RESEARCH MEMORANDUM

THERMODYNAMIC PROPERTIES OF PRODUCTS OF COMBUSTION OF HYDROGEN WITH AIR FOR TEMPERATURES OF 600° TO 4400° R

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NATIONAL ADVISORY COMMITTEE
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SUMMARY

Thermodynamic properties of hydrogen and its products of combustion with air are tabulated in a form convenient for use in cycle analysis and design of turbojet engines. Only low pressures are considered, and the effects of dissociation are ignored. Several thermodynamic processes were analyzed, and their analysis is illustrated by numerical example.

INTRODUCTION

Interest in use of liquid hydrogen as a fuel for turbojet engines has recently increased. For example, reference 1 shows that large gains in performance can be obtained for aircraft designed for the use of this fuel in high-altitude flight. Accurate analysis of engines using this fuel requires information on properties of the combustion products. For example, it is shown in reference 2 that simple correction of the properties of JP-4 fuel will result in errors of 3 and 5 percent in the calculation of fuel specific impulse and thrust per unit air flow, respectively. Tables and charts for thermodynamic calculations involving air, hydrogen, and other fuels, taking into account the effects of dissociation, are given in reference 3; the tables, which neglect dissociation, present gas properties for intervals of 50° R.

The purpose of the analysis contained herein is to present thermodynamic properties of hydrogen and its combustion products and methods for using these properties in a form convenient for cycle analysis and design of turbojet engines.

The general method of attack is similar to that in reference 4. Data on gas properties were obtained from reference 5. Properties of the combustion products are presented in table I for temperatures from 600° to 2999° R. These data are intended for use in combination with air properties in reference 5; for this purpose, the properties of air in table 1 of reference 5 were interpolated to 1° intervals for temperatures from

3000° to 4400° R. Properties of air and combustion products are presented in table II for temperatures of 3000° to 4400° R. The data presented are for low pressures, and the effects of dissociation are ignored.

The enthalpy of gaseous hydrogen fuel (considered to be the real gas, para-hydrogen, at 1-atm pressure) was evaluated from reference 6, and the results are tabulated in table III from the boiling point (36.5° R) to 1260° R in 10° increments.

The general methods for using the tabulated data are described in the section APPLICATION OF TABLES. Their use is also illustrated by several numerical examples. The method of construction of tables I and II is presented in appendix A.

SYMBOLS

A_{cr}	ideal nozzle throat area required to pass 1 (lb air)/sec at critical conditions
a_{cr}	critical velocity, $\sqrt{\frac{2\gamma}{\gamma+1} gRT_t}$, ft/sec
b	gas b, $(H_2O - \frac{1}{2} O_2)$
c_p	specific heat at constant pressure, Btu/(lb)(°R)
c_v	specific heat at constant volume, Btu/(lb)(°R)
f	fuel-air ratio
g	standard gravitational acceleration, 32.174 ft/sec^2
H	chemical energy of hydrogen corresponding to enthalpy values of tables I to III, Btu/lb
h	specific enthalpy, Btu/lb
h_f	specific enthalpy of fuel, Btu/lb
J	mechanical equivalent of heat, 778.16 ft-lb/Btu
K_φ	constant of integration in eq. (4)
K_ψ	constant of integration in eq. (5)
m	molecular weight
p	pressure, lb/sq ft
q	lower heating value of hydrogen at 25° C and constant pressure, Btu/lb

R gas constant, ft-lb/(lb)($^{\circ}$R)

R_a gas constant for air, 53.342 ft-lb/(lb)($^{\circ}$R)

$\overline{R}$ universal gas constant, 1545.32 ft-lb/(lb-mole)($^{\circ}$R)

T temperature, $^{\circ}$R

dT_h largest acceptable interval in T for satisfactory tabulation of enthalpy h, $^{\circ}$R

dT_{ψ_h} largest acceptable interval in T for satisfactory tabulation of ψ_h, $^{\circ}$R

dT_{ψ_φ} largest acceptable interval in T for satisfactory tabulation of ψ_φ, $^{\circ}$R

V velocity, ft/sec

W weight of gas, lb

β empirical constant in eq. (B4)

γ ratio of specific heats, c_p/c_v

η_B combustion efficiency

$\eta_{\infty,C}$ small-stage, or polytropic, compression efficiency

$\eta_{\infty,T}$ small-stage, or polytropic, expansion efficiency

φ $\int \frac{c_p}{T} dT$, Btu/(lb)($^{\circ}$R)

ψ_{c_p} $c_{p,b} - c_{p,a}$, Btu/(lb)($^{\circ}$R)

ψ_h $h_b - h_a$, Btu/lb

ψ_R $R_b - R_a$, 329.92 ft-lb/(lb)($^{\circ}$R)

ψ_φ $\varphi_b - \varphi_a$, Btu/(lb)($^{\circ}$R)

ω ratio of specific heats, $c_{p,b}/c_{p,a}$

Subscripts:

a air (gas a)

b gas b, $\left(H_2O - \frac{1}{2} O_2\right)$

c combustion gases in numerical example 4

d air in numerical example 4

s static conditions

t total conditions

1 initial

2 final

Superscripts:

— units of per lb mole

' first approximation

" second approximation

APPLICATION OF TABLES

Determining h and φ

In computing enthalpy h and φ for a known temperature and fuel-air ratio, use the following equations:

$$h = h_a + \frac{f}{1 + f} \psi_h \qquad (A10)$$

$$\varphi = \varphi_a + \frac{f}{1 + f} \psi_\varphi \qquad (A11)$$

The values of h_a and φ_a may be obtained from either table II of this report or table 1 of reference 5, the source depending on whether the temperature is greater or less than 3000° R. Both ψ_h and ψ_φ may be read from tables I and II herein.

Determining T from h and f

For a known combination of enthalpy h and fuel-air ratio f, a first approximation of the temperature T' can be obtained by setting

$$h'_a \equiv h \qquad (1)$$

and reading T' from table II or table 1 of reference 5. Corresponding to the temperature T', a value of ψ_h' can then be determined from table I or II. A second approximation of the temperature T'' can be obtained from

$$h_a'' \equiv h - \frac{f}{1 + f} \psi_h' \tag{2}$$

This process can be continued to obtain additional, successive approximations of the temperature. For the gases resulting from combustion of hydrogen with air, this process converges.

The work of carrying this process to convergence can be reduced through the use of the following equation, developed in appendix B:

$$\psi_h = \frac{(1 + f)\ \psi_h'}{1 + f\ \omega'(1 - 0.00025\ T'f)} \tag{B4}$$

The derivatives $d\psi_h/dT$ and dh_a/dT are assumed constant from T to T' in the derivation. For temperatures T of 600° to 3500° R, use of equation (B4) permits determination of the temperature directly from the value of ψ_h in the equation. The greatest error in T obtained from this process, which occurs for stoichiometric mixtures at high temperatures, is less than 7°. A more accurate result can be obtained by substituting ψ_h from equation (B4) into equation (A10) and determining T from the resulting value of h_a; for temperatures of 600° to 3500° R, the error is then no greater than 2°.

For a temperature T of 3500° R and a stoichiometric fuel-air ratio of 0.02921, the temperature T' is 4356° R. In order to permit use of this technique for temperatures as high as 3500° R, table II was extended to 4400° R. Although properties may be read from the table for temperatures up to 4400° R, use of equation (B4) is not always possible for temperatures above 3500° R.

Determining T from φ and f

The theoretical problem of determining temperature T from φ and f is just like that of finding T from h and f. However, two separate methods for obtaining approximate values of T are presented. The choice of the method to be used depends on the temperature range.

The relation corresponding to equation (B4) is

$$\psi_\varphi = \frac{(1 + f)\ \psi_\varphi'}{1 + f\ \omega'(1 - 0.0016\ T'f)} \tag{3}$$

and ψ_{ϕ}' is the value of ψ_{φ} at a temperature T' such that $\varphi_a' \equiv \varphi$. A value of ψ_{φ} from equation (3) can be substituted into equation (All) and the resulting value of φ_a used to determine temperature; a basic limitation on this equation restricts its use to temperatures of 600° to 1000° R, where the error in the resultant temperature will be less than 2°.

The basic limitation on application of equation (3) is the large difference between T and T', T' being considerably the larger. For a temperature of 1500° R and the stoichiometric fuel-air ratio of 0.02921, the value of φ exceeds the value for air φ_a at a temperature of 4400° R. It was therefore considered impractical to extend the gas tables to temperatures high enough to permit use of this technique for temperatures as high as 3500° R.

Because of the inherent limitation on use of equation (3), an alternative technique was developed that is suitable for use over a wider range of temperature but that proved to yield less accurate results than equation (3). If both $c_{p,a}$ and ψ_{c_p} are considered to be constant, then the relations

$$\varphi_a \equiv \int \frac{c_{p,a}}{T} \, dT$$

and

$$\psi_{\varphi} = \int \frac{\psi_{c_p}}{T} \, dT$$

reduce to

$$\varphi_a = c_{p,a} \ln T + K_{\varphi} \tag{4}$$

$$\psi_{\varphi} = \psi_{c_p} \ln T + K_{\psi} \tag{5}$$

Combination of equations (4) and (5) with equation (All) yields

$$\varphi_a = \frac{(1 + f)\varphi + [(\omega - 1)K_{\varphi} - K_{\psi}]f}{1 + f\omega} \tag{6}$$

Equation (6) is only approximate, because $c_{p,a}$, ψ_{c_p}, and, thus, ω were considered to be constant in its derivation. The terms ω and $[(\omega - 1)K_{\varphi} - K_{\psi}]$ were assigned values that keep low the error in equation (6). The resulting relation is

$$\varphi_a = \frac{(1 + f)\varphi - 3.5307\ f}{1 + 10.663\ f} \tag{7}$$

A value of φ_a computed from equation (7) can be used to determine temperature in table II or in table 1 of reference 5. The temperatures so determined are within 10° of the correct value for temperatures of 1000° to 2850° R, and the greatest error is only 5° for temperatures of 1200° to 2700° R.

After evaluating φ_a from equation (7) to obtain a first approximation, increasingly accurate values of temperature can be obtained by performing the following successive operations:

(1) For an estimated temperature, read ψ_φ from table I or II.

(2) Compute φ_a from equation (A11).

(3) Use this value of φ_a with table II or table 1 of reference 5 to obtain a next approximation of the temperature.

Successive repetitions of this process converge to the correct value. At 3500° R and stoichiometric fuel-air ratio, the error in temperature is reduced about 65 percent by each successive computation. At lower temperatures and lower fuel-air ratios, the reduction in error is greater than 65 percent.

Gas Constant R

For the perfect gases assumed herein, the problem of determining the gas constant R is simpler than that of either h or φ because of the lack of variation in R with temperature. From equations (A9) and (A14),

$$R = 53.342 + \frac{329.92\ f}{1 + f} \tag{8}$$

Specific Heats and Ratio of Specific Heats γ

Specific heat for constant pressure can be determined from

$$c_p = c_{p,a} + \frac{f}{1 + f}\psi_{c_p} \tag{A12}$$

Specific heat for constant volume is

$$c_v = c_p - \frac{R}{J} \tag{9}$$

Ratio of specific heats γ is

$$\gamma = \frac{c_p}{c_p - \frac{R}{J}} \tag{10}$$

Values of $c_{p,a}$ and ψ_{c_p} in tables I and II permit determination of each of these three variables - c_p, c_v, and γ. For many thermodynamic processes involving small changes in temperature, these properties can be used with both greater precision and convenience than the values of h and φ from tables I and II.

Thermodynamic Processes

The same methods for analyzing thermodynamic processes in gas turbines as described in reference 4 may be employed.

Isentropic compression or expansion. - Equation (4) of reference 4 states that

$$\frac{R}{J} \ln \frac{p_2}{p_1} = \varphi_2 - \varphi_1 \tag{11}$$

Constant small-stage efficiency. - For compression with constant small-stage, or polytropic, efficiency $\eta_{\infty,C}$, equation (7) of reference 4 states that

$$\varphi_2 - \varphi_1 = \frac{R}{J \eta_{\infty,C}} \ln \frac{p_2}{p_1} \tag{12}$$

For expansion with constant small-stage efficiency $\eta_{\infty,T}$, equation (6) of reference 4 may be written as

$$\varphi_2 - \varphi_1 = \eta_{\infty,T} \frac{R}{J} \ln \frac{p_2}{p_1} \tag{13}$$

Combustion. - For combustion of fuel with air, equations (8) and (9) of reference 4 are, respectively,

$$\eta_B f H = (1 + f) h_{t,2} - h_{a,t,1} - f h_{f,1} \tag{14}$$

and

$$f = \frac{h_{a,t,2} - h_{a,t,1}}{\eta_B H - h_{a,t,2} - \psi_{h,t,2} + h_{f,1}} \tag{15}$$

Correction of the heating value to a value corresponding to the datum temperatures of tables I and II and reference 5 results in a chemical energy H for use in equation (15) of 50965.4 Btu per pound (see appendix C).

Data for the fuel enthalpy h_f were obtained from references 6 and 7 and are presented in table III. Reference 6 contains the most extensive correlation of the properties of hydrogen available. Reference 7 presents some of the data from reference 6 in a form that is more convenient for engineering calculations. Table III presents values of enthalpy in Btu per pound for the real gas para-hydrogen for a pressure of 1 atmosphere, in 10° increments, from the boiling point (36.5°) to 1260° R. A discussion of the derivation of table III is given in appendix D.

Values of ideal-gas enthalpy at temperatures above 1260° R may be read from table 6-12 of reference 7. At these elevated temperatures the difference between ideal-gas and real-gas enthalpies at 1-atmosphere pressure is negligible for engineering calculations.

The boiling point of liquid para-hydrogen at atmospheric pressure is given in table 29 of reference 6 as 20.27° K (36.5° R). The latent heat of vaporization at this temperature from equation (9.3) of reference 6 is 213.4 calories per mole (190.5 Btu/lb).

NUMERICAL EXAMPLES

The following six examples demonstrate use of the tables and some of the problems for which they are applicable. The problems are stated and solved, and the sources of information (equations and tables) are listed at the right margin.

1. Calculation of h and φ

Values of the enthalpy h and the function φ may be calculated directly for given temperatures T_1 and T_2 and fuel-air ratio f.

Given:

$$T_1 = 1200^\circ \text{ R}$$

$$T_2 = 3200^\circ \text{ R}$$

$$f = 0.020$$

To find:

$$h_2 - h_1$$

$$\varphi_2 - \varphi_1$$

Method:

$$\left.\begin{aligned} h_{a,1} &= 291.30 \text{ Btu/(lb air) at } T_1 \\ \varphi_{a,1} &= 0.79628 \text{ Btu/(lb air)}(^\circ\text{R}) \end{aligned}\right\} \text{(table 1, ref. 5)}$$

$$\left.\begin{aligned} h_{a,2} &= 849.48 \text{ Btu/(lb air) at } T_2 \\ \varphi_{a,2} &= 1.06676 \text{ Btu/(lb air)}(^\circ\text{R}) \end{aligned}\right\} \text{(table II)}$$

$$\left.\begin{aligned} \psi_{h,1} &= 2440.6 \text{ Btu/lb} \\ \psi_{\varphi,1} &= 11.2760 \text{ Btu/(lb)}(^\circ\text{R}) \end{aligned}\right\} \text{(table I)}$$

$$\left.\begin{aligned} \psi_{h,2} &= 8046.8 \text{ Btu/lb} \\ \psi_{\varphi,2} &= 13.9355 \text{ Btu/(lb)}(^\circ\text{R}) \end{aligned}\right\} \text{(table II)}$$

Therefore,

$$\left.\begin{aligned} h &= h_a + \frac{f}{1+f}\psi_h \\ h_1 &= 291.30 + \frac{0.020}{1.020}(2440.6) = 339.15 \text{ Btu/(lb gas)} \\ h_2 &= 849.48 + \frac{0.020}{1.020}(8046.8) = 1007.26 \text{ Btu/(lb gas)} \end{aligned}\right\} \text{(eq. (A10))}$$

$$h_2 - h_1 = 668.11 \text{ Btu/(lb gas)}$$

$$\left.\begin{aligned} \varphi &= \varphi_a + \frac{f}{1+f}\psi_\varphi \\ \varphi_1 &= 0.79628 + \frac{0.020}{1.020}(11.2760) = 1.01738 \text{ Btu/(lb gas)}(^\circ\text{R}) \\ \varphi_2 &= 1.06676 + \frac{0.020}{1.020}(13.9355) = 1.34000 \text{ Btu/(lb gas)}(^\circ\text{R}) \end{aligned}\right\} \text{(eq. (A11))}$$

$$\varphi_2 - \varphi_1 = 0.32262 \text{ Btu/(lb gas)}(^\circ\text{R})$$

2. Compression Process

A constant small-stage efficiency $\eta_{\infty,C}$ for the compression process is assumed.

Given:

$$T_1 = 800^\circ \text{ R}$$

$$\eta_{\infty,C} = 0.92$$

$$p_2/p_1 = 4.0$$

Gas = Air

To find:

$$T_2$$

$$h_2 - h_1$$

Method:

$\varphi_1 = 0.69558$ Btu/(lb)($^\circ$R) at T_1

$h_1 = 191.81$ Btu/lb at T_1 } (table 1, ref. 5)

$$\varphi_2 - 0.69558 = \frac{53.342}{778.16(0.92)} \ln(4.0)$$

$\varphi_2 = 0.79887$ Btu/(lb)($^\circ$R) } (eq. (12))

$T_2 = 1212.3^\circ$ R at φ_2

$h_2 = 294.43$ Btu/lb at φ_2 } (table 1, ref. 5)

$h_2 - h_1 = 102.62$ Btu/lb

3. Combustion Process

The ideal temperature after combustion will be calculated for a given initial temperature and fuel-air ratio.

Given:

$$T_{t,1} = 1200^\circ \text{ R}$$

$$f = 0.015$$

$$\eta_B = 1.00$$

The gaseous hydrogen fuel and the air are assumed to be fully mixed at the initial temperature $T_{t,1}$.

To find:

$$T_{t,2}$$

Method:

$h_{a,t,1} = 291.30$ Btu/(lb air) (table 1, ref. 5)

$H = 50965.4$ Btu/(lb fuel) (appendix C)

$h_{f,t,1} = 4102.44$ Btu/(lb fuel) (table III)

$$\eta_B f H = (1 + f)h_{t,2} - h_{a,t,1} - f h_{f,t,1}$$

$$h_{t,2} = \frac{\eta_B f H + h_{a,t,1} + f h_{f,t,1}}{1 + f}$$

$$= \frac{(1.00)(0.015)(50965.4) + 291.30 + (0.015)(4102.44)}{1.015}$$

$$= 1100.81 \text{ Btu/(lb mixture)}$$

(eq. (14))

The first approximate temperature is obtained from table II:

$T'_{t,2} = 4042^{\circ}$ R at $h_{t,2} = h'_{a,t,2}$

$\psi'_{h,t,2} = 11012.5$ Btu/lb at $T'_{t,2}$

$\omega'_{t,2} = 13.150$ at $T'_{t,2}$

(table II)

$$\psi''_{h,t,2} = \frac{(1 + f)\psi'_{h,t,2}}{1 + f\omega'_{t,2}\left(1 - 0.00025\, T'_{t,2} f\right)}$$

$$= \frac{(1.015)(11012.5)}{1 + (0.015)(13.150)\left[1 - (0.00025)(4042)(0.015)\right]}$$

$$= 9359.5 \text{ Btu/lb}$$

(eq. (B4))

$$h''_{a,t,2} = h_{t,2} - \frac{f}{1 + f}\psi''_{h,t,2}$$

$$= 1100.81 - \frac{0.015}{1.015}(9359.5)$$

$$= 962.49 \text{ Btu/lb air}$$

(eq. (A10))

$$T_{t,2} = T''_{t,2} = 3581^{\circ} \text{ R at } h''_{a,t,2} \qquad \text{(table II)}$$

Verification of this result using equation (A10) indicates the temperature is correct within 0.5° R.

4. A Mixing Process

A mixing process is considered in which a quantity of dry air at a given temperature is mixed with combustion gases having a different temperature. A constant pressure level is assumed for the process. Such a process might occur in an air-cooled turbine in which the cooling air is exhausted into the main gas stream. The temperature, enthalpy, and other properties of the gas will be determined after mixing occurs.

Given:

Consider gases c (combustion gases) and d (air) at condition 1 to be mixed, yielding a mixture at condition 2.

$$W_c = 1 \text{ lb}$$

$$f_{c,1} = 0.015$$

$$T_{c,t,1} = 3600^{\circ} \text{ R}$$

$$W_d = 0.05 \text{ lb air}$$

$$T_{d,t,1} = 1800^{\circ} \text{ R}$$

To find:

$h_{t,2}$

f_2

$T_{t,2}$

R_2

$\Phi_{t,2}$

Method:

A heat-balance equation for the mixing process may be written

$$W_c(h_{c,t,1} - h_{c,t,2}) - W_d(h_{d,t,2} - h_{d,t,1}) = 0$$

or, rearranging and dividing by the total weight,

$$h_{t,2} = \frac{W_c h_{c,t,2} + W_d h_{d,t,2}}{W_d + W_c} = \frac{W_c h_{c,t,1} + W_d h_{d,t,1}}{W_d + W_c} \qquad (16)$$

$$\left.\begin{aligned} h_{c,t,1} &= h_{a,c,t,1} + \frac{f_{c,1}}{1 + f_{c,1}} \Psi_{h,c,t,1} \\ &= 968.21 + \left(\frac{0.015}{1.015}\right)(9425.2) \\ &= 1107.50 \text{ Btu/(lb combustion gases)} \end{aligned}\right\} \text{(eq. (A10); table II)}$$

$$h_{d,t,1} = 449.71 \text{ Btu/(lb air)} \qquad \text{(table 1, ref. 5)}$$

$$\left.\begin{aligned} h_{t,2} &= \frac{(1)(1107.50) + (0.05)(449.71)}{1.05} \\ &= 1076.18 \text{ Btu/(lb mixture)} \end{aligned}\right\} \text{(eq. (16))}$$

The fuel-air ratio of the final mixture f_2 may be derived as

$$f_2 = \frac{f_{c,1} W_c}{W_c + (1 + f_{c,1}) W_d}$$

$$= \frac{(0.015)(1)}{(1) + (1.015)(0.05)}$$

$$= 0.01428$$

The temperature $T_{t,2}$ may now be found in the same manner as in example 3. The first approximation of temperature $T'_{t,2}$ is 3960° R (table II at $h_{t,2}$).

$$\left.\begin{aligned} \Psi''_{h,t,2} &= \frac{(1 + f_2)\Psi'_{h,t,2}}{1 + f_2 \omega'_{t,2}(1 - 0.00025\, T'_{t,2} f_2)} \\ &= \frac{(1.01428)(10713.6)}{1 + (0.01428)(13.097)[1 - (0.00025)(3960)(0.01428)]} \\ &= 9174.9 \text{ Btu/lb} \end{aligned}\right\} \text{(eq. (B4); table II)}$$

$$h''_{a,t,2} = h_{t,2} - \frac{f_2}{1 + f_2} \psi''_{h,t,2}$$

$$= 1076.18 - \frac{0.01428}{1.01428} (9174.9)$$

$$= 947.01 \text{ Btu/(lb air)}$$

(eq. (A10))

$$T''_{t,2} = 3529^\circ \text{ R}$$

(table II)

Verification of this result using equation (A10) indicates the temperature is correct within 0.5° R.

The gas constant R_2 for the final mixture is

$$R_2 = 53.342 + \frac{329.92 f_2}{1 + f_2}$$

$$= 53.342 + \frac{0.01428}{1.01428} (329.92)$$

$$= 57.987 \text{ ft-lb/(lb)}(^\circ\text{R})$$

(eq. (8))

The function $\varphi_{t,2}$ is

$$\varphi_{t,2} = \varphi_{a,t,2} + \frac{f_2}{1 + f_2} \psi_{\varphi,t,2}$$

$$\varphi_{a,t,2} = 1.09579 \text{ at } T_{t,2}$$

$$\psi_{\varphi,t,2} = 14.2728 \text{ at } T_{t,2}$$

$$\varphi_{t,2} = 1.09579 + \frac{0.01428}{1.01428} (14.2728)$$

$$= 1.2967 \text{ Btu/(lb mixture)}(^\circ\text{R})$$

(eq. (A11); table II)

5. Calculation of Critical Velocity for a Mixture of Combustion Gases

The critical velocity for a mixture of combustion gases is found as follows.

Given:

$T_t = 3529^\circ$ R

$f = 0.01428$

$R = 57.987$ ft-lb/(lb)($^\circ$R) (see example 4)

To find:

$$a_{cr} \equiv \sqrt{\frac{2\gamma}{\gamma + 1} gRT_t}$$ (eq. 3.4, ref. 8; symbols changed to correspond to those used herein)

Method:

$$c_p = c_{p,a} + \frac{f}{1 + f} \psi_{c_p}$$

$c_{p,a} = 0.2980$ Btu/(lb)($^\circ$R) at T_t

$\psi_{c_p} = 3.504$ Btu/(lb)($^\circ$R) at T_t

$$c_p = 0.2980 + \frac{0.01428}{1.01428}(3.504)$$

$= 0.3473$ Btu/(lb)($^\circ$R)

(eq. (A12); table II)

$$\gamma = \frac{c_p}{c_p - \frac{R}{J}}$$

$$= \frac{0.3473}{0.3473 - \left(\frac{57.987}{778.16}\right)}$$

$= 1.273$

(eq. (10))

$$a_{cr} = \sqrt{\frac{2\gamma}{\gamma + 1} gRT_t}$$

$$= \sqrt{\frac{2(1.273)}{2.273}(32.174)(57.987)(3529)}$$

$= 2716$ ft/sec

(eq. 3.4, ref. 8)

6. Expansion in a Nozzle

The exit static temperature, velocity, and throat area for the expansion of a mixture of combustion gases in an ideal nozzle will be evaluated.

Given:

$$T_{t,1} = 2500^\circ \text{ R}$$

$$p_{t,1} = 2116.22 \text{ lb/sq ft}$$

$$f = 0.01428$$

$$p_{t,1}/p_{s,2} = 20.0$$

$$R = 57.987 \text{ Btu/(lb)}(^\circ\text{R}) \qquad \text{(see example 4)}$$

To find:

$$T_{s,2}$$

$$V_2$$

$$A_{cr}$$

At temperature $T_{t,1}$,

$$\varphi_{a,t,1} = 0.99497 \text{ Btu/(lb)}(^\circ\text{R}) \qquad \text{(table 1, ref. 5)}$$

$$\psi_{\varphi,t,1} = 13.1455 \text{ Btu/(lb)}(^\circ\text{R}) \qquad \text{(table I)}$$

$$\left.\begin{aligned} \varphi_{t,1} &= \varphi_{a,t,1} + \frac{f}{1+f}\psi_{\varphi,t,1} \\ &= 0.99497 + \frac{0.01428}{1.01428}(13.1455) \\ &= 1.18005 \text{ Btu/(lb)}(^\circ\text{R}) \end{aligned}\right\} \quad \text{(eq. (A11))}$$

For ideal expansion in a nozzle,

$$\left.\begin{aligned} \varphi_{s,2} &= \varphi_{t,1} + \frac{R}{J}\ln\frac{p_{s,2}}{p_{t,1}} \\ &= 1.18005 + \frac{57.987}{778.16}\ln\left(\frac{1}{20}\right) \\ &= 0.95681 \text{ Btu/(lb gas)}(^\circ\text{R}) \end{aligned}\right\} \quad \text{(eq. (13))}$$

The first approximation for temperature $T_{s,2}$ may be obtained by using equation (7):

$$\left.\begin{aligned}\varphi'_{a,s,2} &= \frac{(1+f)\varphi_{s,2} - 3.5307\,f}{1 + 10.663\,f} \\ &= \frac{(1.01428)(0.95681) - 3.5307(0.01428)}{1 + 10.663(0.01428)} \\ &= 0.79847 \text{ Btu/(lb air)}(^\circ\text{R})\end{aligned}\right\} \text{(eq. (7))}$$

$$T'_{s,2} = 1210^\circ \text{ R} \qquad \text{(table 1, ref. 5)}$$

Using the steps on page 7 of the APPLICATION OF TABLES for the succeeding approximations,

$$\psi'_{\varphi,s,2} = 11.2947 \text{ Btu/(lb)}(^\circ\text{R}) \text{ at } T'_{s,2} \qquad \text{(table I)}$$

$$\left.\begin{aligned}\varphi''_{a,s,2} &= \varphi_{s,2} - \frac{f}{1+f}\psi'_{\varphi,s,2} \\ &= 0.95681 - \frac{0.01428}{1.01428}(11.2947) \\ &= 0.79779 \text{ Btu/(lb air)}(^\circ\text{R})\end{aligned}\right\} \text{(eq. (A11))}$$

$$T_{s,2} = T''_{s,2} = 1207^\circ \text{ R at } \varphi''_{a,s,2} \qquad \text{(table 1, ref. 5)}$$

Further approximations are unnecessary, as the same temperature T_2 would result.

Calculate V_2 from

$$\frac{V_2^2}{2gJ} = h_{t,1} - h_{s,2}$$

$$\left.\begin{aligned}h_{t,1} &= 645.78 + \frac{0.01428}{1.01428}(5809.4) \\ &= 727.57 \text{ Btu/(lb gas)}\end{aligned}\right\} \text{(eq. (A10); table 1, ref. 5; table I)}$$

$$\left.\begin{aligned}h_{s,2} &= 293.09 + \frac{0.01428}{1.01428}(2456.0) \\ &= 327.67 \text{ Btu/(lb gas)}\end{aligned}\right\} \text{(eq. (A10); table 1, ref. 5; table I)}$$

$$V_2 = \sqrt{2gJ(h_{t,1} - h_{s,2})}$$

$$= \sqrt{2(32.174)(778.16)(727.57 - 327.67)}$$

$$= 4475 \text{ ft/sec}$$

The ideal nozzle throat area required to pass 1 pound of air per second (assuming constant γ from the inlet total state to the throat) is

$$A_{cr} = \frac{1}{\left(\frac{2}{\gamma_{t,1}+1}\right)^{\frac{\gamma_{t,1}+1}{2(\gamma_{t,1}-1)}} p_{t,1}\sqrt{\frac{\gamma_{t,1} g}{RT_{t,1}}}}$$

$$c_{p,t,1} = c_{p,a,t,1} + \frac{f}{1+f}\Psi c_{p,t,1}$$

$$c_{p,a,t,1} = 0.2863 \text{ Btu/(lb)(}^\circ\text{R) at } T_{t,1}$$

$$\Psi c_{p,t,1} = 3.011 \text{ Btu/(lb)(}^\circ\text{R) at } T_{t,1}$$

(eq. (A12); table I)

$$c_{p,t,1} = 0.2863 + \frac{0.01428}{1.01428}(3.011)$$

$$= 0.32869 \text{ Btu/(lb)(}^\circ\text{R)}$$

$$\gamma_{t,1} = \frac{c_{p,t,1}}{c_{p,t,1} - \frac{R}{J}}$$

$$= \frac{0.32869}{0.32869 - \left(\frac{57.987}{778.16}\right)}$$

$$= 1.2932$$

(eq. (10))

$$A_{cr} = \frac{1}{\left(\frac{2}{1.2932+1}\right)^{\frac{1.2932+1}{2(1.2932-1)}} 2116.22\sqrt{\frac{(1.2932)(32.174)}{(57.987)(2500)}}}$$

$$A_{cr} = 0.04763 \text{ (sq ft)(sec)/lb}$$

APPENDIX A

DERIVATION OF TABLES I AND II, COMBUSTION-GAS VALUES OF ψ_h, ψ_φ, ω, $c_{p,a}$, and ψ_{c_p} FOR THE COMBUSTION OF HYDROGEN WITH AIR

Physical Relations

The following composition of air on a volume basis was chosen in reference 5 and was assumed herein as well:

Oxygen	0.2099
Nitrogen	.7803
Argon	.0098
	1.0000

The following atomic weights were also taken from reference 5:

Oxygen	16.000
Nitrogen	14.008
Argon	39.950
Hydrogen	1.0080

Complete combustion of f pounds of hydrogen with 1 pound of air results in the following relation:

$$\frac{f}{2.016} H_2 + \frac{1}{28.9692} (0.2099\ O_2 + 0.7803\ N_2 + 0.0098\ A) \rightarrow$$

$$\frac{f}{2.016} \left(H_2O - \frac{1}{2} O_2\right) + \frac{1}{28.9692} (0.2099\ O_2 + 0.7803\ N_2 + 0.0098\ A) \tag{A1}$$

The stoichiometric fuel-air ratio is 0.02921.

