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CONSTANT ENTROPY PROPERTIES FOR
AN APPROXIMATE MODEL OF
EQUILIBRIUM AIR

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SUMMARY

Approximate analytic solutions for properties of equilibrium air up to 15,000° K have been programmed for machine computation. Temperature, compressibility, enthalpy, specific heats, and speed of sound are tabulated as constant entropy functions of temperature. The reciprocal of acoustic impedance and its integral with respect to pressure are also given for the purpose of evaluating the Riemann constants for one-dimensional, isentropic flow.

INTRODUCTION

The solutions of compressible fluid flow problems generally depend on the thermodynamic state relations of the fluid. In the case of air at normal temperatures, it is a good approximation to assume that the pressure, density, and temperature are related by the ideal gas law and that the specific heats are constant. As a consequence, many solutions to air-flow problems may be expressed in rather simple analytic form.

At high temperatures, such as occur in high-speed flight through the atmosphere, the state relations are not so simple because the air molecules are excited in vibration, dissociation, and ionization reactions. For such cases, the equilibrium thermodynamic properties of air have been tabulated by Gilmore (ref. 1) and Hilsenrath and Beckett (ref. 2). Feldman (ref. 3) and Moeckel and Weston (ref. 4) have presented the results of reference 2 in the form of Mollier diagrams, which can be used in calculating solutions for shock waves and also for isentropic flow. (In the latter case, changes in the flow must be gradual enough so that the air is essentially everywhere in local equilibrium.) Such solutions to high temperature air flow lose their simple analytic form, of course, and are given only in numerical form.

It is perhaps most convenient to program numerical solutions to real gas flows on electronic computing machines. For this purpose, analytic approximations to the equation of state, such as given in reference 5, have been found useful. These solutions may be expressed in terms of pressure and temperature, or of density and temperature, as the independent variables. For isentropic flow problems it is desirable to have entropy as one of the independent variables, and to have the computer perform an iteration of the analytic approximations to obtain the thermodynamic properties as functions of entropy. It is felt that a tabulation of some of these constant entropy functions which are required for solutions of isentropic flow would be a useful adjunct to the Mollier diagrams. In addition, such tables provide a means for rapid evaluation of the accuracy limitations for the approximate model of air. Accordingly, it is the purpose of this report to tabulate the temperature, compressibility, enthalpy, specific heats, speed of sound, and the integral of acoustic admittance (i.e., the inverse of the product of density and speed of sound), as constant entropy functions of pressure.

SYMBOLS

a	speed of sound
a_o	speed of sound at standard conditions (273.1° K, 1 atm)
c_p	specific heat per mol at constant pressure
c_v	specific heat per mol at constant density
E	energy per mol
H	enthalpy per mol
I	$\frac{p}{a_o a\rho}$ or $\frac{p}{a_o}\frac{dl}{dp}$, dimensionless
I^*	value of I for ideal air, $\frac{1}{1.4}\sqrt{\frac{T}{T_o}}$
l	integral of acoustic admittance, $\int_o^p \frac{dp}{a\rho}$
M	molecular weight
p	pressure
R	gas constant
S	entropy per mol
T	absolute temperature
T_o	standard temperature (273.1° K)
t	time

u stream velocity

x distance

Z compressibility, moles of gas produced from a mol of air at standard conditions

γ ratio of specific heats, $\frac{c_p}{c_v}$

ρ density

ν Prandtl-Meyer expansion angle

A390

RESULTS AND DISCUSSION

The properties of an approximate model of air in equilibrium (ref. 5) have been computed for values of the dimensionless entropy ZS/R from 25 to 100, and for temperatures up to 15,000° K or pressures up to 1000 atmospheres. The symbol S signifies the entropy per mol of air and Z is the number of moles of gas formed from one mol of air at normal conditions (i.e., undissociated air). Thus, the product ZS is the entropy in Z moles of air and is proportional to the entropy per unit mass. Any desired unit of mass may be used, of course, provided the gas constant R is taken to be in the same units. The constant entropy properties are tabulated in table I. The necessary equations are summarized in appendix A and these were programmed for use with an IBM 704 computer. The tabulated quantities are as follows. The pressure p is given in atmospheres and T in degrees Kelvin. Enthalpy and specific heat per unit mass are given in dimensionless form ZH/RT and Zc_p/R, respectively, where, like the entropy parameter, the unit of mass is established by the units of the gas constant. The ratio of specific heats c_p/c_v is denoted by the quantity γ. The speed of sound is the square root of the derivative of pressure with respect to density at constant entropy

$$a = \sqrt{\left(\frac{\partial p}{\partial \rho}\right)_s} \tag{1}$$

and is given in units of a_o, the speed of sound at standard conditions (273.1° K and 1 atmosphere pressure). In addition, the dimensionless quantity

$$I = \frac{p}{a_o a \rho} \tag{2}$$

and the integral

$$\frac{l}{a_o} = \frac{1}{a_o}\int_0^p \frac{dp}{a\rho} = \int_0^p I \frac{dp}{p} \tag{3a}$$

are both given so that the Riemann constants for one-dimensional, isentropic flow (ref. 6) can be quickly calculated. The singularity at $p = 0$ in equation (3a) is easily handled, since at low temperatures the air behaves as an ideal gas where the integral is simply (see Courant and Friedrichs, ref. 6)

$$\frac{l}{a_o} = \frac{2}{\gamma - 1}\frac{a}{a_o} = \frac{2}{\gamma - 1}\sqrt{\frac{T}{T_o}} \tag{3b}$$

Thus, the integral (eq. (3a)) can be broken into two parts for any given isentrope: a low temperature, low pressure part where air obeys the ideal gas laws, and the higher temperature region where the integrand I (eq. (2)) deviates from its ideal gas value, $a/\gamma a_o$, due to the excitation of the vibration, dissociation, and ionization reactions. Equation (3b) is used for the low temperature region, and numerical integration of equation (3a) is used to evaluate the high temperature part of the integral.

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The change in velocity of isentropic gas flow along the characteristic directions is given by (see ref. 6)

$$u - u_i = \pm(l_i - l) \tag{4}$$

where the subscript i refers to initial conditions, the positive sign corresponds to the positive characteristic

$$\frac{dx}{dt} = u + a \tag{5a}$$

and the negative sign to the negative characteristic

$$\frac{dx}{dt} = u - a \tag{5b}$$

in the time-distance (x,t) plane, respectively. Thus, equations (4) and (5) relate all the changes of gas properties in one-dimensional isentropic flow through the changes in the velocity parameter.

Where very small changes in flow properties are desired, as in the construction of a fine net characteristics solution, it may be more convenient to work with just the integrand rather than with the integrated expression, and for this reason the partial integrand I is tabulated in addition to the integral l/a_o. For example, small changes along the characteristic directions are approximately given by

$$\frac{u - u_i}{a_o} \simeq I(\Delta \ln p) \simeq I\left(\frac{p_i - p}{p_i}\right) \tag{6}$$

In equation (6) the algebraic sign on the pressure change, $p_i - p$, corresponds to the sign of the characteristic direction.

Figure 1 presents, in graphical form, some of the results calculated for the integrand, I. The ordinate of the figure is the ratio of I to its ideal value, I^* or $(1/\gamma)\sqrt{T/T_0}$, where γ is equal to 1.4. These ratios are plotted as functions of temperature for the isentropes $ZS/R = 30$, 40, 50, 60, 70, 80, 90, and 100. The normalized value of I for an arbitrary entropy may be obtained fairly accurately by interpolation on such a graph, and then the velocity change, corresponding to an isentropic pressure change, is obtained through equation (6).

The utility of the integral l/a_0 in one-dimensional flow problems lies partly in the fact that it is a function only of the local gas properties, so that it need be computed only once for any given entropy and pressure (or temperature). In the case of two- or three-dimensional flow, the relations between changes in flow properties depend not only on local gas properties, but on the initial or stagnation conditions as well. For example, the change in Prandtl-Meyer expansion angle may be expressed

$$\nu_2 - \nu_1 = \int_{u_1}^{u_2} \left(\frac{u^2}{a^2} - 1\right)^{\frac{1}{2}} \frac{du}{u} \tag{7}$$

where the integration is performed along a constant isentrope. The limits of the integral are functions of the local enthalpy per unit mass H/M and the stagnation enthalpy H_t/M

$$\frac{u^2}{2} = \frac{H_t - H}{M} \tag{8}$$

Thus it would be necessary to add another dimension to a table of the Prandtl-Meyer angle which would specify the stagnation conditions. Since a double interpolation is involved when a three-dimensional table is used, it appears simpler to calculate each case independently, using the equations in appendix A as a machine subroutine for the equation of state relations.

The accuracy of the approximate air model is discussed in reference 5. According to comparisons with precise calculations made for equilibrium air by Hilsenrath and Beckett (ref. 2) and Logan and Treanor (ref. 7), at sea level density or lower, entropy is accurate to 1 percent, compressibility to 2 percent, and enthalpy within 4 percent. The specific heat and speed of sound, involving the derivatives of these quantities, are accurate to 5 percent, while the ratio of specific heats is within 1 percent. The inaccuracies become more serious at higher densities. At 100 times sea level density they may be more than double the above figures. Precise values of l do not seem to be available for comparison, but the error in the integral will normally be somewhat less than the random errors of the variables in the integrand, perhaps the order of 2 percent or less. The solutions to fluid flow problems often involve additional averaging or integration procedures which minimize the effects of random errors. Thus it is concluded that the properties tabulated for this model of air will be satisfactory for some engineering purposes.

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APPENDIX A

SUMMARY OF EQUATIONS FOR THE APPROXIMATE MODEL OF AIR

The properties of equilibrium air were calculated by the method of reference 5. Approximate partition functions were used and all chemical reactions were neglected except the excitation of molecular vibrations, the dissociation of oxygen molecules, the dissociation of nitrogen molecules, and the ionization of oxygen and nitrogen atoms. The ratio of nitrogen to oxygen atoms has been taken as 4 to 1. The following subscript notation will be used:

A
3
9
0

1	O_2
2	N_2
3	O
4	N
5a	O^+
5b	N^+
6	e^-
α	$O_2 \leftrightarrows 2O$
β	$N_2 \leftrightarrows 2N$
γ	$O \leftrightarrows O^+ + e^-$ and $N \leftrightarrows N^+ + e^-$

The reciprocals of the vibrational partition functions are

$$v_1 = 1 - \exp\left(-\frac{2270}{T}\right) \tag{A1}$$

$$v_2 = 1 - \exp\left(-\frac{3390}{T}\right) \tag{A2}$$

while the electronic partition functions are

$$q_1 = 3 + 2 \exp\left(-\frac{11390}{T}\right) + \exp\left(-\frac{18990}{T}\right) \tag{A3}$$

$$q_2 = 1 \tag{A4}$$

$$q_3 = 5 + 3 \exp\left(-\frac{228}{T}\right) + \exp\left(-\frac{326}{T}\right) + 5 \exp\left(-\frac{22800}{T}\right) + \exp\left(-\frac{48600}{T}\right) \tag{A5}$$

$$q_4 = 4 + 10 \exp\left(-\frac{27700}{T}\right) + 6 \exp\left(-\frac{41500}{T}\right) \tag{A6}$$

$$q_{5a} = 4 + 10 \exp\left(-\frac{38600}{T}\right) + 6 \exp\left(-\frac{58200}{T}\right) \tag{A7}$$

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$$q_{5b} = 1 + 3 \exp\left(-\frac{70.6}{T}\right) + 5 \exp\left(-\frac{188.9}{T}\right) + 5 \exp\left(-\frac{22000}{T}\right) + \exp\left(-\frac{47000}{T}\right) + 5 \exp\left(-\frac{67900}{T}\right) \tag{A8}$$

$$q_6 = 2 \tag{A9}$$

The derivatives of these quantities with respect to the $\ln T$ will be designated by a superscript prime. The negative derivatives of v_1 and v_2 are

$$v'_1 = \frac{2270}{T} \exp\left(-\frac{2270}{T}\right) \tag{A10}$$

$$v'_2 = \frac{3390}{T} \exp\left(-\frac{3390}{T}\right) \tag{A11}$$

and the positive derivatives of the q_i are

$$q'_1 = 2\left(\frac{11390}{T}\right) \exp\left(-\frac{11390}{T}\right) + \left(\frac{18990}{T}\right) \exp\left(-\frac{18990}{T}\right) \tag{A12}$$

$$q'_2 = 0 \tag{A13}$$

$$q'_3 = 3\left(\frac{228}{T}\right) \exp\left(-\frac{228}{T}\right) + \left(\frac{326}{T}\right) \exp\left(-\frac{326}{T}\right) + 5\left(\frac{22800}{T}\right) \exp\left(-\frac{22800}{T}\right) + \left(\frac{48600}{T}\right) \exp\left(-\frac{48600}{T}\right) \tag{A14}$$

$$q'_4 = 10\left(\frac{27700}{T}\right)\exp\left(-\frac{27700}{T}\right) + 6\left(\frac{41500}{T}\right)\exp\left(-\frac{41500}{T}\right) \tag{A15}$$

$$q'_{5a} = 10\left(\frac{38600}{T}\right)\exp\left(-\frac{38600}{T}\right) + 6\left(\frac{58200}{T}\right)\exp\left(-\frac{58200}{T}\right) \tag{A16}$$

$$\begin{aligned} q'_{5b} = {} & 3\left(\frac{70.6}{T}\right)\exp\left(-\frac{70.6}{T}\right) + 5\left(\frac{188.9}{T}\right)\exp\left(-\frac{188.9}{T}\right) \\ & + 5\left(\frac{22000}{T}\right)\exp\left(-\frac{22000}{T}\right) + \left(\frac{47000}{T}\right)\exp\left(-\frac{47000}{T}\right) \\ & + 5\left(\frac{67900}{T}\right)\exp\left(-\frac{67900}{T}\right) \end{aligned} \tag{A17}$$

$$q'_6 = 0 \tag{A18}$$

The natural logarithms of the partition functions at unit pressure for the major components in air will be designated by Q_i

