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THREE-REFERENCE-CURVE METHOD IN CONSTRUCTING THE EQUATION OF STATE OF A GAS AND A LIQUID

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A method of constructing the thermal equation of state of a gas and a liquid is considered; the method requires information only on three reference curves.

In [1-4], methods of constructing an equation of state common to gas and liquid were proposed on the basis of the use of a well-known thermodynamic relation between the thermal parameters of the material and its internal energy. The fundamental feature of these methods is the use of reference curves chosen on the thermal surface of the material and satisfying definite requirements in constructing the equation of state.

In developing the equation of state within the framework of the above-noted methods, two different approaches may be distinguished: in one, only one reference curve is used [1]; in the other, two basic curves are used [2-4]. The second approach offers great possibilities. On the one hand, it allows a complex multiconstant equation describing both thermal and caloric properties of the material with near-experimental accuracy to be constructed [2]. On the other, the use of two reference curves offers the possibility of developing an equation of state of gas and liquid of relatively simple form, requiring a minimum of a priori experimental information, suitable for use in solving a wide range of practical problems [3, 4]. Equations of this class are called engineering equations of state. For example, in [4], the simplest version of a unified equation of state for gas and liquid obtained on the basis of two reference curves — the ideal-gas curve $T_{IG}(\rho)$ and the saturation line $T_S(\rho)$ — was considered:

$$p(\rho, T) = \frac{RT}{\mu}\rho - \left[\frac{RT_S(\rho)}{\mu}\rho - p_S(T_S)\right]\frac{T_{IG}(\rho) - T}{T_{IG}(\rho) - T_S(\rho)}, \qquad (1)$$

where $p_S(T_S)$ is the equation of saturated vapor pressure.

Note that the term "ideal-gas curve" used here and in many other works is not entirely appropriate. Below, the curve of the thermodynamic surface of the material characterized by a single compressibility will be called the Bachinskii curve and denoted by $T_Z(\rho)$; Bachinskii [5] was one of the first researchers to study the features of this curve.

Qualitative analysis of Eq. (1) confirms its advantages resulting from the choice of the liquid—vapor equilibrium line and the Bachinskii curve as the reference curves. It rigorously gives two universal reference curves, is defined over a broad density range from zero to the liquid density at the triple point, satisfies the critical conditions and, in the limiting case as $\rho \to 0$, ensures transition to the ideal-gas equation. In addition, Eq. (1) is distinguished by simplicity of structure, requires a limited quantity of experimental data in its construction, and may be used for a series of thermodynamically similar materials.

Quantitative analysis of Eq. (1) for argon, using a dependence approximating the saturation and extensibility lines [4], shows that the mean-square deviation of the thermal parameters calculated using Eq. (1) from the reference data is 1.3% with respect to the density, for the whole mass of reference experimental data [6-10]. Taking account of the structural

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TABLE 1. Comparison of the Mean-Square Deviations $\delta\rho^{m.s}$ of the Reference Experimental Data [6-10] from the Results Given by Eqs. (1) and (8), %

Range of $\rho\cdot 10^{-3}$, kg/m³	Calc. by Eq.	Range of T, K						
		$T<115$	$115\leqslant T<130$	$130\leqslant T<150$	$150\leqslant T<175$	$175\leqslant T<250$	$250\leqslant T<350$	$350\leqslant T<425$
<0,1	(1)	—	0,759	1,721	1,894	2,470	0,666	1,264
	(8)	—	0,627	1,020	0,849	0,298	0,131	0,062
0,1—0,3	(1)	—	—	1,752	3,550	2,772	0,892	0,448
	(8)	—	—	0,672	1,079	1,281	0,627	0,431
0,3—0,4	(1)	—	—	2,374	4,248	2,747	0,594	0,889
	(8)	—	—	2,053	3,175	0,715	0,221	0,735
0,4—0,6	(1)	—	—	—	2,703	1,019	0,279	0,776
	(8)	—	—	—	2,539	1,141	0,430	1,292
0,6—1,0	(1)	—	—	0,203	1,782	0,351	0,761	1,280
	(8)	—	—	0,136	0,583	0,347	0,225	0,598
>1,0	(1)	0,779	0,652	0,507	0,579	0,642	2,442	3,420
	(8)	0,587	0,435	0,359	0,379	0,139	0,659	0,580