In order to simplify the determination of mixture characteristics that follows, the combustion products were considered to be a mixture of two gases a and b, where gas a is air and gas b is the hypothetical gas $\left(H_2O - \frac{1}{2} O_2\right)$. One pound of gas b is

$$b = \frac{1}{2.016} \left(H_2O - \frac{1}{2} O_2\right) \tag{A2}$$

For a mixture of these two gases,

$$c_p = \frac{W_a c_{p,a} + W_b c_{p,b}}{W_a + W_b}$$

which can be modified to read

$$c_p = \frac{W_b}{W_a + W_b} (c_{p,b} - c_{p,a}) + c_{p,a} \tag{A3}$$

where

$$W_a = 1 \quad \text{and} \quad W_b = f \tag{A4}$$

Similarly,

$$R = \frac{W_b}{W_a + W_b} (R_b - R_a) + R_a \tag{A5}$$

$$h = \frac{W_b}{W_a + W_b} (h_b - h_a) + h_a \tag{A6}$$

$$\varphi = \frac{W_b}{W_a + W_b} (\varphi_b - \varphi_a) + \varphi_a \tag{A7}$$

For

$$\left.\begin{aligned} \psi_R &\equiv R_b - R_a \\ \psi_h &\equiv h_b - h_a \\ \psi_\varphi &\equiv \varphi_b - \varphi_a \\ \psi_{c_p} &\equiv c_{p,b} - c_{p,a} \end{aligned}\right\} \tag{A8}$$

equations (A3) to (A7) can be modified to yield

$$R = R_a + \frac{f}{1 + f} \psi_R \tag{A9}$$

$$h = h_a + \frac{f}{1 + f} \psi_h \tag{A10}$$

$$\varphi = \varphi_a + \frac{f}{1 + f} \psi_\varphi \tag{A11}$$

$$c_p = c_{p,a} + \frac{f}{1 + f} \psi_{c_p} \tag{A12}$$

For the universal gas constant $\overline{R}$ on page 201 of reference 5 and the value of R_a on page 202,

$$R_b = \frac{\overline{R}}{m_b} = \frac{1545.32}{4.032} = 383.26 \text{ ft-lb/(lb)(}^\circ\text{R)} \tag{A13}$$

$$\psi_R = 383.26 - 53.342 = 329.92 \text{ ft-lb/(lb)(}^\circ\text{R)} \tag{A14}$$

where the average molecular weight of gas b is 4.032 (1/2 mole having a weight of 2.016 lb).

Computations

The properties ψ_h, ψ_φ, and ψ_{c_p} were determined from the tabular values in reference 5 and equations (A8). These values were computed at 20° intervals in temperature and then quadratically interpolated to 1° intervals for ψ_h and ψ_φ and to 5° intervals for ψ_{c_p}. Both specific heat for air $c_{p,a}$ and ω were also computed for 5° intervals in temperature, where

$$\omega \equiv \frac{c_{p,b}}{c_{p,a}}$$

which can be rewritten as

$$\omega = \frac{\psi_{c_p}}{c_{p,a}} + 1 \tag{A15}$$

The temperature intervals for tabulation were established by employing the following criterion: For both convenience and accuracy, direct use of the tabular values without interpolation should permit computation of both h and φ with an error corresponding to a temperature change of no greater than 0.5°. Use of the relation

$$h = \int c_p \, dT$$

permits reducing equation (A10) to

$$c_p \, dT = c_{p,a} \, dT + \frac{f}{1 + f} \psi_{c_p} \, dT \tag{A16}$$

The selected criterion for satisfactory computation of h is satisfied if enthalpy h is determined at a temperature corresponding to the nearest integer. Because the tabulations of enthalpy for air h_a in table I of reference 5 and its extension in table II herein are for 1° intervals in temperature, this requirement is automatically fulfilled, and the first term on the right side of equation (A16) may be set equal to zero. Equation (A16) can then be rewritten as

$$c_p \, dT_h = \frac{f}{1 + f} \psi_{c_p} \, dT_{\psi_h} \tag{A17}$$

where, according to the selected criterion for satisfactory error in h, $dT_h \leq 1.0$. From equation (A17) and the definition of ω,

$$dT_{\psi_h} \leq \frac{1 + f}{(\omega - 1)f} \tag{A18}$$

Because dT_{ψ_h} becomes smaller as f and ω increase, the most extreme conditions occur at high temperature and fuel-air ratio. The value of greatest dT_{ψ_h} for a temperature of 4400° R and stoichiometric fuel-air ratio (0.02921) is 2.8°. A temperature interval of 1° is thus satisfactory for tabulation of ψ_h.

Use of the relation

$$\varphi \equiv \int \frac{c_p}{T} \, dT$$

in equation (A11) yields

$$\frac{c_p}{T}\,dT = \frac{c_{p,a}}{T}\,dT + \frac{f}{1+f}\,\frac{\psi_{c_p}}{T}\,dT \qquad \text{(A19)}$$

In a fashion directly paralleling that for equation (A16), equation (A19) can be reduced to a form like that of equation (A18), namely,

$$dT_{\psi_\varphi} \leq \frac{1+f}{(\omega-1)f}$$

This relation is satisfied by tabulating ψ_φ for each 1° R.

An interval of 5° R was arbitrarily selected for tabulation of each of the factors ω, $c_{p,a}$, and ψ_{c_p}.

APPENDIX B

DERIVATION OF EQUATION FOR DETERMINING T FROM h AND f

Assume that the derivatives $d\psi_h/dT$ and dh_a/dT are constant from T to T', that is,

$$\frac{h_a' - h_a}{T' - T} = \frac{dh_a}{dT} \tag{B1}$$

and

$$\frac{\psi_h' - \psi_h}{T' - T} = \frac{d\psi_h}{dT} \tag{B2}$$

Division of equation (B2) by (B1) yields

$$\frac{\psi_h' - \psi_h}{h_a' - h_a} = \frac{\frac{d\psi_h}{dT}}{\frac{dh_a}{dT}}$$

Use of the definition of ψ_h in equation (A8) permits reducing this expression to

$$\frac{\psi_h' - \psi_h}{h_a' - h_a} = \frac{\frac{dh_b}{dT} - \frac{dh_a}{dT}}{\frac{dh_a}{dT}}$$

$$= \frac{c_{p,b}}{c_{p,a}} - 1$$

$$= \omega - 1$$

Combination of this expression with equations (A10) and (A11) yields

$$\psi_h = \frac{(1 + f)\psi_h'}{1 + f\omega} \tag{B3}$$

Because of the approximate nature of equations (B1) and (B2), equation (B3) yields only approximate results. In order to obtain better results than those obtainable from equation (B3), the relation was adjusted to produce

$$\psi_h = \frac{(1 + f)\psi_h'}{1 + f\omega'(1 - \beta T'f)} \tag{B4}$$

where β is an empirically determined coefficient.

An investigation of a suitable value of β resulted in

$$\beta = 0.00025 \tag{B5}$$

APPENDIX C

CALCULATION OF THE LOWER HEATING VALUE OF HYDROGEN USING VALUES OF ENTHALPY FROM TABLES I TO III

The lower heating value of hydrogen at 25° C and constant pressure is given in reference 9 as $q = 51571.4$ Btu per pound.

The chemical energy H corresponding to the enthalpy values of air, combustion products, and fuel given in tables I to III may be evaluated from the following heat-balance equation at a temperature of 25° C (536.69° R):

$$h_a + fh_f + fH = (1 + f)\left(h_a + \frac{f}{1 + f}\psi_h\right) + fq$$

or

$$H = h_a + \psi_h + q - h_f \qquad \text{(C1)}$$

$h_a = 128.3$ Btu/lb (table 1, ref. 5)

$h_f = 1793.7$ Btu/lb (table III)

$$\psi_h = h_b - h_a \qquad \text{(A8)}$$

From equation (A2),

$$h_b = \left(\bar{h}_{H_2O} - \frac{1}{2}\bar{h}_{O_2}\right)\left(\frac{1}{2.016}\right) \qquad \text{(C2)}$$

$\bar{h}_{H_2O} = 4255.9$ Btu/(lb mole) (table 15, ref. 5)

$\bar{h}_{O_2} = 3723.0$ Btu/(lb mole) (table 13, ref. 5)

$$\left.\begin{aligned} h_b &= \left(4255.9 - \frac{3723.0}{2}\right)\left(\frac{1}{2.016}\right) \\ &= 1187.7 \text{ Btu/lb} \end{aligned}\right\} \quad \text{(eq. (C2))}$$

$$\left.\begin{aligned} \psi_h &= 1187.7 - 128.3 \\ &= 1059.4 \text{ Btu/lb} \end{aligned}\right\} \quad \text{(eq. (A8))}$$

$$\left.\begin{aligned} H &= 128.3 + 1059.4 + 51571.4 - 1793.7 \\ &= 50965.4 \text{ Btu/(lb fuel)} \end{aligned}\right\} \quad \text{(eq. (C1))}$$

APPENDIX D

DERIVATION OF TABLE III, ENTHALPY OF THE REAL GAS PARA-HYDROGEN AT A PRESSURE OF 1 ATMOSPHERE

The two modifications of hydrogen, para-hydrogen ($\underline{p}$-H_2) and ortho-hydrogen ($\underline{o}$-H_2) have differing thermal properties at low temperatures. The enthalpies and other properties of each of the modifications are given in reference 6. At temperatures of 900° R and above, the equilibrium composition is 75 percent $\underline{o}$-H_2 and 25 percent $\underline{p}$-H_2; this composition is referred to as normal hydrogen ($\underline{n}$-H_2). At lower temperatures the equilibrium percentage of $\underline{p}$-H_2 increases until at the saturation temperature (36.5° R) the equilibrium composition is 99.80 percent $\underline{p}$-H_2 and 0.20 percent $\underline{o}$-H_2 (see table 12, ref. 6).

The enthalpy of $\underline{p}$-H_2 at low temperatures is considerably lower than that for $\underline{o}$-H_2. For example, the heat given off in the conversion of $\underline{n}$-H_2 to $\underline{p}$-H_2 at the saturation temperature is 226.8 Btu per pound. Liquid hydrogen produced for use in aircraft will probably be essentially $\underline{p}$-H_2, because it would otherwise be impractical to store this fuel. Reference 10 (ch. IV) indicates that the reconversion of $\underline{p}$-H_2 to $\underline{o}$-H_2 is a relatively slow process at the low temperatures (less than about 620° R) at which there is an appreciable difference in the enthalpy for $\underline{o}$-H_2 and $\underline{p}$-H_2. Therefore, for all practical purposes in cycle analysis, the enthalpy for pure $\underline{p}$-H_2 can be used over the entire range for which gas-property data are available.

The basic data in preparing table III were obtained from table 4 of reference 6, which gives enthalpy values for the ideal gas $\underline{p}$-H_2. In order to obtain values for the real gas, correction factors from table 23 of reference 6 and from table 6-4 of reference 7 were used. Although in both references this ideal- to real-gas enthalpy correction is for $\underline{n}$-H_2, the error in applying it to the enthalpy for $\underline{p}$-H_2 is probably very small, because the correction is for an intermolecular effect, whereas the difference between $\underline{o}$-H_2 and $\underline{p}$-H_2 occurs within the molecule. The values for the real-gas enthalpy of $\underline{p}$-H_2 obtained for the temperatures listed in table 4 of reference 6 were quadratically interpolated at temperature intervals of 10° R for table III.

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TABLE I. - COMBUSTION-GAS VALUES OF Ψ_h, Ψ_φ, α, $c_{p,a}$, AND Ψ_{c_p} FOR COMBUSTION OF HYDROGEN WITH AIR

[T = 600° to 2998° R]

T, °R	Ψ_h, Btu/lb	Ψ_φ, Btu/(lb)(°R)	α	$c_{p,a}$, Btu/(lb)(°R)	Ψ_{c_p}, Btu/(lb)(°R)	T, °R	Ψ_h, Btu/lb	Ψ_φ, Btu/(lb)(°R)	α	$c_{p,a}$, Btu/(lb)(°R)	Ψ_{c_p}, Btu/(lb)(°R)
600	1186.1	9.8348	9.350	0.2403	2.006	650	1286.7	9.9962	9.369	0.2408	2.016
601	1188.1	9.8382				651	1288.8	9.9993			
602	1190.1	9.8415				652	1290.8	10.0023			
603	1192.1	9.8449				653	1292.8	10.0054			
604	1194.1	9.8482				654	1294.8	10.0085			
605	1196.2	9.8516	9.352	.2403	2.007	655	1296.8	10.0116	9.371	.2409	2.017
606	1198.2	9.8549				656	1298.9	10.0146			
607	1200.2	9.8583				657	1300.9	10.0177			
608	1202.2	9.8616				658	1302.9	10.0208			
609	1204.2	9.8649				659	1304.9	10.0238			
610	1206.2	9.8682	9.354	.2404	2.008	660	1306.9	10.0269	9.373	.2410	2.018
611	1208.2	9.8715				661	1309.0	10.0300			
618	1210.2	9.8748				668	1311.0	10.0331			
613	1212.2	9.8781				663	1313.0	10.0361			
614	1214.2	9.8814				664	1315.0	10.0392			
615	1216.2	9.8847	9.356	.2404	2.009	665	1317.0	10.0423	9.375	.2410	2.019
616	1218.3	9.8880				666	1319.1	10.0453			
617	1220.3	9.8913				667	1321.1	10.0484			
618	1222.3	9.8946				668	1323.1	10.0514			
619	1224.3	9.8978				669	1325.1	10.0544			
620	1226.3	9.9011	9.356	.2405	2.010	670	1327.1	10.0575	9.377	.2411	2.020
621	1228.3	9.9043				671	1329.2	10.0605			
622	1230.3	9.9076				672	1331.2	10.0635			
623	1232.3	9.9108				673	1333.2	10.0665			
624	1234.3	9.9141				674	1335.2	10.0695			
625	1236.4	9.9173	9.360	.2405	2.011	675	1337.2	10.0725	9.379	.2412	2.021
626	1238.4	9.9205				676	1339.3	10.0755			
627	1240.4	9.9238				677	1341.3	10.0785			
628	1242.4	9.9270				678	1343.3	10.0815			
629	1244.4	9.9302				679	1345.3	10.0844			
630	1246.4	9.9334	9.362	.2406	2.013	680	1347.3	10.0874	9.381	.2413	2.022
631	1248.4	9.9366				681	1349.4	10.0903			
632	1250.4	9.9398				682	1351.4	10.0932			
633	1252.5	9.9430				683	1353.4	10.0961			
634	1254.5	9.9462				684	1355.4	10.0990			
635	1256.5	9.9493	9.364	.2406	2.013	685	1357.5	10.1019	9.383	.2413	2.023
636	1258.5	9.9525				686	1359.5	10.1048			
637	1260.5	9.9557				687	1361.5	10.1077			
638	1262.5	9.9588				688	1363.5	10.1106			
639	1264.5	9.9620				689	1365.5	10.1135			
640	1266.6	9.9651	9.366	.2407	2.014	690	1367.6	10.1164	9.385	.2414	2.024
641	1268.6	9.9682				691	1369.6	10.1193			
642	1270.6	9.9714				692	1371.6	10.1222			
643	1272.6	9.9745				693	1373.6	10.1251			
644	1274.6	9.9776				694	1375.7	10.1280			
645	1276.7	9.9807	9.367	.2408	2.015	695	1377.7	10.1309	9.387	.2415	2.025
646	1278.7	9.9838				696	1379.7	10.1338			
647	1280.7	9.9869				697	1381.7	10.1367			
648	1282.7	9.9900				698	1383.8	10.1396			
649	1284.7	9.9931				699	1385.8	10.1425			

TABLE I. - Continued. COMBUSTION-GAS VALUES OF ψ_h, ψ_φ, α, $c_{p,s}$, AND ψ_{c_p} FOR COMBUSTION OF HYDROGEN WITH AIR

[T = 800° to 2999° R.]

T, °R	ψ_h, Btu/lb	ψ_φ, Btu/(lb)(°R)	α	$c_{p,s}$, Btu/(lb)(°R)	ψ_{c_p}, Btu/(lb)(°R)	T, °R	ψ_h, Btu/lb	ψ_φ, Btu/(lb)(°R)	α	$c_{p,s}$, Btu/(lb)(°R)	ψ_{c_p}, Btu/(lb)(°R)
700	1387.8	10.1454	9.389	0.2416	2.037	750	1489.5	10.2858	9.411	0.2434	2.039
701	1389.9	10.1484				751	1491.6	10.2886			
702	1391.9	10.1513				752	1493.6	10.2913			
703	1393.9	10.1543				753	1495.6	10.2940			
704	1395.9	10.1572				754	1497.7	10.2968			
705	1398.0	10.1602	9.398	.2416	2.038	755	1499.7	10.2995	9.413	.2435	2.040
706	1400.0	10.1631				756	1501.8	10.3022			
707	1402.0	10.1660				757	1503.8	10.3049			
708	1404.1	10.1689				758	1505.9	10.3076			
709	1406.1	10.1718				759	1507.9	10.3103			
710	1408.1	10.1747	9.394	.2417	2.039	760	1509.9	10.3130	9.415	.2436	2.041
711	1410.2	10.1776				761	1512.0	10.3156			
712	1412.2	10.1805				762	1514.0	10.3183			
713	1414.2	10.1834				763	1516.1	10.3209			
714	1416.2	10.1863				764	1518.1	10.3235			
715	1418.3	10.1891	9.396	.2418	2.030	765	1520.2	10.3262	9.417	.2437	2.042
716	1420.3	10.1920				766	1522.2	10.3288			
717	1422.3	10.1948				767	1524.3	10.3314			
718	1424.4	10.1977				768	1526.3	10.3341			
719	1426.4	10.2005				769	1528.4	10.3367			
720	1428.4	10.2033	9.398	.2419	2.031	770	1530.4	10.3394	9.419	.2437	2.044
721	1430.5	10.2061				771	1532.4	10.3420			
722	1432.5	10.2088				772	1534.5	10.3446			
723	1434.5	10.2116				773	1536.5	10.3473			
724	1436.6	10.2143				774	1538.6	10.3499			
725	1438.6	10.2170	9.400	.2419	2.032	775	1540.6	10.3525	9.421	.2438	2.045
726	1440.6	10.2198				776	1542.7	10.3552			
727	1442.7	10.2225				777	1544.7	10.3578			
728	1444.7	10.2253				778	1546.8	10.3604			
729	1446.7	10.2280				779	1548.8	10.3631			
730	1448.8	10.2308	9.402	.2420	2.034	780	1550.9	10.3657	9.424	.2439	2.046
731	1450.8	10.2335				781	1552.9	10.3684			
732	1452.8	10.2363				782	1555.0	10.3711			
733	1454.9	10.2390				783	1557.0	10.3738			
734	1456.9	10.2417				784	1559.0	10.3764			
735	1458.9	10.2445	9.404	.2421	2.035	785	1561.1	10.3791	9.426	.2440	2.048
736	1461.0	10.2472				786	1563.1	10.3817			
737	1463.0	10.2500				787	1565.2	10.3844			
738	1465.0	10.2527				788	1567.2	10.3870			
739	1467.1	10.2554				789	1569.3	10.3897			
740	1469.1	10.2582	9.407	.2422	2.036	790	1571.3	10.3923	9.428	.2441	2.049
741	1471.1	10.2610				791	1573.4	10.3949			
742	1473.2	10.2638				792	1575.4	10.3976			
743	1475.2	10.2665				793	1577.5	10.4002			
744	1477.3	10.2693				794	1579.5	10.4028			
745	1479.3	10.2721	9.409	.2423	2.037	795	1581.6	10.4054	9.430	.2438	2.051
746	1481.3	10.2748				796	1583.6	10.4080			
747	1483.4	10.2776				797	1585.7	10.4106			
748	1485.4	10.2804				798	1587.7	10.4132			
749	1487.5	10.2831				799	1589.8	10.4158			

TABLE I. - Continued. COMBUSTION-GAS VALUES OF ψ_h, ψ_s, α, $c_{p,a}$, AND ψ_{c_p} FOR COMBUSTION OF HYDROGEN WITH AIR

[T = 600° to 2999° R.]

T, °R	ψ_h, Btu/lb	ψ_s, Btu/(lb)(°R)	α	$c_{p,a}$, Btu/(lb)(°R)	ψ_{c_p}, Btu/(lb)(°R)	T, °R	ψ_h, Btu/lb	ψ_s, Btu/(lb)(°R)	α	$c_{p,a}$, Btu/(lb)(°R)	ψ_{c_p}, Btu/(lb)(°R)
800	1591.8	10.4183	9.432	0.2434	2.052	850	1694.8	10.5426	9.452	0.2445	2.067
801	1593.9	10.4209				851	1696.8	10.5450			
802	1595.9	10.4234				852	1698.9	10.5474			
803	1598.0	10.4259				853	1701.0	10.5498			
804	1600.0	10.4284				854	1703.0	10.5522			
805	1602.1	10.4309	9.434	.2435	2.053	855	1705.1	10.5546	9.454	.2446	2.068
806	1604.1	10.4334				856	1707.2	10.5570			
807	1606.2	10.4360				857	1709.2	10.5594			
808	1608.2	10.4385				858	1711.3	10.5618			
809	1610.3	10.4410				859	1713.4	10.5642			
810	1612.3	10.4435	9.436	.2436	2.055	860	1715.4	10.5666	9.456	.2447	2.070
811	1614.4	10.4460				861	1717.5	10.5690			
812	1616.5	10.4485				862	1719.6	10.5714			
813	1618.5	10.4510				863	1721.7	10.5738			
814	1620.6	10.4536				864	1723.7	10.5763			
815	1622.6	10.4561	9.438	.2437	2.056	865	1725.8	10.5787	9.459	.2449	2.071
816	1624.7	10.4586				866	1727.9	10.5811			
817	1626.7	10.4611				867	1729.9	10.5835			
818	1628.8	10.4636				868	1732.0	10.5859			
819	1630.8	10.4661				869	1734.1	10.5883			
820	1632.9	10.4686	9.440	.2438	2.058	870	1736.2	10.5907	9.461	.2450	2.073
821	1635.0	10.4711				871	1738.2	10.5931			
822	1637.0	10.4737				872	1740.3	10.5955			
823	1639.1	10.4762				873	1742.4	10.5979			
824	1641.1	10.4787				874	1744.5	10.6003			
825	1643.2	10.4813	9.442	.2439	2.059	875	1746.5	10.6026	9.463	.2451	2.074
826	1645.3	10.4838				876	1748.6	10.6050			
827	1647.3	10.4863				877	1750.7	10.6074			
828	1649.4	10.4888				878	1752.8	10.6098			
829	1651.5	10.4913				879	1754.8	10.6122			
830	1653.5	10.4938	9.444	.2440	2.061	880	1756.9	10.6145	9.465	.2452	2.076
831	1655.6	10.4963				881	1759.0	10.6169			
832	1657.6	10.4988				882	1761.1	10.6193			
833	1659.7	10.5013				883	1763.2	10.6217			
834	1661.8	10.5038				884	1765.2	10.6241			
835	1663.8	10.5062	9.446	.2441	2.062	885	1767.3	10.6264	9.467	.2454	2.078
836	1665.9	10.5087				886	1769.4	10.6288			
837	1668.0	10.5112				887	1771.5	10.6312			
838	1670.0	10.5136				888	1773.6	10.6335			
839	1672.1	10.5161				889	1775.6	10.6359			
840	1674.1	10.5185	9.448	.2443	2.064	890	1777.7	10.6383	9.470	.2455	2.079
841	1676.2	10.5209				891	1779.8	10.6406			
842	1678.3	10.5234				892	1781.9	10.6429			
843	1680.3	10.5258				893	1784.0	10.6453			
844	1682.4	10.5282				894	1786.0	10.6476			
845	1684.5	10.5306	9.450	.2444	2.065	895	1788.1	10.6500	9.472	.2456	2.081
846	1686.5	10.5330				896	1790.2	10.6523			
847	1688.6	10.5354				897	1792.3	10.6546			
848	1690.6	10.5378				898	1794.4	10.6570			
849	1692.7	10.5402				899	1796.5	10.6593			

TABLE I. - Continued. COMBUSTION-GAS VALUES OF ψ_h, ψ_s, ω, $c_{p,a}$, AND ψ_{c_p} FOR COMBUSTION OF HYDROGEN WITH AIR

[T = 600° to 2999° R]

T, °R	ψ_h, Btu/lb	ψ_s, Btu/(lb)(°R)	ω	$c_{p,a}$, Btu/(lb)(°R)	ψ_{c_p}, Btu/(lb)(°R)	T, °R	ψ_h, Btu/lb	ψ_s, Btu/(lb)(°R)	α	$c_{p,a}$, Btu/(lb)(°R)	ψ_{c_p}, Btu/(lb)(°R)
900	1798.6	10.6616	9.474	0.8458	2.083	950	1903.1	10.7746	9.497	0.8471	2.100
901	1800.6	10.6639				951	1905.2	10.7768			
902	1802.7	10.6668				952	1907.3	10.7790			
903	1804.8	10.6685				953	1909.4	10.7812			
904	1806.9	10.6708				954	1911.5	10.7833			
905	1809.0	10.6731	9.476	.8459	2.084	955	1913.6	10.7855	9.500	.8473	2.103
906	1811.1	10.6753				956	1915.7	10.7877			
907	1813.2	10.6776				957	1917.8	10.7899			
908	1815.3	10.6799				958	1919.9	10.7921			
909	1817.3	10.6822				959	1922.1	10.7943			
910	1819.4	10.6845	9.479	.8460	2.086	960	1924.2	10.7965	9.502	.8474	2.104
911	1821.5	10.6868				961	1926.3	10.7987			
912	1823.6	10.6891				962	1928.4	10.8009			
913	1825.7	10.6913				963	1930.5	10.8030			
914	1827.8	10.6936				964	1932.6	10.8052			
915	1829.9	10.6959	9.481	.8462	2.088	965	1934.7	10.8074	9.505	.8475	2.105
916	1832.0	10.6982				966	1936.8	10.8096			
917	1834.0	10.7005				967	1938.9	10.8118			
918	1836.1	10.7027				968	1941.0	10.8140			
919	1838.2	10.7050				969	1943.1	10.8161			
920	1840.3	10.7073	9.483	.8463	2.089	970	1945.2	10.8183	9.507	.8477	2.107
921	1842.4	10.7096				971	1947.3	10.8205			
922	1844.5	10.7119				972	1949.4	10.8227			
923	1846.6	10.7142				973	1951.6	10.8248			
924	1848.7	10.7165				974	1953.7	10.8270			
925	1850.8	10.7187	9.485	.8464	2.091	975	1955.8	10.8292	9.510	.8478	2.109
926	1852.8	10.7210				976	1957.9	10.8313			
927	1854.9	10.7233				977	1960.0	10.8335			
928	1857.0	10.7256				978	1962.1	10.8357			
929	1859.1	10.7278				979	1964.2	10.8378			
930	1861.2	10.7301	9.488	.8466	2.093	980	1966.3	10.8400	9.513	.8480	2.111
931	1863.3	10.7324				981	1968.4	10.8422			
932	1865.4	10.7346				982	1970.5	10.8443			
933	1867.5	10.7369				983	1972.6	10.8465			
934	1869.6	10.7391				984	1974.7	10.8487			
935	1871.7	10.7414	9.490	.8467	2.095	985	1976.9	10.8508	9.515	.8481	2.113
936	1873.8	10.7436				986	1979.0	10.8530			
937	1875.9	10.7459				987	1981.1	10.8551			
938	1878.0	10.7481				988	1983.2	10.8573			
939	1880.1	10.7503				989	1985.3	10.8594			
940	1882.2	10.7526	9.493	.8468	2.096	990	1987.4	10.8616	9.518	.8483	2.115
941	1884.3	10.7548				991	1989.5	10.8637			
942	1886.3	10.7570				992	1991.6	10.8659			
943	1888.4	10.7592				993	1993.7	10.8680			
944	1890.5	10.7614				994	1995.9	10.8701			
945	1892.6	10.7636	9.495	.8470	2.098	995	1998.0	10.8723	9.520	.8484	2.117
946	1894.7	10.7658				996	2000.1	10.8744			
947	1896.8	10.7680				997	2002.2	10.8765			
948	1898.9	10.7702				998	2004.3	10.8786			
949	1901.0	10.7724				999	2006.4	10.8807			

TABLE I. - Continued. COMBUSTION-GAS VALUES OF ψ_h, ψ_e, ω, $c_{p,a}$, AND ψ_{c_p} FOR COMBUSTION OF HYDROGEN WITH AIR

[T = 600° to 2999° R]

T, °R	ψ_h, Btu/lb	ψ_e, Btu/(lb)(°R)	ω	$c_{p,a}$, Btu/(lb)(°R)	ψ_{c_p}, Btu/(lb)(°R)	T, °R	ψ_h, Btu/lb	ψ_e, Btu/(lb)(°R)	ω	$c_{p,a}$, Btu/(lb)(°R)	ψ_{c_p}, Btu/(lb)(°R)
1000	2008.6	10.8828	9.523	0.8486	2.118	1050	2115.1	10.9869	9.552	0.8500	2.138
1001	2010.7	10.8849				1051	2117.2	10.9889			
1002	2012.8	10.8870				1052	2119.3	10.9910			
1003	2014.9	10.8890				1053	2121.5	10.9930			
1004	2017.1	10.8911				1054	2123.6	10.9950			
1005	2019.2	10.8931	9.586	.2487	2.180	1055	2125.8	10.9971	9.555	.2508	2.140
1006	2021.3	10.8952				1056	2127.9	10.9991			
1007	2023.4	10.8973				1057	2130.0	11.0011			
1008	2025.6	10.8993				1058	2132.2	11.0031			
1009	2027.7	10.9014				1059	2134.3	11.0052			
1010	2029.8	10.9035	9.529	.2488	2.189	1060	2136.5	11.0072	9.558	.2503	2.148
1011	2031.9	10.9056				1061	2138.6	11.0092			
1012	2034.1	10.9076				1062	2140.7	11.0112			
1013	2036.2	10.9097				1063	2142.9	11.0132			
1014	2038.3	10.9118				1064	2145.0	11.0151			
1015	2040.4	10.9139	9.531	.2490	2.124	1065	2147.2	11.0171	9.561	.2505	2.144
1016	2042.6	10.9159				1066	2149.3	11.0191			
1017	2044.7	10.9180				1067	2151.5	11.0211			
1018	2046.8	10.9201				1068	2153.6	11.0231			
1019	2049.0	10.9222				1069	2155.7	11.0251			
1020	2051.1	10.9243	9.534	.2491	2.126	1070	2157.9	11.0271	9.564	.2506	2.147
1021	2053.2	10.9264				1071	2160.0	11.0290			
1022	2055.3	10.9285				1072	2162.2	11.0310			
1023	2057.5	10.9307				1073	2164.3	11.0330			
1024	2059.6	10.9328				1074	2166.5	11.0350			
1025	2061.7	10.9349	9.537	.2493	2.128	1075	2168.6	11.0370	9.567	.2508	2.149
1026	2063.9	10.9370				1076	2170.8	11.0390			
1027	2066.0	10.9391				1077	2172.9	11.0410			
1028	2068.1	10.9412				1078	2175.1	11.0429			
1029	2070.2	10.9433				1079	2177.2	11.0449			
1030	2072.4	10.9454	9.540	.2494	2.130	1080	2179.4	11.0469	9.570	.2509	2.151
1031	2074.5	10.9475				1081	2181.5	11.0489			
1032	2076.6	10.9496				1082	2183.7	11.0509			
1033	2078.8	10.9517				1083	2185.8	11.0528			
1034	2080.9	10.9538				1084	2188.0	11.0548			
1035	2083.0	10.9559	9.543	.2496	2.132	1085	2190.1	11.0568	9.573	.2511	2.153
1036	2085.2	10.9580				1086	2192.3	11.0588			
1037	2087.3	10.9601				1087	2194.4	11.0608			
1038	2089.4	10.9622				1088	2196.6	11.0627			
1039	2091.6	10.9643				1089	2198.7	11.0647			
1040	2093.7	10.9663	9.546	.2497	2.134	1090	2200.9	11.0667	9.577	.2513	2.155
1041	2095.8	10.9684				1091	2203.0	11.0687			
1042	2098.0	10.9705				1092	2205.2	11.0706			
1043	2100.1	10.9725				1093	2207.4	11.0726			
1044	2102.2	10.9746				1094	2209.5	11.0746			
1045	2104.4	10.9766	9.549	.2499	2.136	1095	2211.7	11.0766	9.580	.2514	2.157
1046	2106.5	10.9787				1096	2213.8	11.0785			
1047	2108.6	10.9808				1097	2216.0	11.0805			
1048	2110.8	10.9828				1098	2218.1	11.0825			
1049	2112.9	10.9848				1099	2220.3	11.0845			