$$Q_1 = \frac{7}{2}\ln T + 0.11 - \ln v_1 + \ln q_1 \tag{A19}$$

$$Q_2 = \frac{7}{2}\ln T - 0.42 - \ln v_2 \tag{A20}$$

$$Q_3 = \frac{5}{2}\ln T + 0.50 + \ln q_3 \tag{A21}$$

$$Q_4 = \frac{5}{2}\ln T + 0.30 + \ln q_4 \tag{A22}$$

$$Q_5 = \frac{5}{2}\ln T + 0.34 + 0.2\ln q_{5a} + 0.8\ln q_{5b} \tag{A23}$$

$$Q_6 = \frac{5}{2}\ln T - 14.24 \tag{A24}$$

In equation (A23), and other relations to follow, the nitrogen and oxygen ions are considered as a single species with population averaged properties. The dimensionless enthalpies of each species are given by

$$h_1 = \frac{7}{2} + \frac{v'_1}{v_1} + \frac{q'_1}{q_1} \tag{A25}$$

$$h_2 = \frac{7}{2} + \frac{v'_2}{v_2} \tag{A26}$$

$$h_3 = \frac{5}{2} + \frac{q'_3}{q_3} \tag{A27}$$

$$h_4 = \frac{5}{2} + \frac{q'_4}{q_4} \tag{A28}$$

$$h_5 = \frac{5}{2} + 0.2\left(\frac{q'_{5a}}{q_{5a}}\right) + 0.8\left(\frac{q'_{5b}}{q_{5b}}\right) \tag{A29}$$

$$h_6 = \frac{5}{2} \tag{A30}$$

where $h_i = (H/RT)_i - (E_o/RT)_i$; E_o is the zero point energy of the species. The dimensionless entropy ($s_i = S_i/R$) of each species is given by

$$s_1 = Q_1 + h_1 \tag{A31}$$

$$s_2 = Q_2 + h_2 \tag{A32}$$

$$s_3 = Q_3 + h_3 \tag{A33}$$

$$s_4 = Q_4 + h_4 \tag{A34}$$

$$s_5 = Q_5 + h_5 \tag{A35}$$

$$s_6 = Q_6 + h_6 \tag{A36}$$

The equilibrium constants for the three reactions in units of standard pressure are

$$K_\alpha = \exp\left(-\frac{59000}{T} + 2Q_3 - Q_1\right) \tag{A37}$$

$$K_\beta = \exp\left(-\frac{113200}{T} + 2Q_4 - Q_2\right) \tag{A38}$$

$$K_\gamma = \exp\left(-\frac{166600}{T} + Q_5 + Q_6 - 0.2Q_3 - 0.8Q_4\right) \tag{A39}$$

Then the compressibility may be expressed

$$Z = 1 + \epsilon_\alpha + \epsilon_\beta + 2\epsilon_\gamma \tag{A40}$$

where the fractions ϵ_α, ϵ_β, and ϵ_γ are, respectively, the fractions of oxygen and nitrogen molecules which are dissociated and the fraction of atoms which are ionized. For constant pressure calculations these are given by

$$\epsilon_\alpha = \frac{-0.8 + \sqrt{0.64 + 0.8(1 + 4p/K_\alpha)}}{2(1 + 4p/K_\alpha)} \tag{A41}$$

$$\epsilon_\beta = \frac{-0.4 + \sqrt{0.16 + 3.84(1 + 4p/K_\beta)}}{2(1 + 4p/K_\beta)} \tag{A42}$$

$$\epsilon_\gamma = (1 + p/K_\gamma)^{-1/2} \tag{A43}$$

where the pressure p is given in atmospheres. For constant density calculations the dissociated and ionized fractions are used in the form

$$\epsilon_\alpha = \frac{\sqrt{(273K_\alpha/\rho T)^2 + 3.2(273K_\alpha/\rho T)} - (273K_\alpha/\rho T)}{8} \tag{A44}$$

$$\epsilon_\beta = \frac{\sqrt{(273K_\beta/\rho T)^2 + 12.8(273K_\beta/\rho T)} - (273K_\beta/\rho T)}{8} \tag{A45}$$

$$\epsilon_\gamma = \frac{\sqrt{(273K_\gamma/\rho T)^2 + 8(273K_\gamma/\rho T)} - (273K_\gamma/\rho T)}{4} \tag{A46}$$

where the density ρ is in units of standard sea level density. The equilibrium mol fractions of the various species are

$$x_1 = \frac{0.2 - \epsilon_\alpha}{Z} \tag{A47}$$

$$x_2 = \frac{0.8 - \epsilon_\beta}{Z} \tag{A48}$$

$$x_3 = \frac{2\epsilon_\alpha - 0.4\epsilon_\gamma}{Z} \tag{A49}$$

$$x_4 = \frac{2\epsilon_\beta - 1.6\epsilon_\gamma}{Z} \tag{A50}$$

$$x_5 = x_6 = \frac{2\epsilon_\gamma}{Z} \tag{A51}$$

Then the total dimensionless entropy for equilibrium air is

$$\begin{aligned}\frac{ZS}{R} = {} & Z(x_1 s_1 + x_2 s_2 + x_3 s_3 + x_4 s_4 + x_5 s_5 + x_6 s_6) - Z[x_1 \ln x_1 + x_2 \ln x_2 \\ & + x_3 \ln x_3 + x_4 \ln x_4 + x_5(\ln x_5 - 0.5004) + x_6 \ln x_6] - Z \ln p\end{aligned} \tag{A52}$$

The constant -0.5004 is $0.2 \ln 0.2 + 0.8 \ln 0.8$ to account for the fact that the positive ions are a mixture of oxygen and nitrogen ions. The machine computing program chooses a value of T for each given pressure and iterates until the solution to equation (A52) agrees with the selected value of entropy.

The following quantities related to second derivatives of the partition functions are defined.

$$v''_1 = \frac{(1135/T)^2}{\sinh^2(1135/T)} \tag{A53}$$

$$v''_2 = \frac{(1695/T)^2}{\sinh^2(1695/T)} \tag{A54}$$

$$q''_1 = 2\left(\frac{11390}{T}\right)^2 \exp\left(-\frac{11390}{T}\right) + \left(\frac{18990}{T}\right)^2 \exp\left(-\frac{18990}{T}\right) \tag{A55}$$

$$q''_2 = 0 \tag{A56}$$

$$q''_3 = 3\left(\frac{228}{T}\right)^2 \exp\left(-\frac{228}{T}\right) + \left(\frac{326}{T}\right)^2 \exp\left(-\frac{326}{T}\right) + 5\left(\frac{22800}{T}\right)^2 \exp\left(-\frac{22800}{T}\right) + \left(\frac{48600}{T}\right)^2 \exp\left(-\frac{48600}{T}\right) \tag{A57}$$

$$q''_4 = 10\left(\frac{27700}{T}\right)^2 \exp\left(-\frac{27700}{T}\right) + 6\left(\frac{41500}{T}\right)^2 \exp\left(-\frac{41500}{T}\right) \tag{A58}$$

$$q''_{5a} = 10\left(\frac{38600}{T}\right)^2 \exp\left(-\frac{38600}{T}\right) + 6\left(\frac{58200}{T}\right)^2 \exp\left(-\frac{58200}{T}\right) \tag{A59}$$

$$q''_{5b} = 3\left(\frac{70.6}{T}\right)^2 \exp\left(-\frac{70.6}{T}\right) + 5\left(\frac{188.9}{T}\right)^2 \exp\left(-\frac{188.9}{T}\right) + 5\left(\frac{22000}{T}\right)^2 \exp\left(-\frac{22000}{T}\right) + \left(\frac{47000}{T}\right)^2 \exp\left(-\frac{47000}{T}\right) + 5\left(\frac{67900}{T}\right)^2 \exp\left(-\frac{67900}{T}\right) \tag{A60}$$

$$q''_e = 0 \tag{A61}$$

The dimensionless specific heats at constant pressure $(c_i = (c_p)_i/R)$ may then be written

$$c_1 = \frac{7}{2} + v''_1 + \frac{q''_1}{q_1} - \left(\frac{q'_1}{q_1}\right)^2 \tag{A62}$$

$$c_2 = \frac{7}{2} + v''_2 \tag{A63}$$

$$c_3 = \frac{5}{2} + \frac{q''_3}{q_3} - \left(\frac{q'_3}{q_3}\right)^2 \tag{A64}$$

$$c_4 = \frac{5}{2} + \frac{q''_4}{q_4} - \left(\frac{q'_4}{q_4}\right)^2 \tag{A65}$$

$$c_5 = \frac{5}{2} + 0.2\left[\frac{q''_{5a}}{q_{5a}} - \left(\frac{q'_{5a}}{q_{5a}}\right)^2\right] + 0.8\left[\frac{q''_{5b}}{q_{5b}} - \left(\frac{q'_{5b}}{q_{5b}}\right)^2\right] \tag{A66}$$

$$c_6 = \frac{5}{2} \tag{A67}$$

The derivatives of the logarithms of the equilibrium constants with respect to the $\ln T$ are designated $K' = \dfrac{d \ln K}{d \ln T}$

$$K'_\alpha = \frac{59000}{T} - h_1 + 2h_3 \tag{A68}$$

$$K'_\beta = \frac{113200}{T} - h_2 + 2h_4 \tag{A69}$$

$$K'_\gamma = \frac{166600}{T} - 0.2h_3 - 0.8h_4 + h_5 + h_6 \tag{A70}$$

The partial derivatives of the reacting fractions with respect to $\ln T$ at constant pressure are designated $\epsilon' = \left(\dfrac{\partial \epsilon}{\partial \ln T}\right)_p$

$$\epsilon'_\alpha = \frac{K'_\alpha}{\dfrac{2}{\epsilon_\alpha} - \dfrac{1}{1+\epsilon_\alpha} + \dfrac{1}{0.2 - \epsilon_\alpha}} \tag{A71}$$

$$\epsilon'_\beta = \frac{K'_\beta}{\dfrac{2}{\epsilon_\beta} - \dfrac{1}{1.2+\epsilon_\beta} + \dfrac{1}{0.8 - \epsilon_\beta}} \tag{A72}$$

$$\epsilon'_\gamma = \frac{K'_\gamma}{\dfrac{2}{\epsilon_\gamma} - \dfrac{1}{1+\epsilon_\gamma} + \dfrac{1}{1-\epsilon_\gamma}} \tag{A73}$$

where the fractions ϵ_i are for a constant pressure as given by equations (A41) to (A43). The corresponding partial derivatives for constant density are designated $\epsilon'' = \left(\dfrac{\partial \epsilon}{\partial \ln T}\right)_\rho$

$$\epsilon''_\alpha = \frac{K'_\alpha - 1}{\dfrac{2}{\epsilon_\alpha} + \dfrac{1}{0.2-\epsilon_\alpha}} \tag{A74}$$

$$\epsilon''_\beta = \frac{K'_\beta - 1}{\dfrac{2}{\epsilon_\beta} + \dfrac{1}{0.8-\epsilon_\beta}} \tag{A75}$$

$$\epsilon''_\gamma = \frac{K'_\gamma - 1}{\dfrac{2}{\epsilon_\gamma} + \dfrac{1}{1-\epsilon_\gamma}} \tag{A76}$$

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and in this case the fractions ϵ_i are given by the constant density solutions, equations (A44) through (A46). The partial derivatives of the product of compressibility and mol fraction with respect to the $\ln T$ $\left(x'_i = \dfrac{\partial Z x_i}{\partial \ln T}\right)$ are

$$x'_1 = -\epsilon'_\alpha \tag{A77}$$

$$x'_2 = -\epsilon'_\beta \tag{A78}$$

$$x'_3 = 2\epsilon'_\alpha - 0.4\epsilon'_\gamma \tag{A79}$$

$$x'_4 = 2\epsilon'_\beta - 1.6\epsilon'_\gamma \tag{A80}$$

$$x'_5 = x'_6 = 2\epsilon'_\gamma \tag{A81}$$

Equations (A77) through (A81) are the partial derivatives at constant pressure. An identical set of relations exists for the derivatives at constant density where the constant density partial derivatives x''_i replace the constant pressure derivatives x'_i, and the ϵ'' replace the corresponding ϵ'. The total dimensionless enthalpy of equilibrium air is

$$\frac{ZH}{RT} = Z\left[x_1h_1 + x_2h_2 + x_3\left(h_3 + \frac{59000}{2T}\right) - x_4\left(h_4 + \frac{113200}{2T}\right) + x_5\left(h_5 + \frac{218000}{T}\right) + x_6h_6\right] \tag{A82}$$

The total dimensionless specific heats are

$$\frac{Zc_p}{R} = Z(x_1c_1 + x_2c_2 + x_3c_3 + x_4c_4 + x_5c_5 + x_6c_6)$$
$$+ \left[h_1x'_1 + h_2x'_2 + \left(h_3 + \frac{59000}{2T}\right) x'_3 + \left(h_4 + \frac{113200}{2T}\right) x'_4 + \left(h_5 + \frac{218000}{T}\right) x'_5 + h_6x'_6\right] \tag{A83}$$

$$\frac{Zc_v}{R} = Z(x_1c_1 + x_2c_2 + x_3c_3 + x_4c_4 + x_5c_5 + x_6c_6 - 1)$$
$$+ \left[(h_1-1)x''_1 + (h_2-1)x''_2 + \left(h_3 + \frac{59000}{2T} - 1\right) x''_3 + \left(h_4 + \frac{113200}{2T} - 1\right) x''_4 + \left(h_5 + \frac{218000}{T} - 1\right) x''_5 + (h_6-1)x''_6\right] \tag{A84}$$

The ratio of specific heats is

$$\gamma = \frac{Zc_p/R}{Zc_v/R} \tag{A85}$$

A dimensionless speed of sound parameter is

$$\alpha = \frac{a^2\rho}{p} = \gamma \frac{Z + \epsilon''_\alpha + \epsilon''_\beta + \epsilon''_\gamma}{Z + \epsilon'_\alpha + \epsilon'_\beta + \epsilon'_\gamma} \tag{A86}$$

from which it is easy to compute the speed of sound ratio a/a_o. The ratio

$$I = \frac{a/a_o}{\alpha} \tag{A87}$$

is used as the integrand to calculate

$$\frac{l}{a_o} = \int_o^p I \frac{dp}{p} \tag{A88}$$

For any given value of entropy, the integration is actually suspended at some finite temperature T_i close to 300° K and the ideal gas relations are used to extend the integral from the pressure p_i (corresponding to T_i) down to zero pressure.

$$\frac{l}{a_o} = \int_{ln\, p_i}^{ln\, p} I\, d(ln\, p) + 5\sqrt{\frac{T_i}{273.1}} \tag{A89}$$

In this equation the gas is assumed to be perfect all the way to 0° K. If the liquefaction process were included, this would merely add some constant to the integral. This constant can always be neglected, provided the integrals are not used for temperatures below the liquefaction point.

