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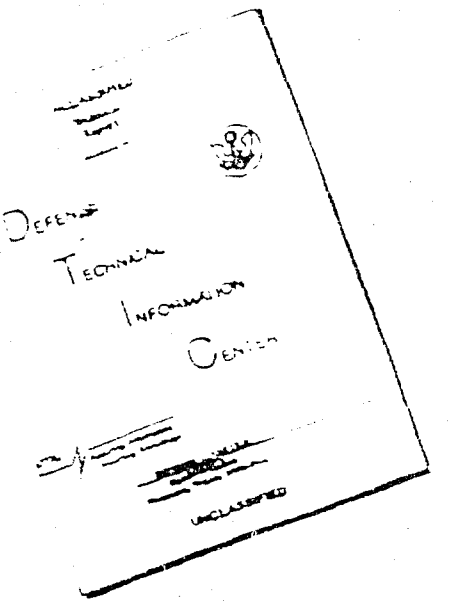


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# NORMAL SHOCK WAVE PARAMETERS IN EQUILIBRIUM AIR

By: Charles E. Wittliff
James T. Curtis

CAL Report No. CAL-111
November 1961

CORNELL AERONAUTICAL LABORATORY, INC.
OF CORNELL UNIVERSITY, BUFFALO 21, N. Y.

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# NORMAL SHOCK WAVE PARAMETERS IN EQUILIBRIUM AIR

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## FOREWORD

This report contains the results of an extensive series of normal shock wave calculations for equilibrium air performed under the direction of the authors at the Cornell Aeronautical Laboratory, Inc. That portion of the calculations relative to the "corridor of continuous flight" were performed for the Eclipse-Pioneer Division of the Bendix Aviation Corporation under Purchase Order No. 34-390785-G-48 (U. S. Air Force Prime Contract No. AF 33(616)-6579) and were reported in CAL Report No. AF-1429-P-1. Additional calculations pertinent to ballistic missile re-entry trajectories were made under Contract No. DA-30-069-509-ORD-3117 with the U. S. Army Rocket and Guided Missile Agency. The remainder of the calculations and the preparation of the present report were funded by the Cornell Aeronautical Laboratory, Inc.

The authors sincerely thank Dr. Russell E. Duff of the Los Alamos Scientific Laboratory for making available the IBM-computer program used in the present work. Grateful acknowledgement is due also to Mr. F. E. Butler of the Computer Services Section who handled the IBM-704 calculations. Finally, the authors wish to thank the various personnel of the Aerodynamic Research Department who contributed additional calculations and valuable assistance in preparing the tables and graphs.

## ABSTRACT

This report presents tables and graphs of normal shock wave parameters for equilibrium air. Composition of the air behind the shock is also tabulated. The results cover the range of velocities from 2000 fps to 26,000 fps in increments of 1000 fps and altitudes from sea level to 300,000 ft at 10,000-ft intervals. The 1959 ARDC model atmosphere has been used to specify ambient conditions ahead of the shock. An effective specific heat ratio, $\gamma_e$, has been tabulated which permits solution of oblique shock waves according to the method given in NASA TR R-63.

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## SYMBOLS

| | |
|---|---|
| $a$ | speed of sound, ft/sec |
| $E$ | internal energy, ft-lb/slug |
| $H$ | enthalpy, ft-lb/slug $= ft^2/sec^2$ |
| $L$ | reference length (Table I), feet |
| $M$ | Mach number |
| $P$ | pressure, psfa |
| $R$ | gas constant, ft-lb/slug-°R |
| $Re$ | Reynolds number, $\rho VL/\mu$ |
| $T$ | temperature, °R |
| $V$ | velocity, ft/sec |
| $Z$ | compressibility factor |
| $\beta$ | dimensionless enthalpy parameter, Eq. (19) |
| $\gamma$ | specific heat ratio |
| $\lambda$ | mean-free-path, feet |
| $\mu$ | viscosity, slugs/ft-sec |
| $\rho$ | density, slugs/cu. ft |

Subscripts

| | |
|---|---|
| 1 | conditions ahead of shock wave |
| 2 | conditions behind shock wave |
| e | effective, applied to specific heat ratio, Eq. (26) |
| T | stagnation-point conditions |

## INTRODUCTION

As indicated in Refs. 1 to 8, there have been published a number of reports of real-air solutions for normal shock waves at hypersonic speeds. Although these reports have found widespread use, it was felt that a more extensive compilation than now exists would prove worthwhile. Hence, calculations undertaken for other programs (see for example Ref. 9) were extended in order to provide a comprehensive tabulation of normal-shock-wave solutions for equilibrium air. Also included here are certain conditions at the stagnation-point behind the normal shock. In addition, the gas composition behind the shock is tabulated. The most recent 1959 ARDC model atmosphere[10] has been used to specify the ambient conditions ahead of the shock wave, and argon has been included in the composition of the air model used. To provide a useful tabulation, velocity and altitude have been taken as the independent parameters, and the increments (1000 fps in velocity and 10,000 ft in altitude) have been chosen to provide convenient interpolation.

The solutions have been obtained using an IBM-704 computer program made available by Dr. Russell E. Duff of the Los Alamos Scientific Laboratory. In this procedure, the machine is supplied with initial conditions and estimates of the conditions behind the shock. Because the composition behind the shock is computed at each step of the program, it is possible to use an arbitrarily complex model for air. The air composition behind the shock was varied somewhat with initial velocity to prevent the machine from seeking negligibly small concentrations of certain species at low velocities.

The results are presented as tables and graphs of the normal shock wave parameters, $\rho_2/\rho_1$, $p_2/p_1$, $T_2/T_1$, $Z_2$ and $H_2/H_1$. Also, certain conditions at a stagnation-point behind the normal shock are given; namely, $H_{T_2}/H_1$, $p_{T_2}/p_1$, and $T_{T_2}/T_1$.

The solution to oblique shock waves can be obtained by the method developed by Trimpi and Jones[11]. To facilitate the application of the present results to oblique shock calculations by their method, the effective specific heat ratio, $\gamma_e$, has been tabulated also. Use of Ref. 11 and the present report permits the solution of any oblique shock wave whose normal velocity component falls within the range of the present tables.

In the present report the air behind the shock has been assumed to be in thermal and chemical equilibrium. There are, of course, two extreme states for the region behind a normal shock wave at hypersonic speeds; they are thermo-chemical equilibrium as assumed here and the chemically "frozen" state for which ideal gas tables apply. At high altitudes and high velocities, both states can exist downstream of a shock wave. The gas will be "frozen" immediately downstream of a shock wave, but will pass through a relaxation zone and emerge in thermodynamic and chemical equilibrium. The nonequilibrium region has been the object of several studies (for example Refs. 12-15) which have resulted in computer programs to obtain numerical solutions.

## NORMAL SHOCK WAVE SOLUTION

### Basic Assumptions

The assumptions contained in the present work are those commonly

made in obtaining normal shock wave solutions for real-air in thermodynamic equilibrium. They are that: the flow is uniform and steady; the air is a homogeneous mixture of ideal gases each obeying its own equation of state; the flow is adiabatic and inviscid; the flow is a continuum; thermo-chemical equilibrium exists behind the shock wave. In addition, the atmospheric properties as given by the 1959 ARDC model atmosphere[10] exist ahead of the shock, and the composition of the air ahead of the shock is taken as 78.09% nitrogen, 20.98% oxygen, and 0.93% argon.

Conservation Equations

The equations for the conservation of mass, momentum, and energy across a normal shock wave are

Mass $$\rho_1 V_1 = \rho_2 V_2 \tag{1}$$

Momentum $$p_1 + \rho_1 V_1^2 = p_2 + \rho_2 V_2^2 \tag{2}$$

Energy $$H_1 + \frac{1}{2} V_1^2 = H_2 + \frac{1}{2} V_2^2 \tag{3}$$

where the subscripts 1 and 2 denote the conditions ahead of and behind the shock, respectively.

Ahead of the shock the air is at low temperature and the ideal-gas relations for equation of state and speed of sound are applicable

$$p_1 = \rho_1 R T_1 \tag{4}$$

$$a_1^2 = \gamma_1 R T_1 = \frac{\gamma_1 p_1}{\rho_1} \tag{5}$$

where $\gamma_1 = 1.4$.

The other information required to obtain the solution for a normal shock wave is the equation of state of the gas behind the shock. This is usually represented by tables of the thermodynamic properties of air at high temperature, e.g., Refs. 16-21.

Rankine-Hugoniot Relations

The velocities may be eliminated from the conservation equations (1-3), and relationships obtained which contain only the thermodynamic properties. These are the well-known Rankine-Hugoniot relations[22] which may be written

$$\frac{1}{2}(p_2 - p_1)\left(\frac{1}{\rho_1} + \frac{1}{\rho_2}\right) = (H_2 - H_1) \tag{6}$$

or, using $H = E + \frac{p}{\rho}$, as

$$\frac{1}{2}(p_1 + p_2)\left(\frac{1}{\rho_1} - \frac{1}{\rho_2}\right) = (E_2 - E_1) \tag{7}$$

These relations hold for both real and ideal gases since they do not introduce the equation of state.

Once a solution to either of these equations has been obtained, the initial velocity may be found from Eqs. (1) and (2) as

$$V_1^2 = \frac{p_1}{\rho_1}\,\frac{p_2/p_1 - 1}{1 - \rho_1/\rho_2} = \frac{p_1}{\rho_1}\,\frac{\rho_2}{\rho_1}\,\frac{p_2/p_1 - 1}{\rho_2/\rho_1 - 1} \tag{8}$$

Introducing the equation of state for the gas ahead of the shock, Eq. (4), and the expression for the speed of sound, Eq. (5), the initial Mach number is

$$M_1^2 = \frac{1}{\gamma_1}\,\frac{p_2/p_1 - 1}{1 - \rho_1/\rho_2} = \frac{1}{\gamma_1}\,\frac{\rho_2}{\rho_1}\,\frac{p_2/p_1 - 1}{\rho_2/\rho_1 - 1} \tag{9}$$

## Solution for Real Air

There are several approaches to solving the Rankine-Hugoniot relation, say Eq. (6), for real air in thermodynamic equilibrium. If the ambient conditions $p_1$, $\rho_1$, $T_1$, and $H_1$, and the initial velocity, $V_1$, are specified, an iterative procedure must be used. This involves estimating two of the conditions behind the shock, say $p_2$ and $T_2$, determining the other thermodynamic properties from tables (Refs. 16-20), and calculating both sides of Eq. (6) and the right side of Eq. (8). This process is repeated until the left and right sides of Eq. (6) are equal and the specified velocity is obtained from Eq. (8) to within the desired accuracy. This method may be used manually or with a high-speed computing machine if the thermodynamic tables are stored in the computer.

An alternate approach is to specify the initial ambient conditions and the temperature behind the shock, but not the initial velocity. Then only Eq. (6) must be solved by iteration after which the velocity is calculated from Eq. (8). This technique has been used in Ref. 8, for example.

For the case where the gas ahead of the shock is ideal, as we have assumed here, there exists a procedure for obtaining a solution in closed form. If the equilibrium thermodynamic state behind the shock and the initial temperature ahead of the shock are specified, the Rankine-Hugoniot relation, Eq. (6), reduces to a quadratic equation in either $p_1$ or $\rho_1$, or in their ratios to the known conditions behind the shock. The exact solution for the density ratio, $\rho_1 / \rho_2$, has been derived independently by Hochstim[5] and Golian[23*]. The quadratic equation and the

---

* Actually, Hochstim derives the equation and gives a solution for the ratio $\rho_2 / \rho_1$, whereas Golian finds $\rho_1 / \rho_2$.

solution for $\rho_1 / \rho_2$ are

$$\left(\frac{\rho_1}{\rho_2}\right)^2 + \left[1 + \frac{2(H_2 - H_1) - Z_2 R T_2}{R T_1}\right]\left(\frac{\rho_1}{\rho_2}\right) - \frac{Z_2 T_2}{T_1} = 0 \tag{10}$$

$$\left(\frac{\rho_1}{\rho_2}\right) = -\frac{1}{2}\left[1 + \frac{2(H_2 - H_1) - Z_2 R T_2}{R T_1}\right] + \sqrt{\frac{1}{4}\left[1 + \frac{2(H_2 + H_1) - Z_2 R T_2}{R T_1}\right]^2 + \frac{Z_2 T_2}{T_1}} \tag{11}$$

Similarly, for the pressure ratio, $p_1/p_2$, one can derive from Eq. (6) the result

$$\left(\frac{p_1}{p_2}\right)^2 + \left[\frac{2(H_2 - H_1) + R T_1}{Z_2 R T_2} - 1\right]\left(\frac{p_1}{p_2}\right) - \frac{T_1}{Z_2 T_2} = 0 \tag{12}$$

$$\frac{p_1}{p_2} = -\frac{1}{2}\left[\frac{2(H_2 - H_1) + R T_1}{Z_2 R T_2} - 1\right] + \sqrt{\frac{1}{4}\left[\frac{2(H_2 - H_1) + R T_1}{Z_2 R T_2} - 1\right]^2 + \frac{T_1}{Z_2 T_2}} \tag{13}$$

Although this procedure results in an exact solution, it is not used widely because the equilibrium state behind the shock rather than ahead of the shock is the primary independent condition. However, it is a convenient means of checking the accuracy of iterative solutions.

## COMPUTATIONAL PROGRAM

### Normal Shock Wave Calculations

The computational program has two phases: the calculation of conditions immediately behind a normal shock and the calculation of conditions at the stagnation point. The latter was added at CAL to Duff's original program. In the computer program the machine is supplied with the temperature, pressure and composition of the gas ahead of a shock of

specified speed and also with initial estimates of the same quantities behind the shock. In addition, the thermodynamic properties of the reactant and product gases are read into the machine by means of "thermo-fit" cards which supply the coefficients in polynomial equations fitted to the tabulated functions*. The thermo-fit equations for the monatomic gases were obtained by Duff. The thermo-fit equations for the diatomic gases were taken from the work of Fickett and Cowan[24]. For both cases, it was necessary to use two sets of cards covering respectively the temperature range 500°K to 3000°K and 3000°K to 12,000°K.

The computing program was essentially as follows:
The equilibrium composition corresponding to the assumed temperature and pressure are calculated by an iterative solution of Brinckley's matrix equations[25,26]. With a tentative chemistry established, the equation of state is known and the specific enthalpy $H_2$ and density $\rho_2$ may be computed. These thermodynamic variables are then substituted into the Hugoniot equation

$$\frac{H_2 - H_1}{RT_1} = \frac{1}{2}\left(\frac{p_2}{p_1} - 1\right)\left(1 + \frac{\rho_1}{\rho_2}\right) \tag{16}$$

to compute an improved value for the pressure ratio $p_2/p_1$, which is used to start a new cycle. When the relative change in $p_2/p_1$ per cycle falls to $10^{-6}$, the pressure iteration is stopped and the shock speed is computed from the equation

$$V_1^2 = \frac{1}{\rho_1^2}\,\frac{p_2 - p_1}{\frac{1}{\rho_1} - \frac{1}{\rho_2}} \tag{17}$$

* These are tabulated in the Appendix.

At this point, one has the option of stopping the calculation and printing out $V_1$ and the other variables as functions of the temperature behind the shock.

For the present purpose, however, it was more convenient to vary $T_2$ until the specified shock speed was obtained. Thus, the whole set of calculations outlined above was repeated with different temperatures until the calculated shock speed agreed with that specified within an error of 1 cm $sec^{-1}$.

The convergence of the multiply-iterative calculational scheme described above was found to depend on the concentrations of the independent components used in the Brinckley scheme to describe the composition behind the shock. A mixture of thirteen chemical species, N, O, A, $e^-$, $N_2$, $N_2^+$, $O_2$, $O_2^+$, NO, $NO^+$, $N^+$, $O^+$, $O^-$, with N, O, A, $e^-$ as the independent components was assumed to exist behind the strongest shocks. This model proved generally satisfactory at shock speeds of 14,000 ft per sec and above, but below this speed the concentration of electrons became too low (mole fraction $< 10^{-5}$) for convergence. Thus, it was necessary at this point to drop ionization leaving an air model consisting of $N_2$, $O_2$, A, N, O, and NO with the molecules $N_2$, $O_2$, A as the independent species. Further decreases in shock speed lowered $T_2$ below 3000°K so that it was necessary to shift to the low-range "thermo-fit" cards. Finally, at very low shock Mach numbers, the concentrations of nitrogen and nitric oxide became too low for the machine to handle and it was necessary to change to a four-species model including only $N_2$, $O_2$, A, and O. Actually, the concentration of atomic oxygen is essentially negligible in

in this range, but its inclusion was necessary to preserve the logic of the calculation.

The air models described above were used in the regions mapped in Fig. 1. In some cases a model was used to compute one or two points beyond the indicated boundaries. In these cases of overlapping data preference was given to that arising from the more complex air model. Where the number of species was the same, preference was given to the computation which used the right thermo-fit cards for the indicated $T_2$.

This overlap gave the opportunity for comparison of the air models employed in the program. Table 1 gives the values of $\Delta T_2/T_{2_{average}}$ and $\Delta p_2/p_{2_{average}}$ computed from the overlapping data at each of the numbered boundary points indicated in Fig 1, where $\Delta T_2$ and $\Delta p_2$ are the differences between the two calculations. It is clear from the minuteness of the relative errors indicated by Table 1 that the air models and their boundaries are reasonably accurate.

Another source of error is the thermodynamic functions. Fickett and Cowan[24] forced their approximate calculations to agree with those performed at the Bureau of Standards[27] over the range $3000°K \leq T \leq 5000°K$. The necessary corrections when extrapolated to 12,000°K amounted to less than 2%. The greatest r-m-s error in fitting cubic equations to the tabulated data was in the low range thermo-fit cards and amounted to 0.26% for NO. No information about the accuracy of the fits for the atomic constituents is available to the authors.

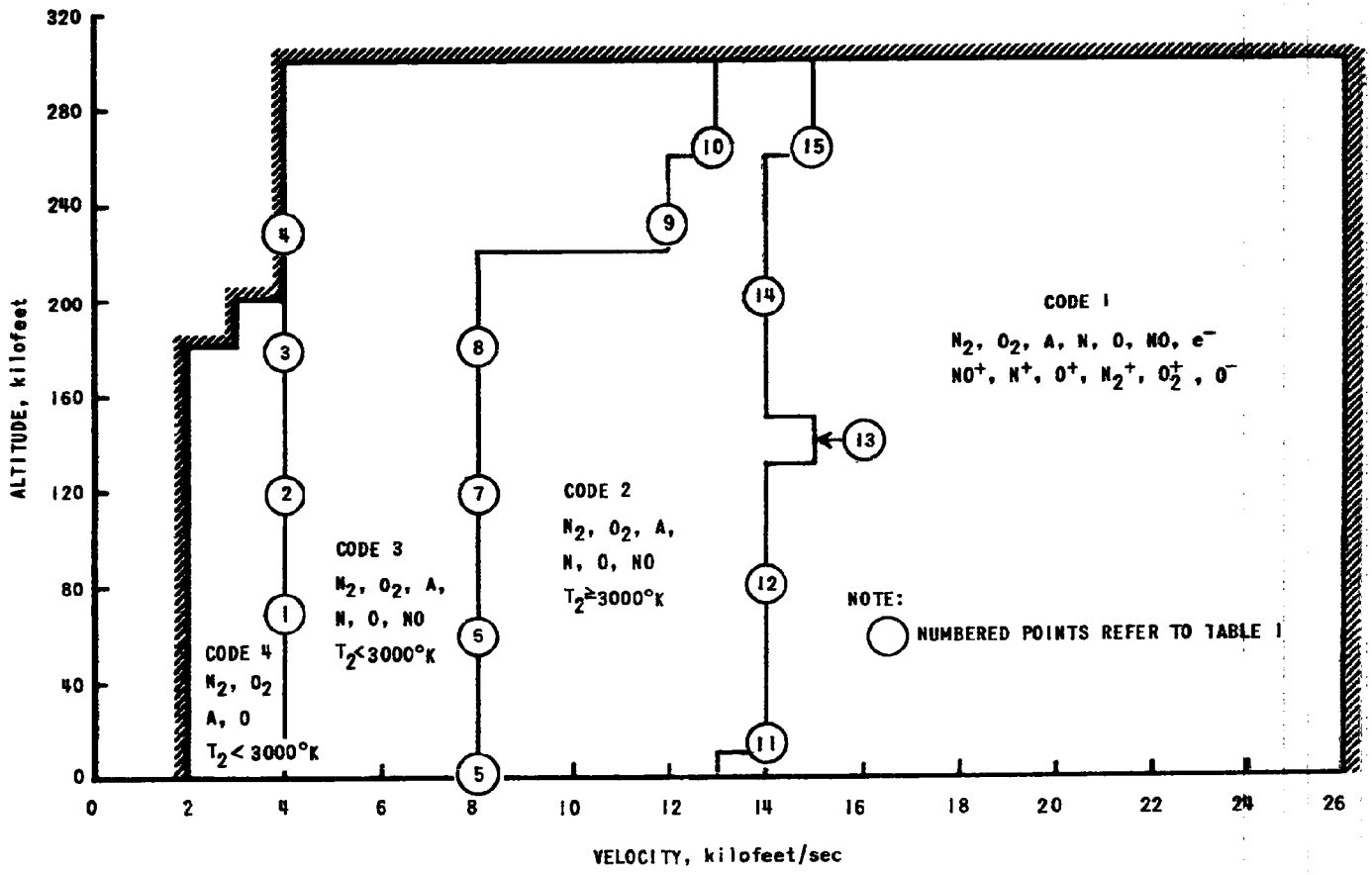


Figure I AIR MODELS ASSUMED FOR SPECIES BEHIND NORMAL SHOCK WAVE

TABLE 1

TYPICAL RELATIVE ERRORS AT MODEL BOUNDARIES
FOR POSITION OF POINTS SEE FIG. 1

| Point No. | $\lvert\Delta T_2\rvert / (T_2)$ avg. | $\lvert\Delta p_2\rvert / (p_2)$ avg. |
|---|---|---|
| 1 | $2.239 \times 10^{-5}$ | $1.132 \times 10^{-5}$ |
| 2 | $3.254 \times 10^{-5}$ | $1.247 \times 10^{-5}$ |
| 3 | $5.301 \times 10^{-5}$ | $2.634 \times 10^{-5}$ |
| 4 | - - - - | - - - - |
| 5 | $90.273 \times 10^{-5}$ | $22.514 \times 10^{-5}$ |
| 6 | $115.624 \times 10^{-5}$ | $23.72 \times 10^{-5}$ |
| 7 | $109.524 \times 10^{-5}$ | $23.985 \times 10^{-5}$ |
| 8 | $109.110 \times 10^{-5}$ | $25.154 \times 10^{-5}$ |
| 9 | $15.723 \times 10^{-5}$ | 0 |
| 10 | $3.305 \times 10^{-5}$ | 0 |
| 11 | $7.284 \times 10^{-5}$ | 0 |
| 12 | $6.263 \times 10^{-5}$ | 0 |
| 13 | $5.962 \times 10^{-5}$ | $7.704 \times 10^{-5}$ |
| 14 | $13.898 \times 10^{-5}$ | $7.732 \times 10^{-5}$ |
| 15 | $7.375 \times 10^{-5}$ | $2.513 \times 10^{-5}$ |

## Stagnation-Point Calculations

The procedure adopted for calculating the stagnation point values $T_{T_2}$, $p_{T_2}$ is based upon the observation that $T_{T_2}$ differs little from $T_2$ and consequently the compressibility factor $Z_2$ is nearly constant along the stagnation streamline.

Essentially, the flow chemistry was frozen at the equilibrium condition immediately behind the shock. Thus, one may assume an isentropic compression described by the equation

$$dH = \frac{1}{\rho}\, dp \tag{18}$$

or, on defining

$$\beta \equiv \frac{H}{ZRT} \tag{19}$$

by

$$\beta \frac{dH}{H} = \frac{dp}{p} \tag{20}$$

It is now assumed that $\beta$ = constant allowing the integration of Eq. (20) in the form

$$\frac{p_{T_2}}{p_2} = \left(\frac{H_{T_2}}{H_2}\right)^{\beta} = \left(1 + \frac{V_2^2}{2H_2}\right)^{\beta} \tag{21}$$

or, to the same degree of approximation

$$\frac{p_{T_2}}{p_2} = \left(1 + \frac{\beta V_2^2}{2H_2}\right) \tag{22}$$

This equation has been used to calculate $p_{T_2}$. Note, however, that by eliminating $\beta$, Eq. (22) can be written as

$$\frac{p_{T_2}}{p_1} = 1 + \gamma_1 M_1^2 \left(1 - \frac{1}{2\rho_2/\rho_1}\right) \tag{23}$$

which is identical to Bernoulli's equation for incompressible flow. This, of course, is to be expected since we have in essence assumed the density to be constant along the stagnation streamline.

The stagnation temperature has been determined from the stagnation enthalpy, since, by assumption, $c_p$ is constant in this region. Thus

$$\frac{T_{T_2}}{T_2} = \frac{H_{T_2}}{H_2} = 1 + \frac{V_2^2}{2H_2} \tag{24}$$

The accuracy of the calculated values of $p_{T_2}$ and $T_{T_2}$ have been spot-checked using Eq. (23) and by calculating a real-gas isentropic compression from $H_2$ to $H_{T_2}$ (which is known a priori) using a Mollier diagram for air. The maximum differences amounted to no more than 2.3% in $p_{T_2}$ and 1% in $T_{T_2}$, and in general were much less than these values.

## 1959 ARDC MODEL ATMOSPHERE

The 1959 model atmosphere[10] on which these tables are based is summarized in Table I*. This new model is an extension and revision of the 1956 model. The revisions were undertaken after satellite data revealed that high altitude densities were considerably larger than had hitherto been expected. Below a geometric altitude of approximately 173,500 feet, the two atmospheric models are identical. Above that altitude the new model has a higher density (higher by a factor of 10 at 300,000 feet) and a lower temperature (a difference of 30°K at 195,300 feet). In the 1959 model, as in its predecessor, the molecular weight of air is taken to be constant up to 300,000 feet, where it begins to decrease owing to dissociation and natural stratifications.

* In Tables I and III the numbers in parentheses indicate the power of 10 that the tabulated number is to be multiplied by.

## RESULTS

### Normal Shock Wave Parameters

The normal shock wave parameters that have been selected for presentation here are:

| | | |
|---|---|---|
| $\rho_2/\rho_1$ | , | the density ratio across the shock |
| $p_2/p_1$ | , | the pressure ratio across the shock |
| $T_2/T_1$ | , | the temperature ratio across the shock |
| $Z_2$ | , | the compressibility factor behind the shock |
| $H_2/H_1$ | , | the enthalpy ratio across the shock |
| $H_{T_2}/H_1$ | , | the ratio of total enthalpy behind the shock to static enthalpy ahead of the shock* |
| $p_{T_2}/p_1$ | , | the ratio of stagnation pressure behind the shock to freestream static pressure |
| $T_{T_2}/T_1$ | , | the ratio of stagnation temperature behind the shock to freestream static temperature |
| $\gamma_e$ | , | the effective specific-heat ratio as defined in Eq. (26) on page 19 |

The velocity behind the shock, $V_2$, can be determined easily from the continuity equation, Eq. (1), that is

$$V_2 = \frac{V_1}{\rho_2/\rho_1} \tag{25}$$

By using thermodynamic charts (AVCO's Mollier Diagram for Air, Ref. 5) or tables (e.g., Ref. 16), the speed of sound, $a_2$, may be determined knowing $p_2$, $T_2$, and $\rho_2$. Then the Mach number behind the shock, $M_2$,

---

* Note that from the conservation of energy $H_{T_2} = H_{T_1} = H_1 + 1/2\ V_1^2$. Hence, this can be determined a priori. The ratio $H_{T_2}/H_1$ is tabulated only for convenience.

can be calculated. The density at the stagnation point downstream of the shock can be found from thermodynamic tables for air knowing $H_{T_2}$, $p_{T_2}$, and $T_{T_2}$. The use of the effective specific heat ratio, $\gamma_e$, to obtain oblique shock wave solutions is described in the next section of the report.

Tables

The normal shock wave parameters listed above are tabulated as functions of free-stream velocity, $V_1$, in Table II. Each page of the table is for a specific altitude. The free-stream Mach number, $M_1$, is also listed. The ambient pressure, density, temperature, enthalpy, and sonic speed for each altitude are also given at the top of each table.

The gas composition behind the shock wave is presented in Table III with the species concentrations given as mole fractions. These are listed for the various species behind the shock as a function of free-stream velocity. Again each page of the table represents a single altitude.

Graphs

Graphs of the following parameters are given at the end of the report:

$$\frac{\rho_2}{\rho_1} \quad \frac{p_2}{p_1} \quad \frac{T_2}{T_1} \quad \frac{H_2}{H_1} \quad \frac{p_{T_2}}{p_1} \quad \frac{T_{T_2}}{T_1}$$

The presentation in the graphs differs from that normally used for normal shock wave parameters. Generally, the parameters have been plotted as a function of velocity or Mach number for constant altitude; e.g., Refs. 1, 4, 7, and 8. Such a presentation permits direct reading of the desired velocity; however, interpolation between altitudes is sometimes awkward. In the present report the parameters are plotted as a function of altitude for constant velocity. The nature of the resulting graph permits direct reading of the altitude and simple interpolation for the velocity which is

plotted in 1000-fps intervals. It should be noted that only in Graph 1 of the density ratio, $\rho_2/\rho_1$, do any of the velocity curves cross. There the curves for 13,000 fps and 14,000 fps cross the 11,000 fps and 12,000 fps curves. This behavior of the density ratio is related to oxygen dissociation occurring behind the shock.

Comparison of the Results with Other Solutions

In making a quantitative comparison of the present results with other calculations, the density ratio $\rho_2/\rho_1$, was selected as the parameter to be compared. The comparisons were made over the Mach number range 10 to 17 which includes the region where oxygen dissociation occurs behind the normal shock. The comparison was made graphically by plotting $\rho_2/\rho_1$ versus $M_1$ for several altitudes. Altitudes above 100,000 feet have not been compared because of increasing differences in ambient conditions for the various atmospheric models. The specific altitudes and references compared are listed in the following table.

TABLE 2

ALTITUDES AND REFERENCES COMPARED WITH PRESENT RESULTS

| Altitude | Reference |
|---|---|
| Sea Level | Bond[1], Romig[2], Feldman[4], and Batchelder[7] |
| 82,020 ft* | Huber[8] |
| 100,000 ft | Bond[1], Moeckel[3], Feldman[4], and Batchelder[7] |

* Compared with present results for 80,000 ft: the free-stream temperatures are equal for 80,000 and 82,020 ft and the atmospheric pressure differs by only 1.6%.

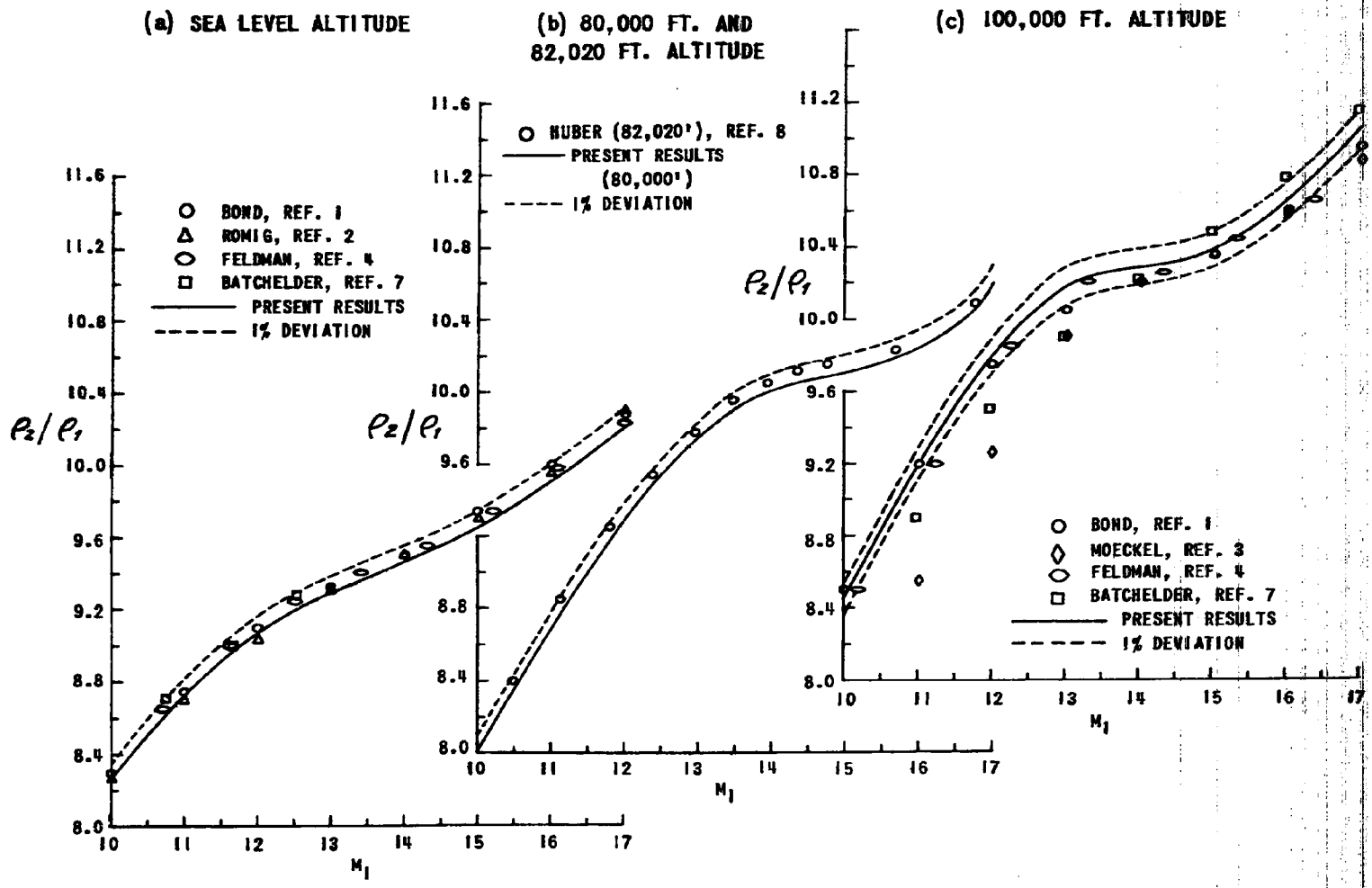


Figure 2 COMPARISON OF DENSITY RATIO

The comparison at sea level showed agreement of 1% or better for Mach number range 10 to 17; the average difference is about 1/2%, Fig. 2a. This is exceptionally good considering that the data being compared with the present results were read from graphs. The data, however, were consistently higher than the present work except for the solution of Ref. 2 from Mach 10 to 12.5. The small, but consistent, discrepancy may be attributable to the inclusion of argon in the air model of the present work or to differences in the thermodynamic properties.

Huber's results at 82,020 feet are also consistently higher than the present results for 80,000 feet, Fig. 2b. Again, however, the difference is always less than 1% and averages about 1/2% in the Mach number range 10 to 17. The small difference in atmospheric pressure at these two altitudes (1.6%) should not introduce any significant error in the comparison of density ratio.

At 100,000 feet altitude the data being compared with the present results show considerably more scatter than at sea level, Fig. 2c. The solutions by Bond[1] and Feldman[4] show the greatest consistency of agreement generally to within 1%; however, the differences are sometimes as large as 2%. Moeckel's results[3] are well below the other data for Mach numbers below 14. At Mach 14 to 17 they agree to better than 2%. The solutions reported by Batchelder et al[7] do not follow the trend consistently, being low below Mach 14 and high above Mach 14.

## APPLICATION TO OBLIQUE SHOCK WAVES

A method of solution for an oblique shock wave attached to a surface at arbitrary angle of attack, sweep and dihedral has been given by Trimpi

and Jones in Ref. 11. The extensive tabulation of the results presented in that reference are applicable to any real gas in thermodynamic equilibrium. To use their results one requires a knowledge of the effective specific-heat ratio $\gamma_e$, as a function of Mach number for a normal shock wave in the particular gas of interest. This effective specific-heat ratio, which is defined as

$$\gamma_e \equiv 2\frac{M_1^{-2} - 1}{\left(\frac{1}{P_2/P_1} - 1\right)} - 1 \tag{26}$$

has been calculated for all the normal shock wave solutions reported herein. Thus the present results can be used in conjunction with Ref. 11 to determine conditions behind oblique waves for a wide range of velocities and flow deflections in the earth's atmosphere.

The procedure for obtaining an oblique shock wave solution using the effective value of specific-heat ratio, $\gamma_e$, is thoroughly described in Ref. 11 and will not be repeated here.

## SUMMARY

Solutions for normal shock waves in air have been computed for velocities from 2000 fps to 26,000 fps and altitudes from sea level to 300,000 feet. The 1959 ARDC Model Atmosphere has been used to define the ambient conditions ahead of the shock wave. In addition to flow conditions just behind a normal shock wave, the isentropic compression to a stagnation point has been calculated under the assumption of constant density behind the shock. Thermodynamic equilibrium is assumed in all calculations.

The results are presented in tabular and graphical form. In addition to the normal-shock and stagnation-point parameters, the composition of the air behind the shock has been tabulated. Also included in the tables is the effective specific-heat ratio, $\gamma_e$, which can be used with Ref. 11 to obtain solutions to oblique shock waves.

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## APPENDIX

## POLYNOMIAL APPROXIMATIONS FOR THERMODYNAMIC FUNCTIONS

The use of the thermo-fit cards has been described in the text. These cards contain the coefficients of polynomial equations for enthalpy or free-energy as a function of temperature. In as much as the source of the thermodynamic properties of high temperature air is pertinent to normal shock wave calculations, the equations utilized in the present work are given here.

Ahead of the normal shock the air is a mixture of nitrogen, oxygen, and argon molecules, and the temperature is relatively low. The enthalpy is expressed as

$$H\ (\text{cal/mole}) = a + bT + cT^2\ ,\ T\ (°K)$$

where the coefficients for the various species are

| Gas | Temperature Range | a | b | c |
|---|---|---|---|---|
| A | 250-400°K | 0 | 4.9679750 | 0 |
| $O_2$ | 250-400°K | 2.8601800(1) | 6.6591078 | 6.2596273(-4) |
| $N_2$ | 250-400°K | 3.8580000 | 6.9106551 | 8.9250203(-5) |

At the high temperature behind the shock, air consists of a mixture of molecules, atoms, and ions. In the present work as many as 13 species are assumed to be present. Because of the large range in temperature behind the shock, higher-order polynomials are used, and in some cases the coefficients are evaluated for discrete temperature ranges.

The equations are

Enthalpy, $$\frac{H - H^o}{R\,T} = a + bT + cT^2 + dT^3 + eT^4$$

Free Energy, $$\frac{F - H^o}{R\,T} = a\,(1 - \ln T) - bT - \frac{c}{2}T^2 - \frac{d}{3}T^3 - \frac{e}{4}T^4 - k$$

where R is the univeral gas constant, $H^o$ is the heat of formation of the various species, and k is a constant for each of the species.

