Chapter 6　Appendix

1. Additivity equation

The additivity equations can be used from the [Data List of Property] window and the [Additivity Equation for Property Prediction] button.

Various conditions in use and sources are shown about each additivity equation below.

A calculation-range/ input-condition shows input items necessary for the calculation, and a property calculated by the additivity equation. An available region/ special-condition shows an applicable composition-range for the equation, and a relating special condition. A source shows an additivity equation's source reference.

(1) Density

① Tohge, Tanaka and Minami (Si-As-Te Chalcogenide)

Calculation-range/ input-condition:

a) The density of Si-As-Te chalcogenide at the room temperature is calculated.

b) Input the composition.

Available region/ special-condition:

a) The equation is available for the composition which consists only of three elements (Si, As and Te).

Source: N. Tohge, T. Minami, M. Tanaka, J. Am. Ceram. Soc., 59, 461 (1976)

② Tohge, Tanaka and Minami (Ge-As-Te Chalcogenide)

Calculation-range/ input-condition:

a) The density of Ge-As-Te chalcogenide at the room temperature is calculated.

b) Input the composition.

Available region/ special-condition:

a) The equation is available for the composition which consists only of three elements (Ge, As and Te).

Source: N. Tohge, T, Minami, M. Tanaka, J. Am. Ceram. Soc., 59, 461 (1976)

③ Tohge, Tanaka and Minami (As-Te-Se Chalcogenide)

Calculation-range/ input-condition:

a) The density of As-Te-Se chalcogenide at the room temperature is calculated.

b) Input the composition.

Available region/ special-condition:

a) The equation is available for the composition which consists only of three elements (As, Te and Se).

Source: N. Tohge, T, Minami, M. Tanaka, J. Am. Ceram. Soc., 59, 461 (1976)

④ Tohge, Tanaka and Minami (Ge-Te-Se Chalcogenide)

Calculation-range/ input-condition:

a) The density of Ge-Te-Se chalcogenide at the room temperature is calculated.

b) Input the composition.

Available region/ special-condition:

a) The equation is available for the composition which consists only of three elements (Ge, Te,and Se).

Source: N. Tohge, T, Minami, M. Tanaka, J. Am. Ceram. Soc., 59, 461 (1976)

⑤ Tanaka and Minami (As-S Chalcogenide)

Calculation-range/ input-condition:

a) The density of As-S chalcogenide at the room temperature is calculated.

b) Input the composition.

Available region/ special-condition:

a) The composition which consists only of two elements (As and S) can be calculated.

b) The equation is available at $0 \leqq As \leqq 43.32$at%(= mol%).

Source: M. Tanaka, T. Minami, Jpn. J. Appl. Phys., 4, 939 (1965)

⑥ Appen (Silicate)

Calculation-range/ input-condition:

a) The density of silicate at the room temperature is calculated.

b) Input the composition.

Available region/ special-condition:

a) The equation is available for the composition which consists of more than one kind of oxide in 17 kinds of oxides in the table.

b) When B_2O_3 is contained, it is available at $44 \leqq SiO_2 \leqq 80$ mol%.

c) When PbO is contained, it is available at $SiO_2 + Al_2O_3 + B_2O_3 \geqq 50$mol%.

Source: A. A. Appen, Kimiya Stekla, Leningrad 1974

⑦ Gan, Fuxi (Fluoride)

Calculation-range/ input-condition:

a) The density of fluoride at the room temperature is calculated.

b) Input the composition.

Available region/ special-condition:

a) The equation is available for the composition which consists of more than one kind of oxide in 39 kinds of fluorides in the table.

Source: F. Gan, J. Non-Cryst. Solids, 184, 9 (1995)

⑧ Huggins (Silicate)

Calculation-range/ input-condition:

a) The density of silicate at the room temperature is calculated.

b) Input the composition.

Available region/ special-condition:

a) The equation is available for the composition which consists of more than one kind of oxide in 21 kinds of oxides in the table.

b) It is available at $$0.27 \leq \frac{SiO_2(mol\%)}{\sum_i Mx_iOy_i(mol\%) \times y_i} \leq 0.50$$

where Mx_iOy_i is an oxide whose ratio of a metallic element and the oxygen element is x_i:y_i.

Source: M. L. Huggins, K-H. Sun, J. Am. Ceram. Soc., 26, 4 (1941)

(2) Young's Modulus

① Inaba, Fujino and Morinaga (Silicate)

Calculation-range/ input-condition:

a) The Young's modulus of silicate at the room temperature is calculated.

b) Input the composition.