TABLE I. - Continued. COMBUSTION-GAS VALUES OF ψ_h, ψ_φ, ω, $c_{p,a}$, AND ψ_{c_p} FOR COMBUSTION OF HYDROGEN WITH AIR

[T = 6000° to 29999° R]

T, °R	ψ_h, Btu/lb	ψ_φ, Btu/(lb)(°R)	ω	$c_{p,a}$, Btu/(lb)(°R)	ψ_{c_p}, Btu/(lb)(°R)	T, °R	ψ_h, Btu/lb	ψ_φ, Btu/(lb)(°R)	ω	$c_{p,a}$, Btu/(lb)(°R)	ψ_{c_p}, Btu/(lb)(°R)
1100	2822.5	11.0864	9.583	0.8516	2.159	1150	2330.9	11.1889	9.616	0.8531	2.181
1101	2824.6	11.0884				1151	2333.1	11.1848			
1102	2826.8	11.0904				1152	2335.3	11.1867			
1103	2828.9	11.0924				1153	2337.5	11.1886			
1104	2831.1	11.0944				1154	2339.6	11.1906			
1105	2833.3	11.0964	9.586	.8517	2.161	1155	2341.8	11.1926	9.619	.8538	2.183
1106	2835.4	11.0984				1156	2344.0	11.1944			
1107	2837.6	11.1004				1157	2346.2	11.1963			
1108	2839.7	11.1023				1158	2348.4	11.1982			
1109	2841.9	11.1043				1159	2350 6	11.2001			
1110	2844.1	11.1063	9.589	.8519	2.163	1160	2352.7	11.2020	9.623	.8534	2.185
1111	2846.2	11.1082				1161	2354.9	11.2039			
1112	2848.4	11.1102				1162	2357.1	11.2058			
1113	2850.6	11.1122				1163	2359.3	11.2078			
1114	2852.7	11.1141				1164	2361.5	11.2097			
1115	2854.9	11.1161	9.593	.8520	2.165	1165	2363.7	11.2116	9.626	.8536	2.187
1116	2857.0	11.1180				1166	2365.9	11.2135			
1117	2859.2	11.1200				1167	2368.0	11.2154			
1118	2861.4	11.1219				1168	2370.2	11.2173			
1119	2863.5	11.1238				1169	2372.4	11.2192			
1120	2865.7	11.1258	9.596	.8522	2.168	1170	2374.6	11.2211	9.630	.8537	2.190
1121	2867.9	11.1277				1171	2376.8	11.2230			
1122	2870.0	11.1296				1172	2379.0	11.2249			
1123	2872.2	11.1315				1173	2381.2	11.2268			
1124	2874.4	11.1333				1174	2383.4	11.2286			
1125	2876.5	11.1352	9.599	.8523	2.170	1175	2385.6	11.2305	9.634	.8539	2.192
1126	2878.7	11.1371				1176	2387.8	11.2324			
1127	2880.9	11.1390				1177	2390.0	11.2343			
1128	2883.0	11.1409				1178	2392.1	11.2361			
1129	2885.2	11.1428				1179	2394.3	11.2380			
1130	2887.4	11.1447	9.603	.8525	2.172	1180	2396.5	11.2398	9.637	.8540	2.194
1131	2889.6	11.1466				1181	2398.7	11.2416			
1132	2891.7	11.1485				1182	2400.9	11.2434			
1133	2893.9	11.1504				1183	2403.1	11.2453			
1134	2896.1	11.1523				1184	2405.3	11.2470			
1135	2898.2	11.1542	9.606	.8526	2.174	1185	2407.5	11.2487	9.641	.8542	2.196
1136	2900.4	11.1561				1186	2409.7	11.2505			
1137	2902.6	11.1580				1187	2411.9	11.2523			
1138	2904.8	11.1599				1188	2414.1	11.2541			
1139	2906.9	11.1618				1189	2416.3	11.2559			
1140	2909.1	11.1637	9.609	.8528	2.176	1190	2418.5	11.2578	9.645	.8543	2.199
1141	2911.3	11.1657				1191	2420.7	11.2596			
1142	2913.5	11.1676				1192	2422.9	11.2614			
1143	2915.7	11.1695				1193	2425.1	11.2632			
1144	2917.8	11.1714				1194	2427.3	11.2650			
1145	2920.0	11.1733	9.612	.8529	2.178	1195	2429.5	11.2668	9.649	.8545	2.201
1146	2922.2	11.1753				1196	2431.7	11.2686			
1147	2924.4	11.1772				1197	2433.9	11.2705			
1148	2926.6	11.1791				1198	2436.1	11.2723			
1149	2928.7	11.1810				1199	2438.3	11.2741			

TABLE I. - Continued. COMBUSTION-GAS VALUES OF Ψ_h, Ψ_ϕ, α, $c_{p,s}$, AND Ψ_{c_p} FOR COMBUSTION OF HYDROGEN WITH AIR

[T = 600° to 2998° R.]

T, °R	Ψ_h, Btu/lb	Ψ_ϕ, Btu/(lb)(°R)	α	$c_{p,s}$, Btu/(lb)(°R)	Ψ_{c_p}, Btu/(lb)(°R)	T, °R	Ψ_h, Btu/lb	Ψ_ϕ, Btu/(lb)(°R)	α	$c_{p,s}$, Btu/(lb)(°R)	Ψ_{c_p}, Btu/(lb)(°R)
1200	2440.6	11.2760	9.652	0.2547	2.203	1250	2551.2	11.3667	9.698	0.2563	2.287
1201	2442.8	11.2779				1251	2553.5	11.3684			
1202	2445.0	11.2797				1252	2555.7	11.3702			
1203	2447.2	11.2816				1253	2557.9	11.3719			
1204	2449.4	11.2835				1254	2560.2	11.3737			
1205	2451.6	11.2854	9.656	.2548	2.206	1255	2562.4	11.3754	9.696	.2564	2.290
1206	2453.8	11.2872				1256	2564.6	11.3772			
1207	2456.0	11.2891				1257	2566.8	11.3790			
1208	2458.2	11.2910				1258	2569.1	11.3807			
1209	2460.4	11.2928				1259	2571.3	11.3825			
1210	2462.6	11.2947	9.660	.2550	2.208	1260	2573.5	11.3843	9.701	.2566	2.292
1211	2464.8	11.2966				1261	2575.8	11.3861			
1212	2467.0	11.2984				1262	2578.0	11.3879			
1213	2469.2	11.3003				1263	2580.2	11.3896			
1214	2471.4	11.3021				1264	2582.5	11.3914			
1215	2473.6	11.3040	9.664	.2551	2.210	1265	2584.7	11.3932	9.705	.2567	2.295
1216	2475.9	11.3058				1266	2586.9	11.3950			
1217	2478.1	11.3077				1267	2589.2	11.3968			
1218	2480.3	11.3095				1268	2591.4	11.3986			
1219	2482.5	11.3113				1269	2593.6	11.4004			
1220	2484.7	11.3132	9.668	.2553	2.213	1270	2595.9	11.4021	9.709	.2569	2.297
1221	2486.9	11.3150				1271	2598.1	11.4039			
1222	2489.1	11.3168				1272	2600.4	11.4057			
1223	2491.3	11.3186				1273	2602.6	11.4075			
1224	2493.5	11.3204				1274	2604.8	11.4093			
1225	2495.7	11.3223	9.673	.2555	2.215	1275	2607.1	11.4110	9.713	.2571	2.300
1226	2498.0	11.3241				1276	2609.3	11.4128			
1227	2500.2	11.3259				1277	2611.6	11.4146			
1228	2502.4	11.3277				1278	2613.8	11.4164			
1229	2504.6	11.3295				1279	2616.0	11.4181			
1230	2506.8	11.3313	9.676	.2556	2.218	1280	2618.3	11.4199	9.718	.2573	2.302
1231	2509.0	11.3331				1281	2620.5	11.4217			
1232	2511.2	11.3349				1282	2622.8	11.4235			
1233	2513.5	11.3367				1283	2625.0	11.4253			
1234	2515.7	11.3385				1284	2627.2	11.4271			
1235	2517.9	11.3403	9.680	.2558	2.220	1285	2629.5	11.4288	9.722	.2574	2.305
1236	2520.1	11.3421				1286	2631.7	11.4306			
1237	2522.3	11.3438				1287	2634.0	11.4324			
1238	2524.6	11.3456				1288	2636.2	11.4342			
1239	2526.8	11.3474				1289	2638.5	11.4359			
1240	2529.0	11.3492	9.684	.2559	2.223	1290	2640.7	11.4377	9.727	.2575	2.307
1241	2531.2	11.3509				1291	2643.0	11.4394			
1242	2533.4	11.3527				1292	2645.2	11.4412			
1243	2535.7	11.3544				1293	2647.5	11.4429			
1244	2537.9	11.3562				1294	2649.7	11.4447			
1245	2540.1	11.3579	9.688	.2561	2.225	1295	2651.9	11.4464	9.731	.2577	2.310
1246	2542.3	11.3596				1296	2654.2	11.4482			
1247	2544.6	11.3614				1297	2656.4	11.4499			
1248	2546.8	11.3631				1298	2658.7	11.4516			
1249	2549.0	11.3649				1299	2660.9	11.4534			

TABLE I. - Continued. COMBUSTION-GAS VALUES OF ψ_h, ψ_φ, α, $c_{p,a}$, AND ψ_{c_p} FOR COMBUSTION OF HYDROGEN WITH AIR

[T = 600° to 2999° R]

T, °R	ψ_h, Btu/lb	ψ_φ, Btu/(lb)(°R)	α	$c_{p,a}$, Btu/(lb)(°R)	ψ_{c_p}, Btu/(lb)(°R)	T, °R	ψ_h, Btu/lb	ψ_φ, Btu/(lb)(°R)	α	$c_{p,a}$, Btu/(lb)(°R)	ψ_{c_p}, Btu/(lb)(°R)
1300	2663.2	11.4551	9.735	0.2579	2.283	1350	2776.4	11.5403	9.781	0.2595	2.278
1301	2665.5	11.4568				1351	2778.7	11.5420			
1302	2667.7	11.4584				1352	2781.0	11.5437			
1303	2670.0	11.4601				1353	2783.2	11.5454			
1304	2672.2	11.4618				1354	2785.5	11.5471			
1305	2674.5	11.4635	9.740	.2580	2.285	1355	2787.8	11.5488	9.786	.2596	2.281
1306	2676.7	11.4652				1356	2790.1	11.5505			
1307	2679.0	11.4668				1357	2792.4	11.5522			
1308	2681.2	11.4685				1358	2794.7	11.5539			
1309	2683.5	11.4702				1359	2796.9	11.5556			
1310	2685.8	11.4719	9.744	.2582	2.258	1360	2799.2	11.5573	9.791	.2598	2.284
1311	2688.0	11.4736				1361	2801.5	11.5590			
1312	2690.3	11.4753				1362	2803.8	11.5607			
1313	2692.5	11.4770				1363	2806.1	11.5624			
1314	2694.8	11.4787				1364	2808.4	11.5641			
1315	2697.1	11.4804	9.749	.2583	2.260	1365	2810.6	11.5658	9.796	.2599	2.287
1316	2699.3	11.4820				1366	2812.9	11.5674			
1317	2701.6	11.4837				1367	2815.2	11.5691			
1318	2703.8	11.4854				1368	2817.5	11.5708			
1319	2706.1	11.4871				1369	2819.8	11.5725			
1320	2708.4	11.4888	9.753	.2585	2.263	1370	2822.1	11.5742	9.801	.2601	2.289
1321	2710.6	11.4906				1371	2824.4	11.5759			
1322	2712.9	11.4923				1372	2826.7	11.5776			
1323	2715.1	11.4940				1373	2828.9	11.5792			
1324	2717.4	11.4957				1374	2831.2	11.5809			
1325	2719.6	11.4974	9.758	.2587	2.268	1375	2833.5	11.5826	9.806	.2603	2.292
1326	2721.9	11.4992				1376	2835.8	11.5842			
1327	2724.2	11.5009				1377	2838.1	11.5859			
1328	2726.4	11.5026				1378	2840.4	11.5876			
1329	2728.7	11.5043				1379	2842.7	11.5892			
1330	2731.0	11.5060	9.768	.2588	2.268	1380	2845.0	11.5909	9.811	.2604	2.298
1331	2733.2	11.5077				1381	2847.3	11.5925			
1332	2735.5	11.5094				1382	2849.6	11.5942			
1333	2737.8	11.5110				1383	2851.9	11.5958			
1334	2740.0	11.5129				1384	2854.2	11.5974			
1335	2742.3	11.5146	9.767	.2590	2.271	1385	2856.5	11.5990	9.816	.2606	2.297
1336	2744.6	11.5163				1386	2858.8	11.6007			
1337	2746.8	11.5180				1387	2861.1	11.6023			
1338	2749.1	11.5197				1388	2863.4	11.6039			
1339	2751.4	11.5214				1389	2865.7	11.6056			
1340	2753.6	11.5231	9.772	.2591	2.273	1390	2868.0	11.6072	9.821	.2607	2.300
1341	2755.9	11.5249				1391	2870.3	11.6088			
1342	2758.2	11.5266				1392	2872.6	11.6105			
1343	2760.5	11.5283				1393	2874.9	11.6121			
1344	2762.7	11.5300				1394	2877.2	11.6138			
1345	2765.0	11.5317	9.777	.2593	2.276	1395	2879.5	11.6154	9.827	.2609	2.303
1346	2767.3	11.5334				1396	2881.8	11.6170			
1347	2769.6	11.5351				1397	2884.1	11.6187			
1348	2771.9	11.5368				1398	2886.4	11.6803			
1349	2774.1	11.5386				1399	2888.7	11.6220			

TABLE I. - Continued. COMBUSTION-GAS VALUES OF ψ_h, ψ_e, ϵ, $c_{p,a}$, AND ψ_{c_p} FOR COMBUSTION OF HYDROGEN WITH AIR

[T = 600° to 2999° R]

T, °R	ψ_h, Btu/lb	ψ_e, Btu/(lb)(°R)	ϵ	$c_{p,a}$, Btu/(lb)(°R)	ψ_{c_p}, Btu/(lb)(°R)	T, °R	ψ_h, Btu/lb	ψ_e, Btu/(lb)(°R)	ϵ	$c_{p,a}$, Btu/(lb)(°R)	ψ_{c_p}, Btu/(lb)(°R)
1400	2891.0	11.6236	9.832	0.2611	2.306	1450	3006.9	11.7052	9.887	0.2624	2.334
1401	2893.3	11.6253				1451	3009.3	11.7068			
1402	2895.6	11.6269				1452	3011.6	11.7084			
1403	2897.9	11.6286				1453	3013.9	11.7100			
1404	2900.2	11.6303				1454	3016.3	11.7116			
1405	2902.5	11.6319	9.837	.2612	2.308	1455	3018.6	11.7132	9.893	.2628	2.337
1406	2904.8	11.6336				1456	3020.9	11.7148			
1407	2907.1	11.6352				1457	3023.3	11.7164			
1408	2909.4	11.6369				1458	3025.6	11.7180			
1409	2911.7	11.6385				1459	3028.0	11.7196			
1410	2914.1	11.6402	9.843	.2614	2.311	1460	3030.3	11.7212	9.899	.2629	2.340
1411	2916.4	11.6418				1461	3032.6	11.7228			
1412	2918.7	11.6435				1462	3035.0	11.7244			
1413	2921.0	11.6451				1463	3037.3	11.7260			
1414	2923.3	11.6468				1464	3039.6	11.7275			
1415	2925.6	11.6484	9.848	.2615	2.314	1465	3042.0	11.7291	9.905	.2631	2.343
1416	2927.9	11.6501				1466	3044.3	11.7307			
1417	2930.2	11.6517				1467	3046.7	11.7323			
1418	2932.6	11.6533				1468	3049.0	11.7339			
1419	2934.9	11.6550				1469	3051.4	11.7354			
1420	2937.2	11.6566	9.854	.2617	2.317	1470	3053.7	11.7370	9.910	.2632	2.346
1421	2939.5	11.6582				1471	3056.0	11.7386			
1422	2941.8	11.6598				1472	3058.4	11.7402			
1423	2944.1	11.6614				1473	3060.7	11.7418			
1424	2946.4	11.6631				1474	3063.1	11.7434			
1425	2948.8	11.6647	9.859	.2618	2.320	1475	3065.4	11.7449	9.916	.2634	2.349
1426	2951.1	11.6663				1476	3067.8	11.7465			
1427	2953.4	11.6679				1477	3070.1	11.7481			
1428	2955.7	11.6695				1478	3072.5	11.7497			
1429	2958.0	11.6711				1479	3074.8	11.7513			
1430	2960.4	11.6727	9.865	.2620	2.323	1480	3077.2	11.7529	9.922	.2635	2.352
1431	2962.7	11.6744				1481	3079.5	11.7545			
1432	2965.0	11.6760				1482	3081.9	11.7561			
1433	2967.3	11.6776				1483	3084.2	11.7577			
1434	2969.6	11.6792				1484	3086.6	11.7593			
1435	2972.0	11.6808	9.870	.2622	2.325	1485	3088.9	11.7609	9.928	.2637	2.354
1436	2974.3	11.6824				1486	3091.3	11.7625			
1437	2976.6	11.6841				1487	3093.6	11.7641			
1438	2978.9	11.6857				1488	3096.0	11.7657			
1439	2981.3	11.6873				1489	3098.3	11.7673			
1440	2983.6	11.6889	9.876	.2623	2.328	1490	3100.7	11.7689	9.934	.2638	2.357
1441	2985.9	11.6905				1491	3103.0	11.7705			
1442	2988.3	11.6922				1492	3105.4	11.7721			
1443	2990.6	11.6938				1493	3107.8	11.7737			
1444	2992.9	11.6954				1494	3110.1	11.7753			
1445	2995.3	11.6970	9.881	.2625	2.331	1495	3112.5	11.7769	9.940	.2640	2.360
1446	2997.6	11.6987				1496	3114.8	11.7785			
1447	2999.9	11.7003				1497	3117.2	11.7800			
1448	3002.3	11.7019				1498	3119.5	11.7816			
1449	3004.6	11.7035				1499	3121.9	11.7832			

TABLE I. - Continued. COMBUSTION-GAS VALUES OF ψ_h, ψ_ϕ, α, $c_{p,a}$, AND ψ_{c_p} FOR COMBUSTION OF HYDROGEN WITH AIR

[T = 500° to 2999° R]

T, °R	ψ_h, Btu/lb	ψ_ϕ, Btu/(lb)(°R)	α	$c_{p,a}$, Btu/(lb)(°R)	ψ_{c_p}, Btu/(lb)(°R)	T, °R	ψ_h, Btu/lb	ψ_ϕ, Btu/(lb)(°R)	α	$c_{p,a}$, Btu/(lb)(°R)	ψ_{c_p}, Btu/(lb)(°R)
1500	3184.3	11.7848	9.946	0.8648	2.363	1550	3843.1	11.8629	10.009	0.8656	2.393
1501	3186.6	11.7864				1551	3845.5	11.8645			
1502	3189.0	11.7880				1552	3847.9	11.8660			
1503	3191.4	11.7895				1553	3850.3	11.8675			
1504	3193.7	11.7911				1554	3852.7	11.8691			
1505	3196.1	11.7927	9.953	.8643	2.366	1555	3855.1	11.8706	10.016	.8658	2.396
1506	3198.4	11.7943				1556	3857.5	11.8722			
1507	3140.8	11.7958				1557	3859.9	11.8737			
1508	3143.2	11.7974				1558	3862.3	11.8752			
1509	3145.5	11.7990				1559	3864.7	11.8768			
1510	3147.9	11.8006	9.959	.8644	2.369	1560	3867.1	11.8783	10.022	.8659	2.399
1511	3150.3	11.8021				1561	3869.5	11.8799			
1512	3152.7	11.8037				1562	3871.9	11.8814			
1513	3155.0	11.8053				1563	3874.3	11.8830			
1514	3157.4	11.8068				1564	3876.7	11.8845			
1515	3159.8	11.8084	9.965	.8646	2.378	1565	3879.1	11.8861	10.029	.8661	2.402
1516	3162.1	11.8100				1566	3881.5	11.8876			
1517	3164.5	11.8116				1567	3883.9	11.8891			
1518	3166.9	11.8131				1568	3886.3	11.8907			
1519	3169.2	11.8147				1569	3888.7	11.8922			
1520	3171.6	11.8163	9.971	.8647	2.375	1570	3891.1	11.8938	10.036	.8662	2.405
1521	3174.0	11.8178				1571	3893.5	11.8953			
1522	3176.4	11.8194				1572	3896.0	11.8969			
1523	3178.7	11.8210				1573	3898.4	11.8984			
1524	3181.1	11.8225				1574	3900.8	11.8999			
1525	3183.5	11.8241	9.977	.8649	2.378	1575	3903.2	11.9015	10.042	.8663	2.408
1526	3185.9	11.8257				1576	3905.6	11.9030			
1527	3188.2	11.8273				1577	3908.0	11.9046			
1528	3190.6	11.8288				1578	3910.4	11.9061			
1529	3193.0	11.8304				1579	3912.8	11.9076			
1530	3195.4	11.8319	9.984	.8650	2.381	1580	3915.2	11.9092	10.049	.8665	2.411
1531	3197.7	11.8335				1581	3917.6	11.9107			
1532	3200.1	11.8351				1582	3920.0	11.9123			
1533	3202.5	11.8366				1583	3922.4	11.9138			
1534	3204.9	11.8382				1584	3924.8	11.9154			
1535	3207.3	11.8397	9.990	.8652	2.384	1585	3927.2	11.9169	10.056	.8666	2.415
1536	3209.7	11.8413				1586	3929.7	11.9185			
1537	3212.0	11.8429				1587	3932.1	11.9200			
1538	3214.4	11.8444				1588	3934.5	11.9216			
1539	3216.8	11.8460				1589	3936.9	11.9231			
1540	3219.2	11.8475	9.996	.8653	2.387	1590	3939.3	11.9246	10.062	.8668	2.418
1541	3221.6	11.8491				1591	3941.7	11.9262			
1542	3224.0	11.8506				1592	3944.1	11.9277			
1543	3226.4	11.8521				1593	3946.5	11.9292			
1544	3228.8	11.8537				1594	3949.0	11.9307			
1545	3231.2	11.8552	10.003	.8655	2.390	1595	3951.4	11.9322	10.069	.8669	2.421
1546	3233.5	11.8568				1596	3953.8	11.9338			
1547	3235.9	11.8583				1597	3956.2	11.9353			
1548	3238.3	11.8598				1598	3958.6	11.9368			
1549	3240.7	11.8614				1599	3961.0	11.9383			

TABLE I. - Continued. COMBUSTION-GAS VALUES OF ψ_h, ψ_s, ω, $c_{p,a}$, AND ψ_{c_p} FOR COMBUSTION OF HYDROGEN WITH AIR

[T = 800° to 2999° R]

T, °R	ψ_h, Btu/lb	ψ_s, Btu/(lb)(°R)	ω	$c_{p,a}$, Btu/(lb)(°R)	ψ_{c_p}, Btu/(lb)(°R)	T, °R	ψ_h, Btu/lb	ψ_s, Btu/(lb)(°R)	ω	$c_{p,a}$, Btu/(lb)(°R)	ψ_{c_p}, Btu/(lb)(°R)
1600	3363.5	11.9398	10.076	0.8671	2.484	1650	3485.4	12.0145	10.148	0.8684	2.455
1601	3365.9	11.9412				1651	3487.9	12.0160			
1602	3368.3	11.9427				1652	3490.3	12.0176			
1603	3370.7	11.9441				1653	3492.8	12.0191			
1604	3373.2	11.9456				1654	3495.2	12.0206			
1605	3375.6	11.9471	10.083	.8678	2.487	1655	3497.7	12.0221	10.155	.8685	2.459
1606	3378.0	11.9485				1656	3500.1	12.0236			
1607	3380.5	11.9500				1657	3502.6	12.0251			
1608	3382.9	11.9515				1658	3505.1	12.0266			
1609	3385.3	11.9529				1659	3507.5	12.0281			
1610	3387.7	11.9544	10.090	.8673	2.480	1660	3510.0	12.0296	10.163	.8687	2.468
1611	3390.2	11.9559				1661	3512.4	12.0312			
1612	3392.6	11.9573				1662	3514.9	12.0327			
1613	3395.0	11.9588				1663	3517.4	12.0342			
1614	3397.5	11.9603				1664	3519.8	12.0357			
1615	3399.9	11.9618	10.098	.8675	2.473	1665	3522.3	12.0373	10.170	.8688	2.465
1616	3402.3	11.9633				1666	3524.7	12.0388			
1617	3404.8	11.9647				1667	3527.2	12.0403			
1618	3407.2	11.9662				1668	3529.7	12.0418			
1619	3409.6	11.9677				1669	3532.1	12.0433			
1620	3412.1	11.9692	10.105	.8676	2.436	1670	3534.6	12.0448	10.177	.8689	2.468
1621	3414.5	11.9707				1671	3537.1	12.0463			
1622	3416.9	11.9722				1672	3539.5	12.0478			
1623	3419.4	11.9737				1673	3542.0	12.0493			
1624	3421.8	11.9752				1674	3544.5	12.0508			
1625	3424.2	11.9767	10.112	.8677	2.440	1675	3546.9	12.0523	10.185	.8691	2.471
1626	3426.7	11.9783				1676	3549.4	12.0537			
1627	3429.1	11.9798				1677	3551.9	12.0552			
1628	3431.5	11.9813				1678	3554.4	12.0567			
1629	3434.0	11.9828				1679	3556.8	12.0582			
1630	3436.4	11.9843	10.119	.8679	2.443	1680	3559.3	12.0596	10.192	.8692	2.475
1631	3438.8	11.9858				1681	3561.8	12.0610			
1632	3441.3	11.9873				1682	3564.2	12.0624			
1633	3443.7	11.9888				1683	3566.7	12.0639			
1634	3446.2	11.9903				1684	3569.2	12.0653			
1635	3448.6	11.9918	10.126	.8680	2.446	1685	3571.7	12.0667	10.199	.8693	2.478
1636	3451.1	11.9933				1686	3574.2	12.0681			
1637	3453.5	11.9949				1687	3576.6	12.0695			
1638	3455.9	11.9964				1688	3579.1	12.0710			
1639	3458.4	11.9979				1689	3581.6	12.0724			
1640	3460.8	11.9994	10.134	.8681	2.449	1690	3584.1	12.0738	10.207	.8695	2.481
1641	3463.3	12.0009				1691	3586.6	12.0752			
1642	3465.8	12.0024				1692	3589.0	12.0767			
1643	3468.2	12.0039				1693	3591.5	12.0781			
1644	3470.7	12.0055				1694	3594.0	12.0795			
1645	3473.1	12.0070	10.141	.8683	2.452	1695	3596.5	12.0810	10.214	.8696	2.484
1646	3475.6	12.0085				1696	3599.0	12.0824			
1647	3478.0	12.0100				1697	3601.5	12.0839			
1648	3480.5	12.0115				1698	3603.9	12.0853			
1649	3483.9	12.0130				1699	3606.4	12.0867			

TABLE I. - Continued. COMBUSTION-GAS VALUES OF ψ_h, ψ_e, ω, $c_{p,a}$, AND ψ_{c_p} FOR COMBUSTION OF HYDROGEN WITH AIR

[T = 600° to 2999° R]

T, °R	ψ_h, Btu/lb	ψ_e, Btu/(lb)(°R)	ω	$c_{p,a}$, Btu/(lb)(°R)	ψ_{c_p}, Btu/(lb)(°R)	T, °R	ψ_h, Btu/lb	ψ_e, Btu/(lb)(°R)	ω	$c_{p,a}$, Btu/(lb)(°R)	ψ_{c_p}, Btu/(lb)(°R)
1700	3608.9	12.0888	10.282	0.2698	2.488	1750	3734.0	12.1603	10.296	0.2711	2.521
1701	3611.4	12.0897				1751	3736.5	12.1618			
1708	3613.9	12.0911				1758	3739.0	12.1633			
1703	3616.4	12.0926				1753	3741.5	12.1648			
1704	3618.9	12.0941				1754	3744.0	12.1664			
1705	3681.3	12.0955	10.289	.2699	2.491	1755	3746.6	12.1679	10.304	.2713	2.554
1706	3623.8	12.0970				1756	3749.1	12.1695			
1707	3626.3	12.0985				1757	3751.6	12.1711			
1708	3628.8	12.0999				1758	3754.1	12.1727			
1709	3631.3	12.1014				1759	3756.7	12.1744			
1710	3633.8	12.1029	10.296	.2700	2.494	1760	3759.2	12.1760	10.312	.2714	2.587
1711	3636.3	12.1043				1761	3761.7	12.1778			
1718	3638.8	12.1058				1762	3764.3	12.1785			
1713	3641.3	12.1073				1763	3766.8	12.1797			
1714	3643.8	12.1087				1764	3769.3	12.1810			
1715	3646.3	12.1108	10.244	.2702	2.497	1765	3771.9	12.1823	10.319	.2715	2.531
1716	3648.8	12.1117				1766	3774.4	12.1836			
1717	3651.2	12.1131				1767	3776.9	12.1849			
1718	3653.7	12.1146				1768	3779.5	12.1863			
1719	3656.2	12.1161				1769	3782.0	12.1877			
1720	3658.7	12.1175	10.251	.2703	2.501	1770	3784.5	12.1891	10.327	.2717	2.534
1721	3661.2	12.1190				1771	3787.1	12.1905			
1722	3663.7	12.1204				1772	3789.6	12.1919			
1723	3666.2	12.1219				1773	3792.1	12.1934			
1724	3668.7	12.1233				1774	3794.7	12.1949			
1725	3671.2	12.1248	10.259	.2704	2.504	1775	3797.2	12.1964	10.335	.2718	2.537
1726	3673.7	12.1262				1776	3799.8	12.1979			
1727	3676.2	12.1277				1777	3802.3	12.1995			
1728	3678.7	12.1291				1778	3804.8	12.2010			
1729	3681.2	12.1306				1779	3807.4	12.2026			
1730	3683.8	12.1320	10.266	.2706	2.507	1780	3809.9	12.2042	10.348	.2719	2.541
1731	3686.3	12.1335				1781	3812.5	12.2056			
1732	3688.8	12.1349				1782	3815.0	12.2071			
1733	3691.3	12.1364				1783	3817.5	12.2085			
1734	3693.8	12.1379				1784	3820.1	12.2099			
1735	3696.3	12.1393	10.274	.2707	2.511	1785	3822.6	12.2113	10.350	.2721	2.544
1736	3698.8	12.1408				1786	3825.2	12.2128			
1737	3701.3	12.1422				1787	3827.7	12.2142			
1738	3703.8	12.1437				1788	3830.2	12.2156			
1739	3706.3	12.1452				1789	3832.8	12.2170			
1740	3708.8	12.1466	10.281	.2709	2.514	1790	3835.3	12.2185	10.358	.2722	2.547
1741	3711.3	12.1479				1791	3837.9	12.2199			
1742	3713.9	12.1493				1792	3840.4	12.2213			
1743	3716.4	12.1508				1793	3843.0	12.2227			
1744	3718.9	12.1519				1794	3845.5	12.2241			
1745	3721.4	12.1538	10.289	.2710	2.517	1795	3848.1	12.2256	10.366	.2723	2.581
1746	3723.9	12.1546				1796	3850.6	12.2270			
1747	3726.4	12.1560				1797	3853.2	12.2284			
1748	3728.9	12.1574				1798	3855.7	12.2298			
1749	3731.5	12.1589				1799	3858.3	12.2312			