The coefficients and constants in these polynomials have been evaluated by Fickett and Cowan for the molecules $N_2$, NO, and $O_2$ for two temperature ranges, 500 to 3000°K and 3000 to 12,000°K. Duff has obtained polynomial fits for the atoms O and N for the same temperature ranges. Since the ionized species occur only at the higher temperatures, polynomicals have been fitted at CAL for the range 3000 to 10,000°K. The coefficients, the heat of formation, $H^o$, and the constant k are given on the following page.

| Gas | Temperature Range | a | b | c | d | e | k | $H^o$ |
|---|---|---|---|---|---|---|---|---|
| $N_2$ | 500- 3,000°K | 3.3443500 | 2.9426000(-4) | 1.9530000(-9) | -6.5745000(-12) | 0 | 3.7586300 | 0 |
| $N_2$ | 3,000-12,000°K | 3.5144300 | 2.5831400(-4) | -2.8410700(-8) | 1.2415400(-12) | 0 | 2.7411300 | 0 |
| NO | 500- 3,000°K | 3.5017400 | 2.9938000(-4) | -9.5880000(-9) | -4.9036000(-12) | 0 | 5.1134600 | 2.1477000(4) |
| NO | 3,000-12,000°K | 3.7449300 | 1.9497500(-4) | -1.8828400(-8) | 7.7028000(-13) | 0 | 3.7132900 | 2.1477000(4) |
| $O_2$ | 500- 3,000°K | 3.2530400 | 6.5235000(-4) | -1.4952400(-7) | 1.5389700(-11) | 0 | 5.7124300 | 0 |
| $O_2$ | 3,000-12,000°K | 3.5506400 | 3.2031200(-4) | -2.8757500(-8) | 1.0052800(-12) | 0 | 4.2094500 | 0 |
| O | 500- 3,000°K | 2.7640276 | -2.5142685(-4) | 1.0018675(-7) | -1.3867004(-11) | 0 | 3.7330900 | 5.8980000(4) |
| O | 3,000-12,000°K | 2.5940875 | -3.8431865(-5) | 7.5142841(-9) | -3.2094308(-13) | 0 | 4.5799300 | 5.8980000(4) |
| N | 500- 3,000°K | 2.4990624 | 2.8744113(-6) | -2.4481595(-9) | 6.1515069(-13) | 0 | 4.1850400 | 1.1259064(5) |
| N | 3,000-12,000°K | 2.7037524 | -1.4179802(-4) | 2.8470463(-8) | -1.1789366(-12) | 0 | 3.0613600 | 1.1259064(5) |
| A | Up to 12,000°K | 2.5000000 | 0 | 0 | 0 | 0 | 0 | 0 |
| $e^-$ | - - - | 2.5000000 | 0 | 0 | 0 | 0 | -1.1735000(1) | 0 |
| $N_2^+$ | 3,000-10,000°K | 2.9711400 | 5.1822203(-4) | -3.7705301(-8) | -1.4528000(-13) | 7.7395703(-17) | 6.6583800 | 3.5922900(5) |
| $O_2^+$ | 3,000-10,000°K | 3.3283300 | 4.7378801(-4) | -9.3131001(-8) | 8.8298702(-12) | -2.7676800(-16) | 5.5694660 | 2.7790900(5) |
| $N^+$ | 3,000-10,000°K | 2.5891600 | 0.5768801(-5) | 1.6864500(-3) | -1.3758700(-12) | 3.9675202(-17) | 4.5120699 | 4.4783700(5) |
| $NO^+$ | 3,000-10,000°K | 3.1350000 | 6.4678501(-4) | -1.8325100(-7) | 2.6243300(-11) | -1.1649800(-15) | 5.5529400 | 2.3533000(5) |
| $O^+$ | 3,000-10,000°K | 2.3755800 | 7.7463703(-5) | -2.3069400(-8) | 3.0130801(-12) | -1.1480600(-16) | 5.1464690 | 3.7296900(5) |
| $O^-$ | 3,000-10,000°K | 2.6245500 | -1.0265300(-4) | 2.6213200(-8) | -2.0612900(-12) | 5.4884502(-17) | 4.1422300 | 2.6701200(4) |

| TABLE I ATMOSPHERIC PROPERITIES AS A FUNCTION OF ALTITUDE | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Alt. (ft) | T (°R) | p (psfa) | $\rho\left(\frac{slugs}{ft^3}\right)$ | $a\left(\frac{ft}{sec}\right)$ | $\mu\left(\frac{slugs}{ft\text{-}sec}\right)$ | $\lambda(ft)$ | $H\left(\frac{ft\text{-}lb}{slug}\right)$ | $\frac{Re}{ML}\left(ft^{-1}\right)$ |
| 0 | 518.69 | 2.1162(+3) | 2.3769(-3) | 1116.4 | 3.7373(-7) | 2.1758(-7) | 3.1047(+6) | 7.1002(+6) |
| 10,000 | 483.04 | 1.4556(+3) | 1.7556(-3) | 1077.4 | 3.5344(-7) | 2.9458(-7) | 2.8907(+6) | 5.3518(+6) |
| 20,000 | 447.43 | 9.7327(+2) | 1.2673(-3) | 1036.9 | 3.3245(-7) | 4.0809(-7) | 2.6770(+6) | 3.9527(+6) |
| 30,000 | 411.86 | 6.2966(+2) | 8.9068(-4) | 994.85 | 3.1070(-7) | 5.8064(-7) | 2.4639(+6) | 2.8519(+6) |
| 40,000 | 389.99 | 3.9312(+2) | 5.8727(-4) | 968.08 | 2.9692(-7) | 8.8062(-7) | 2.3330(+6) | 1.9147(+6) |
| 50,000 | 389.99 | 2.4361(+2) | 3.6391(-4) | 968.08 | 2.9692(-7) | 1.4211(-6) | 2.3330(+6) | 1.1865(+6) |
| 60,000 | 389.99 | 1.5103(+2) | 2.2561(-4) | 968.08 | 2.9692(-7) | 2.2623(-6) | 2.3330(+6) | 7.3558(+5) |
| 70,000 | 389.99 | 9.3672(+1) | 1.3993(-4) | 968.08 | 2.9692(-7) | 3.6958(-6) | 2.3330(+6) | 4.5623(+5) |
| 80,000 | 389.99 | 5.8125(+1) | 8.6831(-5) | 968.08 | 2.9692(-7) | 5.9560(-6) | 2.3330(+6) | 2.8310(+5) |
| 90,000 | 402.48 | 3.6292(+1) | 5.2531(-5) | 983.46 | 3.0484(-7) | 9.8449(-6) | 2.4078(+6) | 1.6947(+5) |
| 100,000 | 418.79 | 2.3085(+1) | 3.2114(-5) | 1003.2 | 3.1501(-7) | 1.6104(-5) | 2.5054(+6) | 1.0227(+5) |
| 110,000 | 435.09 | 1.4947(+1) | 2.0014(-5) | 1022.5 | 3.2499(-7) | 2.5840(-5) | 2.6031(+6) | 6.2969(+4) |
| 120,000 | 451.37 | 9.8372 | 1.2697(-5) | 1041.5 | 3.3480(-7) | 4.0731(-5) | 2.7007(+6) | 3.9498(+4) |
| 130,000 | 467.63 | 6.5735 | 8.1894(-6) | 1060.1 | 3.4444(-7) | 6.3150(-5) | 2.7982(+6) | 2.5205(+4) |
| 140,000 | 483.88 | 4.4552 | 5.3640(-6) | 1078.3 | 3.5392(-7) | 9.6413(-5) | 2.8957(+6) | 1.6343(+4) |
| 150,000 | 500.11 | 3.0597 | 3.5642(-6) | 1096.3 | 3.6324(-7) | 1.4510(-4) | 2.9931(+6) | 1.0757(+4) |
| 160,000 | 508.79 | 2.1247 | 2.4329(-6) | 1105.7 | 3.6816(-7) | 2.1257(-4) | 3.0452(+6) | 7.3068(+3) |
| 170,000 | 508.79 | 1.4784 | 1.6929(-6) | 1105.7 | 3.6816(-7) | 3.0549(-4) | 3.0452(+6) | 5.0843(+3) |
| 180,000 | 497.49 | 1.0272 | 1.2028(-6) | 1093.4 | 3.6175(-7) | 4.2995(-4) | 2.9773(+6) | 3.6355(+3) |
| 190,000 | 473.24 | 7.0278(-1) | 8.6517(-7) | 1066.4 | 3.4773(-7) | 5.9776(-4) | 2.8319(+6) | 2.6533(+3) |
| 200,000 | 449.00 | 4.7151(-1) | 6.1180(-7) | 1038.7 | 3.3339(-7) | 8.4532(-4) | 2.6864(+6) | 1.9061(+3) |
| 210,000 | 424.79 | 3.0955(-1) | 4.2454(-7) | 1010.3 | 3.1870(-7) | 1.2182(-3) | 2.5413(+6) | 1.3458(+3) |
| 220,000 | 400.60 | 1.9835(-1) | 2.8845(-7) | 981.16 | 3.0365(-7) | 1.7929(-3) | 2.3966(+6) | 9.3205(+2) |
| 230,000 | 376.44 | 1.2368(-1) | 1.9141(-7) | 951.11 | 2.8822(-7) | 2.7019(-3) | 2.2519(+6) | 6.3164(+2) |
| 240,000 | 352.30 | 7.4774(-2) | 1.2365(-7) | 920.11 | 2.7237(-7) | 4.1824(-3) | 2.1076(+6) | 4.1771(+2) |
| 250,000 | 328.2 | 4.364(-2) | 7.748(-8) | 888.1 | 2.561(-7) | 6.675 (-3) | 1.9636(+6) | 2.687 (+2) |
| 260,000 | 304.1 | 2.446(-2) | 4.686(-8) | 854.8 | 2.394(-7) | 1.104(-2) | 1.8198(+6) | 1.673 (+2) |
| 270,000 | 298.2 | 1.327(-2) | 2.593(-8) | 846.5 | 2.352(-7) | 1.995(-2) | 1.7847(+6) | 8.778(+1) |
| 280,000 | 298.2 | 7.194(-3) | 1.406(-8) | 846.5 | 2.352(-7) | 3.679(-2) | 1.7847(+6) | 5.060(+1) |
| 290,000 | 298.2 | 3.902(-3) | 7.624(-9) | 846.5 | 2.352(-7) | 6.784(-2) | 1.7847(+6) | 2.744(+1) |
| 300,000 | 299.2 | 2.118(-3) | 4.123(-9) | 848.3 | 2.359(-7) | 1.254(-1) | 1.7906(+6) | 1.483(+1) |

NUMBERS IN PARENTHESIS INDICATE POWER OF 10 THE NUMBER IS TO BE MULTIPLIED BY; e.g. $2.118(-3) \equiv 2.118 \times 10^{-3}$

## TABLE II - NORMAL-SHOCK WAVE PARAMETERS

Altitude: 0 feet

Pressure: 2116.2 psfa

Density: $2.3769 \times 10^{-3}$ slugs/ft$^3$

Temperature: 518.69°R

Enthalpy: $3.1047 \times 10^6$ ft-lb/slug

Sonic Speed: 1116.4 ft/sec

| $V_1$ | $M_1$ | $\rho_2/\rho_1$ | $p_2/p_1$ | $T_2/T_1$ | $Z_2$ | $H_2/H_1$ | $H_{T_2}/H_1$ | $p_{T_2}/p_1$ | $T_{T_2}/T_1$ | $\gamma_e$ |
|---|---|---|---|---|---|---|---|---|---|---|
| 2000 | 1.791 | 2.325 | 3.559 | 1.531 | 1.000 | 1.525 | 1.644 | 4.527 | 1.650 | 1.416 |
| 3000 | 2.687 | 3.615 | 8.309 | 2.299 | 1.000 | 2.338 | 2.449 | 9.707 | 2.408 | 1.382 |
| 4000 | 3.583 | 4.537 | 15.00 | 3.307 | 1.000 | 3.451 | 3.577 | 16.98 | 3.427 | 1.366 |
| 5000 | 4.479 | 5.217 | 23.69 | 4.540 | 1.000 | 4.877 | 5.026 | 26.38 | 4.678 | 1.351 |
| 6000 | 5.374 | 5.768 | 34.41 | 5.966 | 1.000 | 6.621 | 6.798 | 37.91 | 6.122 | 1.336 |
| 7000 | 6.270 | 6.261 | 47.22 | 7.542 | 1.000 | 8.687 | 8.891 | 51.62 | 7.717 | 1.320 |
| 8000 | 7.166 | 6.731 | 62.18 | 9.230 | 1.001 | 11.08 | 11.31 | 67.52 | 9.420 | 1.303 |
| 9000 | 8.062 | 7.204 | 79.31 | 10.96 | 1.004 | 13.78 | 14.04 | 85.63 | 11.16 | 1.287 |
| 10,000 | 8.957 | 7.697 | 98.68 | 12.64 | 1.014 | 16.83 | 17.10 | 106.0 | 12.85 | 1.270 |
| 11,000 | 9.853 | 8.184 | 120.2 | 14.26 | 1.030 | 20.18 | 20.49 | 128.5 | 14.47 | 1.255 |
| 12,000 | 10.75 | 8.617 | 143.9 | 15.86 | 1.053 | 23.86 | 24.19 | 153.3 | 16.07 | 1.243 |
| 13,000 | 11.64 | 8.960 | 169.6 | 17.52 | 1.080 | 27.85 | 28.22 | 180.2 | 17.73 | 1.235 |
| 14,000 | 12.54 | 9.198 | 197.1 | 19.31 | 1.110 | 32.19 | 32.56 | 209.1 | 19.53 | 1.230 |
| 15,000 | 13.44 | 9.360 | 226.6 | 21.27 | 1.138 | 36.80 | 37.24 | 240.1 | 21.51 | 1.227 |
| 16,000 | 14.33 | 9.510 | 258.2 | 23.28 | 1.166 | 41.75 | 42.23 | 273.3 | 23.53 | 1.224 |
| 17,000 | 15.23 | 9.702 | 292.0 | 25.20 | 1.194 | 47.02 | 47.54 | 308.7 | 25.47 | 1.220 |
| 18,000 | 16.12 | 9.941 | 328.2 | 26.96 | 1.224 | 52.62 | 53.18 | 346.5 | 27.23 | 1.215 |
| 19,000 | 17.02 | 10.21 | 366.6 | 28.57 | 1.257 | 58.56 | 59.14 | 386.4 | 28.84 | 1.210 |
| 20,000 | 17.91 | 10.49 | 407.3 | 30.05 | 1.292 | 64.79 | 65.42 | 428.7 | 30.32 | 1.204 |
| 21,000 | 18.81 | 10.76 | 450.1 | 31.45 | 1.330 | 71.38 | 72.02 | 473.1 | 31.72 | 1.199 |
| 22,000 | 19.71 | 11.03 | 495.1 | 32.78 | 1.370 | 78.28 | 78.95 | 519.7 | 33.05 | 1.194 |
| 23,000 | 20.60 | 11.27 | 542.2 | 34.07 | 1.412 | 85.50 | 86.19 | 568.6 | 34.34 | 1.190 |
| 24,000 | 21.50 | 11.49 | 591.4 | 35.35 | 1.456 | 93.04 | 93.76 | 619.5 | 35.62 | 1.186 |
| 25,000 | 22.39 | 11.69 | 642.7 | 36.62 | 1.501 | 100.9 | 101.7 | 672.7 | 36.89 | 1.183 |
| 26,000 | 23.29 | 11.86 | 695.9 | 37.91 | 1.548 | 109.0 | 109.9 | 727.9 | 38.18 | 1.180 |

## TABLE II - NORMAL-SHOCK WAVE PARAMETERS

Altitude: 10,000 feet

Pressure: 1455.6 psfa

Density: $1.7656 \times 10^{-3}$ slugs/ft$^3$

Temperature: 483.04 °R

Enthalpy: $2.8907 \times 10^6$ ft-lb/slug

Sonic Speed: 1077.4 ft/sec

| $V_1$ | $M_1$ | $\rho_2/\rho_1$ | $p_2/p_1$ | $T_2/T_1$ | $Z_2$ | $H_2/H_1$ | $H_{T_2}/H_1$ | $p_{T_2}/p_1$ | $T_{T_2}/T_1$ | $\gamma_2$ |
|---|---|---|---|---|---|---|---|---|---|---|
| 2000 | 1.856 | 2.421 | 3.830 | 1.582 | 1.000 | 1.574 | 1.692 | 4.826 | 1.701 | 1.418 |
| 3000 | 2.784 | 3.711 | 8.926 | 2.405 | 1.000 | 2.443 | 2.557 | 10.39 | 2.516 | 1.385 |
| 4000 | 3.713 | 4.617 | 16.11 | 3.489 | 1.000 | 3.637 | 3.768 | 18.20 | 3.614 | 1.368 |
| 5000 | 4.641 | 5.281 | 25.43 | 4.816 | 1.000 | 5.168 | 5.324 | 28.29 | 4.960 | 1.353 |
| 6000 | 5.569 | 5.818 | 36.94 | 6.349 | 1.000 | 7.041 | 7.227 | 40.67 | 6.515 | 1.337 |
| 7000 | 6.497 | 6.300 | 50.69 | 8.046 | 1.000 | 9.258 | 9.476 | 55.38 | 8.231 | 1.321 |
| 8000 | 7.425 | 6.774 | 66.76 | 9.847 | 1.001 | 11.82 | 12.07 | 72.46 | 10.05 | 1.304 |
| 9000 | 8.353 | 7.243 | 85.16 | 11.70 | 1.005 | 14.74 | 15.01 | 91.91 | 11.91 | 1.287 |
| 10,000 | 9.282 | 7.748 | 106.0 | 13.48 | 1.015 | 18.00 | 18.30 | 113.8 | 13.69 | 1.270 |
| 11,000 | 10.21 | 8.249 | 129.2 | 15.16 | 1.033 | 21.62 | 21.93 | 138.0 | 15.38 | 1.254 |
| 12,000 | 11.14 | 8.695 | 154.6 | 16.83 | 1.057 | 25.58 | 25.91 | 164.6 | 17.05 | 1.242 |
| 13,000 | 12.07 | 9.045 | 182.2 | 18.57 | 1.085 | 29.86 | 30.23 | 193.5 | 18.79 | 1.233 |
| 14,000 | 12.99 | 9.283 | 211.8 | 20.46 | 1.115 | 34.50 | 34.90 | 224.6 | 20.69 | 1.228 |
| 15,000 | 13.92 | 9.440 | 243.5 | 22.54 | 1.144 | 39.46 | 39.92 | 257.9 | 22.79 | 1.225 |
| 16,000 | 14.85 | 9.590 | 277.4 | 24.68 | 1.172 | 44.78 | 45.28 | 293.5 | 24.95 | 1.223 |
| 17,000 | 15.78 | 9.790 | 313.8 | 26.70 | 1.200 | 50.44 | 50.99 | 331.6 | 26.98 | 1.219 |
| 18,000 | 16.71 | 10.04 | 352.7 | 28.54 | 1.231 | 56.48 | 57.04 | 372.1 | 28.82 | 1.213 |
| 19,000 | 17.64 | 10.32 | 394.0 | 30.21 | 1.264 | 62.83 | 63.44 | 415.1 | 30.49 | 1.207 |
| 20,000 | 18.56 | 10.61 | 437.8 | 31.75 | 1.300 | 69.56 | 70.19 | 460.5 | 32.03 | 1.202 |
| 21,000 | 19.49 | 10.89 | 483.8 | 33.19 | 1.338 | 76.61 | 77.28 | 508.2 | 33.47 | 1.196 |
| 22,000 | 20.42 | 11.17 | 532.2 | 34.58 | 1.379 | 84.04 | 84.72 | 558.4 | 34.86 | 1.191 |
| 23,000 | 21.35 | 11.42 | 582.9 | 35.92 | 1.421 | 91.75 | 92.50 | 610.8 | 36.20 | 1.187 |
| 24,000 | 22.28 | 11.65 | 635.8 | 37.24 | 1.466 | 99.88 | 100.6 | 665,6 | 37.52 | 1.183 |
| 25,000 | 23.20 | 11.85 | 690.9 | 38.56 | 1.512 | 108.3 | 109.1 | 722.7 | 38.83 | 1.180 |
| 26,000 | 24.13 | 12.02 | 748.1 | 39.89 | 1.560 | 117.1 | 117.9 | 782.1 | 40.17 | 1.178 |

## TABLE II - NORMAL-SHOCK WAVE PARAMETERS

Altitude: 20,000 feet
Pressure: 973.27 psfa
Density: $1.2673 \times 10^{-3}$ slugs/ft$^3$
Temperature: 447.43 °R
Enthalpy: $2.6770 \times 10^6$ ft-lb/slug
Sonic Speed: 1036.9 ft/sec

| $V_1$ | $M_1$ | $\rho_2/\rho_1$ | $p_2/p_1$ | $T_2/T_1$ | $Z_2$ | $H_2/H_1$ | $H_{T_2}/H_1$ | $p_{T_2}/p_1$ | $T_{T_2}/T_1$ | $\gamma_e$ |
|---|---|---|---|---|---|---|---|---|---|---|
| 2000 | 1.929 | 2.526 | 4.145 | 1.641 | 1.000 | 1.630 | 1.747 | 5.176 | 1.759 | 1.421 |
| 3000 | 2.893 | 3.813 | 9.642 | 2.528 | 1.000 | 2.565 | 2.681 | 11.18 | 2.642 | 1.387 |
| 4000 | 3.858 | 4.700 | 17.39 | 3.701 | 1.000 | 3.852 | 3.988 | 19.61 | 3.831 | 1.370 |
| 5000 | 4.822 | 5.345 | 27.45 | 5.135 | 1.000 | 5.504 | 5.669 | 30.50 | 5.288 | 1.354 |
| 6000 | 5.786 | 5.868 | 39.87 | 6.794 | 1.000 | 7.526 | 7.724 | 43.86 | 6.970 | 1.339 |
| 7000 | 6.751 | 6.340 | 54.71 | 8.629 | 1.000 | 9.920 | 10.15 | 59.75 | 8.827 | 1.322 |
| 8000 | 7.715 | 6.801 | 72.05 | 10.58 | 1.001 | 12.69 | 12.95 | 78.17 | 10.80 | 1.305 |
| 9000 | 8.680 | 7.284 | 91.95 | 12.55 | 1.005 | 15.83 | 16.13 | 99.19 | 12.78 | 1.287 |
| 10,000 | 9.644 | 7.803 | 114.5 | 14.43 | 1.017 | 19.37 | 19.68 | 122.8 | 14.46 | 1.269 |
| 11,000 | 10.61 | 8.321 | 139.6 | 16.20 | 1.035 | 23.26 | 23.60 | 149.0 | 16.43 | 1.253 |
| 12,000 | 11.57 | 8.780 | 167.1 | 17.94 | 1.061 | 27.54 | 27.90 | 177.7 | 18.17 | 1.240 |
| 13,000 | 12.54 | 9.137 | 196.9 | 19.77 | 1.090 | 32.18 | 32.57 | 208.9 | 20.00 | 1.231 |
| 14,000 | 13.50 | 9.375 | 228.9 | 21.78 | 1.121 | 37.18 | 37.61 | 242.5 | 22.02 | 1.227 |
| 15,000 | 14.47 | 9.527 | 263.1 | 24.00 | 1.150 | 42.53 | 43.02 | 278.5 | 24.26 | 1.224 |
| 16,000 | 15.43 | 9.677 | 299.8 | 26.29 | 1.178 | 48.27 | 48.81 | 317.0 | 26.57 | 1.221 |
| 17,000 | 16.40 | 9.886 | 339.1 | 28.42 | 1.207 | 54.41 | 54.98 | 358.1 | 28.71 | 1.217 |
| 18,000 | 17.36 | 10.15 | 381.1 | 30.35 | 1.238 | 60.92 | 61.52 | 401.9 | 30.64 | 1.211 |
| 19,000 | 18.32 | 10.44 | 425.8 | 32.09 | 1.271 | 67.77 | 68.43 | 448.3 | 32.38 | 1.205 |
| 20,000 | 19.29 | 10.74 | 473.1 | 33.69 | 1.308 | 75.07 | 75.71 | 497.4 | 33.98 | 1.199 |
| 21,000 | 20.25 | 11.04 | 523.0 | 35.19 | 1.346 | 82.63 | 83.37 | 549.0 | 35.48 | 1.194 |
| 22,000 | 21.22 | 11.32 | 575.3 | 36.62 | 1.388 | 90.68 | 91.40 | 603.1 | 36.91 | 1.189 |
| 23,000 | 22.18 | 11.58 | 630.0 | 38.02 | 1.431 | 99.03 | 99.80 | 659.8 | 38.30 | 1.185 |
| 24,000 | 23.15 | 11.82 | 687.2 | 39.39 | 1.476 | 107.7 | 108.6 | 719.0 | 39.67 | 1.181 |
| 25,000 | 24.11 | 12.03 | 746.8 | 40.77 | 1.523 | 116.9 | 117.7 | 780.6 | 41.05 | 1.178 |
| 26,000 | 25.07 | 12.21 | 808.7 | 42.16 | 1.572 | 126.4 | 127.2 | 844.8 | 42.44 | 1.175 |

## TABLE II - NORMAL-SHOCK WAVE PARAMETERS

Altitude: 30,000 feet

Pressure: 629.66 psfa

Density: $8.9068 \times 10^{-4}$ slugs/ft$^3$

Temperature: 411.86°R

Enthalpy: $2.4639 \times 10^6$ ft-lb/slug

Sonic Speed: 994.85 ft/sec

| $V_1$ | $M_1$ | $\rho_2/\rho_1$ | $p_2/p_1$ | $T_2/T_1$ | $Z_2$ | $H_2/H_1$ | $H_{T_2}/H_1$ | $p_{T_2}/p_1$ | $T_{T_2}/T_1$ | $\gamma_e$ |
|---|---|---|---|---|---|---|---|---|---|---|
| 2000 | 2.010 | 2.641 | 4.514 | 1.709 | 1.000 | 1.695 | 1.812 | 5.585 | 1.827 | 1.422 |
| 3000 | 3.016 | 3.921 | 10.48 | 2.672 | 1.000 | 2.707 | 2.826 | 12.10 | 2.790 | 1.389 |
| 4000 | 4.021 | 4.786 | 18.90 | 3.948 | 1.000 | 4.104 | 4.247 | 21.26 | 4.084 | 1.372 |
| 5000 | 5.026 | 5.412 | 29.82 | 5.509 | 1.000 | 5.898 | 6.073 | 33.08 | 5.671 | 1.356 |
| 6000 | 6.031 | 5.920 | 43.30 | 7.315 | 1.000 | 8.095 | 8.306 | 47.60 | 7.503 | 1.340 |
| 7000 | 7.036 | 6.381 | 59.42 | 9.312 | 1.000 | 10.70 | 10.94 | 64.85 | 9.524 | 1.324 |
| 8000 | 8.041 | 6.838 | 78.26 | 11.43 | 1.001 | 13.70 | 13.99 | 84.87 | 11.66 | 1.306 |
| 9000 | 9.047 | 7.328 | 99.47 | 13.49 | 1.006 | 17.05 | 17.37 | 107.2 | 13.73 | 1.288 |
| 10,000 | 10.05 | 7.864 | 123.9 | 15.47 | 1.018 | 20.86 | 21.20 | 132.8 | 15.71 | 1.269 |
| 11,000 | 11.06 | 8.400 | 151.1 | 17.32 | 1.039 | 25.10 | 25.45 | 161.2 | 17.56 | 1.252 |
| 12,000 | 12.06 | 8.874 | 180.9 | 19.14 | 1.065 | 29.71 | 30.09 | 192.3 | 19.38 | 1.238 |
| 13,000 | 13.07 | 9.240 | 213.2 | 21.05 | 1.096 | 34.74 | 35.15 | 226.0 | 21.29 | 1.230 |
| 14,000 | 14.07 | 9.476 | 247.8 | 23.20 | 1.127 | 40.13 | 40.60 | 262.4 | 23.46 | 1.225 |
| 15,000 | 15.08 | 9.621 | 286.1 | 25.70 | 1.157 | 46.15 | 46.66 | 302.6 | 25.97 | 1.222 |
| 16,000 | 16.08 | 9.772 | 325.9 | 28.15 | 1.185 | 52.40 | 52.95 | 344.4 | 28.44 | 1.219 |
| 17,000 | 17.09 | 9.991 | 368.7 | 30.41 | 1.213 | 59.02 | 59.65 | 389.2 | 30.71 | 1.215 |
| 18,000 | 18.09 | 10.27 | 414.5 | 32.43 | 1.245 | 66.12 | 66.75 | 436.8 | 32.73 | 1.209 |
| 19,000 | 19.10 | 10.58 | 463.2 | 34.25 | 1.279 | 73.59 | 74.26 | 487.3 | 34.55 | 1.203 |
| 20,000 | 20.10 | 10.89 | 514.6 | 35.92 | 1.316 | 81.49 | 82.17 | 540.6 | 36.22 | 1.197 |
| 21,000 | 21.11 | 11.20 | 568.8 | 37.49 | 1.355 | 89.73 | 90.49 | 596.7 | 37.79 | 1.191 |
| 22,000 | 22.11 | 11.49 | 625.8 | 38.98 | 1.397 | 98.43 | 99.22 | 655.6 | 39.28 | 1.186 |
| 23,000 | 23.12 | 11.76 | 685.4 | 40.44 | 1.441 | 107.5 | 108.4 | 717.2 | 40.73 | 1.182 |
| 24,000 | 24.12 | 12.01 | 747.6 | 41.87 | 1.487 | 117.0 | 117.9 | 781.5 | 42.16 | 1.178 |
| 25,000 | 25.13 | 12.22 | 812.4 | 43.31 | 1.535 | 127.0 | 127.8 | 848.5 | 43.60 | 1.175 |
| 26,000 | 26.13 | 12.41 | 879.8 | 44.77 | 1.584 | 137.3 | 138.2 | 918.3 | 45.06 | 1.172 |

## TABLE II - NORMAL-SHOCK WAVE PARAMETERS

Altitude: 40,000 feet
Pressure: 393.12 psfa
Density: $5.8727 \times 10^{-4}$ slugs/ft$^3$

Temperature: 389.99°R
Enthalpy: $2.3330 \times 10^6$ ft-lb/slug
Sonic Speed: 968.08 ft/sec

| $V_1$ | $M_1$ | $\rho_2/\rho_1$ | $p_2/p_1$ | $T_2/T_1$ | $Z_2$ | $H_2/H_1$ | $H_{T_2}/H_1$ | $p_{T_2}/p_1$ | $T_{T_2}/T_1$ | $\gamma_e$ |
|---|---|---|---|---|---|---|---|---|---|---|
| 2000 | 2.066 | 2.717 | 4.775 | 1.757 | 1.000 | 1.741 | 1.857 | 5.874 | 1.874 | 1.423 |
| 3000 | 3.099 | 3.991 | 11.07 | 2.774 | 1.000 | 2.807 | 2.929 | 12.76 | 2.894 | 1.391 |
| 4000 | 4.132 | 4.841 | 19.96 | 4.122 | 1.000 | 4.282 | 4.429 | 22.42 | 4.263 | 1.373 |
| 5000 | 5.165 | 5.454 | 31.49 | 5.773 | 1.000 | 6.176 | 6.358 | 34.91 | 5.941 | 1.357 |
| 6000 | 6.198 | 5.952 | 45.72 | 7.682 | 1.000 | 8.495 | 8.715 | 50.24 | 7.879 | 1.341 |
| 7000 | 7.231 | 6.407 | 62.75 | 9.793 | 1.000 | 11.24 | 11.50 | 68.46 | 10.02 | 1.325 |
| 8000 | 8.264 | 6.865 | 82.64 | 12.02 | 1.001 | 14.41 | 14.72 | 89.61 | 12.27 | 1.307 |
| 9000 | 9.297 | 7.370 | 105.5 | 14.22 | 1.007 | 18.04 | 18.36 | 113.7 | 14.47 | 1.287 |
| 10,000 | 10.33 | 7.929 | 131.5 | 16.25 | 1.021 | 22.09 | 22.43 | 140.9 | 16.50 | 1.267 |
| 11,000 | 11.36 | 8.489 | 160.4 | 18.13 | 1.042 | 26.55 | 26.93 | 171.0 | 18.38 | 1.250 |
| 12,000 | 12.40 | 8.981 | 192.1 | 19.98 | 1.071 | 31.49 | 31.86 | 204.1 | 20.22 | 1.236 |
| 13,000 | 13.43 | 9.356 | 226.4 | 21.95 | 1.102 | 36.77 | 37.22 | 239.9 | 22.20 | 1.227 |
| 14,000 | 14.46 | 9.588 | 263.1 | 24.18 | 1.135 | 42.54 | 43.01 | 278.4 | 24.44 | 1.222 |
| 15,000 | 15.49 | 9.724 | 302.4 | 26.71 | 1.165 | 48.72 | 49.22 | 319.7 | 26.99 | 1.220 |
| 16,000 | 16.53 | 9.879 | 344.6 | 29.26 | 1.192 | 55.27 | 55.87 | 363.9 | 29.56 | 1.217 |
| 17,000 | 17.56 | 10.11 | 389.9 | 31.57 | 1.221 | 62.31 | 62.94 | 411.2 | 31.88 | 1.212 |
| 18,000 | 18.59 | 10.41 | 438.3 | 33.61 | 1.253 | 69.79 | 70.44 | 461.6 | 33.92 | 1.206 |
| 19,000 | 19.63 | 10.73 | 489.8 | 35.44 | 1.287 | 77.64 | 78.37 | 514.9 | 35.74 | 1.200 |
| 20,000 | 20.66 | 11.07 | 544.3 | 37.12 | 1.325 | 85.99 | 86.73 | 571.3 | 37.42 | 1.194 |
| 21,000 | 21.69 | 11.39 | 601.7 | 38.70 | 1.365 | 94.73 | 95.51 | 630.6 | 39.00 | 1.188 |
| 22,000 | 22.73 | 11.69 | 661.9 | 40.20 | 1.408 | 103.9 | 104.7 | 692.8 | 40.49 | 1.183 |
| 23,000 | 23.76 | 11.98 | 724.9 | 41.66 | 1.453 | 113.6 | 114.4 | 757.9 | 41.95 | 1.178 |
| 24,000 | 24.79 | 12.23 | 790.8 | 43.11 | 1.500 | 123.6 | 124.4 | 825.9 | 43.40 | 1.175 |
| 25,000 | 25.82 | 12.46 | 859.3 | 44.56 | 1.548 | 134.0 | 134.9 | 896.8 | 44.85 | 1.171 |
| 26,000 | 26.86 | 12.65 | 930.6 | 46.04 | 1.598 | 144.9 | 145.9 | 970.5 | 46.33 | 1.169 |

## TABLE II - NORMAL-SHOCK WAVE PARAMETERS

Altitude: 50,000 feet
Pressure: 243.61 psfa
Density: $3.6391 \times 10^{-4}$ slugs/ft$^3$

Temperature: 389.99°R
Enthalpy: $2.3330 \times 10^6$ ft-lb/slug
Sonic Speed: 968.08 ft/sec

| $V_1$ | $M_1$ | $\rho_2/\rho_1$ | $p_2/p_1$ | $T_2/T_1$ | $Z_2$ | $H_2/H_1$ | $H_{T_2}/H_1$ | $p_{T_2}/p_1$ | $T_{T_2}/T_1$ | $\gamma_e$ |
|---|---|---|---|---|---|---|---|---|---|---|
| 2000 | 2.066 | 2.717 | 4.775 | 1.757 | 1.000 | 1.741 | 1.857 | 5.874 | 1.874 | 1.423 |
| 3000 | 3.099 | 3.991 | 11.07 | 2.774 | 1.000 | 2.807 | 2.929 | 12.76 | 2.894 | 1.391 |
| 4000 | 4.132 | 4.841 | 19.96 | 4.122 | 1.000 | 4.282 | 4.429 | 22.42 | 4.263 | 1.373 |
| 5000 | 5.165 | 5.454 | 31.49 | 5.773 | 1.000 | 6.176 | 6.358 | 34.91 | 5.941 | 1.357 |
| 6000 | 6.198 | 5.952 | 45.72 | 7.682 | 1.000 | 8.495 | 8.715 | 50.24 | 7.879 | 1.341 |
| 7000 | 7.231 | 6.408 | 62.75 | 9.791 | 1.000 | 11.24 | 11.50 | 68.46 | 10.01 | 1.325 |
| 8000 | 8.264 | 6.874 | 82.66 | 12.00 | 1.002 | 14.43 | 14.72 | 89.62 | 12.25 | 1.306 |
| 9000 | 9.297 | 7.405 | 105.6 | 14.14 | 1.008 | 18.03 | 18.36 | 113.8 | 14.39 | 1.286 |
| 10,000 | 10.33 | 7.997 | 131.6 | 16.08 | 1.024 | 22.09 | 22.43 | 141.0 | 16.32 | 1.264 |
| 11,000 | 11.36 | 8.585 | 160.6 | 17.86 | 1.047 | 26.56 | 26.93 | 171.2 | 18.10 | 1.246 |
| 12,000 | 12.40 | 9.099 | 192.4 | 19.63 | 1.077 | 31.47 | 31.86 | 204.2 | 19.86 | 1.232 |
| 13,000 | 13.43 | 9.482 | 226.7 | 21.53 | 1.111 | 36.82 | 37.22 | 240.0 | 21.76 | 1.223 |
| 14,000 | 14.46 | 9.707 | 263.5 | 23.74 | 1.144 | 42.56 | 43.01 | 278.6 | 23.99 | 1.219 |
| 15,000 | 15.49 | 9.833 | 302.8 | 26.25 | 1.173 | 48.70 | 49.22 | 319.9 | 26.52 | 1.217 |
| 16,000 | 16.53 | 9.996 | 345.0 | 28.75 | 1.200 | 55.28 | 55.87 | 364.1 | 29.03 | 1.214 |
| 17,000 | 17.56 | 10.25 | 390.4 | 30.98 | 1.229 | 62.31 | 62.94 | 411.5 | 31.27 | 1.209 |
| 18,000 | 18.59 | 10.57 | 439.0 | 32.92 | 1.262 | 69.81 | 70.44 | 461.9 | 33.21 | 1.203 |
| 19,000 | 19.63 | 10.92 | 490.7 | 34.65 | 1.297 | 77.69 | 78.37 | 515.4 | 34.94 | 1.196 |
| 20,000 | 20.66 | 11.27 | 545.3 | 36.23 | 1.335 | 85.99 | 86.73 | 571.8 | 36.52 | 1.190 |
| 21,000 | 21.69 | 11.61 | 602.8 | 37.72 | 1.377 | 94.79 | 95.51 | 631.1 | 38.00 | 1.184 |
| 22,000 | 22.73 | 11.93 | 663.1 | 39.14 | 1.420 | 104.0 | 104.7 | 693.4 | 39.41 | 1.179 |
| 23,000 | 23.76 | 12.23 | 726.3 | 40.52 | 1.466 | 113.6 | 114.4 | 758.6 | 40.79 | 1.174 |
| 24,000 | 24.79 | 12.49 | 792.2 | 41.90 | 1.514 | 123.6 | 124.4 | 826.7 | 42.17 | 1.170 |
| 25,000 | 25.82 | 12.73 | 860.9 | 43.28 | 1.563 | 134.1 | 134.9 | 897.6 | 43.55 | 1.167 |
| 26,000 | 26.86 | 12.93 | 932.3 | 44.69 | 1.614 | 145.0 | 145.9 | 971.4 | 44.95 | 1.165 |

## TABLE II - NORMAL-SHOCK WAVE PARAMETERS

Altitude: 60,000 feet
Pressure: 151.03 psfa
Density: $2.2561 \times 10^{-4}$ slugs/ft$^3$

Temperature: 389.99 °R
Enthalpy: $2.3330 \times 10^6$ ft-lb/slug
Sonic Speed: 968.08 ft/sec

| $V_1$ | $M_1$ | $\rho_2/\rho_1$ | $p_2/p_1$ | $T_2/T_1$ | $Z_2$ | $H_2/H_1$ | $H_{T_2}/H_1$ | $p_{T_2}/p_1$ | $T_{T_2}/T_1$ | $\gamma_e$ |
|---|---|---|---|---|---|---|---|---|---|---|
| 2000 | 2.066 | 2.717 | 4.775 | 1.757 | 1.000 | 1.741 | 1.857 | 5.874 | 1.874 | 1.423 |
| 3000 | 3.099 | 3.991 | 11.07 | 2.774 | 1.000 | 2.807 | 2.929 | 12.76 | 2.894 | 1.391 |
| 4000 | 4.132 | 4.841 | 19.96 | 4.122 | 1.000 | 4.282 | 4.429 | 22.42 | 4.263 | 1.373 |
| 5000 | 5.165 | 5.454 | 31.49 | 5.773 | 1.000 | 6.176 | 6.358 | 34.91 | 5.941 | 1.357 |
| 6000 | 6.198 | 5.952 | 45.72 | 7.682 | 1.000 | 8.495 | 8.715 | 50.24 | 7.879 | 1.341 |
| 7000 | 7.231 | 6.409 | 62.75 | 9.789 | 1.000 | 11.24 | 11.50 | 68.46 | 10.01 | 1.324 |
| 8000 | 8.264 | 6.886 | 82.69 | 11.98 | 1.002 | 14.42 | 14.72 | 89.63 | 12.22 | 1.306 |
| 9000 | 9.297 | 7.445 | 105.7 | 14.06 | 1.010 | 18.04 | 18.36 | 113.8 | 14.30 | 1.284 |
| 10,000 | 10.33 | 8.070 | 131.8 | 15.90 | 1.027 | 22.09 | 22.43 | 141.1 | 16.14 | 1.261 |
| 11,000 | 11.36 | 8.688 | 160.9 | 17.59 | 1.053 | 26.59 | 26.93 | 171.3 | 17.82 | 1.243 |
| 12,000 | 12.40 | 9.222 | 192.7 | 19.27 | 1.084 | 31.49 | 31.86 | 204.4 | 19.49 | 1.229 |
| 13,000 | 13.43 | 9.613 | 227.1 | 21.12 | 1.119 | 36.83 | 37.22 | 240.2 | 21.34 | 1.220 |
| 14,000 | 14.46 | 9.827 | 263.9 | 23.31 | 1.152 | 42.55 | 43.01 | 278.8 | 23.55 | 1.216 |
| 15,000 | 15.49 | 9.941 | 303.2 | 25.83 | 1.181 | 48.72 | 49.22 | 320.1 | 26.09 | 1.214 |
| 16,000 | 16.53 | 10.12 | 345.5 | 28.27 | 1.208 | 55.31 | 55.87 | 364.4 | 28.54 | 1.211 |
| 17,000 | 17.56 | 10.40 | 391.0 | 30.40 | 1.237 | 62.47 | 62.94 | 411.8 | 30.68 | 1.206 |
| 18,000 | 18.59 | 10.74 | 439.7 | 32.24 | 1.270 | 69.81 | 70.44 | 462.3 | 32.52 | 1.199 |
| 19,000 | 19.63 | 11.11 | 491.5 | 33.87 | 1.306 | 77.72 | 78.37 | 515.8 | 34.14 | 1.192 |
| 20,000 | 20.66 | 11.48 | 546.2 | 35.37 | 1.345 | 86.04 | 86.73 | 572.2 | 35.64 | 1.186 |
| 21,000 | 21.69 | 11.84 | 603.9 | 36.77 | 1.387 | 94.80 | 95.51 | 631.7 | 37.03 | 1.180 |
| 22,000 | 22.73 | 12.18 | 664.3 | 38.12 | 1.432 | 104.0 | 104.7 | 694.0 | 38.38 | 1.175 |
| 23,000 | 23.76 | 12.48 | 727.6 | 39.43 | 1.478 | 113.6 | 114.4 | 759.3 | 39.68 | 1.170 |
| 24,000 | 24.79 | 12.76 | 793.7 | 40.73 | 1.527 | 123.6 | 124.4 | 827.4 | 40.98 | 1.167 |
| 25,000 | 25.82 | 13.01 | 862.5 | 42.05 | 1.577 | 134.1 | 134.9 | 898.4 | 42.30 | 1.163 |
| 26,000 | 26.86 | 13.21 | 934.0 | 43.40 | 1.629 | 145.0 | 145.9 | 972.2 | 43.65 | 1.161 |

## TABLE II - NORMAL-SHOCK WAVE PARAMETERS

Altitude: 70,000 feet
Pressure: 93.672 psfa
Density: $1.3993 \times 10^{-4}$ slugs/ft$^3$

Temperature: 389.99 °R
Enthalpy: $2.3330 \times 10^6$ ft-lb/slug
Sonic Speed: 968.08 ft/sec

| $V_1$ | $M_1$ | $\rho_2/\rho_1$ | $p_2/p_1$ | $T_2/T_1$ | $Z_2$ | $H_2/H_1$ | $H_{T_2}/H_1$ | $p_{T_2}/p_1$ | $T_{T_2}/T_1$ | $\gamma_e$ |
|---|---|---|---|---|---|---|---|---|---|---|
| 2000 | 2.066 | 2.717 | 4.775 | 1.757 | 1.000 | 1.741 | 1.857 | 5.874 | 1.874 | 1.428 |
| 3000 | 3.099 | 3.991 | 11.07 | 2.774 | 1.000 | 2.807 | 2.929 | 12.76 | 2.894 | 1.391 |
| 4000 | 4.132 | 4.841 | 19.96 | 4.122 | 1.000 | 4.282 | 4.429 | 22.42 | 4.263 | 1.373 |
| 5000 | 5.165 | 5.454 | 31.49 | 5.773 | 1.000 | 6.176 | 6.358 | 34.91 | 5.941 | 1.357 |
| 6000 | 6.198 | 5.952 | 45.72 | 7.682 | 1.000 | 8.495 | 8.715 | 50.24 | 7.879 | 1.341 |
| 7000 | 7.231 | 6.411 | 62.75 | 9.786 | 1.000 | 11.24 | 11.50 | 68.46 | 10.01 | 1.324 |
| 8000 | 8.264 | 6.901 | 82.72 | 11.96 | 1.003 | 14.43 | 14.72 | 89.64 | 12.20 | 1.305 |
| 9000 | 9.297 | 7.490 | 105.8 | 13.96 | 1.012 | 18.04 | 18.36 | 113.9 | 14.20 | 1.281 |
| 10,000 | 10.33 | 8.151 | 132.0 | 15.71 | 1.031 | 22.10 | 22.43 | 141.2 | 15.95 | 1.258 |
| 11,000 | 11.36 | 8.798 | 161.1 | 17.31 | 1.058 | 26.59 | 26.93 | 171.4 | 17.54 | 1.239 |
| 12,000 | 12.40 | 9.352 | 193.0 | 18.92 | 1.091 | 31.50 | 31.86 | 204.5 | 19.15 | 1.225 |
| 13,000 | 13.43 | 9.747 | 227.5 | 20.72 | 1.126 | 36.81 | 37.22 | 240.4 | 20.96 | 1.216 |
| 14,000 | 14.46 | 9.946 | 264.2 | 22.90 | 1.160 | 42.57 | 43.01 | 279.0 | 23.13 | 1.213 |
| 15,000 | 15.49 | 10.05 | 303.5 | 25.43 | 1.188 | 48.73 | 49.22 | 320.3 | 25.68 | 1.212 |
| 16,000 | 16.53 | 10.24 | 345.9 | 27.81 | 1.215 | 55.32 | 55.87 | 364.6 | 28.07 | 1.208 |
| 17,000 | 17.56 | 10.55 | 391.6 | 29.84 | 1.245 | 62.36 | 62.94 | 412.1 | 30.11 | 1.202 |
| 18,000 | 18.59 | 10.92 | 440.5 | 31.58 | 1.278 | 69.83 | 70.44 | 463.5 | 31.84 | 1.195 |
| 19,000 | 19.63 | 11.31 | 492.4 | 33.12 | 1.315 | 77.74 | 78.37 | 516.2 | 33.38 | 1.188 |
| 20,000 | 20.66 | 11.70 | 547.2 | 34.53 | 1.355 | 86.07 | 86.73 | 572.8 | 34.78 | 1.182 |
| 21,000 | 21.69 | 12.07 | 605.0 | 35.86 | 1.397 | 94.83 | 95.51 | 632.2 | 36.11 | 1.176 |
| 22,000 | 22.73 | 12.43 | 665.5 | 37.13 | 1.442 | 104.0 | 104.7 | 694.6 | 37.37 | 1.171 |
| 23,000 | 23.76 | 12.75 | 728.9 | 38.38 | 1.490 | 113.6 | 114.4 | 759.9 | 38.62 | 1.166 |
| 24,000 | 24.79 | 13.04 | 795.1 | 39.62 | 1.539 | 123.7 | 124.4 | 828.1 | 39.85 | 1.163 |
| 25,000 | 25.82 | 13.29 | 864.0 | 40.87 | 1.590 | 134.1 | 135.0 | 899.2 | 41.10 | 1.159 |
| 26,000 | 26.86 | 13.51 | 935.7 | 42.17 | 1.643 | 145.0 | 145.9 | 973.0 | 42.40 | 1.157 |

## TABLE II - NORMAL-SHOCK WAVE PARAMETERS

Altitude: 80,000 feet

Pressure: 58.125 psfa

Density: $8.6831 \times 10^{-5}$ slugs/ft$^3$

Temperature: 389.99°R

Enthalpy: $2.3330 \times 10^6$ ft-lb/slug

Sonic Speed: 968.08 ft/sec

| $V_1$ | $M_1$ | $\rho_2/\rho_1$ | $p_2/p_1$ | $T_2/T_1$ | $Z_2$ | $H_2/H_1$ | $H_{T_2}/H_1$ | $p_{T_2}/p_1$ | $T_{T_2}/T_1$ | $\gamma_e$ |
|---|---|---|---|---|---|---|---|---|---|---|
| 2000 | 2.066 | 2.717 | 4.775 | 1.757 | 1.000 | 1.741 | 1.857 | 5.874 | 1.874 | 1.423 |
| 3000 | 3.099 | 3.991 | 11.07 | 2.774 | 1.000 | 2.807 | 2.929 | 12.76 | 2.894 | 1.391 |
| 4000 | 4.132 | 4.841 | 19.96 | 4.122 | 1.000 | 4.282 | 4.429 | 22.42 | 4.263 | 1.373 |
| 5000 | 5.165 | 5.454 | 31.49 | 5.773 | 1.000 | 6.176 | 6.358 | 34.91 | 5.941 | 1.357 |
| 6000 | 6.198 | 5.952 | 45.72 | 7.682 | 1.000 | 8.495 | 8.715 | 50.24 | 7.879 | 1.341 |
| 7000 | 7.231 | 6.413 | 62.76 | 9.783 | 1.000 | 11.24 | 11.50 | 68.46 | 10.01 | 1.324 |
| 8000 | 8.264 | 6.918 | 82.75 | 11.92 | 1.003 | 14.42 | 14.72 | 89.66 | 12.16 | 1.304 |
| 9000 | 9.297 | 7.542 | 105.9 | 13.85 | 1.014 | 18.05 | 18.36 | 113.9 | 14.09 | 1.279 |
| 10,000 | 10.33 | 8.238 | 132.2 | 15.51 | 1.035 | 22.12 | 22.43 | 141.3 | 15.74 | 1.255 |
| 11,000 | 11.36 | 8.913 | 161.4 | 17.03 | 1.063 | 26.59 | 26.93 | 171.5 | 17.24 | 1.235 |
| 12,000 | 12.40 | 9.486 | 193.4 | 18.57 | 1.098 | 31.51 | 31.86 | 204.7 | 18.77 | 1.221 |
| 13,000 | 13.43 | 9.884 | 227.8 | 20.32 | 1.134 | 36.83 | 37.22 | 240.6 | 20.53 | 1.213 |
| 14,000 | 14.46 | 10.06 | 264.6 | 22.52 | 1.167 | 42.56 | 43.01 | 279.1 | 22.74 | 1.210 |
| 15,000 | 15.49 | 10.16 | 303.9 | 25.05 | 1.195 | 48.76 | 49.22 | 320.4 | 25.29 | 1.209 |
| 16,000 | 16.53 | 10.37 | 346.4 | 27.36 | 1.221 | 55.32 | 55.87 | 364.8 | 27.61 | 1.205 |
| 17,000 | 17.56 | 10.70 | 392.2 | 29.29 | 1.251 | 62.35 | 62.94 | 412.4 | 29.54 | 1.199 |
| 18,000 | 18.59 | 11.10 | 441.2 | 30.93 | 1.285 | 69.83 | 70.44 | 463.0 | 31.18 | 1.192 |
| 19,000 | 19.63 | 11.51 | 493.2 | 32.39 | 1.323 | 77.77 | 78.37 | 516.6 | 32.63 | 1.185 |
| 20,000 | 20.66 | 11.92 | 548.2 | 33.72 | 1.364 | 86.12 | 86.73 | 573.2 | 33.96 | 1.178 |
| 21,000 | 21.69 | 12.31 | 606.0 | 34.98 | 1.407 | 94.86 | 95.51 | 632.8 | 35.21 | 1.172 |
| 22,000 | 22.73 | 12.68 | 666.7 | 36.19 | 1.453 | 104.1 | 104.7 | 695.2 | 36.41 | 1.167 |
| 23,000 | 23.76 | 13.02 | 730.2 | 37.37 | 1.501 | 113.7 | 114.4 | 760.6 | 37.59 | 1.163 |
| 24,000 | 24.79 | 13.32 | 796.5 | 38.55 | 1.551 | 123.7 | 124.4 | 828.8 | 38.77 | 1.159 |
| 25,000 | 25.82 | 13.59 | 865.5 | 39.75 | 1.603 | 134.2 | 134.9 | 899.9 | 39.96 | 1.156 |
| 26,000 | 26.86 | 13.81 | 937.3 | 40.99 | 1.656 | 145.0 | 145.9 | 973.9 | 41.20 | 1.153 |