Available region/ special-condition:

a) The equation is available for the composition which consists of more than one kind of oxide in 18 kinds of oxides in the table.

b) The density necessary for the calculation is calculated by the equation of Huggins(Silicate).

Source: S. Inaba, S. Fujino, K. Morinaga, J. Am. Ceram. Soc., 82, 3501 (1999)

② Makishima and Mackenzie

Calculation-range/ input-condition:

a) The Young's modulus of silicate at the room temperature is calculated.

b) Input the composition.

Available region/ special-condition:

a) The equation is available for the composition which consists of more than one kind of oxide in 18 kinds of oxides in the table.

b) The density necessary for the calculation is calculated by the equation of Huggins(Silicate).

Source: A. Makishima, J. D. Mackenzie, J. Non-Cryst. Solids, 12, 35 (1973)

(3) Surface Tension

① Dietzel (Silicate)

Calculation-range/ input-condition:

a) The surface tension of silicate at 900℃ is calculated.

b) Input the composition.

Available region/ special-condition:

a) The equation is available for the composition which consists of more than one kind of oxide in 19 kinds of oxides in the table.

Source: A. Dietzel, Sprechsaal, 75, 82 (1942)

② Lyon (Silicate)

Calculation-range/ input-condition:

a) The surface tension of silicate at 1200℃ is calculated.

b) Input the composition.

Available region/ special-condition:

a) The equation is available for the composition which consists of more than one kind of oxide in 9 kinds of oxides in the table.

b) It is available at SiO_2 / Na_2O (weight ratio) > 3.25.

Source: K. C. Lyon, J. Am. Ceram. Soc., 27, 186 (1944)

③ Appen (Silicate)

Calculation-range/ input-condition:

a) The surface tension of silicate at 1300℃ is calculated.

b) Input the composition.

Available region/ special-condition:

a) The equation is available for the composition which consists of more than one kind of oxide in 18 kinds of oxides in the table.

Source: A. A. Appen, Silikattechn, 5, 11 (1954)

④ Sasek (Silicate)

Calculation-range/ input-condition:

a) The surface tension of silicate at 1200℃ and 1400℃ is calculated.

b) Input the composition.

Available region/ special-condition:

a) The equation is available for the composition which consists of more than one kind of oxide in 7 kinds of oxides in the table. The available composition range has been corrected to be narrower than that in Ver. 6.

Source: L. Sasek, M. Houser, Chem. Technol. Silik., L5, 49 (1974)

(4) Linear Expansion Coefficient

① Appen (Silicate)

Calculation-range/ input-condition:

a) The thermal expansion coefficient of silicate at the temperature range 20 ~ 400℃ is calculated.

b) Input the composition.

Available region/ special-condition:

a) The equation is available for the composition which consists of more than one kind of oxide in 27 kinds of oxides in the table.

Source: A. A. Appen, Kimiya Stekla, Leningrad 1974

② Winkelmann and Schott (Silicate)

Calculation-range/ input-condition:

a) The thermal expansion coefficient of silicate at the temperature range 10 ~ 100℃ is calculated.

b) Input the composition.

Available region/ special-condition:

a) The equation is available for the composition which consists of more than one kind of oxide in 21 kinds of oxides in the table.

Source: A. Winkelmann, O. Schott, Ann. Physik, 51,735 (1894)

③ Takahashi (0 ~ 100℃) (Silicate)

Calculation-range/ input-condition:

a) The thermal expansion coefficient of silicate at the temperature range 0 ~ 100℃ is calculated.

b) Input the composition.

Available region/ special-condition:

a) The equation is available for the composition which consists of more than one kind of oxide in 19 kinds of oxides in the table.

b) When B_2O_3 is contained, it is available at the following range:

$$0 \leq \frac{B_2O_3(mol\%) \times 2}{\sum_i Mx_iOy_i(mol\%) \times x_i} \times 100 \leq 35$$

where Mx_iOy_i is an oxide whose ratio of a metallic element and the oxygen element is x_i:y_i.

Source: K. Takahashi, J. Ceram. Soc. Japan, 63, 142 (1955)

④ Takahashi (0 ~ 400℃) (Silicate)

Calculation-range/ input-condition:

a) The thermal expansion coefficient of silicate at the temperature range 0 ~ 400℃ is calculated.

b) Input the composition.

Available region/ special-condition:

a) The equation is available the composition which consists of more than one kind of oxide in 19 kinds of oxides in the table.

b) When B_2O_3 is contained, it is available at the following range:

$$0 \le \frac{B_2O_3(mol\%) \times 2}{\sum_i Mx_iOy_i(mol\%) \times x_i} \times 100 \le 35$$

where Mx_iOy_i is an oxide whose ratio of a metallic element and the oxygen element is x_i:y_i.