simplicity of Eq. (1), this accuracy of description of the mass of experimental data in the density range $14.77 \leq \rho \leq 1499.7$ kg/m³ and the temperature range $92.74 \leq T \leq 423.15$°K may be regarded as completely acceptable.

However, analysis of the description of various regions of the thermal surface of argon by Eq. (1) reveals (Table 1) one of its significant deficiencies: unsatisfactory accuracy of the calculation in the low-density region, where the mean-square deviation with respect to the density is a few percent.

Several variants allowing the deficiencies seen in Eq. (1) to be eliminated may be proposed. One of these is analyzed in the present work.

As in the methods considered above, the well-known thermodynamic relation between the internal energy of the material and its thermal parameters is taken as the starting point: $\rho^2(\partial u/\partial\rho)_T = -T^2[\partial(p/T)\partial T]_\rho$. If some curve $T_{RE_1}(\rho)$ is taken as the reference curve on the thermal surface of the material, an equation of the following form may be obtained from this thermodynamic relation:

$$p(\rho,\ T)=\frac{p_{RE.1}(\rho)}{T_{RE1}(\rho)}T-\rho^2T\int\limits_{T_{RE.1}(\rho)}^{T}\frac{(\partial u/\partial\rho)_T}{T^2}\,dT. \tag{2}$$

The final functional form of the equation of state will depend on the form of the expression approximating the internal energy. For example, in [4], $u(\rho,\ T)$ was specified in the form: $u(\rho,\ T) = u_{IG}(T) + u_1(\rho)/T^n$, where $u_1(\rho)$ is a structural function of the internal energy, the specific form of which is found using the second reference curve. In particular, setting $n = 1$ and finding $u_1(\rho)$ using the phase-equilibrium line, Eq. (1) may be obtained from Eq. (2) [4]. The tendency to improve the accuracy of the equation of state derived from Eq. (2) somewhat complicates the expression for $u(\rho,\ T)$, while retaining the overall features of its structure

$$u(\rho,\ T)=u_{IG}(T)+u_1(\rho)\frac{1}{T^n}+u_2(\rho)\frac{1}{T^m}\,; \tag{3}$$

$u_1(\rho)$ and $u_2(\rho)$ may be found if two further reference curves $T_{RE_2}(\rho)$ and $T_{RE_3}(\rho)$ are introduced into consideration. First of all, Eq. (3) is substituted into Eq. (2), to give

$$p(\rho,\ T)=\frac{p_{RE\ 1}(\rho)}{T_{RE\ 1}(\rho)}T+\rho^2T\{u_1'(\rho)F_n(T)+u_2'(\rho)F_m(T)\}, \tag{4}$$

where

$$F_n(x) = \frac{1}{(n+1)x^{n+1}}\left\{1 - \left[\frac{x}{T_{\mathrm{RE}\,1}(\rho)}\right]^{n+1}\right\},$$
$$F_m(x) = \frac{1}{(m+1)x^{m+1}}\left\{1 - \left[\frac{x}{T_{\mathrm{RE}\,1}(\rho)}\right]^{m+1}\right\}.$$