## TABLE II - NORMAL-SHOCK WAVE PARAMETERS

Altitude: 90,000 feet
Pressure: 36.292 psfa
Density: $5.2531 \times 10^{-5}$ slugs/ft$^3$

Temperature: 402.48 °R
Enthalpy: $2.4078 \times 10^6$ ft-lb/slug
Sonic Speed: 983.46 ft/sec

| $V_1$ | $M_1$ | $\rho_2/\rho_1$ | $p_2/p_1$ | $T_2/T_1$ | $Z_2$ | $H_2/H_1$ | $H_{T_2}/H_1$ | $p_{T_2}/p_1$ | $T_{T_2}/T_1$ | $\gamma_e$ |
|---|---|---|---|---|---|---|---|---|---|---|
| 2000 | 2.034 | 2.673 | 4.622 | 1.729 | 1.000 | 1.714 | 1.831 | 5.705 | 1.846 | 1.419 |
| 3000 | 3.050 | 3.951 | 10.73 | 2.715 | 1.000 | 2.749 | 2.869 | 12.37 | 2.833 | 1.390 |
| 4000 | 4.067 | 4.810 | 19.34 | 4.020 | 1.000 | 4.178 | 4.323 | 21.74 | 4.158 | 1.372 |
| 5000 | 5.084 | 5.430 | 30.51 | 5.619 | 1.000 | 6.014 | 6.192 | 33.84 | 5.783 | 1.357 |
| 6000 | 6.101 | 5.934 | 44.31 | 7.467 | 1.000 | 8.261 | 8.476 | 48.70 | 7.659 | 1.341 |
| 7000 | 7.118 | 6.402 | 60.82 | 9.497 | 1.000 | 10.92 | 11.18 | 66.36 | 9.713 | 1.323 |
| 8000 | 8.135 | 6.931 | 80.24 | 11.53 | 1.004 | 14.01 | 14.29 | 86.92 | 11.76 | 1.302 |
| 9000 | 9.151 | 7.595 | 102.8 | 13.31 | 1.016 | 17.52 | 17.82 | 110.5 | 13.54 | 1.276 |
| 10,000 | 10.17 | 8.330 | 128.3 | 14.83 | 1.039 | 21.47 | 21.77 | 137.0 | 15.04 | 1.251 |
| 11,000 | 11.19 | 9.036 | 156.7 | 16.22 | 1.069 | 25.81 | 26.13 | 166.4 | 16.41 | 1.231 |
| 12,000 | 12.20 | 9.627 | 187.7 | 17.65 | 1.105 | 30.58 | 30.90 | 198.5 | 17.84 | 1.217 |
| 13,000 | 13.22 | 10.02 | 221.1 | 19.31 | 1.142 | 35.73 | 36.09 | 233.3 | 19.50 | 1.209 |
| 14,000 | 14.24 | 10.18 | 256.7 | 21.47 | 1.175 | 41.30 | 41.70 | 270.7 | 21.67 | 1.207 |
| 15,000 | 15.25 | 10.26 | 294.8 | 23.92 | 1.201 | 47.26 | 47.72 | 310,7 | 24.14 | 1.206 |
| 16,000 | 16.27 | 10.50 | 336.1 | 26.07 | 1.228 | 53.66 | 54.16 | 353.8 | 26.30 | 1.202 |
| 17,000 | 17.29 | 10.87 | 380.7 | 27.84 | 1.258 | 60.48 | 61.01 | 399.9 | 28.07 | 1.195 |
| 18,000 | 18.30 | 11.29 | 428.2 | 29.34 | 1.293 | 67.74 | 68.28 | 449.0 | 29.57 | 1.188 |
| 19,000 | 19.32 | 11.73 | 478.8 | 30.67 | 1.331 | 75.40 | 75.97 | 501.0 | 30.89 | 1.181 |
| 20,000 | 20.34 | 12.16 | 532.1 | 31.89 | 1.373 | 83.48 | 84.06 | 555.9 | 32.10 | 1.174 |
| 21,000 | 21.35 | 12.57 | 588.3 | 33.03 | 1.417 | 91.96 | 92.58 | 613.7 | 33.24 | 1.168 |
| 22,000 | 22.37 | 12.96 | 647.2 | 34.14 | 1.463 | 100.9 | 101.5 | 674.3 | 34.34 | 1.163 |
| 23,000 | 23.39 | 13.31 | 708.9 | 35.22 | 1.512 | 110.2 | 110.9 | 737.6 | 35.42 | 1.159 |
| 24,000 | 24.40 | 13.62 | 773.2 | 36.31 | 1.563 | 119.9 | 120.6 | 803.8 | 36.51 | 1.155 |
| 25,000 | 25.42 | 13.90 | 840.2 | 37.42 | 1.616 | 130.1 | 130.8 | 872.8 | 37.61 | 1.152 |
| 26,000 | 26.44 | 14.13 | 909.6 | 38.67 | 1.670 | 140.6 | 141.4 | 944.5 | 38.76 | 1.149 |

## TABLE II - NORMAL-SHOCK WAVE PARAMETERS

Altitude: 100,000 feet
Pressure: 23.085 psfa
Density: $3.2144 \times 10^{-5}$ slugs/ft$^3$
Temperature: 418.79 °R
Enthalpy: $2.5054 \times 10^6$ ft-lb/slug
Sonic Speed: 1003.2 ft/sec

| $V_1$ | $M_1$ | $\rho_2/\rho_1$ | $p_2/p_1$ | $T_2/T_1$ | $Z_2$ | $H_2/H_1$ | $H_{T_2}/H_1$ | $p_{T_2}/p_1$ | $T_{T_2}/T_1$ | $\gamma_e$ |
|---|---|---|---|---|---|---|---|---|---|---|
| 2000 | 1.994 | 2.618 | 4.437 | 1.695 | 1.000 | 1.682 | 1.798 | 5.500 | 1.812 | 1.419 |
| 3000 | 2.990 | 3.900 | 10.31 | 2.643 | 1.000 | 2.677 | 2.796 | 11.91 | 2.733 | 1.388 |
| 4000 | 3.987 | 4.769 | 18.58 | 3.896 | 1.000 | 4.052 | 4.193 | 20.92 | 4.031 | 1.371 |
| 5000 | 4.984 | 5.399 | 29.32 | 5.431 | 1.000 | 5.816 | 5.989 | 32.54 | 5.591 | 1.356 |
| 6000 | 5.981 | 5.910 | 42.59 | 7.206 | 1.000 | 7.976 | 8.184 | 46.82 | 7.392 | 1.340 |
| 7000 | 6.978 | 6.388 | 58.47 | 9.149 | 1.000 | 10.53 | 10.78 | 63.80 | 9.357 | 1.323 |
| 8000 | 7.974 | 6.944 | 77.18 | 11.06 | 1.005 | 13.51 | 13.77 | 83.59 | 11.28 | 1.300 |
| 9000 | 8.971 | 7.652 | 98.91 | 12.69 | 1.019 | 16.88 | 17.17 | 106.3 | 12.90 | 1.272 |
| 10,000 | 9.968 | 8.425 | 123.5 | 14.06 | 1.043 | 20.66 | 20.96 | 131.8 | 14.25 | 1.247 |
| 11,000 | 10.96 | 9.159 | 150.9 | 15.32 | 1.075 | 24.84 | 25.15 | 160.1 | 15.50 | 1.226 |
| 12,000 | 11.96 | 9.768 | 180.7 | 16.64 | 1.112 | 29.42 | 29.74 | 191.0 | 16.81 | 1.213 |
| 13,000 | 12.96 | 10.16 | 212.9 | 18.22 | 1.150 | 34.40 | 34.73 | 224.4 | 18.39 | 1.205 |
| 14,000 | 13.96 | 10.28 | 247.0 | 20.33 | 1.182 | 39.75 | 40.12 | 260.3 | 20.52 | 1.204 |
| 15,000 | 14.95 | 10.37 | 283.7 | 22.68 | 1.207 | 46.47 | 45.90 | 298.8 | 22.89 | 1.204 |
| 16,000 | 15.95 | 10.64 | 323.5 | 24.66 | 1.234 | 51.62 | 52.09 | 340.3 | 24.88 | 1.199 |
| 17,000 | 16.95 | 11.03 | 366.4 | 26.26 | 1.265 | 58.18 | 58.68 | 384.6 | 26.47 | 1.192 |
| 18,000 | 17.94 | 11.48 | 412.3 | 27.62 | 1.300 | 65.14 | 65.66 | 431.9 | 27.83 | 1.184 |
| 19,000 | 18.94 | 11.94 | 460.9 | 28.82 | 1.339 | 72.51 | 73.04 | 482.0 | 29.02 | 1.177 |
| 20,000 | 19.94 | 12.40 | 512.3 | 29.93 | 1.381 | 80.28 | 80.83 | 534.8 | 30.12 | 1.170 |
| 21,000 | 20.93 | 12.83 | 566.4 | 30.97 | 1.426 | 88.44 | 89.01 | 590.3 | 31.16 | 1.164 |
| 22,000 | 21.93 | 13.23 | 623.1 | 31.97 | 1.473 | 97.01 | 97.59 | 648.6 | 32.15 | 1.159 |
| 23,000 | 22.93 | 13.60 | 682.5 | 32.96 | 1.523 | 106.0 | 106.6 | 709.5 | 33.14 | 1.155 |
| 24,000 | 23.92 | 13.92 | 744.4 | 33.96 | 1.574 | 115.3 | 116.0 | 773.1 | 34.13 | 1.151 |
| 25,000 | 24.92 | 14.21 | 808.9 | 34.97 | 1.628 | 125.1 | 125.7 | 839.5 | 35.14 | 1.148 |
| 26,000 | 25.92 | 14.44 | 875.9 | 36.04 | 1.683 | 135.2 | 135.9 | 908.4 | 36.21 | 1.146 |

## TABLE II - NORMAL-SHOCK WAVE PARAMETERS

Altitude: 110,000 feet
Pressure: 14.947 psfa
Density: $2.0014 \times 10^{-5}$ slugs/ft$^3$

Temperature: 435.09 °R
Enthalpy: $2.6031 \times 10^6$ ft-lb/slug
Sonic Speed: 1022.5 ft/sec

| $V_1$ | $M_1$ | $\rho_2/\rho_1$ | $p_2/p_1$ | $T_2/T_1$ | $Z_2$ | $H_2/H_1$ | $H_{T_2}/H_1$ | $p_{T_2}/p_1$ | $T_{T_2}/T_1$ | $\gamma_e$ |
|---|---|---|---|---|---|---|---|---|---|---|
| 2000 | 1.956 | 2.565 | 4.266 | 1.663 | 1.000 | 1.651 | 1.768 | 5.310 | 1.781 | 1.421 |
| 3000 | 2.934 | 3.850 | 9.917 | 2.576 | 1.000 | 2.612 | 2.729 | 11.48 | 2.691 | 1.388 |
| 4000 | 3.912 | 4.730 | 17.89 | 3.782 | 1.000 | 3.935 | 4.073 | 20.15 | 3.914 | 1.371 |
| 5000 | 4.890 | 5.368 | 28.23 | 5.258 | 1.000 | 5.634 | 5.802 | 31.34 | 5.414 | 1.355 |
| 6000 | 5.868 | 5.887 | 41.00 | 6.964 | 1.000 | 7.713 | 7.915 | 45.09 | 7.144 | 1.339 |
| 7000 | 6.846 | 6.375 | 56.29 | 8.825 | 1.001 | 10.18 | 10.41 | 61.44 | 9.026 | 1.322 |
| 8000 | 7.824 | 6.962 | 74.35 | 10.62 | 1.006 | 13.04 | 13.29 | 80.51 | 10.82 | 1.297 |
| 9000 | 8.802 | 7.713 | 95.35 | 12.10 | 1.022 | 16.29 | 16.56 | 102.4 | 12.30 | 1.268 |
| 10,000 | 9.780 | 8.522 | 119.1 | 13.34 | 1.048 | 19.94 | 20.21 | 127.0 | 13.52 | 1.242 |
| 11,000 | 10.76 | 9.283 | 145.5 | 14.50 | 1.081 | 23.97 | 24.24 | 154.2 | 14.66 | 1.222 |
| 12,000 | 11.74 | 9.907 | 174.3 | 15.72 | 1.119 | 28.38 | 28.66 | 184.0 | 15.88 | 1.208 |
| 13,000 | 12.71 | 10.29 | 205.2 | 17.24 | 1.157 | 33.15 | 33.46 | 216.2 | 17.40 | 1.202 |
| 14,000 | 13.69 | 10.38 | 238.0 | 19.32 | 1.187 | 38.27 | 38.65 | 250.7 | 19.50 | 1.201 |
| 15,000 | 14.67 | 10.47 | 273.4 | 21.55 | 1.212 | 43.81 | 44.22 | 287.8 | 21.74 | 1.201 |
| 16,000 | 15.65 | 10.77 | 311.8 | 23.37 | 1.239 | 49.73 | 50.17 | 327.7 | 23.57 | 1.196 |
| 17,000 | 16.63 | 11.20 | 353.2 | 24.83 | 1.271 | 56.05 | 56.51 | 370.5 | 25.03 | 1.188 |
| 18,000 | 17.60 | 11.67 | 397.5 | 26.06 | 1.307 | 62.76 | 63.24 | 416.1 | 26.25 | 1.180 |
| 19,000 | 18.58 | 12.16 | 444.4 | 27.16 | 1.346 | 69.85 | 70.34 | 464.3 | 27.34 | 1.173 |
| 20,000 | 19.56 | 12.63 | 494.0 | 28.16 | 1.389 | 77.33 | 77.83 | 515.2 | 28.33 | 1.166 |
| 21,000 | 20.54 | 13.08 | 546.1 | 29.11 | 1.434 | 85.18 | 85.71 | 568.7 | 29.28 | 1.160 |
| 22,000 | 21.52 | 13.50 | 600.8 | 30.03 | 1.482 | 93.43 | 93.97 | 624.8 | 30.20 | 1.155 |
| 23,000 | 22.49 | 13.88 | 658.0 | 30.94 | 1.532 | 102.0 | 102.6 | 683.5 | 31.10 | 1.151 |
| 24,000 | 23.47 | 14.22 | 717.7 | 31.85 | 1.585 | 111.1 | 111.6 | 744.8 | 32.01 | 1.147 |
| 25,000 | 24.45 | 14.51 | 779.9 | 32.79 | 1.639 | 120.4 | 121.1 | 808.7 | 32.94 | 1.144 |
| 26,000 | 25.43 | 14.76 | 844.4 | 33.78 | 1.694 | 130.2 | 130.8 | 875.1 | 33.93 | 1.142 |

## TABLE II - NORMAL-SHOCK WAVE PARAMETERS

Altitude: 120,000 feet
Pressure: 9.8372 psfa
Density: $1.2697 \times 10^{-5}$ slugs/ft$^3$

Temperature: 451.37 °R
Enthalpy: $2.7007 \times 10^6$ ft-lb/slug
Sonic Speed: 1041.5 ft/sec

| $V_1$ | $M_1$ | $\rho_2/\rho_1$ | $p_2/p_1$ | $T_2/T_1$ | $Z_2$ | $H_2/H_1$ | $H_{T_2}/H_1$ | $p_{T_2}/p_1$ | $T_{T_2}/T_1$ | $\gamma_e$ |
|---|---|---|---|---|---|---|---|---|---|---|
| 2000 | 1.920 | 2.514 | 4.108 | 1.634 | 1.000 | 1.623 | 1.741 | 5.134 | 1.752 | 1.420 |
| 3000 | 2.880 | 3.802 | 9.557 | 2.514 | 1.000 | 2.550 | 2.666 | 11.09 | 2.628 | 1.387 |
| 4000 | 3.841 | 4.691 | 17.24 | 3.676 | 1.000 | 3.827 | 3.962 | 19.44 | 3.805 | 1.370 |
| 5000 | 4.801 | 5.338 | 27.21 | 5.097 | 1.000 | 5.465 | 5.629 | 30.23 | 5.249 | 1.354 |
| 6000 | 5.761 | 5.864 | 39.52 | 6.740 | 1.000 | 7.469 | 7.665 | 43.49 | 6.915 | 1.339 |
| 7000 | 6.721 | 6.363 | 54.28 | 8.524 | 1.001 | 9.847 | 10.07 | 59.25 | 8.718 | 1.320 |
| 8000 | 7.681 | 6.983 | 71.74 | 10.20 | 1.007 | 12.60 | 12.85 | 77.66 | 10.40 | 1.295 |
| 9000 | 8.641 | 7.776 | 92.06 | 11.55 | 1.025 | 15.74 | 16.00 | 98.78 | 11.74 | 1.264 |
| 10,000 | 9.602 | 8.619 | 115.0 | 12.69 | 1.052 | 19.26 | 19.51 | 122.5 | 12.86 | 1.238 |
| 11,000 | 10.56 | 9.406 | 140.5 | 13.75 | 1.086 | 23.13 | 23.40 | 148.8 | 13.90 | 1.218 |
| 12,000 | 11.52 | 10.04 | 168.3 | 14.89 | 1.125 | 27.38 | 27.66 | 177.5 | 15.03 | 1.204 |
| 13,000 | 12.48 | 10.41 | 198.1 | 16.36 | 1.163 | 31.98 | 32.29 | 208.6 | 16.51 | 1.198 |
| 14,000 | 13.44 | 10.46 | 229.7 | 18.41 | 1.193 | 36.96 | 37.29 | 241.8 | 18.58 | 1.199 |
| 15,000 | 14.40 | 10.57 | 263.8 | 20.52 | 1.216 | 42.27 | 42.66 | 277.6 | 20.70 | 1.198 |
| 16,000 | 15.36 | 10.90 | 301.0 | 22.20 | 1.244 | 47.98 | 48.40 | 316.1 | 22.38 | 1.193 |
| 17,000 | 16.32 | 11.36 | 341.0 | 23.52 | 1.276 | 54.08 | 54.51 | 357.4 | 23.70 | 1.185 |
| 18,000 | 17.28 | 11.86 | 383.8 | 24.65 | 1.313 | 60.54 | 60.99 | 401.4 | 24.82 | 1.177 |
| 19,000 | 18.24 | 12.37 | 429.1 | 25.65 | 1.353 | 67.38 | 67.84 | 447.9 | 25.82 | 1.169 |
| 20,000 | 19.20 | 12.86 | 476.9 | 26.57 | 1.396 | 74.57 | 75.06 | 497.0 | 26.73 | 1.163 |
| 21,000 | 20.16 | 13.32 | 527.2 | 27.44 | 1.442 | 82.17 | 82.65 | 548.6 | 27.59 | 1.157 |
| 22,000 | 21.12 | 13.76 | 580.0 | 28.29 | 1.490 | 90.12 | 90.61 | 602.7 | 28.44 | 1.152 |
| 23,000 | 22.08 | 14.15 | 635.3 | 29.12 | 1.541 | 98.42 | 98.94 | 659.4 | 29.27 | 1.148 |
| 24,000 | 23.04 | 14.51 | 692.9 | 29.96 | 1.594 | 107.1 | 107.6 | 718.5 | 30.10 | 1.144 |
| 25,000 | 24.00 | 14.81 | 752.9 | 30.83 | 1.649 | 116.2 | 116.7 | 780.1 | 30.97 | 1.141 |
| 26,000 | 24.96 | 15.06 | 815.2 | 31.75 | 1.705 | 125.6 | 126.2 | 844.2 | 31.89 | 1.139 |

## TABLE II - NORMAL-SHOCK WAVE PARAMETERS

Altitude: 130,000 feet
Pressure: 6.5735 psfa
Density: $8.1894 \times 10^{-6}$ slugs/ft$^3$

Temperature: 467.63 °R
Enthalpy: $2.7982 \times 10^6$ ft-lb/slug
Sonic Speed: 1060.1 ft/sec

| $V_1$ | $M_1$ | $\rho_2/\rho_1$ | $p_2/p_1$ | $T_2/T_1$ | $Z_2$ | $H_2/H_1$ | $H_{T_2}/H_1$ | $p_{T_2}/p_1$ | $T_{T_2}/T_1$ | $\gamma_e$ |
|---|---|---|---|---|---|---|---|---|---|---|
| 2000 | 1.887 | 2.465 | 3.961 | 1.606 | 1.000 | 1.597 | 1.715 | 4.971 | 1.725 | 1.419 |
| 3000 | 2.830 | 3.755 | 9.223 | 2.456 | 1.000 | 2.949 | 2.608 | 10.72 | 2.569 | 1.386 |
| 4000 | 3.773 | 4.653 | 16.64 | 3.577 | 1.000 | 3.726 | 3.859 | 18.78 | 3.704 | 1.369 |
| 5000 | 4.717 | 5.308 | 26.27 | 4.948 | 1.000 | 5.307 | 5.467 | 29.20 | 5.096 | 1.353 |
| 6000 | 5.660 | 5.841 | 38.16 | 6.532 | 1.000 | 7.242 | 7.433 | 41.99 | 6.702 | 1.338 |
| 7000 | 6.603 | 6.353 | 52.41 | 8.242 | 1.001 | 9.536 | 9.756 | 57.22 | 8.430 | 1.319 |
| 8000 | 7.546 | 7.009 | 69.33 | 9.808 | 1.009 | 12.21 | 12.44 | 75.01 | 9.997 | 1.292 |
| 9000 | 8.490 | 7.843 | 89.01 | 11.05 | 1.027 | 15.23 | 15.47 | 95.44 | 11.22 | 1.260 |
| 10,000 | 9.433 | 8.718 | 111.2 | 12.08 | 1.056 | 18.63 | 18.87 | 118.4 | 12.23 | 1.234 |
| 11,000 | 10.38 | 9.528 | 135.9 | 13.06 | 1.092 | 22.39 | 22.62 | 143.8 | 13.20 | 1.214 |
| 12,000 | 11.32 | 10.18 | 162.7 | 14.14 | 1.131 | 26.48 | 26.73 | 171.5 | 14.27 | 1.201 |
| 13,000 | 12.26 | 10.53 | 191.5 | 15.56 | 1.169 | 30.92 | 31.20 | 201.5 | 15.70 | 1.195 |
| 14,000 | 13.21 | 10.54 | 221.9 | 17.59 | 1.197 | 35.69 | 36.02 | 233.5 | 17.74 | 1.197 |
| 15,000 | 14.15 | 10.67 | 254.9 | 19.58 | 1.220 | 40.83 | 41.20 | 268.1 | 19.75 | 1.196 |
| 16,000 | 15.09 | 11.03 | 290.9 | 21.12 | 1.248 | 46.35 | 46.74 | 305.4 | 21.29 | 1.190 |
| 17,000 | 16.04 | 11.52 | 329.6 | 22.33 | 1.281 | 52.24 | 52.64 | 345.3 | 22.50 | 1.182 |
| 18,000 | 16.98 | 12.04 | 371.0 | 23.36 | 1.318 | 58.48 | 58.90 | 387.7 | 23.52 | 1.174 |
| 19,000 | 17.92 | 12.57 | 414.8 | 24.28 | 1.359 | 65.07 | 65.51 | 432.7 | 24.43 | 1.166 |
| 20,000 | 18.87 | 13.08 | 461.0 | 25.13 | 1.403 | 72.03 | 72.47 | 480.1 | 25.28 | 1.159 |
| 21,000 | 19.81 | 13.57 | 509.7 | 25.93 | 1.449 | 79.35 | 79.80 | 529.9 | 26.07 | 1.154 |
| 22,000 | 20.75 | 14.01 | 560.7 | 26.71 | 1.498 | 87.02 | 87.48 | 582.2 | 26.85 | 1.149 |
| 23,000 | 21.70 | 14.42 | 614.1 | 27.48 | 1.549 | 95.03 | 95.53 | 636.9 | 27.61 | 1.144 |
| 24,000 | 22.64 | 14.79 | 669.8 | 28.26 | 1.603 | 103.4 | 103.9 | 694.0 | 28.39 | 1.141 |
| 25,000 | 23.58 | 15.10 | 727.8 | 29.07 | 1.658 | 112.1 | 112.7 | 753.5 | 29.20 | 1.138 |
| 26,000 | 24.53 | 15.36 | 788.0 | 29.93 | 1.715 | 121.2 | 121.8 | 815.4 | 30.05 | 1.136 |

## TABLE II - NORMAL-SHOCK WAVE PARAMETERS

Altitude: 140,000 feet

Pressure: 4.4552 psfa

Density: $5.3640 \times 10^{-6}$ slugs/ft$^3$

Temperature: 483.88°R

Enthalpy: $2.8957 \times 10^6$ ft-lb/slug

Sonic Speed: 1078.3 ft/sec

| $V_1$ | $M_1$ | $\rho_2/\rho_1$ | $p_2/p_1$ | $T_2/T_1$ | $Z_2$ | $H_2/H_1$ | $H_{T_2}/H_1$ | $p_{T_2}/p_1$ | $T_{T_2}/T_1$ | $\gamma_e$ |
|---|---|---|---|---|---|---|---|---|---|---|
| 2000 | 1.855 | 2.419 | 3.824 | 1.581 | 1.000 | 1.572 | 1.691 | 4.819 | 1.699 | 1.419 |
| 3000 | 2.782 | 3.709 | 8.911 | 2.403 | 1.000 | 2.441 | 2.554 | 10.37 | 2.514 | 1.385 |
| 4000 | 3.710 | 4.615 | 16.08 | 3.485 | 1.000 | 3.632 | 3.763 | 18.17 | 3.609 | 1.368 |
| 5000 | 4.637 | 5.279 | 25.39 | 4.809 | 1.000 | 5.160 | 5.317 | 28.24 | 4.953 | 1.353 |
| 6000 | 5.564 | 5.818 | 36.88 | 6.338 | 1.000 | 7.030 | 7.216 | 40.60 | 6.503 | 1.337 |
| 7000 | 6.492 | 6.345 | 50.67 | 7.977 | 1.001 | 9.245 | 9.461 | 55.32 | 8.158 | 1.318 |
| 8000 | 7.419 | 7.037 | 67.08 | 9.437 | 1.010 | 11.83 | 12.05 | 72.55 | 9.615 | 1.289 |
| 9000 | 8.346 | 7.911 | 86.16 | 10.57 | 1.030 | 14.76 | 14.99 | 92.23 | 10.73 | 1.257 |
| 10,000 | 9.274 | 8.816 | 107.7 | 11.52 | 1.060 | 18.04 | 18.27 | 114.5 | 11.66 | 1.230 |
| 11,000 | 10.20 | 9.649 | 131.5 | 12.43 | 1.097 | 21.67 | 21.89 | 139.1 | 12.56 | 1.210 |
| 12,000 | 11.13 | 10.31 | 157.5 | 13.45 | 1.136 | 25.62 | 25.86 | 165.9 | 13.57 | 1.197 |
| 13,000 | 12.06 | 10.64 | 185.3 | 14.83 | 1.174 | 29.91 | 30.18 | 194.8 | 14.96 | 1.191 |
| 14,000 | 12.98 | 10.62 | 214.7 | 16.84 | 1.201 | 34.53 | 34.84 | 225.8 | 16.99 | 1.195 |
| 15,000 | 13.91 | 10.76 | 246.6 | 18.72 | 1.224 | 39.50 | 39.85 | 259.2 | 18.88 | 1.193 |
| 16,000 | 14.84 | 11.17 | 281.5 | 20.13 | 1.252 | 44.83 | 45.20 | 295.3 | 20.29 | 1.187 |
| 17,000 | 15.77 | 11.68 | 319.0 | 21.24 | 1.286 | 50.51 | 50.90 | 333.9 | 21.39 | 1.179 |
| 18,000 | 16.69 | 12.22 | 359.0 | 22.19 | 1.324 | 56.55 | 56.95 | 375.0 | 22.34 | 1.170 |
| 19,000 | 17.62 | 12.77 | 401.4 | 23.03 | 1.365 | 62.93 | 63.33 | 418.5 | 23.16 | 1.163 |
| 20,000 | 18.55 | 13.30 | 446.2 | 23.81 | 1.409 | 69.66 | 70.07 | 465.5 | 23.94 | 1.156 |
| 21,000 | 19.48 | 13.80 | 493.3 | 24.55 | 1.456 | 76.72 | 77.15 | 512.5 | 24.68 | 1.151 |
| 22,000 | 20.40 | 14.26 | 542.6 | 25.27 | 1.505 | 84.13 | 84.57 | 563.0 | 25.39 | 1.146 |
| 23,000 | 21.33 | 14.69 | 594.3 | 25.99 | 1.557 | 91.88 | 92.34 | 616.0 | 26.11 | 1.141 |
| 24,000 | 22.26 | 15.06 | 648.2 | 26.71 | 1.611 | 99.98 | 100.5 | 671.2 | 26.83 | 1.138 |
| 25,000 | 23.18 | 15.38 | 704.3 | 27.47 | 1.667 | 108.4 | 108.9 | 728.7 | 27.59 | 1.135 |
| 26,000 | 24.11 | 15.64 | 762.5 | 28.27 | 1.724 | 117.7 | 117.2 | 788.5 | 28.39 | 1.133 |

## TABLE II - NORMAL-SHOCK WAVE PARAMETERS

Altitude: 150,000 feet

Pressure: 3.0597 psfa

Density: $3.5642 \times 10^{-6}$ slugs/ft$^3$

Temperature: 500.11°R

Enthalpy: $2.9931 \times 10^6$ ft-lb/slug

Sonic Speed: 1096.3 ft/sec

| $V_1$ | $M_1$ | $\rho_2/\rho_1$ | $p_2/p_1$ | $T_2/T_1$ | $Z_2$ | $H_2/H_1$ | $H_{T_2}/H_1$ | $p_{T_2}/p_1$ | $T_{T_2}/T_1$ | $\gamma_e$ |
|---|---|---|---|---|---|---|---|---|---|---|
| 2000 | 1.824 | 2.374 | 3.696 | 1.557 | 1.000 | 1.549 | 1.668 | 4.677 | 1.676 | 1.417 |
| 3000 | 2.736 | 3.664 | 8.620 | 2.352 | 1.000 | 2.391 | 2.503 | 10.05 | 2.462 | 1.383 |
| 4000 | 3.649 | 4.578 | 15.56 | 3.399 | 1.000 | 3.544 | 3.673 | 17.60 | 3.521 | 1.367 |
| 5000 | 4.561 | 5.250 | 24.57 | 4.679 | 1.000 | 5.023 | 5.176 | 27.34 | 4.820 | 1.352 |
| 6000 | 5.473 | 5.796 | 35.69 | 6.156 | 1.000 | 6.832 | 7.014 | 39.30 | 6.318 | 1.336 |
| 7000 | 6.385 | 6.338 | 49.05 | 7.727 | 1.002 | 8.983 | 9.185 | 53.56 | 7.903 | 1.316 |
| 8000 | 7.297 | 7.070 | 64.98 | 9.087 | 1.011 | 11.46 | 11.69 | 70.25 | 9.257 | 1.286 |
| 9000 | 8.209 | 7.981 | 83.50 | 10.13 | 1.033 | 14.32 | 14.53 | 89.41 | 10.28 | 1.253 |
| 10,000 | 9.122 | 8.915 | 104.4 | 11.00 | 1.064 | 17.49 | 17.70 | 110.9 | 11.13 | 1.226 |
| 11,000 | 10.03 | 9.768 | 127.5 | 11.85 | 1.101 | 21.00 | 21.21 | 134.7 | 11.97 | 1.206 |
| 12,000 | 10.95 | 10.43 | 152.6 | 12.81 | 1.142 | 24.83 | 25.06 | 160.6 | 12.92 | 1.194 |
| 13,000 | 11.86 | 10.74 | 179.5 | 14.18 | 1.179 | 28.98 | 29.23 | 188.6 | 14.30 | 1.190 |
| 14,000 | 12.77 | 10.68 | 207.8 | 16.15 | 1.204 | 33.44 | 33.74 | 218.5 | 16.29 | 1.193 |
| 15,000 | 13.68 | 10.86 | 238.8 | 17.92 | 1.227 | 38.25 | 38.59 | 250.9 | 18.07 | 1.191 |
| 16,000 | 14.59 | 11.30 | 272.7 | 19.21 | 1.256 | 43.41 | 43.76 | 285.9 | 19.36 | 1.184 |
| 17,000 | 15.51 | 11.83 | 309.0 | 20.24 | 1.290 | 48.92 | 49.28 | 323.3 | 20.38 | 1.176 |
| 18,000 | 16.42 | 12.40 | 347.8 | 21.11 | 1.329 | 54.75 | 55.12 | 363.0 | 21.25 | 1.167 |
| 19,000 | 17.33 | 12.97 | 388.9 | 21.89 | 1.370 | 60.92 | 61.31 | 405.2 | 22.02 | 1.160 |
| 20,000 | 18.24 | 13.51 | 432.3 | 22.61 | 1.415 | 67.42 | 67.82 | 449.5 | 22.73 | 1.153 |
| 21,000 | 19.16 | 14.03 | 477.9 | 23.30 | 1.462 | 74.27 | 74.67 | 496.2 | 23.42 | 1.148 |
| 22,000 | 20.07 | 14.51 | 525.7 | 23.97 | 1.512 | 81.44 | 81.85 | 545.2 | 24.08 | 1.143 |
| 23,000 | 20.98 | 14.94 | 575.7 | 24.63 | 1.564 | 88.94 | 89.37 | 596.4 | 24.74 | 1.139 |
| 24,000 | 21.89 | 15.33 | 627.9 | 25.31 | 1.619 | 96.78 | 97.22 | 649.8 | 25.42 | 1.135 |
| 25,000 | 22.80 | 15.66 | 682.3 | 26.01 | 1.675 | 104.9 | 105.4 | 705.5 | 26.12 | 1.132 |
| 26,000 | 23.72 | 15.93 | 738.7 | 26.77 | 1.733 | 113.4 | 113.9 | 763.4 | 26.88 | 1.130 |

## TABLE II - NORMAL-SHOCK WAVE PARAMETERS

Altitude: 160,000 feet
Pressure: 2.1247 psfa
Density: $2.4329 \times 10^{-6}$ slugs/ft$^3$

Temperature: 508.79°R
Enthalpy: $3.0452 \times 10^6$ ft-lb/slug
Sonic Speed: 1105.7 ft/sec

| $V_1$ | $M_1$ | $\rho_2/\rho_1$ | $p_2/p_1$ | $T_2/T_1$ | $Z_2$ | $H_2/H_1$ | $H_{T_2}/H_1$ | $p_{T_2}/p_1$ | $T_{T_2}/T_1$ | $\gamma_e$ |
|---|---|---|---|---|---|---|---|---|---|---|
| 2000 | 1.809 | 2.351 | 3.631 | 1.544 | 1.000 | 1.538 | 1.657 | 4.605 | 1.664 | 1.417 |
| 3000 | 2.713 | 3.641 | 8.472 | 2.327 | 1.000 | 2.366 | 2.478 | 9.889 | 2.436 | 1.383 |
| 4000 | 3.618 | 4.559 | 15.30 | 3.355 | 1.000 | 3.500 | 3.627 | 17.30 | 3.476 | 1.366 |
| 5000 | 4.522 | 5.235 | 24.15 | 4.613 | 1.000 | 4.954 | 5.105 | 26.88 | 4.752 | 1.351 |
| 6000 | 5.426 | 5.785 | 35.08 | 6.064 | 1.000 | 6.732 | 6.911 | 38.64 | 6.223 | 1.336 |
| 7000 | 6.331 | 6.341 | 48.24 | 7.593 | 1.002 | 8.844 | 9.045 | 52.66 | 7.765 | 1.315 |
| 8000 | 7.235 | 7.107 | 63.94 | 8.882 | 1.013 | 11.29 | 11.51 | 69.10 | 9.046 | 1.283 |
| 9000 | 8.140 | 8.052 | 82.19 | 9.854 | 1.036 | 14.09 | 14.30 | 87.96 | 9.998 | 1.249 |
| 10,000 | 9.044 | 9.012 | 102.8 | 10.68 | 1.068 | 17.22 | 17.42 | 109.1 | 10.81 | 1.222 |
| 11,000 | 9.948 | 9.884 | 125.5 | 11.48 | 1.106 | 20.66 | 20.87 | 132.5 | 11.59 | 1.203 |
| 12,000 | 10.85 | 10.55 | 150.2 | 12.41 | 1.146 | 24.42 | 24.64 | 158.0 | 12.52 | 1.191 |
| 13,000 | 11.76 | 10.83 | 176.6 | 13.78 | 1.183 | 28.50 | 28.75 | 185.5 | 13.89 | 1.188 |
| 14,000 | 12.66 | 10.75 | 204.4 | 15.76 | 1.207 | 32.89 | 33.18 | 214.9 | 15.89 | 1.191 |
| 15,000 | 13.57 | 10.96 | 235.0 | 17.43 | 1.230 | 37.63 | 37.94 | 246.8 | 17.57 | 1.189 |
| 16,000 | 14.47 | 11.42 | 268.3 | 18.65 | 1.260 | 42.69 | 43.03 | 281.2 | 18.80 | 1.181 |
| 17,000 | 15.37 | 11.98 | 304.2 | 19.61 | 1.294 | 48.10 | 48.45 | 318.0 | 19.75 | 1.173 |
| 18,000 | 16.28 | 12.57 | 342.3 | 20.43 | 1.333 | 53.84 | 54.20 | 357.1 | 20.56 | 1.165 |
| 19,000 | 17.18 | 13.15 | 382.8 | 21.17 | 1.375 | 59.91 | 60.27 | 398.5 | 21.29 | 1.157 |
| 20,000 | 18.09 | 13.72 | 425.4 | 21.85 | 1.420 | 66.30 | 66.68 | 442.1 | 21.97 | 1.151 |
| 21,000 | 18.99 | 14.25 | 470.3 | 22.49 | 1.468 | 73.03 | 73.41 | 488.0 | 22.60 | 1.145 |
| 22,000 | 19.90 | 14.74 | 517.4 | 23.12 | 1.518 | 80.07 | 80.47 | 536.2 | 23.23 | 1.140 |
| 23,000 | 20.80 | 15.19 | 566.6 | 23.75 | 1.571 | 87.46 | 87.86 | 586.5 | 23.85 | 1.136 |
| 24,000 | 21.71 | 15.58 | 617.9 | 24.40 | 1.625 | 95.16 | 95.57 | 639.1 | 24.50 | 1.133 |
| 25,000 | 22.61 | 15.92 | 671.4 | 25.07 | 1.682 | 103.2 | 103.6 | 693.9 | 25.17 | 1.130 |
| 26,000 | 23.51 | 16.20 | 726.9 | 25.79 | 1.740 | 111.5 | 112.0 | 750.8 | 25.89 | 1.128 |

## TABLE II - NORMAL-SHOCK WAVE PARAMETERS

Altitude: 170,000 feet

Pressure: 1.4784 psfa

Density: $1.6929 \times 10^{-6}$ slugs/ft$^3$

Temperature: 508.79°R

Enthalpy: $3.0452 \times 10^6$ ft-lb/slug

Sonic Speed: 1105.7 ft/sec

| $V_1$ | $M_1$ | $\rho_2/\rho_1$ | $p_2/p_1$ | $T_2/T_1$ | $Z_2$ | $H_2/H_1$ | $H_{T_2}/H_1$ | $p_{T_2}/p_1$ | $T_{T_2}/T_1$ | $\gamma_e$ |
|---|---|---|---|---|---|---|---|---|---|---|
| 2000 | 1.809 | 2.351 | 3.631 | 1.544 | 1.000 | 1.538 | 1.657 | 4.605 | 1.664 | 1.417 |
| 3000 | 2.713 | 3.641 | 8.472 | 2.327 | 1.000 | 2.366 | 2.478 | 9.886 | 2.436 | 1.383 |
| 4000 | 3.618 | 4.559 | 15.30 | 3.355 | 1.000 | 3.500 | 3.627 | 17.30 | 3.476 | 1.366 |
| 5000 | 4.522 | 5.235 | 24.15 | 4.613 | 1.000 | 4.954 | 5.105 | 26.88 | 4.752 | 1.351 |
| 6000 | 5.426 | 5.786 | 35.08 | 6.063 | 1.000 | 6.732 | 6.911 | 38.64 | 6.222 | 1.336 |
| 7000 | 6.331 | 6.353 | 48.25 | 7.579 | 1.002 | 8.841 | 9.045 | 52.67 | 7.750 | 1.314 |
| 8000 | 7.235 | 7.151 | 64.01 | 8.824 | 1.014 | 11.30 | 11.51 | 69.13 | 8.985 | 1.281 |
| 9000 | 8.140 | 8.127 | 82.30 | 9.755 | 1.038 | 14.10 | 14.30 | 88.00 | 9.894 | 1.246 |
| 10,000 | 9.044 | 9.110 | 102.9 | 10.55 | 1.071 | 17.22 | 17.42 | 109.2 | 10.67 | 1.219 |
| 11,000 | 9.948 | 10.00 | 125.6 | 11.33 | 1.109 | 20.66 | 20.87 | 132.6 | 11.44 | 1.200 |
| 12,000 | 10.85 | 10.68 | 150.4 | 12.24 | 1.151 | 24.42 | 24.64 | 158.1 | 12.34 | 1.188 |
| 13,000 | 11.76 | 10.92 | 176.7 | 13.64 | 1.187 | 28.51 | 28.75 | 185.6 | 13.75 | 1.186 |
| 14,000 | 12.66 | 10.82 | 204.6 | 15.64 | 1.209 | 32.90 | 33.18 | 215.0 | 15.77 | 1.190 |
| 15,000 | 13.57 | 11.06 | 235.2 | 17.26 | 1.233 | 37.63 | 37.94 | 246.9 | 17.40 | 1.187 |
| 16,000 | 14.47 | 11.55 | 268.6 | 18.42 | 1.263 | 42.70 | 43.03 | 281.3 | 18.56 | 1.179 |
| 17,000 | 15.37 | 12.13 | 304.5 | 19.34 | 1.298 | 48.10 | 48.45 | 318.1 | 19.47 | 1.171 |
| 18,000 | 16.28 | 12.74 | 342.7 | 20.13 | 1.337 | 53.85 | 54.20 | 357.3 | 20.25 | 1.162 |
| 19,000 | 17.18 | 13.34 | 383.2 | 20.84 | 1.379 | 59.92 | 60.27 | 398.7 | 20.96 | 1.155 |
| 20,000 | 18.09 | 13.91 | 425.9 | 21.49 | 1.424 | 66.32 | 66.68 | 442.4 | 21.60 | 1.148 |
| 21,000 | 18.99 | 14.46 | 470.8 | 22.11 | 1.472 | 73.04 | 73.41 | 488.3 | 22.21 | 1.143 |
| 22,000 | 19.90 | 14.96 | 517.9 | 22.72 | 1.523 | 80.09 | 80.47 | 536.4 | 22.82 | 1.138 |
| 23,000 | 20.80 | 15.42 | 567.2 | 23.33 | 1.576 | 87.47 | 87.86 | 586.8 | 23.43 | 1.134 |
| 24,000 | 21.71 | 15.83 | 618.6 | 23.95 | 1.631 | 95.17 | 95.57 | 639.5 | 24.05 | 1.130 |
| 25,000 | 22.61 | 16.18 | 672.1 | 24.61 | 1.688 | 103.2 | 103.6 | 694.2 | 24.70 | 1.128 |
| 26,000 | 23.51 | 16.45 | 727.7 | 25.32 | 1.747 | 111.5 | 112.0 | 751.2 | 25.41 | 1.126 |

## TABLE II - NORMAL-SHOCK WAVE PARAMETERS

Altitude: 180,000 feet
Pressure: 1.0272 psfa
Density: $1.2028 \times 10^{-6}$ slugs/ft$^3$