Source: K. Takahashi, J. Ceram. Soc. Japan, 63, 142 (1955)

⑤ Tanaka and Minami (As-S Chalcogenide)

Calculation-range/ input-condition:

a) The thermal expansion coefficient of As-S chalcogenide at the room temperature is calculated.

b) Input the composition.

Available region/ special-condition:

a) The equation is available for the composition which consists only of two elements (As and S).

b) It is available at 0≦As≦43.32at%(= mol%).

Source: M. Tanaka, T. Minami, M. Hattori, Jpn. J Appl. Phys., 5, 185 (1966)

(5) Thermal Conductivity

① Ratcliffe (Silicate)

Calculation-range/ input-condition:

a) The thermal conductivity of silicate at -100℃, 0℃ and 100℃ is calculated.

b) Input the temperature and the composition.

Available region/ special-condition:

a) The equation is available for the composition which consists of more than one kind of oxide in 12 kinds of oxides in the table.

Source: E. H. Ratcliffe, Glass Technol., 4, 113 (1963)

② Russ (Silicate)

Calculation-range/ input-condition:

a) The thermal conductivity of silicate at 0℃ is calculated.

b) Input the composition.

Available region/ special-condition:

a) The equation is available for the composition which consists of more than one kind of oxide in 10 kinds of oxides in the table.

Source: A. Russ, Sprechsaal, 61, 887 (1921)

③ Ammar (Silicate and Borate)

Calculation-range/ input-condition:

a) The thermal conductivity of silicate or Borate at 30℃ is calculated.

b) Input the composition.

Available region/ special-condition:

a) The equation is available for the composition which consists of more than one kind of oxide in 13 kinds of oxides in the table.

Source: M. M. Ammar, S. A. Gharib, M. M. Halawa, H. A. El-Batal, K. El-Badry, Communications of American Ceramic Society, May 1983, C-76

(6) Specific Heat

① Sharp and Ginther (mean over 0 ～ t ℃) (Silicate)

Calculation-range/ input-condition:

a) The mean specific heat between 0 and t℃ (t=0~1300) of silicate is calculated.

b) Input the composition and temperature t℃.

Available region/ special-condition:

a) The equation is available for the composition which consists of more than one kind of oxide in 11 kinds of oxides in the table.

b) When Mn_3O_4 or Fe_2O_3 is contained, it is available only for temperatures lower than 600℃.

Source: D. E. Sharp, L. B. Ginther, and J. Am. Ceram. Soc., 34, 260 (1951)

② Sharp and Moore (Silicate)

Calculation-range/ input-condition:

a) The specific heat of silicate at an arbitrary temperature in the temperature range of 0~1300 ℃ is calculated.

b) Input the composition and temperature.

Available region/ special-condition:

a) The equation is available for the composition which consists of more than one kind of oxide in 11 kinds of oxides in the table.

b) When Mn_3O_4 or Fe_2O_3 is contained, it is available only for temperatures lower than 600℃.

Source: J. Moore, D. E. Sharp, and J. Am. Ceram. Soc., 41, 461 (1958)

③ Schwiete and Ziegler (Silicate)

Calculation-range/ input-condition:

a) The specific heat of silicate at an arbitrary temperature in the temperature range of 0 ~ 1300 ℃ is calculated.

b) Input the composition and temperature.

Available region/ special-condition:

a) The equation is available for the composition which consists of more than one kind of oxide in 8 kinds of oxides in the table.

b) When Mn_3O_4 or Fe_2O_3 is contained, it is available only for temperatures lower than 600℃.

Source: H. E. Schwiete, G. Ziegler, and Glastechn. Ber., 28, 137 (1955)

(7) Viscosity (Standard Point)

① Lakatos (1978) (Silicate)

Calculation-range/ input-condition:

a) The temperature at the viscosity of $10^{2.5}$, $10^{3.5}$ and $10^{4.5}$ dPa・s of silicate is calculated.

b) Input the composition and viscosity.

Available region/ special-condition:

a) The equation is available for the composition which consists of more than one kind of oxide in 11 kinds of oxides in the table.

b) It is available within the range of the composition shown in the table. The available composition range has been corrected to be wider than that in Ver. 6.