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TABLE I.- CONSTANT ENTROPY PROPERTIES FOR MODEL EQUILIBRIUM AIR

(a) $ZS/R = 25$

$\log_{10} p$	T, °K	Z	ZH/RT	Zc_p/R	γ	a/a_o	I	l/a_o
3.0	2371	1.000	3.986	4.408	1.294	2.833	2.189	16.276
2.8	2134	1.000	3.942	4.359	1.298	2.692	2.074	15.295
2.6	1919	1.000	3.898	4.314	1.302	2.556	1.964	14.365
2.4	1724	1.000	3.854	4.267	1.306	2.427	1.858	13.485
2.2	1547	1.000	3.809	4.216	1.311	2.303	1.757	12.653
2.0	1386	1.000	3.765	4.160	1.316	2.184	1.659	11.867
1.8	1239	1.000	3.722	4.098	1.323	2.071	1.565	11.124
1.6	1107	1.000	3.681	4.029	1.330	1.962	1.475	10.424
1.4	986	1.000	3.642	3.955	1.338	1.858	1.388	9.765
1.2	877	1.000	3.608	3.879	1.347	1.758	1.305	9.145
1.0	778	1.000	3.578	3.802	1.357	1.661	1.224	8.563
.8	688	1.000	3.554	3.729	1.366	1.568	1.148	8.017
.6	607	1.000	3.535	3.664	1.375	1.478	1.075	7.505
.4	535	1.000	3.521	3.610	1.383	1.391	1.006	7.026
.2	471	1.000	3.512	3.569	1.389	1.308	.941	6.578
.0	414	1.000	3.506	3.540	1.394	1.228	.881	6.159
-.2	363	1.000	3.503	3.521	1.397	1.151	.824	5.766
-.4	318	1.000	3.501	3.510	1.398	1.079	.772	5.399

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TABLE I.- CONSTANT ENTROPY PROPERTIES FOR MODEL EQUILIBRIUM AIR - Continued

(b) $ZS/R = 30$

$\log_{10} p$	T, °K	Z	ZH/RT	Zc_p/R	γ	a/a_o	I	l/a_o
3.0	5591	1.084	5.243	8.919	1.268	4.420	3.588	30.685
2.8	5191	1.072	5.131	8.934	1.259	4.224	3.445	29.066
2.6	4827	1.059	5.010	8.846	1.250	4.041	3.309	27.511
2.4	4492	1.048	4.879	8.628	1.241	3.871	3.180	26.017
2.2	4182	1.037	4.744	8.269	1.235	3.712	3.056	24.581
2.0	3891	1.027	4.606	7.776	1.231	3.565	2.933	23.202
1.8	3613	1.019	4.471	7.176	1.230	3.427	2.811	21.880
1.6	3345	1.012	4.343	6.517	1.234	3.296	2.687	20.614
1.4	3082	1.007	4.229	5.864	1.243	3.172	2.560	19.406
1.2	2823	1.004	4.132	5.292	1.257	3.049	2.431	18.256
1.0	2571	1.002	4.054	4.859	1.272	2.925	2.302	17.167
.8	2328	1.001	3.992	4.580	1.285	2.798	2.178	16.136
.6	2100	1.000	3.940	4.419	1.294	2.667	2.060	15.160
.4	1890	1.000	3.893	4.328	1.301	2.536	1.949	14.237
.2	1697	1.000	3.848	4.265	1.306	2.408	1.844	13.364
.0	1523	1.000	3.803	4.210	1.312	2.286	1.743	12.538
-.2	1364	1.000	3.759	4.152	1.317	2.168	1.646	11.758
-.4	1220	1.000	3.716	4.098	1.324	2.055	1.552	11.022
-.6	1089	1.000	3.675	4.019	1.331	1.947	1.463	10.328
-.8	970	1.000	3.637	3.945	1.340	1.843	1.376	9.674
-1.0	862	1.000	3.604	3.868	1.349	1.744	1.293	9.060
-1.2	764	1.000	3.575	3.792	1.358	1.648	1.213	8.483
-1.4	676	1.000	3.551	3.720	1.368	1.555	1.137	7.942
-1.6	597	1.000	3.533	3.656	1.376	1.466	1.065	7.435
-1.8	526	1.000	3.520	3.604	1.384	1.379	.997	6.961
-2.0	462	1.000	3.511	3.564	1.390	1.296	.933	6.517
-2.2	406	1.000	3.506	3.537	1.394	1.217	.873	6.101
-2.4	356	1.000	3.503	3.519	1.397	1.141	.817	5.712
-2.6	312	1.000	3.501	3.509	1.399	1.069	.764	5.348

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TABLE I.- CONSTANT ENTROPY PROPERTIES FOR MODEL EQUILIBRIUM AIR - Continued

(c) ZS/R = 35

$\log_{10} p$	T, °K	Z	ZH/RT	Zc_p/R	γ	a/a_o	I	l/a_o
3.0	9017	1.303	7.312	15.868	1.252	6.072	5.061	50.485
2.8	8482	1.283	7.160	14.884	1.243	5.839	4.873	48.197
2.6	7973	1.264	7.011	13.779	1.236	5.620	4.690	45.995
2.4	7484	1.246	6.872	12.589	1.231	5.412	4.509	43.878
2.2	7010	1.231	6.747	11.373	1.230	5.214	4.328	41.843
2.0	6546	1.216	6.642	10.226	1.233	5.025	4.145	39.892
1.8	6089	1.204	6.562	9.300	1.241	4.839	3.961	38.025
1.6	5645	1.192	6.506	8.810	1.250	4.652	3.782	36.243
1.4	5226	1.179	6.459	8.952	1.254	4.455	3.618	34.539
1.2	4850	1.166	6.400	9.736	1.252	4.254	3.477	32.907
1.0	4522	1.151	6.311	10.917	1.244	4.060	3.353	31.335
.8	4239	1.135	6.189	12.169	1.234	3.883	3.242	29.816
.6	3991	1.120	6.038	13.238	1.224	3.724	3.139	28.347
.4	3771	1.104	5.863	13.977	1.214	3.580	3.041	26.925
.2	3573	1.088	5.671	14.319	1.205	3.450	2.948	25.545
.0	3390	1.074	5.466	14.247	1.197	3.331	2.859	24.208
-.2	3219	1.060	5.252	13.774	1.190	3.220	2.771	22.912
-.4	3056	1.047	5.033	12.931	1.184	3.118	2.685	21.656
-.6	2899	1.035	4.815	11.768	1.182	3.022	2.597	20.439
-.8	2742	1.025	4.601	10.357	1.183	2.932	2.507	19.264
-1.0	2583	1.016	4.401	8.802	1.190	2.848	2.411	18.131
-1.2	2416	1.009	4.222	7.257	1.206	2.768	2.304	17.045
-1.4	2238	1.004	4.076	5.926	1.233	2.689	2.186	16.011
-1.6	2048	1.001	3.970	5.003	1.264	2.604	2.061	15.033
-1.8	1856	1.000	3.897	4.515	1.289	2.502	1.941	14.112
-2.0	1670	1.000	3.844	4.307	1.304	2.387	1.831	13.244
-2.2	1499	1.000	3.797	4.211	1.312	2.268	1.729	12.424
-2.4	1342	1.000	3.752	4.144	1.318	2.151	1.632	11.651
-2.6	1200	1.000	3.710	4.079	1.325	2.039	1.539	10.921
-2.8	1071	1.000	3.669	4.008	1.332	1.932	1.450	10.232
-3.0	954	1.000	3.632	3.934	1.341	1.829	1.364	9.585
-3.2	847	1.000	3.599	3.857	1.350	1.730	1.281	8.976
-3.4	751	1.000	3.571	3.781	1.360	1.634	1.202	8.404
-3.6	664	1.000	3.548	3.710	1.369	1.542	1.127	7.868
-3.8	586	1.000	3.531	3.648	1.378	1.453	1.055	7.366
-4.0	516	1.000	3.518	3.597	1.385	1.367	.987	6.896
-4.2	454	1.000	3.510	3.560	1.391	1.285	.924	6.456
-4.4	398	1.000	3.505	3.534	1.395	1.206	.864	6.044
-4.6	350	1.000	3.502	3.517	1.397	1.130	.809	5.659
-4.8	307	1.000	3.501	3.508	1.399	1.059	.757	5.298

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TABLE I.- CONSTANT ENTROPY PROPERTIES FOR MODEL EQUILIBRIUM AIR - Continued

(d) ZS/R = 40

$\log_{10} p$	T, °K	Z	ZH/RT	Zc_p/R	γ	a/a_o	I	l/a_o
3.0	11330	1.603	10.336	26.487	1.315	7.566	6.277	73.647
2.8	10701	1.570	10.192	27.392	1.305	7.254	6.057	70.808
2.6	10129	1.538	10.032	28.046	1.295	6.966	5.850	68.066
2.4	9605	1.507	9.858	28.442	1.284	6.698	5.654	65.418
2.2	9124	1.478	9.672	28.575	1.274	6.449	5.470	62.857
2.0	8679	1.450	9.476	28.444	1.263	6.216	5.295	60.379
1.8	8265	1.422	9.272	28.049	1.252	5.997	5.128	57.979
1.6	7880	1.397	9.061	27.391	1.241	5.792	4.970	55.654
1.4	7517	1.372	8.845	26.473	1.230	5.599	4.818	53.401
1.2	7175	1.348	8.625	25.300	1.220	5.416	4.672	51.216
1.0	6850	1.326	8.404	23.878	1.210	5.244	4.531	49.097
.8	6539	1.305	8.184	22.217	1.201	5.080	4.394	47.042
.6	6239	1.285	7.967	20.331	1.194	4.925	4.260	45.049
.4	5945	1.267	7.758	18.243	1.189	4.777	4.125	43.118
.2	5654	1.250	7.563	15.986	1.186	4.636	3.989	41.250
.0	5359	1.235	7.391	13.621	1.188	4.502	3.847	39.445
-.2	5054	1.222	7.253	11.253	1.196	4.374	3.695	37.708
-.4	4730	1.212	7.170	9.083	1.215	4.253	3.525	36.045
-.6	4382	1.203	7.163	7.497	1.242	4.129	3.340	34.464
-.8	4025	1.195	7.221	7.154	1.258	3.967	3.173	32.966
-1.0	3710	1.186	7.263	8.623	1.240	3.757	3.063	31.532
-1.2	3463	1.173	7.220	11.456	1.214	3.560	2.985	30.140
-1.4	3269	1.158	7.095	14.614	1.197	3.402	2.911	28.783
-1.6	3109	1.143	6.917	17.411	1.186	3.273	2.839	27.459
-1.8	2971	1.127	6.703	19.553	1.178	3.163	2.769	26.168
-2.0	2848	1.112	6.467	20.953	1.171	3.066	2.701	24.908
-2.2	2736	1.097	6.214	21.612	1.165	2.978	2.635	23.679
-2.4	2631	1.082	5.950	21.570	1.159	2.896	2.572	22.481
-2.6	2531	1.069	5.680	20.884	1.154	2.821	2.509	21.311
-2.8	2435	1.056	5.405	19.619	1.149	2.749	2.446	20.170
-3.0	2341	1.044	5.129	17.846	1.147	2.682	2.383	19.058
-3.2	2246	1.033	4.857	15.650	1.146	2.618	2.318	17.975
-3.4	2149	1.023	4.593	13.139	1.150	2.558	2.247	16.924
-3.6	2044	1.014	4.347	10.477	1.161	2.501	2.168	15.907
-3.8	1927	1.007	4.131	7.925	1.186	2.450	2.073	14.929
-4.0	1791	1.003	3.964	5.889	1.229	2.401	1.956	14.001
-4.2	1635	1.001	3.858	4.726	1.277	2.338	1.831	13.129
-4.4	1474	1.000	3.794	4.290	1.306	2.244	1.718	12.312
-4.6	1321	1.000	3.747	4.148	1.318	2.134	1.619	11.544
-4.8	1181	1.000	3.704	4.070	1.326	2.024	1.526	10.820
-5.0	1054	1.000	3.664	3.998	1.334	1.917	1.438	10.138
-5.2	938	1.000	3.627	3.923	1.342	1.815	1.352	9.495
-5.4	833	1.000	3.595	3.846	1.351	1.716	1.270	8.892
-5.6	738	1.000	3.567	3.770	1.361	1.621	1.191	8.325
-5.8	653	1.000	3.545	3.700	1.370	1.529	1.116	7.794
-6.0	576	1.000	3.529	3.640	1.379	1.441	1.045	7.297
-6.2	507	1.000	3.517	3.591	1.386	1.355	.978	6.831
-6.4	445	1.000	3.509	3.555	1.391	1.273	.915	6.396
-6.6	391	1.000	3.505	3.531	1.395	1.195	.856	5.988
-6.8	343	1.000	3.502	3.516	1.397	1.120	.801	5.606
-7.0	301	1.000	3.501	3.507	1.399	1.049	.750	5.249

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TABLE I.- CONSTANT ENTROPY PROPERTIES FOR MODEL EQUILIBRIUM AIR - Continued