Temperature: 497.49°R
Enthalpy: $2.9773 \times 10^6$ ft-lb/slug
Sonic Speed: 1093.4 ft/sec

| $V_1$ | $M_1$ | $\rho_2/\rho_1$ | $p_2/p_1$ | $T_2/T_1$ | $Z_2$ | $H_2/H_1$ | $H_{T_2}/H_1$ | $p_{T_2}/p_1$ | $T_{T_2}/T_1$ | $\gamma_e$ |
|---|---|---|---|---|---|---|---|---|---|---|
| 2000 | 1.829 | 2.381 | 3.716 | 1.560 | 1.000 | 1.553 | 1.672 | 4.742 | 1.614 | 1.417 |
| 3000 | 2.744 | 3.671 | 8.665 | 2.360 | 1.000 | 2.399 | 2.511 | 10.00 | 2.470 | 1.384 |
| 4000 | 3.658 | 4.584 | 15.64 | 3.412 | 1.000 | 3.558 | 3.687 | 17.69 | 3.535 | 1.367 |
| 5000 | 4.573 | 5.255 | 24.69 | 4.699 | 1.000 | 5.045 | 5.198 | 27.48 | 4.841 | 1.352 |
| 6000 | 5.487 | 5.802 | 35.88 | 6.183 | 1.000 | 6.863 | 7.046 | 39.51 | 6.345 | 1.336 |
| 7000 | 6.402 | 6.376 | 49.36 | 7.722 | 1.003 | 9.028 | 9.229 | 53.86 | 7.895 | 1.314 |
| 8000 | 7.317 | 7.202 | 65.51 | 8.958 | 1.015 | 11.53 | 11.75 | 70.72 | 9.116 | 1.279 |
| 9000 | 8.231 | 8.204 | 84.26 | 9.874 | 1.040 | 14.39 | 14.60 | 90.04 | 10.02 | 1.244 |
| 10,000 | 9.146 | 9.209 | 105.3 | 10.66 | 1.073 | 17.59 | 17.79 | 111.7 | 10.78 | 1.217 |
| 11,000 | 10.06 | 10.12 | 128.6 | 11.43 | 1.112 | 21.12 | 21.32 | 135.6 | 11.54 | 1.197 |
| 12,000 | 10.98 | 10.80 | 153.9 | 12.36 | 1.154 | 24.97 | 25.18 | 161.8 | 12.46 | 1.186 |
| 13,000 | 11.89 | 11.01 | 180.8 | 13.81 | 1.190 | 29.13 | 29.38 | 189.8 | 13.92 | 1.184 |
| 14,000 | 12.80 | 10.89 | 209.3 | 15.87 | 1.211 | 33.62 | 33.92 | 219.9 | 16.00 | 1.189 |
| 15,000 | 13.72 | 11.15 | 240.7 | 17.47 | 1.235 | 38.47 | 38.79 | 252.6 | 17.61 | 1.185 |
| 16.000 | 14.63 | 11.67 | 275.0 | 18.62 | 1.266 | 43.65 | 43.99 | 287.8 | 18.75 | 1.177 |
| 17,000 | 15.55 | 12.27 | 311.7 | 19.53 | 1.301 | 49.19 | 49.53 | 325.5 | 19.66 | 1.168 |
| 18,000 | 16.46 | 12.89 | 350.8 | 20.30 | 1.340 | 55.06 | 55.41 | 365.5 | 20.42 | 1.160 |
| 19,000 | 17.38 | 13.51 | 392.3 | 21.00 | 1.383 | 61.26 | 61.63 | 407.9 | 21.11 | 1.153 |
| 20,000 | 18.29 | 14.10 | 436.0 | 21.64 | 1.428 | 67.82 | 68.17 | 452.7 | 21.75 | 1.146 |
| 21,000 | 19.21 | 14.66 | 482.0 | 22.26 | 1.477 | 74.69 | 75.06 | 499.6 | 22.36 | 1.141 |
| 22,000 | 20.12 | 15.18 | 530.2 | 22.86 | 1.528 | 81.91 | 82.28 | 548.9 | 22.96 | 1.136 |
| 23,000 | 21.04 | 15.65 | 580.7 | 23.47 | 1.581 | 89.45 | 89.84 | 600.5 | 23.57 | 1.132 |
| 24,000 | 21.95 | 16.06 | 633.3 | 24.08 | 1.637 | 97.33 | 97.73 | 654.3 | 24.17 | 1.128 |
| 25,000 | 22.86 | 16.42 | 688.1 | 24.73 | 1.694 | 105.5 | 106.0 | 710.4 | 24.82 | 1.126 |
| 26,000 | 23.78 | 16.70 | 744.9 | 25.44 | 1.753 | 114.1 | 114.5 | 768.6 | 25.53 | 1.124 |

## TABLE II - NORMAL-SHOCK WAVE PARAMETERS

Altitude: 190,000 feet
Pressure: $7.0278 \times 10^{-1}$ psfa
Density: $8.6517 \times 10^{-7}$ slugs/ft$^3$

Temperature: 473.24 °R
Enthalpy: $2.8319 \times 10^6$ ft-lb/slug
Sonic Speed: 1066.4 ft/sec

| $V_1$ | $M_1$ | $\rho_2/\rho_1$ | $p_2/p_1$ | $T_2/T_1$ | $Z_2$ | $H_2/H_1$ | $H_{T_2}/H_1$ | $p_{T_2}/p_1$ | $T_{T_2}/T_1$ | $\gamma_e$ |
|---|---|---|---|---|---|---|---|---|---|---|
| 2000 | 1.875 | | | | | | 1.706 | | | |
| 3000 | 2.813 | 3.739 | 9.113 | 2.437 | 1.000 | 2.475 | 2.589 | 10.71 | 2.558 | 1.385 |
| 4000 | 3.751 | 4.639 | 16.44 | 3.544 | 1.000 | 3.693 | 3.825 | 18.57 | 3.670 | 1.368 |
| 5000 | 4.689 | 5.298 | 25.96 | 4.899 | 1.000 | 5.255 | 5.414 | 28.86 | 5.046 | 1.353 |
| 6000 | 5.626 | 5.836 | 37.71 | 6.461 | 1.000 | 7.167 | 7.356 | 41.50 | 6.630 | 1.337 |
| 7000 | 6.564 | 6.412 | 51.89 | 8.070 | 1.003 | 9.441 | 9.652 | 56.60 | 8.250 | 1.315 |
| 8000 | 7.502 | 7.260 | 68.90 | 9.338 | 1.016 | 12.08 | 12.30 | 74.33 | 9.504 | 1.278 |
| 9000 | 8.440 | 8.286 | 88.64 | 10.27 | 1.042 | 15.09 | 15.30 | 94.66 | 10.41 | 1.243 |
| 10,000 | 9.377 | 9.312 | 110.8 | 11.07 | 1.076 | 18.44 | 18.66 | 117.4 | 11.19 | 1.215 |
| 11,000 | 10.32 | 10.24 | 135.3 | 11.86 | 1.115 | 22.16 | 22.36 | 142.6 | 11.97 | 1.196 |
| 12,000 | 11.25 | 10.92 | 162.0 | 12.82 | 1.157 | 26.21 | 26.42 | 170.1 | 12.92 | 1.184 |
| 13,000 | 12.19 | 11.10 | 190.2 | 14.38 | 1.192 | 30.59 | 30.84 | 199.6 | 14.49 | 1.183 |
| 14,000 | 13.13 | 10.97 | 220.2 | 16.55 | 1.213 | 35.30 | 35.61 | 231.2 | 16.69 | 1.188 |
| 15,000 | 14.07 | 11.26 | 253.2 | 18.19 | 1.237 | 40.40 | 40.73 | 265.6 | 18.33 | 1.184 |
| 16,000 | 15.00 | 11.79 | 289.3 | 19.35 | 1.268 | 45.85 | 46.20 | 302.6 | 19.49 | 1.176 |
| 17,000 | 15.94 | 12.41 | 327.9 | 20.27 | 1.304 | 51.68 | 52.03 | 342.3 | 20.40 | 1.167 |
| 18,000 | 16.88 | 13.05 | 369.1 | 21.06 | 1.343 | 57.84 | 58.21 | 384.4 | 21.18 | 1.158 |
| 19,000 | 17.82 | 13.68 | 412.7 | 21.76 | 1.386 | 64.37 | 64.74 | 428.9 | 21.88 | 1.151 |
| 20,000 | 18.75 | 14.29 | 458.7 | 22.42 | 1.432 | 71.26 | 71.62 | 476.0 | 22.53 | 1.144 |
| 21,000 | 19.69 | 14.86 | 507.1 | 23.05 | 1.481 | 78.48 | 78.86 | 525.4 | 23.15 | 1.139 |
| 22,000 | 20.63 | 15.39 | 557.9 | 23.66 | 1.532 | 86.07 | 86.46 | 577.2 | 23.76 | 1.134 |
| 23,000 | 21.57 | 15.87 | 610.9 | 24.28 | 1.586 | 94.00 | 94.40 | 631.5 | 24.37 | 1.130 |
| 24,000 | 22.51 | 16.30 | 666.3 | 24.91 | 1.642 | 102.3 | 102.7 | 688.1 | 25.00 | 1.127 |
| 25,000 | 23.44 | 16.66 | 723.9 | 25.57 | 1.699 | 110.9 | 111.4 | 747.0 | 25.66 | 1.124 |
| 26,000 | 24.38 | 16.94 | 783.7 | 26.30 | 1.758 | 119.9 | 120.4 | 808.3 | 26.39 | 1.122 |

## TABLE II - NORMAL-SHOCK WAVE PARAMETERS

Altitude: 200,000 feet

Pressure: $4.7151 \times 10^{-1}$ psfa

Density: $6.1180 \times 10^{-7}$ slugs/ft$^3$

Temperature: 449.00°R

Enthalpy: $2.6864 \times 10^6$ ft-lb/slug

Sonic Speed: 1038.7 ft/sec

| $V_1$ | $M_1$ | $\rho_2/\rho_1$ | $p_2/p_1$ | $T_2/T_1$ | $Z_2$ | $H_2/H_1$ | $H_{T_2}/H_1$ | $p_{T_2}/p_1$ | $T_{T_2}/T_1$ | $\gamma_e$ |
|---|---|---|---|---|---|---|---|---|---|---|
| 2000 | 1.925 | | | | | | 1.745 | | | |
| 3000 | 2.888 | 3.809 | 9.608 | 2.523 | 1.000 | 2.559 | 2.675 | 11.14 | 2.636 | 1.387 |
| 4000 | 3.851 | 4.696 | 17.33 | 3.691 | 1.000 | 3.842 | 3.978 | 19.54 | 3.820 | 1.370 |
| 5000 | 4.814 | 5.343 | 27.35 | 5.120 | 1.000 | 5.489 | 5.653 | 30.39 | 5.272 | 1.354 |
| 6000 | 5.776 | 5.871 | 39.74 | 6.768 | 1.000 | 7.503 | 7.700 | 43.72 | 6.943 | 1.338 |
| 7000 | 6.739 | 6.450 | 54.70 | 8.455 | 1.003 | 9.898 | 10.12 | 59.63 | 8.642 | 1.315 |
| 8000 | 7.702 | 7.322 | 72.67 | 9.756 | 1.017 | 12.68 | 12.91 | 78.34 | 9.927 | 1.277 |
| 9000 | 8.665 | 8.374 | 93.51 | 10.70 | 1.044 | 15.86 | 16.08 | 99.78 | 10.85 | 1.241 |
| 10,000 | 9.627 | 9.421 | 116.9 | 11.51 | 1.078 | 19.39 | 19.61 | 123.8 | 11.63 | 1.213 |
| 11,000 | 10.59 | 10.36 | 142.8 | 12.33 | 1.118 | 23.30 | 23.52 | 150.4 | 12.44 | 1.194 |
| 12,000 | 11.55 | 11.05 | 170.9 | 13.33 | 1.160 | 27.57 | 27.80 | 179.3 | 13.44 | 1.182 |
| 13,000 | 12.52 | 11.19 | 200.6 | 15.00 | 1.195 | 32.19 | 32.46 | 210.4 | 15.10 | 1.182 |
| 14,000 | 13.48 | 11.05 | 232.2 | 17.30 | 1.215 | 37.17 | 37.48 | 243.7 | 17.44 | 1.187 |
| 15,000 | 14.44 | 11.36 | 267.1 | 18.97 | 1.239 | 42.53 | 42.88 | 280.0 | 19.11 | 1.182 |
| 16,000 | 15.40 | 11.92 | 305.1 | 20.15 | 1.270 | 48.30 | 48.65 | 319.1 | 20.29 | 1.174 |
| 17,000 | 16.37 | 12.56 | 346.0 | 21.08 | 1.306 | 54.43 | 54.79 | 360.9 | 21.21 | 1.165 |
| 18,000 | 17.33 | 13.22 | 389.4 | 21.88 | 1.346 | 60.93 | 61.31 | 405.3 | 22.00 | 1.156 |
| 19,000 | 18.29 | 13.87 | 435.4 | 22.60 | 1.389 | 67.81 | 68.19 | 452.3 | 22.72 | 1.149 |
| 20,000 | 19.25 | 14.49 | 483.9 | 23.27 | 1.436 | 75.06 | 75.45 | 501.8 | 23.38 | 1.142 |
| 21,000 | 20.22 | 15.07 | 535.0 | 23.91 | 1.485 | 82.68 | 83.08 | 554.0 | 24.02 | 1.137 |
| 22,000 | 21.18 | 15.61 | 588.5 | 24.54 | 1.536 | 90.69 | 91.09 | 608.6 | 24.64 | 1.132 |
| 23,000 | 22.14 | 16.10 | 644.5 | 25.16 | 1.590 | 99.06 | 99.46 | 665.8 | 25.26 | 1.128 |
| 24,000 | 23.11 | 16.54 | 702.9 | 25.81 | 1.646 | 107.8 | 108.2 | 725.4 | 25.90 | 1.125 |
| 25,000 | 24.07 | 16.91 | 763.7 | 26.49 | 1.705 | 116.9 | 117.3 | 787.6 | 26.58 | 1.122 |
| 26,000 | 25.03 | 17.20 | 826.8 | 27.25 | 1.764 | 126.4 | 126.8 | 852.3 | 27.34 | 1.120 |

## TABLE II - NORMAL-SHOCK WAVE PARAMETERS

Altitude: 210,000 feet

Pressure: $3.0955 \times 10^{-1}$ psfa

Density: $4.2454 \times 10^{-7}$ slugs/ft$^3$

Temperature: 424.79°R

Enthalpy: $2.5413 \times 10^{6}$ ft-lb/slug

Sonic Speed: 1010.3 ft/sec

| $V_1$ | $M_1$ | $\rho_2/\rho_1$ | $p_2/p_1$ | $T_2/T_1$ | $Z_2$ | $H_2/H_1$ | $H_{T_2}/H_1$ | $p_{T_2}/p_1$ | $T_{T_2}/T_1$ | $\gamma_e$ |
|---|---|---|---|---|---|---|---|---|---|---|
| 2000 | 1.980 | | | | | | 1.787 | | | |
| 3000 | 2.969 | | | | | | 2.771 | | | |
| 4000 | 3.959 | 4.755 | 18.32 | 3.853 | 1.000 | 4.008 | 4.148 | 20.63 | 3.987 | 1.371 |
| 5000 | 4.949 | 5.388 | 28.91 | 5.366 | 1.000 | 5.748 | 5.919 | 32.09 | 5.524 | 1.356 |
| 6000 | 5.939 | 5.906 | 42.00 | 7.110 | 1.000 | 7.877 | 8.083 | 46.17 | 7.293 | 1.339 |
| 7000 | 6.929 | 6.490 | 57.82 | 8.880 | 1.003 | 10.40 | 10.64 | 63.00 | 9.076 | 1.315 |
| 8000 | 7.918 | 7.388 | 76.86 | 10.21 | 1.018 | 13.35 | 13.59 | 82.80 | 10.39 | 1.276 |
| 9000 | 8.908 | 8.467 | 98.93 | 11.18 | 1.045 | 16.71 | 16.94 | 105.1 | 11.33 | 1.239 |
| 10,000 | 9.898 | 9.537 | 123.7 | 12.01 | 1.080 | 20.46 | 20.68 | 130.9 | 12.14 | 1.211 |
| 11,000 | 10.89 | 10.50 | 151.1 | 12.84 | 1.121 | 24.58 | 24.81 | 159.0 | 12.95 | 1.192 |
| 12,000 | 11.88 | 11.19 | 180.8 | 13.89 | 1.163 | 29.10 | 29.33 | 189.6 | 14.00 | 1.181 |
| 13,000 | 12.87 | 11.29 | 212.1 | 15.71 | 1.197 | 33.98 | 34.25 | 222.4 | 15.83 | 1.181 |
| 14,000 | 13.86 | 11.13 | 245.5 | 18.14 | 1.216 | 39.24 | 39.56 | 257.6 | 18.28 | 1.186 |
| 15,000 | 14.85 | 11.48 | 282.6 | 19.83 | 1.241 | 44.91 | 45.27 | 296.0 | 19.98 | 1.181 |
| 16,000 | 15.84 | 12.06 | 322.8 | 21.03 | 1.273 | 51.00 | 51.37 | 337.4 | 21.17 | 1.172 |
| 17,000 | 16.83 | 12.72 | 366.0 | 21.98 | 1.309 | 57.49 | 57.86 | 381.6 | 22.11 | 1.163 |
| 18,000 | 17.82 | 13.40 | 412.0 | 22.79 | 1.349 | 64.37 | 64.75 | 428.5 | 22.92 | 1.155 |
| 19,000 | 18.81 | 14.06 | 460.7 | 23.52 | 1.393 | 71.64 | 72.03 | 478.2 | 23.64 | 1.147 |
| 20,000 | 19.80 | 14.70 | 512.0 | 24.21 | 1.439 | 79.30 | 79.70 | 530.6 | 24.32 | 1.141 |
| 21,000 | 20.79 | 15.29 | 566.0 | 24.86 | 1.489 | 87.36 | 87.77 | 585.7 | 24.96 | 1.135 |
| 22,000 | 21.78 | 15.85 | 622.6 | 25.50 | 1.541 | 95.82 | 96.23 | 643.5 | 25.60 | 1.130 |
| 23,000 | 22.77 | 16.35 | 681.8 | 26.14 | 1.595 | 104.7 | 105.1 | 704.0 | 26.24 | 1.126 |
| 24,000 | 23.76 | 16.80 | 743.6 | 26.80 | 1.651 | 113.9 | 114.3 | 767.1 | 26.89 | 1.123 |
| 25,000 | 24.75 | 17.18 | 807.9 | 27.51 | 1.710 | 123.5 | 124.0 | 832.9 | 27.60 | 1.120 |
| 26,000 | 25.73 | 17.47 | 874.7 | 28.28 | 1.770 | 133.5 | 134.0 | 901.2 | 28.38 | 1.118 |

## TABLE II - NORMAL-SHOCK WAVE PARAMETERS

Altitude: 220,000 feet

Pressure: $1.9835 \times 10^{-1}$ psfa

Density: $2.8845 \times 10^{-7}$ slugs/ft$^3$

Temperature: 400.60°R

Enthalpy: $2.3966 \times 10^6$ ft-lb/slug

Sonic Speed: 981.16 ft/sec

| $V_1$ | $M_1$ | $\rho_2/\rho_1$ | $p_2/p_1$ | $T_2/T_1$ | $Z_2$ | $H_2/H_1$ | $H_{T_2}/H_1$ | $p_{T_2}/p_1$ | $T_{T_2}/T_1$ | $\gamma_e$ |
|---|---|---|---|---|---|---|---|---|---|---|
| 2000 | 2.038 | | | | | | 1.835 | | | |
| 3000 | 3.058 | | | | | | 2.878 | | | |
| 4000 | 4.077 | 4.815 | 19.43 | 4.035 | 1.000 | 4.193 | 4.338 | 21.84 | 4.174 | 1.372 |
| 5000 | 5.096 | 5.434 | 30.65 | 5.641 | 1.000 | 6.037 | 6.216 | 34.00 | 5.806 | 1.357 |
| 6000 | 6.115 | 5.942 | 44.52 | 7.492 | 1.000 | 8.295 | 8.511 | 48.93 | 7.685 | 1.340 |
| 7000 | 7.134 | 6.532 | 61.32 | 9.354 | 1.004 | 10.98 | 11.22 | 66.78 | 9.559 | 1.315 |
| 8000 | 8.154 | 7.459 | 81.56 | 10.72 | 1.020 | 14.12 | 14.35 | 87.80 | 10.90 | 1.275 |
| 9000 | 9.173 | 8.567 | 105.0 | 11.70 | 1.047 | 17.66 | 17.90 | 111.9 | 11.85 | 1.237 |
| 10,000 | 10.19 | 9.661 | 131.3 | 12.55 | 1.083 | 21.63 | 21.86 | 138.8 | 12.68 | 1.209 |
| 11,000 | 11.21 | 10.64 | 160.4 | 13.41 | 1.124 | 26.01 | 26.24 | 168.6 | 13.53 | 1.190 |
| 12,000 | 12.23 | 11.34 | 191.9 | 14.51 | 1.167 | 30.80 | 31.04 | 201.1 | 14.62 | 1.179 |
| 13,000 | 13.25 | 11.38 | 225.1 | 16.50 | 1.199 | 35.97 | 36.26 | 235.9 | 16.63 | 1.180 |
| 14,000 | 14.27 | 11.22 | 260.5 | 19.06 | 1.218 | 41.55 | 41.89 | 273.2 | 19.21 | 1.185 |
| 15,000 | 15.29 | 11.60 | 299.8 | 20.79 | 1.243 | 47.57 | 47.94 | 313.9 | 20.94 | 1.179 |
| 16,000 | 16.31 | 12.21 | 342.6 | 22.00 | 1.275 | 54.03 | 54.41 | 357.9 | 22.15 | 1.170 |
| 17,000 | 17.33 | 12.89 | 388.5 | 22.97 | 1.312 | 60.90 | 61.29 | 404.8 | 23.11 | 1.161 |
| 18,000 | 18.35 | 13.59 | 437.3 | 23.80 | 1.353 | 68.20 | 68.60 | 454.6 | 23.93 | 1.153 |
| 19,000 | 19.36 | 14.27 | 488.9 | 24.54 | 1.396 | 75.91 | 76.32 | 507.3 | 24.66 | 1.145 |
| 20,000 | 20.38 | 14.92 | 543.4 | 25.24 | 1.443 | 84.04 | 84.45 | 562.9 | 25.35 | 1.139 |
| 21,000 | 21.40 | 15.53 | 600.7 | 25.91 | 1.493 | 92.60 | 93.01 | 621.4 | 26.02 | 1.133 |
| 22,000 | 22.42 | 16.10 | 660.8 | 26.56 | 1.545 | 101.6 | 102.0 | 682.8 | 26.66 | 1.128 |
| 23,000 | 23.44 | 16.62 | 723.7 | 27.22 | 1.600 | 110.9 | 111.4 | 746.8 | 27.32 | 1.124 |
| 24,000 | 24.46 | 17.08 | 789.2 | 27.90 | 1.657 | 120.7 | 121.2 | 813.8 | 28.01 | 1.121 |
| 25,000 | 25.48 | 17.46 | 857.5 | 28.63 | 1.715 | 130.9 | 131.4 | 883.5 | 28.72 | 1.118 |
| 26,000 | 26.50 | 17.77 | 928.3 | 29.43 | 1.776 | 141.6 | 142.0 | 956.0 | 29.52 | 1.116 |

## TABLE II - NORMAL-SHOCK WAVE PARAMETERS

Altitude: 230,000 feet

Pressure: $1.2368 \times 10^{-1}$ psfa

Density: $1.9141 \times 10^{-7}$ slugs/ft$^3$

Temperature: 376.44°R

Enthalpy: $2.2519 \times 10^6$ ft-lb/slug

Sonic Speed: 951.11 ft/sec

| $V_1$ | $M_1$ | $\rho_2/\rho_1$ | $p_2/p_1$ | $T_2/T_1$ | $Z_2$ | $H_2/H_1$ | $H_{T_2}/H_1$ | $p_{T_2}/p_1$ | $T_{T_2}/T_1$ | $\gamma_e$ |
|---|---|---|---|---|---|---|---|---|---|---|
| 2000 | 2.103 | | | | | | 1.888 | | | |
| 3000 | 3.154 | | | | | | 2.998 | | | |
| 4000 | 4.206 | 4.876 | 20.68 | 4.240 | 1.000 | 4.402 | 4.553 | 23.21 | 4.384 | 1.374 |
| 5000 | 5.257 | 5.480 | 32.62 | 5.952 | 1.000 | 6.364 | 6.551 | 36.15 | 6.124 | 1.358 |
| 6000 | 6.308 | 5.978 | 47.37 | 7.924 | 1.000 | 8.776 | 8.993 | 52.03 | 8.126 | 1.341 |
| 7000 | 7.360 | 6.577 | 65.28 | 9.885 | 1.004 | 11.63 | 11.88 | 71.04 | 10.10 | 1.315 |
| 8000 | 8.411 | 7.536 | 86.87 | 11.29 | 1.021 | 14.96 | 15.21 | 93.44 | 11.48 | 1.273 |
| 9000 | 9.463 | 8.668 | 111.8 | 12.30 | 1.050 | 18.75 | 18.98 | 119.1 | 12.46 | 1.236 |
| 10,000 | 10.51 | 9.791 | 139.9 | 13.16 | 1.086 | 22.97 | 23.20 | 147.8 | 13.29 | 1.207 |
| 11,000 | 11.57 | 10.79 | 170.8 | 14.05 | 1.127 | 27.62 | 27.87 | 179.5 | 14.17 | 1.187 |
| 12,000 | 12.62 | 11.49 | 204.4 | 15.21 | 1.170 | 32.72 | 32.97 | 214.1 | 15.32 | 1.177 |
| 13,000 | 13.67 | 11.47 | 239.6 | 17.39 | 1.201 | 38.23 | 38.52 | 251.1 | 17.52 | 1.179 |
| 14,000 | 14.72 | 11.32 | 277.4 | 20.09 | 1.219 | 44.16 | 44.52 | 290.8 | 20.24 | 1.184 |
| 15,000 | 15.77 | 11.74 | 319.4 | 21.85 | 1.245 | 50.57 | 50.96 | 334.2 | 22.01 | 1.178 |
| 16,000 | 16.82 | 12.37 | 365.0 | 23.09 | 1.278 | 57.45 | 57.84 | 382.4 | 23.24 | 1.168 |
| 17,000 | 17.87 | 13.07 | 413.8 | 24.07 | 1.315 | 64.76 | 65.17 | 430.9 | 24.21 | 1.159 |
| 18,000 | 18.92 | 13.79 | 465.8 | 24.92 | 1.356 | 72.53 | 72.94 | 484.0 | 25.05 | 1.150 |
| 19,000 | 19.98 | 14.49 | 520.9 | 25.68 | 1.400 | 80.74 | 81.15 | 540.1 | 25.80 | 1.143 |
| 20,000 | 21.03 | 15.16 | 578.9 | 26.39 | 1.447 | 89.40 | 89.81 | 599.4 | 26.50 | 1.136 |
| 21,000 | 22.08 | 15.79 | 640.0 | 27.08 | 1.497 | 98.49 | 98.92 | 661.6 | 27.19 | 1.131 |
| 22,000 | 23.13 | 16.37 | 703.9 | 27.75 | 1.550 | 108.0 | 109.5 | 726.8 | 27.85 | 1.126 |
| 23,000 | 24.18 | 16.90 | 770.9 | 28.43 | 1.605 | 118.0 | 118.5 | 795.1 | 28.53 | 1.122 |
| 24,000 | 25.23 | 17.37 | 840.7 | 29.13 | 1.662 | 128.4 | 128.9 | 866.4 | 29.23 | 1.119 |
| 25,000 | 26.29 | 17.77 | 913.4 | 29.87 | 1.721 | 139.3 | 139.8 | 940.6 | 29.96 | 1.116 |
| 26,000 | 27.34 | 18.08 | 988.9 | 30.71 | 1.782 | 150.6 | 151.1 | 1018. | 30.81 | 1.114 |

## TABLE II - NORMAL-SHOCK WAVE PARAMETERS

Altitude: 240,000 feet
Pressure: $7.4774 \times 10^{-2}$ psfa
Density: $1.2365 \times 10^{-7}$ slugs/ft$^3$

Temperature: 352.30°R
Enthalpy: $2.1076 \times 10^{6}$ ft-lb/slug
Sonic Speed: 920.11 ft/sec

| $V_1$ | $M_1$ | $\rho_2/\rho_1$ | $p_2/p_1$ | $T_2/T_1$ | $Z_2$ | $H_2/H_1$ | $H_{T_2}/H_1$ | $p_{T_2}/p_1$ | $T_{T_2}/T_1$ | $\gamma_e$ |
|---|---|---|---|---|---|---|---|---|---|---|
| 2000 | 2.174 | | | | | | 1.949 | | | |
| 3000 | 3.260 | | | | | | 3.135 | | | |
| 4000 | 4.347 | 4.939 | 22.09 | 4.473 | 1.000 | 4.639 | 4.796 | 24.78 | 4.623 | 1.375 |
| 5000 | 5.434 | 5.528 | 34.85 | 6.304 | 1.000 | 6.735 | 6.931 | 38.60 | 6.481 | 1.359 |
| 6000 | 6.521 | 6.015 | 50.61 | 8.413 | 1.000 | 9.302 | 9.541 | 55.58 | 8.621 | 1.342 |
| 7000 | 7.608 | 6.626 | 69.77 | 10.48 | 1.004 | 12.36 | 12.62 | 75.92 | 10.70 | 1.315 |
| 8000 | 8.695 | 7.619 | 92.90 | 11.93 | 1.022 | 15.91 | 16.18 | 99.86 | 12.13 | 1.272 |
| 9000 | 9.781 | 8.782 | 119.6 | 12.95 | 1.052 | 19.96 | 20.22 | 127.3 | 13.11 | 1.233 |
| 10,000 | 10.87 | 9.933 | 149.7 | 13.84 | 1.088 | 24.48 | 24.72 | 158.2 | 13.97 | 1.205 |
| 11,000 | 11.96 | 10.95 | 182.7 | 14.76 | 1.130 | 29.46 | 29.71 | 192.1 | 14.88 | 1.186 |
| 12,000 | 13.04 | 11.65 | 218.6 | 15.99 | 1.173 | 34.90 | 35.16 | 228.8 | 16.11 | 1.175 |
| 13,000 | 14.13 | 11.56 | 256.2 | 18.41 | 1.203 | 40.78 | 41.09 | 268.5 | 18.55 | 1.178 |
| 14,000 | 15.22 | 11.43 | 296.6 | 21.25 | 1.221 | 47.12 | 47.50 | 311.0 | 21.41 | 1.182 |
| 15,000 | 16.30 | 11.88 | 341.6 | 23.05 | 1.248 | 53.98 | 54.38 | 357.3 | 23.21 | 1.176 |
| 16,000 | 17.39 | 12.54 | 390.4 | 24.30 | 1.281 | 61.32 | 61.73 | 407.5 | 24.45 | 1.166 |
| 17,000 | 18.48 | 13.27 | 442.7 | 25.31 | 1.318 | 69.14 | 69.56 | 461.1 | 25.45 | 1.157 |
| 18,000 | 19.56 | 14.00 | 498.3 | 26.17 | 1.359 | 77.45 | 77.87 | 517.5 | 26.30 | 1.148 |
| 19,000 | 20.65 | 14.72 | 557.1 | 26.95 | 1.404 | 86.22 | 86.64 | 577.7 | 27.07 | 1.141 |
| 20,000 | 21.74 | 15.41 | 619.2 | 27.69 | 1.451 | 95.46 | 95.90 | 641.1 | 27.81 | 1.134 |
| 21,000 | 22.82 | 16.06 | 684.5 | 28.39 | 1.501 | 105.2 | 105.6 | 707.4 | 28.50 | 1.129 |
| 22,000 | 23.91 | 16.66 | 753.0 | 29.08 | 1.554 | 115.4 | 115.8 | 785.4 | 29.18 | 1.124 |
| 23,000 | 25.00 | 17.20 | 824.5 | 29.77 | 1.610 | 126.0 | 126.5 | 850.6 | 29.87 | 1.120 |
| 24,000 | 26.08 | 17.69 | 899.3 | 30.50 | 1.667 | 137.1 | 137.6 | 926.4 | 30.60 | 1.117 |
| 25,000 | 27.17 | 18.09 | 977.0 | 31.27 | 1.727 | 148.8 | 149.3 | 1005. | 31.36 | 1.114 |
| 26,000 | 28.26 | 18.41 | 1058. | 32.14 | 1.788 | 160.9 | 161.4 | 1089. | 32.23 | 1.112 |

## TABLE II - NORMAL-SHOCK WAVE PARAMETERS

Altitude: 250,000 feet
Pressure: $4.364 \times 10^{-2}$ psfa
Density: $7.748 \times 10^{-8}$ slugs/ft$^3$

Temperature: 328.2°R
Enthalpy: $1.9636 \times 10^{6}$ ft-lb/slug
Sonic Speed: 888.11 ft/sec

| $V_1$ | $M_1$ | $\rho_2/\rho_1$ | $p_2/p_1$ | $T_2/T_1$ | $Z_2$ | $H_2/H_1$ | $H_{T_2}/H_1$ | $p_{T_2}/p_1$ | $T_{T_2}/T_1$ | $\gamma_e$ |
|---|---|---|---|---|---|---|---|---|---|---|
| 2000 | 2.252 | | | | | | 2.019 | | | |
| 3000 | 3.378 | | | | | | 3.292 | | | |
| 4000 | 4.504 | 5.004 | 23.72 | 4.740 | 1.000 | 4.910 | 5.074 | 26.55 | 4.897 | 1.376 |
| 5000 | 5.630 | 5.576 | 37.40 | 6.708 | 1.000 | 7.159 | 7.366 | 41.38 | 6.899 | 1.360 |
| 6000 | 6.756 | 6.053 | 54.32 | 8.974 | 1.000 | 9.912 | 10.17 | 59.60 | 9.200 | 1.343 |
| 7000 | 7.882 | 6.678 | 74.92 | 11.16 | 1.005 | 13.13 | 13.20 | 81.44 | 11.40 | 1.314 |
| 8000 | 9.008 | 7.711 | 99.83 | 12.64 | 1.024 | 17.02 | 17.30 | 107.2 | 12.85 | 1.270 |
| 9000 | 10.13 | 8.907 | 128.6 | 13.70 | 1.054 | 21.35 | 21.63 | 136.7 | 13.87 | 1.231 |
| 10,000 | 11.26 | 10.09 | 160.8 | 14.61 | 1.091 | 26.19 | 26.46 | 169.6 | 14.76 | 1.203 |
| 11,000 | 12.39 | 11.13 | 196.4 | 15.57 | 1.134 | 31.56 | 31.81 | 206.1 | 15.69 | 1.183 |
| 12,000 | 13.51 | 11.82 | 234.9 | 16.88 | 1.177 | 37.41 | 37.67 | 245.7 | 17.00 | 1.173 |
| 13,000 | 14.64 | 11.65 | 275.1 | 19.59 | 1.205 | 43.71 | 44.03 | 288.0 | 19.73 | 1.178 |
| 14,000 | 15.76 | 11.54 | 318.6 | 22.57 | 1.223 | 50.51 | 50.91 | 333.7 | 22.74 | 1.181 |
| 15,000 | 16.89 | 12.04 | 367.0 | 24.40 | 1.250 | 57.88 | 58.29 | 383.6 | 24.57 | 1.174 |
| 16,000 | 18.02 | 12.73 | 419.5 | 25.68 | 1.284 | 65.78 | 66.19 | 437.3 | 25.84 | 1.164 |
| 17,000 | 19.14 | 13.48 | 475.7 | 26.71 | 1.321 | 74.15 | 74.59 | 494.7 | 26.86 | 1.154 |
| 18,000 | 20.27 | 14.24 | 535.5 | 27.59 | 1.363 | 83.06 | 83.50 | 555.7 | 27.73 | 1.146 |
| 19,000 | 21.39 | 14.98 | 598.7 | 28.39 | 1.408 | 92.48 | 92.93 | 620.1 | 28.51 | 1.138 |
| 20,000 | 22.52 | 15.69 | 665.4 | 29.[illegible] | 1.456 | 102.4 | 102.9 | 688.1 | 29.27 | 1.132 |
| 21,000 | 23.65 | 16.35 | 735.6 | 29.87 | 1.506 | 112.8 | 113.3 | 759.5 | 29.98 | 1.126 |
| 22,000 | 24.77 | 16.97 | 809.1 | 30.58 | 1.559 | 123.8 | 124.2 | 834.5 | 30.69 | 1.122 |
| 23,000 | 25.90 | 17.53 | 886.0 | 31.30 | 1.615 | 135.2 | 135.7 | 912.8 | 31.40 | 1.118 |
| 24,000 | 27.02 | 18.03 | 966.3 | 32.04 | 1.673 | 147.2 | 147.7 | 994.6 | 32.14 | 1.115 |
| 25,000 | 28.15 | 18.45 | 1050. | 32.85 | 1.733 | 159.6 | 160.1 | 1080. | 32.95 | 1.112 |
| 26,000 | 29.28 | 18.77 | 1137. | 33.76 | 1.794 | 172.6 | 173.1 | 1169. | 33.85 | 1.110 |

## TABLE II - NORMAL-SHOCK WAVE PARAMETERS

Altitude: 260,000 feet
Pressure: $2.446 \times 10^{-2}$ psfa
Density: $4.686 \times 10^{-8}$ slugs/ft$^3$

Temperature: 304.1°R
Enthalpy: $1.8198 \times 10^6$ ft-lb/slug
Sonic Speed: 854.8 ft/sec

| $V_1$ | $M_1$ | $\rho_2/\rho_1$ | $p_2/p_1$ | $T_2/T_1$ | $Z_2$ | $H_2/H_1$ | $H_{T_2}/H_1$ | $p_{T_2}/p_1$ | $T_{T_2}/T_1$ | $\gamma_e$ |
|---|---|---|---|---|---|---|---|---|---|---|
| 2000 | 2.340 | | | | | | 2.099 | | | |
| 3000 | 3.510 | | | | | | 3.473 | | | |
| 4000 | 4.679 | 5.070 | 25.60 | 5.048 | 1.000 | 5.224 | 5.396 | 28.62 | 5.213 | 1.378 |
| 5000 | 5.849 | 5.626 | 40.36 | 7.175 | 1.000 | 7.650 | 7.869 | 44.62 | 7.379 | 1.361 |
| 6000 | 7.019 | 6.091 | 58.62 | 9.622 | 1.000 | 10.62 | 10.89 | 64.28 | 9.864 | 1.344 |
| 7000 | 8.189 | 6.736 | 80.90 | 11.94 | 1.006 | 14.16 | 14.46 | 87.87 | 12.20 | 1.314 |
| 8000 | 9.359 | 7.810 | 107.9 | 13.47 | 1.026 | 18.29 | 18.59 | 115.7 | 13.68 | 1.267 |
| 9000 | 10.53 | 9.042 | 139.0 | 14.55 | 1.057 | 22.99 | 23.26 | 147.5 | 14.73 | 1.228 |
| 10,000 | 11.70 | 10.25 | 173.8 | 15.49 | 1.094 | 28.19 | 28.48 | 183.2 | 15.63 | 1.200 |
| 11,000 | 12.87 | 11.32 | 212.2 | 16.49 | 1.137 | 33.97 | 34.25 | 222.5 | 16.62 | 1.181 |
| 12,000 | 14.04 | 12.01 | 253.8 | 17.91 | 1.180 | 40.26 | 40.57 | 265.3 | 18.03 | 1.171 |
| 13,000 | 15.21 | 11.74 | 297.1 | 20.96 | 1.207 | 47.09 | 47.44 | 310.9 | 21.11 | 1.177 |
| 14,000 | 16.38 | 11.67 | 344.2 | 24.08 | 1.225 | 54.45 | 54.85 | 360.3 | 24.26 | 1.179 |
| 15,000 | 17.55 | 12.21 | 396.6 | 25.94 | 1.253 | 62.41 | 62.82 | 414.2 | 26.11 | 1.171 |
| 16,000 | 18.72 | 12.93 | 453.3 | 27.25 | 1.287 | 70.91 | 71.34 | 472.2 | 27.41 | 1.161 |
| 17,000 | 19.89 | 13.71 | 514.1 | 28.30 | 1.325 | 79.96 | 80.41 | 534.3 | 28.45 | 1.152 |
| 18,000 | 21.06 | 14.49 | 578.6 | 29.21 | 1.367 | 89.57 | 90.02 | 600.0 | 29.35 | 1.143 |
| 19,000 | 22.23 | 15.25 | 647.0 | 30.04 | 1.412 | 99.74 | 100.2 | 669.6 | 30.17 | 1.136 |
| 20,000 | 23.40 | 15.98 | 719.1 | 30.81 | 1.460 | 110.4 | 110.9 | 743.0 | 30.93 | 1.130 |
| 21,000 | 24.57 | 16.67 | 794.8 | 31.56 | 1.511 | 121.7 | 122.2 | 822.2 | 31.67 | 1.124 |
| 22,000 | 25.74 | 17.31 | 874.3 | 32.29 | 1.564 | 133.5 | 134.0 | 901.0 | 32.40 | 1.119 |
| 23,000 | 26.91 | 17.89 | 957.4 | 33.04 | 1.620 | 145.8 | 146.4 | 985.7 | 33.14 | 1.116 |
| 24,000 | 28.08 | 18.40 | 1044. | 33.81 | 1.678 | 158.7 | 159.3 | 1074. | 33.91 | 1.112 |
| 25,000 | 29.25 | 18.83 | 1134. | 34.65 | 1.739 | 172.2 | 172.7 | 1166. | 34.75 | 1.110 |
| 26,000 | 30.42 | 19.16 | 1228. | 35.60 | 1.800 | 186.2 | 186.7 | 1262. | 35.70 | 1.108 |

## TABLE II - NORMAL-SHOCK WAVE PARAMETERS

Altitude: 270,000 feet
Pressure: $1.327 \times 10^{-2}$ psfa
Density: $2.593 \times 10^{-8}$ slugs/ft$^3$

Temperature: 298.2°R
Enthalpy: $1.7847 \times 10^6$ ft-lb/slug
Sonic Speed: 846.5 ft/sec

| $V_1$ | $M_1$ | $\rho_2/\rho_1$ | $p_2/p_1$ | $T_2/T_1$ | $Z_2$ | $H_2/H_1$ | $H_{T_2}/H_1$ | $p_{T_2}/p_1$ | $T_{T_2}/T_1$ | $\gamma_e$ |
|---|---|---|---|---|---|---|---|---|---|---|
| 2000 | 2.363 | | | | | | 2.121 | | | |
| 3000 | 3.544 | | | | | | 3.522 | | | |
| 4000 | 4.725 | 5.087 | 26.10 | 5.131 | 1.000 | 5.308 | 5.483 | 29.17 | 5.299 | 1.378 |
| 5000 | 5.907 | 5.638 | 41.16 | 7.301 | 1.000 | 7.782 | 8.004 | 45.49 | 7.507 | 1.362 |
| 6000 | 7.088 | 6.103 | 59.78 | 9.793 | 1.000 | 10.81 | 11.09 | 65.54 | 10.04 | 1.344 |
| 7000 | 8.269 | 6.790 | 82.59 | 12.08 | 1.007 | 14.43 | 14.73 | 89.64 | 12.33 | 1.311 |
| 8000 | 9.451 | 7.921 | 110.2 | 13.53 | 1.028 | 18.64 | 18.93 | 118.1 | 13.74 | 1.263 |
| 9000 | 10.63 | 9.196 | 142.0 | 14.57 | 1.060 | 23.42 | 23.69 | 150.6 | 14.74 | 1.224 |
| 10,000 | 11.81 | 10.44 | 177.6 | 15.48 | 1.099 | 28.76 | 29.02 | 186.9 | 15.62 | 1.196 |
| 11,000 | 12.99 | 11.53 | 216.8 | 16.46 | 1.142 | 34.65 | 34.90 | 227.0 | 16.58 | 1.177 |
| 12,000 | 14.18 | 12.20 | 259.2 | 17.92 | 1.185 | 41.07 | 41.35 | 270.7 | 18.04 | 1.168 |
| 13,000 | 15.36 | 11.82 | 303.1 | 21.21 | 1.208 | 47.98 | 48.35 | 317.1 | 21.36 | 1.176 |
| 14,000 | 16.54 | 11.82 | 351.3 | 24.23 | 1.227 | 55.50 | 55.91 | 367.5 | 24.40 | 1.177 |
| 15,000 | 17.72 | 12.40 | 404.9 | 26.00 | 1.256 | 63.62 | 64.04 | 422.7 | 26.17 | 1.168 |
| 16,000 | 18.90 | 13.17 | 462.9 | 27.25 | 1.290 | 72.27 | 72.73 | 481.9 | 27.41 | 1.158 |
| 17,000 | 20.08 | 13.98 | 525.0 | 28.26 | 1.329 | 81.52 | 81.97 | 545.2 | 28.40 | 1.149 |
| 18,000 | 21.26 | 14.79 | 590.9 | 29.14 | 1.371 | 91.31 | 91.78 | 612.3 | 29.27 | 1.140 |
| 19,000 | 22.44 | 15.58 | 660.7 | 29.94 | 1.417 | 101.7 | 102.1 | 683.4 | 30.06 | 1.133 |
| 20,000 | 23.63 | 16.33 | 734.3 | 30.68 | 1.465 | 112.6 | 113.1 | 758.2 | 30.79 | 1.127 |
| 21,000 | 24.81 | 17.04 | 811.6 | 31.41 | 1.516 | 124.1 | 124.6 | 836.9 | 31.52 | 1.121 |
| 22,000 | 25.99 | 17.70 | 892.7 | 32.12 | 1.570 | 136.1 | 136.6 | 919.4 | 32.22 | 1.117 |
| 23,000 | 27.17 | 18.30 | 977.6 | 32.84 | 1.627 | 148.7 | 149.2 | 1006. | 32.94 | 1.113 |
| 24,000 | 28.35 | 18.83 | 1066. | 33.60 | 1.685 | 161.9 | 162.4 | 1096. | 33.69 | 1.110 |
| 25,000 | 29.53 | 19.27 | 1158. | 34.42 | 1.746 | 175.6 | 176.1 | 1190. | 34.51 | 1.107 |
| 26,000 | 30.71 | 19.61 | 1254. | 35.36 | 1.808 | 189.8 | 190.4 | 1288. | 35.45 | 1.105 |