Source: T. Lakatos, L.-G. Johansson, B. Simminingskold, Glasteknisk Tidskrift, 33, 55-59 (1978)

② Lakatos (1979) (Silicate)

Calculation-range/ input-condition:

a) The temperature at the viscosity of 10^{2}, 10^{4} and 10^{6} dPa・s of silicate is calculated.

b) Input the composition and viscosity.

Available region/ special-condition:

a) The equation is available for the composition which consists of more than one kind of oxide in 11 kinds of oxides in the table.

b) It is available within the range of the composition shown in the table. The available composition range has been corrected to be wider than that in Ver. 6.

Source: T. Lakatos, L.-G. Johansson, B. Simminingskold, Glasteknisk Tidskrift, 34, 61-65 (1979)

③ Okhotin (SiO_2-Na_2O-CaO)

Calculation-range/ input-condition:

a) The temperature at the viscosity of $10^3 \sim 10^{13}$ dPa・s of silicate is calculated.

b) Input the composition and viscosity.

Available region/ special-condition:

a) The equation is available for the composition which consists of more than one kind of oxide in 5 kinds of oxides in the table.

b) It is available within the range of the composition shown in the table. The available composition range has been corrected to be wider than that in Ver. 6.

Source: M. V. Okhotin, Steklo i Keramika, 11, 1 (1954)

④ Sasek (SiO_2-Na_2O-CaO-MgO)

Calculation-range/ input-condition:

a) The temperature at the viscosity of 10^{13} dPa・s of silicate is calculated.

b) Input the composition.

Available region/ special-condition:

a) The equation is available for the composition which consists of more than one kind of oxide in 7 kinds of oxides in the table.

b) It is available within the range of the composition shown in the table. The available composition range has been corrected to be wider than that in Ver. 6.

Source: L. Sasek, Silikaty, 16, 207 (1973)

⑤ Fluegel (2007) (T at 1E2.5 dPa·s)

Calculation-range/ input-condition:

a) The temperature at the viscosity of $10^{2.5}$ dPa・s of silicate is calculated.

b) Input the composition.

Available region/ special-condition:

a) The equation is available for the composition which consists of SiO_2 and more than one kind of oxides in the table.

b) It is available within the range of the composition shown in the table. The available composition range has been corrected to be wider than that in the original source.

Source: A. Fluegel, Glass Technol.:Eur. J. Glass Sci. Technol. A, vol. 48(1), 13-30 (2007)

⑥ Fluegel (2007) (T at 1E7.6 dPa·s)

Calculation-range/ input-condition:

a) The temperature at the viscosity of $10^{7.6}$ dPa・s of silicate is calculated.

b) Input the composition.

Available region/ special-condition:

a) The equation is available for the composition which consists of SiO_2 and more than one kind of oxides in the table.

b) It is available within the range of the composition shown in the table. The available composition range has been corrected to be wider than that in the original source.

Source: A. Fluegel, Glass Technol.:Eur. J. Glass Sci. Technol. A, vol. 48(1), 13-30 (2007)

⑦ Fluegel (2007) (T at 1E13.0 dPa·s)

Calculation-range/ input-condition:

a) The temperature at the viscosity of $10^{13.0}$ dPa・s of silicate is calculated.
b) Input the composition.

Available region/ special-condition:

a) The equation is available for the composition which consists of SiO_2 and more than one kind of oxides in the table.
b) It is available within the range of the composition shown in the table. The available composition range has been corrected to be wider than that in the original source.

Source: A. Fluegel, Glass Technol.:Eur. J. Glass Sci. Technol. A, vol. 48(1), 13-30 (2007)

(8) Transition Temperature

① Tanaka and Minami (As-S Chalcogenide)

Calculation-range/ input-condition:

a) The transition temperature of As-S chalcogenide is calculated.
b) Input the composition.

Available region/ special-condition:

a) The equation is available for the composition which consists only of two elements (As and S).
b) It is available at $0 \leqq As \leqq 43.32$at%(= mol%).

Source: M. Tanaka, T. Minami, M. Hattori, Jpn. J Appl. Phys., 5, 185 (1966)

(9) Viscosity

① Lakatos(1975) (Silicate)

Calculation-range/ input-condition:

a) The viscosity of silicate at an arbitrary temperature within the viscosity range $10^2 \sim 10^6$ dPa・s is calculated.
b) Input the temperature and composition.

Available region/ special-condition:

a) The equation is available for the composition which consists of more than one kind of oxide in 11 kinds of oxides in the table.
b) It is available for within the range of $SiO_2 \geqq 50$mass%.