(e) ZS/R = 45

$\log_{10} p$	T,°K	Z	ZH/RT	Zc_p/R	γ	a/a_o	I	l/a_o
3.0	14122	1.928	12.742	16.785	1.315	9.479	7.513	98.267
2.8	13086	1.893	12.836	19.129	1.308	8.978	7.219	94.876
2.6	12198	1.858	12.875	21.814	1.302	8.532	6.948	91.614
2.4	11431	1.822	12.864	24.667	1.298	8.134	6.697	88.473
2.2	10760	1.786	12.810	27.534	1.294	7.776	6.463	85.444
2.0	10167	1.750	12.719	30.295	1.290	7.452	6.245	82.518
1.8	9638	1.715	12.598	32.864	1.286	7.156	6.041	79.689
1.6	9161	1.680	12.451	35.177	1.282	6.884	5.849	76.952
1.4	8729	1.647	12.282	37.191	1.276	6.633	5.668	74.301
1.2	8334	1.614	12.096	38.878	1.270	6.400	5.498	71.730
1.0	7972	1.582	11.893	40.218	1.263	6.182	5.337	69.235
.8	7637	1.552	11.676	41.200	1.255	5.980	5.185	66.813
.6	7327	1.523	11.448	41.818	1.247	5.789	5.040	64.459
.4	7038	1.494	11.209	42.070	1.239	5.611	4.903	62.169
.2	6767	1.467	10.961	41.957	1.230	5.442	4.772	59.942
.0	6513	1.441	10.706	41.482	1.221	5.284	4.648	57.773
-.2	6273	1.416	10.445	40.651	1.212	5.133	4.528	55.660
-.4	6046	1.393	10.179	39.469	1.203	4.991	4.413	53.602
-.6	5830	1.370	9.909	37.944	1.194	4.855	4.303	51.595
-.8	5623	1.348	9.636	36.085	1.185	4.727	4.196	49.638
-1.0	5423	1.328	9.363	33.904	1.177	4.604	4.092	47.730
-1.2	5230	1.308	9.091	31.414	1.169	4.486	3.990	45.869
-1.4	5041	1.290	8.822	28.630	1.163	4.374	3.889	44.055
-1.6	4854	1.273	8.560	25.576	1.158	4.266	3.788	42.288
-1.8	4667	1.256	8.310	22.283	1.154	4.162	3.685	40.567
-2.0	4475	1.242	8.078	18.801	1.155	4.063	3.577	38.894
-2.2	4274	1.228	7.877	15.216	1.160	3.968	3.460	37.274
-2.4	4053	1.217	7.727	11.687	1.176	3.881	3.324	35.710
-2.6	3800	1.208	7.663	8.529	1.210	3.804	3.156	34.217
-2.8	3501	1.202	7.739	6.332	1.264	3.726	2.954	32.809
-3.0	3178	1.198	7.947	5.973	1.285	3.572	2.787	31.491
-3.2	2912	1.191	8.097	8.499	1.228	3.326	2.728	30.224
-3.4	2733	1.179	8.064	13.309	1.183	3.135	2.689	28.976
-3.6	2604	1.165	7.912	18.468	1.164	3.006	2.640	27.749
-3.8	2500	1.150	7.698	22.954	1.154	2.908	2.587	26.545
-4.0	2411	1.136	7.447	26.436	1.149	2.826	2.534	25.366
-4.2	2331	1.122	7.174	28.853	1.144	2.754	2.483	24.211
-4.4	2257	1.108	6.885	30.242	1.140	2.688	2.433	23.079
-4.6	2189	1.094	6.586	30.676	1.136	2.627	2.384	21.970
-4.8	2123	1.081	6.280	30.237	1.132	2.570	2.337	20.883
-5.0	2060	1.069	5.970	29.008	1.128	2.516	2.289	19.818
-5.2	1999	1.057	5.657	27.071	1.124	2.465	2.242	18.774
-5.4	1938	1.046	5.344	24.510	1.122	2.415	2.194	17.753
-5.6	1876	1.035	5.033	21.413	1.121	2.368	2.145	16.753
-5.8	1811	1.025	4.730	17.890	1.124	2.323	2.091	15.778
-6.0	1741	1.017	4.439	14.098	1.132	2.280	2.031	14.828
-6.2	1662	1.009	4.175	10.303	1.152	2.243	1.956	13.910
-6.4	1564	1.004	3.958	7.010	1.196	2.214	1.854	13.031
-6.6	1439	1.001	3.817	4.961	1.264	2.182	1.727	12.206
-6.8	1299	1.000	3.745	4.247	1.310	2.110	1.610	11.439
-7.0	1162	1.000	3.698	4.071	1.326	2.007	1.514	10.720
-7.2	1036	1.000	3.659	3.988	1.335	1.902	1.425	10.043
-7.4	922	1.000	3.622	3.912	1.343	1.800	1.340	9.407
-7.6	819	1.000	3.591	3.835	1.353	1.702	1.258	8.808
-7.8	725	1.000	3.564	3.760	1.362	1.608	1.180	8.247
-8.0	641	1.000	3.543	3.691	1.372	1.516	1.106	7.721
-8.2	565	1.000	3.527	3.632	1.380	1.428	1.035	7.228
-8.4	497	1.000	3.516	3.585	1.387	1.343	.969	6.767
-8.6	437	1.000	3.508	3.551	1.392	1.262	.906	6.335
-8.8	384	1.000	3.504	3.528	1.396	1.184	.848	5.931

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TABLE I.- CONSTANT ENTROPY PROPERTIES FOR MODEL EQUILIBRIUM AIR - Continued

(f) ZS/R = 50

$\log_{10} p$	T, °K	Z	ZH/RT	Zc_p/R	γ	a/a_o	I	l/a_o
2.4	15361	2.075	13.845	15.359	1.300	10.326	8.076	112.684
2.2	14135	2.045	14.056	14.733	1.291	9.805	7.713	109.050
2.0	13009	2.018	14.296	14.566	1.285	9.313	7.372	105.577
1.8	11993	1.990	14.546	15.207	1.278	8.843	7.061	102.255
1.6	11103	1.962	14.767	16.955	1.271	8.397	6.785	99.068
1.4	10341	1.931	14.925	19.844	1.265	7.984	6.542	96.001
1.2	9696	1.898	15.008	23.615	1.260	7.614	6.322	93.039
1.0	9145	1.864	15.020	27.898	1.257	7.285	6.120	90.175
.8	8669	1.829	14.972	32.363	1.256	6.992	5.931	87.400
.6	8251	1.794	14.875	36.766	1.255	6.727	5.755	84.710
.4	7878	1.759	14.741	40.942	1.253	6.487	5.589	82.098
.2	7543	1.726	14.576	44.784	1.251	6.267	5.433	79.561
.0	7238	1.693	14.386	48.223	1.248	6.064	5.286	77.093
-.2	6960	1.661	14.175	51.218	1.244	5.875	5.146	74.691
-.4	6702	1.630	13.946	53.745	1.240	5.699	5.014	72.352
-.6	6464	1.600	13.703	55.792	1.235	5.535	4.889	70.072
-.8	6242	1.572	13.448	57.355	1.229	5.380	4.770	67.848
-1.0	6034	1.544	13.181	58.437	1.223	5.234	4.656	65.678
-1.2	5839	1.517	12.905	59.043	1.216	5.096	4.547	63.559
-1.4	5654	1.492	12.622	59.182	1.209	4.966	4.444	61.489
-1.6	5480	1.467	12.331	58.865	1.202	4.842	4.344	59.465
-1.8	5315	1.444	12.034	58.101	1.195	4.724	4.248	57.487
-2.0	5157	1.421	11.733	56.905	1.187	4.612	4.156	55.552
-2.2	5006	1.399	11.427	55.288	1.180	4.505	4.068	53.658
-2.4	4861	1.378	11.118	53.263	1.172	4.402	3.982	51.805
-2.6	4722	1.359	10.808	50.844	1.165	4.304	3.898	49.991
-2.8	4586	1.339	10.496	48.045	1.158	4.210	3.817	48.215
-3.0	4455	1.321	10.185	44.882	1.151	4.119	3.737	46.475
-3.2	4326	1.304	9.875	41.369	1.144	4.032	3.658	44.773
-3.4	4198	1.287	9.569	37.527	1.139	3.948	3.580	43.106
-3.6	4071	1.271	9.270	33.378	1.134	3.866	3.502	41.475
-3.8	3942	1.256	8.981	28.956	1.131	3.787	3.421	39.881
-4.0	3809	1.242	8.709	24.307	1.131	3.711	3.336	38.325
-4.2	3668	1.230	8.464	19.512	1.135	3.638	3.244	36.809
-4.4	3512	1.219	8.264	14.723	1.148	3.571	3.135	35.340
-4.6	3328	1.209	8.147	10.256	1.178	3.515	2.995	33.927
-4.8	3094	1.203	8.186	6.779	1.243	3.476	2.801	32.590
-5.0	2803	1.200	8.452	5.177	1.315	3.400	2.588	31.351
-5.2	2521	1.197	8.815	6.104	1.278	3.173	2.488	30.189
-5.4	2336	1.189	8.945	11.162	1.185	2.922	2.487	29.043
-5.6	2223	1.177	8.842	18.386	1.148	2.782	2.461	27.903
-5.8	2140	1.164	8.634	25.298	1.135	2.691	2.422	26.778
-6.0	2072	1.151	8.375	31.068	1.130	2.620	2.381	25.672
-6.2	2013	1.137	8.089	35.505	1.127	2.560	2.339	24.586
-6.4	1959	1.124	7.784	38.621	1.124	2.506	2.299	23.518
-6.6	1908	1.112	7.467	40.497	1.121	2.456	2.260	22.468
-6.8	1861	1.099	7.142	41.231	1.118	2.409	2.221	21.436
-7.0	1816	1.087	6.810	40.924	1.115	2.365	2.184	20.422
-7.2	1772	1.076	6.474	39.673	1.112	2.323	2.147	19.425
-7.4	1729	1.065	6.136	37.567	1.109	2.283	2.110	18.445
-7.6	1687	1.054	5.796	34.693	1.106	2.244	2.073	17.482
-7.8	1644	1.044	5.457	31.135	1.104	2.206	2.035	16.536
-8.0	1600	1.034	5.121	26.984	1.104	2.169	1.995	15.608
-8.2	1554	1.025	4.791	22.348	1.106	2.134	1.953	14.698
-8.4	1504	1.017	4.473	17.382	1.113	2.101	1.904	13.810
-8.6	1446	1.009	4.178	12.361	1.131	2.073	1.842	12.947
-8.8	1371	1.004	3.930	7.872	1.176	2.055	1.751	12.118
-9.0	1268	1.001	3.768	5.022	1.261	2.045	1.623	11.340
-9.2	1142	1.000	3.696	4.151	1.319	1.985	1.505	10.622
-9.4	1019	1.000	3.653	3.984	1.335	1.887	1.413	9.950

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TABLE I.- CONSTANT ENTROPY PROPERTIES FOR MODEL EQUILIBRIUM AIR - Continued

(g) ZS/R = 55

$\log_{10} p$	T, °K	Z	ZH/RT	Zc_p/R	γ	a/a_o	I	l/a_o
1.6	14885	2.177	15.394	23.290	1.278	10.279	8.246	122.716
1.4	13915	2.139	15.438	21.645	1.265	9.825	7.924	118.993
1.2	12997	2.105	15.516	19.842	1.256	9.404	7.610	115.416
1.0	12119	2.074	15.644	17.975	1.251	9.010	7.297	111.984
.8	11269	2.047	15.838	16.222	1.250	8.639	6.985	108.695
.6	10446	2.022	16.113	14.940	1.253	8.280	6.674	105.551
.4	9663	1.999	16.455	14.779	1.255	7.915	6.385	102.545
.2	8960	1.974	16.796	16.536	1.250	7.534	6.142	99.663
.0	8369	1.946	17.048	20.463	1.239	7.166	5.945	96.881
-.2	7885	1.915	17.179	25.983	1.231	6.841	5.772	94.183
-.4	7483	1.882	17.204	32.300	1.228	6.562	5.613	91.562
-.6	7141	1.848	17.150	38.824	1.226	6.319	5.462	89.012
-.8	6842	1.815	17.037	45.194	1.226	6.104	5.320	86.530
-1.0	6576	1.782	16.881	51.196	1.225	5.909	5.186	84.111
-1.2	6336	1.749	16.691	56.710	1.225	5.732	5.059	81.752
-1.4	6118	1.718	16.476	61.666	1.223	5.567	4.939	79.450
-1.6	5916	1.688	16.239	66.031	1.222	5.415	4.824	77.203
-1.8	5729	1.659	15.985	69.789	1.219	5.272	4.715	75.006
-2.0	5555	1.631	15.717	72.936	1.216	5.138	4.611	72.859
-2.2	5392	1.603	15.437	75.480	1.212	5.012	4.512	70.758
-2.4	5239	1.577	15.146	77.429	1.207	4.893	4.417	68.702
-2.6	5094	1.552	14.847	78.799	1.203	4.779	4.326	66.689
-2.8	4956	1.528	14.539	79.604	1.197	4.672	4.239	64.717
-3.0	4826	1.504	14.225	79.862	1.192	4.569	4.155	62.784
-3.2	4701	1.481	13.905	79.588	1.186	4.471	4.075	60.890
-3.4	4582	1.460	13.580	78.801	1.180	4.378	3.997	59.031
-3.6	4468	1.439	13.251	77.518	1.174	4.288	3.921	57.208
-3.8	4359	1.418	12.918	75.755	1.167	4.202	3.849	55.419
-4.0	4253	1.399	12.583	73.528	1.161	4.119	3.778	53.663
-4.2	4151	1.380	12.245	70.855	1.155	4.039	3.709	51.939
-4.4	4052	1.362	11.905	67.750	1.148	3.962	3.642	50.246
-4.6	3955	1.344	11.565	64.230	1.142	3.888	3.577	48.584
-4.8	3861	1.328	11.225	60.310	1.136	3.816	3.513	46.952
-5.0	3768	1.311	10.886	56.007	1.131	3.747	3.450	45.348
-5.2	3677	1.296	10.549	51.338	1.125	3.679	3.387	43.774
-5.4	3585	1.281	10.217	46.323	1.120	3.614	3.325	42.229
-5.6	3493	1.267	9.891	40.986	1.117	3.550	3.261	40.712
-5.8	3400	1.253	9.576	35.358	1.114	3.487	3.196	39.225
-6.0	3302	1.241	9.276	29.489	1.114	3.427	3.127	37.769
-6.2	3197	1.229	9.002	23.458	1.117	3.369	3.051	36.346
-6.4	3080	1.218	8.771	17.419	1.128	3.315	2.960	34.962
-6.6	2938	1.209	8.621	11.717	1.158	3.274	2.839	33.625
-6.8	2749	1.203	8.640	7.169	1.228	3.257	2.656	32.357
-7.0	2492	1.200	8.946	4.989	1.325	3.219	2.431	31.186
-7.2	2221	1.199	9.453	5.051	1.325	3.038	2.294	30.104
-7.4	2030	1.194	9.769	9.446	1.195	2.746	2.309	29.047
-7.6	1928	1.184	9.722	18.371	1.136	2.590	2.306	27.983
-7.8	1861	1.172	9.520	27.617	1.120	2.505	2.278	26.927
-8.0	1808	1.160	9.255	35.659	1.115	2.444	2.244	25.886
-8.2	1763	1.147	8.957	42.150	1.112	2.393	2.211	24.860
-8.4	1721	1.135	8.639	47.071	1.111	2.348	2.177	23.850
-8.6	1683	1.123	8.309	50.502	1.109	2.306	2.145	22.855
-8.8	1648	1.112	7.969	52.556	1.107	2.268	2.113	21.874
-9.0	1613	1.101	7.623	53.346	1.105	2.231	2.082	20.908
-9.2	1581	1.090	7.272	52.983	1.103	2.196	2.051	19.957
-9.4	1549	1.079	6.917	51.570	1.100	2.163	2.021	19.019
-9.6	1517	1.069	6.560	49.201	1.098	2.130	1.992	18.095
-9.8	1486	1.059	6.202	45.962	1.095	2.099	1.962	17.185
-10.0	1455	1.049	5.844	41.937	1.093	2.068	1.931	16.288
-10.2	1424	1.040	5.487	37.209	1.091	2.038	1.900	15.406