## TABLE II - NORMAL-SHOCK WAVE PARAMETERS

Altitude: 280,000 feet

Pressure: $7.194 \times 10^{-3}$ psfa

Density: $1.406 \times 10^{-8}$ slugs/ft$^3$

Temperature: 298.2 °R

Enthalpy: $1.7847 \times 10^6$ ft-lb/slug

Sonic Speed: 846.5 ft/sec

| $V_1$ | $M_1$ | $\rho_2/\rho_1$ | $p_2/p_1$ | $T_2/T_1$ | $Z_2$ | $H_2/H_1$ | $H_{T_2}/H_1$ | $p_{T_2}/p_1$ | $T_{T_2}/T_1$ | $\gamma_e$ |
|---|---|---|---|---|---|---|---|---|---|---|
| 2000 | 2.363 | | | | | | 2.121 | | | |
| 3000 | 3.544 | | | | | | 3.522 | | | |
| 4000 | 4.725 | 5.087 | 26.10 | 5.131 | 1.000 | 5.308 | 5.483 | 29.17 | 5.299 | 1.378 |
| 5000 | 5.907 | 5.638 | 41.16 | 7.301 | 1.000 | 7.782 | 8.004 | 45.49 | 7.507 | 1.362 |
| 6000 | 7.088 | 6.107 | 59.79 | 9.787 | 1.000 | 10.81 | 11.09 | 65.55 | 10.03 | 1.344 |
| 7000 | 8.269 | 6.847 | 82.71 | 11.98 | 1.008 | 14.43 | 14.73 | 89.70 | 12.23 | 1.308 |
| 8000 | 9.451 | 8.038 | 110.4 | 13.33 | 1.031 | 18.65 | 18.93 | 118.2 | 13.53 | 1.259 |
| 9000 | 10.63 | 9.356 | 142.3 | 14.30 | 1.063 | 23.42 | 23.69 | 150.7 | 14.46 | 1.220 |
| 10,000 | 11.81 | 10.64 | 177.9 | 15.17 | 1.103 | 28.77 | 29.02 | 187.1 | 15.30 | 1.192 |
| 11,000 | 12.99 | 11.75 | 217.2 | 16.12 | 1.146 | 34.63 | 34.90 | 227.2 | 16.23 | 1.173 |
| 12,000 | 14.18 | 12.40 | 259.5 | 17.61 | 1.189 | 41.07 | 41.35 | 270.9 | 17.72 | 1.165 |
| 13,000 | 15.36 | 11.90 | 303.3 | 21.07 | 1.210 | 48.00 | 48.35 | 317.2 | 21.22 | 1.174 |
| 14,000 | 16.54 | 11.97 | 351.8 | 23.90 | 1.230 | 55.53 | 55.91 | 367.8 | 24.06 | 1.174 |
| 15,000 | 17.72 | 12.61 | 405.5 | 25.54 | 1.259 | 63.62 | 64.04 | 423.0 | 25.70 | 1.165 |
| 16,000 | 18.90 | 13.41 | 463.6 | 26.71 | 1.294 | 72.30 | 72.73 | 482.3 | 26.86 | 1.155 |
| 17,000 | 20.08 | 14.25 | 525.8 | 27.66 | 1.333 | 81.53 | 81.97 | 545.6 | 27.80 | 1.146 |
| 18,000 | 21.26 | 15.09 | 591.8 | 28.49 | 1.376 | 91.35 | 91.78 | 612.7 | 28.62 | 1.137 |
| 19,000 | 22.45 | 15.91 | 661.6 | 29.25 | 1.422 | 101.7 | 102.1 | 683.8 | 29.36 | 1.130 |
| 20,000 | 23.63 | 16.69 | 735.3 | 29.95 | 1.471 | 112.7 | 113.1 | 758.7 | 30.06 | 1.124 |
| 21,000 | 24.81 | 17.43 | 812.8 | 30.64 | 1.522 | 124.1 | 124.6 | 837.5 | 30.74 | 1.118 |
| 22,000 | 25.99 | 18.11 | 893.9 | 31.32 | 1.576 | 136.1 | 136.6 | 920.1 | 31.41 | 1.114 |
| 23,000 | 27.17 | 18.73 | 978.9 | 32.00 | 1.633 | 148.7 | 149.2 | 1007. | 32.09 | 1.110 |
| 24,000 | 28.35 | 19.28 | 1067. | 32.73 | 1.692 | 161.9 | 162.4 | 1097. | 32.82 | 1.107 |
| 25,000 | 29.53 | 19.74 | 1160. | 33.52 | 1.753 | 175.6 | 176.1 | 1191. | 33.61 | 1.104 |
| 26,000 | 30.71 | 20.09 | 1255. | 34.43 | 1.815 | 189.9 | 190.4 | 1288. | 34.51 | 1.103 |

## TABLE II - NORMAL-SHOCK WAVE PARAMETERS

Altitude: 290,000 feet
Pressure: $3.902 \times 10^{-3}$ psfa
Density: $7.624 \times 10^{-9}$ slugs/ft$^3$

Temperature: 298.2°R
Enthalpy: $1.7847 \times 10^6$ ft-lb/slug
Sonic Speed: 846.5 ft/sec

| $V_1$ | $M_1$ | $\rho_2/\rho_1$ | $p_2/p_1$ | $T_2/T_1$ | $Z_2$ | $H_2/H_1$ | $H_{T_2}/H_1$ | $p_{T_2}/p_1$ | $T_{T_2}/T_1$ | $\gamma_e$ |
|---|---|---|---|---|---|---|---|---|---|---|
| 2000 | 2.363 | | | | | | 2.121 | | | |
| 3000 | 3.544 | | | | | | 3.522 | | | |
| 4000 | 4.725 | 5.087 | 26.10 | 5.131 | 1.000 | 5.308 | 5.483 | 29.17 | 5.299 | 1.378 |
| 5000 | 5.907 | 5.638 | 41.16 | 7.301 | 1.000 | 7.782 | 8.004 | 45.49 | 7.507 | 1.362 |
| 6000 | 7.088 | 6.113 | 59.80 | 9.779 | 1.000 | 10.81 | 11.09 | 65.55 | 10.02 | 1.344 |
| 7000 | 8.269 | 6.911 | 82.84 | 11.88 | 1.009 | 14.43 | 14.73 | 89.76 | 12.11 | 1.304 |
| 8000 | 9.451 | 8.158 | 110.7 | 13.12 | 1.033 | 18.65 | 18.93 | 118.3 | 13.32 | 1.254 |
| 9000 | 10.63 | 9.519 | 142.6 | 14.04 | 1.067 | 23.44 | 23.69 | 150.9 | 14.19 | 1.215 |
| 10,000 | 11.81 | 10.84 | 178.3 | 14.86 | 1.107 | 28.77 | 29.02 | 187.3 | 14.98 | 1.188 |
| 11,000 | 12.99 | 11.98 | 217.6 | 15.78 | 1.151 | 34.66 | 34.90 | 227.4 | 15.89 | 1.169 |
| 12,000 | 14.18 | 12.58 | 259.8 | 17.32 | 1.193 | 41.07 | 41.35 | 271.0 | 17.43 | 1.162 |
| 13,000 | 15.36 | 11.97 | 303.5 | 20.92 | 1.211 | 47.98 | 48.35 | 317.2 | 21.06 | 1.173 |
| 14,000 | 16.54 | 12.13 | 352.2 | 23.57 | 1.232 | 55.53 | 55.91 | 368.0 | 23.73 | 1.172 |
| 15,000 | 17.72 | 12.82 | 406.1 | 25.09 | 1.262 | 63.63 | 64.04 | 423.2 | 25.24 | 1.162 |
| 16,000 | 18.90 | 13.66 | 464.3 | 26.19 | 1.298 | 72.32 | 72.73 | 482.6 | 26.33 | 1.152 |
| 17,000 | 20.08 | 14.53 | 526.5 | 27.09 | 1.337 | 81.54 | 81.97 | 545.9 | 27.22 | 1.142 |
| 18,000 | 21.26 | 15.40 | 592.6 | 27.87 | 1.380 | 91.34 | 91.78 | 613.2 | 27.99 | 1.134 |
| 19,000 | 22.45 | 16.25 | 662.6 | 28.58 | 1.427 | 101.8 | 102.1 | 684.3 | 28.69 | 1.127 |
| 20,000 | 23.63 | 17.06 | 736.3 | 29.25 | 1.476 | 112.7 | 113.1 | 759.2 | 29.35 | 1.121 |
| 21,000 | 24.81 | 17.82 | 813.8 | 29.90 | 1.527 | 124.1 | 124.6 | 838.0 | 29.99 | 1.115 |
| 22,000 | 25.99 | 18.52 | 895.1 | 30.55 | 1.582 | 136.2 | 136.6 | 920.6 | 30.64 | 1.111 |
| 23,000 | 27.17 | 19.16 | 980.1 | 31.21 | 1.639 | 148.8 | 149.2 | 1007. | 31.29 | 1.107 |
| 24,000 | 28.35 | 19.73 | 1069. | 31.90 | 1.698 | 161.9 | 162.4 | 1097. | 31.98 | 1.109 |
| 25,000 | 29.53 | 20.21 | 1161. | 32.65 | 1.760 | 175.6 | 176.1 | 1191. | 32.73 | 1.102 |
| 26,000 | 30.71 | 20.56 | 1257. | 33.54 | 1.822 | 189.9 | 190.4 | 1289. | 33.62 | 1.100 |

## TABLE II - NORMAL-SHOCK WAVE PARAMETERS

Altitude: 300,000 feet
Pressure: $2.118 \times 10^{-3}$ psfa
Density: $4.123 \times 10^{-9}$ slugs/ft$^3$

Temperature: 299.2 °R
Enthalpy: $1.7906 \times 10^6$ ft-lb/slug
Sonic Speed: 848.3 ft/sec

| $V_1$ | $M_1$ | $\rho_2/\rho_1$ | $p_2/p_1$ | $T_2/T_1$ | $Z_2$ | $H_2/H_1$ | $H_{T_2}/H_1$ | $p_{T_2}/p_1$ | $T_{T_2}/T_1$ | $\gamma_e$ |
|---|---|---|---|---|---|---|---|---|---|---|
| 2000 | 2.358 | | | | | | 2.117 | | | |
| 3000 | 3.538 | | | | | | 3.513 | | | |
| 4000 | 4.716 | 5.084 | 26.02 | 5.117 | 1.000 | 5.294 | 5.468 | 29.08 | 5.284 | 1.378 |
| 5000 | 5.896 | 5.636 | 41.02 | 7.279 | 1.000 | 7.759 | 7.981 | 45.34 | 7.485 | 1.362 |
| 6000 | 7.075 | 6.118 | 59.62 | 9.738 | 1.001 | 10.78 | 11.05 | 65.34 | 9.981 | 1.343 |
| 7000 | 8.254 | 6.980 | 82.71 | 11.72 | 1.011 | 14.40 | 14.68 | 89.54 | 11.95 | 1.300 |
| 8000 | 9.433 | 8.283 | 110.5 | 12.88 | 1.036 | 18.61 | 18.87 | 118.0 | 13.06 | 1.249 |
| 9000 | 10.61 | 9.685 | 142.4 | 13.73 | 1.070 | 23.36 | 23.62 | 150.5 | 13.87 | 1.211 |
| 10,000 | 11.79 | 11.04 | 178.0 | 14.52 | 1.111 | 28.70 | 28.93 | 186.8 | 14.64 | 1.183 |
| 11,000 | 12.97 | 12.20 | 217.2 | 15.41 | 1.155 | 34.55 | 34.79 | 226.9 | 15.51 | 1.166 |
| 12,000 | 14.15 | 12.74 | 259.3 | 17.00 | 1.196 | 40.94 | 41.21 | 270.3 | 17.10 | 1.160 |
| 13,000 | 15.33 | 12.05 | 302.6 | 20.70 | 1.213 | 47.86 | 48.19 | 316.3 | 20.84 | 1.172 |
| 14,000 | 16.51 | 12.29 | 351.4 | 23.16 | 1.234 | 55.33 | 55.73 | 367.0 | 23.31 | 1.169 |
| 15,000 | 17.69 | 13.04 | 405.3 | 24.57 | 1.265 | 63.43 | 63.83 | 422.1 | 24.71 | 1.159 |
| 16,000 | 18.87 | 13.91 | 463.4 | 25.60 | 1.301 | 72.08 | 72.49 | 481.4 | 25.73 | 1.149 |
| 17,000 | 20.05 | 14.82 | 525.5 | 26.44 | 1.341 | 81.29 | 81.70 | 544.5 | 26.56 | 1.139 |
| 18,000 | 21.23 | 15.72 | 591.5 | 27.18 | 1.385 | 91.11 | 91.48 | 611.5 | 27.29 | 1.131 |
| 19,000 | 22.40 | 16.69 | 661.3 | 27.85 | 1.431 | 101.4 | 101.8 | 682.4 | 27.95 | 1.124 |
| 20,000 | 23.58 | 17.43 | 734.8 | 28.49 | 1.480 | 112.3 | 112.7 | 757.2 | 28.58 | 1.118 |
| 21,000 | 24.76 | 18.21 | 812.2 | 29.10 | 1.533 | 123.8 | 124.2 | 835.8 | 29.19 | 1.113 |
| 22,000 | 25.94 | 18.94 | 893.3 | 29.71 | 1.587 | 135.7 | 136.2 | 918.1 | 29.79 | 1.108 |
| 23,000 | 27.12 | 19.60 | 978.1 | 30.34 | 1.645 | 148.3 | 148.7 | 1004. | 30.42 | 1.105 |
| 24,000 | 28.30 | 20.19 | 1067. | 31.00 | 1.704 | 161.4 | 161.8 | 1094. | 31.07 | 1.102 |
| 25,000 | 29.48 | 20.68 | 1159. | 31.72 | 1.766 | 175.1 | 175.5 | 1188. | 31.79 | 1.099 |
| 26,000 | 30.66 | 21.05 | 1254. | 32.58 | 1.829 | 189.3 | 189.8 | 1285. | 32.65 | 1.098 |

Altitude: 0 feet

TABLE III - GAS COMPOSITION BEHIND NORMAL-SHOCK WAVE

MOLE FRACTION CONCENTRATIONS

| $V_1$ | $N_2$ | $O_2$ | $A$ | $NO$ | $N$ | $O$ | $e$ | $N_2^+$ | $O_2^+$ | $NO^+$ | $N^+$ | $O^+$ | $O^-$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2000 | 7.809 (-1) | 2.098 (-1) | 9.324 (-3) | | | 9.050 (-28) | | | | | | | |
| 3000 | 7.809 (-1) | 2.098 (-1) | 9.324 (-3) | | | 8.859 (-18) | | | | | | | |
| 4000 | 7.809 (-1) | 2.098 (-1) | 9.324 (-3) | 2.005 (-5) | 3.833 (-24) | 4.123 (-12) | | | | | | | |
| 5000 | 7.809 (-1) | 2.098 (-1) | 9.324 (-3) | 4.488 (-4) | 3.879 (-17) | 1.919 (-8) | | | | | | | |
| 6000 | 7.783 (-1) | 2.082 (-1) | 9.324 (-3) | 3.250 (-3) | 1.184 (-12) | 4.211 (-6) | | | | | | | |
| 7000 | 7.748 (-1) | 2.037 (-1) | 9.323 (-3) | 1.205 (-2) | 1.132 (-9) | 1.485 (-4) | | | | | | | |
| 8000 | 7.656 (-1) | 1.942 (-1) | 9.316 (-3) | 2.918 (-2) | 1.278 (-7) | 1.684 (-3) | | | | | | | |
| 9000 | 7.511 (-1) | 1.781 (-1) | 9.282 (-3) | 5.267 (-2) | 3.514 (-6) | 8.923 (-3) | | | | | | | |
| 10.000 | 7.319 (-1) | 1.550 (-1) | 9.196 (-3) | 7.640 (-2) | 3.613 (-5) | 2.747 (-2) | | | | | | | |
| 11.000 | 7.103 (-1) | 1.267 (-1) | 9.049 (-3) | 9.490 (-2) | 1.975 (-4) | 5.888 (-2) | | | | | | | |
| 12.000 | 6.882 (-1) | 9.624 (-2) | 8.858 (-3) | 1.056 (-1) | 7.459 (-4) | 1.003 (-1) | | | | | | | |
| 13.000 | 6.676 (-1) | 6.692 (-2) | 8.630 (-3) | 1.080 (-1) | 2.286 (-3) | 1.465 (-1) | 7.626 (-8) | 4.531 (-10) | 5.317 (-8) | 1.035 (-5) | 1.456 (-11) | 1.599 (-9) | 2.777 (-6) |
| 14.000 | 6.494 (-1) | 4.217 (-2) | 8.403 (-3) | 1.025 (-1) | 6.208 (-3) | 1.913 (-1) | 2.141 (-5) | 5.043 (-9) | 1.684 (-7) | 2.808 (-5) | 3.860 (-10) | 1.497 (-8) | 6.866 (-6) |
| 15.000 | 6.325 (-1) | 2.457 (-2) | 8.191 (-3) | 9.166 (-2) | 1.524 (-2) | 2.277 (-1) | 5.342 (-5) | 4.529 (-8) | 4.276 (-7) | 6.693 (-5) | 6.087 (-9) | 1.072 (-7) | 1.410 (-5) |
| 16.000 | 6.136 (-1) | 1.422 (-2) | 7.996 (-3) | 7.938 (-2) | 3.272 (-2) | 2.519 (-1) | 1.155 (-4) | 3.002 (-7) | 8.830 (-7) | 1.381 (-4) | 7.145 (-8) | 5.590 (-7) | 2.441 (-5) |
| 17.000 | 5.896 (-1) | 8.761 (-3) | 7.808 (-3) | 6.856 (-2) | 5.981 (-2) | 2.650 (-1) | 2.133 (-4) | 1.368 (-6) | 1.520 (-6) | 2.446 (-4) | 5.129 (-7) | 2.059 (-6) | 3.868 (-5) |
| 18.000 | 5.602 (-1) | 5.859 (-3) | 7.616 (-3) | 5.984 (-2) | 9.498 (-2) | 2.707 (-1) | 3.451 (-4) | 4.451 (-6) | 2.282 (-6) | 3.802 (-4) | 2.387 (-6) | 5.649 (-6) | 4.988 (-5) |
| 19.000 | 5.257 (-1) | 4.199 (-3) | 7.418 (-3) | 5.280 (-2) | 1.358 (-1) | 2.720 (-1) | 5.078 (-4) | 1.122 (-5) | 3.117 (-6) | 5.364 (-4) | 8.639 (-6) | 1.250 (-5) | 6.356 (-5) |
| 20.000 | 4.903 (-1) | 3.166 (-3) | 7.215 (-3) | 4.697 (-2) | 1.802 (-1) | 2.706 (-1) | 7.004 (-4) | 2.353 (-5) | 3.985 (-6) | 7.052 (-4) | 2.150 (-5) | 2.377 (-5) | 7.769 (-5) |
| 21.000 | 4.524 (-1) | 2.477 (-3) | 7.011 (-3) | 4.198 (-2) | 2.266 (-1) | 2.675 (-1) | 9.247 (-4) | 4.313 (-5) | 4.861 (-6) | 8.797 (-4) | 4.872 (-5) | 4.057 (-5) | 9.226 (-5) |
| 22.000 | 4.136 (-1) | 1.991 (-3) | 6.806 (-3) | 3.760 (-2) | 2.739 (-1) | 2.635 (-1) | 1.185 (-3) | 7.144 (-5) | 5.725 (-6) | 1.054 (-3) | 9.775 (-5) | 6.401 (-5) | 1.076 (-4) |
| 23.000 | 3.767 (-1) | 1.631 (-3) | 6.604 (-3) | 3.370 (-2) | 3.214 (-1) | 2.588 (-1) | 1.439 (-3) | 1.094 (-4) | 6.564 (-6) | 1.222 (-3) | 1.789 (-4) | 9.523 (-5) | 1.289 (-4) |
| 24.000 | 3.362 (-1) | 1.355 (-3) | 6.405 (-3) | 3.015 (-2) | 3.682 (-1) | 2.537 (-1) | 1.645 (-3) | 1.575 (-4) | 7.372 (-6) | 1.380 (-3) | 3.053 (-4) | 1.356 (-4) | 1.445 (-4) |
| 25.000 | 2.984 (-1) | 1.137 (-3) | 6.210 (-3) | 2.690 (-2) | 4.141 (-1) | 2.484 (-1) | 2.267 (-3) | 2.156 (-4) | 8.146 (-6) | 1.524 (-3) | 4.933 (-4) | 1.867 (-4) | 1.606 (-4) |
| 26.000 | 2.616 (-1) | 9.615 (-4) | 6.022 (-3) | 2.388 (-2) | 4.585 (-1) | 2.431 (-1) | 2.773 (-3) | 2.831 (-4) | 8.891 (-6) | 1.648 (-3) | 7.641 (-4) | 2.508 (-4) | 1.817 (-4) |

Altitude: 10,000 feet

## TABLE III - GAS COMPOSITION BEHIND NORMAL-SHOCK WAVE

MOLE FRACTION CONCENTRATIONS

| $V_1$ | $N_2$ | $O_2$ | A | NO | N | O | e | $N_2^+$ | $O_2^+$ | $NO^+$ | $N^+$ | $O^+$ | $O^-$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2000 | 7.809 (-1) | 2.098 (-1) | 9.324 (-3) | | | 7.348 (-25) | | | | | | | |
| 3000 | 7.808 (-1) | 2.098 (-1) | 9.324 (-3) | | | 1.710 (-18) | | | | | | | |
| 4000 | 7.809 (-1) | 2.098 (-1) | 9.324 (-3) | 1.639 (-5) | 1.542 (-24) | 2.732 (-12) | | | | | | | |
| 5000 | 7.807 (-1) | 2.096 (-1) | 9.324 (-3) | 4.033 (-4) | 2.628 (-17) | 1.676 (-8) | | | | | | | |
| 6000 | 7.799 (-1) | 2.083 (-1) | 9.324 (-3) | 3.073 (-3) | 1.024 (-12) | 4.186 (-6) | | | | | | | |
| 7000 | 7.750 (-1) | 2.039 (-1) | 9.323 (-3) | 1.166 (-2) | 1.105 (-9) | 1.575 (-4) | | | | | | | |
| 8000 | 7.659 (-1) | 1.944 (-1) | 9.315 (-3) | 2.655 (-2) | 1.320 (-7) | 1.840 (-3) | | | | | | | |
| 9000 | 7.512 (-1) | 1.780 (-1) | 9.278 (-3) | 5.163 (-2) | 3.672 (-6) | 9.804 (-3) | | | | | | | |
| 10,000 | 7.319 (-1) | 1.544 (-1) | 9.184 (-3) | 7.458 (-2) | 3.724 (-5) | 2.992 (-2) | | | | | | | |
| 11,000 | 7.100 (-1) | 1.254 (-1) | 9.028 (-3) | 9.205 (-2) | 2.000 (-4) | 6.333 (-2) | | | | | | | |
| 12,000 | 6.877 (-1) | 9.432 (-2) | 8.823 (-3) | 1.017 (-1) | 7.466 (-4) | 1.067 (-1) | | | | | | | |
| 13,000 | 6.670 (-1) | 6.452 (-2) | 8.593 (-3) | 1.031 (-1) | 2.294 (-3) | 1.545 (-1) | | | | | | | |
| 14,000 | 6.487 (-1) | 3.964 (-2) | 8.362 (-3) | 9.686 (-2) | 6.257 (-3) | 2.001 (-1) | 2.133 (-5) | 4.250 (-9) | 1.488 (-7) | 2.685 (-5) | 3.049 (-10) | 1.406 (-8) | 5.[illegible] (-6) |
| 15,000 | 6.319 (-1) | 2.236 (-2) | 8.149 (-3) | 8.549 (-2) | 1.560 (-2) | 2.364 (-1) | 5.354 (-5) | 3.990 (-8) | 3.784 (-7) | 6.461 (-5) | 5.688 (-9) | 1.038 (-7) | 1.[illegible] (-5) |
| 16,000 | 6.127 (-1) | 1.258 (-2) | 7.955 (-3) | 7.316 (-2) | 3.387 (-2) | 2.595 (-1) | 1.161 (-4) | 2.740 (-7) | 7.809 (-7) | 1.343 (-4) | 6.974 (-8) | 5.539 (-7) | 1.[illegible] (-5) |
| 17,000 | 5.880 (-1) | 7.625 (-3) | 7.767 (-3) | 6.269 (-2) | 6.210 (-2) | 2.713 (-1) | 2.134 (-4) | 1.267 (-6) | 1.325 (-6) | 2.379 (-4) | 5.101 (-7) | 2.057 (-6) | 2.[illegible] (-5) |
| 18,000 | 5.578 (-1) | 5.055 (-3) | 7.575 (-3) | 5.443 (-2) | 9.843 (-2) | 2.759 (-1) | 3.429 (-4) | 4.131 (-6) | 2.003 (-6) | 3.686 (-4) | 2.882 (-6) | 5.644 (-6) | 8.[illegible] (-5) |
| 19,000 | 5.235 (-1) | 3.603 (-3) | 7.377 (-3) | 4.786 (-2) | 1.403 (-1) | 2.763 (-1) | 5.011 (-4) | 1.040 (-5) | 2.725 (-6) | 5.179 (-4) | 8.012 (-6) | 1.246 (-5) | 5.[illegible] (-6) |
| 20,000 | 4.864 (-1) | 2.707 (-3) | 7.174 (-3) | 4.245 (-2) | 1.856 (-1) | 2.742 (-1) | 6.870 (-4) | 2.176 (-5) | 3.474 (-6) | 6.780 (-4) | 2.138 (-5) | 2.364 (-5) | 6.[illegible] (-5) |
| 21,000 | 4.476 (-1) | 2.112 (-3) | 6.968 (-3) | 3.764 (-2) | 2.328 (-1) | 2.706 (-1) | 9.027 (-4) | 3.980 (-5) | 4.227 (-6) | 8.424 (-4) | 4.640 (-5) | 4.080 (-5) | 7.[illegible] (-5) |
| 22,000 | 4.085 (-1) | 1.692 (-3) | 6.763 (-3) | 3.382 (-2) | 2.808 (-1) | 2.660 (-1) | 1.153 (-3) | 6.584 (-5) | 4.968 (-6) | 1.005 (-3) | 8.706 (-5) | 6.358 (-5) | 8.[illegible] (-5) |
| 23,000 | 3.692 (-1) | 1.382 (-3) | 6.560 (-3) | 3.022 (-2) | 3.287 (-1) | 2.609 (-1) | 1.444 (-3) | 1.007 (-4) | 5.685 (-6) | 1.162 (-3) | 1.777 (-4) | 8.449 (-5) | 8.[illegible] (-5) |
| 24,000 | 3.302 (-1) | 1.145 (-3) | 6.361 (-3) | 2.697 (-2) | 3.761 (-1) | 2.554 (-1) | 1.787 (-3) | 1.448 (-4) | 6.370 (-6) | 1.308 (-3) | 3.034 (-4) | 1.345 (-4) | 1.[illegible] (-4) |
| 25,000 | 2.921 (-1) | 8.56[illegible] (-4) | 6.166 (-3) | 2.399 (-2) | 4.223 (-1) | 2.498 (-1) | 2.194 (-3) | 1.980 (-4) | 7.022 (-6) | 1.438 (-3) | 4.908 (-4) | 1.852 (-4) | 1.250 (-4) |
| 26,000 | 2.551 (-1) | 8.073 (-4) | 5.978 (-3) | 2.123 (-2) | 4.670 (-1) | 2.442 (-1) | 2.686 (-3) | 2.594 (-4) | 7.642 (-6) | 1.551 (-3) | 7.611 (-4) | 2.480 (-4) | 1.815 (-4) |

Altitude: 20,000 feet

## TABLE III - GAS COMPOSITION BEHIND NORMAL-SHOCK WAVE

MOLE FRACTION CONCENTRATIONS

| $V_1$ | $N_2$ | $O_2$ | $A$ | $NO$ | $N$ | $O$ | $e$ | $N_2^+$ | $O_2^+$ | $NO^+$ | $N^+$ | $O^+$ | $O^-$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2000 | 7.809 (-1) | 2.098 (-1) | 9.324 (-3) | | | 4.769 (-30) | | | | | | | |
| 3000 | 7.809 (-1) | 2.098 (-1) | 9.324 (-3) | | | 5.586 (-19) | | | | | | | |
| 4000 | 7.809 (-1) | 2.098 (-1) | 9.324 (-3) | 1.329 (-5) | 6.027 (-25) | 1.793 (-12) | | | | | | | |
| 5000 | 7.807 (-1) | 2.096 (-1) | 9.324 (-3) | 3.631 (-4) | 1.776 (-17) | 1.470 (-8) | | | | | | | |
| 6000 | 7.784 (-1) | 2.083 (-1) | 9.324 (-3) | 2.904 (-3) | 8.909 (-13) | 4.198 (-6) | | | | | | | |
| 7000 | 7.752 (-1) | 2.041 (-1) | 9.323 (-3) | 1.128 (-2) | 1.039 (-9) | 1.667 (-4) | | | | | | | |
| 8000 | 7.661 (-1) | 1.946 (-1) | 9.315 (-3) | 2.792 (-2) | 1.375 (-7) | 2.930 (-3) | | | | | | | |
| 9000 | 7.514 (-1) | 1.780 (-1) | 9.273 (-3) | 5.053 (-2) | 3.853 (-6) | 1.085 (-2) | | | | | | | |
| 10,000 | 7.318 (-1) | 1.537 (-1) | 9.171 (-3) | 7.260 (-2) | 3.838 (-5) | 3.273 (-2) | | | | | | | |
| 11,000 | 7.096 (-1) | 1.240 (-1) | 9.005 (-3) | 8.896 (-2) | 2.019 (-4) | 6.831 (-2) | | | | | | | |
| 12,000 | 6.870 (-1) | 9.217 (-2) | 8.791 (-3) | 9.757 (-2) | 7.442 (-4) | 1.137 (-1) | | | | | | | |
| 13,000 | 6.662 (-1) | 6.190 (-2) | 8.553 (-3) | 9.800 (-2) | 2.276 (-3) | 1.631 (-1) | | | | | | | |
| 14,000 | 6.480 (-1) | 3.693 (-2) | 8.318 (-3) | 9.093 (-2) | 6.301 (-3) | 2.095 (-1) | 2.113 (-5) | 3.539 (-9) | 1.300 (-7) | 2.559 (-5) | 2.660 (-10) | 1.311 (-8) | 9.609 (-6) |
| 15,000 | 6.312 (-1) | 2.008 (-2) | 8.105 (-3) | 7.907 (-2) | 1.601 (-2) | 2.459 (-1) | 5.349 (-5) | 3.501 (-8) | 3.313 (-7) | 6.235 (-5) | 5.310 (-9) | 1.004 (-7) | 9.382 (-6) |
| 16,000 | 6.117 (-1) | 1.096 (-2) | 7.913 (-3) | 6.680 (-2) | 3.518 (-2) | 2.672 (-1) | 1.163 (-4) | 2.498 (-7) | 6.835 (-7) | 1.306 (-4) | 6.840 (-8) | 5.502 (-7) | 1.685 (-5) |
| 17,000 | 5.862 (-1) | 6.532 (-3) | 7.726 (-3) | 5.677 (-2) | 6.467 (-2) | 2.776 (-1) | 2.128 (-4) | 1.171 (-6) | 1.167 (-6) | 2.313 (-4) | 5.091 (-7) | 2.058 (-6) | 2.338 (-5) |
| 18,000 | 5.551 (-1) | 4.294 (-3) | 7.534 (-3) | 4.905 (-2) | 1.022 (-1) | 2.810 (-1) | 3.394 (-4) | 3.820 (-6) | 1.737 (-6) | 3.569 (-4) | 2.380 (-6) | 5.638 (-6) | 3.144 (-5) |
| 19,000 | 5.199 (-1) | 3.047 (-3) | 7.335 (-3) | 4.298 (-2) | 1.452 (-1) | 2.804 (-1) | 4.923 (-4) | 9.587 (-6) | 2.354 (-6) | 4.990 (-4) | 7.982 (-6) | 1.241 (-5) | 3.938 (-5) |
| 20,000 | 4.821 (-1) | 2.282 (-3) | 7.181 (-3) | 3.802 (-2) | 1.914 (-1) | 2.776 (-1) | 6.708 (-4) | 2.080 (-5) | 2.992 (-6) | 6.503 (-4) | 2.121 (-5) | 2.848 (-5) | 4.718 (-5) |
| 21,000 | 4.429 (-1) | 1.775 (-3) | 6.925 (-3) | 3.380 (-2) | 2.394 (-1) | 2.734 (-1) | 8.770 (-4) | 3.649 (-5) | 3.632 (-6) | 8.045 (-4) | 4.788 (-5) | 3.994 (-5) | 5.555 (-5) |
| 22,000 | 4.031 (-1) | 1.418 (-3) | 6.719 (-3) | 3.013 (-2) | 2.880 (-1) | 2.683 (-1) | 1.116 (-3) | 6.025 (-5) | 4.260 (-6) | 9.563 (-4) | 9.614 (-5) | 6.291 (-5) | 6.424 (-5) |
| 23,000 | 3.632 (-1) | 1.155 (-3) | 6.515 (-3) | 2.686 (-2) | 3.365 (-1) | 2.628 (-1) | 1.394 (-3) | 9.205 (-5) | 4.864 (-6) | 1.101 (-3) | 1.760 (-4) | 9.354 (-5) | 7.372 (-5) |
| 24,000 | 3.239 (-1) | 9.541 (-4) | 6.316 (-3) | 2.390 (-2) | 3.843 (-1) | 2.569 (-1) | 1.722 (-3) | 1.322 (-4) | 5.439 (-6) | 1.234 (-3) | 3.008 (-4) | 1.332 (-4) | 8.391 (-5) |
| 25,000 | 2.855 (-1) | 7.958 (-4) | 6.121 (-3) | 2.119 (-2) | 4.310 (-1) | 2.510 (-1) | 2.114 (-3) | 1.804 (-4) | 5.981 (-6) | 1.352 (-3) | 4.871 (-4) | 1.835 (-4) | 8.546 (-5) |
| 26,000 | 2.482 (-1) | 6.681 (-4) | 5.933 (-3) | 1.868 (-2) | 4.760 (-1) | 2.451 (-1) | 2.591 (-3) | 2.360 (-4) | 6.491 (-6) | 1.453 (-3) | 7.565 (-4) | 2.467 (-4) | 1.077 (-4) |

Altitude: 30,000 feet

TABLE III - GAS COMPOSITION BEHIND NORMAL-SHOCK WAVE

MOLE FRACTION CONCENTRATIONS

| $V_1$ | $N_2$ | $O_2$ | $A$ | $NO$ | $N$ | $O$ | $e$ | $N_2^+$ | $O_2^+$ | $NO^+$ | $N^+$ | $O^+$ | $O^-$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2000 | 7.809 (-1) | 2.098 (-1) | 9.324 (-3) | | | 2.406 (-31) | | | | | | | |
| 3000 | 7.809 (-1) | 2.098 (-1) | 9.324 (-3) | | | 1.782 (-19) | | | | | | | |
| 4000 | 7.809 (-1) | 2.098 (-1) | 9.324 (-3) | 1.070 (-5) | 2.292 (-25) | 1.167 (-12) | | | | | | | |
| 5000 | 7.807 (-1) | 2.096 (-1) | 9.324 (-3) | 3.260 (-4) | 1.200 (-17) | 1.297 (-8) | | | | | | | |
| 6000 | 7.795 (-1) | 2.084 (-1) | 9.324 (-3) | 2.740 (-3) | 7.814 (-13) | 4.254 (-6) | | | | | | | |
| 7000 | 7.754 (-1) | 2.042 (-1) | 9.323 (-3) | 1.091 (-2) | 1.084 (-9) | 1.829 (-4) | | | | | | | |
| 8000 | 7.664 (-1) | 1.948 (-1) | 9.313 (-3) | 2.729 (-2) | 1.847 (-7) | 2.266 (-3) | | | | | | | |
| 9000 | 7.514 (-1) | 1.778 (-1) | 9.267 (-3) | 4.837 (-2) | 4.079 (-6) | 1.215 (-2) | | | | | | | |
| 10.000 | 7.315 (-1) | 1.527 (-1) | 9.156 (-3) | 7.043 (-2) | 3.961 (-5) | 3.608 (-2) | | | | | | | |
| 11.000 | 7.090 (-1) | 1.222 (-1) | 8.978 (-3) | 8.557 (-2) | 2.033 (-4) | 7.402 (-2) | | | | | | | |
| 12.000 | 6.863 (-1) | 8.970 (-2) | 8.754 (-3) | 9.304 (-2) | 7.388 (-4) | 1.215 (-1) | | | | | | | |
| 13.000 | 6.653 (-1) | 5.897 (-2) | 8.509 (-3) | 9.247 (-2) | 2.257 (-3) | 1.725 (-1) | | | | | | | |
| 14.000 | 6.472 (-1) | 3.405 (-2) | 8.271 (-3) | 8.468 (-2) | 6.341 (-3) | 2.194 (-1) | 2.031 (-5) | 2.909 (-9) | 1.121 (-7) | 2.432 (-5) | 2.297 (-10) | 1.216 (-8) | 3.040 (-6) |
| 15.000 | 6.305 (-1) | 1.774 (-2) | 8.059 (-3) | 7.240 (-2) | 1.589 (-2) | 2.547 (-1) | 6.325 (-5) | 3.062 (-8) | 2.867 (-7) | 6.015 (-5) | 4.970 (-9) | 9.732 (-8) | 7.821 (-6) |
| 16.000 | 6.105 (-1) | 9.372 (-3) | 7.870 (-3) | 6.032 (-2) | 3.670 (-2) | 2.749 (-1) | 1.161 (-4) | 2.277 (-7) | 5.910 (-7) | 1.270 (-4) | 6.752 (-8) | 5.481 (-7) | 1.221 (-5) |
| 17.000 | 5.842 (-1) | 5.493 (-3) | 7.684 (-3) | 5.084 (-2) | 6.755 (-2) | 2.837 (-1) | 2.114 (-4) | 1.079 (-6) | 1.004 (-6) | 2.247 (-4) | 5.101 (-7) | 2.061 (-6) | 1.791 (-5) |
| 18.000 | 5.522 (-1) | 3.584 (-3) | 7.492 (-3) | 4.372 (-2) | 1.064 (-1) | 2.859 (-1) | 3.344 (-4) | 3.515 (-6) | 1.486 (-6) | 3.451 (-4) | 2.381 (-6) | 5.629 (-6) | 2.368 (-5) |
| 19.000 | 5.161 (-1) | 2.533 (-3) | 7.292 (-3) | 3.818 (-2) | 1.505 (-1) | 2.844 (-1) | 4.813 (-4) | 8.782 (-6) | 2.005 (-6) | 4.797 (-4) | 7.945 (-6) | 1.233 (-5) | 2.950 (-5) |
| 20.000 | 4.775 (-1) | 1.892 (-3) | 7.087 (-3) | 3.368 (-2) | 1.977 (-1) | 2.808 (-1) | 6.516 (-4) | 1.624 (-5) | 2.541 (-5) | 6.219 (-4) | 2.106 (-5) | 2.325 (-5) | 3.541 (-5) |
| 21.000 | 4.376 (-1) | 1.468 (-3) | 6.880 (-3) | 2.988 (-2) | 2.464 (-1) | 2.759 (-1) | 8.475 (-4) | 3.318 (-5) | 3.076 (-5) | 7.658 (-4) | 4.744 (-5) | 3.948 (-5) | 4.150 (-5) |
| 22.000 | 3.972 (-1) | 1.170 (-3) | 6.674 (-3) | 2.656 (-2) | 2.957 (-1) | 2.704 (-1) | 1.074 (-3) | 5.466 (-5) | 3.600 (-4) | 9.064 (-4) | 9.484 (-5) | 6.211 (-5) | 4.790 (-5) |
| 23.000 | 3.569 (-1) | 9.501 (-4) | 6.470 (-3) | 2.361 (-2) | 3.448 (-1) | 2.644 (-1) | 1.338 (-3) | 8.337 (-5) | 4.103 (-4) | 1.039 (-3) | 1.738 (-4) | 9.232 (-5) | 5.476 (-5) |
| 24.000 | 3.172 (-1) | 7.823 (-4) | 6.270 (-3) | 2.095 (-2) | 3.931 (-1) | 2.582 (-1) | 1.651 (-3) | 1.196 (-4) | 4.578 (-4) | 1.160 (-3) | 2.972 (-4) | 1.315 (-4) | 6.224 (-5) |
| 25.000 | 2.785 (-1) | 6.503 (-4) | 6.075 (-3) | 1.851 (-2) | 4.401 (-1) | 2.520 (-1) | 2.025 (-3) | 1.629 (-4) | 5.022 (-4) | 1.266 (-3) | 4.819 (-4) | 1.812 (-4) | 7.965 (-5) |
| 26.000 | 2.409 (-1) | 5.439 (-4) | 5.887 (-3) | 1.626 (-2) | 4.854 (-1) | 2.459 (-1) | 2.486 (-3) | 2.128 (-4) | 5.436 (-4) | 1.353 (-3) | 7.499 (-4) | 2.430 (-4) | 7.994 (-5) |

Altitude: 40,000 feet

TABLE III - GAS COMPOSITION BEHIND NORMAL-SHOCK WAVE

MOLE FRACTION CONCENTRATIONS

| $V_1$ | $N_2$ | $O_2$ | $A$ | $NO$ | $N$ | $O$ | $e$ | $N_2^+$ | $O_2^+$ | $NO^+$ | $N^+$ | $O^+$ | $O^-$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2000 | 7.809 (-1) | 2.096 (-1) | 9.324 (-3) | | | 3.643 (-32) | | | | | | | |
| 3000 | 7.809 (-1) | 2.096 (-1) | 9.324 (-3) | | | 9.272 (-20) | | | | | | | |
| 4000 | 7.809 (-1) | 2.096 (-1) | 9.324 (-3) | 9.318 (-6) | 1.367 (-25) | 9.791 (-13) | | | | | | | |
| 5000 | 7.807 (-1) | 2.096 (-1) | 9.324 (-3) | 3.046 (-4) | 1.034 (-17) | 1.321 (-8) | | | | | | | |
| 6000 | 7.796 (-1) | 2.085 (-1) | 9.324 (-3) | 2.643 (-3) | 7.941 (-13) | 4.731 (-6) | | | | | | | |
| 7000 | 7.755 (-1) | 2.043 (-1) | 9.323 (-3) | 1.068 (-2) | 1.192 (-9) | 2.121 (-4) | | | | | | | |
| 8000 | 7.664 (-1) | 1.948 (-1) | 9.312 (-3) | 2.683 (-2) | 1.627 (-7) | 2.659 (-3) | | | | | | | |
| 9000 | 7.513 (-1) | 1.772 (-1) | 9.259 (-3) | 4.821 (-2) | 4.447 (-6) | 1.389 (-2) | | | | | | | |
| 10,000 | 7.310 (-1) | 1.512 (-1) | 8.135 (-3) | 6.801 (-2) | 4.138 (-5) | 4.048 (-2) | | | | | | | |
| 11,000 | 7.082 (-1) | 1.198 (-1) | 8.945 (-3) | 8.171 (-2) | 2.053 (-4) | 6.116 (-2) | | | | | | | |
| 12,000 | 6.852 (-1) | 8.655 (-2) | 8.710 (-3) | 8.786 (-2) | 7.331 (-4) | 1.310 (-1) | | | | | | | |
| 13,000 | 6.641 (-1) | 5.540 (-2) | 8.454 (-3) | 8.620 (-2) | 2.241 (-3) | 1.836 (-1) | | | | | | | |
| 14,000 | 6.461 (-1) | 3.056 (-2) | 8.215 (-3) | 7.746 (-2) | 6.431 (-3) | 2.311 (-1) | 2.045 (-5) | 2.357 (-9) | 9.445 (-8) | 2.308 (-5) | 1.982 (-10) | 1.129 (-8) | 2.740 (-6) |
| 15,000 | 6.295 (-1) | 1.509 (-2) | 8.007 (-3) | 6.483 (-2) | 1.719 (-2) | 2.652 (-1) | 5.310 (-5) | 2.683 (-8) | 2.425 (-7) | 5.820 (-5) | 4.746 (-9) | 9.552 (-8) | 5.464 (-6) |
| 16,000 | 6.090 (-1) | 7.681 (-3) | 7.821 (-3) | 5.315 (-2) | 3.883 (-2) | 2.833 (-1) | 1.161 (-4) | 2.083 (-7) | 4.986 (-7) | 1.238 (-4) | 6.817 (-8) | 5.534 (-7) | 9.073 (-6) |
| 17,000 | 5.816 (-1) | 4.421 (-3) | 7.037 (-3) | 4.442 (-2) | 7.137 (-2) | 2.901 (-1) | 2.095 (-4) | 9.924 (-7) | 8.408 (-7) | 2.181 (-4) | 5.188 (-7) | 2.082 (-6) | 1.302 (-5) |
| 18,000 | 5.483 (-1) | 2.874 (-3) | 7.444 (-3) | 3.802 (-2) | 1.118 (-1) | 2.909 (-1) | 3.279 (-4) | 3.208 (-6) | 1.235 (-5) | 3.325 (-4) | 2.402 (-6) | 5.639 (-6) | 1.703 (-5) |
| 19,000 | 5.112 (-1) | 2.025 (-3) | 7.243 (-3) | 3.310 (-2) | 1.571 (-1) | 2.883 (-1) | 4.676 (-4) | 7.947 (-6) | 1.657 (-5) | 4.588 (-4) | 7.935 (-6) | 1.226 (-5) | 2.104 (-5) |
| 20,000 | 4.718 (-1) | 1.509 (-3) | 7.137 (-3) | 2.912 (-2) | 2.053 (-1) | 2.839 (-1) | 6.281 (-4) | 1.639 (-5) | 2.090 (-5) | 5.909 (-4) | 2.087 (-5) | 2.200 (-5) | 2.509 (-5) |
| 21,000 | 4.312 (-1) | 1.168 (-3) | 6.829 (-3) | 2.576 (-2) | 2.549 (-1) | 2.784 (-1) | 8.121 (-4) | 2.968 (-5) | 2.523 (-5) | 7.234 (-4) | 4.681 (-5) | 3.891 (-5) | 2.887 (-5) |
| 22,000 | 3.902 (-1) | 9.286 (-4) | 6.522 (-3) | 2.284 (-2) | 3.049 (-1) | 2.724 (-1) | 1.024 (-3) | 3.365 (-5) | 2.946 (-5) | 8.517 (-4) | 9.346 (-5) | 6.111 (-5) | 3.365 (-5) |
| 23,000 | 3.494 (-1) | 7.522 (-4) | 6.418 (-3) | 2.024 (-2) | 3.546 (-1) | 2.660 (-1) | 1.272 (-3) | 3.837 (-5) | 3.350 (-5) | 9.715 (-4) | 1.710 (-4) | 9.076 (-5) | 3.837 (-5) |
| 24,000 | 3.093 (-1) | 6.174 (-4) | 6.218 (-3) | 1.790 (-2) | 4.033 (-1) | 2.594 (-1) | 1.567 (-3) | 4.355 (-5) | 3.729 (-5) | 1.079 (-3) | 2.825 (-4) | 1.293 (-4) | 4.355 (-5) |
| 25,000 | 2.702 (-1) | 5.113 (-4) | 6.023 (-3) | 1.576 (-2) | 4.507 (-1) | 2.528 (-1) | 1.923 (-3) | 4.935 (-5) | 4.081 (-5) | 1.171 (-3) | 4.750 (-4) | 1.783 (-4) | 4.936 (-5) |
| 26,000 | 2.324 (-1) | 4.259 (-4) | 5.835 (-3) | 1.378 (-2) | 4.963 (-1) | 2.464 (-1) | 2.363 (-3) | 5.598 (-5) | 4.404 (-5) | 1.246 (-3) | 7.409 (-4) | 2.404 (-4) | 5.598 (-5) |