Now Eq. (4) is written for the curves $T_{RE2}(\rho)$ and $T_{RE3}(\rho)$:

$$\begin{aligned}\frac{p_{\mathrm{RE}\,2}(\rho)}{T_{\mathrm{RE}\,2}(\rho)} &= \frac{p_{\mathrm{RE}\,1}(\rho)}{T_{\mathrm{RE}\,1}(\rho)} + \rho^2\left[u_1'(\rho)F_n(T_{\mathrm{RE}\,2}) + u_2'(\rho)F_m(T_{\mathrm{RE}\,2})\right],\\ \frac{p_{\mathrm{RE}3}(\rho)}{T_{\mathrm{RE}3}(\rho)} &= \frac{p_{\mathrm{RE}1}(\rho)}{T_{\mathrm{RE}1}(\rho)} + \rho^2\left[u_1'(\rho)F_n(T_{\mathrm{RE}3}) + u_2'(\rho)F_m(T_{\mathrm{RE}3})\right].\end{aligned} \tag{5}$$

As well as the well-known functions specifying the three reference curves, Eq. (5) includes the as-yet-undetermined functions $u_1(\rho)$ and $u_2(\rho)$. Solving Eq. (5) for $u'_1(\rho)$ and $u'_2(\rho)$, simple manipulations lead to the result

$$\begin{aligned}u_1'(\rho) = \frac{1}{\rho^2}\Bigg\{&\left[\frac{p_{\mathrm{RE}2}(\rho)}{T_{\mathrm{RE}2}(\rho)} - \frac{p_{\mathrm{RE}1}(\rho)}{T_{\mathrm{RE}1}(\rho)}\right]\times\\ &\times\frac{F_m(T_{\mathrm{RE}3})}{F_n(T_{\mathrm{RE}2})F_m(T_{\mathrm{RE}3}) - F_m(T_{\mathrm{RE}2})F_n(T_{\mathrm{RE}3})} -\\ &-\left[\frac{p_{\mathrm{RE}3}(\rho)}{T_{\mathrm{RE}3}(\rho)} - \frac{p_{\mathrm{RE}1}(\rho)}{T_{\mathrm{RE}1}(\rho)}\right]\frac{F_m(T_{\mathrm{RE}2})}{F_n(T_{\mathrm{RE}2})F_m(T_{\mathrm{RE}3}) - F_m(T_{\mathrm{RE}2})F_n(T_{\mathrm{RE}3})}\Bigg\},\\ u_2'(\rho) = \frac{1}{\rho^2}\Bigg\{&\left[\frac{p_{\mathrm{RE}3}(\rho)}{T_{\mathrm{RE}3}(\rho)} - \frac{p_{\mathrm{RE}1}(\rho)}{T_{\mathrm{RE}1}(\rho)}\right]\times\\ &\times\frac{F_n(T_{\mathrm{RE}2})}{F_n(T_{\mathrm{RE}2})F_m(T_{\mathrm{RE}3}) - F_m(T_{\mathrm{RE}2})F_n(T_{\mathrm{RE}3})} -\\ &-\left[\frac{p_{\mathrm{RE}2}(\rho)}{T_{\mathrm{RE}2}(\rho)} - \frac{p_{\mathrm{RE}1}(\rho)}{T_{\mathrm{RE}1}(\rho)}\right]\frac{F_n(T_{\mathrm{RE}3})}{F_n(T_{\mathrm{RE}2})F_m(T_{\mathrm{RE}3}) - F_m(T_{\mathrm{RE}2})F_n(T_{\mathrm{RE}3})}\Bigg\}.\end{aligned} \tag{6}$$

The expressions obtained for the components of the internal energy in Eq. (6) are then substituted into Eq. (4), to give the equation of state for gas and liquid structurally including three reference curves

$$\begin{aligned}p(\rho, T) = {}&\frac{p_{\mathrm{RE}1}(\rho)}{T_{\mathrm{RE}1}(\rho)}T(1 - \Theta_1 - \Theta_2) +\\ &+ p_{\mathrm{RE}2}(\rho)\frac{T}{T_{\mathrm{RE}2}(\rho)}\Theta_1 + p_{\mathrm{RE}3}(\rho)\frac{T}{T_{\mathrm{RE}3}(\rho)}\Theta_2,\end{aligned} \tag{7}$$