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TABLE I.- CONSTANT ENTROPY PROPERTIES FOR MODEL EQUILIBRIUM AIR - Continued

(h) ZS/R = 60

$\log_{10} p$	T, °K	Z	ZH/RT	Zc_p/R	γ	a/a_o	I	l/a_o
1.0	14696	2.325	17.504	36.559	1.284	10.483	8.527	135.816
.8	13895	2.279	17.422	35.054	1.268	10.055	8.236	131.956
.6	13147	2.235	17.344	33.209	1.253	9.657	7.959	128.228
.4	12441	2.194	17.279	31.034	1.241	9.285	7.691	124.625
.2	11770	2.157	17.233	28.548	1.230	8.938	7.430	121.143
.0	11123	2.122	17.221	25.783	1.222	8.611	7.171	117.781
-.2	10492	2.091	17.257	22.795	1.218	8.304	6.911	114.539
-.4	9863	2.063	17.369	19.693	1.219	8.015	6.641	111.418
-.6	9226	2.039	17.591	16.705	1.227	7.741	6.356	108.424
-.8	8573	2.017	17.962	14.358	1.242	7.471	6.055	105.566
-1.0	7922	1.997	18.475	13.838	1.252	7.166	5.776	102.844
-1.2	7345	1.974	18.977	16.739	1.237	6.798	5.580	100.233
-1.4	6891	1.947	19.295	23.060	1.217	6.452	5.439	97.697
-1.6	6538	1.916	19.423	31.261	1.206	6.172	5.309	95.222
-1.8	6251	1.884	19.421	40.079	1.202	5.943	5.183	92.807
-2.0	6007	1.852	19.333	48.834	1.202	5.748	5.063	90.448
-2.2	5793	1.820	19.186	57.179	1.202	5.575	4.947	88.143
-2.4	5601	1.790	18.998	64.937	1.203	5.420	4.838	85.890
-2.6	5427	1.760	18.779	72.019	1.203	5.277	4.733	83.686
-2.8	5266	1.731	18.535	78.381	1.203	5.145	4.634	81.530
-3.0	5117	1.703	18.272	84.008	1.202	5.021	4.539	79.418
-3.2	4979	1.675	17.993	88.901	1.201	4.905	4.448	77.349
-3.4	4848	1.649	17.701	93.070	1.199	4.795	4.361	75.321
-3.6	4725	1.624	17.399	96.531	1.197	4.692	4.278	73.331
-3.8	4609	1.599	17.086	99.303	1.194	4.593	4.198	71.380
-4.0	4498	1.576	16.766	101.407	1.190	4.499	4.121	69.465
-4.2	4393	1.553	16.439	102.864	1.186	4.409	4.047	67.584
-4.4	4293	1.531	16.105	103.697	1.182	4.323	3.975	65.737
-4.6	4196	1.509	15.767	103.927	1.177	4.241	3.906	63.923
-4.8	4104	1.489	15.423	103.575	1.173	4.162	3.840	62.139
-5.0	4015	1.469	15.076	102.663	1.168	4.086	3.775	60.386
-5.2	3930	1.449	14.724	101.209	1.162	4.013	3.712	58.662
-5.4	3847	1.430	14.370	99.234	1.157	3.942	3.652	56.966
-5.6	3768	1.412	14.013	96.754	1.152	3.874	3.593	55.298
-5.8	3690	1.395	13.654	93.789	1.146	3.808	3.535	53.657
-6.0	3615	1.378	13.294	90.356	1.141	3.745	3.479	52.042
-6.2	3541	1.361	12.932	86.469	1.135	3.683	3.424	50.453
-6.4	3469	1.346	12.570	82.146	1.130	3.623	3.370	48.888
-6.6	3399	1.330	12.209	77.403	1.125	3.565	3.318	47.348
-6.8	3330	1.315	11.848	72.254	1.119	3.508	3.266	45.833
-7.0	3261	1.301	11.488	66.717	1.115	3.453	3.214	44.341
-7.2	3192	1.287	11.132	60.809	1.110	3.399	3.163	42.872
-7.4	3124	1.274	10.781	54.550	1.106	3.346	3.111	41.428
-7.6	3054	1.261	10.436	47.963	1.103	3.294	3.058	40.007
-7.8	2982	1.249	10.102	41.082	1.101	3.244	3.004	38.611
-8.0	2907	1.237	9.784	33.955	1.101	3.194	2.946	37.241
-8.2	2826	1.226	9.491	26.668	1.104	3.147	2.881	35.899
-8.4	2733	1.217	9.242	19.390	1.115	3.104	2.802	34.590
-8.6	2617	1.208	9.079	12.521	1.146	3.073	2.691	33.324
-8.8	2453	1.202	9.109	7.121	1.227	3.075	2.509	32.123
-9.0	2219	1.200	9.488	4.808	1.338	3.053	2.282	31.021
-9.2	1969	1.200	10.108	4.688	1.350	2.888	2.139	30.007
-9.4	1784	1.196	10.577	8.638	1.202	2.587	2.158	29.024
-9.6	1695	1.187	10.569	19.250	1.125	2.422	2.173	28.024
-9.8	1641	1.176	10.366	30.743	1.107	2.345	2.152	27.027
-10.0	1599	1.165	10.091	40.945	1.102	2.293	2.125	26.042
-10.2	1563	1.153	9.782	49.402	1.101	2.249	2.097	25.070
-10.4	1531	1.142	9.454	56.074	1.100	2.211	2.069	24.111
-10.6	1501	1.131	9.112	61.048	1.099	2.177	2.041	23.165
-10.8	1474	1.121	8.761	64.443	1.098	2.144	2.014	22.231

TABLE I.- CONSTANT ENTROPY PROPERTIES FOR MODEL EQUILIBRIUM AIR - Continued

(i) ZS/R = 65

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$\log_{10} p$	T, °K	Z	ZH/RT	Zc_p/R	γ	a/a_o	I	l/a_o
.6	14790	2.527	20.159	52.371	1.306	10.947	8.932	152.184
.4	14061	2.472	20.024	51.855	1.291	10.516	8.646	148.137
.2	13385	2.420	19.878	50.904	1.275	10.117	8.375	144.219
.0	12757	2.371	19.727	49.519	1.261	9.745	8.119	140.421
-.2	12169	2.325	19.572	47.706	1.247	9.397	7.874	136.739
-.4	11616	2.281	19.418	45.471	1.234	9.071	7.640	133.167
-.6	11091	2.240	19.270	42.821	1.222	8.764	7.414	129.701
-.8	10590	2.201	19.135	39.770	1.212	8.475	7.195	126.337
-1.0	10107	2.165	19.020	36.333	1.203	8.201	6.979	123.074
-1.2	9635	2.131	18.936	32.538	1.196	7.941	6.765	119.909
-1.4	9169	2.100	18.900	28.428	1.192	7.695	6.547	116.844
-1.6	8697	2.072	18.937	24.083	1.193	7.462	6.318	113.881
-1.8	8207	2.047	19.090	19.658	1.202	7.242	6.069	111.028
-2.0	7682	2.026	19.424	15.515	1.223	7.038	5.784	108.297
-2.2	7109	2.008	20.024	12.647	1.254	6.827	5.468	105.706
-2.4	6538	1.990	20.810	13.554	1.252	6.501	5.234	103.248
-2.6	6093	1.966	21.389	20.150	1.213	6.112	5.126	100.865
-2.8	5775	1.937	21.644	30.236	1.191	5.819	5.029	98.526
-3.0	5531	1.907	21.695	41.441	1.183	5.601	4.927	96.234
-3.2	5329	1.877	21.629	52.660	1.181	5.424	4.824	93.989
-3.4	5155	1.847	21.489	63.409	1.182	5.271	4.725	91.790
-3.6	4999	1.818	21.300	73.466	1.184	5.135	4.630	89.636
-3.8	4858	1.790	21.075	82.727	1.185	5.011	4.539	87.525
-4.0	4729	1.762	20.824	91.148	1.186	4.896	4.452	85.455
-4.2	4608	1.735	20.552	98.716	1.187	4.788	4.369	83.424
-4.4	4496	1.709	20.264	105.434	1.187	4.687	4.289	81.431
-4.6	4390	1.684	19.962	111.319	1.187	4.592	4.212	79.473
-4.8	4290	1.660	19.649	116.390	1.186	4.501	4.139	77.550
-5.0	4195	1.637	19.326	120.672	1.184	4.415	4.068	75.661
-5.2	4104	1.614	18.995	124.190	1.182	4.332	4.000	73.803
-5.4	4018	1.592	18.657	126.970	1.179	4.253	3.934	71.977
-5.6	3935	1.571	18.313	129.038	1.176	4.178	3.870	70.180
-5.8	3856	1.550	17.963	130.420	1.173	4.105	3.809	68.412
-6.0	3780	1.530	17.609	131.140	1.170	4.035	3.749	66.672
-6.2	3707	1.510	17.250	131.222	1.166	3.968	3.691	64.959
-6.4	3636	1.492	16.887	130.689	1.162	3.903	3.635	63.272
-6.6	3568	1.473	16.521	129.563	1.158	3.840	3.581	61.610
-6.8	3502	1.455	16.153	127.866	1.153	3.779	3.528	59.974
-7.0	3438	1.438	15.781	125.617	1.149	3.720	3.476	58.361
-7.2	3375	1.421	15.408	122.836	1.144	3.663	3.426	56.772
-7.4	3315	1.405	15.032	119.540	1.139	3.608	3.377	55.205
-7.6	3256	1.389	14.656	115.748	1.134	3.554	3.329	53.661
-7.8	3198	1.374	14.278	111.475	1.130	3.502	3.283	52.138
-8.0	3142	1.359	13.899	106.739	1.125	3.451	3.237	50.637
-8.2	3087	1.345	13.520	101.553	1.120	3.401	3.192	49.157
-8.4	3032	1.331	13.141	95.935	1.115	3.353	3.147	47.698
-8.6	2978	1.317	12.764	89.898	1.111	3.306	3.104	46.258
-8.8	2925	1.304	12.387	83.458	1.106	3.260	3.060	44.839
-9.0	2872	1.291	12.013	76.630	1.102	3.214	3.017	43.440
-9.2	2819	1.278	11.643	69.431	1.098	3.170	2.974	42.060
-9.4	2765	1.266	11.277	61.883	1.094	3.126	2.930	40.701
-9.6	2710	1.255	10.919	54.007	1.092	3.083	2.885	39.362
-9.8	2653	1.244	10.572	45.840	1.090	3.041	2.838	38.044
-10.0	2593	1.233	10.241	37.434	1.090	3.000	2.788	36.748
-10.2	2526	1.223	9.937	28.884	1.095	2.961	2.731	35.477
-10.4	2449	1.214	9.680	20.388	1.107	2.926	2.659	34.235
-10.6	2349	1.207	9.523	12.456	1.142	2.906	2.552	33.033
-10.8	2198	1.202	9.604	6.564	1.243	2.929	2.358	31.899
-11.0	1975	1.200	10.103	4.603	1.355	2.898	2.139	30.867
-11.2	1746	1.200	10.837	4.555	1.361	2.731	2.007	29.915