Source: T. Lakatos, L.-G. Johansson, B. Simminingskold, Glasteknisk Tidskrift, 33, 55-59 (1978)

② Lakatos (1976) (Silicate)

Calculation-range/ input-condition:

a) The viscosity of silicate at an arbitrary temperature within the viscosity range $10^2 \sim 10^6$ dPa・s is calculated.
b) Input the temperature and composition.

Available region/ special-condition:

a) The equation is available for the composition which consists of more than one kind of oxide in 11 kinds of oxides in the table.
b) It is available within the range of the composition shown in the table. The available composition range has been corrected to be wider than that in Ver. 6.

Source: T. Lakatos, Glasteknisk Tidskrift, 31, and 51-54 (1976)

③ Sasek (Silicate)

Calculation-range/ input-condition:

a) The viscosity of silicate at an arbitrary temperature within the viscosity range $10^{2.3} \sim 10^4$dPa・s is calculated.

b) Input the temperature and composition.

Available region/ special-condition:

a) The equation is available for the composition which consists of more than one kind of oxide in 7 kinds of oxides in the table.

b) It is available within the range of the composition shown in the table. The available composition range has been corrected to be wider than that in Ver. 6.

Source: L. Sasek, Silikaty, 16, 207(1973)

④ Hrma (Silicate)

Calculation-range/ input-condition:

a) The viscosity of silicate at an arbitrary temperature within the temperature range 950～1250℃ is calculated.

b) Input the temperature and composition.

Available region/ special-condition:

a) The equation is available for the composition which consists of more than one kind of oxide in 9 kinds of oxides in the table.

b) It is available within the range of the composition shown in the table.

Source: P. Hrma, R. J. Robertus, Ceram. Eng. Sci. Proc., 14, 187 (1993)

⑤ Urbain (Silicate)

Calculation-range/ input-condition:

a) The viscosity of silicate (SiO_2-Al_2O_3-CaO) at an arbitrary temperature within the temperature range 950～1250℃ is calculated.

b) Input the temperature and composition.

Available region/ special-condition:

a) The equation is available for only the composition of SiO_2-Al_2O_3-CaO.

Source: G. Urbain, F. Cambier, M. Deletter, M. R. Anseau, Trans. J. Br. Ceram. Soc., 80, 139 (1981)

(10) Refractive Index

① Appen (Silicate)

Calculation-range/ input-condition:

a) The refractive index D-line of silicate at the room temperature is calculated.

b) Input the composition.

Available region/ special-condition:

a) The equation is available for the composition which consists of more than one kind of oxide in 17 kinds of oxides in the table.

b) When B_2O_3 is contained, it is available at $44 \leqq SiO_2 \leqq 64$ mol% or $71 \leqq SiO_2 \leqq 80$ mol%.

c) When TiO_2 is contained, it is available at (total of R_2O) <15mol% and $50 \leqq SiO_2 \leqq 80$mol%.

d) When CdO or PbO is contained, it is available at $SiO_2 + Al_2O_3 + B_2O_3 \geqq 50$mol%.

Source: A. A. Appen, Kimiya Stekla, Leningrad (1974)

② Gan Fuxi (Fluoride)

Calculation-range/ input-condition:

a) The refractive index D-line of fluoride at the room temperature is calculated.

b) Input the composition.

Available region/ special-condition:

a) The equation is available for the composition which consists of more than one kind of oxide in 39 kinds of fluorides in the table.

Source: F. Gan, J. Non-Cryst. Solids, 184, 9 (1995)

③ Huggins (Silicate)

Calculation-range/ input-condition:

a) The refractive index D-line of silicate at the room temperature is calculated.

b) Input the composition.

Available region/ special-condition:

a) The equation is available for the composition which consists of more than one kind of oxide in 21 kinds of oxides in the table.

b) It is available at $0.27 \leq \dfrac{SiO_2(mol\%)}{\sum_i Mx_iOy_i(mol\%) \times y_i} \leq 0.50$

where Mx_iOy_i is an oxide whose ratio of a metallic element and the oxygen element is x_i:y_i.

Source: M. L. Huggins, K-H. Sun, J. Am. Ceram. Soc., 26, 4 (1941)

(11) Abbe's Number

① Appen (Silicate)

Calculation-range/ input-condition:

a) The abbe's number (nd-1)/(nF-nC) of silicate at the room temperature is calculated.

b) Input the composition.

Available region/ special-condition:

a) The equation is available for the composition which consists of more than one kind of oxide in 17 kinds of oxides in the table.

b) When B_2O_3 is contained, it is available at 44≦SiO_2≦64 mol% or 71≦SiO_2≦80 mol%.

c) When TiO_2 is contained, it is available at (total of R_2O) <15mol% and 50≦ SiO_2 ≦80mol%.

d) When CdO or PbO is contained, it is available at SiO_2 + Al_2O_3 + B_2O_3 ≧ 50mol%.