where

$$\Theta_1 = \frac{F_n(T)F_m(T_{\mathrm{RE}3}) - F_n(T_{\mathrm{RE}3})F_m(T)}{F_n(T_{\mathrm{RE}2})F_m(T_{\mathrm{RE}3}) - F_m(T_{\mathrm{RE}2})F_n(T_{\mathrm{RE}3})},$$
$$\Theta_2 = \frac{F_n(T_{\mathrm{RE}2})F_m(T) - F_m(T_{\mathrm{RE}2})F_n(T)}{F_n(T_{\mathrm{RE}2})F_m(T_{\mathrm{RE}3}) - F_m(T_{\mathrm{RE}2})F_n(T_{\mathrm{RE}3})}.$$

It is simple to establish that the equation obtained satisfies all three reference curves. In fact, if T is set equal to $T_{RE2}(\rho)$, then $\Theta_2 = 0$, $\Theta_1 = 1$, and Eq. (7) gives $p(\rho, T_{RE2}(\rho)) = p_{RE2}(\rho)$. If $T = T_{RE3}(\rho)$, then $\Theta_2 = 1$, $\Theta_1 = 0$, and as a result $p(\rho, T_{RE3}(\rho)) = p_{RE3}(\rho)$. Finally, when $T = T_{RE1}(\rho)$, $F_n(T_{RE1}) = F_m(T_{RE1}) = 0$ and hence $\Theta_1 = \Theta_2 = 0$. Consequently, $p(\rho, T_{RE1}(\rho)) = p_{RE1}(\rho)$.

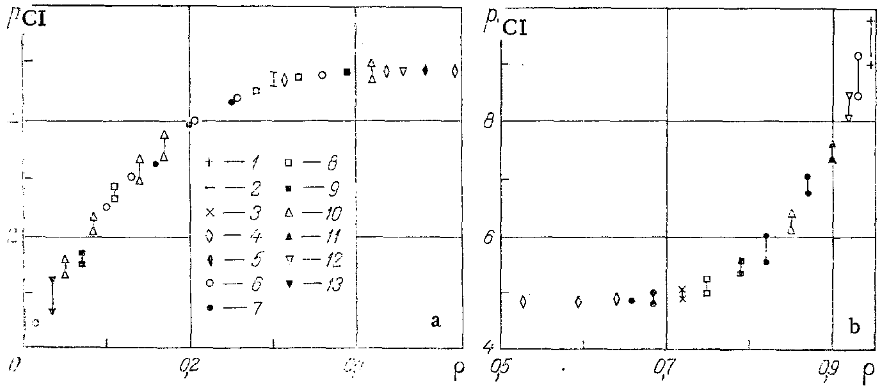

Fig. 1. Dependence of the pressure on the critical isotherm plotted from the experimental data in the single-phase region on the density: 1) from data at the isotherm T = 118.15°K; 2) 148.15; 3) 150.65; 4) 153.15; 5) 163.15; 6) 233.15; 7) 248.15; 8) 273.15; 9) 298.15; 10) 323.15; 11) 348.15; 12) 373.15; 13) 423.15. p_{CI}, MPa; ρ, kg/m³·10⁻³.

After establishing the general form of the equation of state being constructed and proceeding to its quantitative analysis, it is necessary to resolve the question of the curves chosen on the thermal surface of the material as reference curves. They must satisfy definite requirements: they must be universal, have a broad range of definition, and be described by dependences that are sufficiently simple in form.

Previous work [1-4] has shown the expediency of taking the reference curves in the form of the liquid—vapor equilibrium line and the Bachinskii curve, which completely correspond to the imposed requirements. In considering the question of the third reference curve, the use of the critical isotherm might be one possible option. The advantage of this approach is that the critical isotherm has a broad range of definition, and also that improvement in the description of both the critical region and the low-density region by the equation of state may be facilitated in choosing the appropriate approximating dependence for this curve. Some of the complications associated with the use of the critical isotherm as the reference curve will be noted below.