TABLE I.- CONSTANT ENTROPY PROPERTIES FOR MODEL EQUILIBRIUM AIR - Continued

(j) ZS/R = 70

$\log_{10} p$	T, °K	Z	ZH/RT	Zc_p/R	γ	a/a_0	I	l/a_0
.4	15300	2.792	23.209	65.614	1.334	11.729	9.525	172.204
.2	14563	2.727	23.079	67.039	1.320	11.265	9.222	167.888
.0	13888	2.666	22.929	67.938	1.307	10.837	8.937	163.708
-.2	13266	2.608	22.761	68.313	1.293	10.439	8.668	159.654
-.4	12690	2.553	22.579	68.166	1.280	10.069	8.415	155.722
-.6	12154	2.500	22.385	67.504	1.267	9.723	8.174	151.902
-.8	11653	2.450	22.182	66.330	1.254	9.400	7.946	148.191
-1.0	11183	2.403	21.972	64.653	1.242	9.096	7.728	144.582
-1.2	10740	2.358	21.760	62.478	1.230	8.809	7.520	141.072
-1.4	10320	2.315	21.547	59.814	1.219	8.539	7.320	137.655
-1.6	9919	2.275	21.337	56.671	1.208	8.282	7.127	134.329
-1.8	9536	2.237	21.135	53.061	1.198	8.039	6.940	131.090
-2.0	9165	2.200	20.947	48.996	1.189	7.807	6.756	127.936
-2.2	8804	2.166	20.779	44.497	1.182	7.586	6.575	124.867
-2.4	8448	2.134	20.643	39.588	1.176	7.374	6.394	121.880
-2.6	8092	2.104	20.553	34.310	1.172	7.172	6.209	118.978
-2.8	7728	2.076	20.535	28.729	1.173	6.978	6.014	116.163
-3.0	7345	2.051	20.632	22.973	1.181	6.797	5.797	113.442
-3.2	6922	2.029	20.920	17.325	1.203	6.634	5.539	110.830
-3.4	6433	2.012	21.544	12.566	1.248	6.491	5.215	108.351
-3.6	5883	1.997	22.591	11.308	1.278	6.252	4.915	106.025
-3.8	5437	1.977	23.493	17.849	1.215	5.810	4.839	103.784
-4.0	5149	1.951	23.881	29.891	1.178	5.498	4.778	101.568
-4.2	4941	1.922	23.977	43.536	1.166	5.292	4.695	99.387
-4.4	4773	1.894	23.924	57.222	1.164	5.132	4.607	97.245
-4.6	4630	1.866	23.786	70.359	1.165	4.997	4.521	95.143
-4.8	4503	1.838	23.593	82.698	1.167	4.878	4.438	93.080
-5.0	4388	1.811	23.361	94.130	1.170	4.770	4.359	91.055
-5.2	4282	1.785	23.102	104.613	1.172	4.670	4.282	89.065
-5.4	4183	1.760	22.822	114.138	1.173	4.576	4.209	87.110
-5.6	4090	1.736	22.525	122.711	1.174	4.488	4.138	85.188
-5.8	4003	1.712	22.214	130.354	1.175	4.404	4.070	83.298
-6.0	3920	1.689	21.891	137.090	1.175	4.324	4.005	81.439
-6.2	3841	1.667	21.560	142.947	1.174	4.248	3.942	79.609
-6.4	3766	1.645	21.219	147.953	1.173	4.176	3.881	77.808
-6.6	3694	1.624	20.872	152.139	1.172	4.106	3.822	76.034
-6.8	3625	1.603	20.519	155.533	1.170	4.039	3.765	74.287
-7.0	3559	1.584	20.160	158.164	1.168	3.974	3.710	72.566
-7.2	3495	1.564	19.797	160.058	1.166	3.912	3.656	70.870
-7.4	3434	1.545	19.429	161.244	1.163	3.852	3.604	69.198
-7.6	3374	1.527	19.057	161.745	1.160	3.793	3.554	67.550
-7.8	3317	1.509	18.682	161.587	1.156	3.737	3.505	65.925
-8.0	3261	1.492	18.304	160.793	1.153	3.683	3.457	64.322
-8.2	3207	1.475	17.923	159.385	1.149	3.630	3.410	62.741
-8.4	3155	1.459	17.540	157.385	1.145	3.578	3.365	61.181
-8.6	3104	1.443	17.155	154.811	1.141	3.528	3.321	59.642
-8.8	3054	1.428	16.768	151.684	1.137	3.480	3.277	58.123
-9.0	3006	1.412	16.379	148.022	1.133	3.433	3.235	56.623
-9.2	2958	1.398	15.989	143.842	1.129	3.387	3.194	55.143
-9.4	2912	1.383	15.598	139.161	1.125	3.342	3.153	53.682
-9.6	2866	1.369	15.206	133.994	1.120	3.298	3.113	52.239
-9.8	2822	1.356	14.814	128.358	1.116	3.255	3.074	50.814
-10.0	2778	1.343	14.422	122.266	1.112	3.213	3.036	49.407
-10.2	2735	1.330	14.030	115.733	1.107	3.172	2.998	48.018
-10.4	2692	1.317	13.639	108.773	1.103	3.132	2.961	46.646
-10.6	2650	1.305	13.249	101.401	1.099	3.093	2.924	45.291
-10.8	2607	1.293	12.861	93.630	1.095	3.055	2.887	43.953
-11.0	2565	1.281	12.475	85.475	1.091	3.017	2.850	42.632
-11.2	2522	1.270	12.094	76.954	1.088	2.979	2.813	41.328
-11.4	2479	1.259	11.718	68.087	1.085	2.942	2.775	40.041

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TABLE I.- CONSTANT ENTROPY PROPERTIES FOR MODEL EQUILIBRIUM AIR - Continued

(k) $ZS/R = 75$

$\log_{10} p$	T, °K	Z	ZH/RT	Zc_p/R	γ	a/a_o	I	l/a_o
.0	14875	2.986	26.248	75.904	1.334	11.937	9.735	187.292
-.2	14186	2.917	26.129	79.211	1.324	11.477	9.432	182.879
-.4	13556	2.851	25.983	81.906	1.313	11.053	9.148	178.602
-.6	12978	2.789	25.814	83.987	1.303	10.659	8.881	174.451
-.8	12443	2.729	25.624	85.456	1.292	10.293	8.630	170.419
-1.0	11947	2.672	25.418	86.317	1.281	9.951	8.391	166.500
-1.2	11485	2.618	25.197	86.578	1.270	9.631	8.166	162.688
-1.4	11054	2.566	24.963	86.247	1.259	9.331	7.951	158.978
-1.6	10648	2.517	24.720	85.331	1.248	9.048	7.747	155.364
-1.8	10267	2.469	24.469	83.842	1.237	8.781	7.552	151.841
-2.0	9905	2.424	24.213	81.788	1.226	8.529	7.365	148.407
-2.2	9563	2.381	23.953	79.182	1.216	8.290	7.186	145.057
-2.4	9236	2.340	23.693	76.033	1.206	8.062	7.013	141.787
-2.6	8923	2.301	23.435	72.355	1.196	7.845	6.846	138.596
-2.8	8622	2.264	23.183	68.159	1.187	7.638	6.684	135.481
-3.0	8331	2.228	22.940	63.460	1.179	7.440	6.526	132.439
-3.2	8047	2.194	22.712	58.275	1.171	7.250	6.371	129.470
-3.4	7769	2.162	22.506	52.623	1.164	7.067	6.216	126.572
-3.6	7491	2.131	22.331	46.530	1.159	6.891	6.061	123.745
-3.8	7211	2.103	22.203	40.036	1.156	6.721	5.901	120.990
-4.0	6922	2.076	22.147	33.203	1.157	6.558	5.731	118.311
-4.2	6614	2.052	22.205	26.149	1.164	6.405	5.541	115.714
-4.4	6268	2.030	22.463	19.131	1.186	6.270	5.309	113.214
-4.6	5850	2.013	23.103	12.846	1.240	6.173	4.990	110.838
-4.8	5330	2.000	24.386	9.835	1.306	6.027	4.626	108.629
-5.0	4887	1.983	25.643	16.449	1.217	5.530	4.583	106.517
-5.2	4628	1.958	26.144	30.628	1.165	5.205	4.555	104.411
-5.4	4452	1.932	26.266	46.740	1.152	5.013	4.487	102.328
-5.6	4313	1.905	26.217	62.853	1.149	4.871	4.412	100.279
-5.8	4194	1.879	26.075	78.323	1.151	4.753	4.337	98.264
-6.0	4089	1.853	25.875	92.893	1.153	4.648	4.264	96.284
-6.2	3994	1.828	25.636	106.457	1.156	4.554	4.193	94.337
-6.4	3906	1.803	25.368	118.977	1.159	4.466	4.125	92.422
-6.6	3824	1.779	25.079	130.447	1.161	4.383	4.060	90.537
-6.8	3746	1.756	24.773	140.878	1.163	4.306	3.997	88.682
-7.0	3673	1.734	24.454	150.294	1.164	4.232	3.937	86.855
-7.2	3604	1.712	24.123	158.721	1.165	4.162	3.878	85.056
-7.4	3538	1.691	23.783	166.190	1.166	4.094	3.822	83.283
-7.6	3475	1.670	23.435	172.733	1.165	4.030	3.767	81.535
-7.8	3414	1.650	23.080	178.380	1.165	3.968	3.714	79.813
-8.0	3356	1.631	22.719	183.163	1.164	3.908	3.663	78.114
-8.2	3300	1.612	22.353	187.113	1.163	3.850	3.613	76.439
-8.4	3246	1.593	21.981	190.259	1.161	3.794	3.565	74.786
-8.6	3193	1.575	21.606	192.630	1.159	3.740	3.517	73.155
-8.8	3143	1.557	21.227	194.253	1.157	3.688	3.472	71.546
-9.0	3094	1.540	20.844	195.154	1.154	3.637	3.427	69.958
-9.2	3046	1.524	20.459	195.359	1.152	3.588	3.384	68.390
-9.4	3000	1.507	20.070	194.892	1.149	3.540	3.341	66.841
-9.6	2955	1.491	19.680	193.774	1.146	3.493	3.300	65.312
-9.8	2911	1.476	19.287	192.029	1.142	3.448	3.260	63.802
-10.0	2869	1.461	18.892	189.676	1.139	3.404	3.220	62.310
-10.2	2827	1.446	18.495	186.735	1.135	3.361	3.182	60.836
-10.4	2787	1.432	18.097	183.225	1.132	3.319	3.144	59.379
-10.6	2747	1.418	17.697	179.165	1.128	3.278	3.107	57.940
-10.8	2708	1.404	17.296	174.571	1.124	3.239	3.071	56.517
-11.0	2670	1.390	16.895	169.459	1.120	3.200	3.035	55.111
-11.2	2633	1.377	16.492	163.845	1.117	3.161	3.001	53.722
-11.4	2596	1.365	16.089	157.744	1.113	3.124	2.966	52.348
-11.6	2560	1.352	15.686	151.171	1.109	3.088	2.933	50.989
-11.8	2525	1.340	15.283	144.139	1.105	3.052	2.899	49.647

A 390

TABLE I.- CONSTANT ENTROPY PROPERTIES FOR MODEL EQUILIBRIUM AIR - Continued

(l) ZS/R = 80

$\log_{10} P$	T, °K	Z	ZH/RT	Zc_p/R	γ	a/a_o	I	l/a_o
-.2	15114	3.243	29.373	76.120	1.332	12.564	10.206	206.278
-.4	14395	3.168	29.328	82.320	1.325	12.067	9.885	201.653
-.6	13745	3.095	29.238	87.851	1.318	11.611	9.584	197.171
-.8	13153	3.026	29.112	92.690	1.311	11.192	9.302	192.823
-1.0	12611	2.960	28.955	96.828	1.303	10.803	9.037	188.601
-1.2	12112	2.896	28.772	100.262	1.295	10.442	8.787	184.498
-1.4	11649	2.836	28.566	102.995	1.286	10.105	8.551	180.506
-1.6	11220	2.778	28.342	105.034	1.278	9.790	8.328	176.620
-1.8	10819	2.723	28.101	106.386	1.269	9.495	8.116	172.834
-2.0	10443	2.670	27.847	107.063	1.259	9.216	7.914	169.143
-2.2	10091	2.619	27.580	107.077	1.250	8.954	7.722	165.543
-2.4	9758	2.571	27.304	106.440	1.241	8.706	7.538	162.030
-2.6	9443	2.525	27.019	105.164	1.231	8.470	7.363	158.599
-2.8	9145	2.480	26.729	103.264	1.222	8.247	7.194	155.248
-3.0	8861	2.438	26.434	100.753	1.213	8.034	7.032	151.972
-3.2	8590	2.397	26.137	97.645	1.204	7.832	6.876	148.770
-3.4	8330	2.358	25.839	93.954	1.195	7.638	6.726	145.638
-3.6	8081	2.320	25.542	89.694	1.186	7.452	6.580	142.574
-3.8	7840	2.284	25.250	84.879	1.178	7.274	6.439	139.577
-4.0	7606	2.249	24.965	79.525	1.170	7.103	6.300	136.644
-4.2	7378	2.216	24.692	73.647	1.162	6.938	6.165	133.774
-4.4	7154	2.185	24.434	67.264	1.155	6.778	6.031	130.965
-4.6	6933	2.154	24.200	60.396	1.149	6.624	5.897	128.219
-4.8	6710	2.126	23.998	53.071	1.145	6.475	5.762	125.534
-5.0	6484	2.098	23.844	45.328	1.142	6.331	5.622	122.912
-5.2	6249	2.073	23.762	37.228	1.143	6.192	5.473	120.357
-5.4	5995	2.050	23.799	28.889	1.151	6.061	5.303	117.875
-5.6	5705	2.029	24.046	20.570	1.173	5.948	5.090	115.479
-5.8	5340	2.012	24.723	12.983	1.234	5.884	4.777	113.202
-6.0	4847	2.001	26.264	8.792	1.337	5.819	4.359	111.101
-6.2	4416	1.986	27.868	16.109	1.214	5.257	4.363	109.105
-6.4	4191	1.963	28.435	32.685	1.153	4.936	4.358	107.093
-6.6	4043	1.938	28.561	51.267	1.139	4.764	4.302	105.098
-6.8	3927	1.912	28.505	69.747	1.137	4.638	4.235	103.133
-7.0	3828	1.888	28.354	87.480	1.139	4.534	4.169	101.198
-7.2	3741	1.864	28.145	104.219	1.142	4.443	4.104	99.293
-7.4	3661	1.840	27.897	119.865	1.145	4.359	4.041	97.417
-7.6	3587	1.817	27.621	134.384	1.148	4.282	3.981	95.570
-7.8	3518	1.795	27.324	147.775	1.151	4.209	3.923	93.750
-8.0	3453	1.773	27.010	160.053	1.153	4.141	3.867	91.957
-8.2	3391	1.751	26.682	171.241	1.155	4.075	3.812	90.189
-8.4	3332	1.731	26.344	181.370	1.157	4.013	3.760	88.445
-8.6	3276	1.711	25.997	190.471	1.158	3.953	3.709	86.725
-8.8	3222	1.691	25.641	198.577	1.158	3.895	3.659	85.029
-9.0	3171	1.672	25.279	205.722	1.158	3.839	3.612	83.355
-9.2	3121	1.653	24.911	211.939	1.158	3.785	3.565	81.702
-9.4	3073	1.635	24.538	217.259	1.157	3.733	3.520	80.071
-9.6	3026	1.617	24.160	221.713	1.156	3.683	3.476	78.460
-9.8	2981	1.600	23.778	225.332	1.155	3.634	3.433	76.870
-10.0	2938	1.583	23.393	228.144	1.153	3.587	3.391	75.298
-10.2	2895	1.567	23.004	230.177	1.152	3.541	3.350	73.746
-10.4	2854	1.551	22.612	231.457	1.150	3.496	3.311	72.212
-10.6	2814	1.535	22.217	232.010	1.147	3.453	3.272	70.697
-10.8	2775	1.519	21.820	231.859	1.145	3.411	3.234	69.198
-11.0	2738	1.504	21.421	231.028	1.142	3.369	3.197	67.718
-11.2	2701	1.490	21.020	229.538	1.139	3.329	3.161	66.253
-11.4	2665	1.475	20.616	227.410	1.137	3.290	3.126	64.806
-11.6	2629	1.461	20.212	224.665	1.133	3.252	3.091	63.374
-11.8	2595	1.448	19.805	221.322	1.130	3.214	3.057	61.959
-12.0	2561	1.434	19.398	217.399	1.127	3.178	3.024	60.559

