THE ELECTRICAL CONDUCTIVITY OF INDUSTRIAL GLASSES
AND THEIR TENDENCY TOWARDS "AUTOMISREGULATION"
IN THE MELT

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Data on the specific electrical conductivity of melts of industrial glass compositions are of primary
importance in order to organize and realize electric glass melting. In this paper data are given on the
conductivity of glasses (structural, vacuum tube, lighting, etc.) over the temperature range 1000–1400°.

Measurements of the specific resistance of the glass melts were made in furnaces with platinum or
silicon carbide heating elements. Alkali glasses were measured in U-shaped quartz cells (cell constant
15–30 cm⁻¹), and low-alkali and alkali-free glasses by a bridge and probe methods [1] in coaxial platinum
cells and in alumina U-channels.

Table 1 gives the nominal alkali oxide content of the glasses investigated.

The temperature dependence of electrical conductivity of glass is adequately described by the known
exponential relation, which appears in the logarithmic form;

\[ \log x = A - \frac{B}{T} \quad (1) \]

where \( A \) and \( B \) are constants; \( x \) is the electrical conductivity.

Table 1 gives the values of \( A \) and \( B \) in Eq. (1) for the glasses investigated. The discrepancies between

<table>
<thead>
<tr>
<th>Type and source of glass</th>
<th>Content ( \text{R}_{2}O )</th>
<th>( A )</th>
<th>( B \times 10^{-3} )</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>( \text{Na}_{2}O )</td>
<td>( \text{K}_{2}O )</td>
<td></td>
</tr>
<tr>
<td>Window; Dagestanskije Ogni Plant</td>
<td>14.72</td>
<td>-</td>
<td>0.8934</td>
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<td>Window; F. E. Dzerzhinski Plant</td>
<td>14.94</td>
<td>-</td>
<td>1.0685</td>
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<td>Rolled; F. E. Dzerzhinski Plant</td>
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<td>-</td>
<td>1.1254</td>
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<td>Bottle; M. I. Kalinina Plant, Borzhom</td>
<td>14.50</td>
<td>-</td>
<td>1.3512</td>
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<td>Semi-white; Glass Container Plant, Kerchen</td>
<td>16.00</td>
<td>-</td>
<td>1.0422</td>
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<td>Semi-white; Chemical Scientific Research Institute, Erevan</td>
<td>14.00</td>
<td>-</td>
<td>1.0744</td>
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<td>16.0</td>
<td>0.9581</td>
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<td>C-89-9 (No. 23)</td>
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<td>7.70</td>
<td>1.1658</td>
</tr>
<tr>
<td>C-89-9 (No. 3001)</td>
<td>5.00</td>
<td>10.00</td>
<td>1.4356</td>
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<tr>
<td>No. 29; Druzhnaya Gorka Plant</td>
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<td>3.00</td>
<td>1.2194</td>
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<td>0.50</td>
<td>1.2222</td>
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<td>-</td>
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<tr>
<td>Perfumery; Glass Plant Dorokhov</td>
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<td>59III; Glass Plant, Klinik</td>
<td>10.80</td>
<td>-</td>
<td>0.6916</td>
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<td>16III; Glass Plant, Klinik</td>
<td>14.20</td>
<td>-</td>
<td>1.1807</td>
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<td>KTs-34; Glass Plant, Klinik</td>
<td>12.16</td>
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<td>KTs-34(5); Glass Plant, Klinik</td>
<td>11.23</td>
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<td>MKR-1; Avtosetsklo</td>
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<td>-</td>
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<td>Ts-18; Avtosetsklo</td>
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<td>1.2759</td>
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<td>Gauge; Avtosetsklo</td>
<td>4.18</td>
<td>1.00</td>
<td>0.3443</td>
</tr>
</tbody>
</table>

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March, 1968.
the experimental results and those calculated from Eq. (1) do not exceed 3-4%.

This study of the conductivity of alkali glass melts shows that the basic factor determining the value of the conductivity is the alkali oxide content. For sodium—calcium—magnesium—aluminosilicate glass melts, the value of the conductivity can be calculated with satisfactory accuracy from the empirical equation

$$\lg x = 1.508 - 0.0204 C - \frac{4935 - 128C}{T},$$

where C is the sodium oxide content in wt.%.

The calculation of the conductivity of the alkali glasses of the compositions in Table 1 using Eq. 2, shows that for all the glass specimens with the exception of 59III, 29, and Ts-18, there is agreement between the calculated and experimental data, (the discrepancies do not exceed 10%). In those cases where the glass contains potassium oxide, it is necessary to use the relationship

$$C = (Na_2O) + \frac{(K_2O)}{2},$$

where (Na_2O) and (K_2O) are, respectively, the sodium oxide and potassium oxide contents of the glass.

To calculate the conductivity it is necessary to use the exact value for the alkali oxide content. It must be noted that, for many of the types of glass in Table 1, the actual alkali oxide content differs slightly from the nominal value, leading to a discrepancy between the calculated and experimental results.

The temperature coefficient of conductivity, which characterizes the so-called "automisregulating" tendency of the glass, is of considerable significance for electric glass melting. The criterion of the automisregulating tendency is known to be the angle $\alpha$ between the abcissa and the tangent to the resistance/temperature curve [2]. Equation (1) can be used to define the temperature coefficient of conductivity.

Given that

$$\lg x = \frac{d \rho}{dT} = \rho',$$

and writing Eq. (1) in the form

$$\rho = \frac{b}{a} \frac{T}{e^T},$$

where $\rho = V, a = 10^A$, and $b = 2.3B$ it is easy to show that

$$\rho' = -\frac{2.3B}{T^2} \rho.$$  (4)

Results of investigations at the Erevan Institute of Chemistry on the electric melting of different glass compositions have shown that both the derivatives, $\rho'$ and $\alpha$, quantitatively characterize the automisregulating tendency of a glass. It is convenient to use also the relationship $\rho' / \rho_s'$, where $\rho_s'$ is the derivative $d \rho_s / dT$ for standard glasses (sodium—calcium—silicate glasses with 15% Na_2O content).

$$\frac{\rho'}{\rho_s'} = \frac{d \rho}{d \rho_s} = \frac{B \rho}{B_s \rho_s},$$

where $B_s$ and $\rho_s$ are, respectively, the coefficient $B$ of Eq. (1), and the specific resistance of the standard glass. The latter can be determined from

$$\lg \rho = -1.207 + \frac{2980}{T}.$$  (6)

Substituting for $B_s$ in Eq. (5) we have finally

$$\frac{d \rho}{d \rho_s} = \frac{B \rho}{2890 \rho_s}.$$  (7)

Thus, using Eq. (7), it is possible qualitatively to characterize the automisregulating tendency of a glass melt.