It is evident from Eq. (8) that, in choosing the critical isotherm, the liquid—vapor equilibrium line, and the Bachinskii curve as the reference curves, the equation of state takes the form

$$p(\rho,\ T)=\frac{p_{CI}(\rho)}{T_K}T(1-\Theta_{1K}-\Theta_{2K})+p_S(T_S)\frac{T}{T_S(\rho)}\Theta_{1K}+\frac{RT\rho}{\mu}\Theta_{2K}, \tag{8}$$

where

$$\Theta_{1K}=\frac{F_{nk}(T)F_{mk}(T_Z)-F_{nk}(T_Z)F_{mk}(T)}{F_{nk}(T_S)F_{mk}(T_Z)-F_{mk}(T_S)F_{nk}(T_Z)},$$

$$\Theta_{2K}=\frac{F_{nk}(T_S)F_{mk}(T)-F_{mk}(T_S)F_{nk}(T)}{F_{nk}(T_S)F_{mk}(T_Z)-F_{mk}(T_S)F_{nk}(T_Z)},$$

$$F_{nk}(x)=\frac{1}{(n+1)x^{n+1}}\left\{1-\left[\frac{x}{T_K}\right]^{n+1}\right\},$$

$$F_{mk}(x)=\frac{1}{(m+1)x^{m+1}}\left\{1-\left[\frac{x}{T_K}\right]^{m+1}\right\}.$$

Here $p_{KI}(\rho)$ is the dependence of the pressure on the density on the critical isotherm. Argon is chosen as the test material to check Eq. (8), since reliable experimental information on the thermal data for argon exists both in the single-phase region and on the liquid—vapor equilibrium line [6-10]. In addition, Eq. (1) is also tested for argon using the same mass of experimental data. This should simplify the comparative analysis of Eqs. (1) and (8). The phase-equilibrium lines — $T_S(\rho)$ and $p_S(T_S)$ — and the Bachinskii curve $T_Z(\rho)$ appear as

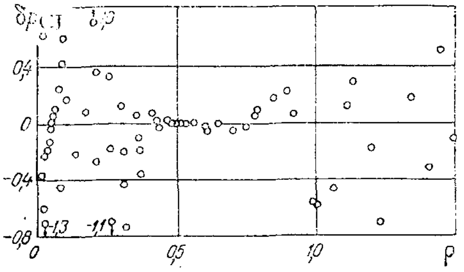

Fig. 2. Deviation of the pressure on the critical isotherm calculated on the basis of Eq. (11) from the values derived from experimental data. δp_{CI}, %; ρ, $kg/m^3 \cdot 10^{-3}$.

component elements in Eqs. (1) and (8). The parameters $T_Z(\rho)$ used here and in [4] are chosen in accordance with [11]: $T_B = 407.76°K$, $\rho_0 = 1.87 \cdot 10^3$ kg/m^3. The expressions for $T_S(\rho)$ and and $p_S(T_S)$ are taken from [4]

$$T_S(\rho) = T_K\left(1 - D_S|\Delta\rho|^{1/\beta} + \sum_{n\geq 4} D_n^{\pm}\Delta\rho^n\right), \tag{9}$$

$$\ln p_S(T_S) = B_{-1}T_S^{-1} + B_0 + B_1 T_S + B_2(T_K - T_S)^{2-\alpha} + B_3 T_S^3, \tag{10}$$

where B_{-1}, ..., B_3, D_S, and $D^{\pm}_n$ are coefficients; the plus sign refers to the case when $\rho > \rho_K$ and the minus sign to $\rho \leq \rho_K$. These coefficients take the following values: $B_{-1} = -9.355833 \cdot 10^2$, $B_0 = 7.626256$, $B_1 = 2.584851 \cdot 10^{-2}$, $B_2 = 4.463291 \cdot 10^{-4}$, $B_3 = -4.173631 \cdot 10^{-7}$, $D_S = 0.2294199$; for the case $\rho > \rho_K$, $\|n\| = \{4, 5, 6\}$, $\|D_n^+\| = \{0.1270440, -4.46682 \cdot 10^{-2}, 7.32122 \cdot 10^{-3}\}$; for the case $\rho \leq \rho_K$; $n = 10n_1 + 1$, $\|n_1\| = \{1, 4, 10\}$, $\|D_n^-\| = \{0{,}154750, 4.45520 \cdot 10^{-2}, 0.571278\}$; $\alpha = 0.112$, $\beta = 0.342$, $T_K = 150.66°K$, $\rho_K = 0.5351 \cdot 10^3$ kg/m^3 [12].

