3.19	2.48	2.10	1.95
1250	4.06	3.23	2.51	2.14	1.99
1260	4.09	3.27	2.55	2.17	2.03
1270	4.12	3.31	2.59	2.21	2.06
1280	4.15	3.35	2.62	2.24	2.10
1290	4.18	3.39	2.66	2.28	2.13
1300	4.21	3.42	2.69	2.31	2.17
1310	4.24	3.46	2.73	2.35	2.21
1320	4.27	3.50	2.76	2.38	2.24
1330	4.30	3.54	2.80	2.42	2.28
1340	4.33	3.58	2.83	2.45	2.31

TABLE 79 b. Temperature-dependent equations

$\kappa = a + bT$ (ohm^{-1} cm^{-1})

Comp. (mol % KF)	a	$b\cdot10^3$	Stand. deviation [87]
60.0	−2.498	3.590	0.0137
70.0	−2.256	3.515	0.0137
80.0	−1.911	3.540	0.0153
90.0	−1.594	3.860	0.0240
100.0	0.388	2.940	0.0179

Reference: [87]. Data reported in equation form.

TABLE 80 a. CeF_3-KF: Density

Numerical values (gcm^{-3})

Mol percent KF

T	100	95	90	85	80	75	70	65	60
1050					2.595	2.759	2.925		
1065				2.418	2.583	2.748	2.913		
1080			2.239	2.406	2.572	2.737	2.902		
1095			2.228	2.395	2.561	2.726	2.891	3.058	
1110		2.046	2.217	2.384	2.550	2.715	2.880	3.047	
1125		2.035	2.206	2.374	2.539	2.704	2.869	3.036	
1140	1.849	2.024	2.195	2.363	2.529	2.694	2.859	3.025	
1155	1.839	2.014	2.184	2.352	2.518	2.683	2.848	3.015	
1170	1.828	2.003	2.174	2.342	2.507	2.672	2.838	3.004	
1185	1.818	1.993	2.163	2.331	2.497	2.662	2.827	2.994	3.162
1200	1.808	1.982	2.153	2.321	2.487	2.652	2.817	2.983	3.152
1215	1.797	1.972	2.143	2.311	2.476	2.641	2.807	2.973	3.142
1230	1.787	1.962	2.133	2.300	2.466	2.631	2.796	2.963	3.132
1245	1.777	1.952	2.123	2.290	2.456	2.621	2.786	2.953	3.122
1260	1.767	1.942	2.113	2.280	2.446	2.611	2.776	2.943	3.112
1275	1.757	1.932	2.103	2.271	2.436	2.601	2.767	2.933	3.102
1290	1.748	1.922	2.093	2.261	2.427	2.592	2.757	2.923	3.092
1305	1.738	1.913	2.084	2.251	2.417	2.582	2.747	2.914	3.082
1320	1.728	1.903	2.074	2.242	2.408	2.572	2.738	2.904	3.073
1335	1.719	1.894	2.065	2.232	2.398	2.563	2.728	2.895	3.063
1350	1.710	1.884	2.055	2.223	2.389	2.554	2.719	2.885	3.054

TABLE 80 b. Two-dimensional equation and statistical parameters

$\rho = a + bT + cC + dT^2 + eC^2 + fC^3$ (gcm^{-3})

a	$b \cdot 10^3$	$c \cdot 10^2$	$d \cdot 10^7$	$e \cdot 10^4$	$f \cdot 10^6$	Max. percent departure	Stand. error of est.
2.94846	−1.21553	3.54550	2.20620	−1.03800	1.44443	0.36 (1133.2K, 0 mol % CeF_3)	0.004

Reference: [98]. Data reported in numerical form.
C=mol % CeF_3.

TABLE 81 a. CeF_3-KF: Density

Numerical values (gcm^{-3})

Mol percent KF

	100.0	90.0	80.0	70.00	60.0
1050			2.593	2.927	
1065			2.582	2.916	
1080		2.236	2.571	2.906	
1095		2.226	2.561	2.895	
1110		2.216	2.550	2.884	
1125		2.206	2.540	2.873	
1140	1.844	2.196	2.529	2.863	
1155	1.834	2.186	2.518	2.852	
1170	1.825	2.176	2.508	2.841	
1185	1.815	2.166	2.497	2.830	3.154
1200	1.806	2.156	2.487	2.819	3.146
1215	1.797	2.146	2.476	2.809	3.138
1230	1.787	2.136	2.466	2.798	3.129
1245	1.778	2.126	2.455	2.787	3.121
1260	1.769	2.116	2.444	2.776	3.112
1275	1.759	2.106	2.434	2.766	3.104
1290	1.750	2.096	2.423	2.755	3.095
1305	1.741	2.086	2.413	2.744	3.087
1320	1.731	2.076	2.402	2.733	3.079
1335	1.722	2.065	2.392	2.723	3.070
1350	1.712	2.055	2.381	2.712	3.062

TABLE 81 b. Temperature-dependent equations

$\rho = a + bT$ (gcm^{-3})

Comp. (mol % KF)	a	$b \cdot 10^4$	Stand. dev. [98]
60.0	3.820	−5.617	0.00985
70.0	3.680	−7.171	0.0119
80.0	3.333	−7.052	0.00376
90.0	2,957	−6.678	0.00253
100.0	2.555	−6.241	0.00276

Reference: [98]. Data reported in equation form.

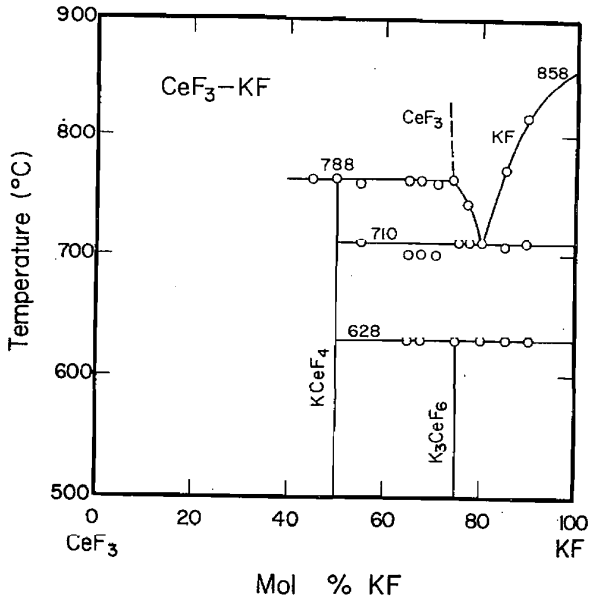

FIGURE 22. Temperature-composition phase diagram for CeF_3-KF. G. A. Bukhalova and E. P. Babaeva, Russ. J. Inorg. Chem., **11**, 337 (1966).

CeF_3-LiF

Electrical Conductance

The recommended values in table 84 are based on the work of Meaker, Porter, and Kesterke (classical ac technique) [87].

TABLE 82 A. Investigations critically re-examined

Ref.	LiF (mol %)	Temp. range (T)
87	70, 76, 81, 88, 100	1083–1343

TABLE 82 B. Comparisons with previous recommendations

Ref.	Recommended value		LiF (mol %)	% Departure			
	Vol.	Page		% (min)	(T)	% (max)	(T)
87	1	2	100	5.1	(1150)	8.2	(1310)

TABLE 82 C. Cell materials and calibration

Cell material	Electrodes	Frequency range (Hz)
Capillary cell consisting of two boron nitride cylinders encased in a graphite jacket [87]	Mo [87]	20–20,000 measurements at 10,000 [87]

Comment: Brief remarks concerning reference [87] are discussed under the system CaF_2–LiF.

Density

The recommended values in tables 85, 86 are based on the work of Meaker and Porter (Archimedean method) [98].

TABLE 83 A. Investigations critically re-examined

Ref.	LiF (mol %)	Temp. range (T)
87	70–100 (graphical)	1273
98	70, 76, 81, 88, 100	1083–1353

TABLE 83 B. Comparisons with previous recommendations

Ref.	Recommended value		LiF (mol %)	% Departure			
	Vol.	Page		% (min)	(T)	% (max)	(T)
98	1	2	100	−4.5	(1310)	−5.6	(1150)

TABLE 83 C. Cell materials and calibration

Cell material	Calibration
Mo plummet connected to a quartz spring by a Mo wire, melt contained in a graphite crucible [87, 98]	Molten KCl [87, 98]

Comment: Brief remarks concerning reference [98] are discussed under the system CaF_2–LiF.

Density values [98] were reported in the form of linear temperature-dependent equations with standard deviations in the range: 1.94×10^{-2} gcm^{-3} (76 mol % LiF) to 19.9×10^{-3} gcm^{-3} (88 mol % LiF).

Melt Preparation and Purification

The preparation of pure salts by Porter et al. [87, 98] is described under the system CaF_2-LiF. Cerium fluoride contained less than 0.1 weight-percent metallic impurities.

TABLE 84 a. CeF_3–LiF: Electrical conductance

Specific conductance: Numerical values (ohm^{-1} cm^{-1})

T	Mol percent LiF				
	100.0	88.0	81.0	76.0	70.0
1090			5.42		
1100			5.49		
1110			5.55		
1120		6.72	5.61		
1130		6.79	5.68		
1140		6.85	5.74		
1150	9.10	6.91	5.81		
1160	9.16	6.98	5.87		
1170	9.22	7.04	5.93		
1180	9.27	7.11	6.00		
1190	9.33	7.17	6.06	5.51	
1200	9.39	7.23	6.12	5.57	
1210	9.45	7.30	6.19	5.64	
1220	9.51	7.36	6.25	5.70	
1230	9.57	7.43	6.32	6.76	5.46
1240	9.62	7.49	6.38	5.83	5.52
1250	9.68	7.55	6.44	5.89	5.58
1260	9.74	7.62	6.51	5.96	5.64
1270	9.80	7.68	6.57	6.02	5.69
1280	9.86	7.75	6.64	6.08	5.75
1290	9.92	7.81	6.70	6.15	5.81
1300	9.97	7.88	6.76	6.21	5.87
1310	10.3	7.94	6.83	6.27	5.93
1320	10.09	8.00	6.89	6.34	5.99
1330	10.15	8.07	6.95	6.40	6.05
1340	10.21	8.13	7.02	6.46	6.11

TABLE 84 b. Temperature-dependent equations

$\kappa = a + bT$ (ohm^{-1} cm^{-1})

Comp. (mol % LiF)	a	$b\ 10^3$	Stand. deviation [87]
70.0	−1.782	5.887	0.0399
76.0	−2.040	6.345	0.0180
81.0	−1.533	6.381	0.0495
88.0	−0.452	6.405	0.0464
100.0	2.395	5.830	0.0500

Reference: [87]. Data reported in equation form.

TABLE 85 a. CeF_3-LiF: Density

Numerical values (gcm^{-3})

Mol percent LiF

T	100	95	90	85	80	75	70	80
1090				2.811				
1105			2.447	2.802	3.116			3.116
1120			2.438	2.792	3.105			3.105
1135	1.701		2.429	2.782	3.095			3.095
1150	1.695		2.420	2.773	3.085			3.085
1165	1.690	2.046	2.412	2.763	3.074	3.322		3.074
1180	1.684	2.039	2.403	2.753	3.064	3.312		3.064
1195	1.679	2.031	2.394	2.743	3.054	3.301	3.461	3.054
1210	1.674	2.024	2.386	2.734	3.044	3.291	3.450	3.044
1225	1.668	2.017	2.377	2.724	3.033	3.280	3.440	3.033
1240	1.663	2.009	2.368	2.714	3.023	3.270	3.430	3.023
1255	1.657	2.002	2.359	2.705	3.013	3.260	3.420	3.013
1270	1.652	1.995	2.351	2.695	3.003	3.249	3.410	3.003
1285	1.647	1.988	2.342	2.685	2.992	3.239	3.400	2.992
1300	1.641	1.980	2.333	2.675	2.982	3.229	3.390	2.982
1315	1.636	1.973	2.324	2.666	2.972	3.218	3.380	2.972
1330	1.630	1.966	2.316	2.656	2.961	3.208	3.370	2.961
1345	1.625	1.958	2.307	2.646	2.951	3.197	3.360	2.951

TABLE 85 b. Two-dimensional equation and statistical parameters

$\rho = a + bT + cC + dC^3 + eTC + fTC^2$ (gcm^{-3})

a	$b \cdot 10^4$	$c \cdot 10^1$	$d \cdot 10^5$	$e \cdot 10^5$	$f \cdot 10^7$	Max. percent departure	Stand. error of est.
2.10920	−3.60006	1.01307	−3.28974	−2.80956	5.92992	0.38 (1193.2 K 30 Mol % CeF_3)	0.006

Reference: [98]. Data reported in equation form.
C=mol percent CeF_3.

TABLE 86 a. CeF_3–LiF: Density

Numerical values (gcm^{-3})

Mol percent LiF

T	100.0	88.0	81.0	76.0	70.0
1095		2.603	3.061		
1110		2.594	3.050		
1125	1.700	2.585	3.039		
1140	1.695	2.575	3.029		
1155	1.690	2.566	3.018	3.297	
1170	1.685	2.557	3.007	3.285	
1185	1.680	2.547	2.997	3.274	
1200	1.675	2.538	2.986	3.263	3.445
1215	1.670	2.528	2.975	3.252	3.437
1230	1.666	2.519	2.965	3.240	3.430
1245	1.661	2.510	2.954	3.229	3.422
1260	1.656	2.500	2.944	3.218	3.414
1275	1.651	2.491	2.933	3.207	3.407
1290	1.646	2.482	2.922	3.196	3.399
1305	1.641	2.472	2.912	3.184	3.391
1320	1.636	2.463	2.901	3.173	3.383
1335	1.631	2.454	2.890	3.162	3.376
1350	1.626	2.444	2.880	3.151	3.368

TABLE 86 b. Temperature-dependent equations

$\rho = a + bT$ (gcm^{-3})

Comp. (mol % LiF)	a	$b \cdot 10^4$	Stand. dev. [98]
70.0	4.061	−5.133	0.0094
76.0	4.161	−7.484	0.00194
81.0	3.837	−7.091	0.0140
88.0	3.286	−6.235	0.0199
100.0	2.074	−3.321	0.00705

Reference: [98]. Data reported in equation form.

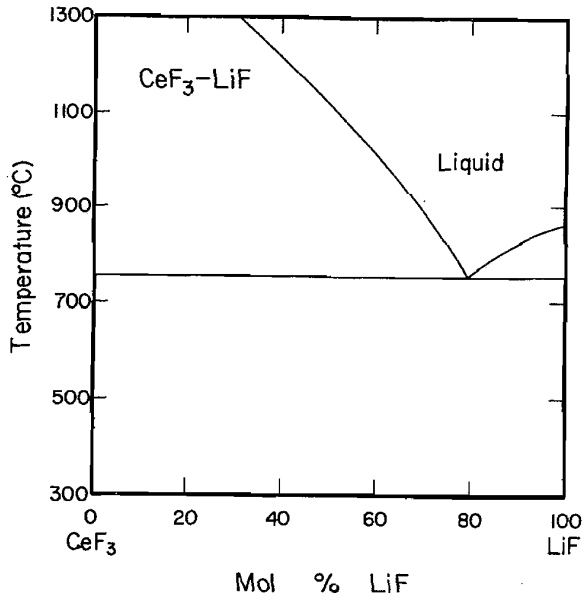

FIGURE 23. Temperature-composition phase diagram for CeF_3-LiF. R. E. Thoma, Progress in Science and Technology of the Rare Earths, Vol. 2, p. 110, Pergamon Press, N.Y. 1966.

CeF_3-NaF

Electrical Conductance

The recommended values in table 89 are based on the work of Meaker, Porter and Kesterke (classical ac technique) [87].

TABLE 87 A. Investigations critically re-examined

Ref.	NaF (mol %)	Temp. range (T)
87	60, 70, 80, 90, 100	1093–1343

TABLE 87 B. Comparisons with previous recommendations

Ref.	Recommended value		NaF (mol %)	% Departure			
	Vol.	Page		% (min)	(T)	% (max)	(T)
87	1	3	0	5.0	(1300)	7.4	(1340)

TABLE 87 C. Cell materials and calibration

Cell material	Electrodes	Frequency range (Hz)
Capillary cell consisting of two boron nitride cylinders encased in a graphite jacket [87]	Mo [87]	20–20,000 measurements at 10,000 [87]

Comment: Brief remarks concerning reference [87] are discussed under the system CaF_2-LiF.

Density

The recommended values in tables 90, 91 are based on the work of Meaker and Porter (Archimedean method) [98].

TABLE 88 A. Investigations critically re-examined

Ref.	NaF (mol %)	Temp. range (T)
87	60–100 (graphical)	1273
98	60, 70, 80, 90, 100	1073–1353

TABLE 88 B. Comparisons with previous recommendations

Ref.	Recommended value		NaF (mol %)	% Departure			
	Vol.	Page		% (min)	(T)	% (max)	(T)
98	1	3	0	−2.2	(1270)	−2.5	(1350)

TABLE 88 C. Cell materials and calibration

Cell material	Calibration
Mo plummet connected to a quartz spring by a Mo wire, melt contained in a graphite crucible [87, 98]	Molten KCl [87, 98]

Comment: Brief remarks concerning reference [98] are discussed under the system CaF_2-LiF.

Density values [98] were reported in the form of linear temperature-dependent equations with standard deviations in the range: 2.39×10^{-3} gcm^{-3} (100 mol % NaF) to 9.40×10^{-3} gcm^{-3} (60 mol % NaF).

Melt Preparation and Purification

The preparation of pure salts by Porter et al. [87, 98] is described under the system CaF_2-LiF. Cerium fluoride contained less than 0.1 weight-percent metallic impurities.

TABLE 89 a. CeF_3–NaF: Electrical conductance

Specific conductance: Numerical values (ohm^{-1} cm^{-1})

T	Mol percent NaF				
	100.0	90.0	80.0	70.0	60.0
1100				2.48	
1110				2.53	
1120			3.08	2.58	
1130			3.12	2.63	
1140			3.17	2.68	2.46
1150			3.22	2.73	2.51
1160			3.27	2.79	2.56
1170			3.32	2.84	2.61
1180			3.37	2.89	2.66
1190			3.42	2.94	2.72
1200			3.47	2.99	2.77
1210			3.51	3.04	2.82
1220			3.56	3.09	2.87
1230			3.61	3.14	2.92
1240			3.66	3.19	2.98
1250		4.28	3.71	3.24	3.03
1260		4.31	3.76	3.29	3.08
1270		4.35	3.81	3.34	3.13
1280		4.39	3.85	3.39	3.18
1290		4.43	3.90	3.44	3.24
1300		4.46	3.95	3.49	3.29
1310	5.33	4.50	4.00	3.55	3.34
1320	5.39	4.54	4.05	3.60	3.39
1330	5.44	4.58	4.10	3.65	3.44
1340	5.50	4.61	4.15	3.70	3.50

TABLE 89 b. Temperature-dependent equations

$\kappa = a + bT$ (ohm^{-1} cm^{-1})

Comp. (mol % NaF)	a	$b \cdot 10^3$	Stand. deviation [87]
60.0	−3.474	5.201	0.0154
70.0	−3.088	5.063	0.0155
80.0	−2.377	4.868	0.0235
90.0	−0.394	3.736	0.0985
100.0	−2.060	5.640	0.0660

Reference: [87]. Data reported in equation form.

TABLE 90 a. CeF_3-NaF: Density

Numerical values (gcm^{-3})

Mol percent NaF

T	100	95	90	85	80	75	70	65	60	72
1080						3.178	3.370			3.295
1095						3.160	3.360			3.286
1110					2.951	3.159	3.351	3.525		3.276
1125					2.942	3.149	3.341	3.515		3.266
1140					2.932	3.139	3.331	3.504		3.256
1155				2.702	2.923	3.130	3.321	3.494		3.247
1170				2.693	2.913	3.120	3.311	3.484		3.237
1185				2.683	2.904	3.111	3.301	3.474	3.627	3.227
1200				2.674	2.895	3.101	3.291	3.464	3.616	3.217
1215			2.432	2.665	2.885	3.091	3.281	3.453	3.605	3.207
1230			2.423	2.655	2.876	3.082	3.272	3.443	3.595	3.198
1245			2.413	2.646	2.866	3.072	3.262	3.433	3.584	3.188
1260			2.404	2.637	2.857	3.063	3.252	3.423	3.573	3.178
1275	1.899	2.151	2.395	2.627	2.847	3.053	3.242	2.412	2.563	2.168
1290	1.890	2.142	2.385	2.618	2.838	3.043	3.232	3.402	3.552	3.159
1305	1.880	2.133	2.376	2.609	2.829	3.034	3.222	3.392	3.541	3.149
1320	1.871	2.123	2.367	2.599	2.819	3.024	3.212	3.382	3.531	3.139
1335	1.861	2.114	2.358	2.590	2.810	3.014	3.202	3.372	3.520	3.129
1350	1.852	2.105	2.348	2.581	2.800	3.005	3.192	3.361	3.509	3.120

TABLE 90 b. Two-dimensional equation and statistical parameters

$\rho = a + bT + cC + dC^3 + eTC + fTC^2$ (gcm^{-3})

a	$b \cdot 10^4$	$c \cdot 10^2$	$d \cdot 10^6$	$e \cdot 10^6$	$f \cdot 10^7$	Max. percent departure	Stand. error of est.
2.70452	−6.31498	4.82510	−2.60170	2.26641	−1.05829	0.17 (1343.2K, 20 mol % CeF)	0.003

Reference: [98]. Data reported in equation form.
C = mol percent CeF_3.

TABLE 91 a. CeF_3–NaF: Density

Numerical values (gcm^{-3})

Mol percent NaF

T	100.0	90.0	80.0	70.0	60.0
1080				3.370	
1095				3.360	
1110			2.951	3.350	
1125			2.941	3.341	
1140			2.932	3.331	
1155			2.922	3.321	
1170			2.912	3.312	
1185			2.902	3.302	3.627
1200			2.893	3.293	3.616
1215		2.435	2.883	3.283	3.605
1230		2.426	2.873	3.273	3.594
1245		2.416	2.863	3.264	3.583
1260		2.407	2.854	3.254	3.573
1275	1.898	2.397	2.844	3.244	3.562
1290	1.889	2.388	2.834	3.235	3.551
1305	1.879	2.378	2.825	3.225	3.540
1320	1.870	2.369	2.815	3.216	3.529
1335	1.861	2.359	2.805	3.206	3.518
1350	1.852	2.350	2.795	3.196	3.507

TABLE 91 b. Temperature-dependent equations

$\rho = a + bT$ (gcm^{-3})

Comp. (mol % NaF)	a	$b \cdot 10^4$	Stand. dev. [98]
60.0	4.486	−7.249	0.00940
70.0	4.063	−6.420	0.00907
80.0	3.670	−6.478	0.00798
90.0	3.207	−6.350	0.00353
100.0	2.682	−6.151	0.00239

Reference: [98]. Data reported in equation form.

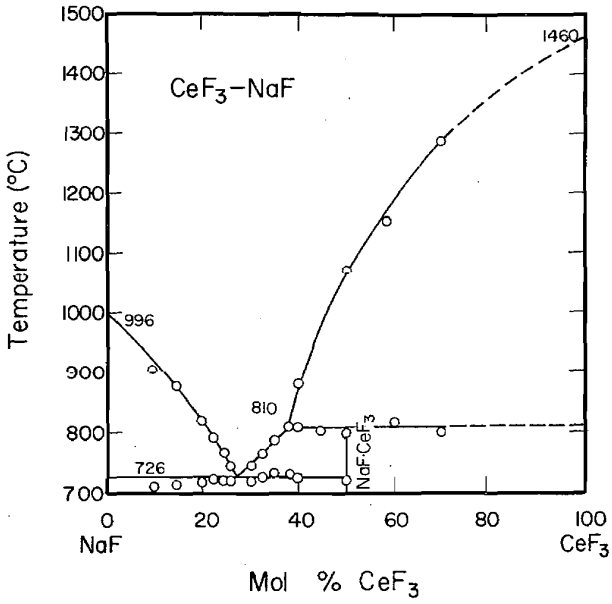

FIGURE 24. Temperature-composition phase diagram for CeF_3-NaF. C. J. Barton, J. D. Redman, and R. A. Strehlow, J. Inorg. Nucl. Chem., **20**, 45 (1961).

$KF\text{-}KBF_4$

Electrical Conductance

The recommended values in table 93 are based on the work of Selivanov and Stender (classical ac technique) [**125**].

TABLE 92 A. Investigations critically re-examined

Ref.	KBF_4 (mol %)	Temp. range (T)
125	16.5–80.6	723–1073

TABLE 92 B. Cell materials and calibration

Cell material	Electrodes	Frequency range (Hz)	Calibration
Corundum crucible [125]	Pt [125]	5000 [125]	Melt containing 62% $CaCl_2$—38% NaCl and molten $Na_2B_4O_7$ [125]

TABLE 93. KF-KBF_4: Electrical conductance

Specific conductance: Numerical values (ohm^{-1} cm^{-1})

Mol percent KBF_4

T	80.6	64.9	51.8	40.9	31.6	23.5	16.5
723.2	0.281	0.519	0.201				
773.2	0.445	0.815	0.355				
823.2	0.915	1.215	0.555				
873.2	1.459	2.225	1.209				
923.2	3.601	4.209	3.150	2.255			
973.2	6.801	7.292	6.806	5.303	3.291		
1023.2	9.807	10.015	9.345	8.406	7.105	3.902	
1073.2	12.703	13.015	12.501	11.495	9.912	8.101	5.001

Reference: [125]. The statistical analysis was unsuccessful therefore the original data are reported.

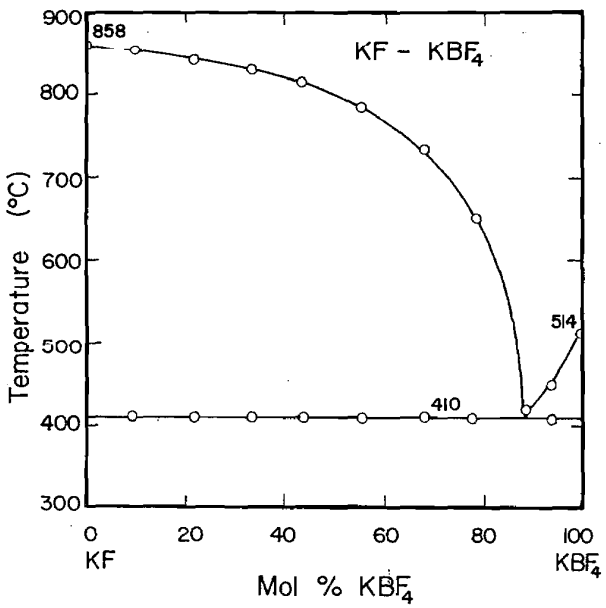

FIGURE 25. Temperature-composition phase diagram for KF-KBF_4. V. G. Selivanov and V. V. Stender, Zhur. Neorg. Khim., 4, 2058 (1959); Russ. J. Inorg. Chem., 4 [9], 934 (1959).

KF-LaF_3

Electrical Conductance

The recommended values in table 96 are based on the work of Meaker, Porter, and Kesterke (classical ac technique) [87].

TABLE 94 A. Investigations critically re-examined

Ref.	LaF_3 (mol %)	Temp. range (T)
87	0, 10.0, 20.0, 30.0, 40.0	1043–1343

TABLE 94 B. Comparisons with previous recommendations

Ref.	Recommended value		LaF_3 (mol %)	% Departure			
	Vol.	Page		% (min)	(T)	% (max)	(T)
87	1	3	0	3.5	(1280)	4.5	(1140)

TABLE 94 C. Cell materials and calibration

Cell material	Electrodes	Frequency range (Hz)
Capillary cell consisting of two boron nitride cylinders encased in a graphite jacket [87]	Mo [87]	20–20,000 measurements at 10,000 [87]

Comment: Brief remarks concerning reference [87] are discussed under the system CaF_2-LiF.

Density

The recommended values in tables 97, 98 are based on the work of Meaker and Porter (Archimedean method) [98].

TABLE 95 A. Investigations critically re-examined

Ref.	LaF_3 (mol %)	Temp. range (T)
87	60–100 (graphical)	1273
98	0.0, 10.0, 20.0, 30.0, 40.0	1043–1353

TABLE 95 B. Comparisons with previous recommendations

Ref.	Recommended value		LaF_3 (mol %)	% Departure			
	Vol.	Page		% (min)	(T)	% (max)	(T)
98	1	3	0	−3.1	(1140–1280)		

Comment: Brief remarks concerning reference [98] are given under the system CaF_2–LiF.