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TABLE I.- CONSTANT ENTROPY PROPERTIES FOR MODEL EQUILIBRIUM AIR - Continued

(m) ZS/R = 85

A390

$\log_{10} p$	T, °K	Z	ZH/RT	Zc_p/R	γ	a/a_o	I	l/a_o
-.4	15384	3.493	32.279	66.075	1.317	13.195	10.652	224.829
-.6	14600	3.412	32.379	75.414	1.314	12.641	10.309	220.003
-.8	13907	3.334	32.399	84.143	1.310	12.143	9.989	215.330
-1.0	13287	3.259	32.358	92.176	1.306	11.690	9.690	210.800
-1.2	12725	3.188	32.267	99.462	1.302	11.275	9.411	206.402
-1.4	12214	3.119	32.135	105.972	1.297	10.891	9.148	202.130
-1.6	11744	3.053	31.970	111.694	1.291	10.536	8.901	197.974
-1.8	11311	2.990	31.777	116.622	1.285	10.205	8.668	193.929
-2.0	10908	2.929	31.560	120.760	1.279	9.895	8.447	189.989
-2.2	10534	2.871	31.322	124.116	1.272	9.605	8.237	186.148
-2.4	10183	2.816	31.066	126.701	1.265	9.332	8.038	182.401
-2.6	9855	2.763	30.795	128.528	1.258	9.074	7.848	178.743
-2.8	9545	2.712	30.512	129.612	1.250	8.830	7.668	175.171
-3.0	9253	2.663	30.217	129.967	1.242	8.599	7.495	171.680
-3.2	8977	2.616	29.912	129.610	1.234	8.380	7.329	168.267
-3.4	8714	2.570	29.600	128.558	1.226	8.171	7.170	164.928
-3.6	8465	2.527	29.282	126.827	1.218	7.973	7.018	161.662
-3.8	8226	2.485	28.958	124.432	1.210	7.783	6.871	158.464
-4.0	7998	2.445	28.631	121.391	1.201	7.601	6.729	155.333
-4.2	7780	2.406	28.303	117.721	1.193	7.427	6.593	152.265
-4.4	7569	2.369	27.974	113.435	1.185	7.260	6.460	149.260
-4.6	7366	2.333	27.646	108.552	1.177	7.099	6.332	146.315
-4.8	7169	2.299	27.322	103.086	1.169	6.945	6.207	143.428
-5.0	6978	2.265	27.004	97.054	1.162	6.795	6.085	140.597
-5.2	6792	2.233	26.695	90.471	1.155	6.651	5.966	137.823
-5.4	6609	2.203	26.398	83.356	1.148	6.511	5.848	135.103
-5.6	6428	2.173	26.119	75.725	1.142	6.376	5.731	132.436
-5.8	6247	2.145	25.864	67.602	1.137	6.244	5.614	129.824
-6.0	6065	2.118	25.643	59.013	1.133	6.115	5.495	127.266
-6.2	5878	2.093	25.471	49.999	1.131	5.991	5.371	124.764
-6.4	5682	2.068	25.376	40.623	1.132	5.870	5.237	122.321
-6.6	5467	2.046	25.405	31.010	1.140	5.758	5.083	119.944
-6.8	5217	2.026	25.662	21.438	1.164	5.664	4.883	117.646
-7.0	4890	2.010	26.416	12.722	1.235	5.631	4.567	115.464
-7.2	4414	2.000	28.290	7.963	1.372	5.625	4.105	113.469
-7.4	4010	1.986	30.176	16.988	1.201	4.986	4.179	111.573
-7.6	3820	1.964	30.746	36.210	1.140	4.691	4.185	109.642
-7.8	3697	1.941	30.856	57.238	1.128	4.540	4.135	107.726
-8.0	3600	1.917	30.786	78.017	1.126	4.430	4.076	105.835
-8.2	3518	1.894	30.623	97.943	1.129	4.339	4.017	103.972
-8.4	3444	1.871	30.404	116.788	1.132	4.259	3.959	102.136
-8.6	3376	1.849	30.146	134.465	1.136	4.185	3.903	100.325
-8.8	3314	1.828	29.861	150.944	1.139	4.116	3.848	98.541
-9.0	3255	1.806	29.555	166.227	1.142	4.052	3.796	96.781
-9.2	3200	1.786	29.234	180.331	1.145	3.991	3.745	95.044
-9.4	3147	1.766	28.899	193.283	1.147	3.932	3.696	93.331
-9.6	3096	1.746	28.554	205.113	1.149	3.876	3.649	91.639
-9.8	3048	1.727	28.199	215.855	1.150	3.822	3.603	89.970
-10.0	3002	1.708	27.837	225.542	1.151	3.770	3.558	88.321
-10.2	2957	1.690	27.469	234.209	1.152	3.720	3.514	86.693
-10.4	2914	1.672	27.095	241.889	1.152	3.672	3.472	85.084
-10.6	2873	1.655	26.716	248.616	1.152	3.625	3.431	83.495
-10.8	2832	1.638	26.332	254.421	1.151	3.579	3.391	81.924
-11.0	2793	1.621	25.944	259.335	1.151	3.535	3.351	80.372
-11.2	2755	1.605	25.553	263.389	1.150	3.492	3.313	78.837
-11.4	2719	1.589	25.159	266.609	1.149	3.450	3.276	77.320
-11.6	2683	1.574	24.761	269.025	1.147	3.409	3.240	75.819
-11.8	2648	1.559	24.361	270.662	1.145	3.369	3.204	74.336
-12.0	2614	1.544	23.959	271.546	1.143	3.331	3.169	72.868
-12.2	2581	1.529	23.554	271.700	1.141	3.293	3.135	71.417

TABLE I.- CONSTANT ENTROPY PROPERTIES FOR MODEL EQUILIBRIUM AIR- Continued

(n) ZS/R = 90

$\log_{10} p$	T, °K	Z	ZH/RT	Zc_p/R	γ	a/a_o	I	l/a_o
-.8	14915	3.646	35.034	57.750	1.297	13.276	10.715	237.949
-1.0	14124	3.565	35.287	69.555	1.293	12.696	10.375	233.094
-1.2	13442	3.487	35.414	80.916	1.291	12.187	10.058	228.390
-1.4	12839	3.410	35.449	91.638	1.289	11.732	9.762	223.827
-1.6	12301	3.337	35.413	101.607	1.287	11.318	9.485	219.396
-1.8	11813	3.266	35.322	110.756	1.285	10.939	9.226	215.088
-2.0	11368	3.198	35.187	119.047	1.282	10.588	8.981	210.896
-2.2	10958	3.133	35.016	126.463	1.279	10.263	8.751	206.814
-2.4	10580	3.071	34.815	132.999	1.275	9.959	8.533	202.834
-2.6	10228	3.011	34.587	138.657	1.270	9.674	8.326	198.953
-2.8	9899	2.953	34.339	143.448	1.265	9.406	8.130	195.164
-3.0	9591	2.898	34.071	147.383	1.260	9.153	7.943	191.464
-3.2	9302	2.845	33.788	150.478	1.254	8.915	7.764	187.848
-3.4	9029	2.794	33.490	152.751	1.248	8.688	7.594	184.312
-3.6	8770	2.745	33.181	154.220	1.241	8.474	7.431	180.852
-3.8	8526	2.697	32.862	154.903	1.235	8.269	7.275	177.467
-4.0	8293	2.652	32.533	154.820	1.228	8.074	7.125	174.151
-4.2	8072	2.608	32.197	153.989	1.220	7.888	6.980	170.904
-4.4	7860	2.566	31.855	152.431	1.213	7.711	6.842	167.721
-4.6	7658	2.525	31.508	150.163	1.206	7.540	6.708	164.602
-4.8	7464	2.486	31.158	147.205	1.199	7.377	6.579	161.542
-5.0	7277	2.448	30.804	143.575	1.191	7.220	6.454	158.542
-5.2	7098	2.411	30.450	139.291	1.184	7.069	6.333	155.597
-5.4	6924	2.376	30.095	134.369	1.176	6.923	6.216	152.708
-5.6	6756	2.342	29.742	128.828	1.169	6.783	6.102	149.872
-5.8	6593	2.309	29.392	122.684	1.162	6.647	5.991	147.087
-6.0	6435	2.277	29.046	115.953	1.155	6.516	5.882	144.354
-6.2	6280	2.247	28.708	108.652	1.148	6.389	5.776	141.669
-6.4	6127	2.217	28.380	100.798	1.142	6.265	5.672	139.033
-6.6	5977	2.188	28.066	92.407	1.136	6.145	5.568	136.445
-6.8	5827	2.161	27.771	83.498	1.130	6.028	5.465	133.905
-7.0	5677	2.135	27.501	74.095	1.126	5.913	5.361	131.412
-7.2	5525	2.110	27.268	64.224	1.122	5.801	5.255	128.967
-7.4	5368	2.086	27.086	53.928	1.121	5.693	5.144	126.572
-7.6	5200	2.063	26.986	43.274	1.123	5.588	5.022	124.231
-7.8	5015	2.042	27.019	32.398	1.132	5.490	4.879	121.950
-8.0	4794	2.023	27.308	21.624	1.159	5.413	4.686	119.745
-8.2	4490	2.008	28.195	11.959	1.245	5.415	4.356	117.654
-8.4	4017	2.000	30.528	7.361	1.405	5.432	3.869	115.768
-8.6	3660	1.986	32.552	19.279	1.180	4.721	4.027	113.951
-8.8	3505	1.965	33.068	41.299	1.127	4.469	4.030	112.092
-9.0	3403	1.943	33.148	64.729	1.118	4.340	3.984	110.246
-9.2	3321	1.921	33.059	87.739	1.117	4.244	3.931	108.423
-9.4	3251	1.899	32.881	109.791	1.120	4.164	3.878	106.625
-9.6	3189	1.877	32.650	130.685	1.124	4.093	3.826	104.851
-9.8	3131	1.856	32.382	150.343	1.127	4.027	3.775	103.101
-10.0	3078	1.836	32.088	168.742	1.131	3.966	3.726	101.374
-10.2	3027	1.816	31.775	185.886	1.134	3.909	3.679	99.669
-10.4	2979	1.797	31.445	201.796	1.137	3.854	3.633	97.985
-10.6	2934	1.777	31.104	216.498	1.140	3.801	3.589	96.322
-10.8	2890	1.759	30.752	230.024	1.142	3.751	3.545	94.680
-11.0	2849	1.741	30.392	242.407	1.144	3.702	3.503	93.056
-11.2	2808	1.723	30.024	253.683	1.145	3.655	3.463	91.453
-11.4	2770	1.706	29.650	263.886	1.146	3.610	3.423	89.867
-11.6	2732	1.689	29.270	273.051	1.147	3.566	3.384	88.300
-11.8	2696	1.672	28.885	281.210	1.147	3.523	3.346	86.750
-12.0	2660	1.656	28.497	288.397	1.147	3.482	3.310	85.217
-12.2	2626	1.640	28.104	294.642	1.147	3.441	3.274	83.702
-12.4	2593	1.624	27.708	299.977	1.146	3.402	3.239	82.202
-12.6	2561	1.609	27.308	304.430	1.145	3.364	3.204	80.719

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TABLE I.- CONSTANT ENTROPY PROPERTIES FOR MODEL EQUILIBRIUM AIR - Continued