Thus, all the structural elements of Eq. (8) have been determined, except for the equation of the critical isotherm $p_{CI}(\rho)$. For argon, the literature does not give reliable experimental information on $p_{CI}(\rho)$. However, this does not exclude the possibility of testing the efficacy of Eq. (8). A possible procedure is as follows: since all the elements of Eq. (8) except $p_{CI}(\rho)$ are known, $p_{CI}(\rho)$ may be calculated from Eq. (8) on the basis of experimental data on the pressure. This calculation must be performed for a wide temperature range. If the data obtained are in good agreement (within the limits of the required error), Eq. (8) may be appropriate for the given range of state parameters.

This procedure has been performed on the basis of the experimental data of [6-10]; p in Eq. (8) is taken both in the form of experimental pressure values p^{exp} from [6-10] and values shifted by ±1% from p^{exp}. The results of the calculation are shown in Fig. 1 and indicate good agreement of the data obtained on the basis of different initial isotherms; in principle, this proves the efficacy of Eq. (8). To get a more precise idea of the quantitative possibilities of Eq. (8), the following procedure may be followed: on the basis of the data obtained (Fig. 1), an equation $p_{CI}(\rho)$ is constructed and used in Eq. (8).

The mass of data on $p_{CI}(\rho)$ obtained in this way in the range from 14.77 to 1499.6 kg/m^3 are approximated using the dependence proposed in [13], of the form

$$\Delta p_{CI}(\Delta\rho) = \operatorname{sign}(\Delta\rho)|\Delta\rho|^{\delta}\exp\left\{\sum_{i=0}^{I} A_i\Delta\rho^i\right\}. \tag{11}$$

Using a specially written program in Fortran-EC, the following values of the coefficients A_i in Eq. (11) are obtained:

$$A_0 = 1.418429;\quad A_1 = -0.08875245;\quad A_2 = -2.279224;$$
$$A_3 = 4.855103;\quad A_4 = 1.101300;\quad A_5 = -12.53900;\quad A_6 = 4.909804;$$
$$A_7 = 14.27654;\quad A_8 = -9.770325;\quad A_9 = -6.722862;$$
$$A_{10} = 6.793004;\quad A_{11} = 0.3832445;\quad A_{12} = -1.624724;$$
$$A_{13} = 0.3751509;\quad \delta = 4.52\ [12];\quad p_K = 4.859\ \text{MPa}.$$

The quality of the approximation of the mass of data on the critical isotherm by Eq. (11) is characterized in Fig. 2.

Thus, all the structural elements appearing in the equation of state constructed by the proposed method, Eq. (8), have been determined; the next step is quantitative analysis of Eq. (8). To this end, the thermal data in the given ranges $14.77 \le \rho \le 1499.6$ kg/m^3 and $92.74 \le T \le 423.15$°K are calculated from Eq. (8), and the results obtained are compared with experimental data [6-10]. The potentialities of Eq. (8) are completely characterized by the data in Table 1. It is evident that the introduction of an extra reference curve in comparison with Eq. (1) improves the description of low-density region by the equation of state. Thereby, the accuracy of the density calculation from Eq. (8) is practically independent of the region of state where the analysis is performed. In the region of relatively large temperatures as $T \to T_{TP}$, in the gas region, and as $\rho \to \rho^L_{TP}$, the error of the density calculation is 0.4-0.9% on average. The mean-square error $\delta\rho^{m.s}$ of the description of the whole mass of data considered [6-10] is 0.8%. For comparison, it may be noted again that for Eq. (1) $\delta\rho^{m.s}$ is 1.3%.