TABLE I. - Continued. COMBUSTION-GAS VALUES OF ψ_h, ψ_φ, α, $c_{p,a}$, AND ψ_{c_p} FOR COMBUSTION OF HYDROGEN WITH AIR

[T = 600° to 2999° R]

T, °R	ψ_h, Btu/lb	ψ_φ, Btu/(lb)(°R)	α	$c_{p,a}$, Btu/(lb)(°R)	ψ_{c_p}, Btu/(lb)(°R)	T, °R	ψ_h, Btu/lb	ψ_φ, Btu/(lb)(°R)	α	$c_{p,a}$, Btu/(lb)(°R)	ψ_{c_p}, Btu/(lb)(°R)
1800	3860.8	12.8337	10.373	0.2735	2.554	1850	3989.8	12.3030	10.453	0.2737	2.588
1801	3863.4	12.8341				1851	3991.8	12.3044			
1802	3865.9	12.8355				1852	3994.4	12.3058			
1803	3868.5	12.8369				1853	3997.0	12.3072			
1804	3871.0	12.8383				1854	3999.6	12.3086			
1805	3873.6	12.8397	10.381	.2726	2.557	1855	4002.1	12.3100	10.461	.2738	2.591
1806	3876.2	12.8411				1856	4004.7	12.3115			
1807	3878.7	12.8425				1857	4007.3	12.3129			
1808	3881.3	12.8439				1858	4009.9	12.3143			
1809	3883.8	12.8454				1859	4012.5	12.3158			
1810	3886.4	12.8468	10.389	.2727	2.561	1860	4015.1	12.3172	10.469	.2740	2.594
1811	3889.0	12.8482				1861	4017.7	12.3186			
1812	3891.5	12.8496				1862	4020.3	12.3200			
1813	3894.1	12.8510				1863	4022.9	12.3213			
1814	3896.6	12.8524				1864	4025.5	12.3227			
1815	3899.2	12.8538	10.397	.2728	2.564	1865	4028.0	12.3241	10.477	.2741	2.598
1816	3901.8	12.8552				1866	4030.6	12.3255			
1817	3904.3	12.8567				1867	4033.2	12.3269			
1818	3906.9	12.8581				1868	4035.8	12.3282			
1819	3909.5	12.8595				1869	4038.4	12.3296			
1820	3912.0	12.8609	10.405	.2730	2.567	1870	4041.0	12.3310	10.485	.2742	2.601
1821	3914.6	12.8623				1871	4043.6	12.3324			
1822	3917.1	12.8637				1872	4046.2	12.3338			
1823	3919.7	12.8651				1873	4048.8	12.3352			
1824	3922.3	12.8666				1874	4051.4	12.3366			
1825	3924.8	12.8680	10.413	.2731	2.571	1875	4054.0	12.3380	10.493	.2743	2.604
1826	3927.4	12.8694				1876	4056.6	12.3394			
1827	3930.0	12.8708				1877	4059.2	12.3408			
1828	3932.5	12.8722				1878	4061.8	12.3422			
1829	3935.1	12.8736				1879	4064.4	12.3436			
1830	3937.7	12.8751	10.421	.2732	2.574	1880	4067.0	12.3450	10.501	.2745	2.608
1831	3940.2	12.8765				1881	4069.7	12.3464			
1832	3942.8	12.8779				1882	4072.3	12.3478			
1833	3945.4	12.8793				1883	4074.9	12.3491			
1834	3947.9	12.8807				1884	4077.5	12.3505			
1835	3950.5	12.8821	10.429	.2733	2.577	1885	4080.1	12.3519	10.509	.2746	2.611
1836	3953.1	12.8835				1886	4082.7	12.3533			
1837	3955.7	12.8849				1887	4085.3	12.3546			
1838	3958.2	12.8863				1888	4087.9	12.3560			
1839	3960.8	12.8877				1889	4090.5	12.3574			
1840	3963.4	12.8892	10.437	.2735	2.581	1890	4093.2	12.3588	10.517	.2747	2.615
1841	3966.0	12.8905				1891	4095.8	12.3602			
1842	3968.5	12.8919				1892	4098.4	12.3615			
1843	3971.1	12.8932				1893	4101.0	12.3629			
1844	3973.7	12.8946				1894	4103.6	12.3643			
1845	3976.3	12.8960	10.445	.2736	2.584	1895	4106.2	12.3657	10.525	.2748	2.618
1846	3978.9	12.8974				1896	4108.8	12.3671			
1847	3981.5	12.8988				1897	4111.5	12.3685			
1848	3984.0	12.9002				1898	4114.1	12.3698			
1849	3986.6	12.9016				1899	4116.7	12.3712			

TABLE I. - Continued. COMBUSTION-GAS VALUES OF ψ_h, ψ_s, s, $c_{p,s}$, AND ψ_{c_p} FOR COMBUSTION OF HYDROGEN WITH AIR

[T = 800° to 2999° R]

T, °R	ψ_h, Btu/lb	ψ_s, Btu/(lb)(°R)	s	$c_{p,s}$, Btu/(lb)(°R)	ψ_{c_p}, Btu/(lb)(°R)	T, °R	ψ_h, Btu/lb	ψ_s, Btu/(lb)(°R)	s	$c_{p,s}$, Btu/(lb)(°R)	ψ_{c_p}, Btu/(lb)(°R)
1900	4119.3	12.3726	10.533	0.8750	8.681	1950	4851.1	12.4414	10.615	0.8761	8.685
1901	4121.9	12.3740				1951	4853.8	12.4428			
1902	4124.6	12.3754				1952	4856.4	12.4442			
1903	4127.2	12.3768				1953	4859.1	12.4458			
1904	4129.8	12.3782				1954	4861.7	12.4469			
1905	4138.4	12.3797	10.542	.8761	8.685	1955	4864.4	12.4483	10.623	.8768	8.658
1906	4135.1	12.3811				1956	4867.1	12.4496			
1907	4137.7	12.3825				1957	4869.7	12.4510			
1908	4140.3	12.3839				1958	4872.4	12.4523			
1909	4142.9	12.3852				1959	4875.0	12.4537			
1910	4145.6	12.3866	10.550	.8759	8.688	1960	4877.7	12.4551	10.631	.8764	8.662
1911	4148.2	12.3880				1961	4880.4	12.4564			
1912	4150.8	12.3894				1962	4883.0	12.4578			
1913	4153.4	12.3908				1963	4885.7	12.4591			
1914	4156.1	12.3922				1964	4888.3	12.4604			
1915	4158.7	12.3936	10.558	.8753	8.691	1965	4891.0	12.4618	10.640	.8765	8.665
1916	4161.3	12.3950				1966	4893.7	12.4631			
1917	4164.0	12.3964				1967	4896.3	12.4645			
1918	4166.6	12.3977				1968	4899.0	12.4658			
1919	4169.2	12.3991				1969	4901.6	12.4672			
1920	4171.8	12.4005	10.566	.8754	8.695	1970	4904.3	12.4685	10.648	.8766	8.669
1921	4174.5	12.4018				1971	4907.0	12.4699			
1922	4177.1	12.4032				1972	4909.6	12.4712			
1923	4179.7	12.4045				1973	4912.3	12.4726			
1924	4182.4	12.4059				1974	4915.0	12.4739			
1925	4185.0	12.4073	10.574	.8755	8.698	1975	4917.6	12.4753	10.656	.8767	8.672
1926	4187.6	12.4086				1976	4920.3	12.4766			
1927	4190.3	12.4100				1977	4923.0	12.4780			
1928	4192.9	12.4113				1978	4925.7	12.4793			
1929	4195.5	12.4127				1979	4928.3	12.4807			
1930	4198.2	12.4140	10.582	.8757	8.648	1980	4931.0	12.4820	10.664	.8768	8.676
1931	4800.8	12.4154				1981	4933.7	12.4834			
1932	4803.4	12.4167				1982	4936.3	12.4848			
1933	4806.1	12.4181				1983	4939.0	12.4861			
1934	4808.7	12.4195				1984	4941.7	12.4875			
1935	4811.4	12.4208	10.590	.8758	8.645	1985	4944.4	12.4888	10.673	.8769	8.679
1936	4814.0	12.4222				1986	4947.1	12.4902			
1937	4816.7	12.4235				1987	4949.7	12.4916			
1938	4819.3	12.4249				1988	4952.4	12.4929			
1939	4821.9	12.4263				1989	4955.1	12.4943			
1940	4824.6	12.4276	10.599	.8759	8.648	1990	4957.8	12.4957	10.681	.8770	8.682
1941	4827.2	12.4290				1991	4960.5	12.4970			
1942	4829.9	12.4304				1992	4963.2	12.4984			
1943	4832.5	12.4318				1993	4965.8	12.4997			
1944	4835.2	12.4332				1994	4968.5	12.5011			
1945	4837.8	12.4345	10.607	.8760	8.652	1995	4971.2	12.5025	10.689	.8771	8.685
1946	4840.5	12.4359				1996	4973.9	12.5038			
1947	4843.2	12.4373				1997	4976.6	12.5052			
1948	4845.8	12.4387				1998	4979.3	12.5065			
1949	4848.5	12.4400				1999	4981.9	12.5079			

TABLE I. - Continued. COMBUSTION-GAS VALUES OF ψ_h, ψ_ϕ, ω, $c_{p,a}$, AND ψ_{c_p} FOR COMBUSTION OF HYDROGEN WITH AIR

[T = 600° to 2999° R.]

T, °R	ψ_h, Btu/lb	ψ_ϕ, Btu/(lb)(°R)	ω	$c_{p,a}$, Btu/(lb)(°R)	ψ_{c_p}, Btu/(lb)(°R)	T, °R	ψ_h, Btu/lb	ψ_ϕ, Btu/(lb)(°R)	ω	$c_{p,a}$, Btu/(lb)(°R)	ψ_{c_p}, Btu/(lb)(°R)
2000	4384.6	12.5092	10.697	0.2773	2.689	3050	4519.7	12.5759	10.781	0.2783	2.728
2001	4387.3	12.5106				3051	4522.4	12.5773			
2002	4390.0	12.5120				3052	4525.2	12.5786			
2003	4392.7	12.5133				3053	4527.9	12.5799			
2004	4395.4	12.5147				3054	4530.6	12.5813			
2005	4398.1	12.5161	10.706	.2774	2.698	3055	4533.3	12.5826	10.789	.2784	2.726
2006	4400.8	12.5174				3056	4536.0	12.5840			
2007	4403.4	12.5188				3057	4538.8	12.5853			
2008	4406.1	12.5201				3058	4541.5	12.5866			
2009	4408.8	12.5215				3059	4544.2	12.5880			
2010	4411.5	12.5228	10.714	.2775	2.695	3060	4546.9	12.5893	10.798	.2785	2.729
2011	4414.2	12.5242				3061	4549.7	12.5907			
2012	4416.9	12.5255				3062	4552.4	12.5920			
2013	4419.6	12.5269				3063	4555.1	12.5934			
2014	4422.3	12.5282				3064	4557.9	12.5947			
2015	4425.0	12.5296	10.722	.2776	2.699	3065	4560.6	12.5961	10.806	.2786	2.732
2016	4427.7	12.5309				3066	4563.3	12.5974			
2017	4430.4	12.5322				3067	4566.1	12.5988			
2018	4433.1	12.5336				3068	4568.8	12.6001			
2019	4435.8	12.5349				3069	4571.5	12.6014			
2020	4438.5	12.5362	10.731	.2777	2.708	3070	4574.3	12.6028	10.814	.2787	2.736
2021	4441.2	12.5375				3071	4577.0	12.6041			
2022	4443.9	12.5388				3072	4579.7	12.6055			
2023	4446.6	12.5401				3073	4582.5	12.6068			
2024	4449.3	12.5415				3074	4585.2	12.6081			
2025	4452.0	12.5428	10.739	.2778	2.706	3075	4587.9	12.6095	10.823	.2788	2.739
2026	4454.7	12.5441				3076	4590.7	12.6108			
2027	4457.4	12.5454				3077	4593.4	12.6121			
2028	4460.1	12.5467				3078	4596.2	12.6135			
2029	4462.8	12.5480				3079	4598.9	12.6148			
2030	4465.5	12.5493	10.748	.2779	2.709	3080	4601.6	12.6161	10.831	.2789	2.742
2031	4468.2	12.5506				3081	4604.4	12.6175			
2032	4470.9	12.5519				3082	4607.1	12.6188			
2033	4473.6	12.5533				3083	4609.9	12.6201			
2034	4476.3	12.5546				3084	4612.6	12.6214			
2035	4479.0	12.5559	10.756	.2780	2.712	3085	4615.4	12.6227	10.840	.2790	2.746
2036	4481.8	12.5572				3086	4618.1	12.6240			
2037	4484.5	12.5585				3087	4620.9	12.6254			
2038	4487.2	12.5599				3088	4623.6	12.6267			
2039	4489.9	12.5618				3089	4626.4	12.6280			
2040	4492.6	12.5625	10.764	.2781	2.716	3090	4629.1	12.6293	10.848	.2791	2.749
2041	4495.3	12.5639				3091	4631.9	12.6306			
2042	4498.0	12.5652				3092	4634.6	12.6319			
2043	4500.7	12.5665				3093	4637.4	12.6333			
2044	4503.4	12.5679				3094	4640.1	12.6346			
2045	4506.2	12.5698	10.773	.2783	2.719	3095	4642.9	12.6359	10.856	.2792	2.752
2046	4508.9	12.5706				3096	4645.6	12.6372			
2047	4511.6	12.5719				3097	4648.4	12.6385			
2048	4514.3	12.5732				3098	4651.1	12.6398			
2049	4517.0	12.5746				3099	4653.9	12.6418			

TABLE I. - Continued. COMBUSTION-GAS VALUES OF ψ_h, ψ_ϕ, σ, $c_{p,s}$, AND ψ_{c_p} FOR COMBUSTION OF HYDROGEN WITH AIR

[T = 500° to 2998° R]

T, °R	ψ_h, Btu/lb	ψ_ϕ, Btu/(lb)(°R)	σ	$c_{p,s}$, Btu/(lb)(°R)	ψ_{c_p}, Btu/(lb)(°R)	T, °R	ψ_h, Btu/lb	ψ_ϕ, Btu/(lb)(°R)	σ	$c_{p,s}$, Btu/(lb)(°R)	ψ_{c_p}, Btu/(lb)(°R)
2100	4656.6	12.6425	10.865	0.2794	2.756	2150	4795.0	12.7073	10.949	0.2803	2.769
2101	4659.4	12.6438				2151	4797.8	12.7085			
2102	4662.1	12.6451				2152	4800.6	12.7098			
2103	4664.9	12.6465				2153	4803.4	12.7111			
2104	4667.6	12.6478				2154	4806.2	12.7124			
2105	4670.4	12.6491	10.873	.2794	2.759	2155	4809.0	12.7137	10.957	.2804	2.772
2106	4673.1	12.6505				2156	4811.7	12.7150			
2107	4675.9	12.6518				2157	4814.5	12.7163			
2108	4678.6	12.6531				2158	4817.3	12.7176			
2109	4681.4	12.6544				2159	4820.1	12.7189			
2110	4684.2	12.6558	10.881	.2795	2.762	2160	4822.9	12.7202	10.965	.2805	2.775
2111	4686.9	12.6571				2161	4825.7	12.7215			
2112	4689.7	12.6584				2162	4828.5	12.7228			
2113	4692.4	12.6597				2163	4831.3	12.7241			
2114	4695.2	12.6610				2164	4834.1	12.7254			
2115	4698.0	12.6623	10.890	.2796	2.766	2165	4836.9	12.7268	10.974	.2806	2.779
2116	4700.7	12.6636				2166	4839.7	12.7281			
2117	4703.5	12.6649				2167	4842.5	12.7294			
2118	4706.3	12.6662				2168	4845.3	12.7307			
2119	4709.0	12.6675				2169	4848.1	12.7320			
2120	4711.8	12.6688	10.898	.2797	2.769	2170	4850.9	12.7333	10.982	.2807	2.808
2121	4714.6	12.6701				2171	4853.7	12.7346			
2122	4717.3	12.6714				2172	4856.5	12.7359			
2123	4720.1	12.6727				2173	4859.3	12.7372			
2124	4722.9	12.6740				2174	4862.1	12.7385			
2125	4725.6	12.6753	10.907	.2798	2.772	2175	4864.9	12.7398	10.990	.2808	2.805
2126	4728.4	12.6765				2176	4867.7	12.7412			
2127	4731.2	12.6778				2177	4870.5	12.7425			
2128	4733.9	12.6791				2178	4873.3	12.7437			
2129	4736.7	12.6804				2179	4876.1	12.7450			
2130	4739.5	12.6817	10.915	.2799	2.776	2180	4878.9	12.7463	10.999	.2809	2.809
2131	4742.3	12.6829				2181	4881.7	12.7476			
2132	4745.0	12.6842				2182	4884.5	12.7489			
2133	4747.8	12.6855				2183	4887.3	12.7502			
2134	4750.6	12.6868				2184	4890.1	12.7514			
2135	4753.4	12.6881	10.923	.2800	2.779	2185	4892.9	12.7527	11.007	.2810	2.812
2136	4756.1	12.6894				2186	4895.8	12.7540			
2137	4758.9	12.6906				2187	4898.6	12.7553			
2138	4761.7	12.6919				2188	4901.4	12.7566			
2139	4764.5	12.6932				2189	4904.2	12.7578			
2140	4767.3	12.6945	10.932	.2801	2.782	2190	4907.0	12.7591	11.015	.2811	2.815
2141	4770.0	12.6958				2191	4909.8	12.7604			
2142	4772.8	12.6970				2192	4912.6	12.7617			
2143	4775.6	12.6983				2193	4915.4	12.7630			
2144	4778.4	12.6996				2194	4918.2	12.7648			
2145	4781.1	12.7009	10.940	.2802	2.786	2195	4921.1	12.7655	11.024	.2812	2.818
2146	4783.9	12.7021				2196	4923.9	12.7668			
2147	4786.7	12.7034				2197	4926.7	12.7681			
2148	4789.5	12.7047				2198	4929.5	12.7694			
2149	4792.3	12.7060				2199	4932.3	12.7707			

TABLE I. - Continued. COMBUSTION-GAS VALUES OF ψ_h, ψ_φ, φ, $c_{p,a}$, AND ψ_{c_p} FOR COMBUSTION OF HYDROGEN WITH AIR

[T = 600° to 2999° R]

T, °R	ψ_h, Btu/lb	ψ_φ, Btu/(lb)(°R)	φ	$c_{p,a}$, Btu/(lb)(°R)	ψ_{c_p}, Btu/(lb)(°R)	T, °R	ψ_h, Btu/lb	ψ_φ, Btu/(lb)(°R)	φ	$c_{p,a}$, Btu/(lb)(°R)	ψ_{c_p}, Btu/(lb)(°R)
2200	4935.2	12.7719	11.038	0.2813	2.822	2250	5076.9	12.8358	11.115	0.2822	2.854
2201	4938.0	12.7732				2251	5079.7	12.8371			
2202	4940.8	12.7746				2252	5082.6	12.8384			
2203	4943.6	12.7759				2253	5085.4	12.8396			
2204	4946.4	12.7772				2254	5088.3	12.8409			
2205	4949.3	12.7785	11.040	.2813	2.825	2255	5091.2	12.8422	11.123	.2823	2.858
2206	4952.1	12.7798				2256	5094.0	12.8435			
2207	4954.9	12.7810				2257	5096.9	12.8447			
2208	4957.7	12.7825				2258	5099.7	12.8460			
2209	4960.6	12.7836				2259	5102.6	12.8473			
2210	4963.4	12.7849	11.049	.2814	2.828	2260	5105.4	12.8485	11.130	.2823	2.861
2211	4966.2	12.7858				2261	5108.3	12.8498			
2212	4969.1	12.7875				2262	5111.1	12.8511			
2213	4971.9	12.7888				2263	5114.0	12.8523			
2214	4974.7	12.7901				2264	5116.9	12.8536			
2215	4977.5	12.7914	11.057	.2815	2.831	2265	5119.7	12.8548	11.140	.2824	2.864
2216	4980.4	12.7926				2266	5122.6	12.8561			
2217	4983.2	12.7939				2267	5125.4	12.8574			
2218	4986.0	12.7952				2268	5128.3	12.8586			
2219	4988.9	12.7965				2269	5131.2	12.8599			
2220	4991.7	12.7978	11.065	.2816	2.835	2270	5134.0	12.8611	11.148	.2825	2.867
2221	4994.5	12.7990				2271	5136.9	12.8624			
2222	4997.3	12.8003				2272	5139.7	12.8637			
2223	5000.2	12.8015				2273	5142.6	12.8649			
2224	5003.0	12.8028				2274	5145.5	12.8662			
2225	5005.8	12.8041	11.074	.2817	2.838	2275	5148.3	12.8675	11.156	.2826	2.870
2226	5008.7	12.8053				2276	5151.2	12.8687			
2227	5011.5	12.8066				2277	5154.1	12.8700			
2228	5014.3	12.8078				2278	5156.9	12.8713			
2229	5017.2	12.8091				2279	5159.8	12.8726			
2230	5020.0	12.8104	11.082	.2818	2.841	2280	5162.7	12.8738	11.165	.2827	2.874
2231	5022.8	12.8116				2281	5165.6	12.8751			
2232	5025.7	12.8129				2282	5168.4	12.8764			
2233	5028.5	12.8141				2283	5171.3	12.8777			
2234	5031.4	12.8154				2284	5174.2	12.8790			
2235	5034.2	12.8167	11.090	.2819	2.845	2285	5177.1	12.8803	11.173	.2828	2.877
2236	5037.0	12.8179				2286	5179.9	12.8816			
2237	5039.9	12.8192				2287	5182.8	12.8828			
2238	5042.7	12.8205				2288	5185.7	12.8841			
2239	5045.6	12.8217				2289	5188.6	12.8854			
2240	5048.4	12.8230	11.099	.2820	2.848	2290	5191.4	12.8867	11.181	.2829	2.880
2241	5051.3	12.8243				2291	5194.3	12.8880			
2242	5054.1	12.8256				2292	5197.2	12.8892			
2243	5056.9	12.8269				2293	5200.1	12.8905			
2244	5059.8	12.8281				2294	5203.0	12.8918			
2245	5062.6	12.8294	11.107	.2821	2.851	2295	5205.9	12.8931	11.189	.2830	2.883
2246	5065.5	12.8307				2296	5208.7	12.8943			
2247	5068.3	12.8320				2297	5211.6	12.8956			
2248	5071.2	12.8333				2298	5214.5	12.8969			
2249	5074.0	12.8345				2299	5217.4	12.8981			

TABLE I. - Continued. COMBUSTION-GAS VALUES OF Ψ_h, Ψ_φ, α, $c_{p,a}$, AND Ψ_{c_p} FOR COMBUSTION OF HYDROGEN WITH AIR

[T = 600° to 2999° R]

T, °R	Ψ_h, Btu/lb	Ψ_φ, Btu/(lb)(°R)	α	$c_{p,a}$, Btu/(lb)(°R)	Ψ_{c_p}, Btu/(lb)(°R)	T, °R	Ψ_h, Btu/lb	Ψ_φ, Btu/(lb)(°R)	α	$c_{p,a}$, Btu/(lb)(°R)	Ψ_{c_p}, Btu/(lb)(°R)
2300	5220.3	12.8994	11.197	0.2831	2.887	2350	5365.2	12.9614	11.278	0.2839	2.918
2301	5223.1	12.9006				2351	5368.1	12.9627			
2302	5226.0	12.9019				2352	5371.0	12.9639			
2303	5228.9	12.9031				2353	5374.0	12.9652			
2304	5231.8	12.9043				2354	5376.9	12.9664			
2305	5234.7	12.9056	11.206	.2831	2.890	2355	5379.8	12.9677	11.286	.2840	2.922
2306	5237.6	12.9068				2356	5382.7	12.9689			
2307	5240.5	12.9081				2357	5385.6	12.9702			
2308	5243.3	12.9093				2358	5388.5	12.9714			
2309	5246.2	12.9105				2359	5391.5	12.9727			
2310	5249.1	12.9118	11.214	.2832	2.893	2360	5394.4	12.9739	11.294	.2841	2.925
2311	5252.0	12.9130				2361	5397.3	12.9752			
2312	5254.9	12.9143				2362	5400.2	12.9765			
2313	5257.8	12.9155				2363	5403.1	12.9778			
2314	5260.7	12.9167				2364	5406.1	12.9791			
2315	5263.6	12.9180	11.222	.2833	2.896	2365	5409.0	12.9804	11.303	.2842	2.928
2316	5266.5	12.9192				2366	5411.9	12.9816			
2317	5269.4	12.9205				2367	5414.8	12.9829			
2318	5272.2	12.9217				2368	5417.8	12.9842			
2319	5275.1	12.9230				2369	5420.7	12.9855			
2320	5278.0	12.9242	11.230	.2834	2.899	2370	5423.6	12.9867	11.311	.2843	2.931
2321	5280.9	12.9254				2371	5426.5	12.9880			
2322	5283.8	12.9267				2372	5429.5	12.9893			
2323	5286.7	12.9279				2373	5432.4	12.9905			
2324	5289.6	12.9292				2374	5435.3	12.9918			
2325	5292.5	12.9304	11.238	.2835	2.903	2375	5438.3	12.9931	11.319	.2843	2.934
2326	5295.4	12.9317				2376	5441.2	12.9943			
2327	5298.3	12.9329				2377	5444.1	12.9956			
2328	5301.2	12.9341				2378	5447.0	12.9968			
2329	5304.1	12.9354				2379	5450.0	12.9981			
2330	5307.0	12.9366	11.246	.2836	2.906	2380	5452.9	12.9993	11.327	.2844	2.937
2331	5309.9	12.9379				2381	5455.8	13.0005			
2332	5312.8	12.9391				2382	5458.8	13.0017			
2333	5315.7	12.9404				2383	5461.7	13.0030			
2334	5318.6	12.9416				2384	5464.7	13.0042			
2335	5321.5	12.9428	11.254	.2837	2.909	2385	5467.6	13.0054	11.335	.2845	2.940
2336	5324.4	12.9441				2386	5470.5	13.0066			
2337	5327.3	12.9453				2387	5473.5	13.0078			
2338	5330.2	12.9466				2388	5476.4	13.0091			
2339	5333.1	12.9478				2389	5479.4	13.0103			
2340	5336.1	12.9491	11.262	.2838	2.912	2390	5482.3	13.0115	11.343	.2846	2.944
2341	5339.0	12.9503				2391	5485.3	13.0127			
2342	5341.9	12.9515				2392	5488.2	13.0139			
2343	5344.8	12.9528				2393	5491.1	13.0152			
2344	5347.7	12.9540				2394	5494.1	13.0164			
2345	5350.6	12.9552	11.270	.2838	2.915	2395	5497.0	13.0176	11.351	.2847	2.947
2346	5353.5	12.9565				2396	5500.0	13.0188			
2347	5356.5	12.9577				2397	5502.9	13.0200			
2348	5359.4	12.9589				2398	5505.9	13.0213			
2349	5362.3	12.9602				2399	5508.8	13.0225			

TABLE I. - Continued. COMBUSTION-GAS VALUES OF Ψ_h, Ψ_φ, ω, $c_{p,a}$, AND Ψ_{c_p} FOR COMBUSTION OF HYDROGEN WITH AIR

[T = 800° to 29990 R]

T, °R	Ψ_h, Btu/lb	Ψ_φ, Btu/(lb)(°R)	ω	$c_{p,a}$, Btu/(lb)(°R)	Ψ_{c_p}, Btu/(lb)(°R)	T, °R	Ψ_h, Btu/lb	Ψ_φ, Btu/(lb)(°R)	ω	$c_{p,a}$, Btu/(lb)(°R)	Ψ_{c_p}, Btu/(lb)(°R)
2400	5611.6	13.0837	11.359	0.2848	2.950	2450	5689.8	13.0843	11.440	0.2855	2.981
2401	5614.7	13.0849				2451	5668.8	13.0855			
2402	5617.6	13.0862				2452	5665.8	13.0867			
2403	5620.6	13.0874				2453	5668.8	13.0879			
2404	5623.5	13.0886				2454	5671.7	13.0892			
2405	5626.5	13.0899	11.367	.2848	2.953	2455	5674.7	13.0904	11.448	.2856	2.984
2406	5629.4	13.0911				2456	5677.7	13.0916			
2407	5632.4	13.0923				2457	5680.7	13.0928			
2408	5635.3	13.0935				2458	5683.7	13.0941			
2409	5638.3	13.0948				2459	5686.6	13.0953			
2410	5641.2	13.0960	11.375	.2849	2.956	2460	5689.6	13.0965	11.455	.2857	2.987
2411	5644.2	13.0972				2461	5692.6	13.0978			
2412	5647.1	13.0984				2462	5695.6	13.0990			
2413	5650.1	13.0996				2463	5698.6	13.1003			
2414	5653.0	13.1009				2464	5701.8	13.1015			
2415	5656.0	13.1021	11.383	.2850	2.959	2465	5704.8	13.1028	11.463	.2857	2.990
2416	5658.9	13.1033				2466	5707.5	13.1040			
2417	5661.9	13.1045				2467	5710.5	13.1052			
2418	5664.8	13.1057				2468	5713.5	13.1065			
2419	5667.8	13.1069				2469	5716.4	13.1077			
2420	5670.8	13.1081	11.391	.2851	2.962	2470	5719.4	13.1089	11.471	.2858	2.993
2421	5673.7	13.1093				2471	5722.4	13.1102			
2422	5676.7	13.1105				2472	5725.4	13.1114			
2423	5679.6	13.1117				2473	5728.4	13.1127			
2424	5682.6	13.1129				2474	5731.4	13.1139			
2425	5685.6	13.1141	11.399	.2851	2.965	2475	5734.4	13.1151	11.479	.2859	2.996
2426	5688.5	13.1153				2476	5737.3	13.1163			
2427	5691.5	13.1164				2477	5740.3	13.1176			
2428	5694.5	13.1176				2478	5743.3	13.1188			
2429	5697.4	13.1188				2479	5746.3	13.1200			
2430	5600.4	13.0600	11.407	.2858	2.968	2480	5749.3	13.1212	11.487	.2860	2.999
2431	5603.3	13.0612				2481	5752.3	13.1225			
2432	5606.3	13.0624				2482	5755.3	13.1237			
2433	5609.3	13.0636				2483	5758.3	13.1249			
2434	5612.2	13.0648				2484	5761.3	13.1261			
2435	5615.2	13.0660	11.416	.2853	2.971	2485	5764.3	13.1273	11.495	.2860	3.002
2436	5618.2	13.0672				2486	5767.3	13.1285			
2437	5621.2	13.0684				2487	5770.3	13.1298			
2438	5624.1	13.0697				2488	5773.3	13.1310			
2439	5627.1	13.0709				2489	5776.3	13.1322			
2440	5630.1	13.0721	11.424	.2854	2.975	2490	5779.3	13.1334	11.503	.2861	3.005
2441	5633.0	13.0733				2491	5782.3	13.1346			
2442	5636.0	13.0745				2492	5785.3	13.1358			
2443	5639.0	13.0757				2493	5788.3	13.1370			
2444	5642.0	13.0769				2494	5791.3	13.1382			
2445	5644.9	13.0782	11.432	.2854	2.978	2495	5794.4	13.1394	11.511	.2862	3.008
2446	5647.9	13.0794				2496	5797.4	13.1406			
2447	5650.9	13.0806				2497	5800.4	13.1419			
2448	5653.9	13.0818				2498	5803.4	13.1431			
2449	5656.9	13.0830				2499	5806.4	13.1443			

TABLE I. - Continued. COMBUSTION-GAS VALUES OF ψ_h, ψ_φ, α, $c_{p,a}$, AND ψ_{c_p} FOR COMBUSTION OF HYDROGEN WITH AIR

[T = 500° to 2999° R.]