Source: A. A. Appen, Kimiya Stekla, Leningrad (1974)

② Gan Fuxi (Fluoride)

Calculation-range/ input-condition:

a) The abbe's number (nd-1)/(nF-nC) of fluoride at the room temperature is calculated.

b) Input the composition.

Available region/ special-condition:

a) The equation is available for the composition which consists of more than one kind of oxide in 39 kinds of fluorides in the table.

Source: F. Gan, J. Non-Cryst. Solids, 184, 9 (1995)

③ Huggins (Silicate)

Calculation-range/ input-condition:

a) The abbe's number (nd-1)/(nF-nC) of silicate at the room temperature is calculated.

b) Input the composition.

Available region/ special-condition:

a) The equation is available for the composition which consists of more than one kind of oxide in 21 kinds of oxides in the table.

Source: M. L. Huggins, K-H. Sun, J. Am. Ceram. Soc., 26, 4 (1941)

(12) Mean Dispersion

① Appen (Silicate)

Calculation-range/ input-condition:

a) The mean dispersion F-C of silicate at the room temperature is calculated.

b) Input the composition.

Available region/ special-condition:

a) The equation is available for the composition which consists of more than one kind of oxide in 17 kinds of oxides in the table.

b) When B_2O_3 is contained, it is available at 44≦SiO_2≦64 mol% or 71≦SiO_2≦80 mol%.

c) When TiO_2 is contained, it is available at (total of R_2O) <15mol% and 50≦ SiO_2 ≦80mol%.

d) When CdO or PbO is contained, it is available at SiO_2 + Al_2O_3 + B_2O_3 ≧ 50mol%.

Source: A. A. Appen, Kimiya Stekla, Leningrad (1974)

② Gan Fuxi (Fluoride)

Calculation-range/ input-condition:

a) The mean dispersion F-C of fluoride at the room temperature is calculated.

b) Input the composition.

Available region/ special-condition:

a) The equation is available for the composition which consists of more than one kind of oxide in 39 kinds of fluorides in the table.

Source: F. Gan, J. Non-Cryst. Solids, 184, 9 (1995)

③ Huggins (Silicate)

Calculation-range/ input-condition:

a) The mean dispersion F-C of silicate at the room temperature is calculated.

b) Input the composition.

Available region/ special-condition:

a) The equation is available for the composition which consists of more than one kind of oxide in 21 kinds of oxides in the table.

b) It is available at $0.27 \le \dfrac{SiO_2(mol\%)}{\sum_i Mx_iOy_i(mol\%) \times y_i} \le 0.50$

where Mx_iOy_i is an oxide whose ratio of a metallic element and the oxygen element is x_i:y_i.

Source: M. L. Huggins, K-H. Sun, J. Am. Ceram. Soc., 26, 4 (1941)

(13) Electric Conductivity

① Sasek and M. (High Temp.) (Silicate)

Calculation-range/ input-condition:

a) The electric conductivity of silicate at an arbitrary temperature within the temperature range 1000～1400℃ is calculated.

b) Input the temperature and the composition.

Available region/ special-condition:

a) The equation is available for the composition which consists of more than one kind of oxide in 7 kinds of oxides in the table.

b) It is available within the range of the composition shown in the table.

Source: L. Sasek, H. Meissnerova, Technol. Silik., L5, 111 (1974)

② Sasek and M. (Low Temp.) (Silicate)

Calculation-range/ input-condition:

a) The electric conductivity of silicate at an arbitrary temperature within the temperature range 320～540℃ is calculated.

b) Input the temperature and the composition.

Available region/ special-condition:

a) The equation is available for the composition which consists of more than one kind of oxide in 7 kinds of oxides in the table.

b) It is available within the range of the composition shown in the table. The available composition range has been corrected to be wider than that in Ver. 6.

Source: L. Sasek, H. Meissnerova, Technol. Silik., L5, 111 (1974)

③ Hrma (Silicate)

Calculation-range/ input-condition:

a) The electric conductivity of silicate at an arbitrary temperature within the temperature range 950～1250℃ is calculated.

b) Input the temperature and the composition.

Available region/ special-condition:

a) The equation is available for the composition which consists of more than one kind of oxide in 9 kinds of oxides in the table.

b) It is available within the range of the composition shown in the table. The available composition range has been corrected to be wider than that in Ver. 6.