Summing up, it may be stated that the method proposed here is applicable for the development of an engineering equation of state of gas and liquid.

In the further perfection and development of this approach, the basic problems are evidently as follows: 1) the development of methods of deriving the critical-isotherm equation from diverse experimental data; 2) investigation of the influence of the accuracy with which the reference curves are specified on the accuracy of the equation being specified; and 3) generalization of the equation of state of the form in Eqs. (1) and (8) to a series of thermodynamically similar materials using the basic conclusions of similarity theory [14].

NOTATION

p, pressure; T, absolute temperature; ρ, density; R, universal gas constant; μ, molar mass; p_K, T_K, and ρ_K, critical parameters; $\Delta p = (p - p_K)/p_K$; $\Delta\rho = (\rho - \rho_K)/\rho_K$; α, β, δ, critical indices; $u(\rho, T)$ and $u_{IG}(T)$, specific internal energy of a real material and an ideal gas; $u_1(\rho)$, $u_2(\rho)$, components of the internal energy; $u'_1(\rho)$, $u'_2(\rho)$, derivatives of the corresponding functions with respect to the density; $p_{RE1}(\rho)$, $T_{RE1}(\rho)$, $p_{RE2}(\rho)$, $T_{RE2}(\rho)$, $p_{RE3}(\rho)$, and $T_{RE3}(\rho)$, equations of reference curves; $T_Z(\rho)$, Bachinskii curve; $T_S(\rho)$, saturation line; $p_S(T_S)$, elasticity curve; $p_{CI}(\rho)$, critical isotherm; T_B, Boyle temperature; ρ_0, density obtained by extrapolation of the Bachinskii curve to T = 0; T_{TP}, temperature of the material at the triple point; ρ^L_{TP}, density of liquid at triple point; $\delta\rho = (\rho^{calc} - \rho^{exp})/\rho^{exp}$; A_i, B_i, $D^{\pm}_i$, constants (the plus sign corresponds to $\rho > \rho_K$ and the minus sign to $\rho \le \rho_K$).

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THERMOPHYSICAL PROPERTIES OF FODDER GRASS SEEDS

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The article presents the values of critical heat in the range −50 to +200°C, thermal conductivities at 25°C, and pressures of 100.641 kPa, and an equation for determining the thermotolerance of fodder grass seeds.

When the seed farming of fodder grasses was put on an industrial basis, it was necessary to work out new technologies, machines, and equipment for the postharvest treatment of a large amount of seeds. An important place in the technological process is held by dryers. For their engineering calculations it is indispensable to have reliable data on the heat capacity, critical temperatures, and thermal conductivity of grass seeds with a view to the variety of their species; at present there are practically no such data in the literature.

Grass seeds are friable, finely disperse, thermolabile material with normalized particle diameter of 0.9-4.0 mm. In regard to their thermophysical properties they belong to the bad heat conductors.

The literature [1-4] presents fairly broadly and fully theoretical and experimental investigations of friable materials of inorganic origin such as quartz sand, pearlite, silica gel, and various metallic powders.

However, by their structure, physicochemical properties, and intervals of critical temperatures, fodder grass seeds differ considerably from the investigated materials. Most similar to them in structure and properties are the seeds of cereal crops [5], but the actual differences between them are such that there is no basis for using their technological characteristics in calculations of thermal installations intended for drying grass seeds.

Investigations carried out with seeds of fodder grasses [6] and of oil-producing crops [7] for determining their thermotolerance do not reveal fully their thermophysical properties with the variety of species taken into account.

It is well known that the specific heat makes it possible to determine the amount of heat necessary for heating a mass to be dried, thermal conductivity permits determining the rate and duration of heating, and the critical temperature determines the boundary of the vital activity of the internal structures of seeds.

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