Density values [98] were reported in the form of linear temperature-dependent equations with standard deviations in the range: 2.76×10^{-3} gcm^{-3} (0 mol % LaF_3) to 5.95×10^{-3} gcm^{-3} (30 mol % LaF_3).

Melt Preparation and Purification

The method of salt purification used by Porter et al. [87, 98] is described under the system CaF_2-LiF.

Lanthanum fluoride contained less than 0.1 weight-percent of metallic impurities.

TABLE 96 a. KF-LaF_3: Electrical conductance

Specific conductance: Numerical values (ohm^{-1} cm^{-1})

T	40.0	30.0	20.0	10.0	0.0
1050		1.45			
1060		1.49			
1070		1.53			
1080		1.56	1.93	2.59	
1090		1.60	1.97	2.62	
1100		1.64	2.01	2.66	
1110		1.68	2.04	2.69	
1120		1.72	2.08	2.73	
1130		1.75	2.12	2.76	
1140		1.79	2.15	2.79	3.74
1150		1.83	2.19	2.83	3.77
1160		1.87	2.23	2.86	3.80
1170		1.90	2.26	2.89	3.83
1180		1.94	2.30	2.93	3.86
1190		1.98	2.34	2.96	3.89
1200	1.89	2.02	2.37	2.99	3.92
1210	1.93	2.05	2.41	3.03	3.95
1220	1.97	2.09	2.45	3.06	3.98
1230	2.01	2.13	2.48	3.10	4.51
1240	2.05	2.17	2.52	3.13	4.03
1250	2.09	2.21	2.56	3.16	4.06
1260	2.13	2.24	2.60	3.20	4.09
1270	2.17	2.28	2.63	3.23	4.12
1280	2.21	2.32	2.67	3.26	4.15
1290	2.25	2.36	2.71	3.30	4.18
1300	2.29	2.39	2.74	3.33	4.21
1310	2.32	2.43	2.78	3.36	4.24
1320	2.36	2.47	2.82	3.40	4.27
1330	2.40	2.51	2.85	3.43	4.30
1340	2.44	2.55	2.89	3.46	4.33

TABLE 96 b. Temperature-dependent equations

$\kappa = a + bT$ (ohm^{-1} cm^{-1})

Comp. (mol % LaF_3)	a	$b\cdot10^3$	Stand. deviation [87]
0.0	0.388	2.940	0.0179
10.0	−1.037	3.359	0.0147
20.0	−2.046	3.683	0.0189
30.0	−2.511	3.773	0.0069
40.2	−2.807	3.917	0.0087

Reference: [87]. Data reported in equation form.

TABLE 97 a. KF-LaF_3: Density

Numerical values (gcm^{-3})

Mol percent LaF_3

T	40	35	30	25	20	15	10	5	0	22
1050				2.764	2.595					2.663
1065				2.752	2.584	2.413				2.651
1080			2.907	2.741	2.573	2.403				2.640
1095			2.895	2.729	2.561	2.392	2.220			2.629
1110			2.883	2.718	2.550	2.381	2.210			2.617
1125		3.034	2.871	2.706	2.539	2.370	2.200	2.027		2.606
1140		3.022	2.859	2.694	2.528	2.360	2.189	2.017	1.843	2.595
1155		3.009	2.847	2.683	2.517	2.349	2.179	2.007	1.834	2.584
1170		2.997	2.835	2.671	2.506	2.338	2.169	1.998	1.824	2.572
1185		2.985	2.823	2.660	2.495	2.327	2.158	1.988	1.815	2.561
1200		2.973	2.811	2.648	2.483	2.317	2.148	1.978	1.806	2.550
1215	3.120	2.961	2.800	2.637	2.472	2.306	2.138	1.968	1.796	2.538
1230	3.107	2.948	2.788	2.625	2.461	2.295	2.128	1.958	1.787	2.527
1245	3.095	2.936	2.776	2.614	2.450	2.285	2.117	1.948	1.778	2.516
1260	3.082	2.924	2.764	2.602	2.439	2.274	2.107	1.938	1.768	2.504
1275	3.070	2.912	2.752	2.591	2.428	2.263	2.097	1.929	1.759	2.493
1290	3.057	2.899	2.740	2.579	2.417	2.252	2.086	1.919	1.750	2.482
1305	2.045	2.887	2.728	2.568	2.405	2.242	2.076	1.909	1.740	2.470
1320	3.032	2.875	2.716	2.556	2.394	2.231	2.066	1.899	1.731	2.459
1335	3.019	2.863	2.704	2.545	2.383	2.220	2.055	1.889	1.722	2.448
1350	3.007	2.851	2.693	2.533	2.372	2.209	2.045	1.879	1.712	2.437

TABLE 97 b. Two-dimensional equations and statistical parameters

$\rho = a + bT + cC + dC^2 + eTC^2$ (gcm^{-3})

a	$b \cdot 10^4$	$c \cdot 10^2$	$d \cdot 10^5$	$e \cdot 10^8$	Max. percent departure	Stand. error of est.
6.05239	−9.55399	−2.73976	−7.58455	3.31696	0.30 (1343.2K, 70 mol % KF)	0.004

Reference: [98]. Data reported in equation form.
C = mol percent KF.

TABLE 98 a. KF-LaF_3: Density

Numerical values (gcm^{-3})

Mol percent LaF_3

T	40.0	30.0	20.0	10.0	0.0
1050			2.593		
1065			2.581		
1080		2.908	2.570		
1095		2.897	2.559	2.222	
1110		2.885	2.547	2.212	
1125		2.874	2.536	2.201	
1140		2.862	2.525	2.191	1.844
1155		2.851	2.513	2.181	1.834
1170		2.839	2.502	2.170	1.825
1185		2.828	2.491	2.160	1.815
1200		2.816	2.479	2.149	1.806
1215	3.114	2.805	2.468	2.139	1.797
1230	3.102	2.793	2.457	2.129	1.787
1245	3.090	2.782	2.445	2.118	1.778
1260	3.078	2.770	2.434	2.108	1.769
1275	3.066	2.759	2.423	2.097	1.759
1290	3.054	2.747	2.411	2.087	1.750
1305	3.042	2.735	2.400	2.076	1.741
1320	3.030	2.724	2.389	2.066	1.731
1335	3.018	2.712	2.377	2.056	1.722
1350	3.006	2.701	2.366	2.045	1.712

TABLE 98 b. Temperature-dependent equations

$\rho = a + bT$ (gcm^{-3})

Comp. (mol % LaF_3)	a	$b \cdot 10^4$	Stand. dev. [98]
0.0	2.555	−6.241	0.00276
10.0	2.983	−6.947	0.00447
20.0	3.386	−7.555	0.00510
30.0	3.738	−7.682	0.00595
40.0	4.090	−8.030	0.00492

Reference: [98]. Data reported in equation form.

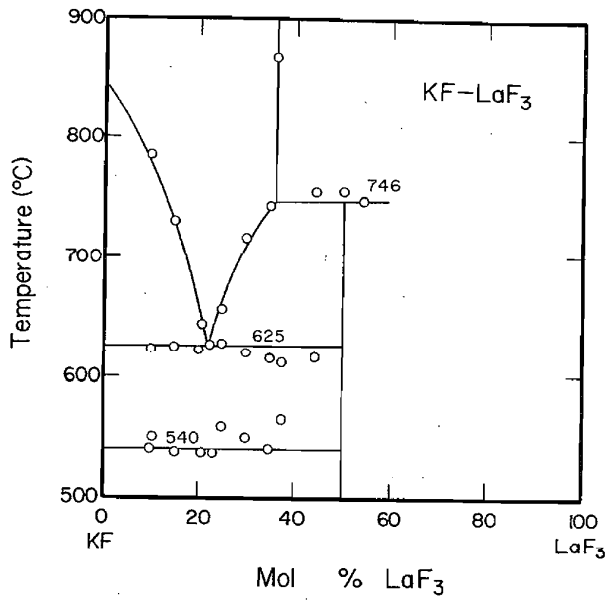

FIGURE 26. Temperature-composition phase diagram for KF-LaF_3.
G. A. Bukhalova, E. P. Babaeva, and T. M. Khliyan, Russ. J. Inorg. Chem., **10**, 1158 (1965).

KF-LiF

Electrical Conductance

The recommended values in table 102 are based on the work of Meaker, Porter, and Kesterke (classical ac technique) [**87**].

TABLE 99 A. Investigations critically re-examined

Ref.	LiF (mol %)	Temp. range (T)
87	0–100	1013–1343

TABLE 99 B. Comparisons with previous recommendations

Ref.	Recommended value		LiF (mol %)	% Departure			
	Vol.	Page		%(min)	(T)	% (max)	(T)
87	1	2	100	5.0	(1160)	6.8	(1270)
87	1	3	0	3.5	(1280)	4.5	(1140)

TABLE 99 C. Cell materials and calibration

Cell material	Electrodes	Frequency range (Hz)
Capillary cell consisting of two boron nitride cylinders encased in a graphite jacket[87].	Mo[87]	20–20,000 measurements at 10,000 [87]

Comment: Brief remarks concerning reference [87] are discussed under the system CaF_2–LiF.

Density

The recommended values in table 103 are based on the work of Porter and Meaker (Archimedean method) [98].

TABLE 100 A. Investigations critically re-examined

Ref.	LiF (mol %)	Temp. range (T)
47	50	788–1011
89	0–100 (graphical)	1073, 1173, 1273
48	50	788–1011
87	0–100 (graphical)	1273
98	0–100	973–1353
30	50	873, 973, 1073

TABLE 100 B. Comparisons with previous recommendations

Ref.	Recommended value		LiF (mol %)	% Departure			
	Vol.	Page		%(min)	(T)	% (max)	(T)
98	1	2	100	−4.5	(1310)	−5.6	(1150)
98	1	3	0	−3.1	(1140–1280)		

TABLE 100 C. Cell materials and calibration

Cell material	Calibration
Tungsten, molybdenum or nickle bob suspended by a W or Mo wire, melt contained in a Mo crucible [89]	
Pt sphere and Pt suspension wire [48]	Water [48]
Biconical Mo plummet suspended from Mo wire, melt contained in graphite crucible [87, 98]	Molten KCl [87, 98]

Comment: Brief remarks concerning reference [98] are given under the system NaF–ThF_4. Density values in reference [98] were reported in the form of linear temperature-dependent equations with standard deviations in the range: 2.76×10^{-3} gcm^{-3} (0 mol % LiF) to 10.6×10^{-3} gcm^{-3} (70 mol % LiF).

Surface Tension

The recommended values in figure 27 are based on the work of Mellors and Senderoff (maximum bubble pressure method) [89].

TABLE 101 A. Investigations critically re-examined

Ref.	LiF (mol %)	Temp. range (T)
89	0, 25, 50, 75, 100 (graphical)	1023–1273

Comment: Mellors and Senderoff [89] corrected for the expansion of the bubble tip with temperature. The accuracy of their method was reported to be ±0.5 dyn cm^{-1}.

Melt Preparation and Purification

Mellors and Senderoff [89] used ACS specified reagents (Harshaw Chemical Company).

The procedure used by Porter et al. [87, 98] is discussed under the system CaF_2-LiF.

TABLE 102. KF-LiF: Electrical conductance

Specific conductance: Numerical values (ohm^{-1} cm^{-1})

Mol percent LiF

T	100.0	85.0	70.0	50.0	35.0	20.0	0.0
1020				3.00	2.96		
1030				3.04	3.00		
1040				3.08	3.04		
1050				3.13	3.08		
1060				3.17	3.12		
1070				3.22	3.16		
1080				3.26	3.20		
1090				3.31	3.24		
1100			4.13	3.35	3.28		
1110			4.18	3.40	3.32	3.41	
1120			4.22	3.44	3.37	3.45	
1130		5.82	4.27	3.48	3.41	3.48	
1140		5.88	4.31	3.53	3.45	3.52	3.74
1150	9.10	5.93	4.36	3.57	3.49	3.55	3.77
1160	9.16	5.99	4.41	3.62	3.53	3.58	3.80
1170	9.22	6.04	4.45	3.66	3.57	3.62	3.83
1180	9.27	6.10	4.50	3.71	3.61	3.65	3.86
1190	9.33	6.15	4.54	3.75	3.65	3.69	3.89
1200	9.39	6.21	4.59	3.80	3.69	3.72	3.92
1210	9.45	6.26	4.64	3.84	3.73	3.76	3.95
1220	9.51	6.32	4.68	3.89	3.77	3.79	3.98
1230	9.57	6.37	4.73	3.93	3.81	3.82	4.01
1240	9.62	6.43	4.78	3.97	3.85	3.86	4.03
1250	9.68	6.48	4.82	4.02	3.89	3.89	4.06
1260	9.74	6.54	4.87	4.06	3.93	3.93	4.09
1270	9.80	6.59	4.91	4.11	3.97	3.96	4.12
1280	9.86	6.65	4.96	4.15	4.02	4.00	4.15
1290	9.92	6.70	5.01	4.20	4.06	4.03	4.18
1300	9.97	6.76	5.05	4.24	4.10	4.07	4.21
1310	10.03	6.81	5.10	4.29	4.14	4.10	4.24
1320	10.09	6.87	5.14	4.33	4.18	4.13	4.27
1330	10.15	6.92	5.19	4.37	4.22	4.17	4.30
1340	10.21	6.97	5.24	4.42	4.26	4.20	4.33

TABLE 102 b. Temperature-dependent equations

$\kappa = a + bT$ (ohm^{-1} cm^{-1})

Comp. (mol % LiF)	$a \cdot 10^1$	$b \cdot 10^3$	Stand. dev. [87]
0.0	3.884	2.940	0.0179
20.0	−3.994	3.434	0.0253
35.0	−11.87	4.064	0.0390
50.0	−15.42	4.448	0.0348
70.0	−9.417	4.610	0.0280
85.0	−3.625	5.475	0.0310
100.0	23.95	5.830	0.0500

Reference: [87]. Data reported in equation form.

TABLE 103 a. KF-LiF: Density

Numerical values (gcm^{-3})

Mol percent LiF

T	100.0	85.0	70.0	50.0	35.0	20.0	0.0
980					1.909		
1000					1.897		
1020					1.885		
1040					1.873		
1060					1.862		
1080					1.850	1.870	
1100					1.838	1.858	
1120		1.756	1.721	1.806	1.826	1.847	
1140	1.695	1.746	1.711	1.796	1.815	1.835	1.844
1160	1.689	1.737	1.701	1.785	1.803	1.824	1.831
1180	1.682	1.728	1.692	1.774	1.791	1.813	1.819
1200	1.675	1.718	1.682	1.764	1.779	1.801	1.806
1220	1.669	1.709	1.672	1.753	1.768	1.790	1.794
1240	1.662	1.700	1.662	1.742	1.756	1.779	1.781
1260	1.656	1.690	1.652	1.731	1.744	1.767	1.769
1280	1.649	1.681	1.642	1.721	1.732	1.756	1.756
1300	1.642	1.672	1.632	1.710	1.721	1.745	1.744
1320	1.636	1.662	1.623	1.699	1.709	1.733	1.731
1340	1.629	1.653	1.613	1.688	1.697	1.722	1.719

TABLE 103 b. Temperature-dependent equations

$\rho = a + bT$ (gcm^{-3})

Comp. (mol % LiF)	a	$b \cdot 10^4$	Stand. dev. [98]
0.0	2.555	−6.241	0.00276
20.0	2.483	−5.680	0.00690
35.0	2.484	−5.872	0.00596
50.0	2.407	−5.362	0.00357
70.0	2.273	−4.927	0.0106
85.0	2.278	−4.663	0.00610
100.0	2.074	−3.321	0.00705

Reference: [98]. Data reported in equation form.

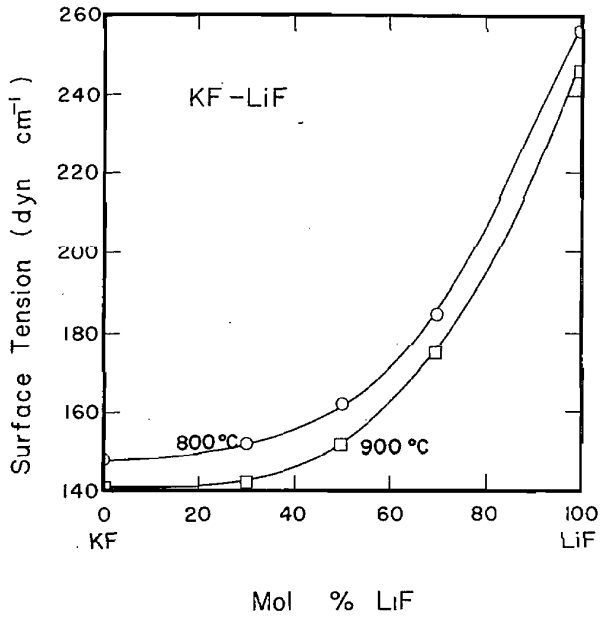

FIGURE 27. Isotherms [89] (°C) of surface tension against molar composition for the system KF-LiF.

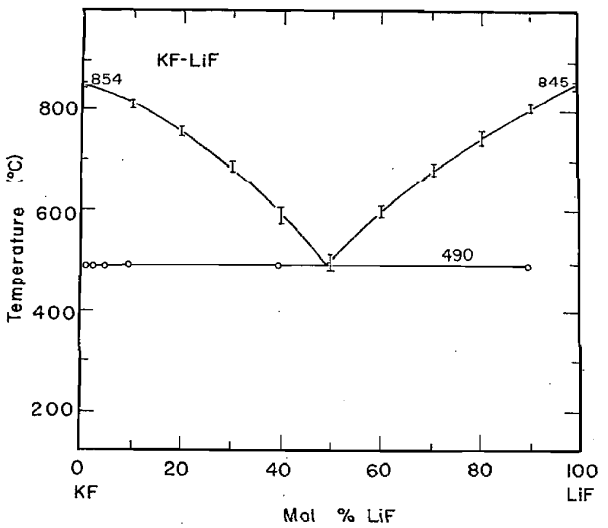

FIGURE 28. Temperature-composition phase diagram for KF-LiF.
A. G. Bergman and N. A. Bychkova-Shul'ga, Zh. Neorg. Khim. **2**, 179 (1957). [J. Inorg. Chem. USSR, **2**, No. 1, 276 (1957)].
E. Akrust, B. Bjorge, H. Flood, and T. Forland, Ann. N.Y. Acad. Sci., **79**, 830 (1960).

KF-NaF

Electrical Conductance

The recommended values in table 107 are based on the work of Meaker, Porter, and Kesterke (classical ac technique) [87].

TABLE 104 A. Investigations critically re-examined

Ref.	NaF (mol %)	Temp. range (T)
14	0–100	1023–1323
87	0–100	1043–1343

TABLE 104 B. Comparisons with previous recommendations

Ref	Recommended value		NaF (mol %)	% Departure			
	Vol.	Page		% (min)	(T)	% (max)	(T)
14	1	3	100	−8.8	(1323)	−18.8	(1273)
87	1	3	100	5.5	(1310)	8.3	(1360)
14	4.1	60	100	−14.1	(1323)	−15.7	(1313)
14	4.1	60	80	−14.3	(1273)	−18.1	(1223)
14	4.1	60	60	−15.0	(1273)	−23.9	(1223)
14	4.1	60	40	−6.5	(1323)	−22.8	(1073)
14	4.1	60	0	−18.9	(1273)	−31.2	(1153)
14	1	3	0	−16.0	(1273)	−28.2	(1153)
87	1	3	0	3.5	(1280)	4.5	(1140)

TABLE 104 C. Cell materials and calibration

Cell material	Electrodes	Frequency range (Hz)	Calibration
Pt crucible [14]	Pt crucible and Pt disc [14]	20–20,000 measurements at 10,000 [87]	KCl solution at 18° C [14]
Capillary cell consisting of two boron nitride cylinders encased in a graphite jacket [87]	Mo [87]		

Comment: Batashev [14] reported an accuracy of 2–3 percent for conductivity measurements. Remarks concerning reference [87] are discussed under the system CaF_2-LiF.

Density

The recommended values in table 108 are based on the work of Porter and Meaker (Archimedean method) [98].

TABLE 105 A. Investigations critically re-examined

Ref.	NaF (mol %)	Temp. range (T)
89	40 (eutectic, graphical)	1023–1153
87	0–100 (graphical)	1273
98	0–100	1043–1353

TABLE 105 B. Comparisons with previous recommendations

Ref.	Recommended value		NaF (mol %)	% Departure			
	Vol.	Page		% (min)	(T)	% (max)	(T)
98	1	3	100	−2.2	(1280)	−2.5	(1340)
98	1	3	0	−3.1	(1140–1280)		

TABLE 105 C. Cell materials and calibration

Cell material	Calibration
W, Mo, or Ni bob suspended by W or Mo wire, melt contained in Mo crucible [89]	Molten KCl [87, **98**]
Mo plummet connected to quartz spring by Mo wire, melt contained in graphite crucible [87, **98**]	

Comment: Remarks concerning reference [98] are under the system CaF_2-LiF. Density values were reported in the form of linear temperature equations with standard deviations in the range: 2.30×10^{-3} gcm^{-3} (80 mol % NaF) to 18.7×10^{-3} (12 mol % NaF).

Surface Tension

The recommended values in figure 29 are based on the work of Mellors and Senderoff (maximum bubble pressure method) [89].

TABLE 106 A. Investigations critically re-examined

Ref.	NaF (mol %)	Temp. range (T)
89	40 (eutectic, graphical)	973–1198

Comment: Remarks concerning reference [89] are under the system KF-LiF.

Melt Preparation and Purification

Batashev [14] dehydrated sodium and potassium fluoride (obtained from Kahlbaum) by melting the salts in a platinum cup. Analysis of KF gave the results: K, 67.27 percent (theoretical 67.30%) and F, 32.51 percent (32.70); and results of NaF showed: Na, 54.63 percent (54.76) and F, 44.99 percent (45.24).

Salts in reference [89] were ACS grade (obtained from Harshaw Chemical Company).

The melt preparation procedure used by Porter et al. [87, 98] is discussed under the system CaF_2-LiF.

TABLE 107a. KF-NaF: Electrical conductance

Specific conductance: Numerical values (ohm^{-1} cm^{-1})

Mol Percent NaF

T	100.0	80.0	60.0	40.0	25.0	12.0	0.0
1050				3.21			
1060				3.25			
1070				3.28			
1080				3.32	3.41		
1090				3.36	3.45	3.45	
1100				3.39	3.49	3.48	
1110			3.76	3.43	3.53	3.52	
1120			3.79	3.46	3.57	3.55	
1130			3.83	3.50	3.61	3.59	
1140			3.86	3.54	3.65	3.62	3.74
1150			3.90	3.57	3.69	3.66	3.77
1160			3.93	3.61	3.73	3.69	3.80
1170			3.97	3.64	3.76	3.73	3.83
1180			4.00	3.68	3.80	3.76	3.86
1190			4.04	3.71	3.84	3.80	3.89
1200			4.07	3.75	3.88	3.83	3.92
1210			4.11	3.79	3.92	3.87	3.95
1220			4.14	3.82	3.96	3.91	3.98
1230		4.39	4.18	3.86	4.00	3.94	4.01
1240		4.42	4.21	3.89	4.04	3.98	4.03
1250		4.46	4.25	3.93	4.08	4.01	4.06
1260		4.49	4.28	3.96	4.12	4.05	4.09
1270		4.52	4.32	4.00	4.16	4.08	4.12
1280		4.56	4.35	4.04	4.20	4.12	4.15
1290		4.59	4.39	4.07	4.24	4.15	4.18
1300		4.63	4.42	4.11	4.28	4.19	4.21
1310	5.33	4.66	4.46	4.14	4.32	4.22	4.24
1320	5.39	4.69	4.49	4.18	4.36	4.26	4.27
1330	5.44	4.73	4.53	4.22	4.40	4.29	4.30
1340	5.50	4.76	4.56	4.25	4.44	4.33	4.33

TABLE 107 b. Temperature-dependent equations

$\kappa = a + bT$ (ohm^{-1} cm^{-1})

Comp. (mol % NaF)	$a \cdot 10^1$	$b \cdot 10^3$	Stand. dev. [87]
0.0	3.884	2.940	0.0179
12.0	−3.959	3.525	0.0253
25.0	−8.667	3.958	0.0100
40.0	−5.467	3.580	0.0420
60.0	−1.282	3.500	0.0226
80.0	1.797	3.420	0.0280
100.0	−20.60	5.640	0.0660

Reference: [87]. Data reported in equation form.

TABLE 108 a. KF-NaF: Density

Numerical values (gcm^{-3})

Mol percent NaF

T	100.0	80.0	60.0	40.0	25.0	12.0	0.0
1050				1.938			
1065				1.929	1.810		
1080				1.920	1.806		
1095				1.911	1.802	1.756	
1110				1.902	1.797	1.755	
1125			1.895	1.893	1.793	1.753	
1140			1.887	1.884	1.789	1.752	1.844
1155			1.878	1.875	1.784	1.750	1.834
1170			1.870	1.866	1.780	1.749	1.825
1185			1.862	1.857	1.776	1.747	1.815
1200		1.896	1.853	1.848	1.772	1.746	1.806
1215		1.887	1.845	1.839	1.767	1.744	1.797
1230		1.878	1.836	1.830	1.763	1.743	1.787
1245		1.869	1.828	1.821	1.759	1.741	1.778
1260		1.860	1.819	1.812	1.755	1.740	1.769
1275	1.898	1.852	1.811	1.803	1.750	1.738	1.759
1290	1.889	1.843	1.802	1.794	1.746	1.737	1.750
1305	1.879	1.834	1.794	1.785	1.742	1.735	1.741
1320	1.870	1.825	1.785	1.776	1.737	1.734	1.731
1335	1.861	1.816	1.777	1.767	1.733	1.732	1.722
1350	1.852	1.807	1.768	1.758	1.729	1.731	1.712

TABLE 108 b. Temperature-dependent equations

$\rho = a + bT$ (gcm^{-3})

Comp. (mol % NaF)	a	$b \cdot 10^4$	Stand. deviation [98]
0.0	2.555	−6.241	0.00276
12.0	1.867	−1.011	0.0187
25.0	2.114	−2.853	0.0145
40.0	2.568	6.000	0.0130
60.0	2.530	−5.641	0.00279
80.0	2.601	−5.878	0.00230
100.0	2.682	−6.151	0.00239

Reference: [98]. Data reported in equation form. Two-dimensional statistical analysis was unsuccessful.

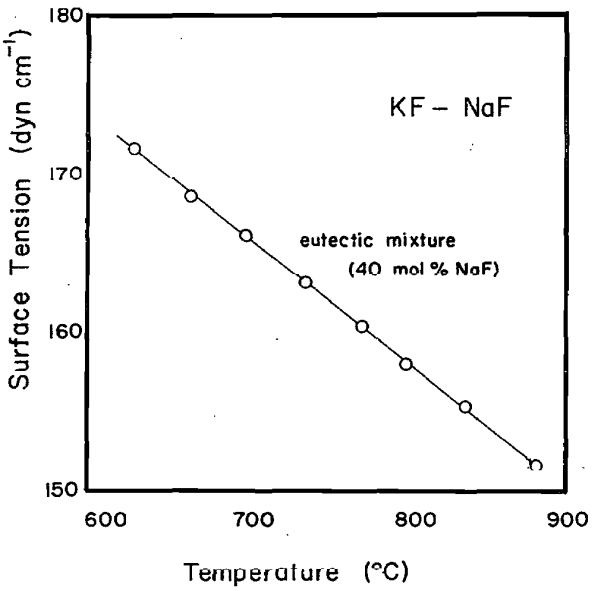

FIGURE 29. Plot [89] of surface tension against temperature for the system KF-NaF.

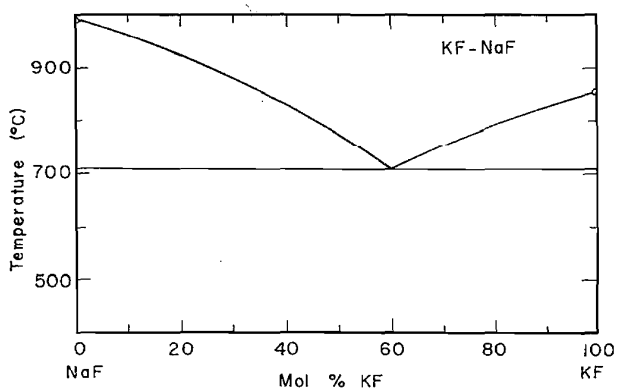

FIGURE 30. Temperature-composition phase diagram for KF-NaF. A. G. Bergman and E. P. Dergunov, "Fusion Diagram of LiF-KF-NaF," Compt. Rend. Acad. Sci. USSR. **31**, 753–54 (1941).