(o) ZS/R = 95

$\log_{10} p$	T, °K	Z	ZH/RT	Zc_p/R	γ	a/a_o	I	l/a_o
-1.6	14456	3.894	39.223	29.231	1.307	13.776	10.689	262.401
-1.8	13444	3.823	40.334	43.453	1.271	12.917	10.410	257.541
-2.0	12677	3.748	40.977	59.106	1.257	12.288	10.116	252.815
-2.2	12054	3.673	41.341	75.023	1.253	11.780	9.831	248.223
-2.4	11525	3.599	41.528	90.597	1.252	11.347	9.561	243.758
-2.6	11061	3.527	41.594	105.501	1.252	10.962	9.307	239.414
-2.8	10647	3.457	41.572	119.551	1.253	10.615	9.069	235.183
-3.0	10271	3.389	41.484	132.646	1.254	10.296	8.844	231.059
-3.2	9928	3.324	41.345	144.730	1.254	10.001	8.632	227.036
-3.4	9611	3.262	41.165	155.776	1.254	9.727	8.431	223.107
-3.6	9317	3.201	40.951	165.777	1.253	9.469	8.240	219.269
-3.8	9043	3.143	40.709	174.735	1.251	9.227	8.059	215.517
-4.0	8786	3.088	40.444	182.660	1.249	8.998	7.886	211.845
-4.2	8544	3.034	40.158	189.570	1.246	8.781	7.721	208.252
-4.4	8316	2.982	39.855	195.483	1.243	8.575	7.563	204.733
-4.6	8100	2.932	39.538	200.422	1.239	8.380	7.412	201.285
-4.8	7895	2.883	39.207	204.409	1.235	8.193	7.267	197.905
-5.0	7700	2.837	38.866	207.469	1.231	8.015	7.128	194.591
-5.2	7514	2.791	38.514	209.624	1.226	7.845	6.994	191.340
-5.4	7336	2.748	38.154	210.900	1.221	7.682	6.864	188.149
-5.6	7166	2.706	37.786	211.320	1.216	7.525	6.740	185.017
-5.8	7004	2.665	37.412	210.908	1.210	7.375	6.620	181.941
-6.0	6847	2.625	37.032	209.687	1.205	7.230	6.504	178.919
-6.2	6697	2.587	36.648	207.680	1.199	7.091	6.392	175.950
-6.4	6553	2.550	36.260	204.908	1.193	6.957	6.283	173.031
-6.6	6413	2.514	35.869	201.393	1.187	6.828	6.178	170.162
-6.8	6278	2.480	35.476	197.156	1.181	6.703	6.075	167.341
-7.0	6148	2.446	35.081	192.216	1.174	6.582	5.976	164.566
-7.2	6021	2.413	34.686	186.592	1.168	6.465	5.880	161.837
-7.4	5899	2.382	34.291	180.305	1.162	6.351	5.786	159.151
-7.6	5779	2.351	33.898	173.370	1.156	6.241	5.694	156.507
-7.8	5663	2.321	33.507	165.805	1.150	6.134	5.604	153.906
-8.0	5549	2.292	33.120	157.628	1.144	6.030	5.517	151.345
-8.2	5437	2.264	32.739	148.855	1.138	5.929	5.431	148.824
-8.4	5328	2.237	32.364	139.500	1.132	5.831	5.347	146.343
-8.6	5219	2.211	31.999	129.581	1.126	5.734	5.263	143.900
-8.8	5112	2.185	31.647	119.114	1.121	5.640	5.181	141.495
-9.0	5005	2.160	31.310	108.114	1.116	5.548	5.099	139.128
-9.2	4898	2.137	30.995	96.603	1.111	5.457	5.016	136.799
-9.4	4789	2.114	30.710	84.601	1.108	5.369	4.932	134.508
-9.6	4677	2.092	30.466	72.139	1.105	5.281	4.845	132.257
-9.8	4559	2.070	30.283	59.266	1.105	5.196	4.751	130.047
-10.0	4430	2.050	30.195	46.065	1.109	5.114	4.646	127.883
-10.2	4283	2.032	30.277	32.723	1.121	5.041	4.516	125.771
-10.4	4094	2.015	30.717	19.751	1.160	5.000	4.317	123.733
-10.6	3796	2.004	32.164	9.085	1.315	5.113	3.891	121.828
-10.8	3324	1.998	35.747	8.106	1.365	4.866	3.569	120.160
-11.0	3100	1.983	37.385	28.828	1.135	4.253	3.780	118.449
-11.2	3000	1.963	37.708	56.427	1.106	4.093	3.764	116.710
-11.4	2929	1.943	37.708	84.471	1.102	3.999	3.723	114.985
-11.6	2871	1.923	37.573	111.749	1.103	3.926	3.679	113.281
-11.8	2820	1.904	37.363	137.880	1.107	3.864	3.635	111.597
-12.0	2774	1.885	37.107	162.716	1.111	3.807	3.592	109.933
-12.2	2731	1.866	36.820	186.203	1.115	3.755	3.550	108.288
-12.4	2691	1.848	36.508	208.331	1.118	3.706	3.510	106.663
-12.6	2653	1.830	36.180	229.109	1.122	3.659	3.471	105.055
-12.8	2616	1.812	35.837	248.560	1.125	3.614	3.432	103.466
-13.0	2582	1.795	35.482	266.712	1.128	3.571	3.395	101.894
-13.2	2548	1.778	35.119	283.597	1.130	3.529	3.359	100.339
-13.4	2516	1.762	34.747	299.251	1.133	3.489	3.324	98.800

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TABLE I.- CONSTANT ENTROPY PROPERTIES FOR MDOEL EQUILIBRIUM AIR - Concluded

(p) ZS/R = 100

$\log_{10} p$	T, °K	Z	ZH/RT	Zc_p/R	γ	a/a_o	I	l/a_o
-1.2	14566	3.781	37.470	44.838	1.287	13.416	10.739	250.458
-1.4	13721	3.703	38.001	58.635	1.276	12.765	10.411	245.589
-1.6	13022	3.625	38.308	72.483	1.272	12.224	10.100	240.867
-1.8	12423	3.548	38.465	85.930	1.270	11.755	9.808	236.283
-2.0	11896	3.474	38.515	98.717	1.270	11.337	9.534	231.831
-2.2	11425	3.402	38.486	110.699	1.270	10.959	9.277	227.500
-2.4	10999	3.333	38.397	121.791	1.269	10.612	9.035	223.284
-2.6	10609	3.266	38.259	131.947	1.268	10.290	8.808	219.176
-2.8	10250	3.202	38.083	141.145	1.266	9.992	8.592	215.170
-3.0	9917	3.141	37.875	149.378	1.264	9.712	8.389	211.260
-3.2	9607	3.082	37.639	156.649	1.261	9.449	8.195	207.442
-3.4	9317	3.025	37.382	162.969	1.257	9.202	8.011	203.711
-3.6	9045	2.970	37.105	168.352	1.253	8.968	7.835	200.062
-3.8	8788	2.917	36.811	172.815	1.249	8.747	7.668	196.493
-4.0	8546	2.867	36.502	176.379	1.244	8.536	7.507	192.999
-4.2	8317	2.818	36.181	179.063	1.239	8.336	7.353	189.578
-4.4	8099	2.771	35.850	180.890	1.233	8.146	7.206	186.225
-4.6	7891	2.725	35.509	181.880	1.228	7.964	7.064	182.940
-4.8	7694	2.682	35.159	182.057	1.221	7.790	6.928	179.718
-5.0	7505	2.639	34.803	181.441	1.215	7.623	6.796	176.558
-5.2	7324	2.598	34.441	180.054	1.209	7.463	6.670	173.458
-5.4	7150	2.559	34.074	177.917	1.202	7.309	6.547	170.415
-5.6	6983	2.521	33.703	175.050	1.196	7.162	6.429	167.427
-5.8	6823	2.484	33.329	171.473	1.189	7.019	6.315	164.492
-6.0	6668	2.448	32.954	167.207	1.182	6.882	6.204	161.610
-6.2	6518	2.413	32.577	162.269	1.176	6.750	6.096	158.778
-6.4	6373	2.380	32.201	156.677	1.169	6.622	5.992	155.995
-6.6	6233	2.348	31.826	150.451	1.162	6.498	5.890	153.259
-6.8	6096	2.316	31.454	143.605	1.156	6.378	5.790	150.570
-7.0	5962	2.286	31.086	136.159	1.149	6.262	5.693	147.926
-7.2	5831	2.257	30.724	128.127	1.143	6.149	5.598	145.326
-7.4	5703	2.228	30.371	119.526	1.137	6.039	5.504	142.770
-7.6	5576	2.201	30.029	110.373	1.131	5.931	5.412	140.256
-7.8	5450	2.174	29.702	100.685	1.125	5.827	5.320	137.785
-8.0	5325	2.149	29.395	90.480	1.120	5.724	5.228	135.356
-8.2	5198	2.124	29.116	79.782	1.116	5.624	5.135	132.970
-8.4	5068	2.101	28.875	68.619	1.113	5.526	5.040	130.627
-8.6	4933	2.078	28.690	57.034	1.112	5.430	4.938	128.329
-8.8	4788	2.057	28.592	45.104	1.115	5.337	4.826	126.080
-9.0	4624	2.037	28.642	32.983	1.126	5.252	4.691	123.888
-9.2	4423	2.019	28.990	21.068	1.157	5.192	4.499	121.768
-9.4	4129	2.006	30.092	10.704	1.268	5.240	4.134	119.769
-9.6	3653	1.999	33.023	7.238	1.414	5.195	3.677	117.994
-9.8	3359	1.985	34.965	23.175	1.157	4.474	3.897	116.237
-10.0	3234	1.964	35.391	48.020	1.116	4.270	3.891	114.441
-10.2	3149	1.943	35.433	73.793	1.109	4.160	3.848	112.659
-10.4	3081	1.922	35.321	98.968	1.110	4.077	3.800	110.898
-10.6	3021	1.902	35.128	123.087	1.113	4.006	3.751	109.159
-10.8	2967	1.882	34.884	145.976	1.117	3.943	3.704	107.442
-11.0	2918	1.862	34.607	167.570	1.121	3.885	3.658	105.747
-11.2	2872	1.843	34.304	187.850	1.124	3.830	3.614	104.073
-11.4	2828	1.824	33.982	206.826	1.128	3.778	3.571	102.419
-11.6	2787	1.805	33.646	224.518	1.131	3.729	3.529	100.784
-11.8	2747	1.787	33.298	240.954	1.133	3.681	3.488	99.168
-12.0	2709	1.770	32.940	256.166	1.136	3.635	3.449	97.571
-12.2	2673	1.752	32.574	270.188	1.138	3.591	3.411	95.991
-12.4	2637	1.735	32.201	283.055	1.139	3.549	3.373	94.429
-12.6	2603	1.719	31.821	294.802	1.141	3.507	3.337	92.884
-12.8	2570	1.703	31.437	305.463	1.142	3.467	3.301	91.356
-13.0	2538	1.687	31.047	315.073	1.142	3.428	3.267	89.843

A
3
9
0

B

A
3
9
0

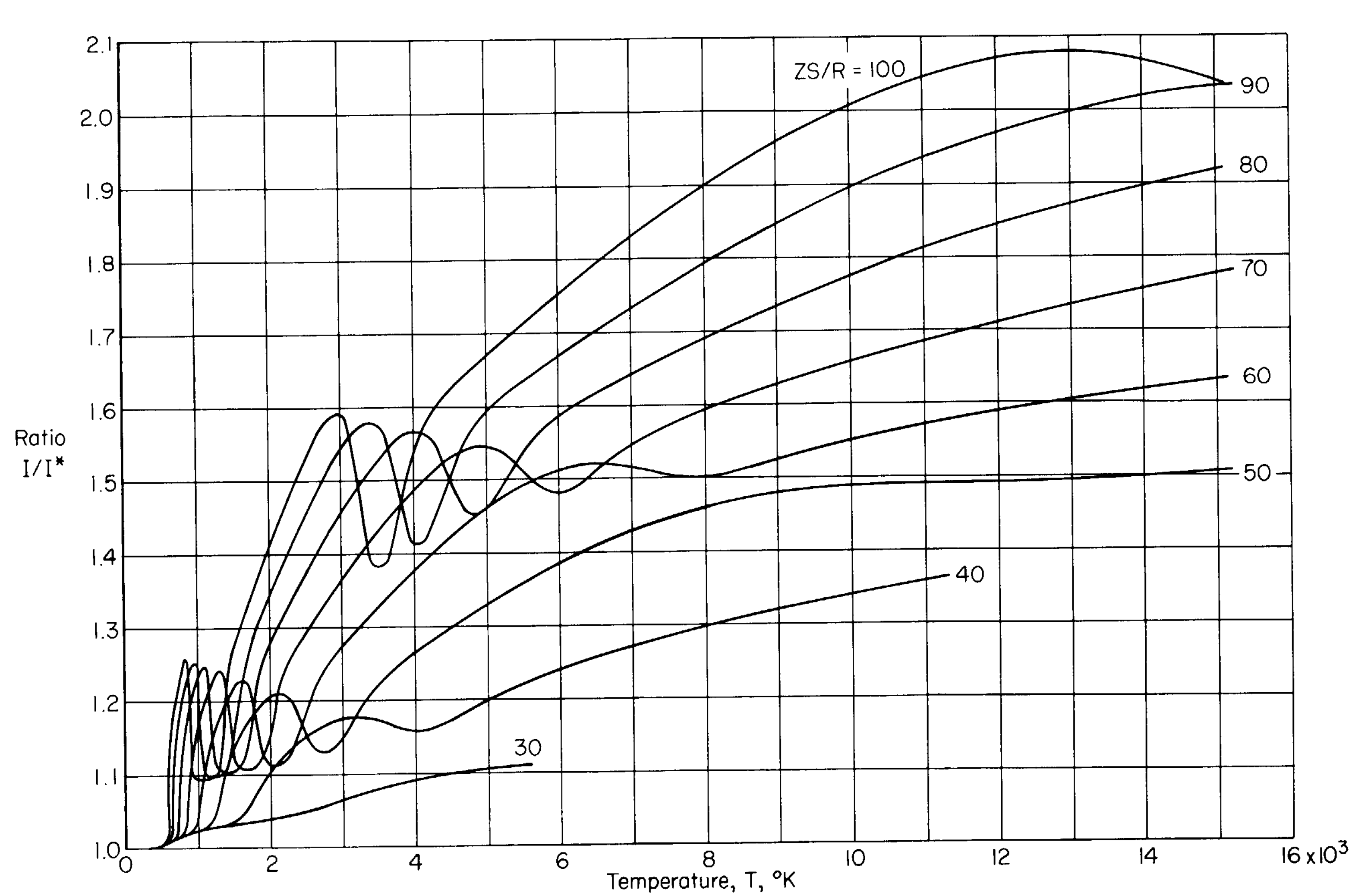

Figure 1.- Ratio I/I* as a function of temperature for constant entropy.