Altitude: 50,000 feet

TABLE III - GAS COMPOSITION BEHIND NORMAL-SHOCK WAVE

MOLE FRACTION CONCENTRATIONS

| $V_1$ | $N_2$ | $O_2$ | $A$ | $NO$ | $N$ | $O$ | $e$ | $N_2^+$ | $O_2^+$ | $NO^+$ | $N^+$ | $O^+$ | $O^-$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2000 | 7.809 (-1) | 2.098 (-1) | 9.324 (-3) | | | 4.628 (-32) | | | | | | | |
| 3000 | 7.809 (-1) | 2.098 (-1) | 9.324 (-3) | | | 1.178 (-19) | | | | | | | |
| 4000 | 7.808 (-1) | 2.096 (-1) | 9.324 (-3) | 8.319 (-6) | 1.737 (-25) | 1.244 (-12) | | | | | | | |
| 5000 | 7.807 (-1) | 2.096 (-1) | 9.324 (-3) | 3.046 (-4) | 1.313 (-17) | 1.678 (-6) | | | | | | | |
| 6000 | 7.798 (-1) | 2.085 (-1) | 9.324 (-3) | 2.643 (-3) | 1.009 (-12) | 6.010 (-6) | | | | | | | |
| 7000 | 7.754 (-1) | 2.043 (-1) | 9.323 (-3) | 1.067 (-2) | 1.507 (-9) | 2.688 (-4) | | | | | | | |
| 8000 | 7.663 (-1) | 1.945 (-1) | 9.309 (-3) | 2.684 (-2) | 1.998 (-7) | 3.315 (-3) | | | | | | | |
| 9000 | 7.508 (-1) | 1.761 (-1) | 9.244 (-3) | 4.714 (-2) | 5.100 (-6) | 1.678 (-2) | | | | | | | |
| 10.000 | 7.300 (-1) | 1.490 (-1) | 9.107 (-3) | 6.533 (-2) | 4.421 (-5) | 4.655 (-2) | | | | | | | |
| 11.000 | 7.067 (-1) | 1.164 (-1) | 8.901 (-3) | 7.730 (-2) | 2.091 (-4) | 9.042 (-2) | | | | | | | |
| 12.000 | 6.835 (-1) | 8.239 (-2) | 8.655 (-3) | 8.195 (-2) | 7.302 (-4) | 1.428 (-1) | | | | | | | |
| 13.000 | 6.625 (-1) | 5.091 (-2) | 8.396 (-3) | 7.906 (-2) | 2.237 (-3) | 1.959 (-1) | | | | | | | |
| 14.000 | 6.448 (-1) | 2.650 (-2) | 8.153 (-3) | 6.941 (-2) | 6.602 (-3) | 2.445 (-1) | 2.011 (-5) | 1.909 (-9) | 7.799 (-8) | 2.199 (-5) | 1.740 (-10) | 1.061 (-8) | 1.964 (-6) |
| 15.000 | 6.283 (-1) | 1.225 (-2) | 7.949 (-3) | 5.657 (-2) | 1.828 (-2) | 2.765 (-1) | 5.318 (-5) | 2.391 (-8) | 2.012 (-7) | 5.673 (-5) | 4.712 (-9) | 9.604 (-8) | 3.897 (-6) |
| 16.000 | 6.068 (-1) | 6.002 (-3) | 7.768 (-3) | 4.559 (-2) | 4.175 (-2) | 2.918 (-1) | 1.162 (-4) | 1.929 (-7) | 4.109 (-7) | 1.213 (-4) | 7.114 (-8) | 5.694 (-7) | 6.396 (-6) |
| 17.000 | 5.780 (-1) | 3.420 (-3) | 7.584 (-3) | 3.780 (-2) | 7.630 (-2) | 2.964 (-1) | 2.071 (-4) | 9.140 (-7) | 6.849 (-7) | 2.118 (-4) | 5.381 (-7) | 2.123 (-6) | 8.956 (-6) |
| 18.000 | 5.435 (-1) | 2.211 (-3) | 7.391 (-3) | 3.223 (-2) | 1.184 (-1) | 2.956 (-1) | 3.199 (-4) | 2.910 (-6) | 9.961 (-7) | 3.194 (-4) | 2.446 (-6) | 5.672 (-6) | 1.157 (-5) |
| 19.000 | 5.053 (-1) | 1.556 (-3) | 7.189 (-3) | 2.798 (-2) | 1.651 (-1) | 2.919 (-1) | 4.510 (-4) | 7.110 (-6) | 1.327 (-6) | 4.366 (-4) | 7.954 (-6) | 1.219 (-5) | 1.417 (-5) |
| 20.000 | 4.650 (-1) | 1.158 (-3) | 6.982 (-3) | 2.456 (-2) | 2.144 (-1) | 2.867 (-1) | 6.006 (-4) | 1.452 (-5) | 1.666 (-6) | 5.579 (-4) | 2.069 (-5) | 2.269 (-5) | 1.679 (-5) |
| 21.000 | 4.236 (-1) | 8.950 (-4) | 6.773 (-3) | 2.167 (-2) | 2.649 (-1) | 2.806 (-1) | 7.713 (-4) | 2.610 (-5) | 2.004 (-6) | 6.783 (-4) | 4.608 (-5) | 3.821 (-5) | 1.945 (-5) |
| 22.000 | 3.820 (-1) | 7.100 (-4) | 6.566 (-3) | 1.916 (-2) | 3.155 (-1) | 2.740 (-1) | 9.679 (-4) | 4.263 (-5) | 2.334 (-6) | 7.938 (-4) | 9.165 (-5) | 5.985 (-5) | 2.231 (-5) |
| 23.000 | 3.408 (-1) | 5.736 (-4) | 6.361 (-3) | 1.693 (-2) | 3.658 (-1) | 2.671 (-1) | 1.198 (-3) | 6.463 (-5) | 2.647 (-6) | 9.001 (-4) | 1.674 (-4) | 8.880 (-5) | 2.587 (-5) |
| 24.000 | 3.003 (-1) | 4.682 (-4) | 6.160 (-3) | 1.491 (-2) | 4.150 (-1) | 2.602 (-1) | 1.473 (-3) | 9.223 (-5) | 2.940 (-6) | 9.940 (-4) | 2.864 (-4) | 1.265 (-4) | 2.876 (-5) |
| 25.000 | 2.608 (-1) | 3.871 (-4) | 5.966 (-3) | 1.307 (-2) | 4.627 (-1) | 2.533 (-1) | 1.809 (-3) | 1.251 (-4) | 3.209 (-6) | 1.072 (-3) | 4.658 (-4) | 1.747 (-4) | 3.250 (-5) |
| 26.000 | 2.228 (-1) | 3.209 (-4) | 5.777 (-3) | 1.136 (-2) | 5.085 (-1) | 2.465 (-1) | 2.226 (-3) | 1.625 (-4) | 3.453 (-6) | 1.133 (-3) | 7.285 (-4) | 2.358 (-4) | 3.702 (-5) |

Altitude: 60,000 feet

TABLE III - GAS COMPOSITION BEHIND NORMAL-SHOCK WAVE

MOLE FRACTION CONCENTRATIONS

| $V_1$ | $N_2$ | $O_2$ | $A$ | $NO$ | $N$ | $O$ | $e$ | $N_2^+$ | $O_2^+$ | $NO^+$ | $N^+$ | $O^+$ | $O^-$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2000 | 7.809 (-1) | 2.098 (-1) | 9.324 (-3) | | | 5.878 (-32) | | | | | | | |
| 3000 | 7.809 (-1) | 2.098 (-1) | 9.324 (-3) | | | 1.496 (-19) | | | | | | | |
| 4000 | 7.809 (-1) | 2.098 (-1) | 9.324 (-3) | 9.318 (-6) | 2.206 (-25) | 1.580 (-12) | | | | | | | |
| 5000 | 7.807 (-1) | 2.096 (-1) | 9.324 (-3) | 3.046 (-4) | 1.668 (-17) | 2.131 (-8) | | | | | | | |
| 6000 | 7.796 (-1) | 2.085 (-1) | 9.324 (-3) | 2.643 (-3) | 1.281 (-12) | 7.632 (-6) | | | | | | | |
| 7000 | 7.754 (-1) | 2.043 (-1) | 9.322 (-3) | 1.066 (-2) | 1.903 (-9) | 3.402 (-4) | | | | | | | |
| 8000 | 7.661 (-1) | 1.941 (-1) | 9.305 (-3) | 2.640 (-2) | 2.434 (-7) | 4.115 (-3) | | | | | | | |
| 9000 | 7.501 (-1) | 1.748 (-1) | 9.231 (-3) | 4.593 (-2) | 5.756 (-6) | 1.994 (-2) | | | | | | | |
| 10,000 | 7.289 (-1) | 1.465 (-1) | 9.077 (-3) | 6.252 (-2) | 4.645 (-5) | 5.301 (-2) | | | | | | | |
| 11,000 | 7.053 (-1) | 1.129 (-1) | 8.857 (-3) | 7.286 (-2) | 2.100 (-4) | 9.986 (-2) | | | | | | | |
| 12,000 | 6.819 (-1) | 7.821 (-2) | 8.601 (-3) | 7.617 (-2) | 7.193 (-4) | 1.544 (-1) | | | | | | | |
| 13,000 | 6.609 (-1) | 4.652 (-2) | 8.335 (-3) | 7.222 (-2) | 2.220 (-3) | 2.098 (-1) | | | | | | | |
| 14,000 | 6.426 (-1) | 2.269 (-2) | 8.094 (-3) | 6.180 (-2) | 6.786 (-3) | 2.570 (-1) | 1.967 (-5) | 1.562 (-9) | 6.413 (-8) | 2.099 (-5) | 1.543 (-10) | 1.000 (-8) | 1.391 (-6) |
| 15,000 | 6.270 (-1) | 9.783 (-3) | 7.896 (-3) | 4.901 (-2) | 1.951 (-2) | 2.867 (-1) | 5.313 (-5) | 2.169 (-8) | 1.665 (-7) | 5.556 (-5) | 4.775 (-9) | 9.746 (-8) | 2.722 (-6) |
| 16,000 | 6.045 (-1) | 4.639 (-3) | 7.719 (-3) | 3.890 (-2) | 4.493 (-2) | 2.991 (-1) | 1.158 (-4) | 1.802 (-7) | 3.374 (-7) | 1.190 (-4) | 7.490 (-8) | 5.875 (-7) | 4.380 (-6) |
| 17,000 | 5.743 (-1) | 2.622 (-3) | 7.536 (-3) | 3.205 (-2) | 8.145 (-2) | 3.016 (-1) | 2.037 (-4) | 8.424 (-7) | 5.554 (-7) | 2.057 (-4) | 5.579 (-7) | 2.161 (-6) | 6.103 (-6) |
| 18,000 | 5.385 (-1) | 1.694 (-3) | 7.342 (-3) | 2.725 (-2) | 1.252 (-1) | 2.994 (-1) | 3.104 (-4) | 2.633 (-6) | 7.999 (-7) | 3.066 (-4) | 2.480 (-6) | 5.678 (-6) | 7.802 (-6) |
| 19,000 | 4.883 (-1) | 1.192 (-3) | 7.138 (-3) | 2.361 (-2) | 1.731 (-1) | 2.948 (-1) | 4.331 (-4) | 6.339 (-6) | 1.059 (-6) | 4.152 (-4) | 7.927 (-6) | 1.206 (-5) | 9.480 (-6) |
| 20,000 | 4.582 (-1) | 8.870 (-4) | 6.931 (-3) | 2.068 (-2) | 2.233 (-1) | 2.889 (-1) | 5.720 (-4) | 1.281 (-5) | 1.323 (-5) | 5.264 (-4) | 2.039 (-5) | 2.227 (-5) | 1.116 (-5) |
| 21,000 | 4.161 (-1) | 6.849 (-4) | 6.721 (-3) | 1.821 (-2) | 2.745 (-1) | 2.822 (-1) | 7.299 (-4) | 2.286 (-5) | 1.587 (-5) | 6.359 (-4) | 4.507 (-5) | 3.733 (-5) | 1.289 (-5) |
| 22,000 | 3.741 (-1) | 5.424 (-4) | 6.513 (-3) | 1.606 (-2) | 3.258 (-1) | 2.751 (-1) | 9.117 (-4) | 3.715 (-5) | 1.843 (-5) | 7.398 (-4) | 8.928 (-5) | 5.882 (-5) | 1.472 (-5) |
| 23,000 | 3.324 (-1) | 4.372 (-4) | 6.308 (-3) | 1.414 (-2) | 3.766 (-1) | 2.679 (-1) | 1.125 (-3) | 5.612 (-5) | 2.087 (-6) | 8.344 (-4) | 1.628 (-4) | 8.646 (-5) | 1.670 (-5) |
| 24,000 | 2.915 (-1) | 3.566 (-4) | 6.107 (-3) | 1.242 (-2) | 4.262 (-1) | 2.606 (-1) | 1.381 (-3) | 7.967 (-5) | 2.313 (-6) | 9.162 (-4) | 2.787 (-4) | 1.232 (-4) | 1.899 (-5) |
| 25,000 | 2.518 (-1) | 2.931 (-4) | 5.913 (-3) | 1.083 (-2) | 4.742 (-1) | 2.535 (-1) | 1.696 (-3) | 1.081 (-4) | 2.519 (-6) | 9.826 (-4) | 4.540 (-4) | 1.703 (-4) | 2.144 (-5) |
| 26,000 | 2.136 (-1) | 2.418 (-4) | 5.725 (-3) | 9.375 (-3) | 5.203 (-1) | 2.465 (-1) | 2.093 (-3) | 1.402 (-4) | 2.704 (-6) | 1.031 (-3) | 7.124 (-4) | 2.306 (-4) | 2.438 (-5) |

Altitude: 70,000 feet

TABLE III - GAS COMPOSITION BEHIND NORMAL-SHOCK WAVE

MOLE FRACTION CONCENTRATIONS

| $V_1$ | $N_2$ | $O_2$ | $A$ | $NO$ | $N$ | $O$ | $e$ | $N_2^+$ | $O_2^+$ | $NO^+$ | $N^+$ | $O^+$ | $O^-$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2000 | 7.809 (-1) | 2.098 (-1) | 9.324 (-3) | | | 7.463 (-32) | | | | | | | |
| 3000 | 7.809 (-1) | 2.098 (-1) | 9.324 (-3) | | | 1.899 (-19) | | | | | | | |
| 4000 | 7.809 (-1) | 2.098 (-1) | 9.324 (-3) | | | 2.008 (-12) | | | | | | | |
| 5000 | 7.809 (-1) | 2.098 (-1) | 9.324 (-3) | | | 2.748 (-8) | | | | | | | |
| 6000 | 7.796 (-1) | 2.085 (-1) | 9.324 (-3) | | | 9.689 (-6) | | | | | | | |
| 7000 | 7.754 (-1) | 2.042 (-1) | 9.322 (-3) | | | 4.303 (-4) | | | | | | | |
| 8000 | 7.658 (-1) | 1.937 (-1) | 9.300 (-3) | | | 5.081 (-3) | | | | | | | |
| 9000 | 7.494 (-1) | 1.733 (-1) | 9.215 (-3) | 4.459 (-2) | 6.391 (-6) | 2.348 (-2) | | | | | | | |
| 10,000 | 7.277 (-1) | 1.438 (-1) | 9.045 (-3) | 5.960 (-2) | 4.800 (-5) | 5.979 (-2) | | | | | | | |
| 11,000 | 7.037 (-1) | 1.094 (-1) | 8.813 (-3) | 6.846 (-2) | 2.081 (-4) | 1.094 (-1) | | | | | | | |
| 12,000 | 6.802 (-1) | 7.404 (-2) | 8.547 (-3) | 7.057 (-2) | 7.017 (-4) | 1.660 (-1) | | | | | | | |
| 13,000 | 6.593 (-1) | 4.223 (-2) | 8.277 (-3) | 6.570 (-2) | 2.193 (-3) | 2.223 (-1) | | | | | | | |
| 14,000 | 6.424 (-1) | 1.915 (-2) | 8.038 (-3) | 5.468 (-2) | 6.997 (-3) | 2.657 (-1) | 1.919 (-5) | 1.297 (-9) | 5.257 (-8) | 2.010 (-5) | 1.390 (-10) | 9.495 (-9) | 9.745 (-7) |
| 15,000 | 6.257 (-1) | 7.693 (-3) | 7.848 (-3) | 4.216 (-2) | 2.094 (-2) | 2.956 (-1) | 5.304 (-5) | 2.003 (-8) | 1.375 (-7) | 5.467 (-5) | 4.942 (-9) | 9.993 (-8) | 1.893 (-6) |
| 16,000 | 6.020 (-1) | 3.553 (-3) | 7.675 (-3) | 3.303 (-2) | 4.838 (-2) | 3.051 (-1) | 1.150 (-4) | 1.692 (-7) | 2.759 (-7) | 1.169 (-4) | 7.933 (-8) | 6.068 (-7) | 3.002 (-6) |
| 17,000 | 5.704 (-1) | 2.001 (-3) | 7.492 (-3) | 2.710 (-2) | 8.678 (-2) | 3.058 (-1) | 1.994 (-4) | 7.757 (-7) | 4.484 (-7) | 1.995 (-4) | 5.769 (-7) | 2.190 (-6) | 9.128 (-6) |
| 18,000 | 5.334 (-1) | 1.294 (-3) | 7.296 (-3) | 2.299 (-2) | 1.319 (-1) | 3.024 (-1) | 3.000 (-4) | 2.374 (-6) | 6.397 (-7) | 2.940 (-4) | 2.501 (-6) | 5.656 (-6) | 5.227 (-6) |
| 19,000 | 4.933 (-1) | 9.119 (-4) | 7.092 (-3) | 1.989 (-2) | 1.810 (-1) | 2.970 (-1) | 4.143 (-4) | 5.628 (-6) | 6.412 (-7) | 3.944 (-4) | 7.851 (-6) | 1.187 (-5) | 6.387 (-6) |
| 20,000 | 4.514 (-1) | 6.787 (-4) | 6.883 (-3) | 1.739 (-2) | 2.321 (-1) | 2.905 (-1) | 5.430 (-4) | 1.125 (-5) | 1.047 (-6) | 4.964 (-4) | 1.995 (-5) | 2.174 (-5) | 7.389 (-6) |
| 21,000 | 4.089 (-1) | 5.238 (-4) | 6.673 (-3) | 1.529 (-2) | 2.840 (-1) | 2.833 (-1) | 6.687 (-4) | 1.993 (-5) | 1.252 (-6) | 5.960 (-4) | 4.378 (-5) | 3.627 (-5) | 8.501 (-6) |
| 22,000 | 3.663 (-1) | 4.143 (-4) | 6.464 (-3) | 1.345 (-2) | 3.358 (-1) | 2.758 (-1) | 8.565 (-4) | 3.223 (-5) | 1.451 (-6) | 6.896 (-4) | 8.639 (-5) | 5.653 (-5) | 9.676 (-6) |
| 23,000 | 3.242 (-1) | 3.332 (-4) | 6.258 (-3) | 1.181 (-2) | 3.869 (-1) | 2.683 (-1) | 1.054 (-3) | 4.852 (-5) | 1.644 (-6) | 7.737 (-4) | 1.573 (-4) | 8.376 (-5) | 1.096 (-5) |
| 24,000 | 2.831 (-1) | 2.711 (-4) | 6.058 (-3) | 1.034 (-2) | 4.369 (-1) | 2.607 (-1) | 1.292 (-3) | 6.887 (-5) | 1.816 (-6) | 8.451 (-4) | 2.694 (-4) | 1.194 (-4) | 1.280 (-5) |
| 25,000 | 2.432 (-1) | 2.220 (-4) | 5.863 (-3) | 8.981 (-3) | 4.852 (-1) | 2.533 (-1) | 1.587 (-3) | 8.303 (-5) | 1.974 (-6) | 9.012 (-4) | 4.399 (-4) | 1.654 (-4) | 1.406 (-5) |
| 26,000 | 2.048 (-1) | 1.823 (-4) | 5.676 (-3) | 7.730 (-3) | 5.316 (-1) | 2.461 (-1) | 1.968 (-3) | 1.204 (-4) | 2.115 (-6) | 9.399 (-4) | 6.927 (-4) | 2.246 (-4) | 1.602 (-5) |

Altitude:80,000 feet

## TABLE III - GAS COMPOSITION BEHIND NORMAL-SHOCK WAVE

MOLE FRACTION CONCENTRATIONS

| $V_1$ | $N_2$ | $O_2$ | $A$ | $NO$ | $N$ | $O$ | $e$ | $N_2^+$ | $O_2^+$ | $NO^+$ | $N^+$ | $O^+$ | $O^-$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2000 | 7.800 (-1) | 2.096 (-1) | 9.324 (-3) | | | 9.475 (-32) | | | | | | | |
| 3000 | 7.800 (-1) | 2.096 (-1) | 9.324 (-3) | | | 2.411 (-19) | | | | | | | |
| 4000 | 7.800 (-1) | 2.098 (-1) | 9.324 (-3) | 9.818 (-6) | 3.555 (-25) | 2.546 (-12) | | | | | | | |
| 5000 | 7.807 (-1) | 2.096 (-1) | 9.324 (-3) | 3.046 (-4) | 2.688 (-17) | 3.436 (-8) | | | | | | | |
| 6000 | 7.796 (-1) | 2.095 (-1) | 9.324 (-3) | 2.683 (-3) | 2.063 (-12) | 1.230 (-5) | | | | | | | |
| 7000 | 7.754 (-1) | 2.092 (-1) | 9.321 (-3) | 1.062 (-2) | 3.017 (-9) | 5.435 (-4) | | | | | | | |
| 8000 | 7.654 (-1) | 1.931 (-1) | 9.295 (-3) | 2.579 (-2) | 3.511 (-7) | 6.236 (-3) | | | | | | | |
| 9000 | 7.486 (-1) | 1.717 (-1) | 9.196 (-3) | 4.313 (-2) | 6.976 (-6) | 2.738 (-2) | | | | | | | |
| 10,000 | 7.294 (-1) | 1.411 (-1) | 9.012 (-3) | 5.662 (-2) | 4.883 (-5) | 6.683 (-2) | | | | | | | |
| 11,000 | 7.022 (-1) | 1.057 (-1) | 8.768 (-3) | 6.412 (-2) | 2.037 (-4) | 1.190 (-1) | | | | | | | |
| 12,000 | 6.786 (-1) | 6.880 (-2) | 8.484 (-3) | 6.519 (-2) | 6.787 (-4) | 1.773 (-1) | | | | | | | |
| 13,000 | 6.577 (-1) | 3.807 (-2) | 8.222 (-3) | 5.952 (-2) | 2.139 (-3) | 2.343 (-1) | | | | | | | |
| 14,000 | 6.412 (-1) | 1.582 (-2) | 7.987 (-3) | 4.805 (-2) | 7.252 (-3) | 2.796 (-1) | 1.872 (-5) | 1.095 (-9) | 4.302 (-8) | 1.934 (-5) | 1.280 (-10) | 9.105 (-9) | 6.773 (-7) |
| 15,000 | 6.243 (-1) | 5.941 (-3) | 7.805 (-3) | 3.803 (-2) | 2.257 (-2) | 3.032 (-1) | 5.294 (-5) | 1.880 (-8) | 1.134 (-7) | 5.401 (-5) | 5.220 (-9) | 1.034 (-7) | 1.307 (-6) |
| 16,000 | 5.983 (-1) | 2.701 (-3) | 7.634 (-3) | 2.783 (-2) | 5.208 (-2) | 3.101 (-1) | 1.139 (-4) | 1.594 (-7) | 2.248 (-7) | 1.168 (-4) | 8.427 (-8) | 6.265 (-7) | 2.042 (-6) |
| 17,000 | 5.663 (-1) | 1.522 (-3) | 7.451 (-3) | 2.286 (-2) | 9.226 (-2) | 3.092 (-1) | 1.948 (-4) | 7.125 (-7) | 3.605 (-7) | 1.933 (-4) | 5.941 (-7) | 2.211 (-6) | 2.774 (-6) |
| 18,000 | 5.283 (-1) | 9.872 (-4) | 7.253 (-3) | 1.937 (-2) | 1.388 (-1) | 3.048 (-1) | 2.887 (-4) | 2.133 (-6) | 5.096 (-7) | 2.815 (-4) | 2.507 (-6) | 5.604 (-6) | 3.484 (-6) |
| 19,000 | 4.873 (-1) | 6.870 (-4) | 7.048 (-3) | 1.674 (-2) | 1.888 (-1) | 2.986 (-1) | 3.950 (-4) | 4.975 (-6) | 6.660 (-7) | 3.742 (-4) | 7.723 (-6) | 1.161 (-5) | 4.178 (-6) |
| 20,000 | 4.448 (-1) | 5.192 (-4) | 6.838 (-3) | 1.462 (-2) | 2.406 (-1) | 2.916 (-1) | 5.139 (-4) | 9.837 (-6) | 8.257 (-7) | 4.676 (-4) | 1.939 (-5) | 2.111 (-5) | 4.872 (-6) |
| 21,000 | 4.017 (-1) | 4.006 (-4) | 6.627 (-3) | 1.253 (-2) | 2.931 (-1) | 2.840 (-1) | 6.482 (-4) | 1.730 (-5) | 9.849 (-7) | 5.582 (-4) | 4.225 (-5) | 3.506 (-5) | 5.585 (-6) |
| 22,000 | 3.588 (-1) | 3.166 (-4) | 6.418 (-3) | 1.126 (-2) | 3.454 (-1) | 2.762 (-1) | 8.029 (-4) | 2.763 (-5) | 1.140 (-5) | 6.427 (-4) | 8.304 (-5) | 5.453 (-5) | 6.391 (-6) |
| 23,000 | 3.164 (-1) | 2.582 (-4) | 6.212 (-3) | 9.866 (-3) | 3.969 (-1) | 2.684 (-1) | 9.858 (-4) | 4.176 (-5) | 1.287 (-5) | 7.176 (-4) | 1.510 (-4) | 8.076 (-5) | 7.168 (-6) |
| 24,000 | 2.750 (-1) | 2.062 (-4) | 6.011 (-3) | 8.603 (-3) | 4.472 (-1) | 2.606 (-1) | 1.207 (-3) | 5.914 (-5) | 1.423 (-5) | 7.800 (-4) | 2.588 (-4) | 1.153 (-4) | 8.108 (-6) |
| 25,000 | 2.348 (-1) | 1.633 (-4) | 5.817 (-3) | 7.485 (-3) | 4.857 (-1) | 2.530 (-1) | 1.483 (-3) | 7.973 (-5) | 1.545 (-5) | 8.274 (-4) | 4.236 (-4) | 1.800 (-4) | 9.192 (-6) |
| 26,000 | 1.963 (-1) | 1.376 (-4) | 5.630 (-3) | 6.374 (-3) | 5.422 (-1) | 2.456 (-1) | 1.839 (-3) | 1.030 (-4) | 1.653 (-5) | 8.576 (-4) | 6.698 (-4) | 2.180 (-4) | 1.105 (-5) |

Altitude: 90.000 feet

TABLE III - GAS COMPOSITION BEHIND NORMAL-SHOCK WAVE

MOLE FRACTION CONCENTRATIONS

| $V_1$ | $N_2$ | $O_2$ | $A$ | $NO$ | $N$ | $O$ | $e$ | $N_2^+$ | $O_2^+$ | $NO^+$ | $N^+$ | $O^+$ | $O^-$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2000 | 7.809 (-1) | 2.098 (-1) | 9.324 (-3) | | | 8.093 (-31) | | | | | | | |
| 3000 | 7.809 (-1) | 2.098 (-1) | 9.324 (-3) | | | 5.091 (-19) | | | | | | | |
| 4000 | 7.809 (-1) | 2.098 (-1) | 9.324 (-3) | 1.009 (-5) | 6.931 (-25) | 4.082 (-12) | | | | | | | |
| 5000 | 7.807 (-1) | 2.096 (-1) | 9.324 (-3) | 3.167 (-4) | 4.241 (-17) | 4.924 (-8) | | | | | | | |
| 6000 | 7.795 (-1) | 2.084 (-1) | 9.324 (-3) | 2.898 (-3) | 2.959 (-12) | 1.675 (-5) | | | | | | | |
| 7000 | 7.752 (-1) | 2.040 (-1) | 9.321 (-3) | 1.072 (-2) | 4.077 (-9) | 7.173 (-4) | | | | | | | |
| 8000 | 7.651 (-1) | 1.923 (-1) | 9.288 (-3) | 2.552 (-2) | 4.326 (-7) | 7.821 (-3) | | | | | | | |
| 9000 | 7.475 (-1) | 1.695 (-1) | 9.174 (-3) | 4.159 (-2) | 7.651 (-6) | 3.215 (-2) | | | | | | | |
| 10.000 | 7.249 (-1) | 1.378 (-1) | 8.975 (-3) | 5.350 (-2) | 4.951 (-5) | 7.485 (-2) | | | | | | | |
| 11.000 | 7.003 (-1) | 1.016 (-1) | 8.720 (-3) | 5.967 (-2) | 1.983 (-4) | 1.294 (-1) | | | | | | | |
| 12.000 | 6.765 (-1) | 6.537 (-2) | 8.439 (-3) | 5.975 (-2) | 6.544 (-4) | 1.693 (-1) | | | | | | | |
| 13.000 | 6.560 (-1) | 3.368 (-2) | 8.164 (-3) | 5.334 (-2) | 2.135 (-3) | 2.467 (-1) | | | | | | | |
| 14.000 | 6.401 (-1) | 1.279 (-2) | 7.936 (-3) | 4.153 (-2) | 7.639 (-3) | 2.900 (-1) | 1.838 (-5) | 9.548 (-10) | 3.500 (-8) | 1.879 (-5) | 1.234 (-10) | 8.970 (-9) | 4.589 (-7) |
| 15.000 | 6.226 (-1) | 4.470 (-3) | 7.763 (-3) | 3.029 (-2) | 2.467 (-2) | 3.101 (-1) | 5.310 (-5) | 1.810 (-8) | 9.265 (-8) | 5.375 (-5) | 5.731 (-9) | 1.094 (-7) | 8.808 (-7) |
| 16.000 | 6.961 (-1) | 2.005 (-3) | 7.595 (-3) | 2.331 (-2) | 5.642 (-2) | 3.143 (-1) | 1.126 (-4) | 1.511 (-7) | 1.807 (-7) | 1.129 (-4) | 9.078 (-8) | 6.509 (-7) | 1.358 (-6) |
| 17.000 | 5.617 (-1) | 1.136 (-3) | 7.410 (-3) | 1.906 (-2) | 9.836 (-2) | 3.119 (-1) | 1.889 (-4) | 6.524 (-7) | 2.856 (-7) | 1.869 (-4) | 6.134 (-7) | 2.230 (-6) | 1.816 (-6) |
| 18.000 | 5.226 (-1) | 7.401 (-4) | 7.211 (-3) | 1.614 (-2) | 1.461 (-1) | 3.066 (-1) | 2.768 (-4) | 1.902 (-6) | 3.997 (-7) | 2.687 (-4) | 2.507 (-6) | 5.535 (-6) | 2.262 (-6) |
| 19.000 | 4.809 (-1) | 5.242 (-4) | 7.004 (-3) | 1.394 (-2) | 1.971 (-1) | 2.998 (-1) | 3.749 (-4) | 4.358 (-6) | 5.192 (-7) | 3.539 (-4) | 7.564 (-6) | 1.131 (-5) | 2.697 (-6) |
| 20.000 | 4.378 (-1) | 3.911 (-4) | 6.793 (-3) | 1.216 (-2) | 2.496 (-1) | 2.923 (-1) | 4.842 (-4) | 8.515 (-6) | 6.412 (-7) | 4.390 (-4) | 1.874 (-5) | 2.039 (-5) | 3.131 (-6) |
| 21.000 | 3.943 (-1) | 3.018 (-4) | 6.582 (-3) | 1.065 (-2) | 3.026 (-1) | 2.844 (-1) | 6.073 (-4) | 1.485 (-5) | 7.630 (-7) | 5.210 (-4) | 4.050 (-5) | 3.370 (-5) | 3.577 (-6) |
| 22.000 | 3.510 (-1) | 2.383 (-4) | 6.372 (-3) | 9.334 (-3) | 3.553 (-1) | 2.763 (-1) | 7.490 (-4) | 2.377 (-5) | 8.617 (-7) | 5.968 (-4) | 7.926 (-5) | 5.230 (-5) | 4.051 (-6) |
| 23.000 | 3.083 (-1) | 1.910 (-4) | 6.166 (-3) | 8.156 (-3) | 4.072 (-1) | 2.682 (-1) | 9.167 (-4) | 3.553 (-5) | 9.944 (-7) | 6.633 (-4) | 1.439 (-4) | 7.743 (-5) | 4.571 (-6) |
| 24.000 | 2.657 (-1) | 1.546 (-4) | 5.965 (-3) | 7.089 (-3) | 4.577 (-1) | 2.602 (-1) | 1.121 (-3) | 5.019 (-5) | 1.098 (-6) | 7.176 (-4) | 2.468 (-4) | 1.106 (-4) | 5.164 (-6) |
| 25.000 | 2.264 (-1) | 1.257 (-4) | 5.771 (-3) | 6.108 (-3) | 5.065 (-1) | 2.524 (-1) | 1.379 (-3) | 6.754 (-5) | 1.192 (-6) | 7.570 (-4) | 4.051 (-4) | 1.540 (-4) | 5.862 (-6) |
| 26.000 | 1.877 (-1) | 1.023 (-4) | 5.584 (-3) | 5.200 (-3) | 5.531 (-1) | 2.449 (-1) | 1.715 (-3) | 8.706 (-5) | 1.273 (-6) | 7.798 (-4) | 6.435 (-4) | 2.106 (-4) | 6.711 (-6) |

Altitude: 100,000 feet

TABLE III - GAS COMPOSITION BEHIND NORMAL-SHOCK WAVE

| | MOLE FRACTION CONCENTRATIONS | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $V_1$ | $N_2$ | $O_2$ | $A$ | $NO$ | $N$ | $O$ | $e$ | $N_2^+$ | $O_2^+$ | $NO^+$ | $N^+$ | $O^+$ | $O^-$ |
| 2000 | 7.800 (-1) | 2.088 (-1) | 9.324 (-3) | | | 2.401 (-30) | | | | | | | |
| 3000 | 7.800 (-1) | 2.088 (-1) | 9.324 (-3) | | | 1.225 (-18) | | | | | | | |
| 4000 | 7.800 (-1) | 2.088 (-1) | 9.324 (-3) | 1.117 (-5) | 1.514 (-24) | 6.931 (-12) | | | | | | | |
| 5000 | 7.807 (-1) | 2.086 (-1) | 9.324 (-3) | 3.330 (-4) | 7.067 (-17) | 7.246 (-8) | | | | | | | |
| 6000 | 7.795 (-1) | 2.084 (-1) | 9.324 (-3) | 2.770 (-3) | 4.360 (-12) | 2.310 (-5) | | | | | | | |
| 7000 | 7.751 (-1) | 2.038 (-1) | 9.320 (-3) | 1.085 (-2) | 5.562 (-9) | 9.488 (-4) | | | | | | | |
| 8000 | 7.645 (-1) | 1.913 (-1) | 9.279 (-3) | 2.523 (-2) | 5.277 (-7) | 9.729 (-3) | | | | | | | |
| 9000 | 7.468 (-1) | 1.672 (-1) | 9.150 (-3) | 4.000 (-2) | 8.260 (-6) | 9.732 (-2) | | | | | | | |
| 10,000 | 7.232 (-1) | 1.343 (-1) | 8.937 (-3) | 5.045 (-2) | 4.958 (-5) | 8.302 (-2) | | | | | | | |
| 11,000 | 6.884 (-1) | 9.753 (-2) | 8.672 (-3) | 5.545 (-2) | 1.916 (-4) | 1.397 (-1) | | | | | | | |
| 12,000 | 6.796 (-1) | 6.093 (-2) | 8.385 (-3) | 5.468 (-2) | 6.285 (-4) | 2.008 (-1) | | | | | | | |
| 13,000 | 6.543 (-1) | 2.853 (-2) | 8.110 (-3) | 4.764 (-2) | 2.118 (-3) | 2.583 (-1) | | | | | | | |
| 14,000 | 6.389 (-1) | 1.010 (-2) | 7.891 (-3) | 3.568 (-2) | 8.139 (-3) | 2.992 (-1) | 1.818 (-5) | 8.640 (-10) | 2.866 (-8) | 1.845 (-5) | 1.244 (-10) | 9.058 (-9) | 3.134 (-7) |
| 15,000 | 6.208 (-1) | 3.324 (-3) | 7.726 (-3) | 2.539 (-2) | 2.706 (-2) | 3.156 (-1) | 5.333 (-5) | 1.774 (-8) | 7.592 (-8) | 5.371 (-5) | 6.412 (-9) | 1.168 (-7) | 5.942 (-7) |
| 16,000 | 5.927 (-1) | 1.690 (-3) | 7.558 (-3) | 1.946 (-2) | 6.096 (-2) | 3.176 (-1) | 1.110 (-4) | 1.434 (-7) | 1.458 (-7) | 1.109 (-4) | 9.767 (-8) | 6.745 (-7) | 8.992 (-7) |
| 17,000 | 5.671 (-1) | 8.504 (-4) | 7.372 (-3) | 1.592 (-2) | 1.045 (-1) | 3.139 (-1) | 1.830 (-4) | 5.964 (-7) | 2.264 (-7) | 1.805 (-4) | 6.298 (-7) | 2.238 (-6) | 1.184 (-6) |
| 18,000 | 5.470 (-1) | 5.576 (-4) | 7.171 (-3) | 1.249 (-2) | 1.534 (-1) | 3.078 (-1) | 2.648 (-4) | 1.683 (-6) | 3.140 (-7) | 2.564 (-4) | 2.492 (-6) | 5.844 (-6) | 1.475 (-6) |
| 19,000 | 4.746 (-1) | 3.964 (-4) | 6.963 (-3) | 1.165 (-2) | 2.052 (-1) | 3.006 (-1) | 3.554 (-4) | 3.812 (-6) | 4.056 (-7) | 3.346 (-4) | 7.364 (-6) | 1.097 (-6) | 1.750 (-6) |
| 20,000 | 4.310 (-1) | 2.963 (-4) | 6.751 (-3) | 1.015 (-2) | 2.582 (-1) | 2.926 (-1) | 4.558 (-4) | 7.360 (-6) | 4.991 (-7) | 4.124 (-4) | 1.800 (-5) | 1.862 (-6) | 2.028 (-6) |
| 21,000 | 3.871 (-1) | 2.288 (-4) | 6.539 (-3) | 8.878 (-3) | 3.117 (-1) | 2.844 (-1) | 5.667 (-4) | 1.274 (-5) | 5.926 (-7) | 4.868 (-4) | 3.861 (-5) | 3.227 (-6) | 2.306 (-6) |
| 22,000 | 3.435 (-1) | 1.806 (-4) | 6.329 (-3) | 7.765 (-3) | 3.647 (-1) | 2.761 (-1) | 6.967 (-4) | 2.028 (-5) | 6.840 (-7) | 5.551 (-4) | 7.526 (-5) | 4.898 (-6) | 2.605 (-6) |
| 23,000 | 3.006 (-1) | 1.445 (-4) | 6.123 (-3) | 6.769 (-3) | 4.168 (-1) | 2.678 (-1) | 8.529 (-4) | 3.021 (-5) | 7.709 (-7) | 6.144 (-4) | 1.365 (-4) | 7.389 (-6) | 2.835 (-6) |
| 24,000 | 2.588 (-1) | 1.167 (-4) | 5.922 (-3) | 5.864 (-3) | 4.676 (-1) | 2.596 (-1) | 1.042 (-3) | 4.258 (-5) | 8.512 (-7) | 6.817 (-4) | 2.363 (-4) | 1.059 (-4) | 3.314 (-6) |
| 25,000 | 2.184 (-1) | 9.460 (-5) | 5.728 (-3) | 5.032 (-3) | 5.165 (-1) | 2.517 (-1) | 1.282 (-3) | 5.719 (-5) | 9.229 (-7) | 6.947 (-4) | 3.856 (-4) | 1.478 (-4) | 3.764 (-6) |
| 26,000 | 1.796 (-1) | 7.665 (-5) | 5.542 (-3) | 4.260 (-3) | 5.632 (-1) | 2.440 (-1) | 1.600 (-3) | 7.359 (-5) | 9.851 (-7) | 7.114 (-4) | 6.156 (-4) | 2.030 (-4) | 4.319 (-6) |