KF-SmF_3

Electrical Conductance

The recommended values in table 111 are based on the work of Meaker, Porter, and Kesterke (classical ac technique) [87].

TABLE 109 A. Investigations critically re-examined

Ref.	SmF_3 (mol %)	Temp. range (T)
87	0, 10.0, 20.0, 30.0, 40.0, 50.0	1063–1343

TABLE 109 B. Comparisons with previous recommendations

Ref.	Recommended value		SmF_3 (mol %)	% Departure			
	Vol.	Page		% (min)	(T)	% (max)	(T)
87	1	3	0	3.5	(1280)	4.5	(1140)

TABLE 109 C. Cell materials and calibration

Cell material	Electrodes	Frequency range (Hz)
Capillary cell consisting of two boron nitride cylinders encased in a graphite jacket [87]	Mo [87]	20–20,000 measurements at 10,000 [87]

Density

The recommended values in table 112 are based on the work of Meaker, Porter, and Kesterke (Archimedean method) [87].

TABLE 110 A. Investigations critically re-examined

Ref.	SmF_3 (mol %)	Temp. range (T)
87	10.0, 20.0, 30.0, 40.0, 50.0	1100–1343

TABLE 110 B. Cell materials and calibration

Cell material	Calibration
Mo plummet connected to a quartz spring by a Mo wire, melt contained in a graphite crucible [87]	Molten KCl [87]

Melt Preparation and Purification

Reagent-grade chemicals were used in references [87] and [98]. After vacuum drying at 400 °C the salts were cooled and combined in the correct proportions. The salts were then placed in graphite crucibles and heated under vacuum (50 μm Hg) to 600 °C. For density and conductance measurements the mixtures were melted in an atmosphere of helium in a controlled-atmosphere chamber. Melt compositions were confirmed by analysis after density measurements.

TABLE 111 b. Temperature-dependent equations

$\kappa = a + bT$ (ohm^{-1} cm^{-1})

Comp. (mol % SmF)	a	$b \cdot 10^3$	Stand. deviation [87]
0.0	0.388	2.940	0.0179
10.0	−1.798	3.953	0.0155
20.0	−1.697	3.226	0.0067
30.0	−1.523	2.736	0.0138
40.0	−2.293	3.196	0.0078
50.0	−2.771	3.550	0.0053

Reference: [87]. Data reported in equation form.

TABLE 111 a. KF-SmF_3: Electrical conductance

Specific conductance: Numerical values (ohm^{-1} cm^{-1})

Mol percent SmF_3

T	50.0	40.0	30.0	20.0	10.0	0.0
1070					2.43	
1080					2.47	
1090					2.51	
1100				1.85	2.55	
1110				1.88	2.59	
1120				1.92	2.63	
1130		1.32		1.95	2.67	
1140		1.35		1.98	2.71	3.74
1150		1.38		2.01	2.75	3.77
1160		1.41		2.05	2.79	3.80
1170		1.45		2.08	2.83	3.83
1180		1.48		2.11	2.87	3.86
1190		1.51	1.73	2.14	2.91	3.89
1200		1.54	1.76	2.17	2.95	3.92
1210		1.57	1.79	2.21	2.99	3.95
1220		1.61	1.81	2.24	3.02	3.98
1230		1.64	1.84	2.27	3.06	4.01
1240		1.67	1.87	2.30	3.10	4.03
1250	1.67	1.70	1.90	2.34	3.14	4.06
1260	1.70	1.73	1.92	2.37	3.18	4.09
1270	1.74	1.77	1.95	2.40	3.22	4.12
1280	1.77	1.80	1.98	2.43	3.26	4.15
1290	1.81	1.83	2.01	2.46	3.30	4.18
1300	1.84	1.86	2.03	2.50	3.34	4.21
1310	1.88	1.89	2.06	2.53	3.38	4.24
1320	1.92	1.93	2.09	2.56	3.42	4.27
1330	1.95	1.96	2.12	2.59	3.46	4.30
1340	1.99	1.99	2.14	2.63	3.50	4.33

TABLE 112 a. KF–SmF_3: Density

Numerical values (gcm^{-3})

Mol percent SmF_3

T	50.0	40.0	30.0	20.0	10.0	0.0
1100				2.678	2.286	
1110				2.670	2.280	
1120				2.663	2.273	
1130		3.445	3.051	2.655	2.266	
1140		3.437	3.043	2.647	2.259	1.844
1150		3.428	3.034	2.640	2.252	1.837
1160		3.419	3.025	2.632	2.245	1.831
1170		3.411	3.017	2.624	2.238	1.825
1180		3.402	3.008	2.617	2.232	1.819
1190		3.394	3.000	2.609	2.225	1.812
1200		3.385	2.991	2.602	2.218	1.806
1210		3.377	2.982	2.594	2.211	1.800
1220		3.368	2.974	2.586	2.204	1.794
1230	3.838	3.359	2.965	2.579	2.197	1.787
1240	3.831	3.351	2.956	2.571	2.191	1.781
1250	3.825	3.342	2.948	2.564	2.184	1.775
1260	3.818	3.334	2.939	2.556	2.177	1.769
1270	3.812	3.325	2.931	2.548	2.170	1.762
1280	3.805	3.316	2.922	2.541	2.163	1.756
1290	3.799	3.308	2.913	2.533	2.156	1.750
1300	3.792	3.299	2.905	2.526	2.150	1.744
1310	3.786	3.291	2.896	2.518	2.143	1.737
1320	3.779	3.282	2.888	2.510	2.136	1.731
1330	3.773	3.274	2.879	2.503	2.129	1.725
1340	3.766	3.265	2.870	2.495	2.122	1.719

TABLE 112 b. Temperature-dependent equations

$\rho = a + bT$ (gcm^{-3})

Comp. (mol % SmF_3)	a	$b \cdot 10^4$	Stand. deviation [87, 98]
0.0	2.555	−6.241	0.00276
10.0	3.038	−6.836	0.0028
20.0	3.515	−7.612	0.0046
30.0	4.024	−8.605	0.0028
40.0	4.414	−8.576	0.0047
50.0	4.636	−6.493	0.0044

References: [87] and [98] (for KF). Data reported in equation form.

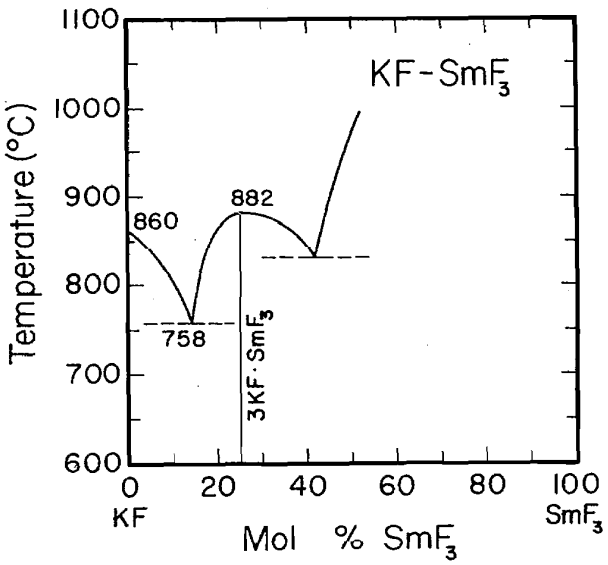

FIGURE 31. Temperature-composition phase diagram for KF-SmF_3. E. P. Dergunov, Dokl. Akad. Nauk SSSR, **85** [5] 1027 (1952).

KF-ThF_4

Electrical Conductance

The recommended values in table 115 are based on the work of Meaker, Porter, and Kesterke (classical ac technique) [**87**].

TABLE 113 A. Investigations critically re-examined

Ref.	ThF_4 (mol %)	Temp. range (T)
87	0.0, 7.1, 13.7, 19.7, 27.5	1103–1343

TABLE 113 B. Comparisons with previous recommendations

Ref.	Recommended value		ThF_4 (mol %)	% Departure			
	Vol.	Page		% (min)	(T)	% (max)	(T)
87	1	3	0	3.5	(1280)	4.5	(1140)

TABLE 113 C. Cell materials and calibration

Cell material	Electrodes	Frequency range (Hz)
Capillary cell consisting of two boron nitride cylinders encased in a graphite jacket [87]	Mo [87]	20–20,000 measurements at 10,000 [87]

Comment: The specific conductance values measured in reference [87] were reported reproducible to ±1 percent. The precision of the measurements was ±3 percent. The measured resistance was found to be independent of frequency over the range 20 to 20,000 hertz.

Density

The recommended values in table 116 are based on the work of Meaker and Porter (Archimedean method) [**98**].

TABLE 114 A. Investigations critically re-examined

Ref.	ThF_4 (mol %)	Temp. range (T)
87	0–28 (graphical)	1273
98	0.0, 7.1, 13.7, 19.7, 27.5	1088–1353

TABLE 114 B. Comparisons with previous recommendations

Ref.	Recommended value		ThF_4 (mol %)	% Departure			
	Vol.	Page		% (min)	(T)	% (max)	(T)
98	1	3	0	−3.1	(1140–1280)		

TABLE 114 C. Cell materials and calibration

Cell material	Calibration
Mo plummet connected to a quartz spring by a Mo wire, melt contained in a graphite crucible [87, 98]	Molten KCl [87, 98]

Comment: Brief remarks concerning reference [98] are discussed under the system CaF_2–LiF.

Density values [98] were reported in the form of linear temperature-dependent equations with standard deviations in the range: 2.76×10^{-3} gcm^{-3} (0 mol % ThF_4) to 32.0×10^{-3} gcm^{-3} (7.1 mol % ThF_4).

TABLE 115 b. Temperature-dependent equations

$\kappa = a + bT$ (ohm^{-1} cm^{-1})

Comp. (mol % ThF_4)	a	$b\cdot10^3$	Stand. deviation [87]
0.0	0.388	2.940	0.0179
7.1	−0.962	3.284	0.0182
13.7	−1.099	2.952	0.0151
19.7	−1.474	2.783	0.00763
27.5	−1.718	2.668	0.00625

Reference: [87]. Data reported in equation form.

Melt Preparation and Purification

The procedure used by Porter et al. [87, 98] for the preparation of pure salts is discussed under the system CaF_2-LiF. Thorium tetrafluoride contained less than 0.1 weight-percent of metallic impurities.

TABLE 115 a. KF-ThF_4: Electrical conductance

Specific conductance: Numerical values (ohm^{-1} cm^{-1})

Mol percent ThF_4

T	27.5	19.7	13.7	7.1	0.0
1110				2.68	
1120				2.72	
1130	1.30			2.75	
1140	1.32			2.78	3.74
1150	1.35		2.30	2.81	3.77
1160	1.38		2.33	2.85	3.80
1170	1.40	1.78	2.35	2.88	3.83
1180	1.43	1.81	2.38	2.91	3.86
1190	1.46	1.84	2.41	2.95	3.89
1200	1.48	1.87	2.44	2.98	3.92
1210	1.51	1.89	2.47	3.01	3.95
1220	1.54	1.92	2.50	3.04	3.98
1230	1.56	1.95	2.53	3.08	4.01
1240	1.59	1.98	2.56	3.11	4.03
1250	1.62	2.00	2.59	3.14	4.06
1260	1.64	2.03	2.62	3.18	4.09
1270	1.67	2.06	2.65	3.21	4.12
1280	1.70	2.09	2.68	3.24	4.15
1290	1.72	2.12	2.71	3.27	4.18
1300	1.75	2.14	2.74	3.31	4.21
1310	1.78	2.17	2.77	3.34	4.24
1320	1.80	2.20	2.80	3.37	4.27
1330	1.83	2.23	2.83	3.41	4.30
1340	1.86	2.26	2.86	3.44	4.33

TABLE 116 a. KF-ThF_4: Density

Numerical values (gcm^{-3})

Mol percent ThF_4

T	27.5	19.7	13.7	7.1	0.0
1090			2.714		
1100			2.706	2.311	
1110			2.697	2.301	
1120	3.297		2.689	2.291	
1130	3.289		2.680	2.281	
1140	3.281		2.672	2.271	1.844
1150	3.272		2.664	2.262	1.837
1160	3.264	2.945	2.655	2.252	1.831
1170	3.256	2.936	2.647	2.242	1.825
1180	3.247	2.927	2.639	2.232	1.819
1190	3.239	2.918	2.630	2.223	1.812
1200	3.231	2.910	2.622	2.213	1.806
1210	3.222	2.901	2.614	2.203	1.800
1220	3.214	2.892	2.605	2.193	1.794
1230	3.206	2.883	2.597	2.184	1.787
1240	3.197	2.874	2.588	2.174	1.781
1250	3.189	2.866	2.580	2.164	1.775
1260	3.181	2.857	2.572	2.154	1.769
1270	3.172	2.848	2.563	2.144	1.762
1280	3.164	2.839	2.555	2.135	1.756
1290	3.156	2.831	2.547	2.125	1.750
1300	3.147	2.822	2.538	2.115	1.744
1310	3.139	2.813	2.530	2.105	1.737
1320	3.131	2.804	2.522	2.096	1.731
1330	3.122	2.795	2.513	2.086	1.725
1340	3.114	2.787	2.505	2.076	1.719
1350	3.106	2.778	2.497	2.066	1.712

TABLE 116 b. Temperature-dependent equations

$\rho = a + bT$ (gcm^{-3})

Comp. (mol % ThF_4)	a	$b \cdot 10^3$	Stand. dev. [98]
0.0	2.555	−0.6241	0.00276
7.1	3.385	−0.9768	0.032
13.7	3.625	0.8359	0.00628
19.7	3.963	−0.8779	0.00913
27.5	4.231	−0.8335	0.00860

Reference: [98]. Data reported in equation form. Two-dimensional statistical analysis was unsuccessful.

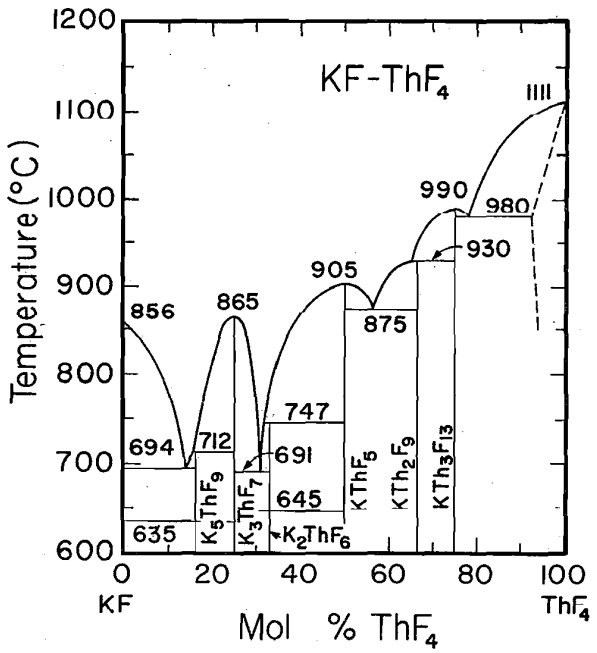

FIGURE 32. Temperature-composition phase diagram for KF-ThF_4. W. J. Asker, E. K. Segnit, and A. W. Wylie, J. Chem. Soc. (London), pg. 4471, Nov. 1952.

KF-UF_4

Electrical Conductance

The recommended values in table 119 are based on the work of Meaker, Porter, and Kesterke (classical ac technique) [87].

TABLE 117 A. Investigations critically re-examined

Ref.	UF_4 (mol %)	Temp. range (T)
87	0, 7.5, 20, 30, 40, 50	1103–1343

TABLE 117 B. Comparisons with previous recommendations

Ref.	Recommended value		UF_4 (mol %)	% Departure			
	Vol.	Page		% (min)	(T)	% (max)	(T)
87	1	3	0	3.5	(1280)	4.5	(1140)

TABLE 117 C. Cell materials and calibration

Cell material	Electrodes	Frequency range (Hz)
Capillary cell consisting of two boron nitride cylinders encased in a graphite jacket [87]	Mo [87]	20–20,000 measurements at 10,000 [87]

Comment: The specific conductance values measured in reference [87] were reported reproducible to ±1 percent. The precision of the measurements was ±3 percent. The measured resistance was found to be independent of frequency over the range 20 to 20,000 hertz.

Density

The recommended values in table 120 are based on the work of Meaker and Porter (Archimedean method) [98].

TABLE 118 A. Investigations critically re-examined

Ref.	UF_4 (mol %)	Temp. range (T)
87	40–100 (graphical	1273
98	0–60	1103–1353

TABLE 118 B. Comparisons with previous recommendations

Ref.	Recommended value		UF_4 (mol %)	% Departure			
	Vol.	Page		% (min)	(T)	% (max)	(T)
98	1	3	0	−3.1	(1140–1280)		

TABLE 118 C. Cell materials and calibration

Cell material	Calibration
Mo plummet connected to a quartz spring by a Mo wire, melt contained in a graphite crucible [87, 98]	Molten KCl [87, 98]

Comment: Remarks concerning reference [98] are given under the system CaF_2–LiF.

Density results [98] were reported in the form of linear temperature-dependent equations with standard deviations in the range: 2.76×10^{-3} gcm^{-3} (0 mol % UF_4) to 42.9×10^{-3} gcm^{-3} (50 mol % UF_4).

TABLE 119 b. Temperature-dependent equations

$\kappa = a + bT$ (ohm^{-1} cm^{-1})

Comp. (mol % UF_4)	a	$b\cdot10^3$	Stand. dev. [87]
0.0	0.388	2.940	0.0179
7.5	−0.448	2.840	0.0134
20.0	−1.129	2.534	0.0121
30.0	−1.355	2.340	0.0166
40.0	−0.870	1.856	0.00913
50.0	−1.248	2.330	0.0206

Reference: [87]. Data reported in equation form.

Melt Preparation and Purification

Reagent-grade chemicals were used in references [87] and [98]. After vacuum drying at 400 °C the salts were cooled and combined in the correct proportions. The salts were then placed in graphite crucibles and heated under vacuum (50 microns) to 600 °C. For density and conductance measurements the mixtures were melted in an atmosphere of helium in a controlled-atmosphere chamber. Melt compositions were confirmed by analyses after density measurements.

TABLE 119 a. KF–UF_4: Electrical conductance

Specific conductance: Numerical values (ohm^{-1} cm^{-1})

Mol percent UF_4

T	50.0	40.0	30.0	20.0	7.5	0.0
1110	1.34					
1120	1.36					
1130	1.38					
1140	1.41					3.74
1150	1.43					3.77
1160	1.45					3.80
1170	1.48				2.87	3.83
1180	1.50	1.32			2.90	3.86
1190	1.52	1.34			2.93	3.89
1200	1.55	1.36			2.96	3.92
1210	1.57	1.38	1.48		2.99	3.95
1220	1.59	1.39	1.50	1.96	3.02	3.98
1230	1.62	1.41	1.52	1.99	3.04	4.01
1240	1.64	1.43	1.55	2.01	3.07	4.03
1250	1.66	1.45	1.57	2.04	3.10	4.06
1260	1.69	1.47	1.59	2.06	3.13	4.09
1270	1.71	1.49	1.62	2.09	3.16	4.12
1280	1.73	1.51	1.64	2.11	3.19	4.15
1290	1.76	1.52	1.66	2.14	3.22	4.18
1300	1.78	1.54	1.69	2.17	3.24	4.21
1310	1.80	1.56	1.71	2.19	3.27	4.24
1320	1.83	1.58	1.73	2.22	3.30	4.27
1330	1.85	1.60	1.76	2.24	3.33	4.30
1340	1.87	1.62	1.78	2.27	3.36	4.33

TABLE 120 a. KF–UF_4: Density

Numerical values (gcm^{-3})

Mol percent UF_4

T	60.0	50.0	40.0	30.0	20.0	7.5	0.0
1110		4.535					
1120	5.044	4.522	3.979				
1130	5.034	4.510	3.968			2.299	
1140	5.024	4.497	3.957			2.289	1.844
1150	5.014	4.484	3.946			2.280	1.837
1160	5.004	4.471	3.935			2.270	1.831
1170	4.993	4.458	3.924			2.260	1.825
1180	4.983	4.445	3.913			2.251	1.819
1190	4.973	4.432	3.902			2.241	1.812
1200	4.963	4.419	3.891			2.232	1.806
1210	4.953	4.406	3.880			2.222	1.800
1220	4.943	4.393	3.869	3.385		2.212	1.794
1230	4.933	4.380	3.858	3.374	2.893	2.203	1.787
1240	4.923	4.367	3.847	3.364	2.887	2.193	1.781
1250	4.913	4.354	3.835	3.354	2.880	2.183	1.775
1260	4.903	4.341	3.824	3.344	2.874	2.174	1.769
1270	4.893	4.328	3.813	3.334	2.867	2.164	1.762
1280	4.882	4.315	3.802	3.324	2.861	2.154	1.756
1290	4.872	4.302	3.791	3.314	2.854	2.145	1.750
1300	4.862	4.289	3.780	3.304	2.848	2.135	1.744
1310	4.852	4.276	3.769	3.294	2.842	2.126	1.737
1320	4.842	4.263	3.758	3.283	2.835	2.116	1.731
1330	4.832	4.250	3.747	3.273	2.829	2.106	1.725
1340	4.822	4.237	3.736	3.263	2.822	2.097	1.719
1350	4.012	4.224	3.725	3.253	2.816	2.087	1.712

TABLE 120 b. Temperature-dependent equations

$\rho = a + bT$ (gcm^{-3})

Comp. (mol % UF_4)	a	$b \cdot 10_4$	Stand. dev. [98]
0.0	2.555	−6.241	0.00276
7.5	3.387	−9.629	0.0206
20.0	3.681	−6.407	0.00800
30.0	4.618	−10.110	0.00398
40.0	5.218	−11.060	0.0254
50.0	5.974	−12.960	0.0429
60.0	6.174	−10.090	0.0201

Reference: [98]. Data reported in equation form.

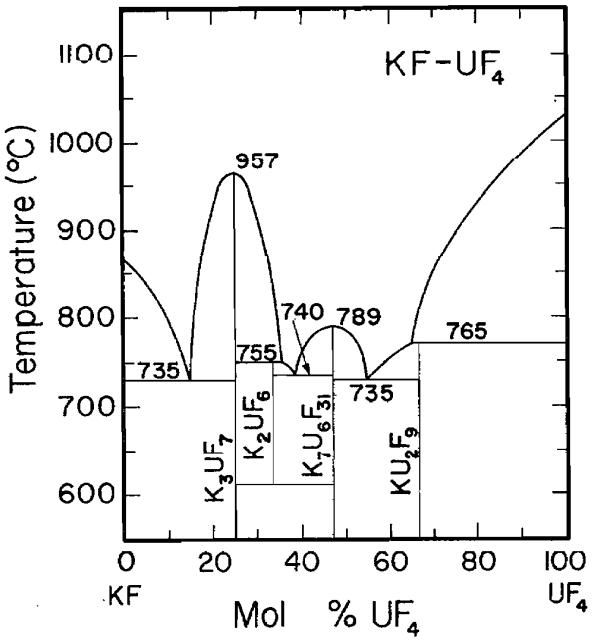

FIGURE 33. Temperature-composition phase diagram for KF-UF_4. R. E. Thoma, H. Insley, B. S. Landau, H. A. Friedman, and W. R. Grimes, J. Amer. Ceram. Soc. **41**, 538 (1958).

KF-YF_3

Electrical Conductance

The recommended values in table 123 are based on the work of Meaker, Porter, and Kesterke (classical ac technique) [87].

TABLE 121 A. Investigations critically re-examined

Ref.	YF_3 (mol %)	Temp. range (T)
87	0, 7.5, 17.5, 30.0, 42.5, 52.5	1123–1343

TABLE 121 B. Comparisons with previous recommendations

Ref.	Recommended value		YF_3 (mol %)	% Departure			
	Vol.	Page		% (min)	(T)	% (max)	(T)
07	1	3	0	3.5	(1280)	4.5	(1140)

TABLE 121 C. Cell materials and calibration

Cell material	Electrodes	Frequency range (Hz)
Capillary cell consisting of two boron nitride cylinders encased in a graphite jacket [87]	Mo [07]	20–20,000 measurements at 10,000 [87]

Comment: The specific conductance values measured in reference [87] were reported reproducible to ±1 percent. The precision of the measurements was ±3 percent. The measured resistance was found to be independent of frequency over the range 20 to 20,000 hertz.

Density

The recommended values in tables 124, 125 are based on the work of Meaker and Porter (Archimedean method) [98].

TABLE 122 A. Investigations critically re-examined

Ref.	YF_3 (mol %)	Temp. range (T)
87	0–53 (graphical)	1273
98	0, 7.5, 17.5, 30.0, 42.5, 52.5	1073–1353

TABLE 122 B. Comparisons with previous recommendations

Ref.	Recommended value		YF_3 (mol %)	% Departure			
	Vol.	Page		% (min)	(T)	% (max)	(T)
98	1	3	0	−3.1	(1140–1280)		

TABLE 122 C. Cell materials and calibration

Cell material	Calibration
Mo plummet connected to a quartz spring by a Mo wire, melt contained in a graphite crucible [87, 98]	Molten KCl [87, 98]]

Comment: Brief remarks concerning reference [98] are given under the system CaF_2–LiF.

Density values [98] were reported in the form of linear temperature-dependent equations with standard deviations in the range: 2.13×10^{-3} gcm^{-3} (7.5 mol % YF_3) to 6.29×10^{-3} gcm^{-3} (52.5 mol % YF_3).

Melt Preparation and Purification

The method used by Porter et al. [87, 98] is described under the system CaF_2-LiF. Yttrium fluoride contained less than 0.1 weight-percent of metallic impurities.

TABLE 123 a. KF-YF_3: Electrical conductance

Specific conductance: Numerical values (ohm^{-1} cm^{-1})

	Mol percent YF_3					
T	52.5	42.5	30.0	17.5	7.5	0.0
1130					2.88	
1140					2.91	3.74
1150	1.20				2.94	3.77
1160	1.24				2.96	3.80
1170	1.28				2.99	3.83
1180	1.31				3.02	3.86
1190	1.35				3.05	3.89
1200	1.39				3.08	3.92
1210	1.43			2.27	3.10	3.95
1220	1.46			2.30	3.13	3.98
1230	1.50		1.51	2.33	3.16	4.01
1240	1.54	1.42	1.54	2.36	3.19	4.03
1250	1.57	1.45	1.56	2.39	3.22	4.06
1260	1.61	1.48	1.59	2.42	3.24	4.09
1270	1.65	1.51	1.61	2.45	3.27	4.12
1280	1.69	1.54	1.64	2.48	3.30	4.15
1290	1.72	1.57	1.67	2.51	3.33	4.18
1300	1.76	1.60	1.69	2.54	3.36	4.21
1310	1.80	1.62	1.72	2.57	3.38	4.24
1320	1.83	1.65	1.74	2.60	3.41	4.27
1330	1.87	1.68	1.77	2.63	3.44	4.30
1340	1.91	1.71	1.79	2.66	3.47	4.33

TABLE 123 b. Temperature-dependent equations

$\kappa = a + bT$ (ohm^{-1} cm^{-1})

Comp. (mol % YF_3)	a	$b\cdot10^3$	Stand. deviation [87]
0.0	0.388	2.940	0.0179
7.5	−0.291	2.805	0.0325
17.5	−1.362	3.000	0.0223
30.0	−1.633	2.557	0.02557
42.5	−2.096	2.839	0.0292
52.5	−3.070	3.715	0.0232

Reference: [87]. Data reported in equation form.