T, °R	ψ_h, Btu/lb	ψ_φ, Btu/(lb)(°R)	α	$c_{p,a}$, Btu/(lb)(°R)	ψ_{c_p}, Btu/(lb)(°R)	T, °R	ψ_h, Btu/lb	ψ_φ, Btu/(lb)(°R)	α	$c_{p,a}$, Btu/(lb)(°R)	ψ_{c_p}, Btu/(lb)(°R)
2500	5809.4	13.1455	11.518	0.2863	3.011	2550	5960.4	13.2056	11.595	0.2870	3.041
2501	5812.4	13.1467				2551	5963.5	13.2068			
2502	5815.4	13.1479				2552	5966.5	13.2080			
2503	5818.4	13.1491				2553	5969.5	13.2092			
2504	5821.4	13.1503				2554	5972.6	13.2104			
2505	5824.4	13.1515	11.526	.2863	3.014	2555	5975.6	13.2116	11.603	.2871	3.044
2506	5827.4	13.1527				2556	5978.7	13.2128			
2507	5830.4	13.1539				2557	5981.7	13.2140			
2508	5833.5	13.1551				2558	5984.8	13.2152			
2509	5836.5	13.1563				2559	5987.8	13.2164			
2510	5839.5	13.1575	11.534	.2864	3.017	2560	5990.8	13.2176	11.610	.2872	3.047
2511	5842.5	13.1587				2561	5993.9	13.2187			
2512	5845.5	13.1599				2562	5996.9	13.2199			
2513	5848.5	13.1611				2563	6000.0	13.2211			
2514	5851.5	13.1623				2564	6003.0	13.2223			
2515	5854.5	13.1638	11.542	.2865	3.020	2565	6006.1	13.2234	11.618	.2872	3.050
2516	5857.6	13.1647				2566	6009.1	13.2246			
2517	5860.6	13.1659				2567	6012.2	13.2258			
2518	5863.6	13.1671				2568	6015.2	13.2269			
2519	5866.6	13.1683				2569	6018.3	13.2281			
2520	5869.6	13.1698	11.549	.2866	3.023	2570	6021.3	13.2293	11.626	.2873	3.053
2521	5872.6	13.1707				2571	6024.4	13.2305			
2522	5875.7	13.1719				2572	6027.4	13.2317			
2523	5878.7	13.1731				2573	6030.5	13.2328			
2524	5881.7	13.1743				2574	6033.5	13.2340			
2525	5884.7	13.1755	11.557	.2866	3.026	2575	6036.6	13.2352	11.633	.2874	3.056
2526	5887.7	13.1767				2576	6039.6	13.2364			
2527	5890.8	13.1779				2577	6042.7	13.2376			
2528	5893.8	13.1791				2578	6045.7	13.2387			
2529	5896.8	13.1803				2579	6048.8	13.2399			
2530	5899.8	13.1815	11.565	.2867	3.029	2580	6051.8	13.2411	11.641	.2875	3.059
2531	5902.9	13.1827				2581	6054.9	13.2423			
2532	5905.9	13.1839				2582	6057.9	13.2435			
2533	5908.9	13.1851				2583	6061.0	13.2447			
2534	5911.9	13.1863				2584	6064.1	13.2459			
2535	5915.0	13.1875	11.572	.2868	3.032	2585	6067.1	13.2471	11.648	.2875	3.062
2536	5918.0	13.1887				2586	6070.2	13.2482			
2537	5921.0	13.1899				2587	6073.2	13.2494			
2538	5924.0	13.1911				2588	6076.3	13.2506			
2539	5927.1	13.1923				2589	6079.4	13.2518			
2540	5930.1	13.1935	11.580	.2869	3.035	2590	6082.4	13.2530	11.655	.2876	3.065
2541	5933.1	13.1947				2591	6085.5	13.2542			
2542	5936.2	13.1959				2592	6088.6	13.2554			
2543	5939.2	13.1971				2593	6091.6	13.2566			
2544	5942.2	13.1984				2594	6094.7	13.2578			
2545	5945.3	13.1996	11.588	.2869	3.038	2595	6097.7	13.2590	11.663	.2877	3.068
2546	5948.3	13.2008				2596	6100.8	13.2602			
2547	5951.3	13.2020				2597	6103.9	13.2613			
2548	5954.4	13.2032				2598	6106.9	13.2625			
2549	5957.4	13.2044				2599	6110.0	13.2637			

TABLE I. - Continued. COMBUSTION-GAS VALUES OF ψ_h, ψ_φ, α, $c_{p,s}$, AND ψ_{c_p} FOR COMBUSTION OF HYDROGEN WITH AIR

[T = 600° to 2999° R.]

T, °R	ψ_h, Btu/lb	ψ_φ, Btu/(lb)(°R)	α	$c_{p,s}$, Btu/(lb)(°R)	ψ_{c_p}, Btu/(lb)(°R)	T, °R	ψ_h, Btu/lb	ψ_φ, Btu/(lb)(°R)	α	$c_{p,s}$, Btu/(lb)(°R)	ψ_{c_p}, Btu/(lb)(°R)
2600	6113.1	13.2649	11.670	0.2878	3.071	2650	6267.0	13.3237	11.744	0.2885	3.099
2601	6116.1	13.2661				2651	6270.1	13.3249			
2602	6119.2	13.2673				2652	6273.2	13.3261			
2603	6122.3	13.2685				2653	6276.3	13.3273			
2604	6125.3	13.2697				2654	6279.4	13.3284			
2605	6128.4	13.2710	11.678	.2878	3.073	2655	6282.5	13.3296	11.751	.2885	3.102
2606	6131.5	13.2722				2656	6285.6	13.3308			
2607	6134.5	13.2733				2657	6288.7	13.3320			
2608	6137.6	13.2745				2658	6291.8	13.3331			
2609	6140.7	13.2757				2659	6294.9	13.3343			
2610	6143.7	13.2769	11.685	.2879	3.076	2660	6298.0	13.3355	11.758	.2886	3.105
2611	6146.8	13.2781				2661	6301.1	13.3366			
2612	6149.9	13.2793				2662	6304.2	13.3378			
2613	6153.0	13.2805				2663	6307.3	13.3389			
2614	6156.0	13.2817				2664	6310.4	13.3401			
2615	6159.1	13.2829	11.693	.2880	3.079	2665	6313.5	13.3412	11.766	.2887	3.108
2616	6162.2	13.2841				2666	6316.6	13.3424			
2617	6165.2	13.2852				2667	6319.7	13.3435			
2618	6168.3	13.2864				2668	6322.8	13.3447			
2619	6171.4	13.2876				2669	6326.0	13.3458			
2620	6174.5	13.2888	11.700	.2880	3.082	2670	6329.1	13.3470	11.773	.2887	3.111
2621	6177.5	13.2899				2671	6332.2	13.3481			
2622	6180.6	13.2910				2672	6335.3	13.3493			
2623	6183.7	13.2922				2673	6338.4	13.3505			
2624	6186.8	13.2933				2674	6341.5	13.3516			
2625	6189.8	13.2945	11.707	.2881	3.085	2675	6344.6	13.3528	11.780	.2888	3.114
2626	6192.9	13.2956				2676	6347.7	13.3539			
2627	6196.0	13.2968				2677	6350.8	13.3551			
2628	6199.1	13.2979				2678	6353.9	13.3563			
2629	6202.2	13.2991				2679	6357.0	13.3574			
2630	6205.2	13.3002	11.715	.2882	3.088	2680	6360.2	13.3586	11.787	.2889	3.116
2631	6208.3	13.3014				2681	6363.3	13.3598			
2632	6211.4	13.3026				2682	6366.4	13.3610			
2633	6214.5	13.3037				2683	6369.5	13.3622			
2634	6217.6	13.3049				2684	6372.6	13.3634			
2635	6220.7	13.3060	11.722	.2883	3.091	2685	6375.7	13.3646	11.794	.2889	3.119
2636	6223.7	13.3072				2686	6378.8	13.3658			
2637	6226.8	13.3084				2687	6381.9	13.3670			
2638	6229.9	13.3095				2688	6385.1	13.3682			
2639	6233.0	13.3107				2689	6388.2	13.3693			
2640	6236.1	13.3119	11.729	.2883	3.094	2690	6391.3	13.3705	11.801	.2890	3.122
2641	6239.2	13.3131				2691	6394.4	13.3717			
2642	6242.3	13.3142				2692	6397.5	13.3729			
2643	6245.4	13.3154				2693	6400.6	13.3741			
2644	6248.5	13.3166				2694	6403.8	13.3752			
2645	6251.8	13.3178	11.737	.2884	3.097	2695	6406.9	13.3764	11.808	.2891	3.128
2646	6254.6	13.3190				2696	6410.0	13.3776			
2647	6257.7	13.3202				2697	6413.1	13.3788			
2648	6260.8	13.3214				2698	6416.2	13.3799			
2649	6263.9	13.3225				2699	6419.4	13.3811			

TABLE I. - Continued. COMBUSTION-GAS VALUES OF ψ_h, ψ_φ, ω, $c_{p,s}$, AND ψ_{c_p} FOR COMBUSTION OF HYDROGEN WITH AIR

[T = 600° to 2999° R.]

T, °R	ψ_h, Btu/lb	ψ_φ, Btu/(lb)(°R)	ω	$c_{p,s}$, Btu/(lb)(°R)	ψ_{c_p}, Btu/(lb)(°R)	T, °R	ψ_h, Btu/lb	ψ_φ, Btu/(lb)(°R)	ω	$c_{p,s}$, Btu/(lb)(°R)	ψ_{c_p}, Btu/(lb)(°R)
2700	6428.5	13.3823	11.815	0.2892	3.127	2750	6579.8	13.4399	11.885	0.2898	3.155
2701	6431.6	13.3834				2751	6582.4	13.4410			
2702	6434.7	13.3845				2752	6585.5	13.4422			
2703	6437.8	13.3857				2753	6588.7	13.4433			
2704	6441.0	13.3868				2754	6591.8	13.4445			
2705	6444.1	13.3879	11.832	.2898	3.130	2755	6595.0	13.4456	11.891	.2899	3.157
2706	6447.2	13.3891				2756	6598.1	13.4467			
2707	6450.3	13.3902				2757	6601.3	13.4479			
2708	6453.5	13.3914				2758	6604.4	13.4490			
2709	6456.6	13.3925				2759	6607.6	13.4502			
2710	6459.7	13.3936	11.829	.2893	3.133	2760	6610.7	13.4513	11.898	.2899	3.160
2711	6462.9	13.3948				2761	6613.9	13.4525			
2712	6466.0	13.3959				2762	6617.0	13.4536			
2713	6469.1	13.3971				2763	6620.2	13.4548			
2714	6472.3	13.3982				2764	6623.4	13.4559			
2715	6475.4	13.3994	11.836	.2894	3.136	2765	6626.5	13.4571	11.905	.2900	3.163
2716	6478.5	13.4005				2766	6629.7	13.4582			
2717	6481.6	13.4017				2767	6632.8	13.4594			
2718	6484.8	13.4028				2768	6636.0	13.4605			
2719	6487.9	13.4040				2769	6639.2	13.4617			
2720	6491.0	13.4052	11.843	.2894	3.138	2770	6642.3	13.4628	11.912	.2901	3.165
2721	6494.2	13.4063				2771	6645.5	13.4640			
2722	6497.3	13.4075				2772	6648.7	13.4651			
2723	6500.4	13.4087				2773	6651.8	13.4663			
2724	6503.5	13.4099				2774	6655.0	13.4674			
2725	6506.7	13.4111	11.850	.2895	3.141	2775	6658.1	13.4685	11.919	.2901	3.168
2726	6509.8	13.4123				2776	6661.3	13.4697			
2727	6512.9	13.4134				2777	6664.5	13.4708			
2728	6516.1	13.4146				2778	6667.6	13.4720			
2729	6519.2	13.4158				2779	6670.8	13.4731			
2730	6522.4	13.4170	11.857	.2896	3.144	2780	6674.0	13.4742	11.925	.2902	3.171
2731	6525.5	13.4181				2781	6677.1	13.4753			
2732	6528.6	13.4193				2782	6680.3	13.4765			
2733	6531.8	13.4205				2783	6683.5	13.4776			
2734	6534.9	13.4216				2784	6686.7	13.4787			
2735	6538.0	13.4228	11.864	.2896	3.147	2785	6689.8	13.4798	11.932	.2903	3.173
2736	6541.2	13.4240				2786	6693.0	13.4809			
2737	6544.3	13.4251				2787	6696.2	13.4820			
2738	6547.5	13.4263				2788	6699.3	13.4831			
2739	6550.6	13.4274				2789	6702.5	13.4843			
2740	6553.8	13.4286	11.871	.2897	3.149	2790	6705.7	13.4854	11.939	.2903	3.176
2741	6556.9	13.4297				2791	6708.9	13.4865			
2742	6560.0	13.4308				2792	6712.0	13.4876			
2743	6563.2	13.4320				2793	6715.2	13.4888			
2744	6566.3	13.4331				2794	6718.4	13.4899			
2745	6569.5	13.4343	11.878	.2897	3.152	2795	6721.5	13.4910	11.945	.2904	3.179
2746	6572.6	13.4354				2796	6724.7	13.4922			
2747	6575.8	13.4365				2797	6727.9	13.4933			
2748	6578.9	13.4376				2798	6731.1	13.4944			
2749	6582.1	13.4388				2799	6734.2	13.4956			

TABLE I. - Continued. COMBUSTION-GAS VALUES OF Ψ_h, Ψ_s, ω, $c_{p,s}$, AND Ψ_{c_p} FOR COMBUSTION OF HYDROGEN WITH AIR

[T = 600° to 2999° R]

T, °R	Ψ_h, Btu/lb	Ψ_s, Btu/(lb)(°R)	ω	$c_{p,s}$, Btu/(lb)(°R)	Ψ_{c_p}, Btu/(lb)(°R)	T, °R	Ψ_h, Btu/lb	Ψ_s, Btu/(lb)(°R)	ω	$c_{p,s}$, Btu/(lb)(°R)	Ψ_{c_p}, Btu/(lb)(°R)
2800	6737.4	13.4967	11.952	0.2905	3.181	2850	6896.8	13.5534	12.018	0.2911	3.207
2801	6740.6	13.4979				2851	6900.0	13.5545			
2802	6743.8	13.4990				2852	6903.3	13.5556			
2803	6746.9	13.5002				2853	6906.5	13.5567			
2804	6750.1	13.5014				2854	6909.7	13.5578			
2805	6753.3	13.5026	11.959	.2905	3.184	2855	6912.9	13.5589	12.025	.2911	3.210
2806	6756.5	13.5037				2856	6916.1	13.5600			
2807	6759.6	13.5049				2857	6919.3	13.5611			
2808	6762.8	13.5061				2858	6922.5	13.5622			
2809	6766.0	13.5072				2859	6925.7	13.5633			
2810	6769.2	13.5084	11.966	.2906	3.186	2860	6928.9	13.5645	12.031	.2912	3.212
2811	6772.4	13.5095				2861	6932.1	13.5656			
2812	6775.5	13.5107				2862	6935.3	13.5668			
2813	6778.7	13.5119				2863	6938.5	13.5679			
2814	6781.9	13.5130				2864	6941.7	13.5690			
2815	6785.1	13.5142	11.972	.2906	3.189	2865	6944.9	13.5702	12.038	.2912	3.215
2816	6788.3	13.5153				2866	6948.1	13.5713			
2817	6791.4	13.5165				2867	6951.3	13.5725			
2818	6794.6	13.5176				2868	6954.6	13.5736			
2819	6797.8	13.5188				2869	6957.8	13.5748			
2820	6801.0	13.5199	11.979	.2907	3.192	2870	6961.0	13.5759	12.044	.2913	3.217
2821	6804.2	13.5211				2871	6964.2	13.5770			
2822	6807.4	13.5223				2872	6967.4	13.5782			
2823	6810.6	13.5234				2873	6970.6	13.5793			
2824	6813.8	13.5246				2874	6973.8	13.5804			
2825	6816.9	13.5257	11.986	.2908	3.194	2875	6977.0	13.5816	12.051	.2914	3.220
2826	6820.1	13.5269				2876	6980.2	13.5827			
2827	6823.3	13.5280				2877	6983.5	13.5838			
2828	6826.5	13.5292				2878	6986.7	13.5850			
2829	6829.7	13.5303				2879	6989.9	13.5861			
2830	6832.9	13.5314	11.992	.2908	3.197	2880	6993.1	13.5872	12.057	.2914	3.222
2831	6836.1	13.5326				2881	6996.3	13.5883			
2832	6839.3	13.5337				2882	6999.5	13.5894			
2833	6842.5	13.5348				2883	7002.8	13.5906			
2834	6845.7	13.5360				2884	7006.0	13.5917			
2835	6848.9	13.5371	11.999	.2909	3.199	2885	7009.2	13.5928	12.063	.2915	3.225
2836	6852.1	13.5382				2886	7012.4	13.5939			
2837	6855.3	13.5393				2887	7015.6	13.5950			
2838	6858.5	13.5405				2888	7018.8	13.5961			
2839	6861.7	13.5416				2889	7022.1	13.5972			
2840	6864.9	13.5427	12.005	.2909	3.202	2890	7025.3	13.5983	12.070	.2915	3.227
2841	6868.0	13.5437				2891	7028.5	13.5995			
2842	6871.2	13.5448				2892	7031.7	13.6006			
2843	6874.4	13.5459				2893	7035.0	13.6017			
2844	6877.6	13.5470				2894	7038.2	13.6028			
2845	6880.8	13.5480	12.012	.2910	3.205	2895	7041.4	13.6039	12.076	.2916	3.230
2846	6884.0	13.5491				2896	7044.6	13.6050			
2847	6887.2	13.5502				2897	7047.9	13.6062			
2848	6890.4	13.5513				2898	7051.1	13.6073			
2849	6893.6	13.5524				2899	7054.3	13.6084			

TABLE I. - Concluded. COMBUSTION-GAS VALUES OF ψ_h, ψ_φ, m, $c_{p,s}$, AND ψ_{c_p} FOR COMBUSTION OF HYDROGEN WITH AIR

[T = 600° to 2999° R]

T, °R	ψ_h, Btu/lb	ψ_φ, Btu/(lb)(°R)	m	$c_{p,s}$, Btu/(lb)(°R)	ψ_{c_p}, Btu/(lb)(°R)	T, °R	ψ_h, Btu/lb	ψ_φ, Btu/(lb)(°R)	m	$c_{p,s}$, Btu/(lb)(°R)	ψ_{c_p}, Btu/(lb)(°R)
2900	7057.5	13.6095	12.082	0.2917	3.238	2950	7219.5	13.6653	12.143	0.2923	3.257
2901	7060.8	13.6106				2951	7222.7	13.6664			
2902	7064.0	13.6118				2952	7226.0	13.6675			
2903	7067.8	13.6129				2953	7229.2	13.6686			
2904	7070.5	13.6140				2954	7232.5	13.6696			
2905	7073.7	13.6152	12.088	.2917	3.235	2955	7235.7	13.6707	12.149	.2923	3.259
2906	7076.9	13.6163				2956	7239.0	13.6718			
2907	7080.1	13.6174				2957	7242.3	13.6729			
2908	7083.4	13.6186				2958	7245.5	13.6740			
2909	7086.6	13.6197				2959	7248.8	13.6751			
2910	7089.8	13.6808	12.095	.2918	3.237	2960	7252.0	13.6762	12.155	.2924	3.262
2911	7093.1	13.6819				2961	7255.3	13.6773			
2912	7096.3	13.6831				2962	7258.5	13.6783			
2913	7099.5	13.6842				2963	7261.8	13.6794			
2914	7102.8	13.6853				2964	7265.0	13.6805			
2915	7106.0	13.6864	12.101	.2918	3.240	2965	7268.3	13.6816	12.161	.2924	3.264
2916	7109.3	13.6876				2966	7271.6	13.6827			
2917	7112.5	13.6887				2967	7274.8	13.6838			
2918	7115.7	13.6898				2968	7278.1	13.6848			
2919	7119.0	13.6909				2969	7281.3	13.6859			
2920	7122.2	13.6381	12.107	.2919	3.242	2970	7284.6	13.6870	12.167	.2925	3.267
2921	7125.4	13.6338				2971	7287.9	13.6881			
2922	7128.7	13.6343				2972	7291.1	13.6892			
2923	7131.9	13.6354				2973	7294.4	13.6903			
2924	7135.2	13.6366				2974	7297.7	13.6914			
2925	7138.4	13.6377	12.113	.2920	3.245	2975	7300.9	13.6925	12.173	.2926	3.269
2926	7141.6	13.6388				2976	7304.2	13.6936			
2927	7144.9	13.6399				2977	7307.4	13.6947			
2928	7148.1	13.6410				2978	7310.7	13.6958			
2929	7151.3	13.6422				2979	7314.0	13.6969			
2930	7154.6	13.6433	12.119	.2920	3.247	2980	7317.2	13.6980	12.179	.2926	3.271
2931	7157.8	13.6444				2981	7320.5	13.6992			
2932	7161.1	13.6455				2982	7323.8	13.7003			
2933	7164.3	13.6466				2983	7327.0	13.7015			
2934	7167.6	13.6477				2984	7330.3	13.7026			
2935	7170.8	13.6488	12.125	.2921	3.250	2985	7333.6	13.7038	12.185	.2927	3.274
2936	7174.0	13.6499				2986	7336.8	13.7049			
2937	7177.3	13.6511				2987	7340.1	13.7061			
2938	7180.5	13.6522				2988	7343.4	13.7072			
2939	7183.8	13.6533				2989	7346.6	13.7083			
2940	7187.0	13.6544	12.131	.2921	3.252	2990	7349.9	13.7095	12.191	.2927	3.276
2941	7190.3	13.6555				2991	7353.2	13.7106			
2942	7193.5	13.6566				2992	7356.4	13.7117			
2943	7196.8	13.6576				2993	7359.7	13.7128			
2944	7200.0	13.6587				2994	7363.0	13.7140			
2945	7203.2	13.6598	12.137	.2922	3.255	2995	7366.3	13.7151	12.197	.2928	3.279
2946	7206.5	13.6609				2996	7369.5	13.7162			
2947	7209.7	13.6620				2997	7372.8	13.7173			
2948	7213.0	13.6631				2998	7376.1	13.7184			
2949	7216.2	13.6642				2999	7379.3	13.7195			

TABLE II. - THERMODYNAMIC PROPERTIES OF AIR AT LOW PRESSURES, AND COMBUSTION-GAS VALUES OF Ψ_h, Ψ_φ, ω, $c_{p,a}$, AND Ψ_{c_p} FOR COMBUSTION OF HYDROGEN WITH AIR

[T = 3000° to 4400° R.]

T, °R	h_a, Btu/lb air	φ_a, Btu/(lb)(°R)	Ψ_h, Btu/lb	Ψ_φ, Btu/(lb)(°R)	ω	$c_{p,a}$, Btu/(lb)(°R)	Ψ_{c_p}, Btu/(lb)(°R)
3000	790.68	1.04779	7382.6	13.7206	12.203	0.2929	3.281
3001	790.97	1.04789	7385.9	13.7217			
3002	791.27	1.04799	7389.2	13.7228			
3003	791.56	1.04809	7392.4	13.7239			
3004	791.85	1.04818	7395.7	13.7250			
3005	792.15	1.04828	7399.0	13.7260	12.209	.2929	3.283
3006	792.44	1.04838	7402.3	13.7271			
3007	792.73	1.04848	7405.6	13.7282			
3008	793.02	1.04857	7408.8	13.7293			
3009	793.32	1.04867	7412.1	13.7304			
3010	793.61	1.04877	7415.4	13.7314	12.215	.2930	3.286
3011	793.90	1.04887	7418.7	13.7325			
3012	794.20	1.04896	7421.9	13.7336			
3013	794.49	1.04906	7425.2	13.7347			
3014	794.78	1.04916	7428.5	13.7358			
3015	795.08	1.04926	7431.8	13.7368	12.221	.2930	3.288
3016	795.37	1.04935	7435.1	13.7379			
3017	795.66	1.04945	7438.4	13.7390			
3018	795.95	1.04955	7441.6	13.7401			
3019	796.25	1.04964	7444.9	13.7412			
3020	796.54	1.04974	7448.2	13.7422	12.226	.2931	3.290
3021	796.83	1.04984	7451.5	13.7433			
3022	797.13	1.04993	7454.8	13.7444			
3023	797.42	1.05003	7458.1	13.7455			
3024	797.71	1.05013	7461.3	13.7465			
3025	798.00	1.05023	7464.6	13.7476	12.232	.2931	3.293
3026	798.30	1.05032	7467.9	13.7487			
3027	798.59	1.05042	7471.2	13.7498			
3028	798.88	1.05052	7474.5	13.7509			
3029	799.18	1.05061	7477.8	13.7519			
3030	799.47	1.05071	7481.1	13.7530	12.238	.2932	3.295
3031	799.76	1.05081	7484.4	13.7541			
3032	800.06	1.05090	7487.7	13.7552			
3033	800.35	1.05100	7490.9	13.7563			
3034	800.65	1.05110	7494.2	13.7573			
3035	800.94	1.05120	7497.5	13.7584	12.244	.2932	3.297
3036	801.24	1.05129	7500.8	13.7595			
3037	801.53	1.05139	7504.1	13.7606			
3038	801.82	1.05149	7507.4	13.7617			
3039	802.12	1.05158	7510.7	13.7628			
3040	802.41	1.05168	7514.0	13.7639	12.250	.2933	3.300
3041	802.70	1.05178	7517.3	13.7650			
3042	803.00	1.05187	7520.6	13.7660			
3043	803.29	1.05197	7523.9	13.7671			
3044	803.58	1.05207	7527.2	13.7682			
3045	803.87	1.05216	7530.5	13.7693	12.256	.2934	3.302
3046	804.17	1.05226	7533.8	13.7704			
3047	804.46	1.05235	7537.1	13.7715			
3048	804.75	1.05245	7540.4	13.7726			
3049	805.05	1.05254	7543.7	13.7737			

TABLE II. - Continued. THERMODYNAMIC PROPERTIES OF AIR AT LOW PRESSURES, AND COMBUSTION-GAS VALUES OF ψ_h, ψ_φ, ω, $c_{p,a}$, AND ψ_{c_p} FOR COMBUSTION OF HYDROGEN WITH AIR

[T = 3000° to 4400° R]

T, °R	h_a, Btu/lb air	φ_a, Btu/(lb)(°R)	ψ_h, Btu/lb	ψ_φ, Btu/(lb)(°R)	ω	$c_{p,a}$, Btu/(lb)(°R)	ψ_{c_p}, Btu/(lb)(°R)
3050	805.34	1.05264	7547.0	13.7748	12.261	0.2934	3.304
3051	805.63	1.05273	7550.3	13.7759			
3052	805.93	1.05283	7553.6	13.7770			
3053	806.28	1.05292	7556.9	13.7781			
3054	806.52	1.05302	7560.2	13.7792			
3055	806.81	1.05311	7563.5	13.7803	12.267	.2935	3.307
3056	807.10	1.05321	7566.8	13.7814			
3057	807.40	1.05330	7570.1	13.7825			
3058	807.69	1.05340	7573.4	13.7836			
3059	807.99	1.05349	7576.7	13.7847			
3060	808.28	1.05359	7580.0	13.7858	12.273	.2935	3.309
3061	808.57	1.05369	7583.3	13.7869			
3062	808.87	1.05378	7586.6	13.7880			
3063	809.16	1.05388	7589.9	13.7892			
3064	809.46	1.05397	7593.2	13.7903			
3065	809.75	1.05407	7596.5	13.7914	12.279	.2936	3.311
3066	810.05	1.05417	7599.8	13.7925			
3067	810.34	1.05426	7603.1	13.7937			
3068	810.63	1.05436	7606.4	13.7948			
3069	810.93	1.05445	7609.7	13.7959			
3070	811.22	1.05455	7613.0	13.7970	12.285	.2936	3.314
3071	811.51	1.05465	7616.3	13.7981			
3072	811.81	1.05474	7619.6	13.7992			
3073	812.10	1.05484	7622.9	13.8003			
3074	812.39	1.05494	7626.2	13.8014			
3075	812.68	1.05503	7629.5	13.8025	12.290	.2937	3.316
3076	812.98	1.05513	7632.9	13.8036			
3077	813.27	1.05522	7636.2	13.8047			
3078	813.56	1.05532	7639.5	13.8057			
3079	813.86	1.05541	7642.8	13.8068			
3080	814.15	1.05551	7646.1	13.8079	12.296	.2937	3.318
3081	814.44	1.05561	7649.4	13.8089			
3082	814.74	1.05570	7652.7	13.8100			
3083	815.03	1.05580	7656.0	13.8110			
3084	815.33	1.05589	7659.4	13.8121			
3085	815.62	1.05599	7662.7	13.8131	12.302	.2938	3.321
3086	815.91	1.05608	7666.0	13.8142			
3087	816.21	1.05618	7669.3	13.8152			
3088	816.50	1.05627	7672.6	13.8162			
3089	816.80	1.05637	7675.9	13.8173			
3090	817.09	1.05646	7679.2	13.8183	12.308	.2938	3.323
3091	817.38	1.05656	7682.6	13.8194			
3092	817.68	1.05665	7685.9	13.8204			
3093	817.97	1.05675	7689.2	13.8215			
3094	818.27	1.05684	7692.5	13.8225			
3095	818.56	1.05694	7695.8	13.8236	12.314	.2939	3.325
3096	818.85	1.05703	7699.2	13.8246			
3097	819.15	1.05713	7702.5	13.8257			
3098	819.44	1.05722	7705.8	13.8267			
3099	819.74	1.05732	7709.1	13.8278			

TABLE II. - Continued. THERMODYNAMIC PROPERTIES OF AIR AT LOW PRESSURES, AND COMBUSTION-GAS VALUES OF ψ_h, ψ_φ, ϖ, $c_{p,a}$, AND ψ_{c_p} FOR COMBUSTION OF HYDROGEN WITH AIR

[T = 3000° to 4400° R.]

T, °R	h_a, Btu/lb air	φ_a, Btu/(lb)(°R)	ψ_h, Btu/lb	ψ_φ, Btu/(lb)(°R)	ϖ	$c_{p,a}$, Btu/(lb)(°R)	ψ_{c_p}, Btu/(lb)(°R)
3100	820.03	1.05741	7712.4	13.8288	12.319	0.2940	3.328
3101	820.32	1.05751	7715.8	13.8299			
3102	820.62	1.05760	7719.1	13.8309			
3103	820.91	1.05770	7722.4	13.8320			
3104	821.21	1.05779	7725.7	13.8330			
3105	821.50	1.05789	7729.1	13.8341	12.325	.2940	3.330
3106	821.79	1.05798	7732.4	13.8351			
3107	822.09	1.05808	7735.7	13.8362			
3108	822.38	1.05817	7739.1	13.8372			
3109	822.68	1.05827	7742.4	13.8383			
3110	822.97	1.05836	7745.7	13.8393	12.331	.2941	3.332
3111	823.26	1.05845	7749.0	13.8404			
3112	823.56	1.05855	7752.4	13.8415			
3113	823.85	1.05864	7755.7	13.8425			
3114	824.14	1.05873	7759.0	13.8436			
3115	824.44	1.05883	7762.4	13.8447	12.337	.2941	3.334
3116	824.73	1.05892	7765.7	13.8457			
3117	825.03	1.05902	7769.0	13.8468			
3118	825.32	1.05911	7772.3	13.8479			
3119	825.62	1.05921	7775.7	13.8489			
3120	825.91	1.05930	7779.0	13.8500	12.343	.2942	3.337
3121	826.21	1.05940	7782.3	13.8511			
3122	826.50	1.05949	7785.7	13.8522			
3123	826.80	1.05959	7789.0	13.8533			
3124	827.09	1.05968	7792.3	13.8543			
3125	827.39	1.05978	7795.7	13.8554	12.349	.2942	3.339
3126	827.68	1.05987	7799.0	13.8565			
3127	827.98	1.05997	7802.3	13.8576			
3128	828.27	1.06006	7805.6	13.8587			
3129	828.57	1.06016	7809.0	13.8598			
3130	828.86	1.06025	7812.3	13.8609	12.354	.2943	3.341
3131	829.15	1.06034	7815.6	13.8619			
3132	829.45	1.06044	7819.0	13.8630			
3133	829.74	1.06053	7822.3	13.8641			
3134	830.03	1.06063	7825.6	13.8652			
3135	830.33	1.06072	7829.0	13.8663	12.360	.2943	3.344
3136	830.62	1.06082	7832.3	13.8674			
3137	830.92	1.06091	7835.7	13.8684			
3138	831.21	1.06100	7839.0	13.8695			
3139	831.51	1.06110	7842.3	13.8706			
3140	831.80	1.06119	7845.7	13.8717	12.366	.2944	3.346
3141	832.10	1.06128	7849.0	13.8727			
3142	832.39	1.06138	7852.3	13.8738			
3143	832.69	1.06147	7855.7	13.8749			
3144	832.98	1.06156	7859.0	13.8760			
3145	833.28	1.06166	7862.4	13.8770	12.372	.2944	3.348
3146	833.57	1.06175	7865.7	13.8781			
3147	833.87	1.06184	7869.1	13.8792			
3148	834.16	1.06193	7872.4	13.8802			
3149	834.46	1.06203	7875.7	13.8813			

TABLE II. - Continued. THERMODYNAMIC PROPERTIES OF AIR AT LOW PRESSURES, AND COMBUSTION-GAS VALUES OF ψ_h, ψ_φ, ω, $c_{p,a}$, AND ψ_{c_p} FOR COMBUSTION OF HYDROGEN WITH AIR

[T = 3000° to 4400° R.]