Source: P. Hrma, R. J. Robertus, Ceram. Eng. Sci. Proc., 14, 187 (1993)

④ Fluegel

Calculation-range/ input-condition:

a) The electric conductivity of silicate at 1000°C, 1200°C or 1400°C is calculated.

b) Input the composition and the temperature..

Available region/ special-condition:

a) The equation is available for the composition which consists of SiO_2 and more than one kind of oxides in the table.

b) It is available within the range of the composition shown in the table. The available composition range has been corrected to be wider than that in the original source.

Source: A. Fluegel, D. A. Earl, A. K. Varshneya, http://glassproperties.com/resistivity/ (2007)

(14) DC Resistivity

① Mazurin (Silicate)

Calculation-range/ input-condition:

a) The DC resistivity of silicate at an arbitrary temperature within the temperature range 100～427℃ is calculated.

b) Input the temperature and the composition.

Available region/ special-condition:

a) The equation is available for the composition which consists of more than one kind of oxide in 10 kinds of oxides in the table.

b) It is available within the range of the composition shown in the table.

c) It is available for $12 \leqq Na_2O + K_2O \leqq 30$ mol% .

b) It is available for $0 \leqq RO \leqq 20$ mol%, where RO = MgO+CaO+BaO+ZnO+PbO.
However, when CaO or BaO exist, singly or together, it is available for $0 \leqq RO \leqq 28$ mol%.

Source: O. V. Mazurin, The structure of glass, Vol. 4: Electrical conductivity and structure of glass, New York. Consultant Bureau (1965)

2. Property equation

The coefficients, activation energy, etc. of the property equations are included as INTERGLAD data. The equations consist of 11 expressions for 8 properties, as below. When the [Figure] pull-down menu of the detail window is clicked for a glass for which the coefficient data of these equations is complete, the relation between the property value and temperature or wavelength is displayed as a figure.

The property equations are shown below. The numerical values in parentheses denote the ID No. of the property.

(1) Viscosity Fulcher's equation

$$\log \eta = A + \frac{B}{T - T_0}$$

η : Viscosity dPa·s
A : Coefficient of Fulcher's equation (1231) log(dPa·s)
B : Coefficient of Fulcher's equation (1232) °C
T_0: Coefficient of Fulcher's equation (1233) °C
T : Temperature °C

(2) Diffusion equations

A: $$D = D_0 \exp\left(-\frac{E_d}{RT}\right)$$

D : Diffusion coefficient m^2/s
R : Gas constant 8.314 $J{\cdot}K^{-1}mol^{-1}$
D_0: Diffusion coefficient factor (1301, 1303, ~, 1377) m^2/s
E_d: Activation energy (1302, 1304, ~, 1378) $J{\cdot}mol^{-1}$ or J/g-atom
T : Temperature K

B: $$D = D_t T \exp\left(-\frac{E_d}{RT}\right)$$

D : Diffusion coefficient m^2/s
R : Gas constant 8.314 $J{\cdot}K^{-1}mol^{-1}$
D_t : Diffusion coefficient factor of equation B (1365, 1367, 1369) m^2/sK
E_d : Activation energy (1302, 1304, ~, 1378) J/mol or J/g-atom
T : Temperature K

(3) Gas permeability equation

$$P = P_0 T \exp\left(-\frac{E_p}{RT}\right)$$

P : Gas permeability coefficient atom/(s·m·atm)
R : Gas constant 8.314 $J{\cdot}K^{-1}mol^{-1}$
P_0 : Gas permeability coefficient factor
(1431, 1432, 1433) atom/(s·m·K·atm)
E_p : Activation energy (1421, 1422, ~, 1427) J/mol or J/g-atom
T : Temperature K

(4) Gas solubility equation

$$S = S_0 \exp\left(-\frac{E_s}{RT}\right)$$

S : Gas solubility coefficient atom/(m^3·atm)
R : Gas constant 8.314 J·$K^{-1}mol^{-1}$
S_0 : Gas solubility coefficient factor
(1571, 1572, 1573) atom/(m^3·atm)
E_s : Activation energy (1581, 1582, 1583) J/mol or J/g-atom
T : Temperature K

(5) Refractive dispersion equation

$$n^2 = A_0 + A_1\lambda^2 + A_2\lambda^{-2} + A_3\lambda^{-4} + A_4\lambda^{-6} + A_5\lambda^{-8}$$

N : Refractive index
λ: Wavelength 0.25~1.55 μm
A_0 ~ A_5: constant of dispersion formula (2101~2106)