TABLE 124 a. KF-YF_3: Density

Numerical values (gcm^{-3})

Mol percent YF_3

T	50	45	40	35	30	25	20	15	10	5	0	43
1080										1.984		
1095									2.081	1.975		
1110									2.072	1.966		
1125									2.063	1.957		
1140								2.159	2.053	1.947	1.841	
1155								2.150	2.044	1.938	1.831	
1170	2.942							2.141	2.035	1.929	1.822	
1185	2.932	2.806					2.238	2.131	2.026	1.920	1.813	
1200	2.923	2.797					2.229	2.122	2.016	1.911	1.804	2.748
1215	2.913	2.787	2.666			2.327	2.219	2.113	2.007	1.901	1.795	2.738
1230	2.903	2.777	2.657	2.540	2.428	2.318	2.210	2.104	1.998	1.892	1.786	2.729
1245	2.893	2.768	2.647	2.531	2.418	2.308	2.201	2.094	1.989	1.883	1.777	2.719
1260	2.884	2.758	2.638	2.521	2.409	2.299	2.191	2.085	1.980	1.874	1.768	2.709
1275	2.874	2.748	2.628	2.512	2.399	2.289	2.182	2.076	1.970	1.865	1.759	2.700
1290	2.864	2.739	2.618	2.502	2.390	2.280	2.173	2.067	1.961	1.856	1.750	2.690
1305	2.855	2.729	2.609	2.493	2.380	2.271	2.163	2.057	1.952	1.847	1.741	2.681
1320	2.845	2.720	2.599	2.483	2.371	2.261	2.154	2.048	1.943	1.838	1.732	2.671
1335	2.835	2.710	2.590	2.474	2.362	2.252	2.145	2.039	1.934	1.829	1.723	2.661
1350	2.826	2.700	2.580	2.464	2.352	2.243	2.136	2.030	1.925	1.820	1.714	2.652

TABLE 124 b. Two-dimensional equation and statistical parameters

$\rho = a + bT + cC + dC^2 + eC^3 + fCT^2$ (gcm^{-3})

a	$b \cdot 10^4$	$c \cdot 10^3$	$d \cdot 10^4$	$e \cdot 10^7$	$f \cdot 10^{10}$	Max. percent departure	Stand. error of est.
5.44520	−6.90657	−4.49311	2.59050	−9.59873	3.48411	−0.43 (1343.2K, 82.5 mol % KF)	0.003

Reference: [98]. Data reported in equation form.
C = mol percent KF.

TABLE 125 a. KF-YF_3: Density

Numerical values (gcm^{-3})

Mol percent YF_3

T	52.5	42.5	30.0	17.5	7.5	0.0
1080					2.037	
1095					2.028	
1110					2.018	
1125					2.009	
1140					2.000	1.844
1155					1.990	1.834
1170	3.008			2.190	1.981	1.825
1185	2.998			1.182	1.971	1.815
1200	2.988	2.738		1.174	1.962	1.806
1215	2.978	2.728		2.165	1.952	1.797
1230	2.968	2.718	2.425	2.157	1.943	1.787
1245	2.959	2.708	2.416	2.149	1.934	1.778
1260	2.949	2.698	2.407	2.141	1.924	1.769
1275	2.939	2.688	2.398	2.133	1.915	1.759
1290	2.929	2.677	2.389	2.125	1.905	1.750
1305	2.919	2.667	2.380	2.117	1.896	1.741
1320	2.909	2.657	2.370	2.108	1.886	1.731
1335	2.900	2.647	2.361	2.100	1.877	1.722
1350	2.890	2.637	3.352	2.092	1.867	1.712

TABLE 125 b. Temperature-dependent equations

$\rho = a + bT$ (gcm^{-3})

Comp. (mol % YF_3)	a	$b \cdot 10^4$	Stand. dev. [98]
0.0	2.555	−6.241	0.00276
7.5	2.717	−6.293	0.00213
17.5	2.825	−5.429	0.00413
30.0	3.177	−6.110	0.00263
42.5	3.551	−6.772	0.00300
52.5	3.775	−6.558	0.00629

Reference: [98]. Data reported in equation form.

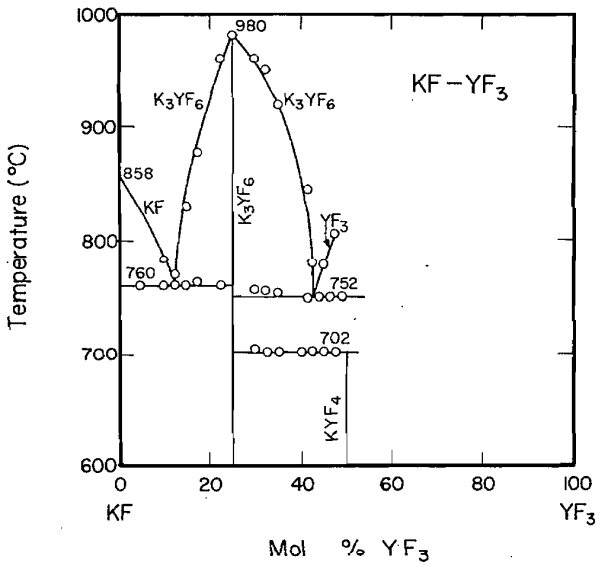

FIGURE 34. Temperature-composition phase diagram for KF-YF_3. G. A. Bukhalova and E. P. Babaeva, Russ. J. Inorg. Chem. **11**, 350 (1966).

$KF-ZrF_4$

Electrical Conductance

The recommended values in table 130 are based on the work of Sheiko (classical ac technique) [**107**].

TABLE 126 A. Investigations critically re-examined

Ref.	ZrF_4 (mol %)	Temp. range (T)
107	0–33.3	1233

TABLE 126 B. Comparisons with previous recommendations

Ref.	Recommended value		ZrF_4 (mol %)	% Departure			
	Vol.	Page		% (min)	(T)	% (max)	(T)
107	1	3	0	51.6	(1233)		

TABLE 126 C. Cell materials and electrodes

Cell material	Electrodes
Porcelain crucible [107]	Pt [107]

Density

The recommended values in table 131 are based on the work of Sheiko (Archimedean method) [107].

TABLE 127 A. Investigations critically re-examined

Ref.	ZrF_4 (mol %)	Temp. range (T)
107	0–33.3	1233

TABLE 127 B. Comparisons with previous recommendations

Ref.	Recommended value		ZrF_4 (mol %)	% Departure			
	Vol.	Page		% (min)	(T)	%(max)	(T)
107	1	3	0	−2.3	(1233)		

Comment: Sheiko [107] used a platinum sphere as the float and used a platinum cup to contain the melt.

Viscosity

The recommended values in table 132 are based on the work of Sheiko (oscillating sphere method) [107].

TABLE 128 A. Investigations critically re-examined

Ref.	ZrF_4 (mol %)	Temp. range (T)
107	0–33.3	1253

Comment: Sheiko [107] used a platinum sphere as the oscillating bob.

Surface Tension

The recommended values in table 133 are based on the work of Sheiko (maximum bubble pressure method) [107].

TABLE 129 A. Investigations critically re-examined

Ref.	ZrF_4 (mol %)	Temp. range (T)
107	0–33.3	1233

TABLE 129 B. Comparisons with previous recommendations

Ref.	Recommended value		ZrF_4 (mol %)	% Departure			
	Vol.	Page		% (min)	(T)	% (max)	(T)
107	1	3	0	0.4	(1233)		

TABLE 130. KF-ZrF_4: Electrical conductance

Specific conductance: Numerical values ($ohm^{-1}\ cm^{-1}$)

Mol percent ZrF_4

T	33.3	32.1	30.8	30.0	29.2	28.6	27.3	25.0	22.2	19.9	16.7	14.3	8.3	0
1233.2	2.61	2.68	2.81	2.96	3.05	3.14	3.37	3.81	3.94	4.28	4.67	4.84	5.30	5.86

Reference: [107]. Due to limited data the experimental values are given.

TABLE 131. $KF\text{-}ZrF_4$: Density

Numerical values (gcm^{-3})

Mol percent ZrF_4

T	33.3	32.1	30.8	29.2	27.3	25.0	22.2	18.8	14.3	8.3	0
1233.2	2.220	2.190	2.173	2.168	2.139	2.129	2.114	2.086	2.043	1.952	1.800

Reference: [107]. Due to limited data the experimental values are given.

TABLE 132. $KF\text{-}ZrF_4$: Viscosity

Numerical values (cp)

Mol percent ZrF_4

T	33.3	32.1	30.2	29.2	27.3	25.0	22.2	18.8	14.3	8.3	0
1253.2	2.28	2.24	2.22	2.19	2.18	2.15	2.01	1.91	1.79	1.69	1.59

Reference: [107]. Due to limited data the experimental values are given.

TABLE 133. $KF\text{-}ZrF_4$: Surface tension

Numerical values (dyn cm^{-1})

Mol percent ZrF_4

T	33.3	32.1	30.8	29.2	27.3	25.0	22.2	18.8	8.3	0
1233.3	93.2	98.4	99.7	102.8	104.5	109.6	120.0	125.9	133.3	135.7

Reference: [107]. Due to limited data the experimental values are given.

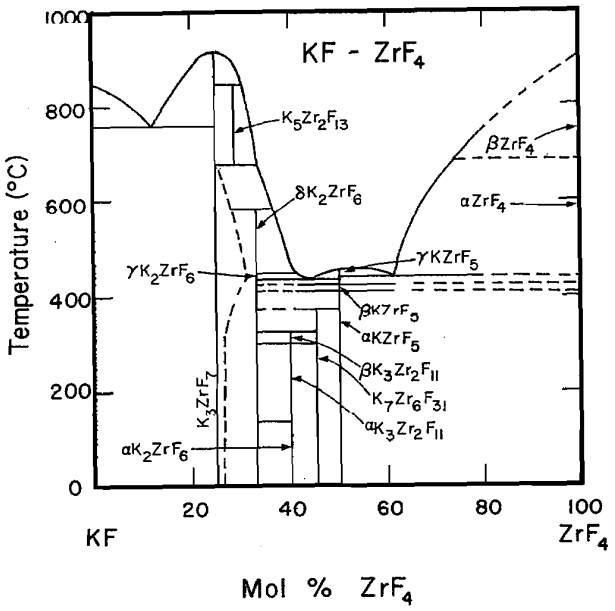

FIGURE 35. Temperature-composition phase diagram for KF-ZrF_4.
A. V. Novoselova, Yu. M. Korenev, and Yu. D. Simanov, Dokl. Akad. Nauk S.S.S.R., **139** [4], 893 (1961).
C. J. Barton, H. Insley, R. E. Metcalf, R. E. Thoma and W. R. Grimes, ORNL-2548, pg. 56 (1959).

LaF_3-LiF

Electrical Conductance

The recommended values in table 136 are based on the work of Meaker, Porter, and Kesterke (classical ac technique) [87].

TABLE 134 A. Investigations critically re-examined

Ref.	LiF (mol %)	Temp. range (*T*)
87	67.55–100	1143–1343

TABLE 134 B. Comparisons with previous recommendations

Ref.	Recommended value		LiF (mol %)	% Departure			
	Vol.	Page		% (min)	(*T*)	% (max)	(*T*)
87	1	2	100	5.1	(1150)	8.2	(1310)

TABLE 134 C. Cell materials and calibration

Cell material	Electrodes	Frequency range (Hz)
Capillary cell consisting of two boron nitride cylinders encased in a graphite jacket [87]	Mo [87]	20–20,000 measurements at 10,000 [87]

Comment: Brief remarks concerning reference [87] are discussed under the system CaF_2–LiF.

Density

The recommended values in table 137 are based on the work of Meaker and Porter (Archimedean method) [98].

TABLE 135 A. Investigations critically re-examined

Ref.	LiF (mol %)	Temp. range (*T*)
87	75–100 (graphical)	1273
98	75, 80, 85, 90, 95, 100	1103–1353

TABLE 135 B. Comparisons with previous recommendations

Ref.	Recommended value		LiF (mol %)	% Departure			
	Vol.	Page		% (min)	(*T*)	% (max)	(*T*)
98	1	2	100	−4.5	(1310)	−5.6	(1150)

TABLE 135 C. Cell materials and calibration

Cell material	Calibration
Mo plummet connected to a quartz spring by a Mo wire, melt contained in a graphite crucible [87, 98]	Molten KCl [87, 98]

Comment: Brief remarks concerning reference [98] are given under the system CaF_2–LiF.

Density values [98] were reported in the form of linear temperature-dependent equations with standard deviations in the range: 2.00×10^{-3} gcm^{-3} (75 mol % LiF) to 7.05×10^{-3} gcm^{-3} (100 mol % LiF).

Melt Preparation and Purification

The method of salt purification used by Porter et al. [87, 98] is described under the system CaF_2-LiF.

Lanthanum fluoride contained less than 0.1 weight-percent of metallic impurities.

TABLE 136 a. LaF_3-LiF: Electrical conductance

Specific conductance: Numerical values (ohm^{-1} cm^{-1})

Mol percent LiF

T	100.0	95.0	90.0	85.0	80.0	75.0	71.0	67.55
1150	9.10							
1160	9.16				6.22		4.98	
1170	9.22		7.47		6.27		5.06	
1180	9.27	8.45	7.54		6.32		5.15	
1190	9.33	8.51	7.60	7.08	6.37	5.51	5.23	
1200	9.39	8.56	7.66	7.13	6.41	5.57	5.32	
1210	9.45	8.62	7.73	7.18	6.46	5.63	5.40	
1220	9.51	8.67	7.79	7.23	6.51	5.69	5.49	
1230	9.57	8.73	7.85	7.28	6.56	5.75	5.57	
1240	9.62	8.78	7.92	7.33	6.60	5.81	5.66	
1250	9.68	8.84	7.98	7.38	6.65	5.87	5.74	
1260	9.74	8.90	8.04	7.42	6.70	5.94	5.83	5.43
1270	9.80	8.95	8.11	7.47	6.75	6.00	5.91	5.52
1280	9.86	9.01	8.17	7.52	6.79	6.06	6.00	5.60
1290	9.92	9.06	8.23	7.57	6.84	6.12	6.08	5.68
1300	9.97	9.12	8.30	7.62	6.89	6.18	6.17	5.76
1310	10.03	9.17	8.36	7.67	6.94	6.24	6.25	5.84
1320	10.90	9.23	8.42	7.72	6.98	6.30	6.34	5.92
1330	10.15	9.29	8.49	7.77	7.03	6.36	6.42	6.01
1340	10.21	9.34	8.55	7.82	7.08	6.42	6.51	6.09

TABLE 136 b. Temperature-dependent equations

$\kappa = a + bT$ (ohm^{-1} cm^{-1})

Comp. (mol % LiF)	a	$b \cdot 10^3$	Stand. deviation [87]
67.55	−4.872	8.179	0.0489
71.0	−4.898	8.513	0.0635
75.0	−1.775	6.119	0.0090
80.0	0.698	4.762	0.0405
85.0	1.255	4.896	0.0182
90.0	0.054	6.340	0.0423
95.0	1.884	5.565	0.0270
100.0	2.395	5.830	0.050

Reference: [87]. Data reported in equation form.

TABLE 137 a. LaF_3-LiF: Density

Numerical values (gcm^{-3})

Mol percent LiF

T	100.0	95.0	90.0	85.0	80.0	75.0
1110				2.761		
1120				2.754		
1130	1.699			2.748	3.004	3.177
1140	1.695	2.075		2.741	2.998	3.171
1150	1.692	2.071		2.734	2.991	3.166
1160	1.689	2.068		2.728	2.985	3.160
1170	1.685	2.064		2.721	2.978	3.155
1180	1.682	2.061	2.431	2.714	2.972	3.149
1190	1.679	2.057	2.428	2.708	2.965	3.144
1200	1.675	2.053	2.425	2.701	2.959	3.138
1210	1.672	2.050	2.422	2.694	2.952	3.133
1220	1.669	2.046	2.419	2.688	2.946	3.127
1230	1.666	2.042	2.415	2.681	2.939	3.122
1240	1.662	2.039	2.412	2.674	2.933	3.116
1250	1.659	2.035	2.409	2.668	2.926	3.111
1260	1.656	2.031	2.406	2.661	2.920	3.105
1270	1.652	2.028	2.403	2.654	2.913	3.100
1280	1.649	2.024	2.400	2.648	2.907	3.094
1290	1.646	2.020	2.397	2.641	2.900	2.089
1300	1.642	2.017	2.394	2.634	2.894	3.083
1310	1.639	2.013	2.391	2.628	2.887	3.078
1320	1.636	2.009	2.387	2.621	2.881	3.072
1330	1.632	2.006	2.384	2.614	2.874	3.067
1340	1.629	2.002	2.381	2.608	2.868	3.061
1350	1.626	1.999	2.378	2.601	2.861	3.056

TABLE 137 b. Temperature-dependent equations

$\rho = a + bT$ (gcm^{-3})

Comp. (mol % LiF)	a	$b \cdot 10^4$	Stand. dev. [98]
75.0	3.799	−5.507	0.00200
80.0	3.737	−6.486	0.00334
85.0	3.500	−6.658	0.00333
90.0	2.799	−3.118	0.00500
95.0	2.491	−3.648	0.00580
100.0	2.074	−3.321	0.00705

Reference: [98]. Data reported in equation form.

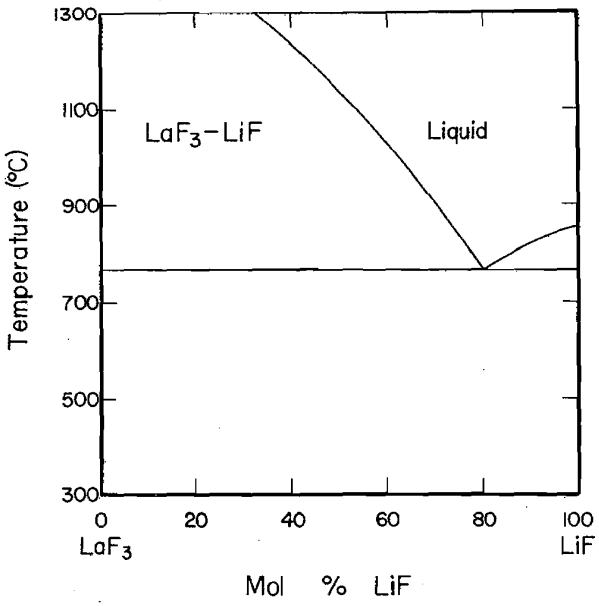

FIGURE 36. Temperature-composition phase diagram for LaF_3-LiF. R. E. Thoma, Progress in Science and Technology of the Rare Earths, Vol. 2, p. 110, Pergamon Press, N.Y. 1966.

LaF_3-NaF

Electrical Conductance

The recommended values in table 140 are based on the work of Meaker, Porter, and Kesterke (classical ac technique) [87].

TABLE 138 A. Investigations critically re-examined

Ref.	NaF (mol %)	Temp. range (*T*)
87	60, 70, 80, 90, 100	1053–1343

TABLE 138 B. Comparisons with previous recommendations

Ref.	Recommended value		NaF (mol %)	% Departure			
	Vol.	Page		% (min)	(*T*)	% (max)	(*T*)
87	1	3	0	5.0	(1300)	7.4	(1340)

TABLE 138 C. Cell materials and calibration

Cell material	Electrodes	Frequency range (Hz)
Capillary cell consisting of two boron nitride cylinders encased in a graphite jacket [87]	Mo [87]	20–20,000 measurements at 10,000 [87]

Comment: Brief remarks concerning reference [87] are discussed under the system CaF_2–LiF.

Density

The recommended values in tables 141, 142 are based on the work of Meaker and Porter (Archimedean method) [98].

TABLE 139 A. Investigations critically re-examined

Ref.	NaF (mol %)	Temp. range (*T*)
87	60–100 (graphical)	1273
98	60, 70, 80, 90, 100	1073–1353

TABLE 139 B. Comparisons with previous recommendations

Ref.	Recommended value		NaF (mol %)	% Departure			
	Vol.	Page		% (min)	(*T*)	% (max)	(*T*)
98	1	3	0	−2.2	(1270)	−2.5	(1350)

TABLE 139 C. Cell materials and calibration

Cell material	Calibration
Mo plummet connected to a quartz spring by a Mo wire, melt contained in a graphite crucible [87, 98]	Molten KCl [87, 98]

Comment: Brief remarks concerning reference [98] are given under the system CaF_2–LiF.

Density values [98] were reported in the form of linear temperature-dependent equations with standard deviations in the range: 2.39×10^{-3} gcm^{-3} (100 mol % NaF) to 10.2×10^{-3} gcm^{-3} (60 mol % NaF).

Melt Preparation and Purification

The method of salt purification used by Porter et al. [87, 98] is described under the system CaF_2-LiF.

Lanthanum fluoride contained less than 0.1 weight-percent of metallic impurities.

TABLE 140 a. LaF_3-NaF: Electrical conductance

Specific conductance: Numerical values (ohm^{-1} cm^{-1})

Mol percent NaF

T	100.0	90.0	80.0	70.0	60.0
1060				2.33	
1070				2.39	
1080				2.45	
1090				2.51	
1100				2.57	
1110				2.63	
1120				2.69	
1130				2.76	
1140				2.82	
1150				2.88	
1160				2.94	
1170			3.34	3.00	
1180			3.39	3.06	
1190			3.44	3.12	
1200			3.49	3.18	
1210			3.54	3.24	2.89
1220			3.59	3.30	2.95
1230			3.64	3.36	3.00
1240		4.26	3.69	3.43	3.05
1250		4.31	3.74	3.49	3.11
1260		4.35	3.79	3.55	3.16
1270		4.40	3.84	3.61	3.21
1280		4.45	3.89	3.67	3.27
1290		4.49	3.94	3.73	3.32
1300		4.54	3.99	3.79	3.38
1310	5.33	4.59	4.04	3.85	3.43
1320	5.39	4.63	4.08	3.91	3.48
1330	5.44	4.68	4.13	3.97	3.54
1340	5.50	4.73	4.18	4.03	3.59

TABLE 140 b. Temperature-dependent equations

$\kappa = a + bT$ (ohm^{-1} cm^{-1})

Comp. (mol % NaF)	a	$b \cdot 10^3$	Stand. deviation [87]
60.0	−3.561	5.334	0.0142
70.0	−4.123	6.087	0.0143
80.0	−2.443	4.945	0.0240
90.0	−1.559	4.691	0.0300
100.0	−2.060	5.640	0.0660

Reference: [87]. Data reported in equation form.

TABLE 141 a. LaF_3-NaF: Density

Numerical values (gcm^{-3})

Mol percent NaF

T	100	95	90	85	80	75	70	65	60	72
1080							3.347			
1095							3.336	3.502		3.264
1110						3.140	3.325	3.491		3.253
1125						3.129	3.314	3.479		3.242
1140						3.118	3.303	3.468		3.231
1155					2.907	3.107	3.291	3.456		3.220
1170					2.896	3.097	3.280	3.444		3.209
1185					2.885	3.086	3.269	3.433		3.198
1200				2.660	2.875	3.075	3.258	3.421		3.187
1215				2.650	2.864	3.064	3.247	3.410	3.551	3.176
1230				2.640	2.854	3.053	3.235	3.398	3.539	3.165
1245			2.403	2.629	2.843	3.042	3.224	3.387	3.527	3.154
1260		2.156	2.393	2.619	2.833	3.032	3.213	3.375	3.515	3.143
1275	1.903	2.146	2.382	2.608	2.822	3.021	3.202	3.363	3.503	3.132
1290	1.893	2.136	2.372	2.598	2.811	3.010	3.191	3.352	3.491	3.121
1305	1.882	2.126	2.362	2.588	2.801	2.999	3.180	3.340	3.479	3.110
1320	1.872	2.116	2.352	2.577	2.790	2.988	3.168	3.329	3.467	3.099
1335	1.862	2.106	2.342	2.567	2.780	2.977	3.157	3.317	3.455	3.088
1350	1.852	2.096	2.331	2.557	2.769	2.966	3.146	3.306	3.443	3.077

TABLE 141 b. Two-dimensional equation and statistical parameters

$\rho = a + bT + cC + dC^3 + eTC^2$ (gcm^{-3})

a	$b \cdot 10^4$	$c \cdot 10^2$	$d \cdot 10^6$	$e \cdot 10^8$	Max. percent departure	Stand. error of est.
2.75981	−6.72268	4.93313	−3.25825	−8.07650	−0.43 (1338.2 K, 10 mol % LaF_3)	0.004

Reference: [98]. Data reported in equation form.
C=mol percent LaF_3.

TABLE 142 a. LaF_3-NaF: Density

Numerical values (gcm^{-3})

	Mol percent NaF				
T	100.0	90.0	80.0	70.0	60.0
1080				3.347	
1095				3.336	
1110				3.325	
1125				3.314	
1140				3.303	
1155			2.910	3.292	
1170			2.898	3.281	
1185			2.886	3.270	
1200			2.875	3.259	
1215			2.863	3.248	3.544
1230			2.852	3.237	3.533
1245		2.406	2.840	3.226	3.523
1260		2.397	2.829	3.215	3.512
1275	1.898	2.388	2.817	3.204	3.502
1290	1.889	2.379	2.805	3.193	3.491
1305	1.879	2.370	2.794	3.181	3.481
1320	1.870	2.360	2.782	3.170	3.470
1335	1.861	2.351	2.771	3.159	3.459
1350	1.852	2.342	2.759	3.148	3.449

TABLE 142 b. Temperature-dependent equations

$\rho = a + bT$ (gcm^{-3})

Comp. (mol % NaF)	a	$b \cdot 10^4$	Stand. dev. [98]
60.0	4.400	−7.045	0.0102
70.0	4.143	−7.368	0.00525
80.0	3.802	−7.726	0.00360
90.0	3.160	−6.057	0.00353
100.0	2.682	−6.151	0.00239

Reference: [98]. Data reported in equation form.

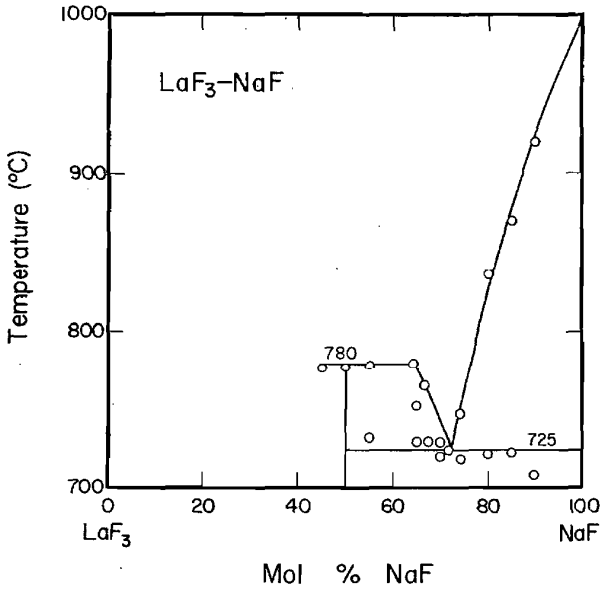

FIGURE 37. Temperature-composition phase diagram for LaF_3-Na
G. A. Bukhalova, E. P. Babaeva, and T. M. Khliyan, Russ. J. Inorg. Chem. **10**, 1158 (1965).

LiF-NaF

Electrical Conductance

The recommended values in table 147 are based on the work of Meaker, Porter, and Kesterke (classical ac technique) [**87**].

TABLE 143 A. Investigations critically re-examined

Ref.	NaF (mol %)	Temp. range (T)
87	0–100	1013–1343

TABLE 143 B. Comparisons with previous recommendations

Ref.	Recommended value		NaF (mol %)	% Departure			
	Vol.	Page		% (min)	(T)	% (max)	(T)
87	1	3	100	5.5	(1310)	8.3	(1360)
87	1	2	0	5.0	(1160)	6.8	(1270)

TABLE 143 C. Cell materials and calibration

Cell material	Electrodes	Frequency range (Hz)
Capillary cell consisting of two boron nitride cylinders encased in a graphite jacket [87]	Mo [87]	20–20,000 measurements at 10,000 [87]

Comment: Brief remarks concerning reference [87] are discussed under the system CaF_2–LiF.

Density

The recommended values in table 148 are based on the work of Matiasovsky (Archimedean method) [75].