T, °R	h_a, Btu/lb air	φ_a, Btu/(lb)(°R)	ψ_h, Btu/lb	ψ_φ, Btu/(lb)(°R)	ω	$c_{p,a}$, Btu/(lb)(°R)	ψ_{c_p}, Btu/(lb)(°R)
3150	834.75	1.06212	7879.1	13.8824	12.377	0.2945	3.350
3151	835.04	1.06221	7882.4	13.8835			
3152	835.34	1.06231	7885.8	13.8845			
3153	835.63	1.06240	7889.1	13.8856			
3154	835.92	1.06249	7892.5	13.8867			
3155	836.22	1.06259	7895.8	13.8878	12.383	.2945	3.353
3156	836.51	1.06268	7899.2	13.8888			
3157	836.81	1.06277	7902.5	13.8899			
3158	837.10	1.06286	7905.8	13.8910			
3159	837.40	1.06296	7909.2	13.8920			
3160	837.69	1.06305	7912.5	13.8931	12.389	.2946	3.355
3161	837.99	1.06314	7915.9	13.8942			
3162	838.28	1.06324	7919.2	13.8953			
3163	838.58	1.06333	7922.6	13.8964			
3164	838.87	1.06342	7925.9	13.8975			
3165	839.17	1.06352	7929.3	13.8985	12.394	.2946	3.357
3166	839.46	1.06361	7932.6	13.8996			
3167	839.76	1.06370	7936.0	13.9007			
3168	840.05	1.06379	7939.3	13.9018			
3169	840.35	1.06389	7942.7	13.9028			
3170	840.64	1.06398	7946.0	13.9039	12.400	.2947	3.359
3171	840.94	1.06407	7949.4	13.9050			
3172	841.23	1.06417	7952.7	13.9061			
3173	841.53	1.06426	7956.1	13.9071			
3174	841.82	1.06435	7959.4	13.9082			
3175	842.12	1.06445	7962.8	13.9093	12.406	.2947	3.361
3176	842.41	1.06454	7966.1	13.9103			
3177	842.71	1.06463	7969.5	13.9114			
3178	843.00	1.06472	7972.8	13.9125			
3179	843.30	1.06482	7976.2	13.9135			
3180	843.59	1.06491	7979.6	13.9146	12.411	.2948	3.364
3181	843.88	1.06500	7982.9	13.9156			
3182	844.18	1.06510	7986.3	13.9167			
3183	844.47	1.06519	7989.6	13.9178			
3184	844.76	1.06528	7993.0	13.9188			
3185	845.06	1.06538	7996.4	13.9199	12.417	.2948	3.366
3186	845.35	1.06547	7999.7	13.9209			
3187	845.65	1.06556	8003.1	13.9220			
3188	845.94	1.06565	8006.4	13.9230			
3189	846.24	1.06575	8009.8	13.9241			
3190	846.53	1.06584	8013.2	13.9251	12.422	.2949	3.368
3191	846.83	1.06593	8016.5	13.9262			
3192	847.12	1.06602	8019.9	13.9272			
3193	847.42	1.06612	8023.2	13.9283			
3194	847.71	1.06621	8026.6	13.9293			
3195	848.01	1.06630	8030.0	13.9303	12.428	.2949	3.370
3196	848.30	1.06639	8033.3	13.9314			
3197	848.60	1.06648	8036.7	13.9324			
3198	848.89	1.06658	8040.1	13.9335			
3199	849.19	1.06667	8043.4	13.9345			

TABLE II. - Continued. THERMODYNAMIC PROPERTIES OF AIR AT LOW PRESSURES, AND COMBUSTION-GAS VALUES OF Ψ_h, Ψ_φ, ϖ, $c_{p,a}$, AND Ψ_{c_p} FOR COMBUSTION OF HYDROGEN WITH AIR

[T = 3000° to 4400° R]

T, °R	h_a, Btu/lb air	φ_a, Btu/(lb)(°R)	Ψ_h, Btu/lb	Ψ_φ, Btu/(lb)(°R)	ϖ	$c_{p,a}$, Btu/(lb)(°R)	Ψ_{c_p}, Btu/(lb)(°R)
3200	849.48	1.06676	8046.8	13.9355	12.433	0.2950	3.372
3201	849.78	1.06685	8050.1	13.9365			
3202	850.07	1.06694	8053.5	13.9376			
3203	850.37	1.06704	8056.9	13.9386			
3204	850.66	1.06713	8060.2	13.9396			
3205	850.96	1.06722	8063.6	13.9406	12.438	.2950	3.375
3206	851.25	1.06731	8067.0	13.9416			
3207	851.55	1.06740	8070.3	13.9426			
3208	851.84	1.06750	8073.7	13.9436			
3209	852.14	1.06759	8077.1	13.9447			
3210	852.43	1.06768	8080.4	13.9457	12.444	.2951	3.377
3211	852.73	1.06777	8083.8	13.9467			
3212	853.02	1.06786	8087.2	13.9477			
3213	853.32	1.06796	8090.5	13.9488			
3214	853.61	1.06805	8093.9	13.9498			
3215	853.91	1.06814	8097.3	13.9508	12.449	.2951	3.379
3216	854.20	1.06823	8100.6	13.9519			
3217	854.50	1.06832	8104.0	13.9529			
3218	854.79	1.06842	8107.4	13.9539			
3219	855.09	1.06851	8110.8	13.9550			
3220	855.38	1.06860	8114.1	13.9560	12.454	.2952	3.381
3221	855.68	1.06869	8117.5	13.9571			
3222	855.97	1.06878	8120.9	13.9581			
3223	856.27	1.06888	8124.3	13.9592			
3224	856.56	1.06897	8127.7	13.9603			
3225	856.86	1.06906	8131.1	13.9613	12.459	.2952	3.383
3226	857.15	1.06915	8134.4	13.9624			
3227	857.45	1.06925	8137.8	13.9635			
3228	857.74	1.06934	8141.2	13.9645			
3229	858.04	1.06943	8144.6	13.9656			
3230	858.33	1.06952	8148.0	13.9666	12.464	.2953	3.385
3231	858.62	1.06961	8151.4	13.9677			
3232	858.92	1.06970	8154.7	13.9688			
3233	859.21	1.06979	8158.1	13.9698			
3234	859.51	1.06988	8161.5	13.9709			
3235	859.80	1.06998	8164.9	13.9719	12.470	.2953	3.387
3236	860.10	1.07007	8168.3	13.9730			
3237	860.39	1.07016	8171.7	13.9741			
3238	860.69	1.07025	8175.0	13.9751			
3239	860.98	1.07034	8178.4	13.9762			
3240	861.28	1.07043	8181.8	13.9773	12.475	.2954	3.389
3241	861.58	1.07052	8185.2	13.9783			
3242	861.87	1.07061	8188.6	13.9794			
3243	862.17	1.07070	8192.0	13.9805			
3244	862.47	1.07080	8195.3	13.9815			
3245	862.76	1.07089	8198.7	13.9826	12.480	.2954	3.392
3246	863.06	1.07098	8202.1	13.9837			
3247	863.35	1.07107	8205.5	13.9847			
3248	863.65	1.07116	8208.9	13.9858			
3249	863.94	1.07125	8212.2	13.9869			

TABLE II. - Continued. THERMODYNAMIC PROPERTIES OF AIR AT LOW PRESSURES, AND COMBUSTION-GAS VALUES OF Ψ_h, Ψ_φ, ω, $c_{p,a}$, AND Ψ_{c_p} FOR COMBUSTION OF HYDROGEN WITH AIR

[T = 3000° to 4400° R.]

T, °R	h_a, Btu/lb air	φ_a, Btu/(lb)(°R)	Ψ_h, Btu/lb	Ψ_φ, Btu/(lb)(°R)	ω	$c_{p,a}$, Btu/(lb)(°R)	Ψ_{c_p}, Btu/(lb)(°R)
3250	864.24	1.07134	8215.6	13.9879	12.485	0.2955	3.394
3251	864.53	1.07143	8219.0	13.9890			
3252	864.83	1.07152	8222.4	13.9900			
3253	865.12	1.07161	8225.8	13.9911			
3254	865.42	1.07170	8229.2	13.9922			
3255	865.71	1.07179	8232.6	13.9932	12.490	.2955	3.396
3256	866.01	1.07188	8236.0	13.9943			
3257	866.30	1.07197	8239.3	13.9953			
3258	866.60	1.07206	8242.7	13.9964			
3259	866.89	1.07215	8246.1	13.9975			
3260	867.19	1.07224	8249.5	13.9985	12.496	.2956	3.398
3261	867.49	1.07233	8252.9	13.9996			
3262	867.78	1.07242	8256.3	14.0006			
3263	868.08	1.07251	8259.7	14.0017			
3264	868.37	1.07261	8263.1	14.0027			
3265	868.67	1.07270	8266.5	14.0038	12.501	.2956	3.400
3266	868.97	1.07279	8269.9	14.0048			
3267	869.26	1.07288	8273.2	14.0059			
3268	869.56	1.07297	8276.6	14.0069			
3269	869.85	1.07306	8280.0	14.0080			
3270	870.15	1.07315	8283.4	14.0090	12.506	.2957	3.402
3271	870.45	1.07324	8286.8	14.0101			
3272	870.74	1.07333	8290.2	14.0111			
3273	871.04	1.07342	8293.6	14.0122			
3274	871.34	1.07351	8297.0	14.0132			
3275	871.63	1.07360	8300.4	14.0143	12.511	.2957	3.404
3276	871.93	1.07369	8303.8	14.0153			
3277	872.22	1.07378	8307.2	14.0164			
3278	872.52	1.07387	8310.6	14.0174			
3279	872.81	1.07396	8314.0	14.0185			
3280	873.11	1.07405	8317.4	14.0195	12.516	.2958	3.406
3281	873.40	1.07414	8320.8	14.0206			
3282	873.70	1.07423	8324.2	14.0216			
3283	873.99	1.07432	8327.6	14.0226			
3284	874.29	1.07441	8331.0	14.0237			
3285	874.58	1.07450	8334.4	14.0247	12.521	.2958	3.408
3286	874.88	1.07459	8337.8	14.0257			
3287	875.17	1.07468	8341.2	14.0268			
3288	875.47	1.07477	8344.6	14.0278			
3289	875.76	1.07486	8348.0	14.0288			
3290	876.06	1.07495	8351.4	14.0299	12.527	.2959	3.410
3291	876.36	1.07504	8354.9	14.0309			
3292	876.65	1.07513	8358.3	14.0320			
3293	876.95	1.07522	8361.7	14.0330			
3294	877.24	1.07531	8365.1	14.0340			
3295	877.54	1.07540	8368.5	14.0351	12.532	.2959	3.412
3296	877.84	1.07549	8371.9	14.0361			
3297	878.13	1.07558	8375.3	14.0372			
3298	878.43	1.07567	8378.7	14.0382			
3299	878.72	1.07576	8382.1	14.0392			

TABLE II. - Continued. THERMODYNAMIC PROPERTIES OF AIR AT LOW PRESSURES, AND COMBUSTION-GAS VALUES OF ψ_h, ψ_φ, ω, $c_{p,a}$, AND ψ_{c_p} FOR COMBUSTION OF HYDROGEN WITH AIR

[T = 3000° to 4400° R.]

T, °R	h_a, Btu/lb air	φ_a, Btu/(lb)(°R)	ψ_h, Btu/lb	ψ_φ, Btu/(lb)(°R)	ω	$c_{p,a}$, Btu/(lb)(°R)	ψ_{c_p}, Btu/(lb)(°R)
3300	879.02	1.07585	8385.5	14.0403	12.537	0.2960	3.415
3301	879.32	1.07594	8388.9	14.0414			
3302	879.61	1.07603	8392.3	14.0424			
3303	879.91	1.07612	8395.7	14.0435			
3304	880.20	1.07621	8399.1	14.0445			
3305	880.50	1.07630	8402.6	14.0456	12.542	.2960	3.417
3306	880.80	1.07639	8406.0	14.0467			
3307	881.09	1.07648	8409.4	14.0477			
3308	881.39	1.07657	8412.8	14.0488			
3309	881.68	1.07666	8416.2	14.0498			
3310	881.98	1.07675	8419.6	14.0509	12.547	.2960	3.419
3311	882.28	1.07684	8423.0	14.0519			
3312	882.57	1.07693	8426.4	14.0530			
3313	882.87	1.07702	8429.8	14.0540			
3314	883.16	1.07711	8433.3	14.0551			
3315	883.46	1.07720	8436.7	14.0561	12.553	.2961	3.421
3316	883.76	1.07728	8440.1	14.0572			
3317	884.05	1.07737	8443.5	14.0582			
3318	884.35	1.07746	8446.9	14.0592			
3319	884.64	1.07755	8450.3	14.0603			
3320	884.94	1.07764	8453.7	14.0613	12.558	.2961	3.423
3321	885.24	1.07773	8457.1	14.0624			
3322	885.53	1.07782	8460.6	14.0634			
3323	885.83	1.07791	8464.0	14.0644			
3324	886.12	1.07800	8467.4	14.0655			
3325	886.42	1.07809	8470.8	14.0665	12.563	.2962	3.425
3326	886.72	1.07817	8474.2	14.0675			
3327	887.01	1.07826	8477.7	14.0686			
3328	887.31	1.07835	8481.1	14.0696			
3329	887.60	1.07844	8484.5	14.0706			
3330	887.90	1.07853	8487.9	14.0716	12.568	.2962	3.427
3331	888.20	1.07862	8491.3	14.0727			
3332	888.49	1.07871	8494.7	14.0737			
3333	888.79	1.07880	8498.2	14.0747			
3334	889.08	1.07889	8501.6	14.0757			
3335	889.38	1.07898	8505.0	14.0768	12.574	.2963	3.429
3336	889.67	1.07906	8508.4	14.0778			
3337	889.97	1.07915	8511.9	14.0788			
3338	890.27	1.07924	8515.3	14.0798			
3339	890.56	1.07933	8518.7	14.0808			
3340	890.86	1.07942	8522.1	14.0819	12.579	.2963	3.431
3341	891.16	1.07951	8525.5	14.0829			
3342	891.45	1.07960	8529.0	14.0839			
3343	891.75	1.07969	8532.4	14.0849			
3344	892.05	1.07978	8535.8	14.0859			
3345	892.35	1.07987	8539.2	14.0868	12.584	.2964	3.433
3346	892.64	1.07996	8542.7	14.0878			
3347	892.94	1.08004	8546.1	14.0888			
3348	893.24	1.08013	8549.5	14.0899			
3349	893.53	1.08022	8552.9	14.0909			

TABLE II. - Continued. THERMODYNAMIC PROPERTIES OF AIR AT LOW PRESSURES, AND COMBUSTION-GAS VALUES OF ψ_h, ψ_φ, α, $c_{p,a}$, AND ψ_{c_p} FOR COMBUSTION OF HYDROGEN WITH AIR

[T = 3000° to 4400° R]

T, °R	h_a, Btu/lb air	φ_a, Btu/(lb)(°R)	ψ_h, Btu/lb	ψ_φ, Btu/(lb)(°R)	α	$c_{p,a}$, Btu/(lb)(°R)	ψ_{c_p}, Btu/(lb)(°R)
3350	893.83	1.08031	8556.4	14.0919	12.589	0.2964	3.435
3351	894.13	1.08040	8559.8	14.0929			
3352	894.42	1.08049	8563.2	14.0939			
3353	894.72	1.08057	8566.6	14.0949			
3354	895.02	1.08066	8570.1	14.0959			
3355	895.32	1.08075	8573.5	14.0969	12.594	.2964	3.437
3356	895.61	1.08084	8576.9	14.0979			
3357	895.91	1.08093	8580.4	14.0989			
3358	896.21	1.08101	8583.8	14.0999			
3359	896.50	1.08110	8587.2	14.1009			
3360	896.80	1.08119	8590.7	14.1019	12.599	.2965	3.439
3361	897.10	1.08128	8594.1	14.1029			
3362	897.39	1.08137	8597.5	14.1039			
3363	897.69	1.08145	8601.0	14.1049			
3364	897.99	1.08154	8604.4	14.1059			
3365	898.29	1.08163	8607.8	14.1069	12.604	.2965	3.441
3366	898.58	1.08172	8611.3	14.1080			
3367	898.88	1.08181	8614.7	14.1090			
3368	899.18	1.08189	8618.1	14.1100			
3369	899.47	1.08198	8621.6	14.1110			
3370	899.77	1.08207	8625.0	14.1120	12.609	.2966	3.443
3371	900.07	1.08216	8628.4	14.1130			
3372	900.36	1.08225	8631.9	14.1140			
3373	900.66	1.08233	8635.3	14.1151			
3374	900.95	1.08242	8638.8	14.1161			
3375	901.25	1.08251	8642.2	14.1171	12.614	.2966	3.445
3376	901.55	1.08260	8645.6	14.1181			
3377	901.84	1.08269	8649.1	14.1191			
3378	902.14	1.08277	8652.5	14.1202			
3379	902.43	1.08286	8655.9	14.1212			
3380	902.73	1.08295	8659.4	14.1222	12.619	.2967	3.447
3381	903.03	1.08304	8662.8	14.1233			
3382	903.32	1.08313	8666.3	14.1243			
3383	903.62	1.08322	8669.7	14.1254			
3384	903.91	1.08330	8673.1	14.1264			
3385	904.21	1.08339	8676.6	14.1275	12.624	.2967	3.449
3386	904.50	1.08348	8680.0	14.1285			
3387	904.80	1.08357	8683.5	14.1295			
3388	905.10	1.08365	8686.9	14.1306			
3389	905.39	1.08374	8690.3	14.1316			
3390	905.69	1.08383	8693.8	14.1327	12.629	.2968	3.451
3391	905.99	1.08392	8697.2	14.1337			
3392	906.28	1.08400	8700.7	14.1348			
3393	906.58	1.08409	8704.1	14.1358			
3394	906.88	1.08418	8707.6	14.1368			
3395	907.17	1.08426	8711.0	14.1379	12.634	.2968	3.453
3396	907.47	1.08435	8714.4	14.1389			
3397	907.77	1.08444	8717.9	14.1399			
3398	908.07	1.08453	8721.3	14.1410			
3399	908.36	1.08461	8724.8	14.1420			

TABLE II. - Continued. THERMODYNAMIC PROPERTIES OF AIR AT LOW PRESSURES, AND COMBUSTION-GAS VALUES OF Ψ_h, Ψ_φ, ϖ, $c_{p,a}$, AND Ψ_{c_p} FOR COMBUSTION OF HYDROGEN WITH AIR

[T = 3000° to 4400° R.]

T, °R	h_a, Btu/lb air	φ_a, Btu/(lb)(°R)	Ψ_h, Btu/lb	Ψ_φ, Btu/(lb)(°R)	ϖ	$c_{p,a}$, Btu/(lb)(°R)	Ψ_{c_p}, Btu/(lb)(°R)
3400	908.66	1.08470	8728.2	14.1430	12.638	0.2969	3.455
3401	908.96	1.08479	8731.7	14.1441			
3402	909.26	1.08488	8735.1	14.1451			
3403	909.56	1.08497	8738.6	14.1462			
3404	909.85	1.08505	8742.0	14.1472			
3405	910.15	1.08514	8745.5	14.1483	12.643	.2969	3.457
3406	910.45	1.08523	8748.9	14.1493			
3407	910.75	1.08532	8752.4	14.1503			
3408	911.04	1.08540	8755.8	14.1514			
3409	911.34	1.08549	8759.3	14.1524			
3410	911.64	1.08558	8762.7	14.1534	12.648	.2969	3.459
3411	911.94	1.08567	8766.2	14.1545			
3412	912.23	1.08575	8769.6	14.1555			
3413	912.53	1.08584	8773.1	14.1565			
3414	912.83	1.08593	8776.6	14.1575			
3415	913.13	1.08602	8780.0	14.1585	12.652	.2970	3.461
3416	913.42	1.08610	8783.5	14.1596			
3417	913.72	1.08619	8786.9	14.1606			
3418	914.02	1.08628	8790.4	14.1616			
3419	914.31	1.08636	8793.8	14.1626			
3420	914.61	1.08645	8797.3	14.1636	12.657	.2970	3.463
3421	914.91	1.08654	8800.7	14.1646			
3422	915.20	1.08662	8804.2	14.1656			
3423	915.50	1.08671	8807.6	14.1665			
3424	915.80	1.08680	8811.1	14.1675			
3425	916.10	1.08689	8814.5	14.1685	12.662	.2971	3.465
3426	916.39	1.08697	8818.0	14.1695			
3427	916.69	1.08706	8821.4	14.1705			
3428	916.99	1.08715	8824.9	14.1715			
3429	917.28	1.08723	8828.4	14.1725			
3430	917.58	1.08732	8831.8	14.1734	12.666	.2971	3.467
3431	917.88	1.08741	8835.3	14.1744			
3432	918.17	1.08749	8838.7	14.1754			
3433	918.47	1.08758	8842.2	14.1764			
3434	918.77	1.08766	8845.6	14.1774			
3435	919.07	1.08775	8849.1	14.1784	12.671	.2972	3.468
3436	919.36	1.08784	8852.6	14.1794			
3437	919.66	1.08792	8856.0	14.1804			
3438	919.96	1.08801	8859.5	14.1814			
3439	920.25	1.08809	8862.9	14.1825			
3440	920.55	1.08818	8866.4	14.1835	12.675	.2972	3.470
3441	920.85	1.08827	8869.9	14.1845			
3442	921.14	1.08835	8873.3	14.1856			
3443	921.44	1.08844	8876.8	14.1866			
3444	921.74	1.08852	8880.3	14.1876			
3445	922.03	1.08861	8883.7	14.1887	12.680	.2973	3.472
3446	922.33	1.08870	8887.2	14.1897			
3447	922.63	1.08878	8890.7	14.1908			
3448	922.93	1.08887	8894.1	14.1918			
3449	923.22	1.08895	8897.6	14.1928			

TABLE II. - Continued. THERMODYNAMIC PROPERTIES OF AIR AT LOW PRESSURES, AND COMBUSTION-GAS VALUES OF ψ_h, ψ_φ, ω, $c_{p,a}$, AND ψ_{c_p} FOR COMBUSTION OF HYDROGEN WITH AIR

[T = 3000° to 4400° R.]

T, °R	h_a, Btu/lb air	φ_a, Btu/(lb)(°R)	ψ_h, Btu/lb	ψ_φ, Btu/(lb)(°R)	ω	$c_{p,a}$, Btu/(lb)(°R)	ψ_{c_p}, Btu/(lb)(°R)
3450	923.52	1.08904	8901.1	14.1939	12.684	0.2973	3.474
3451	923.82	1.08913	8904.6	14.1949			
3452	924.12	1.08921	8908.0	14.1959			
3453	924.41	1.08930	8911.5	14.1969			
3454	924.71	1.08938	8915.0	14.1980			
3455	925.01	1.08947	8918.4	14.1990	12.689	.2974	3.476
3456	925.31	1.08956	8921.9	14.2000			
3457	925.61	1.08964	8925.4	14.2010			
3458	925.90	1.08973	8928.8	14.2020			
3459	926.20	1.08981	8932.3	14.2031			
3460	926.50	1.08990	8935.8	14.2041	12.694	.2974	3.478
3461	926.80	1.08999	8939.3	14.2051			
3462	927.10	1.09007	8942.7	14.2061			
3463	927.40	1.09016	8946.2	14.2071			
3464	927.69	1.09024	8949.7	14.2081			
3465	927.99	1.09033	8953.1	14.2091	12.698	.2974	3.480
3466	928.29	1.09042	8956.6	14.2100			
3467	928.59	1.09050	8960.1	14.2110			
3468	928.88	1.09059	8963.6	14.2120			
3469	929.18	1.09067	8967.0	14.2130			
3470	929.48	1.09076	8970.5	14.2140	12.703	.2975	3.482
3471	929.78	1.09085	8974.0	14.2150			
3472	930.07	1.09093	8977.5	14.2160			
3473	930.37	1.09102	8980.9	14.2170			
3474	930.67	1.09111	8984.4	14.2180			
3475	930.97	1.09119	8987.9	14.2190	12.707	.2975	3.484
3476	931.26	1.09128	8991.4	14.2200			
3477	931.56	1.09136	8994.8	14.2210			
3478	931.86	1.09145	8998.3	14.2220			
3479	932.15	1.09153	9001.8	14.2229			
3480	932.45	1.09162	9005.3	14.2239	12.712	.2976	3.485
3481	932.75	1.09171	9008.8	14.2249			
3482	933.04	1.09179	9012.2	14.2259			
3483	933.34	1.09188	9015.7	14.2268			
3484	933.64	1.09196	9019.2	14.2278			
3485	933.93	1.09205	9022.7	14.2288	12.716	.2976	3.487
3486	934.23	1.09213	9026.1	14.2298			
3487	934.53	1.09222	9029.6	14.2307			
3488	934.83	1.09230	9033.1	14.2317			
3489	935.12	1.09239	9036.6	14.2327			
3490	935.42	1.09247	9040.1	14.2337	12.721	.2977	3.489
3491	935.72	1.09256	9043.5	14.2347			
3492	936.02	1.09264	9047.0	14.2356			
3493	936.31	1.09273	9050.5	14.2366			
3494	936.61	1.09281	9054.0	14.2376			
3495	936.91	1.09290	9057.5	14.2386	12.726	.2977	3.491
3496	937.21	1.09298	9060.9	14.2396			
3497	937.51	1.09307	9064.4	14.2406			
3498	937.80	1.09315	9067.9	14.2416			
3499	938.10	1.09324	9071.4	14.2426			

TABLE II. - Continued. THERMODYNAMIC PROPERTIES OF AIR AT LOW PRESSURES, AND COMBUSTION-GAS VALUES OF ψ_h, ψ_φ, ω, $c_{p,a}$, AND ψ_{c_p} FOR COMBUSTION OF HYDROGEN WITH AIR

[T = 3000° to 4400° R.]

T, °R	h_a, Btu/lb air	φ_a, Btu/(lb)(°R)	ψ_h, Btu/lb	ψ_φ, Btu/(lb)(°R)	ω	$c_{p,a}$, Btu/(lb)(°R)	ψ_{c_p}, Btu/(lb)(°R)
3500	938.40	1.09332	9074.9	14.2436	12.730	0.2978	3.493
3501	938.70	1.09341	9078.4	14.2446			
3502	939.00	1.09349	9081.8	14.2456			
3503	939.29	1.09358	9085.3	14.2466			
3504	939.59	1.09366	9088.8	14.2476			
3505	939.89	1.09375	9092.3	14.2486	12.735	.2978	3.495
3506	940.19	1.09383	9095.8	14.2496			
3507	940.49	1.09392	9099.3	14.2506			
3508	940.78	1.09400	9102.8	14.2516			
3509	941.08	1.09409	9106.3	14.2526			
3510	941.38	1.09417	9109.7	14.2536	12.739	.2978	3.497
3511	941.68	1.09426	9113.2	14.2546			
3512	941.98	1.09434	9116.7	14.2556			
3513	942.27	1.09443	9120.2	14.2566			
3514	942.57	1.09451	9123.7	14.2576			
3515	942.87	1.09460	9127.2	14.2586	12.744	.2979	3.498
3516	943.17	1.09468	9130.7	14.2597			
3517	943.47	1.09477	9134.2	14.2607			
3518	943.76	1.09485	9137.7	14.2617			
3519	944.06	1.09494	9141.2	14.2627			
3520	944.36	1.09502	9144.7	14.2637	12.749	.2979	3.500
3521	944.66	1.09511	9148.2	14.2647			
3522	944.96	1.09519	9151.6	14.2657			
3523	945.25	1.09528	9155.1	14.2667			
3524	945.55	1.09536	9158.6	14.2677			
3525	945.85	1.09545	9162.1	14.2687	12.753	.2980	3.502
3526	946.15	1.09553	9165.6	14.2697			
3527	946.45	1.09562	9169.1	14.2708			
3528	946.74	1.09570	9172.6	14.2718			
3529	947.04	1.09579	9176.1	14.2728			
3530	947.34	1.09587	9179.6	14.2738	12.758	.2980	3.504
3531	947.64	1.09595	9183.1	14.2748			
3532	947.94	1.09604	9186.6	14.2758			
3533	948.23	1.09612	9190.1	14.2768			
3534	948.53	1.09621	9193.6	14.2778			
3535	948.83	1.09629	9197.1	14.2788	12.762	.2980	3.506
3536	949.13	1.09637	9200.6	14.2798			
3537	949.43	1.09646	9204.1	14.2808			
3538	949.72	1.09654	9207.6	14.2818			
3539	950.02	1.09663	9211.1	14.2828			
3540	950.32	1.09671	9214.6	14.2838	12.767	.2981	3.508
3541	950.62	1.09679	9218.1	14.2848			
3542	950.92	1.09688	9221.6	14.2858			
3543	951.21	1.09696	9225.1	14.2868			
3544	951.51	1.09705	9228.6	14.2878			
3545	951.81	1.09713	9232.1	14.2888	12.771	.2981	3.509
3546	952.11	1.09722	9235.6	14.2898			
3547	952.41	1.09730	9239.1	14.2908			
3548	952.70	1.09738	9242.6	14.2918			
3549	953.00	1.09747	9246.1	14.2928			

TABLE II. - Continued. THERMODYNAMIC PROPERTIES OF AIR AT LOW PRESSURES, AND COMBUSTION-GAS VALUES OF Ψ_h, Ψ_φ, ϖ, $c_{p,a}$, AND Ψ_{c_p} FOR COMBUSTION OF HYDROGEN WITH AIR

[T = 3000° to 4400° R.]