(6) Refractive Sellmeier dispersion equation

$$n^2 = 1 + \frac{A_1\lambda^2}{\lambda^2 - \mathrm{B}_1} + \frac{A_2\lambda^2}{\lambda^2 - \mathrm{B}_2} + \frac{A_3\lambda^2}{\lambda^2 - \mathrm{B}_3}$$

n : Refractive index
λ : Wavelength 0.25~1.55 μm
A_1 ~A_3, B_1~B_3 : Constants of Sellmeier equation (2081~2086)

(7) Electric conductivity equations

A: $$\sigma = S_0 \exp\left(-\frac{E}{RT}\right)$$

σ : Electric Conductivity S/m
R : Gas constant 8.314 J·$K^{-1}mol^{-1}$
S_0: Coefficient of Equation A (3041~3044) S/m
E : Activation energy (3045~3048) J·mol^{-1}
T : Temperature K

B: $$\sigma T = C_0 \exp\left(-\frac{E}{RT}\right)$$

σ : Electric Conductivity S/m
T : Temperature K
R : Gas constant 8.314 J·$K^{-1}mol^{-1}$
C_0 : Coefficient of Equation B (3049) SK/m
E : Activation energy (3045) J/mol

(8) DC volume resistivity equation

$$\rho = R_0 \exp\left(\frac{E}{RT}\right)$$

ρ : DC Volume Resistivity Ohm·m
R : Gas constant 8.314 $J \cdot K^{-1} mol^{-1}$
R_0 : Coefficient of Equation (3077) Ohm·m
E : Activation energy (3078) $J \cdot mol^{-1}$
T : Temperature K

(9) AC volume resistivity equation

$$\rho = R_0 \exp\left(\frac{E}{RT}\right)$$

ρ : AC Volume Resistivity Ohm·m
R : Gas constant 8.314 $J \cdot K^{-1} mol^{-1}$
R_0 : Coefficient of Equation (3085) Ohm·m
E : Activation energy (3086) $J \cdot mol^{-1}$
T : Temperature K

3. Table data

The properties which can be shown in a figure are given below. The values of these properties can be maintained as table data, and displayed by clicking the [Figure] pulldown menu of the [Detail Data of Property] window. Refer 2. 3 (2) (A) 1) in Chapter 4.

The number to the right of each property is the property ID.

･Thermal expansion curve (α-T Curve)	1040
･UV~IR Transmission Spectrum	2218
･UV~IR Absorption Spectrum	2278
･UV~IR Reflectance Spectrum	2398
･Emission Spectrum	2509

Registered figure data are 50 for UV~IR Transmission Spectrum.
By using the registration function of User Data, the user can register XY data and show XY plots for the properties above. Refer Chapter 4, 6.2 (2) (B) <Property> 8).

(1) Table data format

The table data format is as follows in a CSV file.

1st row: Title of figure
2nd row: Label name (unit) for X-axis, minimum value, maximum value
3rd row: Label name (unit) for Y-axis, minimum value, maximum value
4th row: Data (X_{11},Y_{11})
. . . .
n+3th row: Data (X_{1n},Y_{1n})
n+4th row: Data (X_{21},Y_{21})
. . . .
2n+3 th row: Data (X_{2n},Y_{2n})
. . . .

X_{1*} and X_{2*} are other curves. A figure can display two or more curves.

(2) File names for table data

The file names for table data are assigned as follows:

expa_<glass code>.csv	: Thermal expansion curve
trns_<glass code>.csv	: UV~IR transmission spectrum
abso_<glass code>.csv	: UV~IR absorption spectrum
refl_<glass code>.csv	: UV~IR reflectance spectrum
emis_<glass code>.csv	: Emission spectrum

(3) Storage of table data

Table data files are stored in the following folder (within the system application folder):

…\INTERGLAD7.0\figure.gp	for Standard edition
…\INTERGLAD7.0SA\figure.gp	for CD Full Function edition

4. Curve data for glass-forming region

The glass-forming region can be displayed for the boundaries in addition to glasses denoted by ○ and ×. The data are input with the table data format. Refer Chapter 4, 6.2 (2) (B) <Composition> 10).
The format is in CSV as follows:

1st row : Unit of composition: 11 or 12 is input respectively as mass% or mol%.
2nd row: ID number of component A, component B and component C
3th row: Data (A_1, B_1, C_1): as triangular coordinates.
. . . .
n+2th row: Data (A_n, B_n, C_n)
. . . .

Each points are connected by the smoothing function in a curve. Therefore, even if there are little points, it is drawn as a smooth curve.