TABLE 144 A. Investigations critically re-examined

Ref.	NaF (mol %)	Temp. range (T)
75	0–100	1123–1373
89	40 (eutectic, graphical)	973–1173
88	40 (eutectic, graphical)	1073, 1123
87	0–100 (graphical)	1273
98	0–100	1023–1353

TABLE 144 B. Comparisons with previous recommendations

Ref.	Recommended value		NaF (mol %)	% Departure			
	Vol.	Page		% (min)	(T)	% (max)	(T)
75	1	3	100	−0.04	(1323)	−0.24	(1373)
98	1	3	100	−2.2	(1280)	−2.5	(1340)
98	4.1	79	100	−2.3	(1323)	−2.4	(1273)
98	4.1	79	80	−2.9	(1233)	−3.7	(1323)
98	4.1	79	60	0.87	(1123)	−3.7	(1323)
98	4.1	79	30	0.58	(1123)	−3.1	(1323)
75	1	2	0	0.0	(1323)	−0.19	(1173)
98	1	2	0	−4.5	(1310)	−5.6	(1150)
98	4.1	79	0	−4.4	(1323)	−5.5	(1123)

TABLE 144 C. Cell materials and calibration

Cell material	Calibration
Spherical Pt sinker suspended by Pt wire, melt contained in Pt crucible [75]	Molten NaCl and KCl [75]
W bob suspended by a W or Mo wire, melt contained in Mo crucible [89, 88]	Molten KCl [87, 98]
Biconical Mo plummet suspended from Mo wire, melt contained in a graphite crucible [87, 98]	

Comment: Matiasovsky [75] determined the volume of the density sinker in melts of NaCl and KCl over the temperature range 800–1050 ° C. The volumes differed by less than 0.2 percent. The reproducibility of measurements was better than 0.1 percent. No surface tension correction was applied.

Brief remarks concerning reference [98] are given under the system NaF–ThF_4. Density values were reported in the form of linear temperature-dependent equations with standard deviations in the range: 2.39×10^{-3} gcm^{-3} (100 mol % NaF) to 44.0×10^{-3} gcm^{-3} (38 mol % NaF).

Viscosity

The recommended values in table 149 are based on the work of Cohen et al. (capillary and rotational cylinder method) [35].

TABLE 145 A. Investigations critically re-examined

Ref.	NaF (mol %)	Temp. range (T)
35	40	973, 1073

Surface Tension

The recommended values in figure 38 are based on the work of Mellors and Senderoff (maximum bubble pressure method) [89].

TABLE 146 A. Investigations critically re-examined

Ref.	NaF (mol %)	Temp. range (T)
89	40 (eutectic, graphical)	973–1223
68	40	973–1073

Comment: Remarks concerning reference [89] are under the system KF-LiF.

Melt Preparation and Purification

Salts used in references [88, 89] were ACS grade (obtained from Harshaw Chemical Company).

The procedure used by Porter et al. [87, 98] is discussed under the system CaF_2-LiF.

TABLE 147 a. LiF-NaF: Electrical conductance

Specific conductance: Numerical values (ohm^{-1} cm^{-1})

	Mol percent NaF							
T	100.0	80.0	60.0	50.0	38.0	30.0	15.0	0.0
1020						5.81		
1030					5.54	5.87		
1040					5.59	5.93		
1050					5.65	5.99		
1060					5.70	6.05	6.97	
1070				5.40	5.76	6.11	7.04	
1080				5.45	5.82	6.17	7.11	
1090				5.51	5.87	6.24	7.18	
1100				5.57	5.93	6.30	7.25	
1110				5.62	5.98	6.36	7.32	
1120				5.68	6.04	6.42	7.39	
1130			5.21	5.74	6.09	6.48	7.46	
1140			5.26	5.79	6.15	6.54	7.53	
1150			5.30	5.85	6.20	6.60	7.60	9.10
1160			5.34	5.90	6.26	6.66	7.67	9.16
1170			5.39	5.96	6.32	6.72	7.74	9.22
1180		5.21	5.43	6.02	6.37	6.79	7.81	9.27
1190		5.26	5.48	6.07	6.43	6.85	7.88	9.33
1200		5.31	5.52	6.13	6.48	6.91	7.95	9.39
1210		5.37	5.56	6.19	6.54	6.97	8.02	9.45
1220		5.42	5.61	6.24	6.59	7.03	8.09	9.51
1230		5.47	5.65	6.30	6.65	7.09	8.16	9.57
1240		5.52	5.69	6.36	6.70	7.15	8.22	9.62
1250		5.57	5.74	6.41	6.76	7.21	8.29	9.68
1260		5.62	5.78	6.47	6.81	7.27	8.36	9.74
1270		5.68	5.82	6.53	6.87	7.34	8.43	9.80
1280		5.73	5.87	6.58	6.93	7.40	8.50	9.86
1290		5.77	5.91	6.64	6.98	7.46	8.57	9.92
1300		5.83	5.95	6.70	7.04	7.52	8.64	9.97
1310	5.33	5.88	6.00	6.75	7.09	7.58	8.71	10.03
1320	5.39	5.93	6.04	6.81	7.15	7.64	8.78	10.09
1330	5.44	5.99	6.08	6.87	7.20	7.70	8.85	10.15
1340	5.50	6.04	6.13	6.92	7.26	7.76	8.92	10.21

TABLE 147 b. Temperature-dependent equations

$\kappa = a + bT$ (ohm^{-1} cm^{-1})

Comp. (mol % NaF)	$a \cdot 10^1$	$b \cdot 10^3$	Stand. dev. [87]
0.0	23.95	5.830	0.0500
15.0	−4.124	6.965	0.0301
30.0	−4.307	6.115	0.0250
38.0	−1.798	5.551	0.0301
50.0	−6.533	5.653	0.0317
60.0	2.936	4.354	0.0246
80.0	−8.848	5.166	0.0307
100.0	−2.060	5.640	0.0660

Reference: [87]. Data reported in equation form.

TABLE 148 a. LiF-NaF: Density

Numerical values (gcm^{-3})

Mol percent NaF

T	100	90	80	70	60	50	40	30	20	10	0
1130				1.964	1.949	1.924	1.905	1.875	1.822	1.856	1.800
1140				1.959	1.944	1.919	1.900	1.869	1.816	1.848	1.795
1150				1.954	1.938	1.913	1.894	1.864	1.811	1.841	1.791
1160				1.948	1.932	1.907	1.888	1.859	1.806	1.833	1.786
1170				1.943	1.927	1.902	1.883	1.854	1.801	1.826	1.781
1180				1.937	1.921	1.896	1.877	1.848	1.796	1.818	1.777
1190				1.932	1.916	1.891	1.872	1.843	1.791	1.811	1.772
1200				1.926	1.910	1.885	1.866	1.838	1.786	1.803	1.767
1210				1.921	1.905	1.879	1.861	1.832	1.781	1.796	1.763
1220				1.916	1.899	1.874	1.855	1.827	1.776	1.788	1.758
1230			1.933	1.910	1.893	1.868	1.850	1.822	1.771	1.781	1.753
1240			1.927	1.905	1.888	1.863	1.844	1.817	1.765	1.773	1.749
1250			1.921	1.899	1.882	1.857	1.838	1.811	1.760	1.766	1.744
1260			1.915	1.894	1.877	1.851	1.833	1.806	1.755	1.758	1.739
1270			1.909	1.888	1.871	1.846	1.827	1.801	1.750	1.751	1.734
1280	1.941	1.922	1.903	1.883	1.865	1.840	1.822	1.796	1.745	1.743	1.730
1290	1.935	1.914	1.897	1.877	1.860	1.835	1.816	1.790	1.740	1.736	1.725
1300	1.928	1.906	1.891	1.872	1.854	1.829	1.811	1.785	1.735	1.728	1.720
1310	1.922	1.898	1.885	1.867	1.849	1.823	1.805	1.780	1.730	1.721	1.716
1320	1.915	1.891	1.879	1.861	1.843	1.818	1.800	1.774	1.725	1.713	1.711

TABLE 148 b. Temperature-dependent equations

$\rho = a + bT$ (gcm^{-3})

Comp. (mol % NaF)	a	$b \cdot 10^4$	Stand. error of est.
0	2.3289	−4.6803	0.0001
10	2.3973	−5.0961	0.0001
20	2.4248	−5.1137	0.0002
30	2.4709	−5.2766	0.0001
40	2.5325	−5.5523	0.0001
50	2.5565	−5.5962	0.0001
60	2.5791	−5.5747	0.0001
70	2.5784	−5.4338	0.0001
80	2.6766	−6.0429	0.0028
90	2.9187	−7.7887	0.0001
100	2.7590	−6.3915	0.0001

Reference: [75]. Data reported in numerical form.

TABLE 149. LiF-NaF: Viscosity

Numerical values (cp)

T	40 Mol % NaF
973.2	3.2
1073.2	2.35

Reference: [35]. Due to limited data the experimental values are given.

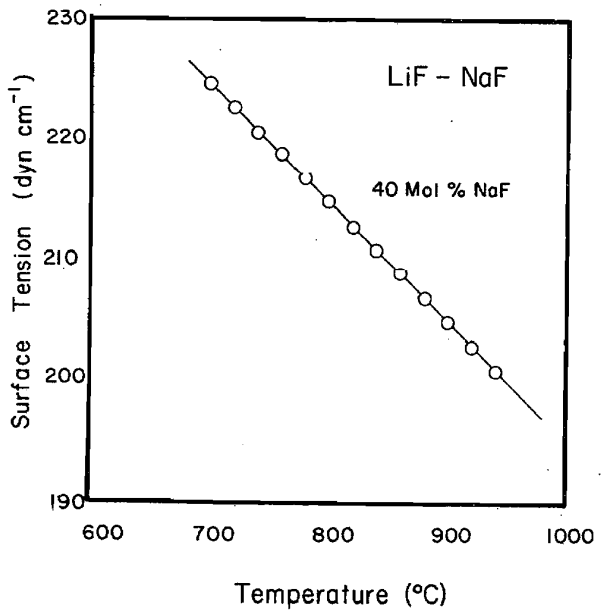

FIGURE 38. Plot [89] of surface tension against temperature for the system LiF-NaF.

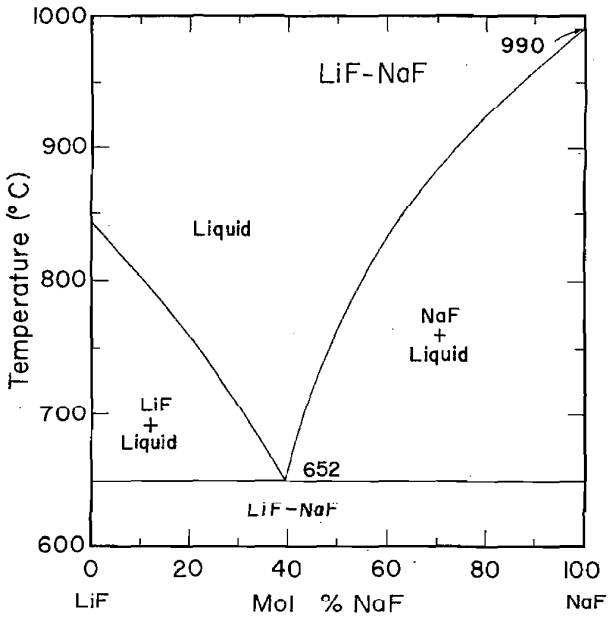

FIGURE 39. Temperature-composition phase diagram for LiF-NaF. A. G. Bergman and E. P. Dergunov, Compt. Rend. Acad. Sci., U.S.S.R., 31, 755 (1941).

LiF-RbF

Density

The recommended values in table 152 are based on the work of Cohen and Jones (Archimedean method) [35].

TABLE 150 A. Investigations critically re-examined

Ref.	RbF (mol %)	Temp. range (T)
35	57	

Comment: Cohen and Jones [35] report an experimental error of ±5 percent in their density measurements.

Viscosity

The recommended values in table 153 are based on the work of Cohen and Jones (capillary and rotational pendulum methods) [35].

TABLE 151 A. Investigations critically re-examined

Ref.	RbF (mol %)	Temp. range (T)
35	57	773–923

Comment: Error limits for viscosity measurements in reference [35] were reported to be ±10 percent.

TABLE 152. LiF-RbF: Density

Temperature-dependent equation

$\rho = a + bT$ (gcm^{-3})

Comp. (mol % RbF)	a	b·10⁴
57	3.56	−9.6

Reference: [35]. Data reported in equation form. No temperature range is given.

TABLE 153. LiF-RbF: Viscosity

Numerical values (cp)

T	57 Mol % RbF
773.2	9.0
823.2	6.2
873.2	4.5
923.2	3.4

Reference: [35]. Due to limited data the experimental values are given.

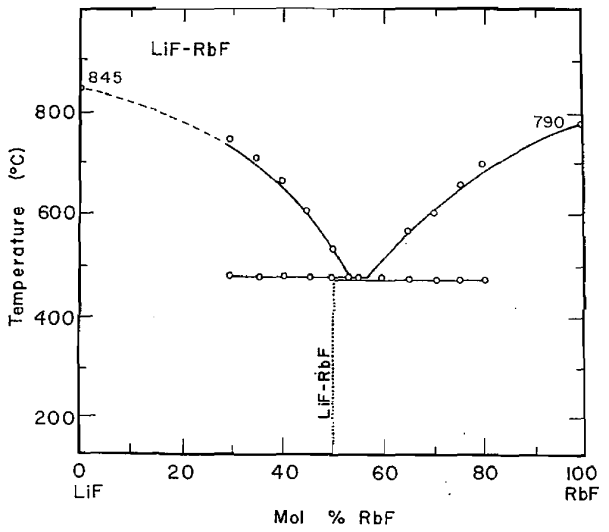

FIGURE 40. Temperature-composition phase diagram for LiF-RbF. E. P. Dergunov, Dokl. Akad. Nauk S.S.S.R., 58, 1369 (1947).

LiF-SmF_3

Electrical Conductance

The recommended values in table 156 are based on the work of Meaker, Porter, and Kesterke (classical ac technique) [87].

TABLE 154 A. Investigations critically re-examined

Ref.	SmF_3 (mol %)	Temp. range (T)
87	0, 10, 20, 30, 40, 50	1073–1343

TABLE 154 B. Comparisons with previous recommendations

Ref.	Recommended value		SmF_3 (mol %)	% Departure			
	Vol.	Page		% (min)	(T)	% (max)	(T)
87	1	2	0	5.1	(1150)	8.2	(1310)

TABLE 154 C. Cell materials and calibration

Cell material	Electrodes	Frequency range (Hz)
Capillary cell consisting of two boron nitride cylinders encased in a graphite jacket [87]	Mo [87]	20–20,000 measurements at 10,000 [87]

Comment: The specific conductance values measured in reference [87] were reported reproducible to ±1 percent. The precision of the measurements was ±3 percent. The measured resistance was found to be independent of frequency over the range 20 to 20,000 hertz.

Density

The recommended values in tables 157, 158 are based on the work of Meaker, Porter, and Kesterke (Archimedean method) [87].

TABLE 155 A. Investigations critically re-examined

Ref.	SmF_3 (mol %)	Temp. range (T)
87	0–50	1073–1343

TABLE 155 B. Cell materials and calibration

Cell material	Calibration
Mo plummet connected to a quartz spring by a Mo wire, melt contained in a graphite crucible [87]	Molten KCl [87]

Melt Preparation and Purification

Reagent-grade chemicals were used in reference [87] and [98]. After vacuum drying at 400 °C the salts were cooled and combined in the correct proportions. The salts were then placed in graphite crucibles and heated under vacuum (50 microns) to 600 °C. For density and conductance measurements the mixtures were melted in an atmosphere of helium in a controlled-atmosphere chamber. Melt compositions were confirmed by analysis after density measurements.

TABLE 156 a. LiF-SmF_3: Electrical conductance

Specific conductance: Numerical values (ohm^{-1} cm^{-1})

Mol percent SmF_3

T	50.0	40.0	30.0	20.0	10.0	0.0
1080			3.90			
1090			3.97			
1100			4.04	5.07		
1110			4.10	5.14		
1120			4.17	5.21	6.80	
1130			4.24	5.28	6.86	
1140			4.30	5.35	6.92	
1150		3.70	4.37	5.42	6.99	9.10
1160		3.76	4.44	5.50	7.05	9.16
1170		3.82	4.50	5.57	7.11	9.22
1180		3.89	4.57	5.64	7.18	9.27
1190		3.95	4.63	5.71	7.24	9.33
1200		4.01	4.70	5.78	7.30	9.39
1210		4.07	4.77	5.85	7.37	9.45
1220		4.13	4.83	5.92	7.43	9.51
1230		4.19	4.90	5.99	7.49	9.57
1240		4.25	4.97	6.06	7.55	9.62
1250		4.31	5.03	6.13	7.62	9.68
1260	3.83	4.37	5.10	6.20	7.68	9.74
1270	3.87	4.43	5.16	6.27	7.74	9.80
1280	3.92	4.49	5.23	6.35	7.81	9.86
1290	3.96	4.55	5.30	6.42	7.87	9.92
1300	4.00	4.61	5.36	6.49	7.93	9.97
1310	4.05	4.67	5.43	6.56	7.99	10.03
1320	4.09	4.73	5.50	6.63	8.06	10.09
1330	4.14	4.79	5.56	6.70	8.12	10.15
1340	4.18	4.85	5.63	6.77	8.18	10.21

TABLE 156 b. Temperature-dependent equations

$\kappa = a + bT$ (ohm^{-1} cm^{-1})

Comp. (mol % SmF_3)	a	$b \cdot 10^3$	Stand. deviation [87]
0.0	2.395	5.830	0.0500
10.0	−0.255	6.297	0.0477
20.0	−2.721	7.083	0.0377
30.0	−3.262	6.635	0.0371
40.0	−3.265	6.059	0.0455
50.0	−1.710	4.395	0.0311

Reference: [87]. Data reported in equation form.

TABLE 157 a. $LiF\text{-}SmF_3$: Density

Numerical values (gcm^{-3})

Mol percent SmF_3

T	50	45	40	35	30	25	20	15	10	5	0	35
1080						3.546	3.268	2.952				
1095					3.781	3.533	3.255	2.941				
1110					3.767	3.520	3.243	2.930	2.573			
1125				3.977	3.753	3.507	3.231	2.919	2.564	2.159	1.697	3.977
1140				3.963	3.740	3.494	3.219	2.908	2.554	2.151	1.691	3.963
1155				3.949	3.726	3.481	3.207	2.898	2.545	2.144	1.686	3.949
1170				3.935	3.713	3.469	3.196	2.887	2.536	2.136	1.680	3.935
1185			4.129	3.922	3.700	3.457	3.185	2.877	2.528	2.130	1.675	3.922
1200			4.115	3.909	3.688	3.445	3.174	2.868	2.520	2.123	1.671	3.909
1215		4.300	4.102	3.896	3.675	3.433	3.163	2.858	2.512	2.117	1.666	3.896
1230		4.287	4.089	3.883	3.663	3.422	3.153	2.849	2.504	2.111	1.662	3.883
1245		4.274	4.075	3.870	3.651	3.410	3.142	2.840	2.496	2.105	1.658	3.870
1260	4.458	4.261	4.062	3.857	3.639	3.399	3.132	2.831	2.489	2.099	1.655	3.857
1275	4.446	4.248	4.050	3.845	3.627	3.388	3.123	2.823	2.482	2.094	1.652	3.845
1290	4.433	4.235	4.037	3.833	3.615	3.378	3.113	2.814	2.475	2.089	1.649	3.833
1305	4.420	4.222	4.025	3.821	3.604	3.367	3.104	2.806	2.469	2.084	1.646	3.821
1320	4.408	4.210	4.012	3.809	3.593	3.357	3.094	2.799	2.463	2.080	1.643	3.809
1335	4.395	4.197	4.000	3.797	3.582	3.347	3.085	2.791	2.457	2.076	1.641	3.797

TABLE 157 b. Two-dimensional equation and statistical parameters

$\rho = a + bC + cC^2 + dC^3 + eTC + fTC^2 + gCT^2$ (gcm^{-3})

a	$b \cdot 10^2$	$c \cdot 10^3$	$d \cdot 10^6$	$e \cdot 10^5$	$f \cdot 10^7$	$g \cdot 10^9$	Max. percent departure	Stand. error of est.
7.92402	−7.07474	1.11561	−9.07294	−4.79804	2.99784	6.23976	0.69 (1073.2 K, 80 mol % LiF)	0.006

Reference: [87] and [98] (for LiF). Data reported in equation form.
C = mol percent LiF.

TABLE 158 a. LiF–SmF_3: Density

Numerical values (gcm^{-3})

Mol percent SmF_3

T	50.0	40.0	30.0	20.0	10.0	0.0
1080			3.811	3.247		
1090			3.802	3.240		
1100			3.792	3.234	2.570	
1110			3.783	3.227	2.565	
1120			3.774	3.221	2.561	
1130			3.765	3.214	2.556	1.699
1140			3.756	3.208	2.551	1.695
1150			3.746	3.201	2.547	1.692
1160			3.737	3.195	2.542	1.689
1170			3.728	3.188	2.537	1.685
1180		4.117	3.719	3.182	2.533	1.682
1190		4.110	3.710	3.175	2.528	1.679
1200		4.102	3.700	3.169	2.523	1.675
1210		4.095	3.691	3.162	2.518	1.672
1220		4.088	3.682	3.156	2.514	1.669
1230		4.080	3.673	3.149	2.509	1.666
1240		4.073	3.664	3.143	2.504	1.662
1250	4.467	4.065	3.655	3.137	2.500	1.659
1260	4.459	4.058	3.645	3.130	2.495	1.656
1270	4.451	4.051	3.636	3.124	2.490	1.652
1280	4.442	4.043	3.627	3.117	2.486	1.649
1290	4.434	4.036	3.618	3.111	2.481	1.646
1300	4.426	4.029	3.609	3.104	2.476	1.642
1310	4.417	4.021	3.599	3.098	2.471	1.639
1320	4.409	4.014	3.590	3.091	2.467	1.636
1330	4.401	4.006	3.581	3.085	2.462	1.632
1340	4.392	3.999	3.572	3.078	2.457	1.629

TABLE 158 b. Temperature-dependent equations

$\rho = a + bT$ (gcm^{-3})

Comp. (mol % SmF_3)	a	$b \cdot 10^4$	Stand. deviation [87, 98]
0.0	2.074	−3.321	0.00705
10.0	3.087	−4.702	0.0083
20.0	3.946	−6.474	0.0144
30.0	4.803	−9.187	0.0126
40.0	4.987	−7.372	0.0153
50.0	5.512	−8.357	0.0953

References: [87] and [98] (for LiF). Data reported in equation form.

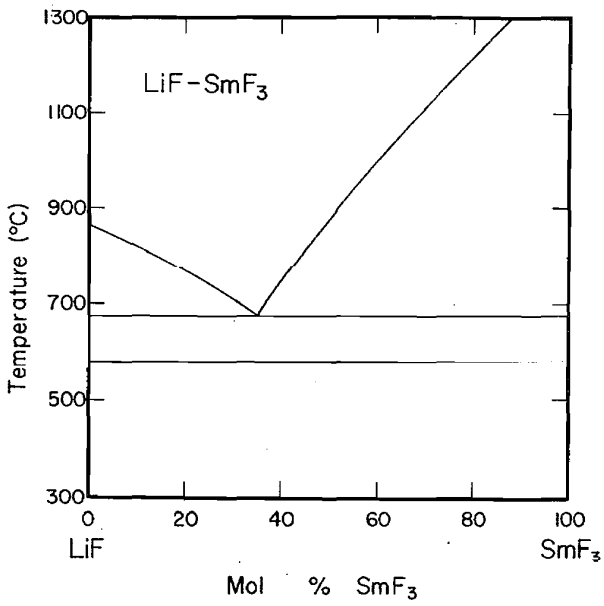

FIGURE 41. Temperature-composition phase diagram for LiF-SmF_3. R. E. Thoma, Progress in Science and Technology of the Rare Earths, Vol. 2, p. 110, Pergamon Press, N.Y. 1966.

LiF-ThF_4

Electrical Conductance

The recommended values in table 161 are based on the work of Brown and Porter (classical ac technique) [24].

TABLE 159 A. Investigations critically re-examined

Ref.	ThF_4 (mol %)	Temp. range (T)
24	0–49.8	913–1273
100*	3.2, 22, 49.8	913–1273
87	0–49.8	913–1343

* Data from reference [24].

TABLE 159 B. Comparisons with previous recommendations

Ref.	Recommended value		ThF_4 (mol %)	% Departure			
	Vol.	Page		% (min)	(T)	% (max)	(T)
24	1	3	0	5.0	(1160)	6.8	(1270)
87	1	3	0	5.0	(1160)	6.8	(1270)

TABLE 159 C. Cell materials and calibration

Cell material	Electrodes	Frequency range (Hz)	Calibration
Boron nitride cylinders with graphite jackets, melt contained in graphite crucible **[24, 87]**.	Mo tubes **[24, 87]**	1000–20,000 experimental values at 10,000 **[24]** 20–20,000 experimental values at 10,000 [87]	Molten KCl **[24]**

Comment: Measured resistances in reference **[24]** did not vary over the frequency range of 1,000 to to 20,000 hertz. Experimental conductivities were corrected for the resistance of the boron nitride cell. The specific conductance values were observed to be reproducible to ±1 percent.

Remarks concerning reference [87] are discussed under the CaF_2-LiF system. Electrical conductivity values reported by Porter, Meaker and Kesterke [87] are identical to the earlier values of Porter and Brown **[24]**.

Density

The recommended values in table 162 are based on the work of Hill, Cantor, and Ward (Archimedean method) **[60]**.

TABLE 160 A. Investigations critically re-examined

Ref.	ThF_4 (mol %)	Temp. range (T)
24	0–49.8	928–1273
60	0–100	1024–1508
87	0–49.8 (graphical)	1273
98	0–49.8	928–1353

TABLE 160 B. Comparisons with previous recommendations

Ref.	Recommended value		ThF_4 (mol %)	% Departure			
	Vol.	Page		% (min)	(T)	% (max)	(T)
60	1	4	100	2.5	(1390)	2.8	(1500)
24	1	2	0	0.0	(1180)	−1.1	(1260)
60	1	2	0	0.0	(1180)	−0.6	(1310)
98	1	2	0	−4.5	(1310)	−5.6	(1150)
24	4.1	86	0	0.0	(1180)	−1.1	(1310)
98	4.1	86	0	−5.6	(1123)	−4.4	(1323)

TABLE 160 C. Cell materials and calibration

Cell material	Calibration
Biconical Mo plummet suspended from Mo wire, melt contained in graphite crucible [24, 87, 98].	Molten KCl [24]
Pt plummet suspended by Pt-Rh wire, melt contained in a nickel cup **[60]**	Distilled water **[60]**

Comment: Hill et al. **[60]** corrected for the surface tension effect of water upon the suspension wire and for the thermal expansion of the Pt plummet with temperature.

Brief remarks concerning references [24] and [98] are given under the system NaF-ThF_4. Density values in references [98] and **[60]** were given in the form of linear temperature-dependent equations. The range of standard deviation in gcm^{-3} in reference **[60]** was 0.13×10^{-4} (18.64 mol % ThF_4) to 12.0×10^{-3} (80 mol % ThF_4); the range reported in reference [98] was 7.05×10^{-3} (0 mol % ThF_4) to 30.0×10^{-3} (22 mol % ThF_4).

Melt Preparation and Purification

Brown and Porter **[24]** used commercial sources of LiF and ThF_4 which on analysis showed less than 0.01 percent metallic contaminants. The individual salts were combined in the desired proportions, vacuum dried to 400 °C at pressures less than 100 μm Hg, and then melted in an atmosphere of helium.

Hill et al. **[60]** purified LiF (Baker and Adamson Reagent Grade) by recrystallizing from slowly cooled melts, from which only clear crystal fragments were selected for use. Spectrochemical analysis showed three metallic impurities were present in concentration greater than 0.01 percent: Al, 0.05 percent; Ca, 0.015 percent; Ni, 0.075 percent. Thorium tetrafluoride was recrystallized in a graphite crucible by slowly heating the commercial, anhydrous product (National Lead Co.) to melting under a He atmosphere. Analysis showed only calcium (0.03%) to be present in large amounts.

The procedure used by Porter et al. [87, 98] is discussed under the system CaF_2-LiF.