Altitude: 110,000 feet

TABLE III - GAS COMPOSITION BEHIND NORMAL-SHOCK WAVE

MOLE FRACTION CONCENTRATIONS

| $V_1$ | $N_2$ | $O_2$ | $A$ | $NO$ | $N$ | $O$ | $e$ | $N_2^+$ | $O_2^+$ | $NO^+$ | $N^+$ | $O^+$ | $O^-$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2000 | 7.809 (-1) | 2.098 (-1) | 9.324 (-3) | | | 1.309 (-29) | | | | | | | |
| 3000 | 7.809 (-1) | 2.098 (-1) | 9.324 (-3) | | | 2.872 (-18) | | | | | | | |
| 4000 | 7.809 (-1) | 2.098 (-1) | 9.324 (-3) | 1.234 (-5) | 3.243 (-24) | 1.160 (-11) | | | | | | | |
| 5000 | 7.807 (-1) | 2.096 (-1) | 9.324 (-3) | 3.499 (-4) | 1.163 (-16) | 1.054 (-7) | | | | | | | |
| 6000 | 7.794 (-1) | 2.084 (-1) | 9.324 (-3) | 2.844 (-3) | 6.353 (-12) | 3.152 (-5) | | | | | | | |
| 7000 | 7.749 (-1) | 2.036 (-1) | 9.318 (-3) | 1.096 (-2) | 7.676 (-9) | 1.240 (-3) | | | | | | | |
| 8000 | 7.638 (-1) | 1.902 (-1) | 9.269 (-3) | 2.486 (-2) | 6.285 (-7) | 1.189 (-2) | | | | | | | |
| 9000 | 7.450 (-1) | 1.648 (-1) | 9.125 (-3) | 3.838 (-2) | 8.736 (-6) | 4.264 (-2) | | | | | | | |
| 10,000 | 7.215 (-1) | 1.310 (-1) | 8.899 (-3) | 4.753 (-2) | 4.899 (-5) | 8.101 (-2) | | | | | | | |
| 11,000 | 6.966 (-1) | 9.356 (-2) | 8.626 (-3) | 5.154 (-2) | 1.836 (-4) | 1.495 (-2) | | | | | | | |
| 12,000 | 6.727 (-1) | 5.673 (-2) | 8.335 (-3) | 5.006 (-2) | 6.015 (-4) | 2.116 (-1) | | | | | | | |
| 13,000 | 6.528 (-1) | 2.572 (-2) | 8.061 (-3) | 4.252 (-2) | 2.106 (-3) | 2.688 (-1) | | | | | | | |
| 14,000 | 6.379 (-1) | 7.878 (-3) | 7.852 (-3) | 3.058 (-2) | 8.747 (-3) | 3.070 (-1) | 1.810 (-5) | 8.093 (-10) | 2.370 (-4) | 1.828 (-5) | 1.304 (-10) | 9.340 (-9) | 2.160 (-7) |
| 15,000 | 6.188 (-1) | 2.478 (-3) | 7.694 (-3) | 2.134 (-2) | 2.964 (-2) | 3.199 (-1) | 5.353 (-5) | 1.753 (-8) | 6.253 (-4) | 5.373 (-5) | 7.213 (-9) | 1.248 (-7) | 4.051 (-7) |
| 16,000 | 5.893 (-1) | 1.117 (-3) | 7.526 (-3) | 1.634 (-2) | 6.553 (-2) | 3.199 (-1) | 1.082 (-4) | 1.359 (-7) | 1.175 (-4) | 1.088 (-4) | 1.043 (-7) | 6.947 (-7) | 6.041 (-7) |
| 17,000 | 5.525 (-1) | 6.438 (-4) | 7.337 (-3) | 1.338 (-2) | 1.105 (-1) | 3.153 (-1) | 1.770 (-4) | 5.441 (-7) | 1.805 (-4) | 1.742 (-4) | 6.411 (-7) | 2.285 (-6) | 7.940 (-7) |
| 18,000 | 5.116 (-1) | 4.248 (-4) | 7.135 (-3) | 1.154 (-2) | 1.603 (-1) | 3.086 (-1) | 2.532 (-4) | 1.506 (-6) | 2.482 (-4) | 2.446 (-4) | 2.460 (-6) | 5.322 (-6) | 9.754 (-7) |
| 19,000 | 4.686 (-1) | 3.032 (-4) | 6.926 (-3) | 9.793 (-3) | 2.127 (-1) | 3.009 (-1) | 3.369 (-4) | 3.335 (-6) | 3.189 (-4) | 3.167 (-4) | 7.128 (-6) | 1.060 (-5) | 1.152 (-6) |
| 20,000 | 4.246 (-1) | 2.271 (-4) | 6.714 (-3) | 8.529 (-3) | 2.663 (-1) | 2.927 (-1) | 4.294 (-4) | 6.369 (-6) | 3.913 (-4) | 3.879 (-4) | 1.721 (-5) | 1.881 (-5) | 1.326 (-6) |
| 21,000 | 3.804 (-1) | 1.755 (-4) | 6.501 (-3) | 7.452 (-3) | 3.201 (-1) | 2.843 (-1) | 5.332 (-4) | 1.094 (-5) | 4.637 (-4) | 4.558 (-4) | 3.665 (-5) | 3.081 (-5) | 1.508 (-6) |
| 22,000 | 3.366 (-1) | 1.384 (-4) | 6.291 (-3) | 6.507 (-3) | 3.734 (-1) | 2.757 (-1) | 6.527 (-4) | 1.734 (-5) | 5.348 (-4) | 5.177 (-4) | 7.117 (-5) | 4.764 (-5) | 1.701 (-6) |
| 23,000 | 2.835 (-1) | 1.107 (-4) | 6.085 (-3) | 5.660 (-3) | 4.257 (-1) | 2.673 (-1) | 7.948 (-4) | 2.575 (-5) | 6.025 (-4) | 5.709 (-4) | 1.290 (-4) | 7.054 (-5) | 1.914 (-6) |
| 24,000 | 2.516 (-1) | 8.817 (-5) | 5.884 (-3) | 4.889 (-3) | 4.766 (-1) | 2.590 (-1) | 9.700 (-4) | 3.621 (-5) | 6.651 (-4) | 6.126 (-4) | 2.216 (-4) | 1.011 (-4) | 2.150 (-6) |
| 25,000 | 2.110 (-1) | 7.206 (-5) | 5.690 (-3) | 4.178 (-3) | 5.257 (-1) | 2.509 (-1) | 1.185 (-3) | 4.857 (-5) | 7.211 (-4) | 6.404 (-4) | 3.658 (-4) | 1.415 (-4) | 2.454 (-6) |
| 26,000 | 1.722 (-1) | 5.813 (-5) | 5.504 (-3) | 3.517 (-3) | 5.725 (-1) | 2.432 (-1) | 1.495 (-3) | 6.241 (-5) | 7.693 (-4) | 6.523 (-4) | 5.870 (-4) | 1.953 (-4) | 2.622 (-6) |

Altitude: 120,000 feet

TABLE III - GAS COMPOSITION BEHIND NORMAL-SHOCK WAVE

MOLE FRACTION CONCENTRATIONS

| $V_1$ | $N_2$ | $O_2$ | $A$ | $NO$ | $N$ | $O$ | $e$ | $N_2^+$ | $O_2^+$ | $NO^+$ | $N^+$ | $O^+$ | $O^-$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2000 | 7.809 (-1) | 2.098 (-1) | 9.324 (-3) | | | 6.649 (-29) | | | | | | | |
| 3000 | 7.809 (-1) | 2.088 (-1) | 9.324 (-3) | | | 6.557 (-18) | | | | | | | |
| 4000 | 7.809 (-1) | 2.088 (-1) | 9.324 (-3) | 1.361 (-5) | 6.817 (-24) | 1.919 (-11) | | | | | | | |
| 5000 | 7.807 (-1) | 2.096 (-1) | 9.324 (-3) | 3.673 (-4) | 1.888 (-16) | 1.518 (-7) | | | | | | | |
| 6000 | 7.794 (-1) | 2.083 (-1) | 9.324 (-3) | 2.919 (-3) | 9.158 (-12) | 4.258 (-5) | | | | | | | |
| 7000 | 7.747 (-1) | 2.033 (-1) | 9.317 (-3) | 1.106 (-2) | 9.901 (-9) | 1.600 (-3) | | | | | | | |
| 8000 | 7.631 (-1) | 1.889 (-1) | 9.257 (-3) | 2.442 (-2) | 7.318 (-7) | 1.430 (-2) | | | | | | | |
| 9000 | 7.437 (-1) | 1.624 (-1) | 9.100 (-3) | 3.674 (-2) | 9.076 (-6) | 4.805 (-2) | | | | | | | |
| 10,000 | 7.169 (-1) | 1.277 (-1) | 8.863 (-3) | 4.476 (-2) | 4.788 (-5) | 9.878 (-2) | | | | | | | |
| 11,000 | 6.948 (-1) | 8.876 (-2) | 8.583 (-3) | 4.792 (-2) | 1.748 (-4) | 1.588 (-1) | | | | | | | |
| 12,000 | 6.709 (-1) | 5.276 (-2) | 8.288 (-3) | 4.587 (-2) | 5.744 (-4) | 2.216 (-1) | | | | | | | |
| 13,000 | 6.514 (-1) | 2.226 (-2) | 8.017 (-3) | 3.792 (-2) | 2.108 (-3) | 2.783 (-1) | | | | | | | |
| 14,000 | 6.369 (-1) | 6.088 (-3) | 7.818 (-3) | 2.616 (-2) | 9.476 (-3) | 3.135 (-1) | 1.814 (-5) | 7.825 (-10) | 1.978 (-8) | 1.826 (-5) | 1.415 (-10) | 9.822 (-9) | 1.505 (-7) |
| 15,000 | 6.158 (-1) | 1.856 (-3) | 7.666 (-3) | 1.799 (-2) | 3.238 (-2) | 3.232 (-1) | 5.368 (-5) | 1.741 (-8) | 5.174 (-8) | 5.375 (-5) | 8.118 (-9) | 1.332 (-7) | 2.790 (-7) |
| 16,000 | 5.858 (-1) | 8.457 (-4) | 7.496 (-3) | 1.379 (-2) | 7.008 (-2) | 3.218 (-1) | 1.072 (-4) | 1.285 (-7) | 9.531 (-8) | 1.066 (-4) | 1.103 (-7) | 7.111 (-7) | 4.103 (-7) |
| 17,000 | 5.480 (-1) | 4.926 (-4) | 7.306 (-3) | 1.131 (-2) | 1.162 (-1) | 3.163 (-1) | 1.710 (-4) | 4.956 (-7) | 1.446 (-7) | 1.680 (-4) | 6.475 (-7) | 2.219 (-6) | 5.846 (-7) |
| 18,000 | 5.064 (-1) | 3.272 (-4) | 7.102 (-3) | 8.599 (-3) | 1.669 (-1) | 3.091 (-1) | 2.419 (-4) | 1.339 (-6) | 1.974 (-7) | 2.334 (-4) | 2.413 (-6) | 5.185 (-6) | 6.531 (-7) |
| 19,000 | 4.629 (-1) | 2.344 (-4) | 6.882 (-3) | 8.288 (-3) | 2.199 (-1) | 3.011 (-1) | 3.195 (-4) | 2.919 (-6) | 2.524 (-7) | 3.000 (-4) | 6.864 (-6) | 1.021 (-5) | 7.683 (-7) |
| 20,000 | 4.184 (-1) | 1.759 (-4) | 6.679 (-3) | 7.214 (-3) | 2.739 (-1) | 2.926 (-1) | 4.048 (-4) | 5.519 (-6) | 3.089 (-7) | 3.655 (-4) | 1.639 (-5) | 1.799 (-5) | 8.830 (-7) |
| 21,000 | 3.742 (-1) | 1.360 (-4) | 6.466 (-3) | 6.298 (-3) | 3.280 (-1) | 2.840 (-1) | 5.005 (-4) | 9.417 (-6) | 3.656 (-7) | 4.277 (-4) | 3.465 (-5) | 2.936 (-5) | 1.001 (-6) |
| 22,000 | 3.301 (-1 | 1.073 (-4) | 6.256 (-3) | 5.491 (-3) | 3.815 (-1) | 2.753 (-1) | 6.106 (-4) | 1.486 (-5) | 4.213 (-7) | 4.841 (-4) | 6.709 (-5) | 4.532 (-5) | 1.126 (-6) |
| 23,000 | 2.869 (-1) | 8.589 (-5) | 6.050 (-3) | 4.766 (-3) | 4.340 (-1) | 2.667 (-1) | 7.419 (-4) | 2.201 (-5) | 4.746 (-7) | 5.321 (-4) | 1.215 (-4) | 6.713 (-5) | 1.266 (-6) |
| 24,000 | 2.449 (-1) | 6.881 (-5) | 5.849 (-3) | 4.105 (-3) | 4.850 (-1) | 2.583 (-1) | 9.045 (-4) | 3.089 (-5) | 5.240 (-7) | 5.692 (-4) | 2.090 (-4) | 9.639 (-5) | 1.428 (-6) |
| 25,000 | 2.043 (-1) | 5.552 (-5) | 5.655 (-3) | 3.495 (-3) | 5.342 (-1) | 2.501 (-1) | 1.114 (-3) | 4.138 (-5) | 5.681 (-7) | 5.927 (-4) | 3.462 (-4) | 1.354 (-4) | 1.628 (-6) |
| 26,000 | 1.654 (-1) | 4.459 (-5) | 5.469 (-3) | 2.926 (-3) | 5.811 (-1) | 2.423 (-1) | 1.399 (-3) | 5.311 (-5) | 6.061 (-7) | 6.008 (-4) | 5.585 (-4) | 1.878 (-4) | 1.871 (-6) |

Altitude: 130,000 feet

TABLE III - GAS COMPOSITION BEHIND NORMAL-SHOCK WAVE

| | MOLE FRACTION CONCENTRATIONS | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $V_1$ | $N_2$ | $O_2$ | $A$ | $NO$ | $N$ | $O$ | $e$ | $N_2^+$ | $O_2^+$ | $NO^+$ | $N^+$ | $O^+$ | $O^-$ |
| 2000 | 7.809 (-1) | 2.098 (-1) | 9.324 (-3) | | | 3.164 (-28) | | | | | | | |
| 3000 | 7.809 (-1) | 2.098 (-1) | 9.324 (-3) | | | 1.461 (-17) | | | | | | | |
| 4000 | 7.809 (-1) | 2.098 (-1) | 9.324 (-3) | 1.496 (-5) | 1.408 (-23) | 3.115 (-11) | | | | | | | |
| 5000 | 7.809 (-1) | 2.096 (-1) | 9.324 (-3) | 3.855 (-4) | 3.032 (-16) | 2.162 (-7) | | | | | | | |
| 6000 | 7.794 (-1) | 2.083 (-1) | 9.374 (-3) | 2.995 (-3) | 1.307 (-11) | 5.699 (-5) | | | | | | | |
| 7000 | 7.745 (-1) | 2.030 (-1) | 9.314 (-3) | 1.115 (-2) | 1.292 (-8) | 2.041 (-3) | | | | | | | |
| 8000 | 7.623 (-1) | 1.876 (-1) | 9.245 (-3) | 2.393 (-2) | 8.340 (-7) | 1.692 (-2) | | | | | | | |
| 9000 | 7.424 (-1) | 1.599 (-1) | 9.075 (-3) | 3.513 (-2) | 9.287 (-6) | 5.350 (-2) | | | | | | | |
| 10,000 | 7.183 (-1) | 1.244 (-1) | 8.828 (-3) | 4.214 (-2) | 6.640 (-5) | 1.063 (-1) | | | | | | | |
| 11,000 | 6.930 (-1) | 8.611 (-2) | 8.542 (-3) | 4.459 (-2) | 1.657 (-4) | 1.676 (-1) | | | | | | | |
| 12,000 | 6.692 (-1) | 4.801 (-2) | 8.245 (-3) | 4.206 (-2) | 5.481 (-4) | 2.309 (-1) | | | | | | | |
| 13,000 | 6.501 (-1) | 1.912 (-2) | 7.976 (-3) | 3.378 (-2) | 2.122 (-3) | 2.869 (-1) | | | | | | | |
| 14,000 | 6.360 (-1) | 4.671 (-3) | 7.789 (-3) | 2.236 (-2) | 1.033 (-2) | 3.185 (-1) | 1.830 (-5) | 7.774 (-10) | 1.665 (-8) | 1.838 (-5) | 1.584 (-10) | 1.050 (-8) | 1.061 (-7) |
| 15,000 | 6.146 (-1) | 1.399 (-3) | 7.641 (-3) | 1.523 (-2) | 3.525 (-2) | 3.257 (-1) | 5.373 (-5) | 1.730 (-8) | 4.297 (-8) | 5.372 (-5) | 9.097 (-9) | 1.417 (-7) | 1.840 (-7) |
| 16,000 | 5.824 (-1) | 6.468 (-4) | 7.469 (-3) | 1.170 (-2) | 7.458 (-2) | 3.231 (-1) | 1.050 (-4) | 1.212 (-7) | 7.767 (-8) | 1.042 (-4) | 1.157 (-7) | 7.234 (-7) | 2.817 (-7) |
| 17,000 | 5.436 (-1) | 3.808 (-4) | 7.277 (-3) | 9.620 (-3) | 1.218 (-1) | 3.159 (-1) | 1.650 (-4) | 4.507 (-7) | 1.165 (-7) | 1.619 (-4) | 6.492 (-7) | 2.192 (-6) | 3.642 (-7) |
| 18,000 | 5.015 (-1) | 2.546 (-4) | 7.072 (-3) | 8.172 (-3) | 1.732 (-1) | 3.093 (-1) | 2.311 (-4) | 1.191 (-6) | 1.579 (-7) | 2.228 (-4) | 2.353 (-6) | 5.033 (-6) | 4.428 (-7) |
| 19,000 | 4.578 (-1) | 1.830 (-4) | 6.861 (-3) | 7.057 (-3) | 2.267 (-1) | 3.010 (-1) | 3.030 (-4) | 2.558 (-6) | 2.011 (-7) | 2.844 (-4) | 6.582 (-6) | 9.803 (-6) | 5.194 (-7) |
| 20,000 | 4.130 (-1) | 1.376 (-4) | 6.647 (-3) | 6.141 (-3) | 2.810 (-1) | 2.924 (-1) | 3.820 (-4) | 4.790 (-6) | 2.455 (-7) | 3.448 (-4) | 1.555 (-5) | 1.717 (-5) | 5.850 (-7) |
| 21,000 | 3.683 (-1) | 1.065 (-4) | 6.434 (-3) | 5.355 (-3) | 3.353 (-1) | 2.835 (-1) | 4.704 (-4) | 8.123 (-6) | 2.902 (-7) | 4.020 (-4) | 3.269 (-5) | 2.792 (-5) | 6.730 (-7) |
| 22,000 | 3.241 (-1) | 8.402 (-5) | 6.224 (-3) | 4.663 (-3) | 3.890 (-1) | 2.747 (-1) | 5.722 (-4) | 1.276 (-5) | 3.343 (-7) | 4.537 (-4) | 6.308 (-5) | 4.306 (-5) | 7.562 (-7) |
| 23,000 | 2.808 (-1) | 6.704 (-5) | 6.017 (-3) | 4.039 (-3) | 4.416 (-1) | 2.661 (-1) | 6.937 (-4) | 1.886 (-5) | 3.766 (-7) | 4.978 (-4) | 1.141 (-4) | 6.380 (-5) | 8.488 (-7) |
| 24,000 | 2.387 (-1) | 5.381 (-5) | 5.817 (-3) | 3.470 (-3) | 4.927 (-1) | 2.576 (-1) | 8.449 (-4) | 2.643 (-5) | 4.160 (-7) | 5.305 (-4) | 1.967 (-4) | 9.180 (-5) | 9.567 (-7) |
| 25,000 | 1.980 (-1) | 4.324 (-5) | 5.623 (-3) | 2.943 (-3) | 5.420 (-1) | 2.493 (-1) | 1.042 (-3) | 3.536 (-5) | 4.512 (-7) | 5.507 (-4) | 3.269 (-4) | 1.294 (-4) | 1.088 (-6) |
| 26,000 | 1.591 (-1) | 3.458 (-5) | 5.437 (-3) | 2.452 (-3) | 5.889 (-1) | 2.414 (-1) | 1.311 (-3) | 4.535 (-5) | 4.815 (-7) | 5.557 (-4) | 5.304 (-4) | 1.804 (-4) | 1.257 (-6) |

Altitude:140,000 feet

TABLE III - GAS COMPOSITION BEHIND NORMAL-SHOCK WAVE

MOLE FRACTION CONCENTRATIONS

| $V_1$ | $N_2$ | $O_2$ | $A$ | $NO$ | $N$ | $O$ | $e$ | $N_2^+$ | $O_2^+$ | $NO^+$ | $N^+$ | $O^+$ | $O^-$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2000 | 7.809 (-1) | 2.096 (-1) | 9.324 (-3) | | | 1.418 (-27) | | | | | | | |
| 3000 | 7.809 (-1) | 2.096 (-1) | 9.324 (-3) | | | 3.183 (-17) | | | | | | | |
| 4000 | 7.809 (-1) | 2.096 (-1) | 9.324 (-3) | 1.647 (-5) | 2.860 (-23) | 5.009 (-11) | | | | | | | |
| 5000 | 7.807 (-1) | 2.096 (-1) | 9.324 (-3) | 4.042 (-4) | 4.815 (-16) | 3.052 (-7) | | | | | | | |
| 6000 | 7.793 (-1) | 2.082 (-1) | 9.324 (-3) | 3.072 (-3) | 1.848 (-11) | 7.563 (-5) | | | | | | | |
| 7000 | 7.743 (-1) | 2.026 (-1) | 9.312 (-3) | 1.122 (-2) | 1.660 (-8) | 2.573 (-3) | | | | | | | |
| 8000 | 7.615 (-1) | 1.862 (-1) | 9.232 (-3) | 2.338 (-2) | 9.319 (-7) | 1.975 (-2) | | | | | | | |
| 9000 | 7.411 (-1) | 1.574 (-1) | 9.049 (-3) | 3.355 (-2) | 9.382 (-6) | 5.893 (-2) | | | | | | | |
| 10,000 | 7.167 (-1) | 1.213 (-1) | 8.795 (-3) | 3.968 (-2) | 4.464 (-5) | 1.135 (-1) | | | | | | | |
| 11,000 | 6.913 (-1) | 8.261 (-2) | 8.503 (-3) | 4.152 (-2) | 1.566 (-4) | 1.759 (-1) | | | | | | | |
| 12,000 | 6.675 (-1) | 4.547 (-2) | 8.204 (-3) | 3.859 (-2) | 5.230 (-4) | 2.397 (-1) | | | | | | | |
| 13,000 | 6.489 (-1) | 1.628 (-2) | 7.940 (-3) | 3.005 (-2) | 2.151 (-3) | 2.947 (-1) | | | | | | | |
| 14,000 | 6.351 (-1) | 3.565 (-3) | 7.765 (-3) | 1.911 (-2) | 1.134 (-2) | 3.232 (-1) | | | | | | | |
| 15,000 | 6.124 (-1) | 1.063 (-3) | 7.618 (-3) | 1.295 (-2) | 3.820 (-2) | 3.277 (-1) | 5.368 (-5) | 1.716 (-8) | 3.582 (-8) | 5.361 (-5) | 1.013 (-8) | 1.499 (-7) | 1.362 (-7) |
| 16,000 | 5.789 (-1) | 4.996 (-4) | 7.445 (-3) | 9.987 (-3) | 7.901 (-2) | 3.239 (-1) | 1.027 (-4) | 1.139 (-7) | 6.356 (-8) | 1.018 (-4) | 1.203 (-7) | 7.318 (-7) | 1.054 (-7) |
| 17,000 | 5.384 (-1) | 2.873 (-4) | 7.250 (-3) | 8.227 (-3) | 1.272 (-1) | 3.173 (-1) | 1.591 (-4) | 4.093 (-7) | 9.431 (-8) | 1.560 (-4) | 6.467 (-7) | 2.157 (-6) | 2.509 (-7) |
| 18,000 | 4.968 (-1) | 2.000 (-4) | 7.044 (-3) | 6.996 (-3) | 1.792 (-1) | 3.094 (-1) | 2.208 (-4) | 1.059 (-6) | 1.270 (-7) | 2.127 (-4) | 2.285 (-6) | 4.871 (-6) | 3.037 (-7) |
| 19,000 | 4.525 (-1) | 1.443 (-4) | 6.832 (-3) | 6.043 (-3) | 2.330 (-1) | 3.008 (-1) | 2.877 (-4) | 2.244 (-6) | 1.612 (-7) | 2.599 (-4) | 6.290 (-6) | 9.395 (-6) | 3.850 (-7) |
| 20,000 | 4.076 (-1) | 1.087 (-4) | 6.618 (-3) | 5.257 (-3) | 2.876 (-1) | 2.920 (-1) | 3.609 (-4) | 4.165 (-6) | 1.964 (-7) | 3.259 (-4) | 1.472 (-5) | 1.636 (-5) | 4.860 (-7) |
| 21,000 | 3.628 (-1) | 8.423 (-5) | 6.405 (-3) | 4.581 (-3) | 3.422 (-1) | 2.831 (-1) | 4.427 (-4) | 7.022 (-6) | 2.319 (-7) | 3.786 (-4) | 3.076 (-5) | 2.652 (-5) | 4.584 (-7) |
| 22,000 | 3.185 (-1) | 6.643 (-5) | 6.194 (-3) | 3.984 (-3) | 3.960 (-1) | 2.742 (-1) | 5.370 (-4) | 1.099 (-5) | 2.670 (-7) | 4.262 (-4) | 5.918 (-5) | 4.086 (-5) | 6.142 (-7) |
| 23,000 | 2.751 (-1) | 5.296 (-5) | 5.988 (-3) | 3.445 (-3) | 4.487 (-1) | 2.654 (-1) | 6.487 (-4) | 1.620 (-5) | 3.010 (-7) | 4.661 (-4) | 1.071 (-4) | 6.059 (-5) | 5.765 (-7) |
| 24,000 | 2.320 (-1) | 4.244 (-5) | 5.767 (-3) | 2.952 (-3) | 4.999 (-1) | 2.568 (-1) | 7.905 (-4) | 2.268 (-5) | 3.326 (-7) | 4.960 (-4) | 1.848 (-4) | 8.786 (-5) | 6.484 (-7) |
| 25,000 | 1.922 (-1) | 3.401 (-5) | 5.594 (-3) | 2.495 (-3) | 5.492 (-1) | 2.485 (-1) | 9.751 (-4) | 3.033 (-5) | 3.611 (-7) | 5.133 (-4) | 3.082 (-4) | 1.236 (-4) | 7.882 (-7) |
| 26,000 | 1.533 (-1) | 2.709 (-5) | 5.408 (-3) | 2.068 (-3) | 5.962 (-1) | 2.406 (-1) | 1.231 (-3) | 3.887 (-5) | 3.855 (-7) | 5.160 (-4) | 5.029 (-4) | 1.732 (-4) | 10.551 (-7) |

Altitude: 150,000 feet

## TABLE III - GAS COMPOSITION BEHIND NORMAL-SHOCK WAVE

MOLE FRACTION CONCENTRATIONS

| $V_1$ | $N_2$ | $O_2$ | $A$ | $NO$ | $N$ | $O$ | $e$ | $N_2^+$ | $O_2^+$ | $NO^+$ | $N^+$ | $O^+$ | $O^-$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2000 | 7.809 (-1) | 2.098 (-1) | 9.324 (-3) | | | 5.999 (-27) | | | | | | | |
| 3000 | 7.809 (-1) | 2.098 (-1) | 9.324 (-3) | | | 6.783 (-17) | | | | | | | |
| 4000 | 7.809 (-1) | 2.098 (-1) | 9.324 (-3) | 1.807 (-5) | 5.717 (-23) | 7.960 (-11) | | | | | | | |
| 5000 | 7.807 (-1) | 2.096 (-1) | 9.324 (-3) | 4.237 (-4) | 7.569 (-16) | 4.271 (-7) | | | | | | | |
| 6000 | 7.783 (-1) | 2.082 (-1) | 9.324 (-3) | 3.149 (-3) | 2.586 (-11) | 9.954 (-5) | | | | | | | |
| 7000 | 7.740 (-1) | 2.022 (-1) | 9.309 (-3) | 1.128 (-2) | 2.101 (-8) | 3.205 (-3) | | | | | | | |
| 8000 | 7.606 (-1) | 1.846 (-1) | 9.218 (-3) | 2.280 (-2) | 1.023 (-6) | 2.274 (-2) | | | | | | | |
| 9000 | 7.398 (-1) | 1.549 (-1) | 9.024 (-3) | 3.201 (-2) | 9.373 (-6) | 6.451 (-2) | | | | | | | |
| 10,000 | 7.151 (-1) | 1.182 (-1) | 8.762 (-3) | 3.738 (-2) | 4.270 (-5) | 1.205 (-1) | | | | | | | |
| 11,000 | 6.896 (-1) | 7.926 (-2) | 8.466 (-3) | 3.869 (-2) | 1.476 (-4) | 1.638 (-1) | | | | | | | |
| 12,000 | 6.660 (-1) | 4.212 (-2) | 8.166 (-3) | 3.544 (-2) | 4.995 (-4) | 2.478 (-1) | | | | | | | |
| 13,000 | 6.478 (-1) | 1.375 (-2) | 7.907 (-3) | 2.659 (-2) | 2.199 (-3) | 3.017 (-1) | | | | | | | |
| 14,000 | 6.341 (-1) | 2.721 (-3) | 7.743 (-3) | 1.635 (-2) | 1.244 (-2) | 3.266 (-1) | 1.864 (-5) | 8.126 (-10) | 1.205 (-8) | 1.887 (-5) | 2.109 (-10) | 1.242 (-8) | 5.430 (-8) |
| 15,000 | 6.101 (-1) | 8.154 (-4) | 7.597 (-3) | 1.107 (-2) | 4.120 (-2) | 3.291 (-1) | 5.349 (-5) | 1.694 (-8) | 2.494 (-8) | 5.357 (-5) | 1.116 (-8) | 1.575 (-7) | 9.644 (-8) |
| 16,000 | 5.756 (-1) | 3.897 (-4) | 7.422 (-3) | 8.566 (-3) | 8.332 (-2) | 3.245 (-1) | 1.002 (-4) | 1.066 (-7) | 5.322 (-8) | 9.931 (-5) | 1.239 (-7) | 7.357 (-7) | 1.369 (-7) |
| 17,000 | 5.354 (-1) | 2.343 (-4) | 7.226 (-3) | 7.074 (-3) | 1.323 (-1) | 3.175 (-1) | 1.553 (-4) | 3.713 (-7) | 7.474 (-8) | 1.502 (-4) | 6.405 (-7) | 2.115 (-6) | 1.747 (-7) |
| 18,000 | 4.922 (-1) | 1.585 (-4) | 7.018 (-3) | 6.022 (-3) | 1.848 (-1) | 3.093 (-1) | 2.110 (-4) | 9.415 (-7) | 1.028 (-7) | 2.032 (-4) | 2.209 (-6) | 4.703 (-6) | 2.107 (-7) |
| 19,000 | 4.477 (-1) | 1.148 (-4) | 6.806 (-3) | 5.204 (-3) | 2.391 (-1) | 3.006 (-1) | 2.733 (-4) | 1.971 (-6) | 1.300 (-7) | 2.564 (-4) | 5.983 (-6) | 5.988 (-6) | 2.456 (-7) |
| 20,000 | 4.026 (-1) | 8.667 (-5) | 6.591 (-3) | 4.525 (-3) | 2.939 (-1) | 2.916 (-1) | 3.413 (-4) | 3.628 (-6) | 1.481 (-7) | 3.083 (-4) | 1.390 (-5) | 1.566 (-5) | 2.808 (-7) |
| 21,000 | 3.577 (-1) | 6.720 (-5) | 6.378 (-3) | 3.941 (-3) | 3.486 (-1) | 2.825 (-1) | 4.172 (-4) | 6.084 (-6) | 1.165 (-7) | 3.572 (-4) | 2.889 (-5) | 2.517 (-5) | 3.168 (-7) |
| 22,000 | 3.133 (-1) | 5.299 (-5) | 6.167 (-3) | 3.423 (-3) | 4.025 (-1) | 2.736 (-1) | 5.047 (-4) | 9.489 (-6) | 2.448 (-7) | 4.012 (-4) | 5.545 (-5) | 3.874 (-5) | 3.538 (-7) |
| 23,000 | 2.698 (-1) | 4.221 (-5) | 5.961 (-3) | 2.955 (-3) | 4.553 (-1) | 2.647 (-1) | 6.095 (-4) | 1.396 (-5) | 2.121 (-7) | 4.379 (-4) | 1.003 (-4) | 6.750 (-5) | 3.869 (-7) |
| 24,000 | 2.275 (-1) | 3.377 (-5) | 5.760 (-3) | 2.525 (-3) | 5.066 (-1) | 2.561 (-1) | 7.403 (-4) | 1.953 (-5) | 2.178 (-7) | 4.650 (-4) | 1.734 (-4) | 8.309 (-5) | 4.462 (-7) |
| 25,000 | 1.868 (-1) | 2.699 (-5) | 5.567 (-3) | 2.127 (-3) | 5.559 (-1) | 2.477 (-1) | 9.142 (-4) | 2.609 (-5) | 2.410 (-7) | 4.801 (-4) | 2.903 (-4) | 1.180 (-4) | 5.080 (-7) |
| 26,000 | 1.479 (-1) | 2.142 (-5) | 5.382 (-3) | 1.754 (-3) | 6.029 (-1) | 2.397 (-1) | 1.157 (-3) | 3.342 (-5) | 3.[illegible]09 (-7) | 4.809 (-4) | 4.764 (-4) | 1.662 (-4) | 5.887 (-7) |

Altitude:60,000 feet

TABLE III - GAS COMPOSITION BEHIND NORMAL-SHOCK WAVE

MOLE FRACTION CONCENTRATIONS

| $V_1$ | $N_2$ | $O_2$ | $A$ | $NO$ | $N$ | $O$ | $e$ | $N_2^+$ | $O_2^+$ | $NO^+$ | $N^+$ | $O^+$ | $O^-$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2000 | 7.809 (-1) | 2.098 (-1) | 9.324 (-3) | | | 1.380 (-26) | | | | | | | |
| 3000 | 7.809 (-1) | 2.098 (-1) | 9.324 (-3) | | | 1.097 (-16) | | | | | | | |
| 4000 | 7.809 (-1) | 2.098 (-1) | 9.324 (-3) | 1.897 (-5) | 8.954 (-23) | 1.104 (-10) | | | | | | | |
| 5000 | 7.807 (-1) | 2.096 (-1) | 9.324 (-3) | 4.343 (-4) | 1.045 (-15) | 5.542 (-7) | | | | | | | |
| 6000 | 7.792 (-1) | 2.081 (-1) | 9.323 (-3) | 3.190 (-3) | 3.356 (-11) | 1.250 (-4) | | | | | | | |
| 7000 | 7.738 (-1) | 2.018 (-1) | 9.306 (-3) | 1.125 (-2) | 2.521 (-8) | 3.859 (-3) | | | | | | | |
| 8000 | 7.588 (-1) | 1.833 (-1) | 9.205 (-3) | 2.215 (-2) | 1.086 (-6) | 2.557 (-2) | | | | | | | |
| 9000 | 7.386 (-1) | 1.527 (-1) | 9.001 (-3) | 3.055 (-2) | 9.211 (-6) | 6.918 (-2) | | | | | | | |
| 10,000 | 7.137 (-1) | 1.155 (-1) | 8.733 (-3) | 3.529 (-2) | 4.052 (-5) | 1.267 (-1) | | | | | | | |
| 11,000 | 6.882 (-1) | 7.631 (-2) | 8.434 (-3) | 3.619 (-2) | 1.385 (-4) | 1.907 (-1) | | | | | | | |
| 12,000 | 6.646 (-1) | 3.919 (-2) | 8.133 (-3) | 3.268 (-2) | 4.762 (-4) | 2.549 (-1) | | | | | | | |
| 13,000 | 6.469 (-1) | 1.164 (-2) | 7.880 (-3) | 2.381 (-2) | 2.253 (-3) | 3.075 (-1) | | | | | | | |
| 14,000 | 6.331 (-1) | 2.105 (-3) | 7.725 (-3) | 1.411 (-2) | 1.358 (-2) | 3.293 (-1) | 1.910 (-5) | 8.364 (-10) | 1.036 (-8) | 1.912 (-5) | 2.430 (-10) | 1.347 (-8) | 3.978 (-8) |
| 15,000 | 6.079 (-1) | 6.378 (-4) | 7.579 (-3) | 9.560 (-3) | 4.403 (-2) | 3.302 (-1) | 5.312 (-5) | 1.659 (-8) | 2.523 (-8) | 5.297 (-5) | 1.207 (-8) | 1.635 (-7) | 6.866 (-8) |
| 16,000 | 5.725 (-1) | 3.097 (-4) | 7.401 (-3) | 7.430 (-3) | 8.728 (-2) | 3.249 (-1) | 9.766 (-5) | 9.951 (-8) | 4.334 (-8) | 9.675 (-5) | 1.261 (-7) | 7.344 (-7) | 9.797 (-8) |
| 17,000 | 5.317 (-1) | 1.679 (-4) | 7.204 (-3) | 6.147 (-3) | 1.370 (-1) | 3.175 (-1) | 1.477 (-4) | 3.369 (-7) | 6.316 (-8) | 1.448 (-4) | 5.293 (-7) | 2.064 (-6) | 1.284 (-7) |
| 18,000 | 4.882 (-1) | 1.279 (-4) | 6.936 (-3) | 5.238 (-3) | 1.899 (-1) | 3.091 (-1) | 2.018 (-4) | 8.398 (-7) | 8.418 (-8) | 1.944 (-4) | 2.126 (-6) | 4.530 (-6) | 1.485 (-7) |
| 19,000 | 4.434 (-1) | 9.287 (-5) | 6.782 (-3) | 4.527 (-3) | 2.444 (-1) | 3.002 (-1) | 2.601 (-4) | 1.739 (-6) | 1.062 (-7) | 2.442 (-4) | 5.695 (-6) | 8.591 (-6) | 1.739 (-7) |
| 20,000 | 3.982 (-1) | 7.022 (-5) | 6.567 (-3) | 3.936 (-3) | 2.995 (-1) | 2.912 (-1) | 3.236 (-4) | 3.179 (-6) | 1.289 (-7) | 2.926 (-4) | 1.310 (-5) | 1.481 (-5) | 1.881 (-7) |
| 21,000 | 3.531 (-1) | 5.448 (-5) | 6.354 (-3) | 3.426 (-3) | 3.543 (-1) | 2.820 (-1) | 3.944 (-4) | 5.306 (-6) | 1.520 (-7) | 3.382 (-4) | 2.712 (-5) | 2.869 (-5) | 2.229 (-7) |
| 22,000 | 3.086 (-1) | 4.296 (-5) | 6.143 (-3) | 2.972 (-3) | 4.083 (-1) | 2.730 (-1) | 4.759 (-4) | 8.255 (-6) | 1.750 (-7) | 3.791 (-4) | 5.196 (-5) | 3.676 (-5) | 2.484 (-7) |
| 23,000 | 2.651 (-1) | 3.420 (-5) | 5.937 (-3) | 2.562 (-3) | 4.612 (-1) | 2.641 (-1) | 5.737 (-4) | 1.212 (-5) | 1.975 (-7) | 4.131 (-4) | 9.396 (-5) | 5.461 (-5) | 2.790 (-7) |
| 24,000 | 2.228 (-1) | 2.732 (-5) | 5.737 (-3) | 2.185 (-3) | 5.125 (-1) | 2.554 (-1) | 6.967 (-4) | 1.694 (-5) | 2.186 (-7) | 4.380 (-4) | 1.628 (-4) | 7.810 (-5) | 3.140 (-7) |
| 25,000 | 1.820 (-1) | 2.178 (-5) | 5.543 (-3) | 1.834 (-3) | 5.618 (-1) | 2.470 (-1) | 8.600 (-4) | 2.263 (-5) | 2.378 (-7) | 4.512 (-4) | 2.735 (-4) | 1.127 (-4) | 3.575 (-7) |
| 26,000 | 1.431 (-1) | 1.722 (-5) | 5.358 (-3) | 1.506 (-3) | 6.089 (-1) | 2.390 (-1) | 1.091 (-3) | 2.898 (-5) | 2.543 (-7) | 4.506 (-4) | 4.515 (-4) | 1.597 (-4) | 4.160 (-7) |

Altitude: 170,000 feet

TABLE III - GAS COMPOSITION BEHIND NORMAL-SHOCK WAVE

MOLE FRACTION CONCENTRATIONS

| $V_1$ | $N_2$ | $O_2$ | $A$ | $NO$ | $N$ | $O$ | $e$ | $N_2^+$ | $O_2^+$ | $NO^+$ | $N^+$ | $O^+$ | $O^-$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2000 | 7.809 (-1) | 2.098 (-1) | 9.324 (-3) | | | 1.655 (-26) | | | | | | | |
| 3000 | 7.809 (-1) | 2.098 (-1) | 9.324 (-3) | | | 1.315 (-16) | | | | | | | |
| 4000 | 7.809 (-1) | 2.098 (-1) | 9.324 (-3) | 1.897 (-5) | 1.073 (-22) | 1.324 (-10) | | | | | | | |
| 5000 | 7.807 (-1) | 2.096 (-1) | 9.324 (-3) | 4.343 (-4) | 1.252 (-15) | 6.644 (-7) | | | | | | | |
| 6000 | 7.792 (-1) | 2.081 (-1) | 9.323 (-3) | 3.188 (-3) | 4.010 (-11) | 1.495 (-4) | | | | | | | |
| 7000 | 7.736 (-1) | 2.015 (-1) | 9.303 (-3) | 1.113 (-2) | 2.572 (-8) | 4.498 (-3) | | | | | | | |
| 8000 | 7.591 (-1) | 1.820 (-1) | 9.193 (-3) | 2.145 (-2) | 1.119 (-6) | 2.819 (-2) | | | | | | | |
| 9000 | 7.376 (-1) | 1.507 (-1) | 8.931 (-3) | 2.915 (-2) | 8.913 (-6) | 7.353 (-2) | | | | | | | |
| 10,000 | 7.126 (-1) | 1.132 (-1) | 8.708 (-3) | 3.336 (-2) | 3.813 (-5) | 1.322 (-1) | | | | | | | |
| 11,000 | 6.869 (-1) | 7.373 (-2) | 8.406 (-3) | 3.394 (-2) | 1.294 (-4) | 1.969 (-1) | | | | | | | |
| 12,000 | 6.634 (-1) | 3.662 (-2) | 8.104 (-3) | 3.025 (-2) | 4.526 (-4) | 2.612 (-1) | | | | | | | |
| 13,000 | 6.462 (-1) | 9.879 (-3) | 7.856 (-3) | 2.130 (-2) | 2.308 (-3) | 3.125 (-1) | | | | | | | |
| 14,000 | 6.322 (-1) | 1.650 (-3) | 7.710 (-3) | 1.226 (-2) | 1.472 (-2) | 3.314 (-1) | 1.929 (-5) | 8.525 (-10) | 6.941 (-9) | 1.929 (-5) | 2.754 (-10) | 1.444 (-8) | 2.950 (-8) |
| 15,000 | 6.059 (-1) | 5.070 (-4) | 7.563 (-3) | 8.327 (-3) | 4.668 (-2) | 3.309 (-1) | 5.253 (-5) | 1.608 (-8) | 2.135 (-8) | 5.236 (-5) | 1.281 (-6) | 1.678 (-7) | 5.100 (-8) |
| 16,000 | 5.696 (-1) | 2.498 (-4) | 7.323 (-3) | 6.495 (-3) | 9.089 (-2) | 3.252 (-1) | 9.501 (-5) | 9.241 (-8) | 3.620 (-8) | 9.410 (-5) | 1.268 (-7) | 7.277 (-7) | 7.116 (-8) |
| 17,000 | 5.284 (-1) | 1.528 (-4) | 7.184 (-3) | 5.384 (-3) | 1.412 (-1) | 3.175 (-1) | 1.423 (-4) | 3.051 (-7) | 5.236 (-8) | 1.394 (-4) | 6.132 (-7) | 2.004 (-6) | 8.996 (-8) |
| 18,000 | 4.845 (-1) | 1.044 (-4) | 6.975 (-3) | 4.591 (-3) | 1.945 (-1) | 3.089 (-1) | 1.932 (-4) | 7.498 (-7) | 6.951 (-8) | 1.861 (-4) | 2.037 (-6) | 4.353 (-6) | 1.078 (-7) |
| 19,000 | 4.395 (-1) | 7.604 (-5) | 6.761 (-3) | 3.969 (-3) | 2.493 (-1) | 2.999 (-1) | 2.479 (-4) | 1.528 (-6) | 8.746 (-8) | 2.328 (-4) | 5.395 (-6) | 8.186 (-6) | 1.251 (-7) |
| 20,000 | 3.941 (-1) | 5.759 (-5) | 6.546 (-3) | 3.450 (-3) | 3.045 (-1) | 2.907 (-1) | 3.074 (-4) | 2.754 (-6) | 1.060 (-7) | 2.782 (-4) | 1.235 (-5) | 1.408 (-5) | 1.423 (-7) |
| 21,000 | 3.489 (-1) | 4.471 (-5) | 6.332 (-3) | 3.001 (-3) | 3.594 (-1) | 2.815 (-1) | 3.736 (-4) | 4.645 (-6) | 1.250 (-7) | 3.209 (-4) | 2.543 (-5) | 2.267 (-5) | 1.599 (-7) |
| 22,000 | 3.044 (-1) | 3.525 (-5) | 6.122 (-3) | 2.601 (-3) | 4.135 (-1) | 2.724 (-1) | 4.498 (-4) | 7.209 (-6) | 1.440 (-7) | 3.591 (-4) | 4.864 (-5) | 3.488 (-5) | 1.787 (-7) |
| 23,000 | 2.608 (-1) | 2.804 (-5) | 5.915 (-3) | 2.236 (-3) | 4.664 (-1) | 2.635 (-1) | 5.413 (-4) | 1.057 (-5) | 1.625 (-7) | 3.909 (-4) | 8.860 (-5) | 5.187 (-5) | 1.997 (-7) |
| 24,000 | 2.185 (-1) | 2.237 (-5) | 5.715 (-3) | 1.905 (-3) | 5.178 (-1) | 2.548 (-1) | 6.567 (-4) | 1.477 (-5) | 1.801 (-7) | 4.139 (-4) | 1.527 (-4) | 7.531 (-5) | 2.246 (-7) |
| 25,000 | 1.777 (-1) | 1.780 (-5) | 5.522 (-3) | 1.595 (-3) | 5.672 (-1) | 2.463 (-1) | 8.107 (-4) | 1.972 (-5) | 1.961 (-7) | 4.257 (-4) | 2.576 (-4) | 1.077 (-4) | 2.958 (-7) |
| 26,000 | 1.388 (-1) | 1.402 (-5) | 5.337 (-3) | 1.303 (-3) | 6.142 (-1) | 2.383 (-1) | 1.030 (-3) | 2.526 (-5) | 2.101 (-7) | 4.240 (-4) | 4.278 (-4) | 1.535 (-4) | 2.974 (-7) |

