ANALYTIC DEPENDENCE OF DENSITY OF LIQUID OXYGEN ON TEMPERATURE AND PRESSURE

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On the basis of experimental data on the density of liquid oxygen, an approximate analytical relation is obtained for the range of temperatures 153°–83° K and pressures (78.5–196) $\cdot 10^5$ N/m^2.

A number of papers have recently been devoted to the study of the density of liquid oxygen [1–4]. Of these, the contributions of Timrot and Borisoglebskii [1, 2] are noteworthy for the accuracy of the measurements of liquid oxygen density and give an analytic dependence of density on the saturation line and tabular data in the range 153°–83° K of temperature and 0–196 $\cdot 10^5$ N/m^2 of pressure. On the basis of these data a nomogram was constructed in [3], relating the density, temperature, and pressure in the above range. No analytic relation between these parameters, except the density on the saturation line, has been offered. On the basis of their own investigations of the thermodynamic properties of liquid oxygen, the authors of [4] put forward an analytic relation between the density of liquid oxygen and temperature and pressure, but this relation is valid only in the range 64°–90° K. At higher temperatures the expressions given in [4] give large errors.

Meanwhile, it is convenient, for a number of technical problems, to use an approximate analytic relation between density, temperature, and pressure, and a simple form for this relation would be desirable. We have therefore worked on the construction of such a relation, based on the experimental data of [2].

A quadratic expression was chosen as the form of the equation, since, in spite of its simplicity, it conforms to the nature of the variation of the parameters. In the interests of improved accuracy, all data processing was done by the least squares method. The resulting relation that we recommend for liquid oxygen density in the range 153°–83° K of temperature and (78.5–196) $\cdot 10^5$ N/m^2 of pressure is

$$\rho = a_0 + a_1\left(\frac{T}{100}\right) + a_2\left(\frac{T}{100}\right)^2,$$

$$a_0 = 1.48472 - 0.08545\left(\frac{1}{p}\right)\cdot 10^7 - 0.06936\left(\frac{1}{p}\right)^2\cdot 10^{14},$$

$$a_1 = -0.3210 + 0.27106\left(\frac{1}{p}\right)\cdot 10^7 + 0.096632\left(\frac{1}{p}\right)^2\cdot 10^{14},$$

$$a_2 = -0.000412 - 0.25723\left(\frac{1}{p}\right)\cdot 10^7 - 0.0026284\left(\frac{1}{p}\right)^2\cdot 10^{14}.$$

Table

Comparison of the Relation $\rho = f(p, T)$ with the experimental data of [2]

T, °K	Relative error (%) at p(N/m^2) equal to						
	$78.45\cdot10^5$	$98.07\cdot10^5$	$117.68\cdot10^5$	$137.3\cdot10^5$	$156.9\cdot10^5$	$176.52\cdot10^5$	$196.13\cdot10^5$
153	+2.43	+1.36	+0.944	+0.484	+0.688	+0.350	0
143	−0.403	−0.182	+0.021	0	+0.312	+0.206	+0.061
113	+0.366	+0.354	+0.38	+0.283	+0.376	+0.374	+0.102
93	+0.492	+0.437	+0.375	+0.269	+0.173	+0.173	+0.017
83	0.00	+0.0842	+0.109	+0.0834	+0.0836	+0.05	−0.067

The results of calculations according to the formula proposed gave satisfactory agreement with experimental data [2]. The largest error occurred at temperatures 153°–143° K and pressures (78.5–98.0) $\cdot 10^5$ N/m^2 (table). In all other regions the deviation was less than 1%.

NOTATION

ρ—density, g/cm^3; p—pressure, N/m^2; T—temperature, ° K.

REFERENCES

1. D. L. Timrot and V. P. Borisoglebskii, ZhETF, 38, no. 6, 1960.
2. D. L. Timrot and V. P. Borisoglebskii, IFZh, 4, no. 1, 1961.
3. A. M. F. Trans, Industr. Chem., 38, no. 451, 469, 1962.
4. A. Van Itterbeek and O. Verbeke, Probl. Low Temperature Phys. and Thermodyn., 3, 1962.

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