TABLE 161 a. LiF–ThF_4: Electrical conductance*

Specific conductance: Numerical values (ohm^{-1} cm^{-1})

Mol percent ThF_4

T	49.8	41.8	28.1	22.0	3.2	0
920			2.06	2.55		
940			2.19	2.71		
960			2.32	2.86		
980			2.44	3.01		
1000			2.57	3.16		
1020			2.70	3.31		
1040			2.82	3.46		
1060			2.95	3.61		
1080		2.45	3.08	3.71		
1100	2.16	2.55	3.21	3.92		
1120	2.24	2.65	3.33	4.07		
1140	2.33	2.74	3.46	4.22		
1160	2.41	2.84	3.59	4.37	7.22	9.16
1180	2.49	2.94	3.71	4.52	7.43	9.28
1200	2.58	3.04	3.84	4.68	7.65	9.39
1220	2.66	3.14	3.97	4.83	7.87	9.51
1240	2.75	3.23	4.09	4.98	8.09	9.63
1260	2.83	3.33	4.22	5.13	8.31	9.75
1270	2.87	3.38	4.28	5.21	8.42	9.80

TABLE 161 b. Temperature-dependent equations

$\kappa = a + bT$ (ohm^{-1} cm^{-1})

Comp. (mol % ThF_4)	a	$b \cdot 10^3$
0	2.40	5.83
3.2	−5.51	10.97
22.0	−4.42	7.58
28.1	−3.78	6.35
41.8	−2.83	4.89
49.8	−2.45	4.19

Reference: [24]. Data reported in equation form.

TABLE 162 a. LiF–ThF_4: Density

Numerical values (gcm^{-3})

Mol percent ThF_4

T	100	80.00	60.00	40.00	20.00	18.64	0
1020					3.926		
1040					3.909	3.932	
1060					3.892	3.914	
1080				5.035	3.875	3.895	
1100				5.014	3.859	3.877	
1120				4.993	3.842	3.859	
1140				4.972	3.825	3.840	1.801
1160				4.951	3.808	3.822	1.791
1180				4.931	3.791	3.803	1.781
1200				4.910	3.774	3.785	1.771
1220			5.567	4.889	3.757	3.767	1.761
1240			5.544	4.868			1.751
1260			5.522	4.847			1.741
1280			5.500				1.731
1300			5.478				1.721
1320		5.981	5.455				1.711
1340		5.960	5.433				1.701
1360		5.940	5.411				1.691
1380		5.919					
1400	6.209	5.898					
1420	6.193	5.877					
1440	6.176	5.856					
1460	6.160						
1480	6.144						
1500	6.128						

TABLE 162 b. Temperature-dependent equations

$\rho = a + bT$ (gcm^{-3})

Comp. (mol % ThF_4)	a	$b \cdot 10^4$
0	2.371	−5.00
18.64	4.889	−9.20
20.00	5.787	−8.44
40.00	6.159	−10.41
60.00	6.927	−11.15
80.00	7.354	−10.40
100	7.340	−8.08

Reference: [60]. Data reported in equation form. Two-dimensional statistical analysis was unsuccessful.

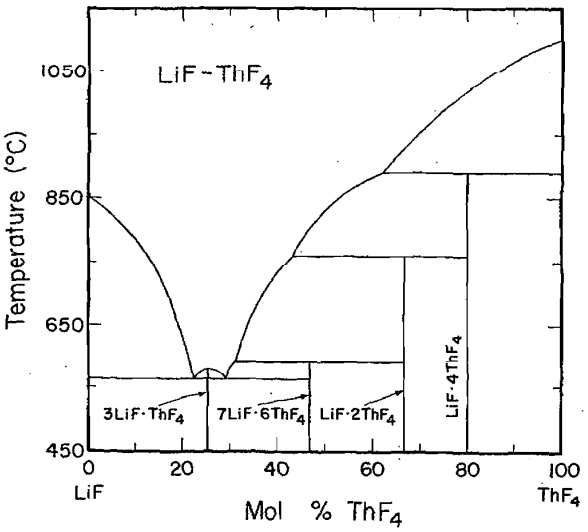

FIGURE 42. Temperature-composition phase diagram for LiF-ThF_4. R. E. Thoma, H. Insley, B. S. Landau, H. A. Friedman, and W. R. Grimes, J. Phys. Chem., **63**, 1127 (1959).

LiF-UF_4

Electrical Conductance

The recommended values in table 166 are based on the work of Brown and Porter (classical ac technique) [**24**].

TABLE 163 A. Investigations critically re-examined

Ref.	UF_4 (mol %)	Temp. range (T)
24	0–60	923–1273
100*	5, 40, 60	973–1273
87	0–60	923–1343

* Data from reference [24].

TABLE 163 B. Comparisons with previous recommendations

Ref.	Recommended value		UF_4 (mol %)	% Departure			
	Vol.	Page		% (min)	(T)	% (max)	(T)
24	1	2	0	5.0	(1160)	6.8	(1270)
87	1	2	0	5.0	(1160)	6.8	(1270)

TABLE 163 C. Cell materials and calibration

Cell material	Electrodes	Frequency range (Hz)	Calibration
Boron nitride cylinders with graphite jackets, melt contained in graphite crucible [**24**, 87]	Mo tubes [**24**, 87]	1000–20,000 experimental values at 10,000 [**24**] 20–20,000 experimental values at 10,000 [87]	Molten KCl [**24**]

Comment: Remarks concerning references [**24**] and [87] are given under the systems LiF–ThF_4 and CaF_2–LiF, respectively. Electrical conductivity values reported by Porter, Meaker and Kesterke [87] are identical to the earlier values of Porter and Brown [**24**].

Density

The recommended values in table 167 are based on the work of Porter and Meaker (Archimedean method) [**78**].

TABLE 164 A. Investigations critically re-examined

Ref.	UF_4 (mol %)	Temp. range (T)
24	0–60	973–1273
18	0–47	973, 1073
87	0–60 (graphical)	1273
98	0–60	973–1353

TABLE 164 B. Comparisons with previous recommendations

Ref.	Recommended value		UF_4 (mol %)	% Departure			
	Vol.	Page		% (min)	(T)	% (max)	(T)
24	1	2	0	0.0	(1180)	−1.1	(1260)
98	1	2	0	−4.5	(1310)	−5.6	(1150)

TABLE 164 C. Cell materials and calibration

Cell material	Calibration
Biconical Mo plummet suspended from Mo wire, melt contained in graphite crucible [24, 87, 98]	Molten KCl [24]
Pt cylinder and Pt suspension wire, melt contained in Inconel crucible [78]	

Comment: Brief remarks concerning references [24] and [98] are given under the system NaF–ThF_4. Density values in [98] were in the form of linear temperature-dependent equations with standard deviations in the range: 7.05×10^{-3} gcm^{-3} (0 mol % UF_4) to 36.0×10^{-3} gcm^{-3} (27.5 mol % UF_4).

Viscosity

The recommended values in table 168 are based on the work of Blanke et al. (rotational cylinder method) [18].

TABLE 165 A. Investigations critically re-examined

Ref.	UF_4 (mol %)	Temp. range (T)
18	0–47	873, 973, 1073

TABLE 165 B. Cell materials and calibration

Cell material
Two concentric Inconel cylinders, nickel shaft connected to inner Mo torsion wire [18].

Comment: the overall error for viscosity measurements in reference [18] was ±5 percent.

Melt Preparation and Purification

Brown and Porter [24] used commercial sources of LiF and UF_4 which on analysis showed less than 0.01 percent metallic contaminants. The individual salts were combined in the desired proportions, vacuum dried to 400 °C (pressure less than 100 μm Hg), and then melted in an atmosphere of helium.

The procedure used by Porter et al. [87, 98] is discussed under the system CaF_2-LiF.

TABLE 166 a. LiF-UF_4: Electrical conductance

Specific conductance: Numerical values (ohm^{-1} cm^{-1})

T	Mol percent UF_4 60.0	50.0	40.0	27.5	15.0	5.0	0
940				2.50			
960				2.62			
980			2.21	2.74			
1000			2.32	2.86			
1020			2.43	2.98			
1040			2.55	3.10			
1060			2.66	3.22			
1080		2.48	2.77	3.34	4.81		
1100		2.57	2.89	3.46	4.93		
1120		2.66	3.00	3.58	5.05		
1140		2.76	3.12	3.70	5.18		
1160		2.85	3.23	3.82	5.30		9.16
1180	2.91	2.94	3.34	3.94	5.42	7.59	9.28
1200	2.98	3.03	3.46	4.06	5.55	7.71	9.39
1220	3.04	3.12	3.57	4.18	5.67	7.83	9.51
1240	3.11	3.22	3.68	4.30	5.80	7.95	9.63
1260	3.18	3.31	3.80	4.42	5.92	8.06	9.75
1270	3.21	3.35	3.85	4.48	5.98	8.12	9.80

TABLE 166 b. Temperature-dependent equations

$\kappa = a + bT$ (ohm^{-1} cm^{-1})

Comp. (mol % UF_4)	a	$b\cdot10^2$
0	2.40	5.83
5.0	0.68	5.86
15.0	−1.88	6.19
27.5	−3.13	5.99
40.0	3.36	5.60
50.0	−2.50	4.61
60.0	−0.97	3.29

Reference: [24]. Data reported in equation form.

TABLE 167 a. $LiF–UF_4$: Density

Numerical values (gcm^{-3})

Mol percent UF_4

T	60.0	50.0	40.0	27.5	15.0	0.0
980			5.242	4.858		
1000			5.219	4.833		
1020			5.196	4.808	3.718	
1040		5.625	5.172	4.782	3.703	
1060		5.599	5.149	4.757	3.689	
1080		5.573	5.125	4.731	3.674	
1100	6.032	5.548	5.102	4.706	3.660	
1120	5.998	5.522	5.078	4.680	3.645	
1140	5.964	5.496	5.055	4.655	3.631	1.695
1160	5.931	5.471	5.031	4.629	3.616	1.689
1180	5.897	5.445	5.008	4.604	3.601	1.682
1200	5.863	5.419	4.984	4.579	3.587	1.675
1220	5.829	5.394	4.961	4.553	3.572	1.669
1240	5.795	5.368	4.937	4.528	3.558	1.662
1260	5.762	5.342	4.914	4.502	3.543	1.656
1280	5.728	5.317	4.890	4.477	3.529	1.649
1300	5.694	5.291	4.867	4.451	3.514	1.642
1320	5.660	5.265	4.843	4.426	3.499	1.636
1340	5.626	5.240	4.820	4.401	3.485	1.629

TABLE 167 b. Temperature-dependent equations

$\rho = a + bT$ (gcm^{-3})

Comp. (mol % UF_4)	a	$b \cdot 10^4$	Stand. deviation [98]
0.0	2.074	−3.321	0.00705
15.0	4.461	−7.285	0.0216
27.5	6.105	−12.720	0.0360
40.0	6.393	−11.740	0.0200
50.0	6.959	−12.830	0.0179
60.0	7.891	−16.900	0.0347

Reference: [98]. Data reported in equation form.

TABLE 168. $LiF-UF_4$: Viscosity

Numerical values (cp)

Mol percent UF_4

T	47	35	20	12	0*
873.2		25.6	16.2		
973.2	16.1	15.3	8.81		
1073.2	9.81	10.05	5.39	6.04	2.32

Reference: [18]. Due to limited data the experimental values are given.

* Extrapolated.

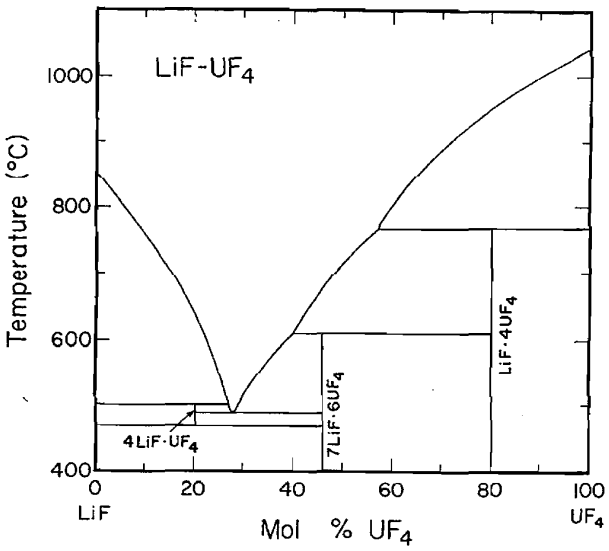

FIGURE 43. Temperature-composition phase diagram for $LiF-UF_4$. C. J. Barton, H. A. Friedman, W. R. Grimes, H. Insley, R. E. Moore, and R. E. Thoma, J. Amer. Ceram. Soc., 41[2], 67 (1958).

$LiF-YF_3$

Electrical Conductance

The recommended values in table 171 are based on the work of Meaker, Porter, and Kesterke (classical ac technique) [87].

TABLE 169 A. Investigations critically re-examined

Ref.	YF_3 (mol %)	Temp. range (T)
87	0, 19, 30, 40, 50, 60	973–1343

TABLE 169 B. Comparisons with previous recommendations

Ref.	Recommended value		YF_3 (mol %)	% Departure			
	Vol.	Page		% (min)	(T)	% (max)	(T)
87	1	2	100	5.1	(1150)	8.2	(1310)

TABLE 169 C. Cell materials and calibration

Cell material	Electrodes	Frequency range (Hz)
Capillary cell consisting of two boron nitride cylinders encased in a graphite jacket [87]	Mo [87]	20–20,000 measurements at 10,000 [87]

Comment: The specific conductance values measured in reference [87] were reported reproducible to ±1 percent. The precision of the measurements was ±3 percent. The measured resistance was found to be independent of frequency over the range 20 to 20,000 hertz.

Density

The recommended values in table 172 are based on the work of Porter and Meaker (Archimedean method) [98].

TABLE 170 A. Investigations critically re-examined

Ref.	YF_3 (mol %)	Temp. range (T)
87	0, 19, 30, 40, 50, 60 (graphical)	1273
98	0, 19, 30, 40, 50, 60	973–1353

TABLE 170 B. Comparisons with previous recommendations

Ref.	Recommended value		YF_3 (mol %)	% Departure			
	Vol.	Page		% (min)	(T)	% (max)	(T)
98	1	2	100	−4.5	(1310)	−5.6	(1150)

TABLE 170 C. Cell materials and calibration

Cell material	Calibration
Mo plummet connected to a quartz spring by a Mo wire, melt contained in a graphite crucible [87, 98]	Molten KCl [87, 98]

Comment: Brief remarks concerning reference [98] are given under the system CaF_2–LiF.

Density values [98] were fitted to linear temperature-dependent equations with standard deviations in the range: 7.05×10^{-3} (100 mol % LiF) to 23.1×10^{-3} gcm^{-3} (60 mol % YF_3).

Melt Preparation and Purification

The method used by Porter et al. [87, 98] is described under the system CaF_2-LiF. Yttrium fluoride contained less than 0.1 weight-percent of metallic impurities.

TABLE 171 a. LiF-YF_3: Electrical conductance

Specific conductance: Numerical values (ohm^{-1} cm^{-1})

T	Mol percent YF_3					
	60.0	50.0	40.0	30.0	19.0	0.0
980					4.10	
1000					4.25	
1020					4.39	
1040					4.54	
1060					4.69	
1080			2.82	3.73	4.84	
1100			2.96	3.85	4.90	
1120			3.10	3.98	5.13	
1140		2.51	3.23	4.10	5.28	
1160		2.63	3.37	4.23	5.42	9.16
1180	2.48	2.75	3.51	4.36	5.57	9.27
1200	2.59	2.87	3.65	4.48	5.72	9.39
1220	2.70	2.99	3.79	4.61	5.87	9.51
1240	2.81	3.11	3.92	4.74	6.01	9.62
1260	2.92	3.24	4.06	4.86	6.16	9.74
1280	3.04	3.36	4.20	4.99	6.31	9.86
1300	3.15	3.48	4.34	5.11	6.46	9.97
1320	3.26	3.60	4.47	5.24	6.60	10.09
1340	3.37	3.72	4.61	5.37	6.75	10.21

TABLE 171 b. Temperature-dependent equations

$\kappa = a + bT$ (ohm^{-1} cm^{-1})

Comp. (mol % YF_3)	a	$b\cdot10^3$	Stand. deviation [87]
0.0	2.395	5.830	0.0500
19.0	−3.117	7.363	0.0529
30.0	−3.088	6.309	0.0309
40.0	−4.634	6.901	0.0278
50.0	−4.415	6.072	0.0205
60.0	−4.146	5.611	0.0123

Reference: [87]. Data reported in equation form.

TABLE 172 a. $LiF\text{-}YF_3$: Density

Numerical values (gcm^{-3})

Mol percent YF_3

T	60.0	50.0	40.0	30.0	19.0	0.0
980					2.706	
1000					2.694	
1020					2.683	
1040					2.672	
1060					2.661	
1080			3.237	2.974	2.650	
1100			3.225	2.961	2.639	
1120		3.479	3.213	2.948	2.627	
1140		3.464	3.200	2.934	2.616	1.695
1160		3.450	3.188	2.921	2.605	1.689
1180		3.436	3.176	2.908	2.594	1.682
1200		3.421	3.164	2.894	2.583	1.675
1220	3.556	3.407	3.151	2.881	2.571	1.669
1240	3.546	3.392	2.139	2.868	2.560	1.662
1260	3.536	3.378	3.127	2.854	2.549	1.656
1280	3.526	3.363	3.114	2.841	2.538	1.649
1300	3.516	3.349	3.102	2.828	2.527	1.642
1320	3.505	3.334	3.090	2.814	2.515	1.636
1340	3.495	3.320	3.077	2.801	2.504	1.629

TABLE 172 b. Temperature-dependent equations

$\rho = a + bT$ (gcm^{-3})

Comp. (mol % YF_3)	a	$b \cdot 10^4$	Stand. dev. [98]
0.0	2.074	−3.321	0.000705
19.0	3.254	−5.595	0.0130
30.0	3.695	−6.672	0.0213
40.0	3.902	−6.154	0.014
50.0	4.287	−7.216	0.0117
60.0	4.174	−5.065	0.0231

Reference: [98]. Data reported in equation form.

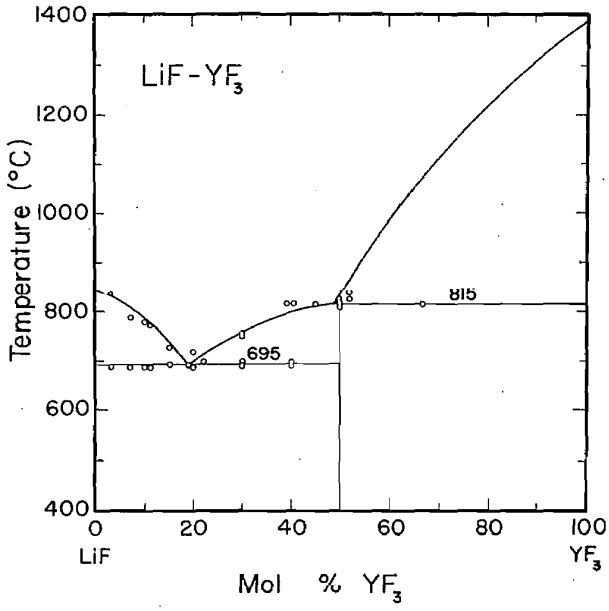

FIGURE 44. Temperature-composition phase diagram for $LiF\text{-}YF_3$. R. E. Thoma, C. F. Weaver, and H. A. Friedman, unpublished work performed at Oakridge National Laboratory 1958–59.

$NaF\text{-}NaBF_4$

Electrical Conductance

The recommended values in table 177 are based on the work of Selivanov and Stender (classical ac technique) [125].

TABLE 173 A. Investigations critically re-examined

Ref.	$NaBF_4$ (mol %)	Temp. range (T)
125	20.3–77.5	723–1073
124*	92, 100	773

* Data taken from reference [125].

TABLE 173 B. Cell materials and calibration.

Cell Material	Electrodes	Frequency range (Hz)	Calibration
Corundum crucible [125]	Pt [125]	5000 [125]	Melt containing 62% CaCl −38% NaCl and molten $Na_2B_4O_7$ [125]

Comment: Cantor [124] combined calculated data for $NaBF_4$ with the results given in reference [125] to interpolate conductance values for the 92 mol percent $NaBF_4$ composition.

Density

The recommended values in table 178 are based on the work of Cantor (dilatometric method) [123].

TABLE 174 A. Investigations critically re-examined

Ref.	$NaBF_4$ (mol %)	Temp. range (T)
122*	92	727, 894
123	92	673–864

* Data in reference [122] are estimates.

Viscosity

The recommended values in table 179 are based on the work of Cantor (oscillating hollow cylinder method) [123].

TABLE 175 A. Investigations critically re-examined

Ref.	$NaBF_4$ (mol %)	Temp. range (T)
122*	92	727, 894
123	92, 100	681–810

*Data in reference [122] are estimates.

Surface Tension

The recommended values in table 180 are based on the work of Cantor et al. [124].

TABLE 176 A. Investigations critically re-examined

Ref.	$NaBF_4$ (mol %)
124*	92, 100

* The data reported in reference [124] are estimates.

TABLE 177. NaF-$NaBF_4$: Electrical conductance

Specific conductance: Numerical values (ohm^{-1} cm^{-1})

Mol percent $NaBF_4$

T	77.5	60.5	47.2	36.5	27.7	20.3
723.2	2.408	2.019	1.559	0.905		
773.2	4.093	3.408	2.755	1.601		
823.2	5.445	4.810	4.115	2.501		
873.2	6.955	6.600	6.015	4.755	2.955	
923.2	8.801	8.555	7.950	6.350	4.095	
973.2	10.305	10.425	10.101	7.803	5.015	
1023.2	11.955	12.300	12.375	10.997	7.451	4.108
1073.2	14.978	15.375	15.201	14.105	12.075	6.502

Reference: [125]. The statistical analysis was unsuccessful therefore the original data are reported.

TABLE 178 a. NaF-$NaBF_4$: Density

Numerical values (gcm^{-3})

T	92 Mol % $NaBF_4$
680	1.963
700	1.948
720	1.934
740	1.920
760	1.906
780	1.891
800	1.877
820	1.863
840	1.849
860	1.835

TABLE 178 b. Temperature-dependent equation

$\rho = a + bT$ (gcm^{-3})

Comp. (mol % $NaBF_4$)	a	$b \cdot 10^4$	Stand. error [123]
92	2.446	7.11	0.0018

Reference: [123]. Data reported in equation form.

TABLE 179 a. $NaF-NaBF_4$: Viscosity

Numerical values (cp)

Mol percent $NaBF_4$

T	100	92
690		2.25
700	2.42	2.15
710	2.31	2.06
720	2.21	1.97
730	2.11	1.89
740	2.02	1.81
750	1.93	1.74
760	1.86	1.67
770	1.78	1.61
780	1.71	1.55
790		1.49
800		1.44
810		1.39

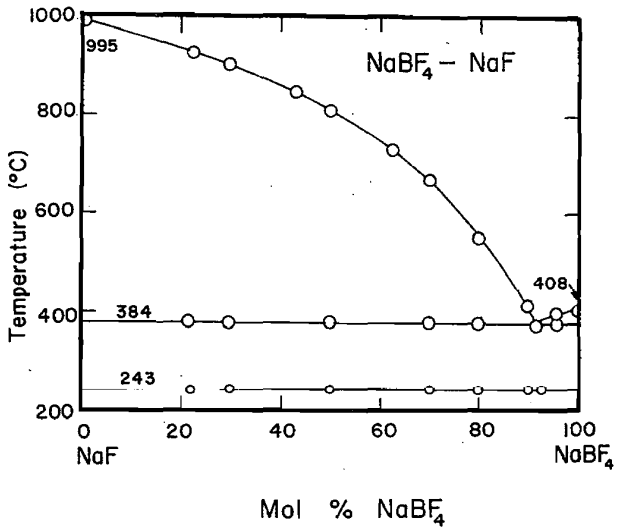

FIGURE 45. Temperature-composition phase diagram for $NaBF_4$-NaF.
M. W. Rosenthal, P. N. Haubenreich, and R. B. Briggs, Oak Ridge National Laboratory, ORNL–4812 (1972).

TABLE 179 b. Temperature-dependent equations

$\eta = A \cdot \exp(E/RT)$ (cp)

Comp (mol % $NaBF_4$)	$A \cdot 10^2$	E (cal mol^{-1})
92	8.77	4451
100	8.32	4689

Reference: [123]. Data reported in equation form.

TABLE 180. $NaF-NaBF_4$: Surface tension

Temperature-dependent equation

$\gamma = a + bT$ (dyn cm^{-1})

Comp. (mol % $NaBF_4$)	a	$b \cdot 10^{-2}$	Uncertainty
92	150	7.5	±30%
100	140	7.5	±25%

Reference: [124]. Data reported in equation form, no temperature ranges were given.

$NaF-SmF_3$

Electrical Conductance

The recommended values in table 183 are based on the work of Meaker, Porter, and Kesterke (classical ac technique) [87].

TABLE 181 A. Investigations critically re-examined

Ref.	SmF_3 (mol %)	Temp. range (T)
87	0, 10, 20, 30, 40, 50	1103–1343

TABLE 181 B. Comparisons with previous recommendations

Ref.	Recommended value		SmF_3 (mol %)	% Departure			
	Vol.	Page		% (min)	(T)	% (max)	(T)
87	1	3	0	5.0	(1300)	7.4	(1340)

TABLE 181 C. Cell materials and calibration

Cell material	Electrodes	Frequency range (Hz)
Capillary cell consisting of two boron nitride cylinders encased in a graphite jacket [87]	Mo [87]	20–20,000 measurements at 10,000 [87]

Comment: The specific conductance values measured in reference [87] were reported reproducible to ±1 percent. The precision of the measurements was ±3 percent. The measured resistance was found to be independent of frequency over the range 20 to 20,000 hertz.

Density

The recommended values in table 184 are based on the work of Meaker, Porter, and Kesterke (Archimedean method) [87].

TABLE 182 A. Investigations critically re-examined

Ref.	SmF_3 (mol %)	Temp. range (T)
87	0–50	1103–1343

TABLE 182 B. Cell materials and calibration

Cell material	Calibration
Mo plummet connected to a quartz spring by a Mo wire, melt contained in a graphite crucible [87]	Molten KCl [87]

Melt Preparation and Purification

Reagent-grade chemicals were used in references [87] and [98]. After vacuum drying at 400 °C the salts were cooled and combined in the correct proportions. The salts were then placed in graphite crucibles and heated under vacuum (50 μm Hg) to 600 °C. For density and conductance measurements the mixtures were melted in an atmosphere of helium in a controlled-atmosphere chamber. Melt compositions were confirmed by analyses after density measurements.

TABLE 183 a. NaF-SmF_3: Electrical conductance

Specific conductance: Numerical values ($ohm^{-1}cm^{-1}$)

Mol percent SmF_3

T	50.0	40.0	30.0	20.0	10.0	0.0
1110				2.88		
1120			2.39	2.92		
1130			2.43	2.97		
1140			2.48	3.02		
1150		2.21	2.53	3.06		
1160		2.26	2.57	3.11		
1170		2.31	2.62	3.16		
1180		2.36	2.66	3.20	3.96	
1190		2.41	2.71	3.25	4.01	
1200		2.46	2.76	3.30	4.06	
1210		2.51	2.80	3.34	4.11	
1220		2.56	2.85	3.39	4.16	
1230		2.61	2.89	3.43	4.21	
1240		2.65	2.94	3.48	4.26	
1250		2.70	2.99	3.53	4.31	
1260		2.75	3.03	3.57	4.36	
1270		2.80	3.08	3.62	4.41	
1280	2.65	2.85	3.01	3.67	4.46	
1290	2.70	2.90	3.17	3.71	4.51	
1300	2.74	2.95	3.22	3.76	4.56	
1310	2.79	3.00	3.26	3.81	4.60	5.33
1320	2.83	3.05	3.31	3.85	4.65	5.39
1330	2.87	3.10	3.35	3.90	4.70	5.44
1340	2.92	3.15	3.40	3.95	4.75	5.50

TABLE 183 b. Temperature-dependent equations

$\kappa = a + bT$ ($ohm^{-1}\ cm^{-1}$)

Comp. (mol % SmF_3)	a	$b \cdot 10_3$	Stand. deviation [87]
0.0	−2.060	5.640	0.0660
10.0	−1.854	4.930	0.0260
20.0	−2.301	4.663	0.0188
30.0	−2.777	4.610	0.0176
40.0	−3.458	4.929	0.0192
50.0	−2.996	4.413	0.00843

Reference: [87]. Data reported in equation form.