T, °R	h_a, Btu/lb air	φ_a, Btu/(lb)(°R)	Ψ_h, Btu/lb	Ψ_φ, Btu/(lb)(°R)	ϖ	$c_{p,a}$, Btu/(lb)(°R)	Ψ_{c_p}, Btu/(lb)(°R)
3550	953.30	1.09755	9249.6	14.2938	12.776	0.2982	3.511
3551	953.60	1.09763	9253.1	14.2948			
3552	953.90	1.09772	9256.6	14.2958			
3553	954.19	1.09780	9260.1	14.2968			
3554	954.49	1.09788	9263.6	14.2978			
3555	954.79	1.09796	9267.1	14.2987	12.780	.2982	3.513
3556	955.09	1.09805	9270.6	14.2997			
3557	955.39	1.09813	9274.1	14.3007			
3558	955.68	1.09821	9277.6	14.3017			
3559	955.98	1.09830	9281.1	14.3027			
3560	956.28	1.09838	9284.6	14.3037	12.785	.2982	3.515
3561	956.58	1.09846	9288.1	14.3047			
3562	956.88	1.09855	9291.6	14.3057			
3563	957.17	1.09863	9295.2	14.3067			
3564	957.47	1.09872	9298.7	14.3077			
3565	957.77	1.09880	9302.2	14.3087	12.789	.2983	3.517
3566	958.07	1.09889	9305.7	14.3097			
3567	958.36	1.09897	9309.2	14.3107			
3568	958.66	1.09905	9312.7	14.3117			
3569	958.96	1.09914	9316.2	14.3127			
3570	959.26	1.09922	9319.7	14.3137	12.794	.2983	3.518
3571	959.56	1.09930	9323.2	14.3147			
3572	959.86	1.09939	9326.7	14.3157			
3573	960.16	1.09947	9330.3	14.3167			
3574	960.46	1.09955	9333.8	14.3177			
3575	960.76	1.09963	9337.3	14.3187	12.798	.2984	3.520
3576	961.06	1.09972	9340.8	14.3197			
3577	961.35	1.09980	9344.3	14.3207			
3578	961.65	1.09988	9347.8	14.3217			
3579	961.95	1.09997	9351.3	14.3226			
3580	962.25	1.10005	9354.8	14.3236	12.802	.2984	3.522
3581	962.55	1.10013	9358.4	14.3246			
3582	962.85	1.10022	9361.9	14.3256			
3583	963.14	1.10030	9365.4	14.3266			
3584	963.44	1.10039	9368.9	14.3276			
3585	963.74	1.10047	9372.4	14.3286	12.807	.2984	3.524
3586	964.04	1.10056	9375.9	14.3296			
3587	964.34	1.10064	9379.4	14.3305			
3588	964.63	1.10072	9383.0	14.3315			
3589	964.93	1.10081	9386.5	14.3325			
3590	965.23	1.10089	9390.0	14.3335	12.811	.2985	3.526
3591	965.53	1.10097	9393.5	14.3345			
3592	965.83	1.10106	9397.0	14.3355			
3593	966.12	1.10114	9400.5	14.3364			
3594	966.42	1.10122	9404.1	14.3374			
3595	966.72	1.10131	9407.6	14.3384	12.815	.2985	3.527
3596	967.02	1.10139	9411.1	14.3394			
3597	967.31	1.10147	9414.6	14.3404			
3598	967.61	1.10155	9418.1	14.3413			
3599	967.91	1.10164	9421.7	14.3423			

TABLE II. - Continued. THERMODYNAMIC PROPERTIES OF AIR AT LOW PRESSURES, AND COMBUSTION-GAS VALUES OF ψ_h, ψ_φ, ω, $c_{p,a}$, AND ψ_{c_p} FOR COMBUSTION OF HYDROGEN WITH AIR

[T = 3000° to 4400° R]

T, °R	h_a, Btu/lb air	φ_a, Btu/(lb)(°R)	ψ_h, Btu/lb	ψ_φ, Btu/(lb)(°R)	ω	$c_{p,a}$, Btu/(lb)(°R)	ψ_{c_p}, Btu/(lb)(°R)
3600	968.21	1.10172	9425.2	14.3433	12.820	0.2986	3.529
3601	968.51	1.10180	9428.7	14.3443			
3602	968.81	1.10189	9432.2	14.3452			
3603	969.11	1.10197	9435.7	14.3462			
3604	969.41	1.10205	9439.3	14.3472			
3605	969.71	1.10214	9442.8	14.3481	12.824	.2986	3.531
3606	970.01	1.10222	9446.3	14.3491			
3607	970.30	1.10230	9449.8	14.3501			
3608	970.60	1.10238	9453.4	14.3510			
3609	970.90	1.10247	9456.9	14.3520			
3610	971.20	1.10255	9460.4	14.3530	12.828	.2986	3.533
3611	971.50	1.10263	9463.9	14.3539			
3612	971.80	1.10271	9467.5	14.3549			
3613	972.09	1.10280	9471.0	14.3559			
3614	972.39	1.10288	9474.5	14.3569			
3615	972.69	1.10296	9478.1	14.3578	12.832	.2987	3.534
3616	972.99	1.10304	9481.6	14.3588			
3617	973.28	1.10312	9485.1	14.3598			
3618	973.58	1.10321	9488.6	14.3608			
3619	973.88	1.10329	9492.2	14.3617			
3620	974.18	1.10337	9495.7	14.3627	12.836	.2987	3.536
3621	974.48	1.10345	9499.2	14.3637			
3622	974.78	1.10354	9502.7	14.3647			
3623	975.08	1.10362	9506.3	14.3657			
3624	975.38	1.10370	9509.8	14.3667			
3625	975.68	1.10379	9513.3	14.3677	12.840	.2988	3.538
3626	975.97	1.10387	9516.9	14.3686			
3627	976.27	1.10395	9520.4	14.3696			
3628	976.57	1.10403	9523.9	14.3706			
3629	976.87	1.10412	9527.4	14.3716			
3630	977.17	1.10420	9531.0	14.3726	12.845	.2988	3.539
3631	977.47	1.10428	9534.5	14.3736			
3632	977.77	1.10436	9538.0	14.3746			
3633	978.07	1.10445	9541.6	14.3755			
3634	978.37	1.10453	9545.1	14.3765			
3635	978.67	1.10461	9548.6	14.3775	12.849	.2988	3.541
3636	978.96	1.10469	9552.2	14.3785			
3637	979.26	1.10477	9555.7	14.3795			
3638	979.56	1.10486	9559.2	14.3804			
3639	979.86	1.10494	9562.8	14.3814			
3640	980.16	1.10502	9566.3	14.3824	12.853	.2989	3.543
3641	980.46	1.10510	9569.8	14.3834			
3642	980.76	1.10518	9573.4	14.3844			
3643	981.06	1.10527	9576.9	14.3853			
3644	981.36	1.10535	9580.4	14.3863			
3645	981.66	1.10543	9584.0	14.3873	12.857	.2989	3.545
3646	981.95	1.10551	9587.5	14.3883			
3647	982.25	1.10560	9591.1	14.3892			
3648	982.55	1.10568	9594.6	14.3902			
3649	982.85	1.10576	9598.1	14.3912			

TABLE II. - Continued. THERMODYNAMIC PROPERTIES OF AIR AT LOW PRESSURES, AND COMBUSTION-GAS VALUES OF ψ_h, ψ_φ, ω, $c_{p,a}$, AND ψ_{c_p} FOR COMBUSTION OF HYDROGEN WITH AIR

[T = 3000° to 4400° R]

T, °R	h_a, Btu/lb air	φ_a, Btu/(lb)(°R)	ψ_h, Btu/lb	ψ_φ, Btu/(lb)(°R)	ω	$c_{p,a}$, Btu/(lb)(°R)	ψ_{c_p}, Btu/(lb)(°R)
3650	983.15	1.10584	9601.7	14.3922	12.861	0.2990	3.546
3651	983.45	1.10592	9605.2	14.3931			
3652	983.75	1.10600	9608.8	14.3941			
3653	984.05	1.10608	9612.3	14.3951			
3654	984.35	1.10616	9615.8	14.3960			
3655	984.65	1.10624	9619.4	14.3970	12.865	.2990	3.548
3656	984.94	1.10632	9622.9	14.3980			
3657	985.24	1.10641	9626.5	14.3990			
3658	985.54	1.10649	9630.0	14.3999			
3659	985.84	1.10657	9633.5	14.4009			
3660	986.14	1.10665	9637.1	14.4019	12.869	.2990	3.550
3661	986.44	1.10673	9640.6	14.4028			
3662	986.74	1.10681	9644.2	14.4038			
3663	987.04	1.10690	9647.7	14.4047			
3664	987.34	1.10698	9651.3	14.4057			
3665	987.64	1.10706	9654.8	14.4066	12.873	.2991	3.551
3666	987.93	1.10714	9658.3	14.4076			
3667	988.23	1.10723	9661.9	14.4085			
3668	988.53	1.10731	9665.4	14.4095			
3669	988.83	1.10739	9669.0	14.4105			
3670	989.13	1.10747	9672.5	14.4114	12.877	.2991	3.553
3671	989.43	1.10755	9676.1	14.4124			
3672	989.73	1.10763	9679.6	14.4133			
3673	990.03	1.10771	9683.2	14.4143			
3674	990.33	1.10779	9686.7	14.4153			
3675	990.63	1.10787	9690.3	14.4162	12.881	.2992	3.555
3676	990.92	1.10795	9693.8	14.4172			
3677	991.22	1.10804	9697.3	14.4182			
3678	991.52	1.10812	9700.9	14.4191			
3679	991.82	1.10820	9704.4	14.4201			
3680	992.12	1.10828	9708.0	14.4211	12.885	.2992	3.556
3681	992.42	1.10836	9711.5	14.4220			
3682	992.72	1.10844	9715.1	14.4230			
3683	993.02	1.10853	9718.6	14.4240			
3684	993.31	1.10861	9722.2	14.4249			
3685	993.61	1.10869	9725.7	14.4259	12.889	.2992	3.558
3686	993.91	1.10877	9729.3	14.4269			
3687	994.21	1.10886	9732.8	14.4279			
3688	994.51	1.10894	9736.4	14.4288			
3689	994.81	1.10902	9739.9	14.4298			
3690	995.11	1.10910	9743.4	14.4308	12.893	.2993	3.560
3691	995.41	1.10918	9747.0	14.4318			
3692	995.71	1.10926	9750.5	14.4327			
3693	996.01	1.10934	9754.1	14.4337			
3694	996.31	1.10943	9757.6	14.4347			
3695	996.61	1.10951	9761.2	14.4356	12.897	.2993	3.561
3696	996.91	1.10959	9764.7	14.4366			
3697	997.21	1.10967	9768.3	14.4376			
3698	997.51	1.10975	9771.9	14.4386			
3699	997.81	1.10983	9775.4	14.4395			

TABLE II. - Continued. THERMODYNAMIC PROPERTIES OF AIR AT LOW PRESSURES, AND COMBUSTION-GAS VALUES OF Ψ_h, Ψ_φ, ω, $c_{p,a}$, AND Ψ_{c_p} FOR COMBUSTION OF HYDROGEN WITH AIR

[T = 3000° to 4400° R.]

T, °R	h_a, Btu/lb air	φ_a, Btu/(lb)(°R)	Ψ_h, Btu/lb	Ψ_φ, Btu/(lb)(°R)	ω	$c_{p,a}$, Btu/(lb)(°R)	Ψ_{c_p}, Btu/(lb)(°R)
3700	998.11	1.10991	9779.0	14.4405	12.901	0.2994	3.563
3701	998.41	1.10999	9782.5	14.4415			
3702	998.71	1.11007	9786.1	14.4425			
3703	999.01	1.11015	9789.6	14.4434			
3704	999.31	1.11023	9793.2	14.4444			
3705	999.61	1.11031	9796.7	14.4454	12.906	.2994	3.565
3706	999.91	1.11039	9800.3	14.4464			
3707	1000.21	1.11047	9803.8	14.4474			
3708	1000.51	1.11055	9807.4	14.4483			
3709	1000.81	1.11063	9810.9	14.4493			
3710	1001.11	1.11071	9814.5	14.4503	12.910	.2994	3.566
3711	1001.41	1.11079	9818.1	14.4512			
3712	1001.71	1.11087	9821.6	14.4522			
3713	1002.01	1.11095	9825.2	14.4532			
3714	1002.30	1.11103	9828.7	14.4542			
3715	1002.60	1.11112	9832.3	14.4551	12.914	.2995	3.568
3716	1002.90	1.11120	9835.9	14.4561			
3717	1003.20	1.11128	9839.4	14.4571			
3718	1003.50	1.11136	9843.0	14.4580			
3719	1003.80	1.11144	9846.5	14.4590			
3720	1004.10	1.11152	9850.1	14.4600	12.918	.2995	3.569
3721	1004.40	1.11160	9853.7	14.4610			
3722	1004.70	1.11168	9857.2	14.4619			
3723	1005.00	1.11176	9860.8	14.4629			
3724	1005.30	1.11185	9864.4	14.4639			
3725	1005.60	1.11193	9867.9	14.4649	12.922	.2995	3.571
3726	1005.90	1.11201	9871.5	14.4658			
3727	1006.20	1.11209	9875.1	14.4668			
3728	1006.50	1.11217	9878.6	14.4678			
3729	1006.80	1.11225	9882.2	14.4687			
3730	1007.10	1.11233	9885.8	14.4697	12.926	.2996	3.573
3731	1007.40	1.11241	9889.3	14.4706			
3732	1007.70	1.11249	9892.9	14.4716			
3733	1008.00	1.11257	9896.5	14.4726			
3734	1008.29	1.11265	9900.0	14.4735			
3735	1008.59	1.11273	9903.6	14.4745	12.930	.2996	3.574
3736	1008.89	1.11281	9907.2	14.4754			
3737	1009.19	1.11289	9910.7	14.4764			
3738	1009.49	1.11297	9914.3	14.4773			
3739	1009.79	1.11305	9917.9	14.4783			
3740	1010.09	1.11313	9921.4	14.4792	12.934	.2996	3.576
3741	1010.39	1.11321	9925.0	14.4801			
3742	1010.69	1.11329	9928.6	14.4810			
3743	1010.99	1.11337	9932.1	14.4819			
3744	1011.29	1.11345	9935.7	14.4828			
3745	1011.59	1.11353	9939.3	14.4838	12.938	.2997	3.578
3746	1011.89	1.11361	9942.8	14.4847			
3747	1012.19	1.11369	9946.4	14.4856			
3748	1012.49	1.11377	9949.9	14.4865			
3749	1012.79	1.11385	9953.5	14.4874			

TABLE II. - Continued. THERMODYNAMIC PROPERTIES OF AIR AT LOW PRESSURES, AND COMBUSTION-GAS VALUES OF Ψ_h, Ψ_φ, ω, $c_{p,a}$, AND Ψ_{c_p} FOR COMBUSTION OF HYDROGEN WITH AIR

[T = 3000° to 4400° R.]

T, °R	h_a, Btu/lb air	φ_a, Btu/(lb)(°R)	Ψ_h, Btu/lb	Ψ_φ, Btu/(lb)(°R)	ω	$c_{p,a}$, Btu/(lb)(°R)	Ψ_{c_p}, Btu/(lb)(°R)
3750	1013.09	1.11393	9957.1	14.4884	12.942	0.2997	3.579
3751	1013.39	1.11401	9960.6	14.4893			
3752	1013.69	1.11409	9964.2	14.4902			
3753	1013.99	1.11417	9967.8	14.4911			
3754	1014.29	1.11425	9971.4	14.4921			
3755	1014.59	1.11433	9974.9	14.4930	12.946	.2997	3.581
3756	1014.89	1.11441	9978.5	14.4939			
3757	1015.19	1.11449	9982.1	14.4949			
3758	1015.49	1.11457	9985.6	14.4958			
3759	1015.79	1.11465	9989.2	14.4967			
3760	1016.09	1.11473	9992.8	14.4977	12.949	.2998	3.582
3761	1016.39	1.11481	9996.3	14.4987			
3762	1016.69	1.11489	9999.9	14.4996			
3763	1016.99	1.11497	10003.5	14.5006			
3764	1017.29	1.11505	10007.1	14.5015			
3765	1017.59	1.11513	10010.6	14.5025	12.953	.2998	3.584
3766	1017.89	1.11521	10014.2	14.5035			
3767	1018.19	1.11529	10017.8	14.5044			
3768	1018.49	1.11537	10021.4	14.5054			
3769	1018.79	1.11545	10024.9	14.5063			
3770	1019.09	1.11553	10028.5	14.5073	12.957	.2998	3.586
3771	1019.39	1.11561	10032.1	14.5083			
3772	1019.69	1.11569	10035.7	14.5092			
3773	1019.99	1.11577	10039.2	14.5102			
3774	1020.29	1.11585	10042.8	14.5112			
3775	1020.59	1.11593	10046.4	14.5121	12.961	.2999	3.587
3776	1020.89	1.11601	10050.0	14.5131			
3777	1021.19	1.11609	10053.6	14.5140			
3778	1021.49	1.11617	10057.1	14.5150			
3779	1021.79	1.11625	10060.7	14.5160			
3780	1022.09	1.11633	10064.3	14.5169	12.965	.2999	3.589
3781	1022.39	1.11641	10067.9	14.5179			
3782	1022.69	1.11649	10071.5	14.5189			
3783	1022.99	1.11657	10075.0	14.5198			
3784	1023.29	1.11665	10078.6	14.5208			
3785	1023.59	1.11673	10082.2	14.5218	12.969	.2999	3.590
3786	1023.89	1.11680	10085.8	14.5227			
3787	1024.19	1.11688	10089.4	14.5237			
3788	1024.49	1.11696	10093.0	14.5247			
3789	1024.79	1.11704	10096.5	14.5256			
3790	1025.09	1.11712	10100.1	14.5266	12.973	.3000	3.592
3791	1025.39	1.11720	10103.7	14.5275			
3792	1025.69	1.11728	10107.3	14.5285			
3793	1025.99	1.11736	10110.9	14.5295			
3794	1026.29	1.11744	10114.5	14.5304			
3795	1026.59	1.11752	10118.0	14.5314	12.977	.3000	3.593
3796	1026.89	1.11759	10121.6	14.5323			
3797	1027.19	1.11767	10125.2	14.5333			
3798	1027.49	1.11775	10128.8	14.5343			
3799	1027.79	1.11783	10132.4	14.5352			

TABLE II. - Continued. THERMODYNAMIC PROPERTIES OF AIR AT LOW PRESSURES, AND COMBUSTION-GAS VALUES OF Ψ_h, Ψ_ϕ, ω, $c_{p,a}$, AND Ψ_{c_p} FOR COMBUSTION OF HYDROGEN WITH AIR

[T = 3000° to 4400° R.]

T, °R	h_a, Btu/lb air	ϕ_a, Btu/(lb)(°R)	Ψ_h, Btu/lb	Ψ_ϕ, Btu/(lb)(°R)	ω	$c_{p,a}$, Btu/(lb)(°R)	Ψ_{c_p}, Btu/(lb)(°R)
3800	1028.09	1.11791	10136.0	14.5362	12.980	0.3001	3.595
3801	1028.39	1.11799	10139.6	14.5371			
3802	1028.69	1.11807	10143.2	14.5381			
3803	1028.99	1.11815	10146.7	14.5390			
3804	1029.29	1.11823	10150.3	14.5400			
3805	1029.59	1.11831	10153.9	14.5410	12.984	.3001	3.597
3806	1029.89	1.11839	10157.5	14.5419			
3807	1030.19	1.11846	10161.1	14.5429			
3808	1030.49	1.11854	10164.7	14.5438			
3809	1030.79	1.11862	10168.3	14.5448			
3810	1031.09	1.11870	10171.9	14.5457	12.988	.3001	3.598
3811	1031.39	1.11878	10175.5	14.5467			
3812	1031.69	1.11886	10179.1	14.5476			
3813	1031.99	1.11893	10182.7	14.5486			
3814	1032.29	1.11901	10186.3	14.5495			
3815	1032.59	1.11909	10189.8	14.5505	12.992	.3002	3.600
3816	1032.89	1.11917	10193.4	14.5514			
3817	1033.19	1.11925	10197.0	14.5524			
3818	1033.49	1.11932	10200.6	14.5533			
3819	1033.79	1.11940	10204.2	14.5542			
3820	1034.09	1.11948	10207.8	14.5552	12.996	.3002	3.601
3821	1034.39	1.11956	10211.4	14.5561			
3822	1034.69	1.11964	10215.0	14.5571			
3823	1034.99	1.11972	10218.6	14.5580			
3824	1035.30	1.11980	10222.2	14.5589			
3825	1035.60	1.11988	10225.8	14.5599	12.999	.3002	3.603
3826	1035.90	1.11996	10229.4	14.5608			
3827	1036.20	1.12003	10233.0	14.5618			
3828	1036.50	1.12011	10236.6	14.5627			
3829	1036.80	1.12019	10240.2	14.5636			
3830	1037.10	1.12027	10243.8	14.5646	13.003	.3003	3.604
3831	1037.40	1.12035	10247.4	14.5655			
3832	1037.70	1.12043	10250.9	14.5665			
3833	1038.00	1.12050	10254.5	14.5674			
3834	1038.30	1.12058	10258.1	14.5683			
3835	1038.60	1.12066	10261.7	14.5693	13.007	.3003	3.606
3836	1038.90	1.12074	10265.3	14.5702			
3837	1039.20	1.12082	10268.9	14.5711			
3838	1039.50	1.12089	10272.5	14.5721			
3839	1039.80	1.12097	10276.1	14.5730			
3840	1040.10	1.12105	10279.7	14.5740	13.010	.3003	3.607
3841	1040.40	1.12113	10283.3	14.5749			
3842	1040.70	1.12121	10286.9	14.5758			
3843	1041.00	1.12128	10290.5	14.5767			
3844	1041.31	1.12136	10294.1	14.5777			
3845	1041.61	1.12144	10297.7	14.5786	13.014	.3004	3.609
3846	1041.91	1.12152	10301.3	14.5795			
3847	1042.21	1.12160	10304.9	14.5805			
3848	1042.51	1.12167	10308.5	14.5814			
3849	1042.81	1.12175	10312.1	14.5823			

TABLE II. - Continued. THERMODYNAMIC PROPERTIES OF AIR AT LOW PRESSURES, AND COMBUSTION-GAS VALUES OF ψ_h, ψ_φ, ω, $c_{p,a}$, AND ψ_{c_p} FOR COMBUSTION OF HYDROGEN WITH AIR

[T = 3000° to 4400° R]

T, °R	h_a, Btu/lb air	φ_a, Btu/(lb)(°R)	ψ_h, Btu/lb	ψ_φ, Btu/(lb)(°R)	ω	$c_{p,a}$, Btu/(lb)(°R)	ψ_{c_p}, Btu/(lb)(°R)
3850	1043.11	1.12183	10315.7	14.5833	13.018	0.3004	3.610
3851	1043.41	1.12191	10319.3	14.5842			
3852	1043.71	1.12199	10322.9	14.5852			
3853	1044.01	1.12206	10386.5	14.5861			
3854	1044.31	1.12214	10330.1	14.5871			
3855	1044.61	1.12222	10333.7	14.5880	13.022	.3004	3.612
3856	1044.91	1.12230	10337.3	14.5889			
3857	1045.21	1.12238	10340.9	14.5899			
3858	1045.51	1.12245	10344.5	14.5908			
3859	1045.81	1.12253	10348.1	14.5918			
3860	1046.11	1.12261	10351.7	14.5927	13.025	.3005	3.613
3861	1046.41	1.12269	10355.3	14.5937			
3862	1046.71	1.12277	10358.9	14.5947			
3863	1047.01	1.12285	10362.5	14.5956			
3864	1047.31	1.12292	10366.1	14.5966			
3865	1047.62	1.12300	10369.7	14.5976	13.029	.3005	3.615
3866	1047.92	1.12308	10373.3	14.5985			
3867	1048.22	1.12316	10376.9	14.5995			
3868	1048.52	1.12323	10380.5	14.6005			
3869	1048.82	1.12331	10384.1	14.6014			
3870	1049.12	1.12339	10387.7	14.6024	13.033	.3005	3.617
3871	1049.42	1.12347	10391.4	14.6034			
3872	1049.72	1.12354	10395.0	14.6043			
3873	1050.02	1.12362	10398.6	14.6053			
3874	1050.33	1.12370	10402.2	14.6063			
3875	1050.63	1.12377	10405.8	14.6072	13.036	.3006	3.618
3876	1050.93	1.12385	10409.4	14.6082			
3877	1051.23	1.12393	10413.0	14.6091			
3878	1051.53	1.12401	10416.6	14.6101			
3879	1051.83	1.12408	10420.2	14.6111			
3880	1052.13	1.12416	10423.8	14.6120	13.040	.3006	3.620
3881	1052.43	1.12424	10427.4	14.6130			
3882	1052.73	1.12432	10431.0	14.6140			
3883	1053.03	1.12440	10434.7	14.6150			
3884	1053.33	1.12447	10438.3	14.6159			
3885	1053.63	1.12455	10441.9	14.6169	13.043	.3006	3.621
3886	1053.93	1.12463	10445.5	14.6179			
3887	1054.23	1.12471	10449.1	14.6189			
3888	1054.53	1.12478	10452.7	14.6198			
3889	1054.83	1.12486	10456.3	14.6208			
3890	1055.13	1.12494	10459.9	14.6217	13.047	.3007	3.623
3891	1055.43	1.12502	10463.5	14.6227			
3892	1055.73	1.12509	10467.2	14.6236			
3893	1056.03	1.12517	10470.8	14.6246			
3894	1056.33	1.12525	10474.4	14.6255			
3895	1056.64	1.12533	10478.0	14.6264	13.051	.3007	3.624
3896	1056.94	1.12540	10481.6	14.6274			
3897	1057.24	1.12548	10485.2	14.6283			
3898	1057.54	1.12556	10488.9	14.6292			
3899	1057.84	1.12563	10492.5	14.6301			

TABLE II. - Continued. THERMODYNAMIC PROPERTIES OF AIR AT LOW PRESSURES, AND COMBUSTION-GAS VALUES OF Ψ_h, Ψ_φ, ω, $c_{p,a}$, AND Ψ_{c_p} FOR COMBUSTION OF HYDROGEN WITH AIR

[T = 3000° to 4400° R.]

T, °R	h_a, Btu/lb air	φ_a, Btu/(lb)(°R)	Ψ_h, Btu/lb	Ψ_φ, Btu/(lb)(°R)	ω	$c_{p,a}$, Btu/(lb)(°R)	Ψ_{c_p}, Btu/(lb)(°R)
3900	1058.14	1.12571	10496.1	14.6311	13.054	0.3008	3.626
3901	1058.44	1.12579	10499.7	14.6319			
3902	1058.74	1.12586	10503.3	14.6328			
3903	1059.04	1.12594	10506.9	14.6336			
3904	1059.34	1.12602	10510.6	14.6345			
3905	1059.65	1.12610	10514.2	14.6353	13.058	.3008	3.627
3906	1059.95	1.12617	10517.8	14.6362			
3907	1060.25	1.12625	10521.4	14.6371			
3908	1060.55	1.12633	10525.0	14.6379			
3909	1060.85	1.12640	10528.6	14.6388			
3910	1061.15	1.12648	10532.3	14.6397	13.061	.3008	3.629
3911	1061.45	1.12656	10535.9	14.6406			
3912	1061.75	1.12663	10539.5	14.6414			
3913	1062.05	1.12671	10543.1	14.6423			
3914	1062.35	1.12679	10546.8	14.6432			
3915	1062.66	1.12687	10550.4	14.6441	13.065	.3009	3.630
3916	1062.96	1.12694	10554.0	14.6450			
3917	1063.26	1.12702	10557.6	14.6459			
3918	1063.56	1.12710	10561.2	14.6468			
3919	1063.86	1.12717	10564.9	14.6477			
3920	1064.16	1.12725	10568.5	14.6486	13.069	.3009	3.632
3921	1064.46	1.12733	10572.1	14.6496			
3922	1064.76	1.12740	10575.7	14.6505			
3923	1065.06	1.12748	10579.4	14.6515			
3924	1065.36	1.12756	10583.0	14.6524			
3925	1065.67	1.12764	10586.6	14.6534	13.072	.3009	3.633
3926	1065.97	1.12771	10590.2	14.6543			
3927	1066.27	1.12779	10593.9	14.6552			
3928	1066.57	1.12787	10597.5	14.6562			
3929	1066.87	1.12794	10601.1	14.6571			
3930	1067.17	1.12802	10604.8	14.6581	13.076	.3010	3.635
3931	1067.47	1.12810	10608.4	14.6590			
3932	1067.77	1.12817	10612.0	14.6599			
3933	1068.07	1.12825	10615.6	14.6609			
3934	1068.37	1.12833	10619.3	14.6618			
3935	1068.68	1.12841	10622.9	14.6628	13.079	.3010	3.636
3936	1068.98	1.12848	10626.5	14.6637			
3937	1069.28	1.12856	10630.2	14.6646			
3938	1069.58	1.12864	10633.8	14.6656			
3939	1069.88	1.12871	10637.4	14.6665			
3940	1070.18	1.12879	10641.0	14.6674	13.083	.3010	3.637
3941	1070.48	1.12887	10644.7	14.6683			
3942	1070.78	1.12894	10648.3	14.6692			
3943	1071.08	1.12902	10651.9	14.6701			
3944	1071.38	1.12909	10655.5	14.6710			
3945	1071.69	1.12917	10659.2	14.6719	13.086	.3011	3.639
3946	1071.99	1.12925	10662.8	14.6729			
3947	1072.29	1.12932	10666.4	14.6738			
3948	1072.59	1.12940	10670.0	14.6747			
3949	1072.89	1.12947	10673.7	14.6756			

TABLE II. - Continued. THERMODYNAMIC PROPERTIES OF AIR AT LOW PRESSURES, AND COMBUSTION-GAS VALUES OF ψ_h, ψ_φ, ω, $c_{p,a}$, AND ψ_{c_p} FOR COMBUSTION OF HYDROGEN WITH AIR

[T = 3000° to 4400° R]

T, °R	h_a, Btu/lb air	φ_a, Btu/(lb)(°R)	ψ_h, Btu/lb	ψ_φ, Btu/(lb)(°R)	ω	$c_{p,a}$, Btu/(lb)(°R)	ψ_{c_p}, Btu/(lb)(°R)
3950	1073.19	1.12955	10677.3	14.6765	13.090	0.3011	3.640
3951	1073.49	1.12963	10680.9	14.6774			
3952	1073.79	1.12970	10684.6	14.6783			
3953	1074.09	1.12978	10688.2	14.6793			
3954	1074.39	1.12985	10691.8	14.6802			
3955	1074.69	1.12993	10695.5	14.6811	13.093	.3011	3.642
3956	1074.99	1.13001	10699.1	14.6820			
3957	1075.30	1.13008	10702.7	14.6830			
3958	1075.60	1.13016	10706.3	14.6839			
3959	1075.90	1.13023	10710.0	14.6848			
3960	1076.20	1.13031	10713.6	14.6857	13.097	.3012	3.643
3961	1076.50	1.13039	10717.3	14.6867			
3962	1076.80	1.13046	10720.9	14.6876			
3963	1077.11	1.13054	10724.5	14.6886			
3964	1077.41	1.13061	10728.2	14.6895			
3965	1077.71	1.13069	10731.8	14.6905	13.100	.3012	3.645
3966	1078.01	1.13077	10735.4	14.6914			
3967	1078.32	1.13084	10739.1	14.6923			
3968	1078.62	1.13092	10742.7	14.6933			
3969	1078.92	1.13099	10746.3	14.6942			
3970	1079.22	1.13107	10750.0	14.6952	13.103	.3012	3.646
3971	1079.52	1.13115	10753.6	14.6961			
3972	1079.82	1.13122	10757.3	14.6971			
3973	1080.12	1.13130	10760.9	14.6980			
3974	1080.42	1.13137	10764.5	14.6989			
3975	1080.73	1.13145	10768.2	14.6999	13.107	.3013	3.648
3976	1081.03	1.13153	10771.8	14.7008			
3977	1081.33	1.13160	10775.4	14.7017			
3978	1081.63	1.13168	10779.1	14.7027			
3979	1081.93	1.13175	10782.7	14.7036			
3980	1082.23	1.13183	10786.4	14.7045	13.110	.3013	3.649
3981	1082.53	1.13191	10790.0	14.7055			
3982	1082.83	1.13198	10793.6	14.7064			
3983	1083.13	1.13206	10797.3	14.7074			
3984	1083.43	1.13214	10800.9	14.7083			
3985	1083.73	1.13221	10804.5	14.7092	13.113	.3013	3.651
3986	1084.03	1.13229	10808.2	14.7101			
3987	1084.34	1.13236	10811.8	14.7111			
3988	1084.64	1.13244	10815.4	14.7120			
3989	1084.94	1.13251	10819.1	14.7129			
3990	1085.24	1.13259	10822.7	14.7139	13.117	.3014	3.652
3991	1085.54	1.13266	10826.4	14.7148			
3992	1085.84	1.13274	10830.0	14.7157			
3993	1086.15	1.13281	10833.6	14.7167			
3994	1086.45	1.13289	10837.3	14.7176			
3995	1086.75	1.13296	10840.9	14.7185	13.120	.3014	3.653
3996	1087.05	1.13304	10844.6	14.7194			
3997	1087.35	1.13311	10848.2	14.7204			
3998	1087.66	1.13319	10851.9	14.7213			
3999	1087.96	1.13326	10855.5	14.7222			

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TABLE II. - Continued. THERMODYNAMIC PROPERTIES OF AIR AT LOW PRESSURES, AND COMBUSTION-GAS VALUES OF Ψ_h, Ψ_φ, ω, $c_{p,a}$, AND Ψ_{c_p} FOR COMBUSTION OF HYDROGEN WITH AIR

[T = 3000° to 4400° R.]