TABLE 184 a. NaF-SmF_3: Density

Numerical values (gcm^{-3})

Mol percent SmF_3

T	50.0	40.0	30.0	20.0	10.0	0.0
1110			3.564	3.181		
1120			3.557	3.173		
1130		3.968	3.550	3.165		
1140		3.960	3.543	3.157		
1150		3.952	3.536	3.148		
1160		3.943	3.530	3.140		
1170		3.935	3.523	3.132		
1180		3.927	3.516	3.123		
1190		3.919	3.509	3.115		
1200		3.910	3.502	3.107		
1210		3.902	3.495	3.099	2.535	
1220		3.894	3.488	3.090	2.529	
1230		3.886	3.481	3.082	2.524	
1240		3.877	3.474	3.074	2.518	
1250		3.869	3.467	3.065	2.512	
1260		3.861	3.460	3.057	2.506	
1270		3.853	3.453	3.049	2.500	
1280	4.229	3.844	3.446	3.041	2.495	1.895
1290	4.221	3.836	3.439	3.032	2.489	1.889
1300	4.212	3.828	3.432	3.024	2.483	1.882
1310	4.204	3.820	3.425	3.016	2.477	1.876
1320	4.195	3.811	3.418	3.007	2.472	1.870
1330	4.186	3.803	3.411	2.999	2.466	1.864
1340	4.178	3.794	3.405	2.991	2.460	1.858

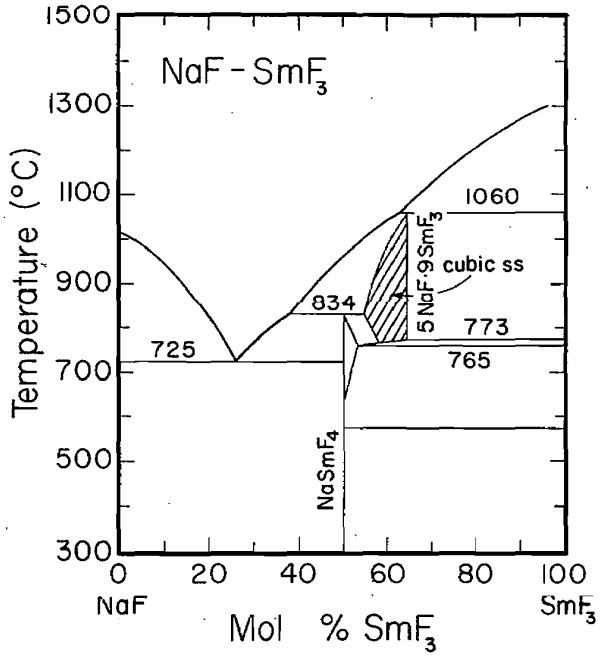

FIGURE 46. Temperature-composition phase diagram for NaF-SmF_3.
R. E. Thoma, H. Insley, and G. M. Herbert, Inorg. Chem., 5 [7], 1224 (1966).

TABLE 184 b. Temperature-dependent equations

$\rho = a + bT$ (gcm^{-3})

Comp. (mol % SmF_3)	a	$b.10^4$	Stand. deviation [87, 98]
0.0	2.682	−6.151	0.00239
10.0	3.233	−5.764	0.0107
20.0	4.101	−8.282	0.0085
30.0	4.335	−6.943	0.0113
40.0	4.901	−8.255	0.0191
50.0	5.324	−8.553	0.0130

References: [87] and [98] (for NaF). Data reported in equation form. Two-dimensional statistical analysis was unsuccessful.

NaF-SrF_2

Electrical Conductance

The recommended values in table 186 are based on the work of Thompson and Kaye (classical ac technique) [111].

TABLE 185 A. Investigations critically re-examined

Ref.	SrF_2 (mol %)	Temp. range (T)
111	40.1	1173–1373
100*	40.1	1173, 1273, 1373

* Data from reference [111].

TABLE 185 B. Cell materials and calibration

Cell material	Electrodes	Frequency range (Hz)	Calibration
Pt crucible [111]	Pt [111]	1000 [111]	Molten KNO_3 [111]

Melt Preparation and Purification

Thompson and Kaye [111] used analyzed chemical reagents (J. T. Baker Chemical Co.) without further purification.

TABLE 186 a. $NaF–SrF_2$: Electrical conductance

Specific conductance: Numerical values (ohm^{-1} cm^{-1})

T	40.1 Mol % SrF_2
1180	4.489
1200	4.609
1220	4.729
1240	4.850
1240	4.970
1280	5.091
1300	5.211
1320	5.332
1340	5.452
1360	5.573

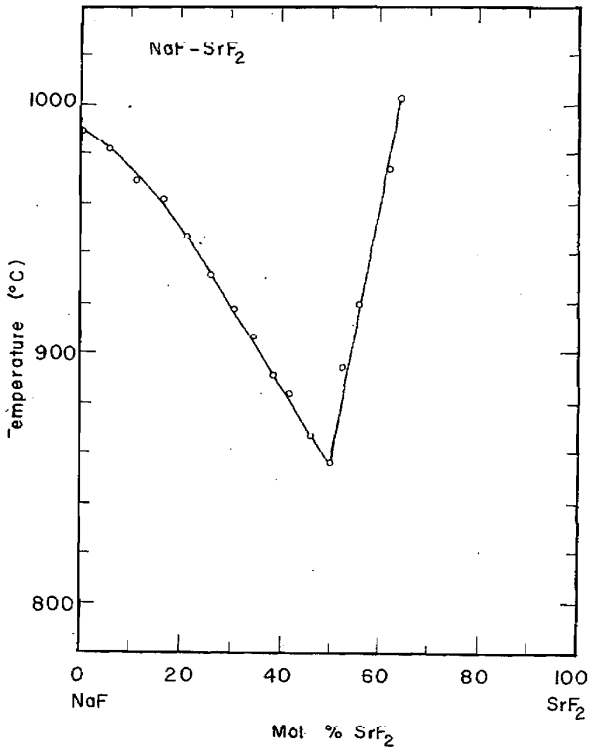

FIGURE 47. Temperature-composition phase diagram for $NaF-SrF_2$.
G. A. Bukhalova, Izv. Sekt. Fiz. Khim. A., **26**, 138 (1955).

TABLE 186 b. Temperature-dependent equations

$K=a+bT$ (ohm^{-1} cm^{-1})

Comp. (mol % SrF_2)	a	$b \cdot 10^3$	Stand. error of est.
40.1	−2.6174	6.0220	0.058

Reference: [111]. Data reported in numerical form.

$NaF-ThF_4$

Electrical Conductance

The recommended values in table 189 are based on the work of Brown and Porter (classical ac technique) [24].

TABLE 187 A. Investigations critically re-examined

Ref.	ThF_4 (mol %)	Temp. range (T)
24	0–50	1073–1363
100*	12, 33, 50	1073–1363
87	0–50	1073–1343

*Data from reference [24].

TABLE 187 B. Comparisons with previous recommendations

Ref.	Recommended value		ThF_4 (mol %)	% Departure			
	Vol.	Page		% (min)	(T)	% (max)	(T)
24	1	3	0	5.5	(1310)	8.3	(1360)
87	1	3	0	5.5	(1310)	8.3	(1360)

TABLE 187 C. Cell materials and calibration

Cell material	Electrodes	Frequency range (Hz)	Calibration
Boron nitride cylinders with graphite jackets, melt contained in graphite crucible [24, 87]	Mo tubes [24, 87]	1000–20,000 experimental values at 10,000 [24] 20–20,000 experimental values at 10,000 [87]	Molten KCl [24]

Comments: Remarks concerning references [24] and [87] are discussed under the LiF-UF_4 and CaF_2-LiF systems, respectively.

Electrical Conductivity values reported by Porter, Meaker and Kesterke [87] are identical to the earlier values of Porter and Brown [24].

Density

The recommended values in table 190 are based on the work of Porter and Meaker (Archimedean method) [98].

TABLE 188 A. Investigations critically re-examined

Ref.	ThF_4 (mol %)	Temp. range (T)
24	0–50	1073–1363
87	0–50 (graphical)	1273
98	0, 12, 20, 33, 40, 50	1073–1353

TABLE 188 B. Comparisons with previous recommendations

Ref.	Recommended value		ThF_4 (mol %)	% Departure			
	Vol.	Page		% (min)	(T)	% (max)	(T)
24	4.1	98	50	2.9	(1073)	3.1	(1353)
24	4.1	98	40	3.0	(1113)	3.2	(1353)
24	4.1	98	33	2.8	(1093)	3.0	(1353)
24	4.1	98	20	2.7	(1123)	2.8	(1343)
24	4.1	98	12	2.6	(1173)	2.7	(1343)
24	4.1	98	0	1.7	(1340)	2.4	(1280)
24	1.1	3	0	0.0	(1330)	0.5	(1360)
98	1.1	3	0	−2.2	(1280)	−2.5	(1340)

TABLE 188 C. Cell Materials and Calibration

Cell material	Calibration
Mo plummet connected to a quartz spring by a Mo wire, melt contained in a graphite crucible [24, 87, 98]	Molten KCl [24, 87, 98]

Comment: The density measurements of molten KCl in the temperature range 810 to 975 ° C for references [24] and [98] agreed with the published values of Van Artsdalen and Yaffe (NSRDS-NBS-15, Molten Salts: Vol. 1, reference 79) to within an average deviation of ±0.4 percent and ±0.3 percent, respectively.

Density values were initially reported by Brown and Porter [24] and then by Porter and Meaker [98]. The more recent measurements [98] were made with an improved apparatus involving a more precise control of the immersed volume of the plummet. Density values [98] were reported in the form of linear temperature-dependent equations with standard deviations in the range: 2.39×10^{-3} gcm^{-3} (0 mol % ThF_4) to 22.5×10^{-3} gcm^{-3} (40 mol % ThF_4).

Melt Preparation and Purification

The procedure used by Brown and Porter [24] is discussed under the LiF-ThF_4 system.

The method of Porter and Meaker [98] is discussed under the system CaF_2-LiF.

TABLE 189 a. NaF-ThF_4: Electrical conductance

Specific conductance: Numerical values (ohm $^{-1}$ cm^{-1})

Mol percent ThF_4

T	50.0	40.0	33.0	20.0	12.0	0
1080	1.52	1.66	1.79	2.45		
1090	1.57	1.70	1.83	2.49		
1100	1.62	1.74	1.87	2.53		
1110	1.68	1.77	1.91	2.56		
1120	1.73	1.81	1.95	2.60		
1130	1.78	1.85	1.98	2.64		
1140	1.83	1.88	2.02	2.68		
1150	1.88	1.92	2.06	2.71		
1160	1.94	1.96	2.10	2.75		
1170	1.99	1.99	2.14	2.79		
1180	2.04	2.03	2.18	2.83	3.51	
1190	2.09	2.07	2.22	2.86	3.55	
1200	2.15	2.10	2.26	2.90	3.58	
1210	2.20	2.14	2.29	2.94	3.62	
1220	2.25	2.18	2.33	2.98	3.66	
1230	2.30	2.21	2.37	3.01	3.70	
1240	2.36	2.25	2.41	3.05	3.73	
1250	2.41	2.29	2.45	3.09	3.77	
1260	2.46	2.32	2.49	3.13	3.81	
1270	2.51	2.36	2.53	3.16	3.84	
1320						5.38
1340						5.50
1360						5.61

TABLE 190 a. NaF–ThF_4: Density

Numerical values (gcm^{-3})

Mol percent ThF_4

T	50.0	40.0	33.0	20.0	12.0	0.0
1080	5.092					
1095	5.080		4.102			
1110	5.068		4.087			
1125	5.056	4.509	4.071	3.306		
1140	5.043	4.488	4.055	3.297		
1155	5.031	4.468	4.040	3.287		
1170	5.019	4.447	4.024	3.277		
1185	5.007	4.427	4.009	3.267	2.861	
1200	4.995	4.406	3.993	3.258	2.848	
1215	4.982	4.386	3.977	3.248	2.835	
1230	4.970	4.366	3.962	3.238	2.822	
1245	4.958	4.345	3.946	3.228	2.809	
1260	4.946	4.325	3.931	3.218	2.796	
1275	4.933	4.304	3.915	3.209	2.783	1.898
1290	4.921	4.284	3.899	3.199	2.770	1.889
1305	4.909	4.263	3.884	3.189	2.757	1.879
1320	4.897	4.243	3.868	3.179	2.744	1.870
1335	4.884	4.222	3.853	3.170	2.732	1.861
1350	4.872	4.202	3.837	3.160	2.719	1.852

TABLE 189 b. Temperature-dependent equations

$\kappa = a + bT$ (ohm^{-1} cm^{-1})

Comp. (mol % ThF_4)	a	$b \cdot 10^3$
0	−2.06	5.64
12.0	−0.90	3.74
20.0	−1.61	3.76
33.0	−2.40	3.88
40.0	−2.29	3.66
50.0	−4.13	5.23

Reference: [24]. Data reported in equation form.

TABLE 190 b. Temperature-dependent equations

$\rho = a + bT$ (gcm^{-3})

Comp. (mol % ThF_4)	a	$b \cdot 10^4$	Stand. dev. [98]
0.0	2.682	−6.151	0.0024
12.0	3.881	−8.610	0.0120
20.0	4.039	−6.512	0.0198
33.0	5.241	−10.400	0.0100
40.0	6.042	−13.630	0.0225
50.0	5.973	−8.154	0.0156

Reference: [98]. Data reported in equation form. Two-dimensional statistical analysis was unsuccessful.

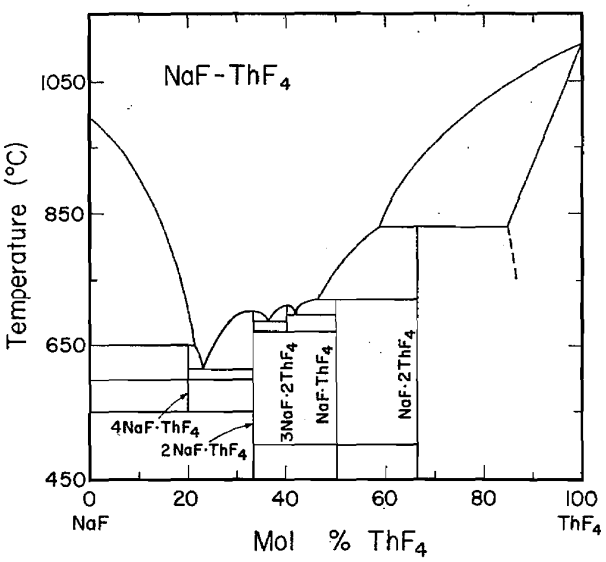

FIGURE 48. Temperature-composition phase diagram for NaF-ThF_4.
R. E. Thoma, H. Insley, B. S. Landau, H. A. Friedman, and W. R. Grimes, J. Phys. Chem., **63**, 1269 (1959).

NaF-UF_4

Electrical Conductance

The recommended values in table 194 are based on the work of Brown and Porter (classical ac technique) [**24**].

TABLE 191 A. Investigations critically re-examined

Ref.	UF_4 (mol %)	Temp. range (T)
24	0–75	973–1363
100*	15, 35, 75	973–1363
87	0–75	973–1343

*Data from reference [**24**].

Table 191 B. Comparisons with previous recommendations

Ref.	Recommended value		UF_4 (mol %)	% Departure			
	Vol.	Page		% (min)	(T)	% (max)	(T)
24	1	3	0	5.5	(1310)	8.3	(1360)

TABLE 191 C. Cell materials and calibration

Cell material	Electrodes	Frequency range (Hz)	Calibration
Boron nitride cylinders with graphite jackets, melt contained in a graphite crucible [**24**, 87]	Mo tubes [**24**, 87]	1000–20,000 experimental values at 10,000 [**24**] 20–20,000 experimental values at 10,000 [87]	Molten KCl [**24**]

Comments: Remarks concerning references [**24**] and [87] are discussed under the LiF–UF_4 and CaF_2–LiF systems, respectively.

Electrical conductivity values reported by Porter, Meaker, and Kesterke [87] are identical to the earlier values of Porter and Brown [**24**].

Density

The recommended values in table 195 are based on the work of Porter and Meaker (Archimedean method) [**98**].

TABLE 192 A. Investigations critically re-examined

Ref.	UF_4 (mol %)	Temp. range (T)
24	0–75	1073–1363
35	33.3	
87	0–75 (graphical)	1273
98	0–75	1073–1353
19	24–70	873, 973, 1073
17	24–70	873, 973, 1073

TABLE 192 B. Comparisons with previous recommendations

Ref.	Recommended value		UF_4 mol %)	% Departure			
	Vol.	Page		% (min)	(T)	% (max)	(T)
24	4.1	100	75.0	2.8	(1223)	3.0	(1323)
24	4.1	100	54.7	2.9	(1073)	3.1	(1353)
24	4.1	100	35.0	2.7	(1073)	3.0	(1353)
24	4.1	100	15	3.1	(1143)	3.4	(1303)
24	4.1	100	0	1.7	(1340)	2.4	(1280)
24	1	3	0	0.0	(1330)	0.5	(1360)
98	1	3	0	−2.2	(1280)	−2.5	(1340)

TABLE 192 C. Cell materials and calibration

Cell material	Calibration
Mo plummet connected to a quartz spring by a Mo wire, melt contained in a graphite crucible [24, 87, **98**]; Pt cylinder and suspension wire, In crucible [19, 17]	Molten KCl [24, 87, **98**]

Comments: Brief remarks concerning references [24] and [**98**] are given under the system NaF-ThF_4. Density values in reference [**98**] were reported in the form of linear temperature-dependent equations with standard deviations in the range: 2.39×10^{-3} gcm^{-3} (0 mol % UF_4) to 36.0×10^{-3} gcm^{-3} (75 mol % UF_4).

Viscosity

The recommended values in tables 196, 197 are based on the work of Cohen et al., (capillary and rotating cylinder methods [**35**]), and Blanke et al. (rotating cylinder method [**19**]).

TABLE 193 A. Investigations critically re-examined

Ref.	UF_4 (mol %)	Temp. range (T)
35	33.3	973, 1073, 1173
19	24–70	973, 1073

TABLE 193 B. Cell materials and calibration

Cell material
Inner and outer cylinder of Inconel, Ni shaft and Mo torsion wire [**19**]

Melt Preparation and Purification

Materials used by Brown and Porter [**24**] are described under the system LiF-ThF_4.

The procedure used by Porter and Meaker [**98**] is discussed under the system CaF_2-LiF.

The preparation of pure NaF by Blanke et al. [19, 17] is given under the system BeF_2-NaF. Oxide impurities were removed from ThF_4 by vacuum heating in Ni crucibles at 750 °C with a HF gas flow over the melt. The melt was cooled to 150 °C and HF was removed by a flow of H_2 gas.

TABLE 194a. NaF-UF_4: Electrical conductance

Specific conductance: Numerical values (ohm^{-1} cm^{-1})

T	Mol percent UF_4 75.0	54.7	46.0	35.0	25.0	22.0	15.0	0
980				1.40		1.66		
1000				1.49		1.74		
1020				1.58		1.82		
1040				1.68		1.90		
1060			1.96	1.77		1.98		
1080		2.02	2.04	1.86	1.90	2.07		
1100		2.10	2.12	1.96	1.99	2.15		
1120		2.18	2.20	2.04	2.07	2.23		
1140		2.25	2.28	2.14	2.16	2.30	2.88	
1160		2.33	2.36	2.23	2.25	2.39	2.95	
1180	2.20	2.42	2.44	2.33	2.34	2.47	3.02	
1200	2.27	2.49	2.52	2.42	2.42	2.55	3.09	
1220	2.34	2.57	2.60	2.51	2.51	2.64	3.16	
1240	2.41	2.65	2.68	2.61	2.60	2.71	3.23	
1260	2.49	2.73	2.76	2.70	2.69	2.79	3.31	
1280	2.56	2.81	2.84	2.79	2.77	2.88	3.38	
1310								5.33
1320								5.38
1340								5.50
1360								5.61

TABLE 194 b. Temperature-dependent equations

$\rho = a + bT$ (ohm^{-1} cm^{-1})

Comp. (mol % UF_4)	a	$b\cdot10^3$
0	−2.06	5.64
15.0	−1.18	3.56
22.0	−2.33	4.07
25.0	−2.82	4.37
35.0	−3.16	4.65
46.0	−2.27	3.99
54.7	−2.21	3.92
75.0	−2.00	3.56

Reference: [24]. Data reported in equation form.

TABLE 195 a. NaF-UF_4: Density

Numerical values (gcm^{-3})

Mol percent UF_4

T	75.0	54.7	46.0	35.0	22.0	15.0	0.0
1080		5.430	4.988	4.357	3.739		
1095		5.401	4.970	4.337	3.725		
1110		5.373	4.953	4.317	3.711		
1125		5.344	4.935	4.296	3.697		
1140		5.316	4.918	4.276	3.683		
1155		5.287	4.900	4.256	3.669	3.252	
1170		5.258	4.882	4.236	3.655	3.222	
1185		5.230	4.865	4.215	3.641	3.193	
1200		5.201	4.847	4.195	3.626	3.163	
1215	6.069	5.173	4.830	4.175	3.612	3.134	
1230	6.009	5.144	4.812	4.155	3.598	3.104	
1245	5.949	5.116	4.794	4.134	3.584	3.075	
1260	5.890	5.087	4.777	4.114	3.570	3.045	
1275	5.830	5.059	4.759	4.094	3.556	3.016	1.898
1290	5.770	5.030	4.742	4.074	3.542	2.986	1.889
1305	5.710	5.002	4.724	4.053	3.528	2.957	1.879
1320	5.651	4.973	4.706	4.033	3.514	2.928	1.870
1335	5.591	4.944	4.689	4.013	3.500	2.898	1.861
1350	5.531	4.916	4.671	3.993	3.486	2.869	1.852

TABLE 195 b. Temperature-dependent equations

$\rho = a + bT$ (gcm^{-3})

Comp. (mol % UF_4)	a	$b \cdot 10^4$	Stand. dev. [98]
0.0	2.682	−6.151	0.00239
15.0	5.520	−19.640	0.0231
22.0	4.753	−9.388	0.0180
35.0	5.815	−13.500	0.0129
46.0	6.256	−11.740	0.0200
54.7	7.485	−19.030	0.0330
75.0	10.907	−39.820	0.0360

Reference: [98]. Data reported in equation form. Two dimensional statistical analysis was unsuccessful.

TABLE 196. NaF–UF_4: Viscosity

Numerical values (cp)

Mol percent UF_4

T	70	60	54	46.16	42	37.5	33.33	25	24
973.2		16.62	16.60	12.93	13.13	12.40	11.50		12.25
1073.2	10.99	10.59	10.98	8.27	8.64	7.62	6.93	5.72	7.24

Reference: [19]. Due to limited data the numerical interpolated values reported in reference [19] are given.

TABLE 197. NaF–UF_4: Viscosity

Numerical values (cp)

T	33.3 Mol % UF_4
973.2	10.25
1073.2	7.0
1173.2	5.15

Reference: [35]. Due to limited data the experimental values are given.

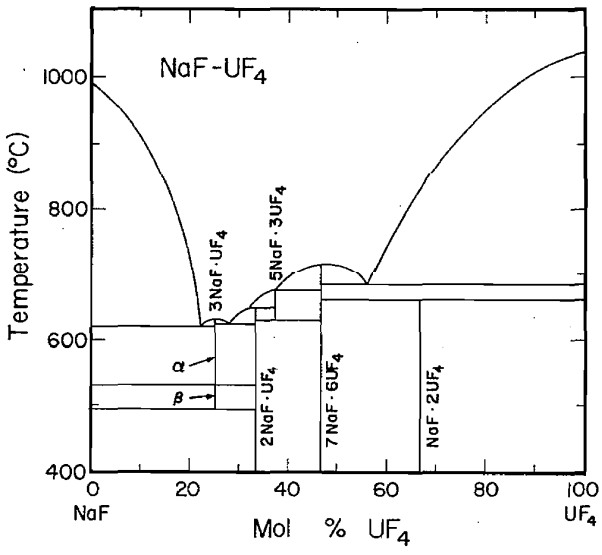

FIGURE 49. Temperature-composition phase diagram for NaF-UF_4. C. J. Barton, H. A. Friedman, W. R. Grimes, H. Insley, R. E. Moore, and R. E. Thoma, J. Amer. Ceram. Soc., 41 [2], 68 (1958).

NaF-YF_3

Electrical Conductance

The recommended values in table 200 are based on the work of Meaker, Porter, and Kesterke (classical ac technique) [87].

TABLE 198 A. Investigations critically re-examined

Ref.	YF_3 (mol %)	Temp. range (T)
87	0, 10, 29, 32, 50	963–1343

TABLE 198 B. Comparisons with previous recommendations

Ref.	Recommended value		YF_3 (mol %)	% Departure			
	Vol.	Page		% (min)	(T)	% (max)	(T)
87	1	3	0	5.0	(1300)	7.4	(1340)

TABLE 198 C. Cell materials and calibration

Cell material	Electrodes	Calibration
Capillary cell consisting of two boron nitride cylinders encased in a graphite jacket [87]	Mo [87]	20–20,000 Hz measurements at 10,000 Hz [87]

Comment: The specific conductance values measured in reference [87] were reported reproducible to ±1 percent. The precision of the measurements was ±3 percent. The measured resistance was found to be indepdendent of frequency over the range 20 to 20,000 hertz.

Density

The recommended values in table 201 are based on the work of Porter and Meaker (Archimedean method) [98].

TABLE 199 A. Investigations critically re-examined

Ref.	YF_3 (mol %)	Temp. range (T)
87	0–50 (graphical)	1273
98	0, 10, 20, 29, 32, 50	993–1353

TABLE 199 B. Comparisons with previous recommendations

Ref.	Recommended value		YF_3 (mol %)	% Departure			
	Vol.	Page		% (min)	(T)	% (max)	(T)
98	1	3	0	−2.2	(1270)	−2.5	(1350)

TABLE 199 C. Cell materials and calibration

Cell material	Electrodes	Frequency range (Hz)
Capillary cell consisting of two boron nitride cylinders encased in a graphite jacket [87]	Mo [87]	20–20,000 measurements at 10,000 [87]

Comment: Brief remarks concerning reference [98] are given under the system CaF_2-LiF.

Density values [98] were reported in the form of linear temperature-dependent equations with standard deviations in the range: 7.05×10^{-3} gcm^{-3} (0 mol % YF_3) to 21.0×10^{-3} gcm^{-3} (50 mol % YF_3).

Melt Preparation and Purification

The method used by Porter et al. [87, 98] is described under the system CaF_2-LiF. Yttrium fluoride contained less than 0.1 weight-percent of metallic impurities.

TABLE 200 a. NaF-YF_3: Electrical conductance

Specific conductance: Numerical values (ohm^{-1} cm^{-1})

Mol percent YF_3

T	50.0	32.0	29.0	20.0	10.0	0.0
980		1.51	1.59			
1000		1.59	1.69			
1020		1.68	1.78			
1040		1.77	1.88			
1060		1.86	1.98			
1080		1.95	2.07			
1100		2.03	2.17	2.67		
1120		2.12	2.27	2.75		
1140		2.21	2.36	2.84		
1160		2.30	2.46	2.92		
1180	1.89	2.39	2.56	2.00		
1200	1.98	2.48	2.66	3.09		
1220	2.07	2.56	2.75	3.17	3.99	
1240	2.16	2.65	2.85	3.25	4.07	
1260	2.25	2.74	2.95	3.33	4.14	
1280	2.34	2.83	3.04	3.42	4.21	
1300	2.44	2.92	3.14	3.50	4.29	
1320	2.53	3.00	3.24	3.58	4.36	5.39
1340	2.62	3.09	3.33	3.67	4.43	5.50

TABLE 200 b. Temperature-dependent equations

$\kappa = a + bT$ ($ohm^{-1}\ cm^{-1}$)

Comp. (mol % YF_3)	a	$b \cdot 10^3$	Stand. deviations [87]
0.0	−2.060	5.640	0.0660
10.0	−0.516	3.694	0.0116
20.0	−1.895	4.150	0.0150
29.0	−3.159	4.845	0.030
32.0	−2.815	4.408	0.0256
50.0	−3.524	4.584	0.0360

Reference: [87]. Data reported in equation form.

TABLE 201 b. Temperature-dependent equations

$\rho = a + bT$ (gcm^{-3})

Comp. (mol % YF_3)	a	$b \cdot 10^4$	Stand. dev. [98]
0.0	2.682	−6.151	0.00239
10.0	3.239	−7.947	0.00870
20.0	3.321	−7.071	0.00956
29.0	3.455	−6.178	0.0103
32.0	3.779	−8.110	0.00760
50.0	4.487	−9.957	0.0210

Reference: [98]. Data reported in equation form. Two-dimensional statistical analysis was unsuccessful.

TABLE 201 a. NaF-YF_3: Density

Numerical values (gcm^{-3})

Mol percent YF_3

T	50.0	32.0	29.0	20.0	10.0	0.0
1005			2.834			
1020			2.825			
1035		2.940	2.816			
1050		2.927	2.806			
1065		2.915	2.797			
1080		2.903	2.788			
1095		2.891	2.779			
1110		2.879	2.769	2.536		
1125		2.867	2.760	2.526		
1140		2.854	2.751	2.515		
1155		2.842	2.741	2.504		
1170		2.830	2.732	2.494		
1185		2.818	2.723	2.483		
1200		2.806	2.714	2.472		
1215		2.794	2.704	2.462	2.273	
1230	3.262	2.781	2.695	2.451	2.262	
1245	3.247	2.769	2.686	2.441	2.250	
1260	3.232	2.757	2.677	2.430	2.238	
1275	3.217	2.745	2.667	2.419	2.226	1.898
1290	3.203	2.733	2.658	2.409	2.214	1.889
1305	3.188	2.721	2.649	2.398	2.202	1.879
1320	3.173	2.708	2.640	2.388	2.190	1.870
1335	3.158	2.696	2.630	2.377	2.178	1.861
1350	3.143	2.684	2.621	2.366	2.166	1.852

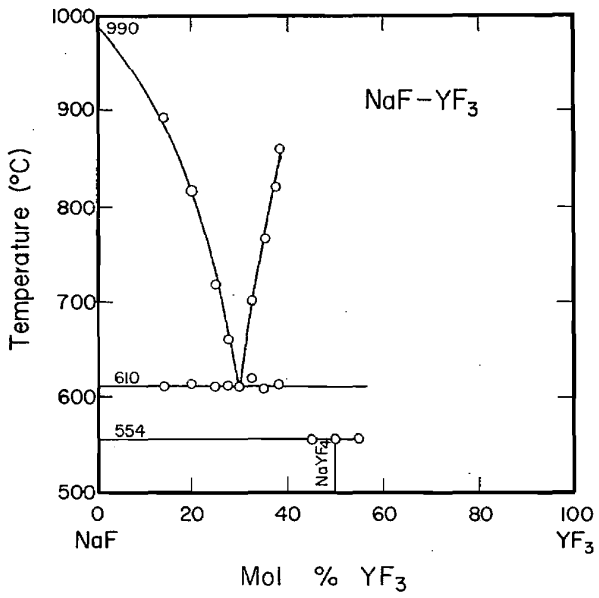

FIGURE 50. Temperature-composition phase diagram for NaF-YF_3. G. A. Bukhalova and E. P. Babaeva, Russ. J. Inorg. Chem., 11, 349 (1966).

$NaF\text{-}ZrF_4$

Electrical Conductance

The recommended values in figure 51 were based on the work of Greene (classical ac technique and modified ac potentiometric method) [54].

TABLE 202 A. Investigations critically re-examined

Ref.	ZrF_4 (mol %)	Temp. range (T)
35*	43, 50	866, 977, 1089
54	43, 50 (graphical)	825–1227
100*	43, 50	838, 1003, 1158
50	0–25 (graphical)	1323

* Data from [54].

TABLE 202 B. Cell materials and calibration

Cell material	Electrodes	Frequency range (Hz)	Calibration
BeO dip cell with melt in Pt crucible [54]	Pt [54]	1000 (500 used with potentiometric method) [54]	KCl solution and molten KCl [54]
Boron nitride cell [50]	Inconel [50]	20–20,000 (measurements at 20,000) [50]	Molten NaF and measured cell dimensions [50]

Comment: Greene [54] used three conductivity cells in his investigation. A beryllium oxide dip-type cell and a low resistance platinum crucible cell were used in conjunction with an ac Wheatstone bridge. A current-potential cell consisting of Pt electrodes immersed in a Pt crucible was used with a modified ac potentiometric bridge. Conductivity values were reported to be accurate to ±10 percent.

Fontana and Winand [50] used a boron nitride cell of the type described by Yim and Feinleib [119].

Density

The recommended values in table 206 and figure 52 are based on the work of Fontana and Winand (Archimedean method) [49].

TABLE 203 A. Investigations critically re-examined

Ref.	ZrF_4 (mol %)	Temp. range (T)
121	50	
35	50	
97	0–33.3	1173, 1273
49	0, 5, 10, 25	1253–1368

TABLE 203 B. Comparisons with previous recommendations

Ref.	Recommended value		ZrF_4 (mol %)	% Departure			
	Vol.	Page		% (min)	(T)	% (max)	(T)
97	1	3	0	−1.83	(1273)		

TABLE 203 C. Cell materials and calibration

Cell material	Calibration
Pt spherical bob [97]	
Pt −10% Rh bob and Pd alloy suspension wire [49]	Molten NaF [49]

Comment: The density apparatus of Fontana and Winand [49] was calibrated with molten NaF using the values of Jaeger (Molten Salts: Vol. 1, reference 25) and Blander (Molten Salt Chemistry, Interscience, N.Y., 1964). The overall error was less than 0.2 percent.

Viscosity

The recommended values in table 207 are based on the work of Cohen et al. (capillary and rotating-cylinder method) [35].

TABLE 204 A. Investigations critically re-examined

Ref.	ZrF_4 (mol %)	Temp. range (T)
102	50	873
35	47, 50	873, 973, 1073

Comment: Cohen [35] reported error limits of ±10 percent for his viscosity measurements.

Surface Tension

The recommended values in table 208 are based on the work of Decroly, Fontana, and Winand (Wilhelmy slide plate method) [43].

TABLE 205 A. Investigations critically re-examined

Ref.	ZrF_4 (mol %)	Temp. range (T)
43	0–25	1213–1325

TABLE 205 B. Comparisons with previous recommendations

Ref.	Recommended value		ZrF_4 (mol %)	% Departure			
	Vol.	Page		% (min)	(T)	% (max)	(T)
43	2	56	0	4.4	(1322)	5.5	(1319)

TABLE 205 C. Cell materials and calibration

Cell material	Calibration
Pt-10% Rh plate and melt contained in graphite crucible [43]	Water, 25 °C [43]

Comment: Surface tension results [43] on molten KCl at 900 and 1000 °C differed from the recommended data of Dahl and Duke (Molten Salts: Vol. 2, reference 31a) by −9.5 percent and −10.6 percent, respectively.

Melt Preparation and Purification

Winand et al. [43, 49, 50] dried pure NaF under vacuum at 180 °C. The ZrF_4 was sublimed and dried under vacuum at 180 °C.

TABLE 206 a. $NaF-ZrF_4$: Density

Numerical va'ues (gcm^{-3})

Mol percent ZrF_4

T	25	20	15	10	5	0
1323.2	2.43	2.36	2.27	2.17	2.05	1.92

TABLE 206 b. Composition-dependent equations

$\rho = a + bx + cx^2$ (gcm^{-3})

(x: mol fraction ZrF_4)

Temperature (T)	a	b	c
1323.2	1.915	2.81	−2.95

TABLE 206 c. Temperature-dependent equation

Comp. (mol % ZrF_4)	a	$b \cdot 10^4$	Temp. range (T)
0 to 25	2.669	−5.7	~1313 to ~1330

Reference: [49]. Data reported in equat on form.

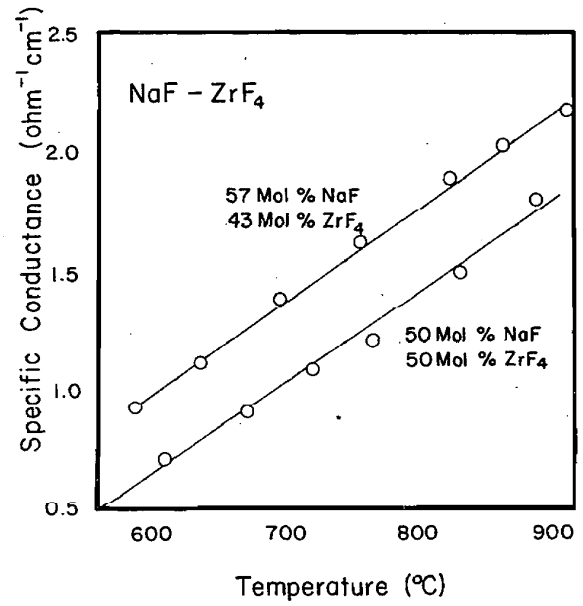

Figure 51. Plots [54] of specific conductance against temperature for the system $NaF-ZrF_4$.

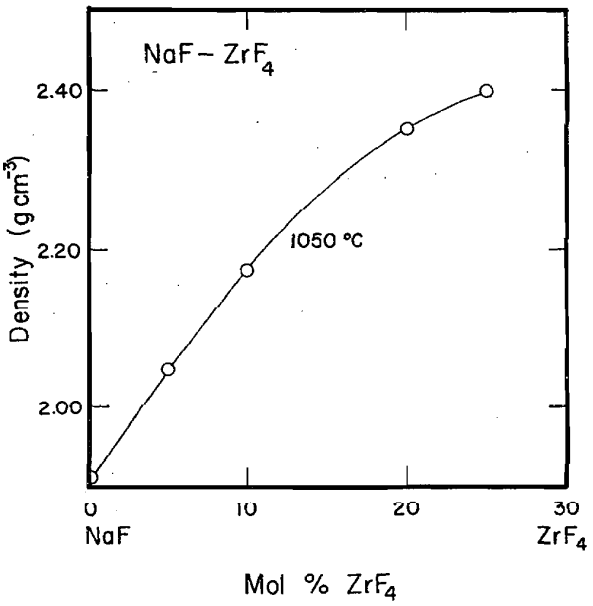

FIGURE 52. Isotherms [49] (°C) of density against molar composition for the system $NaF-ZrF_4$.

TABLE 207. $NaF\text{-}ZrF_4$: Viscosity

Numerical values (cp)

Mol percent ZrF_4

T	50	47
873.2	2.60	7.5
973.2	1.66	4.6
1073.2	1.13	3.2

Reference: [35]. Due to limited data the experimental values are given.

TABLE 208. $NaF\text{-}ZrF_4$: Surface tension

Numerical values (dyn cm^{-1})

Mol percent ZrF_4

T	25	20	15	10	5	0
1213.2			162.8			
1222.2				175.0		
1284.2		148.6				
1316.2					175.0	
1318.2			155.4			
1319.2		144.2		164.8		
1324.2	134.8					
1325.2						186.3

Reference: [43]. Due to limited data the experimental values are given.

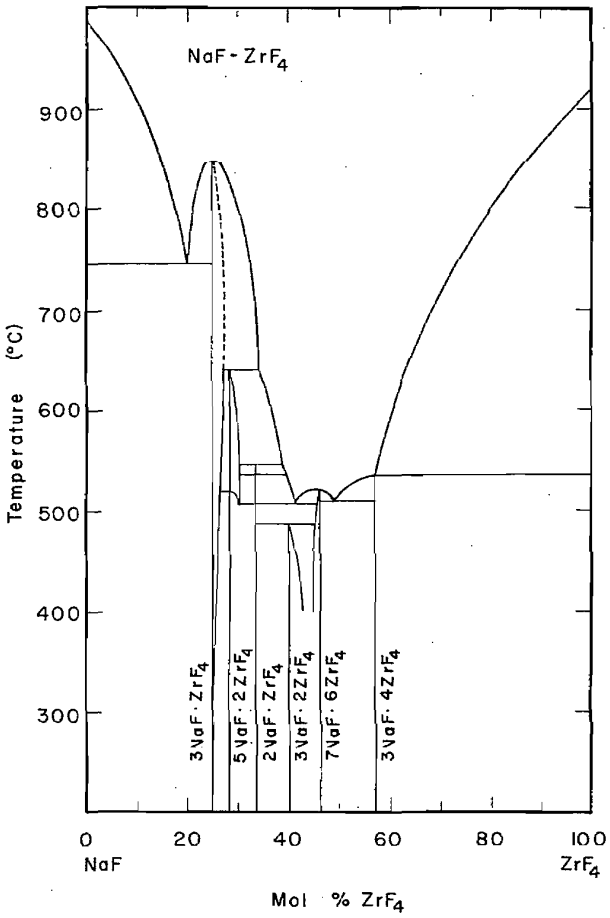

FIGURE 53. Temperature-composition phase diagram for $NaF\text{-}ZrF_4$. W. R. Grimes, D. R. Cuneo, F. F. Blankenship, G. W. Keilholtz, H. F. Poppendick, M. T. Robinson in "Fluid Fuel Reactors", by Lane, MacPherson, Maslaw, p. 570, chap. 12, 1958.

TiF_4-XeF_2

Electrical Conductance

The recommended values in figure 54 are based on the work of Rüdiger and Meinert (classical ac technique) [105].

TABLE 209A. Investigations critically re-examined

Ref.	XeF_2 (mol %)	Temp. range (T)
105	≅37–81 (graphical)	405

TABLE 209B. Cell materials and electrodes

Cell material	Electrodes
Quartz [105]	Pt [105]

Comment: After three measurements the Pt electrodes were replaced due to attack by the melt.

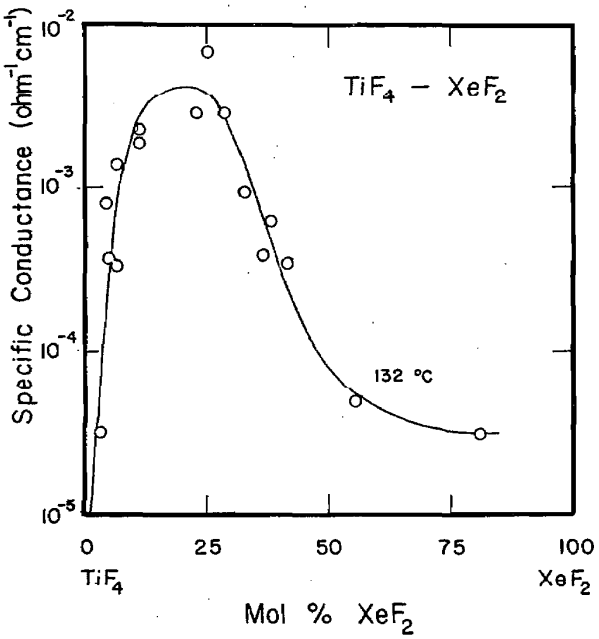

FIGURE 54. Isotherms [105] (°C) of specific conductance against molar composition for the system TiF_4-XeF_2.

6.2. General Summary Tables

TABLE 210. Total and recommended investigations [a]

System		κ		ρ		η		γ	
		No. of invest.	Recommended reference	No. of invest.	Recommended reference	No. of invest.	Recommended reference	No. of invest.	Recommended reference
AlF_3	-CsF			2	[25]				
	-KF	4	[120]	2	[74]				
	-LiF	11	[80]	8	[75, 95]	1	[108]		
	-NaF	25	[45, 46]	21	[75, 95]	5	[5]	2	[20]
	-RbF			2	[25, 74]				
BaF_2	-CsF			1	[26]				
	-KF			1	[26]				
	-LiF			1	[26]				
	-NaF	3	[111]	2	[7]				
BeF_2	-KF					3	[35]		
	-LiF	7	[102]	8	[30, 33]	7	[33]	3	[109]
	-NaF	1	[30]	4	[17]	4	[19, 35]	1	[72]
	-RbF			1	[35]	1	[35]		
	-UF_4			1	[18]				
CaF_2	-LiF	1	[87]	2	[98]				
	-NaF	3	[111]	1	[7]				
CeF_3	-KF	1	[87]	2	[98]				
	-LiF	1	[87]	2	[98]				
	-NaF	1	[87]	2	[98]				
KF	-KBF_4	1	[611]						
	-LaF_3	1	[87]	2	[98]				
	-LiF	1	[87]	6	[98]			1	[89]
	-NaF	2	[87]	3	[98]			1	[89]
	-SmF_3	1	[87]	1	[98]				
	-ThF_4	1	[87]	2	[98]				
	-UF_4	1	[87]	2	[98]				
	-YF_3	1	[87]	2	[98]				
	-ZrF_4	1	[107]	1	[107]	1	[107]	1	[107]
LaF_3	-LiF	1	[87]	2	[98]				
	-NaF	1	[87]	2	[98]				
LiF	-NaF	1	[87]	5	[75]	1	[35]	2	[89]
	-RbF			1	[35]	1	[35]		
	-SmF_3	1	[87]	1	[87]				
	-ThF_4	3	[24]	4	[60]				
	-UF_4	3	[24]	4	[98]	1	[18]		
	-YF_3	1	[87]	2	[98]				
NaF	-$NaBF_4$	2	[125]	2	[123]	2	[123]	1	[124]
	-SmF_3	1	[87]	1	[87]				
	-SrF_2	2	[111]						
	-ThF_4	3	[24]	3	[98]				
	-UF_4	3	[24]	6	[98]	2	[19, 35]		
	-YF_3	1	[87]	2	[98]				
	-ZrF_4	4	[54]	4	[49]			1	[43]
TiF_4	-XeF_2	1	[105]						

[a] Total number of investigations and recommended references for specific conductance, density, viscosity, and surface tension of molten fluoride mixtures.

TABLE 211 a. References [a]

Specific conductance

System	No. of invest.	Literature references
AlF_3 –KF	4	14, 15, 100, **120**
–LiF	11	6, 40, 41, 42, 77, 79, **80**, 84, 86, 100, 120
–NaF	25	5, 6, 10, 12, 14, 39, 40, 41, **45**, **46**, 51, 70, 77, 79, 80, 81, 82, 85, 86, 96, 104, 110, 114, 116, 120
BaF_2 –NaF	3	100, 110, **111**
BeF_2 –LiF	7	22, 29, 30, 55, 57, 58, **102**
–NaF	1	**30**
CaF_2 –LiF	1	**87**
–NaF	3	10, 100, **111**
CeF_3 –KF	1	**87**
–LiF	1	**87**
–NaF	1	**87**
KF –KBF_4	1	**125**
–LaF_3	1	**87**
–LiF	1	**87**
–NaF	2	14, **87**
–SmF_3	1	**87**
–ThF_4	1	**87**
–UF_4	1	**87**
–YF_3	1	**87**
–ZrF_4	1	**107**
LaF_3 –LiF	1	**87**
–NaF	1	**87**
LiF –NaF	1	**87**
–SmF_3	1	**87**
–ThF_4	3	**24**, 87 100
–UF_4	3	**24**, 87, 100
–YF_3	1	**87**
NaF –$NaBF_4$	2	124, **125**
–SmF_3	1	**87**
–SrF_2	2	100, **111**
–ThF_4	3	**24**, 87, 100
–UF_4	3	**24**, 87, 100
–YF_3	1	**87**
–ZrF_4	4	35, 50, **54**, 100
TiF_4 –XeF_2	1	**105**

[a] Total number of investigations, recommended and literature references for specific conductance of molten fluoride mixtures.

TABLE 211 b. References [a]

Density

System	No. of invest.	Literature references
AlF_3 –CsF	2	**25**, 74
–KF	2	25, **74**
–LiF	8	74, **75**, 83, 84, 86, 94, **95**, 108
–NaF	21	4, 5, 7, 25, 45, 46, 52, 65, **75**, 83, 84, 85, 86, 92, 93, 94, **95**, 96, 103, 108, 115
–RbF	2	**25**, **74**
BaF_2 –CsF	1	**26**
–KF	1	**26**
–LiF	1	**26**
–NaF	2	7, 26
BeF_2 –LiF	8	18, 29, **30**, 32, **33**, 35, 57, 121
–NaF	4	**17**, 19, 30, 35
–RbF	1	**35**
–UF_4	1	**18**
CaF_2 –LiF	2	87, **98**
–NaF	1	**7**
CeF_3 –KF	2	87, **98**
–LiF	2	87, **98**
–NaF	2	87, **98**
KF –LaF_3	2	87, **98**
–LiF	6	35, 47, 48, 87, 89, **98**
–NaF	3	87, 89, **98**
–SmF_3	1	**87**
–ThF_4	2	87, **98**
–UF_4	2	87, **98**
–YF_3	2	87, **98**
–ZrF_4	1	**107**
LaF_3 –LiF	2	87, **98**
–NaF	2	87, **98**
LiF –NaF	5	**75**, 87, 88, 89, 98
–RbF	1	**35**
–SmF_3	1	**87**
–ThF_4	4	24, **60**, 87, 98
–UF_4	4	18, 24, 87, **98**
–YF_3	2	87, **98**
NaF –$NaBF_4$	2	122, **123**
–SmF_3	1	**87**
–ThF_4	3	24, 87, **98**
–UF_4	6	17, 19, 24, 35, 87, **98**
–YF_3	2	87, **98**
–ZrF_4	4	35, **49**, 97, 121

[a] Total number of investigations, recommended and literature references for density of molten fluoride mixtures.

TABLE 211 c. References [a]

Viscosity

System	No. of invest.	Literature references
AlF_3 –LiF	1	**108**
–NaF	5	5, 92, 93, 108, 117
BeF_2 –KF	3	**35**, 36, 37
–LiF	7	18, 29, **33**, 35, 37, 68, 121
–NaF	4	**19**, **35**, 56, 121
–RbF	1	**35**
KF –ZrF_4	1	**107**
LiF –NaF	1	**35**
–RbF	1	**35**
–UF_4	1	**18**
NaF –$NaBF_4$	2	122, **123**
–UF_4	2	**19**, **35**

[a] Total number of investigations, recommended and literature references for viscosity of molten fluoride mixtures.

TABLE 211 d. References [a]

Surface tension

System	No. of invest.	Literature references
AlF_3 –NaF	2	5, **20**
BeF_2 –LiF	3	29, 68, **109**
–NaF	1	**109**
KF –LiF	1	**89**
–NaF	1	**89**
–ZrF_4	1	**107**
Lif –NaF	2	68, **89**
NaF –$NaBF_4$	1	**124**
–ZrF_4	1	**43**

[a] Total number of investigations, recommended and literature references for surface tension of molten fluoride mixtures.

TABLE 212 a. Techniques

Specific conductance

A: Classical ac technique

B: Potentiometric ac technique

System	Technique*	Recommended reference
AlF_3 –KF	A	**120** Yim and Feinleib
–LiF	A	**80** Matiasovsky et al.
–NaF	A	**45** Edwards et al.
BaF_2 –NaF	A	**111** Thompson and Kaye
BeF_2 –LiF	A	**102** Robbins and Braunstein
–NaF	A	**30** Robbins and Braunstein
CaF_2 –LiF	A	**87** Meaker, Porter, and Kesterke
–NaF	A	**111** Thompson and Kaye
CeF_3 –KF	A	**87** Meaker, Porter, and Kesterke
–LiF	A	**87** Meaker, Porter, and Kesterke
–NaF	A	**87** Meaker, Porter, and Kesterke
KF –KBF	A	**125** Selivanov and Stender
–LaF_3	A	**87** Meaker, Porter, and Kesterke
–LiF	A	**87** Meaker, Porter, and Kesterke
–NAF	A	**87** Meaker, Porter, and Kesterke
–SmF_3	A	**87** Meaker, Porter, and Kesterke
–ThF_4	A	**87** Meaker, Porter, and Kesterke
–UF_4	A	**87** Meaker, Porter, and Kesterke
–YF_3	A	**87** Meaker, Porter, and Kesterke
–ZrF_4	A	**107** Sheiko
LaF_3 –LiF	A	**87** Meaker, Porter, and Kesterke
–NaF	A	**87** Meaker, Porter, and Kesterke
LiF –NaF	A	**87** Meaker, Porter, and Kesterke
–SmF_3	A	**87** Meaker, Porter, and Kesterke
–ThF_4	A	**24** Brown and Porter
–UF_4	A	**24** Brown and Porter
–YF_3	A	**87** Meaker, Porter, and Kesterke
NaF –$NaBF_4$	A	**125** Selivanov and Stender
–SmF_3	A	**87** Meaker, Porter, and Kesterke
–SrF_2	A	**111** Thompson and Kaye
–ThF_4	A	**24** Brown and Porter
–UF_4	A	**24** Brown and Porter
–YF_3	A	**87** Meaker, Porter, and Kesterke
–ZrF_4	A and B used for Ref. **54**. B used for Ref. 35	**54** Greene
TiF_4 –YeF_4	A	**105** Rudigert and Meinert

*The technique indicated applies to all references given for each system in tables 211 a–211 d.

TABLE 212 b. Techniques

Density

A: Archimedean method
B: Dilatometric method

System	Technique*	Recommended reference
AlF_3 –CsF	A	**25** Mal'tsev and Bukhalova
–KF	A	**79** Mal'tsev and Bukhalova
–LiF	A	**75** Matiasovski et al.
–NaF	A	**75** Matiasovski et al.
–RbF	A	**25** Ma'tsev and Bukhalova
BaF_2 –CsF	A	**26** Bukhalova and Yagub'yan
–KF	A	**26** Bukhalova and Yagub'yan
–LiF	A	**26** Bukhalova and Yagub'yan
–NaF	A	**7** Abramov and Kozunov
BeF_2 –LiF	A and B used for Ref. **33** and **30**	**33** Cantor, Ward, and Moynihan
–NaF	A and B is used for Ref. **30**	**17** Blanke et al.
–RbF	A	**35** Cohen et al.
$-UF_4$	A	**18** Blanke et al.
CaF_2 –LiF	A	**98** Porter and Meaker
–NaF	A	**7** Abramov and Kozunov
CeF_3 –KF	A	**98** Porter and Meaker
–LiF	A	**98** Porter and Meaker
–NaF	A	**98** Porter and Meaker
KF $-LaF_3$	A	**98** Porter and Meaker
–LiF	A	**98** Porter and Meaker
–NaF	A	**98** Porter and Meaker
$-SmF_3$	A	**87** Porter and Meaker
$-ThF_4$	A	**98** Porter and Meaker
$-UF_4$	A	**98** Porter and Meaker
$-YF_3$	A	**98** Porter and Meaker
$-ZrF_4$	A	**107** Sheiko
LaF_3 –LiF	A	**98** Porter and Meaker
–NaF	A	**98** Porter and Meaker
LiF –NaF	A	**75** Matiasovsky
–RbF	A	**35** Cohen and Jones
$-SmF_3$	A	**87** Meaker, Porter, and Kesterke
$-ThF_4$	A	**60** Hill, Cantor, and Ward
$-UF_4$	A	**98** Porter and Meaker
$-YF_3$	A	**98** Porter and Meaker
NaF $-NaBF_4$	B	**123** Cantor
$-SmF_3$	A	**87** Meaker, Porter, and Kesterke
$-ThF_4$	A	**98** Porter and Meaker
$-UF_4$	A	**98** Porter and Meaker
$-YF_3$	A	**98** Porter and Meaker
$-ZrF_4$	A	**49** Fontana and Winand

* The technique indicated applies to all references given for each system in table 211a–211d.

TABLE 212 c. Techniques

Viscosity

A: Capillary technique
B: Oscillating sphere technique
C: Oscillating hollow cylinder technique
D: Rotational cylinder technique

System	Technique	Recommended reference
AlF_3 –LiF	B **108**	**108** Vetyukov and Sipriya
–NaF	B **5**, 92, 93, 108 D 117	**5** Abramov
BeF_2 –KF	A and D **35**, 36, 37	**35** Cohen et al.
–LiF	D **18**, 29, 33, 68 A and D 102, 35, 37	**33** Cantor, Ward and Moynihan
–NaF	D **19**, 56	**35** Cohen et al.
	A and D **35**, 121	**19** Blanke et al.
–RbF	A and D **35**	**35** Cohen et al.
KF $-ZrF_4$	B **107**	**107** Sheiko
LiF –NaF	A and D **35**	**35** Cohen et al.
–RbF	A and D **35**	**35** Cohen et al.
$-UF_4$	D **18**	**18** Blanke et al.
NaF $-NaBF_4$	C **123**	**123** Cantor
$-UF_4$	A and D **35**	**35** Cohen et al.
	D **19**	**19** Blanke et al.

TABLE 212 d. Techniques

Surface tension

A: Maximum Bubble Pressure Method
B: Wilhelmy Slide Plate Method

System	Technique*	Recommended reference
AlF_3 –NaF	A	**20** Bloom and Burrows
BeF_2 –LiF	A	**109** Sturm
–NaF	A	**72** MacPherson
KF –LiF	A	**89** Mellors and Senderoff
–NaF	A	**89** Mellors and Senderoff
$-ZrF_4$	A	**107** Sheiko
LiF –NaF	A	**89** Mellors and Senderoff
NaF $-ZrF_4$	B	**43** Decroly, Fontana, and Winand

* The technique indicated applies to the references given for each system in tables 211a–211d.

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