T, °R	h_a, Btu/lb air	φ_a, Btu/(lb)(°R)	Ψ_h, Btu/lb	Ψ_φ, Btu/(lb)(°R)	ω	$c_{p,a}$, Btu/(lb)(°R)	Ψ_{c_p}, Btu/(lb)(°R)
4000	1088.26	1.13334	10859.1	14.7231	13.123	0.3015	3.655
4001	1088.56	1.13342	10862.8	14.7241			
4002	1088.86	1.13349	10866.4	14.7250			
4003	1089.17	1.13357	10870.1	14.7259			
4004	1089.47	1.13365	10873.7	14.7269			
4005	1089.77	1.13372	10877.4	14.7278	13.127	.3015	3.656
4006	1090.07	1.13380	10881.1	14.7287			
4007	1090.37	1.13387	10884.7	14.7296			
4008	1090.68	1.13395	10888.4	14.7305			
4009	1090.98	1.13402	10892.0	14.7315			
4010	1091.28	1.13410	10895.7	14.7324	13.130	.3015	3.658
4011	1091.58	1.13418	10899.3	14.7333			
4012	1091.88	1.13425	10903.0	14.7342			
4013	1092.19	1.13433	10906.6	14.7351			
4014	1092.49	1.13440	10910.3	14.7360			
4015	1092.79	1.13448	10913.9	14.7369	13.133	.3016	3.659
4016	1093.09	1.13455	10917.6	14.7379			
4017	1093.39	1.13463	10921.2	14.7388			
4018	1093.70	1.13470	10924.9	14.7397			
4019	1094.00	1.13478	10928.5	14.7406			
4020	1094.30	1.13485	10932.2	14.7415	13.136	.3016	3.660
4021	1094.60	1.13493	10935.8	14.7423			
4022	1094.90	1.13500	10939.5	14.7432			
4023	1095.21	1.13508	10943.1	14.7441			
4024	1095.51	1.13515	10946.8	14.7449			
4025	1095.81	1.13523	10950.4	14.7458	13.139	.3016	3.662
4026	1096.11	1.13530	10954.1	14.7467			
4027	1096.41	1.13538	10957.7	14.7475			
4028	1096.72	1.13545	10961.4	14.7484			
4029	1097.02	1.13553	10965.0	14.7493			
4030	1097.32	1.13560	10968.7	14.7502	13.143	.3017	3.663
4031	1097.62	1.13568	10972.3	14.7510			
4032	1097.92	1.13575	10976.0	14.7519			
4033	1098.23	1.13583	10979.6	14.7528			
4034	1098.53	1.13590	10983.3	14.7537			
4035	1098.83	1.13598	10986.9	14.7546	13.146	.3017	3.665
4036	1099.13	1.13605	10990.6	14.7555			
4037	1099.43	1.13613	10994.2	14.7564			
4038	1099.74	1.13620	10997.9	14.7573			
4039	1100.04	1.13628	11001.5	14.7582			
4040	1100.34	1.13635	11005.2	14.7591	13.149	.3017	3.666
4041	1100.64	1.13642	11008.9	14.7600			
4042	1100.94	1.13650	11012.5	14.7609			
4043	1101.25	1.13657	11016.2	14.7618			
4044	1101.55	1.13665	11019.8	14.7627			
4045	1101.85	1.13672	11023.5	14.7637	13.152	.3018	3.667
4046	1102.15	1.13679	11027.1	14.7646			
4047	1102.46	1.13687	11030.8	14.7655			
4048	1102.76	1.13694	11034.4	14.7664			
4049	1103.06	1.13702	11038.1	14.7674			

TABLE II. - Continued. THERMODYNAMIC PROPERTIES OF AIR AT LOW PRESSURES, AND COMBUSTION-GAS VALUES OF ψ_h, ψ_φ, ω, $c_{p,a}$, AND ψ_{c_p} FOR COMBUSTION OF HYDROGEN WITH AIR

[T = 3000° to 4400° R.]

T, °R	h_a, Btu/lb air	φ_a, Btu/(lb)(°R)	ψ_h, Btu/lb	ψ_φ, Btu/(lb)(°R)	ω	$c_{p,a}$, Btu/(lb)(°R)	ψ_{c_p}, Btu/(lb)(°R)
4050	1103.36	1.13709	11041.8	14.7683	13.155	0.3018	3.669
4051	1103.66	1.13716	11045.4	14.7692			
4052	1103.96	1.13724	11049.1	14.7701			
4053	1104.26	1.13731	11052.7	14.7710			
4054	1104.56	1.13739	11056.4	14.7719			
4055	1104.86	1.13746	11060.1	14.7729	13.158	.3018	3.670
4056	1105.16	1.13753	11063.7	14.7738			
4057	1105.47	1.13761	11067.4	14.7747			
4058	1105.77	1.13768	11071.0	14.7756			
4059	1106.07	1.13776	11074.7	14.7765			
4060	1106.37	1.13783	11078.4	14.7774	13.161	.3019	3.671
4061	1106.67	1.13790	11082.0	14.7783			
4062	1106.97	1.13798	11085.7	14.7792			
4063	1107.28	1.13805	11089.4	14.7801			
4064	1107.58	1.13812	11093.0	14.7810			
4065	1107.88	1.13820	11096.7	14.7819	13.164	.3019	3.673
4066	1108.18	1.13827	11100.3	14.7828			
4067	1108.48	1.13835	11104.0	14.7838			
4068	1108.79	1.13842	11107.7	14.7847			
4069	1109.09	1.13850	11111.3	14.7856			
4070	1109.39	1.13857	11115.0	14.7865	13.168	.3019	3.674
4071	1109.69	1.13865	11118.7	14.7874			
4072	1110.00	1.13872	11122.3	14.7883			
4073	1110.30	1.13880	11126.0	14.7892			
4074	1110.60	1.13887	11129.7	14.7901			
4075	1110.91	1.13895	11133.3	14.7910	13.171	.3020	3.675
4076	1111.21	1.13902	11137.0	14.7919			
4077	1111.51	1.13910	11140.7	14.7928			
4078	1111.81	1.13917	11144.3	14.7937			
4079	1112.12	1.13925	11148.0	14.7946			
4080	1112.42	1.13932	11151.7	14.7955	13.174	.3020	3.677
4081	1112.72	1.13939	11155.3	14.7964			
4082	1113.02	1.13947	11159.0	14.7973			
4083	1113.33	1.13954	11162.7	14.7983			
4084	1113.63	1.13962	11166.3	14.7992			
4085	1113.93	1.13969	11170.0	14.8001	13.177	.3020	3.678
4086	1114.23	1.13977	11173.7	14.8010			
4087	1114.53	1.13984	11177.3	14.8019			
4088	1114.84	1.13991	11181.0	14.8028			
4089	1115.14	1.13999	11184.7	14.8037			
4090	1115.44	1.14006	11188.4	14.8046	13.180	.3021	3.680
4091	1115.74	1.14013	11192.0	14.8055			
4092	1116.04	1.14021	11195.7	14.8064			
4093	1116.35	1.14028	11199.4	14.8073			
4094	1116.65	1.14035	11203.0	14.8082			
4095	1116.95	1.14042	11206.7	14.8091	13.183	.3021	3.681
4096	1117.25	1.14050	11210.4	14.8100			
4097	1117.55	1.14057	11214.0	14.8109			
4098	1117.86	1.14064	11217.7	14.8118			
4099	1118.16	1.14072	11221.4	14.8127			

TABLE II. - Continued. THERMODYNAMIC PROPERTIES OF AIR AT LOW PRESSURES, AND COMBUSTION-GAS VALUES OF $\mathscr{h}$, $\mathscr{\varphi}$, ω, $c_{p,a}$, AND $\mathscr{c}_p$ FOR COMBUSTION OF HYDROGEN WITH AIR

[T = 3000° to 4400° R]

T, °R	h_a, Btu/lb air	φ_a, Btu/(lb)(°R)	$\mathscr{h}$, Btu/lb	$\mathscr{\varphi}$, Btu/(lb)(°R)	ω	$c_{p,a}$, Btu/(lb)(°R)	$\mathscr{c}_p$, Btu/(lb)(°R)
4100	1118.46	1.14079	11225.0	14.8136	13.186	0.3022	3.682
4101	1118.76	1.14086	11228.7	14.8145			
4102	1119.07	1.14094	11232.4	14.8154			
4103	1119.37	1.14101	11236.1	14.8163			
4104	1119.67	1.14109	11239.7	14.8172			
4105	1119.98	1.14116	11243.4	14.8181	13.189	.3022	3.683
4106	1120.28	1.14123	11247.1	14.8190			
4107	1120.58	1.14131	11250.7	14.8199			
4108	1120.88	1.14138	11254.4	14.8208			
4109	1121.19	1.14146	11258.1	14.8217			
4110	1121.49	1.14153	11261.8	14.8225	13.191	.3022	3.685
4111	1121.79	1.14160	11265.4	14.8234			
4112	1122.09	1.14168	11269.1	14.8243			
4113	1122.40	1.14175	11272.8	14.8252			
4114	1122.70	1.14183	11276.5	14.8261			
4115	1123.00	1.14190	11280.1	14.8270	13.194	.3023	3.686
4116	1123.30	1.14198	11283.8	14.8279			
4117	1123.60	1.14205	11287.5	14.8288			
4118	1123.91	1.14212	11291.2	14.8297			
4119	1124.21	1.14220	11294.8	14.8306			
4120	1124.51	1.14227	11298.5	14.8315	13.197	.3023	3.687
4121	1124.81	1.14234	11302.2	14.8324			
4122	1125.12	1.14242	11305.9	14.8333			
4123	1125.42	1.14249	11309.5	14.8342			
4124	1125.72	1.14256	11313.2	14.8352			
4125	1126.03	1.14264	11316.9	14.8361	13.200	.3023	3.689
4126	1126.33	1.14271	11320.6	14.8370			
4127	1126.63	1.14278	11324.3	14.8379			
4128	1126.93	1.14285	11327.9	14.8388			
4129	1127.24	1.14293	11331.6	14.8397			
4130	1127.54	1.14300	11335.3	14.8406	13.203	.3024	3.690
4131	1127.84	1.14307	11339.0	14.8415			
4132	1128.14	1.14315	11342.6	14.8424			
4133	1128.45	1.14322	11346.3	14.8433			
4134	1128.75	1.14329	11350.0	14.8442			
4135	1129.05	1.14337	11353.7	14.8451	13.206	.3024	3.691
4136	1129.35	1.14344	11357.4	14.8460			
4137	1129.65	1.14351	11361.1	14.8469			
4138	1129.96	1.14358	11364.7	14.8478			
4139	1130.26	1.14366	11368.4	14.8487			
4140	1130.56	1.14373	11372.1	14.8496	13.209	.3024	3.693
4141	1130.86	1.14380	11375.8	14.8505			
4142	1131.17	1.14388	11379.5	14.8514			
4143	1131.47	1.14395	11383.2	14.8523			
4144	1131.77	1.14402	11386.8	14.8532			
4145	1132.08	1.14410	11390.5	14.8541	13.211	.3025	3.694
4146	1132.38	1.14417	11394.2	14.8550			
4147	1132.68	1.14424	11397.9	14.8559			
4148	1132.98	1.14431	11401.6	14.8568			
4149	1133.29	1.14439	11405.3	14.8577			

TABLE II. - Continued. THERMODYNAMIC PROPERTIES OF AIR AT LOW PRESSURES, AND COMBUSTION-GAS VALUES OF Ψ_h, Ψ_φ, ω, $c_{p,a}$, AND Ψ_{c_p} FOR COMBUSTION OF HYDROGEN WITH AIR

[T = 3000° to 4400° R.]

T, °R	h_a, Btu/lb air	φ_a, Btu/(lb)(°R)	Ψ_h, Btu/lb	Ψ_φ, Btu/(lb)(°R)	ω	$c_{p,a}$, Btu/(lb)(°R)	Ψ_{c_p}, Btu/(lb)(°R)
4150	1133.59	1.14446	11409.0	14.8586	13.214	0.3025	3.695
4151	1133.89	1.14453	11412.7	14.8595			
4152	1134.19	1.14461	11416.3	14.8604			
4153	1134.50	1.14468	11420.0	14.8613			
4154	1134.80	1.14475	11423.7	14.8622			
4155	1135.10	1.14483	11427.4	14.8631	13.217	.3025	3.697
4156	1135.40	1.14490	11431.1	14.8640			
4157	1135.70	1.14497	11434.8	14.8648			
4158	1136.01	1.14504	11438.5	14.8657			
4159	1136.31	1.14512	11442.2	14.8666			
4160	1136.61	1.14519	11445.8	14.8675	13.220	.3026	3.698
4161	1136.91	1.14526	11449.5	14.8684			
4162	1137.22	1.14534	11453.2	14.8693			
4163	1137.52	1.14541	11456.9	14.8702			
4164	1137.82	1.14548	11460.6	14.8711			
4165	1138.13	1.14556	11464.3	14.8720	13.223	.3026	3.699
4166	1138.43	1.14563	11467.9	14.8729			
4167	1138.73	1.14570	11471.6	14.8738			
4168	1139.03	1.14577	11475.3	14.8747			
4169	1139.34	1.14585	11479.0	14.8756			
4170	1139.64	1.14592	11482.7	14.8765	13.226	.3027	3.700
4171	1139.94	1.14599	11486.4	14.8774			
4172	1140.25	1.14607	11490.1	14.8783			
4173	1140.55	1.14614	11493.8	14.8792			
4174	1140.85	1.14621	11497.4	14.8801			
4175	1141.16	1.14629	11501.1	14.8810	13.229	.3027	3.702
4176	1141.46	1.14636	11504.8	14.8819			
4177	1141.76	1.14643	11508.5	14.8828			
4178	1142.06	1.14650	11512.2	14.8836			
4179	1142.37	1.14658	11515.9	14.8845			
4180	1142.67	1.14665	11519.6	14.8854	13.231	.3027	3.703
4181	1142.97	1.14672	11523.3	14.8863			
4182	1143.27	1.14679	11527.0	14.8872			
4183	1143.58	1.14687	11530.7	14.8880			
4184	1143.88	1.14694	11534.4	14.8889			
4185	1144.18	1.14701	11538.1	14.8898	13.234	.3028	3.704
4186	1144.48	1.14708	11541.8	14.8906			
4187	1144.78	1.14715	11545.5	14.8915			
4188	1145.09	1.14723	11549.2	14.8924			
4189	1145.39	1.14730	11552.9	14.8932			
4190	1145.69	1.14737	11556.5	14.8941	13.237	.3028	3.705
4191	1145.99	1.14744	11560.2	14.8950			
4192	1146.30	1.14751	11563.9	14.8959			
4193	1146.60	1.14759	11567.6	14.8967			
4194	1146.90	1.14766	11571.3	14.8976			
4195	1147.21	1.14773	11575.0	14.8985	13.240	.3028	3.707
4196	1147.51	1.14780	11578.7	14.8993			
4197	1147.81	1.14787	11582.4	14.9002			
4198	1148.11	1.14795	11586.1	14.9011			
4199	1148.42	1.14802	11589.8	14.9020			

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TABLE II. - Continued. THERMODYNAMIC PROPERTIES OF AIR AT LOW PRESSURES, AND COMBUSTION-GAS VALUES OF ψ_h, ψ_φ, ω, $c_{p,a}$, AND ψ_{c_p} FOR COMBUSTION OF HYDROGEN WITH AIR

[T = 3000° to 4400° R]

T, °R	h_a, Btu/lb air	φ_a, Btu/(lb)(°R)	ψ_h, Btu/lb	ψ_φ, Btu/(lb)(°R)	ω	$c_{p,a}$, Btu/(lb)(°R)	ψ_{c_p}, Btu/(lb)(°R)
4200	1148.72	1.14809	11593.5	14.9028	13.243	0.3029	3.708
4201	1149.02	1.14816	11597.2	14.9037			
4202	1149.33	1.14823	11600.9	14.9045			
4203	1149.63	1.14831	11604.6	14.9054			
4204	1149.93	1.14838	11608.3	14.9062			
4205	1150.24	1.14845	11612.0	14.9071	13.246	.3029	3.709
4206	1150.54	1.14852	11615.7	14.9080			
4207	1150.84	1.14859	11619.4	14.9088			
4208	1151.14	1.14867	11623.1	14.9097			
4209	1151.45	1.14874	11626.8	14.9106			
4210	1151.75	1.14881	11630.5	14.9114	13.249	.3029	3.711
4211	1152.05	1.14888	11634.2	14.9123			
4212	1152.36	1.14895	11637.9	14.9132			
4213	1152.66	1.14903	11641.6	14.9141			
4214	1152.96	1.14910	11645.3	14.9149			
4215	1153.27	1.14917	11649.0	14.9158	13.252	.3029	3.712
4216	1153.57	1.14924	11652.7	14.9167			
4217	1153.87	1.14931	11656.4	14.9176			
4218	1154.17	1.14939	11660.1	14.9185			
4219	1154.48	1.14946	11663.8	14.9193			
4220	1154.78	1.14953	11667.5	14.9202	13.255	.3030	3.713
4221	1155.08	1.14960	11671.2	14.9212			
4222	1155.39	1.14967	11674.9	14.9221			
4223	1155.69	1.14975	11678.6	14.9230			
4224	1155.99	1.14982	11682.3	14.9239			
4225	1156.30	1.14989	11686.1	14.9248	13.257	.3030	3.714
4226	1156.60	1.14996	11689.8	14.9258			
4227	1156.90	1.15003	11693.5	14.9267			
4228	1157.20	1.15011	11697.2	14.9276			
4229	1157.51	1.15018	11700.9	14.9285			
4230	1157.81	1.15025	11704.6	14.9294	13.260	.3030	3.716
4231	1158.11	1.15032	11708.3	14.9303			
4232	1158.42	1.15039	11712.0	14.9312			
4233	1158.72	1.15047	11715.7	14.9321			
4234	1159.02	1.15054	11719.4	14.9330			
4235	1159.33	1.15061	11723.1	14.9339	13.263	.3031	3.717
4236	1159.63	1.15068	11726.8	14.9348			
4237	1159.93	1.15076	11730.5	14.9357			
4238	1160.23	1.15083	11734.2	14.9366			
4239	1160.54	1.15090	11737.9	14.9375			
4240	1160.84	1.15097	11741.6	14.9384	13.266	.3031	3.718
4241	1161.14	1.15104	11745.3	14.9393			
4242	1161.45	1.15111	11749.0	14.9401			
4243	1161.75	1.15118	11752.8	14.9410			
4244	1162.05	1.15125	11756.5	14.9419			
4245	1162.36	1.15133	11760.2	14.9427	13.269	.3031	3.719
4246	1162.66	1.15140	11763.9	14.9436			
4247	1162.96	1.15147	11767.6	14.9445			
4248	1163.26	1.15154	11771.3	14.9453			
4249	1163.57	1.15161	11775.0	14.9462			

TABLE II. - Continued. THERMODYNAMIC PROPERTIES OF AIR AT LOW PRESSURES, AND COMBUSTION-GAS VALUES OF ψ_h, ψ_φ, ω, $c_{p,a}$, AND ψ_{c_p} FOR COMBUSTION OF HYDROGEN WITH AIR

[T = 3000° to 4400° R]

T, °R	h_a, Btu/lb air	φ_a, Btu/(lb)(°R)	ψ_h, Btu/lb	ψ_φ, Btu/(lb)(°R)	ω	$c_{p,a}$, Btu/(lb)(°R)	ψ_{c_p}, Btu/(lb)(°R)
4250	1163.87	1.15168	11778.7	14.9471	13.272	0.3032	3.720
4251	1164.17	1.15175	11782.4	14.9479			
4252	1164.48	1.15182	11786.1	14.9488			
4253	1164.78	1.15189	11789.8	14.9497			
4254	1165.08	1.15196	11793.5	14.9506			
4255	1165.38	1.15204	11797.2	14.9514	13.275	.3032	3.722
4256	1165.69	1.15211	11800.9	14.9523			
4257	1165.99	1.15218	11804.6	14.9532			
4258	1166.29	1.15225	11808.3	14.9541			
4259	1166.60	1.15232	11812.1	14.9549			
4260	1166.90	1.15239	11815.8	14.9558	13.278	.3032	3.723
4261	1167.20	1.15246	11819.5	14.9567			
4262	1167.51	1.15253	11823.2	14.9576			
4263	1167.81	1.15260	11826.9	14.9585			
4264	1168.12	1.15267	11830.6	14.9594			
4265	1168.42	1.15275	11834.4	14.9603	13.280	.3032	3.724
4266	1168.73	1.15282	11838.1	14.9612			
4267	1169.03	1.15289	11841.8	14.9621			
4268	1169.33	1.15296	11845.5	14.9629			
4269	1169.64	1.15303	11849.2	14.9638			
4270	1169.94	1.15310	11853.0	14.9647	13.283	.3033	3.725
4271	1170.24	1.15317	11856.7	14.9656			
4272	1170.55	1.15324	11860.4	14.9665			
4273	1170.85	1.15331	11864.1	14.9674			
4274	1171.15	1.15338	11867.8	14.9682			
4275	1171.46	1.15346	11871.5	14.9691	13.286	.3033	3.727
4276	1171.76	1.15353	11875.3	14.9700			
4277	1172.06	1.15360	11879.0	14.9709			
4278	1172.36	1.15367	11882.7	14.9717			
4279	1172.67	1.15374	11886.4	14.9726			
4280	1172.97	1.15381	11890.1	14.9735	13.289	.3033	3.728
4281	1173.27	1.15388	11893.8	14.9743			
4282	1173.58	1.15395	11897.6	14.9752			
4283	1173.88	1.15402	11901.3	14.9760			
4284	1174.18	1.15410	11905.0	14.9769			
4285	1174.48	1.15417	11908.7	14.9777	13.292	.3034	3.729
4286	1174.79	1.15424	11912.4	14.9786			
4287	1175.09	1.15431	11916.2	14.9794			
4288	1175.39	1.15438	11919.9	14.9803			
4289	1175.70	1.15445	11923.6	14.9811			
4290	1176.00	1.15452	11927.3	14.9820	13.294	.3034	3.730
4291	1176.30	1.15459	11931.0	14.9829			
4292	1176.61	1.15466	11934.7	14.9837			
4293	1176.91	1.15473	11938.5	14.9846			
4294	1177.22	1.15480	11942.2	14.9854			
4295	1177.52	1.15487	11945.9	14.9863	13.297	.3034	3.731
4296	1177.82	1.15494	11949.6	14.9872			
4297	1178.13	1.15501	11953.3	14.9881			
4298	1178.43	1.15508	11957.1	14.9889			
4299	1178.74	1.15515	11960.8	14.9898			

TABLE II. - Continued. THERMODYNAMIC PROPERTIES OF AIR AT LOW PRESSURES, AND COMBUSTION-GAS VALUES OF ψ_h, ψ_φ, ϖ, $c_{p,a}$, AND ψ_{c_p} FOR COMBUSTION OF HYDROGEN WITH AIR

[T = 3000° to 4400° R.]

T, °R	h_a, Btu/lb air	φ_a, Btu/(lb)(°R)	ψ_h, Btu/lb	ψ_φ, Btu/(lb)(°R)	ϖ	$c_{p,a}$, Btu/(lb)(°R)	ψ_{c_p}, Btu/(lb)(°R)
4300	1179.04	1.15522	11964.5	14.9907	13.300	0.3035	3.733
4301	1179.34	1.15529	11968.2	14.9916			
4302	1179.65	1.15536	11971.9	14.9925			
4303	1179.95	1.15543	11975.6	14.9934			
4306	1180.87	1.15551	11979.4	14.9943			
4305	1180.56	1.15558	11983.1	14.9952	13.303	.3035	3.734
4306	1180.87	1.15565	11986.8	14.9961			
4307	1181.17	1.15572	11990.5	14.9970			
4308	1181.47	1.15579	11994.2	14.9979			
4309	1181.78	1.15586	11998.0	14.9988			
4310	1182.08	1.15593	12001.7	14.9997	13.306	.3035	3.735
4311	1182.38	1.15600	12005.4	15.0006			
4312	1182.69	1.15607	12009.1	15.0015			
4313	1182.99	1.15614	12012.9	15.0024			
4314	1183.29	1.15621	12016.6	15.0033			
4315	1183.59	1.15628	12020.3	15.0042	13.308	.3035	3.736
4316	1183.90	1.15635	12024.0	15.0051			
4317	1184.20	1.15642	12027.8	15.0060			
4318	1184.50	1.15649	12031.5	15.0069			
4319	1184.81	1.15656	12035.2	15.0077			
4320	1185.11	1.15663	12038.9	15.0086	13.311	.3036	3.738
4321	1185.41	1.15670	12042.7	15.0095			
4322	1185.72	1.15677	12046.4	15.0103			
4323	1186.02	1.15684	12050.1	15.0112			
4324	1186.33	1.15692	12053.9	15.0121			
4325	1186.63	1.15699	12057.6	15.0129	13.314	.3036	3.739
4326	1186.93	1.15706	12061.3	15.0138			
4327	1187.24	1.15713	12065.0	15.0147			
4328	1187.54	1.15720	12068.8	15.0155			
4329	1187.85	1.15727	12072.5	15.0164			
4330	1188.15	1.15734	12076.2	15.0172	13.317	.3036	3.740
4331	1188.45	1.15741	12080.0	15.0181			
4332	1188.76	1.15748	12083.7	15.0190			
4333	1189.06	1.15755	12087.4	15.0198			
4334	1189.37	1.15762	12091.2	15.0207			
4335	1189.67	1.15769	12094.9	15.0215	13.319	.3037	3.741
4336	1189.97	1.15776	12098.6	15.0224			
4337	1190.28	1.15783	12102.4	15.0232			
4338	1190.58	1.15790	12106.1	15.0241			
4339	1190.89	1.15797	12109.8	15.0250			
4340	1191.19	1.15804	12113.6	15.0258	13.322	.3037	3.742
4341	1191.49	1.15811	12117.3	15.0267			
4342	1191.80	1.15818	12121.0	15.0275			
4343	1192.10	1.15825	12124.8	15.0283			
4344	1192.41	1.15832	12128.5	15.0292			
4345	1192.71	1.15839	12132.2	15.0300	13.325	.3037	3.744
4346	1193.02	1.15846	12136.0	15.0309			
4347	1193.32	1.15853	12139.7	15.0317			
4348	1193.62	1.15860	12143.4	15.0326			
4349	1193.93	1.15867	12147.2	15.0334			

TABLE II. - Concluded. THERMODYNAMIC PROPERTIES OF AIR AT LOW PRESSURES, AND COMBUSTION-GAS VALUES OF ψ_h, ψ_φ, ω, $c_{p,a}$, AND ψ_{c_p} FOR COMBUSTION OF HYDROGEN WITH AIR

[T = 3000° to 4400° R]

T, °R	h_a, Btu/lb air	φ_a, Btu/(lb)(°R)	ψ_h, Btu/lb	ψ_φ, Btu/(lb)(°R)	ω	$c_{p,a}$, Btu/(lb)(°R)	ψ_{c_p}, Btu/(lb)(°R)
4350	1194.23	1.15874	12150.9	15.0343	13.327	0.3038	3.745
4351	1194.53	1.15881	12154.6	15.0351			
4352	1194.84	1.15888	12158.4	15.0360			
4353	1195.14	1.15895	12162.1	15.0368			
4354	1195.44	1.15902	12165.8	15.0377			
4355	1195.74	1.15909	12169.6	15.0385	13.330	.3038	3.746
4356	1196.05	1.15915	12173.3	15.0394			
4357	1196.35	1.15922	12177.0	15.0402			
4358	1196.65	1.15929	12180.8	15.0411			
4359	1196.96	1.15936	12184.5	15.0419			
4360	1197.26	1.15943	12188.2	15.0428	13.333	.3038	3.747
4361	1197.56	1.15950	12192.0	15.0436			
4362	1197.87	1.15957	12195.7	15.0445			
4363	1198.17	1.15964	12199.4	15.0454			
4364	1198.48	1.15970	12203.2	15.0462			
4365	1198.78	1.15977	12206.9	15.0471	13.335	.3038	3.748
4366	1199.08	1.15984	12210.6	15.0480			
4367	1199.39	1.15991	12214.4	15.0488			
4368	1199.69	1.15998	12218.1	15.0497			
4369	1200.00	1.16005	12221.9	15.0505			
4370	1200.30	1.16012	12225.6	15.0514	13.338	.3039	3.749
4371	1200.60	1.16019	12229.3	15.0523			
4372	1200.91	1.16026	12233.1	15.0531			
4373	1201.21	1.16033	12236.8	15.0540			
4374	1201.52	1.16040	12240.5	15.0548			
4375	1201.82	1.16047	12244.3	15.0557	13.341	.3039	3.751
4376	1202.12	1.16054	12248.0	15.0566			
4377	1202.43	1.16061	12251.8	15.0574			
4378	1202.73	1.16068	12255.5	15.0583			
4379	1203.04	1.16075	12259.2	15.0591			
4380	1203.34	1.16082	12263.0	15.0600	13.343	.3039	3.752
4381	1203.64	1.16089	12266.7	15.0608			
4382	1203.95	1.16096	12270.5	15.0617			
4383	1204.25	1.16103	12274.2	15.0625			
4384	1204.56	1.16109	12278.0	15.0633			
4385	1204.86	1.16116	12281.7	15.0642	13.346	.3040	3.753
4386	1205.16	1.16123	12285.4	15.0650			
4387	1205.47	1.16130	12289.2	15.0659			
4388	1205.77	1.16137	12292.9	15.0667			
4389	1206.08	1.16144	12296.7	15.0676			
4390	1206.38	1.16151	12300.4	15.0684	13.349	.3040	3.754
4391	1206.68	1.16158	12304.2	15.0693			
4392	1206.99	1.16165	12307.9	15.0701			
4393	1207.29	1.16172	12311.6	15.0710			
4394	1207.60	1.16179	12315.4	15.0718			
4395	1207.90	1.16186	12319.1	15.0727	13.351	.3040	3.755
4396	1208.20	1.16193	12322.9	15.0735			
4397	1208.51	1.16200	12326.6	15.0744			
4398	1208.81	1.16207	12330.4	15.0752			
4399	1209.12	1.16214	12334.1	15.0761			
4400	1209.42	1.16221	12337.9	15.0768	13.354	.3041	3.756

TABLE III. - ENTHALPY OF THE REAL GAS PARA-HYDROGEN

AT A PRESSURE OF 1 ATMOSPHERE

T, °R	h_f, Btu/lb	T, °R	h_f, Btu/lb	T, °R	h_f, Btu/lb
36.5	81.41				
40	90.97				
50	117.81	450	1481.70	850	2886.59
60	143.92	460	1518.33	860	2921.31
70	169.30	470	1554.80	870	2956.02
80	194.40	480	1591.10	880	2990.73
90	219.63	490	1627.23	890	3025.43
100	244.94	500	1663.20	900	3060.14
110	270.34	510	1699.00	910	3094.85
120	296.25	520	1734.63	920	3129.56
130	322.85	530	1770.10	930	3164.27
140	350.14	540	1805.39	940	3198.98
150	378.30	550	1840.70	950	3233.70
160	407.59	560	1875.97	960	3268.40
170	437.97	570	1911.20	970	3303.11
180	469.44	580	1946.41	980	3337.83
190	504.33	590	1981.57	990	3372.53
200	539.52	600	2016.70	1000	3407.24
210	575.01	610	2051.79	1010	3441.96
220	610.81	620	2086.84	1020	3476.67
230	646.92	630	2121.87	1030	3511.38
240	683.35	640	2156.84	1040	3546.09
250	720.08	650	2191.79	1050	3580.81
260	757.11	660	2226.71	1060	3615.51
270	794.46	670	2261.57	1070	3650.23
280	832.11	680	2296.42	1080	3684.95
290	870.08	690	2331.22	1090	3719.71
300	908.35	700	2365.99	1100	3754.47
310	946.93	710	2400.71	1110	3789.25
320	985.82	720	2435.41	1120	3824.03
330	1025.02	730	2470.12	1130	3858.80
340	1064.52	740	2504.82	1140	3893.60
350	1104.33	750	2539.53	1150	3928.39
360	1144.46	760	2574.24	1160	3963.20
370	1182.60	770	2608.94	1170	3997.99
380	1220.57	780	2643.64	1180	4032.81
390	1258.37	790	2678.35	1190	4067.63
400	1296.02	800	2713.06	1200	4102.44
410	1333.48	810	2747.76	1210	4137.27
420	1370.79	820	2782.47	1220	4172.10
430	1407.92	830	2817.18	1230	4206.94
440	1444.89	840	2851.89	1240	4241.78
				1250	4276.63
				1260	4311.49

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