Altitude: 180,000 feet

TABLE III - GAS COMPOSITION BEHIND NORMAL-SHOCK WAVE

| | MOLE FRACTION CONCENTRATIONS | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $V_1$ | $N_2$ | $O_2$ | $A$ | $NO$ | $N$ | $O$ | $e$ | $N_2^+$ | $O_2^+$ | $NO^+$ | $N^+$ | $O^+$ | $O^-$ |
| 2000 | 7.809 (-1) | 2.096 (-1) | 9.324 (-3) | | | 8.478 (-27) | | | | | | | |
| 3000 | 7.809 (-1) | 2.096 (-1) | 9.324 (-3) | | | 1.069 (-16) | | | | | | | |
| 4000 | 7.809 (-1) | 2.096 (-1) | 9.324 (-3) | 1.780 (-5) | 9.099 (-23) | 1.314 (-10) | | | | | | | |
| 5000 | 7.807 (-1) | 2.096 (-1) | 9.324 (-3) | 4.205 (-4) | 1.252 (-15) | 7.197 (-7) | | | | | | | |
| 6000 | 7.782 (-1) | 2.081 (-1) | 9.323 (-3) | 3.131 (-3) | 4.320 (-11) | 1.685 (-4) | | | | | | | |
| 7000 | 7.735 (-1) | 2.013 (-1) | 9.300 (-3) | 1.091 (-2) | 3.078 (-8) | 5.053 (-3) | | | | | | | |
| 8000 | 7.586 (-1) | 1.810 (-1) | 9.182 (-3) | 2.071 (-2) | 1.116 (-6) | 3.042 (-2) | | | | | | | |
| 9000 | 7.368 (-1) | 1.492 (-1) | 8.864 (-3) | 2.782 (-2) | 8.488 (-6) | 7.722 (-2) | | | | | | | |
| 10,000 | 7.116 (-1) | 1.112 (-1) | 8.686 (-3) | 3.161 (-2) | 3.556 (-5) | 1.368 (-1) | | | | | | | |
| 11,000 | 6.859 (-1) | 7.158 (-2) | 8.381 (-3) | 3.194 (-2) | 1.202 (-4) | 2.021 (-1) | | | | | | | |
| 12,000 | 6.624 (-1) | 3.446 (-2) | 8.079 (-3) | 2.812 (-2) | 4.281 (-4) | 2.665 (-1) | | | | | | | |
| 13,000 | 6.456 (-1) | 5.457 (-3) | 7.837 (-3) | 1.916 (-2) | 2.354 (-3) | 3.166 (-1) | | | | | | | |
| 14,000 | 6.314 (-1) | 1.318 (-3) | 7.698 (-3) | 1.075 (-2) | 1.577 (-2) | 3.330 (-1) | 1.935 (-5) | 8.564 (-10) | 7.735 (-9) | 1.935 (-5) | 3.035 (-10) | 1.521 (-8) | 2.216 (-8) |
| 15,000 | 6.040 (-1) | 4.106 (-4) | 7.549 (-3) | 7.323 (-3) | 4.904 (-2) | 3.315 (-1) | 5.173 (-5) | 1.540 (-8) | 1.816 (-8) | 5.155 (-5) | 1.330 (-8) | 1.699 (-7) | 3.790 (-8) |
| 16,000 | 5.671 (-1) | 2.047 (-4) | 7.368 (-3) | 5.729 (-3) | 9.408 (-2) | 3.253 (-1) | 9.229 (-5) | 8.540 (-8) | 3.046 (-8) | 9.138 (-5) | 1.258 (-7) | 7.156 (-7) | 5.255 (-8) |
| 17,000 | 5.254 (-1) | 1.261 (-4) | 7.168 (-3) | 4.757 (-3) | 1.449 (-1) | 3.174 (-1) | 1.371 (-4) | 2.762 (-7) | 4.380 (-8) | 1.343 (-4) | 5.934 (-7) | 1.939 (-6) | 6.620 (-8) |
| 18,000 | 4.818 (-1) | 8.652 (-5) | 6.958 (-3) | 4.060 (-3) | 1.965 (-1) | 3.087 (-1) | 1.851 (-4) | 6.701 (-7) | 5.794 (-8) | 1.784 (-4) | 1.940 (-6) | 4.170 (-6) | 7.916 (-8) |
| 19,000 | 4.381 (-1) | 6.315 (-5) | 6.743 (-3) | 3.510 (-3) | 2.535 (-1) | 2.996 (-1) | 2.366 (-4) | 1.364 (-6) | 7.277 (-8) | 2.224 (-4) | 5.094 (-6) | 7.812 (-6) | 9.173 (-8) |
| 20,000 | 3.906 (-1) | 4.785 (-5) | 6.528 (-3) | 3.050 (-3) | 3.089 (-1) | 2.903 (-1) | 2.926 (-4) | 2.467 (-5) | 8.815 (-8) | 2.651 (-4) | 1.159 (-5) | 1.238 (-5) | 1.042 (-7) |
| 21,000 | 3.453 (-1) | 3.717 (-5) | 6.313 (-3) | 2.651 (-3) | 3.639 (-1) | 2.811 (-1) | 3.547 (-4) | 4.088 (-6) | 1.039 (-7) | 2.053 (-4) | 2.383 (-5) | 2.152 (-5) | 1.169 (-7) |
| 22,000 | 3.007 (-1) | 2.830 (-5) | 6.103 (-3) | 2.295 (-3) | 4.181 (-1) | 2.719 (-1) | 4.262 (-4) | 6.332 (-6) | 1.197 (-7) | 3.412 (-4) | 4.554 (-5) | 3.311 (-5) | 1.805 (-7) |
| 23,000 | 2.571 (-1) | 2.329 (-5) | 5.897 (-3) | 1.973 (-3) | 4.711 (-1) | 2.629 (-1) | 5.120 (-4) | 9.277 (-6) | 1.353 (-7) | 3.710 (-4) | 8.244 (-5) | 4.930 (-5) | 1.457 (-7) |
| 24,000 | 2.147 (-1) | 1.856 (-5) | 5.696 (-3) | 1.676 (-3) | 5.225 (-1) | 2.542 (-1) | 6.206 (-4) | 1.295 (-5) | 1.501 (-7) | 3.925 (-4) | 1.438 (-4) | 7.176 (-5) | 1.687 (-7) |
| 25,000 | 1.739 (-1) | 1.473 (-5) | 5.503 (-3) | 1.399 (-3) | 5.719 (-1) | 2.457 (-1) | 7.663 (-4) | 1.731 (-5) | 1.636 (-7) | 4.032 (-4) | 2.428 (-4) | 1.034 (-4) | 1.865 (-7) |
| 26,000 | 1.350 (-1) | 1.157 (-5) | 5.318 (-3) | 1.139 (-3) | 6.190 (-1) | 2.376 (-1) | 9.757 (-4) | 2.217 (-5) | 1.755 (-7) | 4.007 (-4) | 4.054 (-4) | 1.475 (-4) | 2.171 (-7) |

Altitude: 180,000 feet

TABLE III - GAS COMPOSITION BEHIND NORMAL-SHOCK WAVE

MOLE FRACTION CONCENTRATIONS

| $V_1$ | $N_2$ | $O_2$ | $A$ | $NO$ | $N$ | $O$ | $e$ | $N_2^+$ | $O_2^+$ | $NO^+$ | $N^+$ | $O^+$ | $O^-$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2000 | | | | | | | | | | | | | |
| 3000 | 7.809 (-1) | 2.088 (-1) | 9.324 (-3) | | | 5.480 (-17) | | | | | | | |
| 4000 | 7.809 (-1) | 2.088 (-1) | 9.324 (-3) | 1.548 (-5) | 5.148 (-23) | 1.050 (-10) | | | | | | | |
| 5000 | 7.807 (-1) | 2.096 (-1) | 9.324 (-3) | 3.919 (-4) | 1.018 (-15) | 6.967 (-7) | | | | | | | |
| 6000 | 7.793 (-1) | 2.082 (-1) | 9.323 (-3) | 3.012 (-3) | 4.149 (-11) | 1.782 (-4) | | | | | | | |
| 7000 | 7.734 (-1) | 2.012 (-1) | 9.298 (-3) | 1.059 (-2) | 3.099 (-8) | 5.476 (-3) | | | | | | | |
| 8000 | 7.583 (-1) | 1.803 (-1) | 9.174 (-3) | 1.991 (-2) | 1.080 (-6) | 3.222 (-2) | | | | | | | |
| 9000 | 7.363 (-1) | 1.480 (-1) | 8.950 (-3) | 2.653 (-2) | 7.949 (-6) | 8.023 (-2) | | | | | | | |
| 10,000 | 7.109 (-1) | 1.097 (-1) | 8.668 (-3) | 2.999 (-2) | 3.283 (-5) | 1.437 (-1) | | | | | | | |
| 11,000 | 6.851 (-1) | 6.985 (-2) | 8.351 (-3) | 3.012 (-2) | 1.107 (-4) | 2.064 (-1) | | | | | | | |
| 12,000 | 6.616 (-1) | 3.266 (-2) | 8.058 (-3) | 2.623 (-2) | 4.018 (-4) | 2.711 (-1) | | | | | | | |
| 13,000 | 6.451 (-1) | 7.304 (-3) | 7.821 (-3) | 1.731 (-2) | 2.384 (-3) | 3.200 (-1) | | | | | | | |
| 14,000 | 6.307 (-1) | 1.069 (-3) | 7.687 (-3) | 9.494 (-3) | 1.671 (-2) | 3.343 (-1) | 1.926 (-5) | 8.422 (-10) | 6.630 (-9) | 1.926 (-5) | 3.245 (-10) | 1.571 (-8) | 1.674 (-8) |
| 15,000 | 6.024 (-1) | 3.369 (-4) | 7.537 (-3) | 6.482 (-3) | 5.112 (-2) | 3.320 (-1) | 5.070 (-5) | 1.456 (-8) | 1.517 (-8) | 5.051 (-5) | 1.353 (-8) | 1.697 (-7) | 2.889 (-8) |
| 16,000 | 5.649 (-1) | 1.697 (-4) | 7.354 (-3) | 5.083 (-3) | 9.689 (-2) | 3.254 (-1) | 8.944 (-5) | 7.839 (-8) | 2.572 (-8) | 8.855 (-5) | 1.233 (-7) | 6.982 (-7) | 3.946 (-8) |
| 17,000 | 5.228 (-1) | 1.051 (-4) | 7.153 (-3) | 4.226 (-3) | 1.481 (-1) | 3.174 (-1) | 1.319 (-4) | 2.492 (-7) | 3.679 (-8) | 1.293 (-4) | 5.696 (-7) | 1.867 (-6) | 4.947 (-8) |
| 18,000 | 4.785 (-1) | 7.253 (-5) | 6.942 (-3) | 3.608 (-3) | 2.021 (-1) | 3.085 (-1) | 1.774 (-4) | 5.985 (-7) | 4.853 (-8) | 1.710 (-4) | 1.840 (-6) | 3.984 (-6) | 5.870 (-8) |
| 19,000 | 4.331 (-1) | 5.288 (-5) | 6.727 (-3) | 3.120 (-3) | 2.573 (-1) | 2.993 (-1) | 2.259 (-4) | 1.210 (-6) | 6.036 (-8) | 2.125 (-4) | 4.793 (-6) | 7.429 (-6) | 6.782 (-8) |
| 20,000 | 3.875 (-1) | 4.013 (-5) | 6.511 (-3) | 2.711 (-3) | 3.127 (-1) | 2.900 (-1) | 2.785 (-4) | 2.178 (-6) | 7.357 (-8) | 2.528 (-4) | 1.085 (-5) | 1.269 (-5) | 7.705 (-8) |
| 21,000 | 3.421 (-1) | 3.116 (-5) | 6.297 (-3) | 2.355 (-3) | 3.679 (-1) | 2.806 (-1) | 3.370 (-4) | 3.600 (-6) | 8.631 (-8) | 2.907 (-4) | 2.226 (-5) | 2.039 (-5) | 8.687 (-8) |
| 22,000 | 2.974 (-1) | 2.456 (-5) | 6.086 (-3) | 2.037 (-3) | 4.222 (-1) | 2.714 (-1) | 4.041 (-4) | 5.569 (-6) | 1.031 (-7) | 3.247 (-4) | 4.252 (-6) | 3.138 (-5) | 9.629 (-8) |
| 23,000 | 2.538 (-1) | 1.951 (-5) | 5.880 (-3) | 1.749 (-3) | 4.752 (-1) | 2.624 (-1) | 4.848 (-4) | 8.155 (-6) | 1.132 (-7) | 3.528 (-4) | 7.705 (-6) | 4.680 (-5) | 1.074 (-7) |
| 24,000 | 2.114 (-1) | 1.552 (-5) | 5.680 (-3) | 1.483 (-3) | 5.266 (-1) | 2.536 (-1) | 5.870 (-4) | 1.139 (-5) | 1.257 (-7) | 3.730 (-4) | 1.344 (-4) | 6.829 (-5) | 1.206 (-7) |
| 25,000 | 1.705 (-1) | 1.230 (-5) | 5.487 (-3) | 1.235 (-3) | 5.761 (-1) | 2.452 (-1) | 7.248 (-4) | 1.522 (-5) | 1.373 (-7) | 3.828 (-4) | 2.284 (-4) | 9.843 (-5) | 1.372 (-7) |
| 26,000 | 1.315 (-1) | 9.626 (-6) | 5.302 (-3) | 1.001 (-3) | 6.232 (-1) | 2.371 (-1) | 9.246 (-4) | 1.951 (-5) | 1.474 (-7) | 3.797 (-4) | 3.836 (-4) | 1.417 (-4) | 1.600 (-7) |

Altitude:200,000 feet

## TABLE III - GAS COMPOSITION BEHIND NORMAL-SHOCK WAVE

MOLE FRACTION CONCENTRATIONS

| $V_1$ | $N_2$ | $O_2$ | $A$ | $NO$ | $N$ | $O$ | $e$ | $N_2^+$ | $O_2^+$ | $NO^+$ | $N^+$ | $O^+$ | $O^-$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2000 | | | | | | | | | | | | | |
| 3000 | 7.809 (-1) | 2.098 (-1) | 9.324 (-3) | | | 2.740 (-17) | | | | | | | |
| 4000 | 7.809 (-1) | 2.088 (-1) | 9.324 (-3) | 1.342 (-5) | 2.882 (-23) | 8.379 (-11) | | | | | | | |
| 5000 | 7.807 (-1) | 2.096 (-1) | 9.324 (-3) | 9.647 (-4) | 8.285 (-16) | 6.777 (-7) | | | | | | | |
| 6000 | 7.794 (-1) | 2.082 (-1) | 9.323 (-3) | 2.896 (-3) | 4.008 (-11) | 1.898 (-4) | | | | | | | |
| 7000 | 7.734 (-1) | 2.011 (-1) | 9.296 (-3) | 1.026 (-2) | 3.123 (-8) | 5.962 (-3) | | | | | | | |
| 8000 | 7.580 (-1) | 1.796 (-1) | 9.165 (-3) | 1.910 (-2) | 1.040 (-6) | 3.418 (-2) | | | | | | | |
| 9000 | 7.357 (-1) | 1.457 (-1) | 8.935 (-3) | 2.523 (-2) | 7.399 (-6) | 8.340 (-2) | | | | | | | |
| 10.000 | 7.102 (-1) | 1.081 (-1) | 8.649 (-3) | 2.635 (-2) | 3.012 (-5) | 1.447 (-1) | | | | | | | |
| 11.000 | 6.843 (-1) | 6.803 (-2) | 8.340 (-3) | 2.831 (-2) | 1.014 (-4) | 2.109 (-1) | | | | | | | |
| 12.000 | 6.607 (-1) | 3.081 (-2) | 8.037 (-3) | 2.436 (-2) | 3.761 (-4) | 2.757 (-1) | | | | | | | |
| 13.000 | 6.447 (-1) | 6.201 (-3) | 7.805 (-3) | 1.551 (-2) | 2.434 (-3) | 3.233 (-1) | | | | | | | |
| 14.000 | 6.299 (-1) | 8.561 (-4) | 7.677 (-3) | 8.327 (-3) | 1.778 (-2) | 3.354 (-1) | 1.918 (-5) | 8.296 (-10) | 5.724 (-9) | 1.917 (-5) | 3.493 (-10) | 1.628 (-8) | 1.246 (-8) |
| 15.000 | 6.007 (-1) | 2.737 (-4) | 7.525 (-3) | 5.701 (-3) | 5.335 (-2) | 3.324 (-1) | 4.959 (-5) | 1.369 (-8) | 1.305 (-8) | 4.941 (-5) | 1.373 (-8) | 1.692 (-7) | 2.033 (-8) |
| 16.000 | 5.626 (-1) | 1.393 (-4) | 7.340 (-3) | 4.483 (-3) | 9.984 (-2) | 3.255 (-1) | 8.646 (-5) | 7.148 (-8) | 2.150 (-8) | 8.560 (-5) | 1.204 (-7) | 6.790 (-7) | 2.874 (-8) |
| 17.000 | 5.201 (-1) | 8.681 (-5) | 7.138 (-3) | 3.732 (-3) | 1.515 (-1) | 3.172 (-1) | 1.267 (-4) | 2.233 (-7) | 3.060 (-8) | 1.241 (-4) | 5.442 (-7) | 1.761 (-6) | 3.596 (-8) |
| 18.000 | 4.755 (-1) | 5.994 (-5) | 6.826 (-3) | 3.188 (-3) | 2.057 (-1) | 3.082 (-1) | 1.695 (-4) | 5.306 (-7) | 4.026 (-8) | 1.634 (-4) | 1.735 (-6) | 3.791 (-6) | 4.284 (-8) |
| 19.000 | 4.300 (-1) | 4.390 (-5) | 6.711 (-3) | 2.757 (-3) | 2.611 (-1) | 2.989 (-1) | 2.151 (-4) | 1.066 (-6) | 5.040 (-8) | 2.026 (-4) | 4.487 (-6) | 7.097 (-6) | 4.949 (-8) |
| 20.000 | 3.842 (-1) | 3.335 (-5) | 6.495 (-3) | 2.395 (-3) | 3.167 (-1) | 2.896 (-1) | 2.645 (-4) | 1.909 (-5) | 6.097 (-8) | 2.405 (-4) | 1.011 (-5) | 1.198 (-5) | 5.608 (-8) |
| 21.000 | 3.388 (-1) | 2.591 (-5) | 6.280 (-3) | 2.079 (-3) | 3.720 (-1) | 2.802 (-1) | 3.193 (-4) | 3.147 (-6) | 7.185 (-8) | 2.762 (-4) | 2.069 (-5) | 1.825 (-5) | 6.280 (-8) |
| 22.000 | 2.941 (-1) | 2.042 (-5) | 6.069 (-3) | 1.797 (-3) | 4.253 (-1) | 2.709 (-1) | 3.822 (-4) | 4.862 (-6) | 8.288 (-8) | 3.082 (-4) | 3.951 (-5) | 2.963 (-5) | 6.993 (-8) |
| 23.000 | 2.503 (-1) | 1.620 (-5) | 5.863 (-3) | 1.541 (-3) | 4.794 (-1) | 2.619 (-1) | 4.578 (-4) | 7.116 (-6) | 9.383 (-8) | 3.347 (-4) | 7.167 (-5) | 4.426 (-5) | 7.792 (-8) |
| 24.000 | 2.079 (-1) | 1.288 (-5) | 5.663 (-3) | 1.304 (-3) | 5.309 (-1) | 2.531 (-1) | 5.537 (-4) | 9.938 (-6) | 1.044 (-7) | 3.537 (-4) | 1.253 (-4) | 6.477 (-5) | 8.743 (-8) |
| 25.000 | 1.671 (-1) | 1.018 (-5) | 5.470 (-3) | 1.088 (-3) | 5.808 (-1) | 2.446 (-1) | 6.835 (-4) | 1.329 (-5) | 1.142 (-7) | 3.626 (-4) | 2.138 (-4) | 9.874 (-5) | 9.054 (-8) |
| 26.000 | 1.281 (-1) | 7.940 (-6) | 5.285 (-3) | 8.738 (-4) | 6.275 (-1) | 2.365 (-1) | 8.734 (-4) | 1.705 (-5) | 1.228 (-7) | 3.591 (-4) | 3.615 (-4) | 1.357 (-4) | 1.161 (-7) |

Altitude:210,000 feet

## TABLE III - GAS COMPOSITION BEHIND NORMAL-SHOCK WAVE

MOLE FRACTION CONCENTRATIONS

| $V_1$ | $N_2$ | $O_2$ | $A$ | $NO$ | $N$ | $O$ | $e$ | $N_2^+$ | $O_2^+$ | $NO^+$ | $N^+$ | $O^+$ | $O^-$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2000 | | | | | | | | | | | | | |
| 3000 | | | | | | | | | | | | | |
| 4000 | 7.809 (-1) | 2.098 (-1) | 9.324 (-3) | 1.159 (-5) | 1.599 (-23) | 6.682 (-11) | | | | | | | |
| 5000 | 7.607 (-1) | 2.096 (-1) | 9.324 (-3) | 3.391 (-4) | 6.768 (-16) | 6.632 (-7) | | | | | | | |
| 6000 | 7.784 (-1) | 2.083 (-1) | 9.323 (-3) | 2.784 (-3) | 3.897 (-11) | 2.038 (-4) | | | | | | | |
| 7000 | 7.734 (-1) | 2.009 (-1) | 9.294 (-3) | 9.927 (-3) | 3.151 (-8) | 6.523 (-3) | | | | | | | |
| 8000 | 7.576 (-1) | 1.787 (-1) | 9.155 (-3) | 1.826 (-2) | 9.959 (-7) | 3.629 (-2) | | | | | | | |
| 9000 | 7.351 (-1) | 1.454 (-1) | 8.920 (-3) | 2.390 (-2) | 6.841 (-6) | 8.674 (-2) | | | | | | | |
| 10,000 | 7.094 (-1) | 1.064 (-1) | 8.630 (-3) | 2.670 (-2) | 2.744 (-5) | 1.488 (-1) | | | | | | | |
| 11,000 | 6.844 (-1) | 6.614 (-2) | 8.319 (-3) | 2.650 (-2) | 9.237 (-5) | 2.156 (-1) | | | | | | | |
| 12,000 | 6.598 (-1) | 2.889 (-2) | 8.015 (-3) | 2.250 (-2) | 3.510 (-4) | 2.804 (-1) | | | | | | | |
| 13,000 | 6.443 (-1) | 5.159 (-3) | 7.790 (-3) | 1.375 (-2) | 2.508 (-3) | 3.265 (-1) | | | | | | | |
| 14,000 | 6.280 (-1) | 6.759 (-4) | 7.667 (-3) | 7.235 (-3) | 1.899 (-2) | 3.364 (-1) | 1.910 (-5) | 8.178 (-10) | 4.861 (-9) | 1.909 (-5) | 3.783 (-10) | 1.692 (-8) | 9.113 (-9) |
| 15,000 | 5.988 (-1) | 2.201 (-4) | 7.513 (-3) | 4.979 (-3) | 5.574 (-2) | 3.326 (-1) | 4.840 (-5) | 1.280 (-8) | 1.090 (-8) | 4.821 (-5) | 1.389 (-8) | 1.683 (-7) | 1.616 (-8) |
| 16,000 | 5.601 (-1) | 1.133 (-4) | 7.326 (-3) | 3.927 (-3) | 1.029 (-1) | 3.254 (-1) | 8.336 (-5) | 6.470 (-8) | 1.778 (-8) | 8.252 (-5) | 1.170 (-7) | 6.578 (-7) | 2.068 (-8) |
| 17,000 | 5.173 (-1) | 7.101 (-5) | 7.122 (-3) | 3.274 (-3) | 1.550 (-1) | 3.170 (-1) | 1.212 (-4) | 1.985 (-7) | 2.518 (-8) | 1.188 (-4) | 5.172 (-7) | 1.711 (-6) | 2.583 (-8) |
| 18,000 | 4.725 (-1) | 4.920 (-5) | 6.910 (-3) | 2.799 (-3) | 2.096 (-1) | 3.079 (-1) | 1.615 (-4) | 4.666 (-7) | 3.303 (-8) | 1.558 (-4) | 1.628 (-6) | 3.592 (-6) | 3.071 (-8) |
| 19,000 | 4.268 (-1) | 3.611 (-5) | 6.694 (-3) | 2.420 (-3) | 2.651 (-1) | 2.986 (-1) | 2.048 (-4) | 9.305 (-7) | 4.129 (-8) | 1.925 (-4) | 4.176 (-6) | 6.636 (-6) | 3.543 (-8) |
| 20,000 | 3.809 (-1) | 2.745 (-5) | 6.478 (-3) | 2.102 (-3) | 3.209 (-1) | 2.891 (-1) | 2.505 (-4) | 1.660 (-6) | 4.992 (-8) | 2.281 (-4) | 9.364 (-6) | 1.127 (-5) | 4.010 (-8) |
| 21,000 | 3.354 (-1) | 2.134 (-5) | 6.263 (-3) | 1.824 (-3) | 3.762 (-1) | 2.797 (-1) | 3.016 (-4) | 2.728 (-6) | 5.883 (-8) | 2.616 (-4) | 1.912 (-5) | 1.809 (-5) | 4.485 (-8) |
| 22,000 | 2.906 (-1) | 1.641 (-5) | 6.052 (-3) | 1.575 (-3) | 4.306 (-1) | 2.704 (-1) | 3.603 (-4) | 4.208 (-6) | 6.790 (-8) | 2.917 (-4) | 3.648 (-5) | 2.785 (-5) | 4.929 (-8) |
| 23,000 | 2.469 (-1) | 1.333 (-5) | 5.846 (-3) | 1.348 (-3) | 4.837 (-1) | 2.613 (-1) | 4.309 (-4) | 6.156 (-6) | 7.696 (-8) | 3.166 (-4) | 6.627 (-5) | 4.168 (-5) | 5.551 (-8) |
| 24,000 | 2.044 (-1) | 1.058 (-5) | 5.646 (-3) | 1.139 (-3) | 5.352 (-1) | 2.525 (-1) | 5.201 (-4) | 8.600 (-6) | 8.575 (-8) | 3.394 (-4) | 1.162 (-4) | 6.118 (-5) | 6.224 (-8) |
| 25,000 | 1.635 (-1) | 8.343 (-6) | 5.453 (-3) | 9.431 (-4) | 5.848 (-1) | 2.440 (-1) | 6.429 (-4) | 1.151 (-5) | 9.396 (-8) | 3.427 (-4) | 1.992 (-4) | 8.694 (-5) | 7.083 (-8) |
| 26,000 | 1.245 (-1) | 6.485 (-6) | 5.269 (-3) | 7.577 (-4) | 6.319 (-1) | 2.358 (-1) | 8.222 (-4) | 1.478 (-5) | 1.013 (-7) | 3.388 (-4) | 3.390 (-4) | 1.296 (-4) | 8.270 (-8) |

Altitude: 220,000feet

## TABLE III - GAS COMPOSITION BEHIND NORMAL-SHOCK WAVE

MOLE FRACTION CONCENTRATIONS

| $V_1$ | $N_2$ | $O_2$ | $A$ | $NO$ | $N$ | $O$ | $e$ | $N_2^+$ | $O_2^+$ | $NO^+$ | $N^+$ | $O^+$ | $O^-$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2000 | | | | | | | | | | | | | |
| 3000 | | | | | | | | | | | | | |
| 4000 | 7.809 (-1) | 2.098 (-1) | 9.324 (-3) | 9.963 (-6) | 8.791 (-24) | 5.330 (-11) | | | | | | | |
| 5000 | 7.807 (-1) | 2.096 (-1) | 9.324 (-3) | 3.148 (-4) | 5.550 (-16) | 6.538 (-7) | | | | | | | |
| 6000 | 7.795 (-1) | 2.083 (-1) | 9.323 (-3) | 2.674 (-3) | 3.818 (-11) | 2.207 (-4) | | | | | | | |
| 7000 | 7.733 (-1) | 2.007 (-1) | 9.291 (-3) | 9.584 (-3) | 3.181 (-8) | 7.174 (-3) | | | | | | | |
| 8000 | 7.571 (-1) | 1.778 (-1) | 9.194 (-3) | 1.739 (-2) | 9.477 (-7) | 3.859 (-2) | | | | | | | |
| 9000 | 7.344 (-1) | 1.439 (-1) | 8.903 (-3) | 2.256 (-2) | 6.277 (-6) | 9.025 (-2) | | | | | | | |
| 10,000 | 7.086 (-1) | 1.046 (-1) | 8.610 (-3) | 2.505 (-2) | 2.481 (-5) | 1.531 (-1) | | | | | | | |
| 11,000 | 6.824 (-1) | 6.415 (-2) | 8.296 (-3) | 2.469 (-2) | 8.353 (-5) | 2.203 (-1) | | | | | | | |
| 12,000 | 6.589 (-1) | 2.691 (-2) | 7.988 (-3) | 2.067 (-2) | 3.266 (-4) | 2.852 (-1) | | | | | | | |
| 13,000 | 6.436 (-1) | 4.192 (-2) | 7.776 (-3) | 1.205 (-2) | 2.615 (-3) | 3.295 (-1) | | | | | | | |
| 14,000 | 6.279 (-1) | 5.258 (-4) | 7.657 (-3) | 6.236 (-3) | 2.036 (-2) | 3.373 (-1) | 1.901 (-5) | 8.056 (-10) | 4.086 (-9) | 1.899 (-5) | 4.116 (-10) | 1.761 (-8) | 6.540 (-9) |
| 15,000 | 5.968 (-1) | 1.743 (-4) | 7.500 (-3) | 4.316 (-3) | 5.831 (-2) | 3.328 (-1) | 4.711 (-5) | 1.188 (-8) | 8.994 (-9) | 4.692 (-5) | 1.401 (-8) | 1.668 (-7) | 1.076 (-8) |
| 16,000 | 5.575 (-1) | 9.110 (-5) | 7.311 (-3) | 3.815 (-3) | 1.062 (-1) | 3.253 (-1) | 8.013 (-5) | 5.807 (-8) | 1.453 (-8) | 7.932 (-5) | 1.131 (-7) | 6.345 (-7) | 1.461 (-8) |
| 17,000 | 5.183 (-1) | 5.746 (-5) | 7.106 (-3) | 2.851 (-3) | 1.587 (-1) | 3.167 (-1) | 1.157 (-4) | 1.749 (-7) | 2.047 (-8) | 1.134 (-4) | 4.886 (-7) | 1.626 (-6) | 1.818 (-8) |
| 18,000 | 4.693 (-1) | 3.995 (-5) | 6.893 (-3) | 2.439 (-3) | 2.135 (-1) | 3.075 (-1) | 1.523 (-4) | 4.065 (-7) | 2.678 (-8) | 1.480 (-4) | 1.517 (-6) | 3.387 (-6) | 2.358 (-8) |
| 19,000 | 4.234 (-1) | 2.938 (-5) | 6.677 (-3) | 2.109 (-3) | 2.692 (-1) | 2.861 (-1) | 1.933 (-4) | 8.049 (-7) | 3.342 (-8) | 1.824 (-4) | 3.861 (-6) | 6.226 (-6) | 2.485 (-8) |
| 20,000 | 3.775 (-1) | 2.236 (-5) | 6.461 (-3) | 1.831 (-3) | 3.251 (-1) | 2.636 (-1) | 2.363 (-4) | 1.429 (-6) | 4.037 (-8) | 2.157 (-4) | 8.616 (-6) | 1.055 (-5) | 2.610 (-8) |
| 21,000 | 3.319 (-1) | 1.739 (-5) | 6.246 (-3) | 1.588 (-3) | 3.805 (-1) | 2.792 (-1) | 2.839 (-4) | 2.343 (-6) | 4.758 (-8) | 2.471 (-4) | 1.755 (-5) | 1.691 (-5) | 2.389 (-8) |
| 22,000 | 2.871 (-1) | 1.370 (-5) | 6.035 (-3) | 1.371 (-3) | 4.349 (-1) | 2.899 (-1) | 3.384 (-4) | 3.607 (-6) | 5.496 (-8) | 2.752 (-4) | 3.347 (-5) | 2.606 (-5) | 2.488 (-8) |
| 23,000 | 2.423 (-1) | 1.086 (-5) | 5.829 (-3) | 1.172 (-3) | 4.881 (-1) | 2.608 (-1) | 4.039 (-4) | 5.275 (-6) | 6.238 (-8) | 2.987 (-4) | 6.066 (-5) | 3.906 (-5) | 2.679 (-8) |
| 24,000 | 2.008 (-1) | 8.602 (-6) | 5.628 (-3) | 9.878 (-4) | 5.396 (-1) | 2.519 (-1) | 4.873 (-4) | 7.374 (-6) | 6.963 (-8) | 3.154 (-4) | 1.070 (-4) | 5.753 (-5) | 4.348 (-8) |
| 25,000 | 1.600 (-1) | 6.769 (-6) | 5.436 (-3) | 8.154 (-4) | 5.892 (-1) | 2.434 (-1) | 6.013 (-4) | 9.879 (-6) | 7.646 (-8) | 3.230 (-4) | 1.844 (-4) | 8.402 (-5) | 4.844 (-8) |
| 26,000 | 1.209 (-1) | 5.240 (-6) | 5.251 (-3) | 6.518 (-4) | 6.364 (-1) | 2.352 (-1) | 7.710 (-4) | 1.270 (-5) | 8.258 (-8) | 3.187 (-4) | 3.162 (-4) | 1.283 (-4) | 5.772 (-8) |

Altitude:230,000 feet

## TABLE III - GAS COMPOSITION BEHIND NORMAL-SHOCK WAVE

MOLE FRACTION CONCENTRATIONS

| $V_1$ | $N_2$ | $O_2$ | $A$ | $NO$ | $N$ | $O$ | $e$ | $N_2^+$ | $O_2^+$ | $NO^+$ | $N^+$ | $O^+$ | $O^-$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2000 | | | | | | | | | | | | | |
| 3000 | | | | | | | | | | | | | |
| 4000 | 7.809 (-1) | 2.098 (-1) | 9.324 (-3) | 8.541 (-6) | 8.789 (-24) | 4.254 (-11) | | | | | | | |
| 5000 | 7.807 (-1) | 2.096 (-1) | 9.324 (-3) | 2.919 (-4) | 4.573 (-18) | 6.496 (-7) | | | | | | | |
| 6000 | 7.795 (-1) | 2.084 (-1) | 9.323 (-3) | 2.567 (-3) | 3.773 (-11) | 2.415 (-4) | | | | | | | |
| 7000 | 7.732 (-1) | 2.004 (-1) | 9.287 (-3) | 9.231 (-3) | 3.211 (-8) | 7.930 (-3) | | | | | | | |
| 8000 | 7.586 (-1) | 1.767 (-1) | 9.132 (-3) | 1.650 (-2) | 8.952 (-7) | 4.109 (-2) | | | | | | | |
| 9000 | 7.334 (-1) | 1.421 (-1) | 8.884 (-3) | 2.123 (-2) | 5.769 (-6) | 9.433 (-2) | | | | | | | |
| 10,000 | 7.076 (-1) | 1.027 (-1) | 8.588 (-3) | 2.340 (-2) | 2.232 (-5) | 1.577 (-1) | | | | | | | |
| 11,000 | 6.814 (-1) | 6.206 (-2) | 8.273 (-3) | 2.290 (-2) | 7.503 (-5) | 2.253 (-1) | | | | | | | |
| 12,000 | 6.579 (-1) | 2.487 (-2) | 7.970 (-3) | 1.885 (-2) | 3.043 (-4) | 2.901 (-1) | | | | | | | |
| 13,000 | 6.435 (-1) | 3.316 (-3) | 7.762 (-3) | 1.042 (-2) | 2.763 (-3) | 3.322 (-1) | | | | | | | |
| 14,000 | 6.267 (-1) | 4.028 (-4) | 7.646 (-3) | 5.324 (-3) | 2.190 (-2) | 3.379 (-1) | 1.889 (-5) | 7.918 (-10) | 3.394 (-9) | 1.887 (-5) | 4.492 (-10) | 1.835 (-8) | 4.598 (-9) |
| 15,000 | 5.946 (-1) | 1.371 (-4) | 7.487 (-3) | 3.709 (-3) | 6.105 (-2) | 3.329 (-1) | 4.572 (-5) | 1.093 (-8) | 7.325 (-9) | 4.553 (-5) | 1.406 (-8) | 1.646 (-7) | 7.473 (-9) |
| 16,000 | 5.547 (-1) | 7.236 (-5) | 7.296 (-3) | 2.945 (-3) | 1.096 (-1) | 3.252 (-1) | 7.676 (-5) | 5.153 (-8) | 1.17[illegible] (-8) | 7.599 (-5) | 1.086 (-7) | 6.091 (-7) | 1.009 (-8) |
| 17,000 | 5.112 (-1) | 4.594 (-5) | 7.090 (-3) | 2.462 (-3) | 1.675 (-1) | 3.164 (-1) | 1.100 (-4) | 1.526 (-7) | 1.692 (-8) | 1.079 (-4) | 4.584 (-7) | 1.538 (-6) | 1.252 (-8) |
| 18,000 | 4.660 (-1) | 3.206 (-5) | 6.876 (-3) | 2.108 (-3) | 2.176 (-1) | 3.071 (-1) | 1.451 (-4) | 3.506 (-7) | 2.14 (-8) | 1.401 (-4) | 1.404 (-6) | 3.176 (-6) | 1.488 (-8) |
| 19,000 | 4.200 (-1) | 2.362 (-5) | 6.660 (-3) | 1.823 (-3) | 2.735 (-1) | 2.976 (-1) | 1.822 (-4) | 6.891 (-7) | 2.664 (-8) | 1.722 (-4) | 3.544 (-6) | 5.810 (-6) | 1.706 (-8) |
| 20,000 | 3.740 (-1) | 1.800 (-5) | 6.442 (-3) | 1.582 (-3) | 3.294 (-1) | 2.881 (-1) | 2.221 (-4) | 1.216 (-6) | 3.221 (-8) | 2.032 (-4) | 7.870 (-6) | 9.820 (-6) | 1.926 (-8) |
| 21,000 | 3.283 (-1) | 1.401 (-5) | 6.228 (-3) | 1.372 (-3) | 3.849 (-1) | 2.786 (-1) | 2.652 (-4) | 1.990 (-6) | 3.79[illegible] (-8) | 2.325 (-4) | 1.599 (-5) | 1.572 (-5) | 2.140 (-8) |
| 22,000 | 2.835 (-1) | 1.103 (-5) | 6.017 (-3) | 1.185 (-3) | 4.394 (-1) | 2.693 (-1) | 3.166 (-4) | 3.060 (-6) | 4.390 (-8) | 2.588 (-4) | 3.048 (-5) | 2.424 (-5) | 2.285 (-8) |
| 23,000 | 2.357 (-1) | 8.736 (-6) | 5.811 (-3) | 1.010 (-3) | 4.926 (-1) | 2.602 (-1) | 3.771 (-4) | 4.473 (-6) | 4.989 (-8) | 2.807 (-4) | 5.550 (-5) | 3.641 (-5) | 2.648 (-8) |
| 24,000 | 1.872 (-1) | 6.913 (-6) | 5.611 (-3) | 8.495 (-4) | 5.441 (-1) | 2.513 (-1) | 4.544 (-4) | 6.254 (-6) | 5.580 (-8) | 2.964 (-4) | 9.789 (-5) | 5.380 (-5) | 2.862 (-8) |
| 25,000 | 1.563 (-1) | 5.425 (-6) | 5.418 (-3) | 6.989 (-4) | 5.938 (-1) | 2.427 (-1) | 5.605 (-4) | 8.389 (-6) | 6.142 (-8) | 3.034 (-4) | 1.696 (-4) | 7.902 (-5) | 3.368 (-8) |
| 26,000 | 1.173 (-1) | 4.183 (-6) | 5.234 (-3) | 5.559 (-4) | 6.410 (-1) | 2.345 (-1) | 7.199 (-4) | 1.080 (-5) | 6.651 (-8) | 2.990 (-4) | 2.932 (-4) | 1.168 (-4) | 3.928 (-8) |

Altitude: 240,000 feet

TABLE III - GAS COMPOSITION BEHIND NORMAL-SHOCK WAVE

| $V_1$ | $N_2$ | $O_2$ | $A$ | $NO$ | $N$ | $O$ | $e$ | $N_2^+$ | $O_2^+$ | $NO^+$ | $N^+$ | $O^+$ | $O^-$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | MOLE FRACTION CONCENTRATIONS | | | | | | | | | | | | |
| 2000 | | | | | | | | | | | | | |
| 3000 | | | | | | | | | | | | | |
| 4000 | 7.809 (-1) | 2.098 (-1) | 9.324 (-3) | 7.289 (-6) | 2.589 (-24) | 3.404 (-11) | | | | | | | |
| 5000 | 7.807 (-1) | 2.097 (-1) | 9.324 (-3) | 2.703 (-4) | 3.798 (-16) | 6.518 (-7) | | | | | | | |
| 6000 | 7.795 (-1) | 2.094 (-1) | 9.323 (-3) | 2.462 (-3) | 3.765 (-11) | 2.673 (-4) | | | | | | | |
| 7000 | 7.730 (-1) | 2.000 (-1) | 9.293 (-3) | 8.889 (-3) | 3.238 (-8) | 8.816 (-3) | | | | | | | |
| 8000 | 7.560 (-1) | 1.755 (-1) | 9.120 (-3) | 1.559 (-2) | 8.384 (-7) | 4.381 (-2) | | | | | | | |
| 9000 | 7.326 (-1) | 1.404 (-1) | 8.866 (-3) | 1.986 (-2) | 5.202 (-6) | 9.831 (-2) | | | | | | | |
| 10,000 | 7.066 (-1) | 1.006 (-1) | 8.586 (-3) | 2.178 (-2) | 1.983 (-5) | 1.625 (-1) | | | | | | | |
| 11,000 | 6.803 (-1) | 5.886 (-2) | 8.250 (-3) | 2.111 (-2) | 6.677 (-5) | 2.304 (-1) | | | | | | | |
| 12,000 | 6.569 (-1) | 2.275 (-2) | 7.947 (-3) | 1.705 (-2) | 2.806 (-4) | 2.951 (-1) | | | | | | | |
| 13,000 | 6.431 (-1) | 2.543 (-3) | 7.749 (-3) | 8.882 (-3) | 2.967 (-3) | 3.346 (-1) | | | | | | | |
| 14,000 | 6.254 (-1) | 8.032 (-4) | 7.636 (-3) | 4.497 (-3) | 2.364 (-2) | 3.395 (-1) | 1.875 (-5) | 7.750 (-10) | 2.780 (-9) | 1.873 (-5) | 4.911 (-10) | 1.912 (-8) | 3.147 (-9) |
| 15,000 | 5.823 (-1) | 1.080 (-4) | 7.473 (-3) | 3.157 (-3) | 6.399 (-2) | 3.329 (-1) | 4.421 (-5) | 9.965 (-9) | 5.876 (-9) | 4.402 (-5) | 1.403 (-8) | 1.617 (-7) | 5.060 (-9) |
| 16,000 | 5.518 (-1) | 5.668 (-5) | 7.281 (-3) | 2.515 (-3) | 1.132 (-1) | 3.249 (-1) | 7.324 (-5) | 4.590 (-8) | 9.303 (-9) | 7.251 (-5) | 1.036 (-7) | 5.814 (-7) | 6.782 (-9) |
| 17,000 | 5.080 (-1) | 3.623 (-5) | 7.073 (-3) | 2.107 (-3) | 1.685 (-1) | 3.160 (-1) | 1.092 (-4) | 1.316 (-7) | 1.297 (-8) | 1.022 (-4) | 4.268 (-7) | 1.846 (-6) | 8.405 (-9) |
| 18,000 | 4.625 (-1) | 2.538 (-5) | 6.859 (-3) | 1.805 (-3) | 2.218 (-1) | 3.067 (-1) | 1.367 (-4) | 2.953 (-7) | 1.686 (-8) | 1.321 (-4) | 1.289 (-6) | 2.960 (-6) | 9.937 (-9) |
| 19,000 | 4.164 (-1) | 1.875 (-5) | 6.642 (-3) | 1.561 (-3) | 2.779 (-1) | 2.971 (-1) | 1.711 (-4) | 5.829 (-7) | 2.098 (-8) | 1.618 (-4) | 3.226 (-6) | 5.387 (-6) | 1.141 (-8) |
| 20,000 | 3.703 (-1) | 1.630 (-5) | 6.425 (-3) | 1.355 (-3) | 3.339 (-1) | 2.875 (-1) | 2.079 (-4) | 1.025 (-6) | 2.531 (-8) | 1.907 (-4) | 7.127 (-6) | 9.080 (-6) | 1.287 (-8) |
| 21,000 | 3.246 (-1) | 1.113 (-5) | 6.210 (-3) | 1.176 (-3) | 3.894 (-1) | 2.780 (-1) | 2.485 (-4) | 1.670 (-6) | 2.[illegible] (-8) | 2.178 (-4) | 1.844 (-5) | 1.453 (-5) | 1.484 (-8) |
| 22,000 | 2.798 (-1) | 8.766 (-6) | 5.990 (-3) | 1.011 (-3) | 4.440 (-1) | 2.687 (-1) | 2.949 (-4) | 2.564 (-6) | 3.453 (-8) | 2.424 (-4) | 2.752 (-5) | 2.241 (-5) | 1.583 (-8) |
| 23,000 | 2.360 (-1) | 6.837 (-6) | 5.793 (-3) | 8.620 (-4) | 4.872 (-1) | 2.595 (-1) | 3.506 (-4) | 3.747 (-6) | 3.930 (-8) | 2.629 (-4) | 5.018 (-5) | 3.873 (-5) | 1.782 (-8) |
| 24,000 | 1.926 (-1) | 5.481 (-6) | 5.583 (-3) | 7.236 (-4) | 5.487 (-1) | 2.506 (-1) | 4.217 (-4) | 5.242 (-6) | 4.405 (-8) | 2.775 (-4) | 8.883 (-5) | 6.003 (-5) | 1.889 (-8) |
| 25,000 | 1.525 (-1) | 4.290 (-6) | 5.400 (-3) | 5.933 (-4) | 5.884 (-1) | 2.420 (-1) | 5.199 (-4) | 7.041 (-6) | 4.863 (-8) | 2.841 (-4) | 1.548 (-4) | 7.391 (-5) | 2.237 (-8) |
| 26,000 | 1.135 (-1) | 3.293 (-6) | 5.216 (-3) | 4.638 (-4) | 6.456 (-1) | 2.339 (-1) | 6.689 (-4) | 9.075 (-6) | 5.281 (-8) | 2.796 (-4) | 2.700 (-4) | 1.102 (-4) | 2.618 (-8) |

Altitude: 250,000 feet

## TABLE III - GAS COMPOSITION BEHIND NORMAL-SHOCK WAVE

MOLE FRACTION CONCENTRATIONS

| $V_1$ | $N_2$ | $O_2$ | $A$ | $NO$ | $N$ | $O$ | $e$ | $N_2^+$ | $O_2^+$ | $NO^+$ | $N^+$ | $O^+$ | $O^-$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2000 | | | | | | | | | | | | | |
| 3000 | | | | | | | | | | | | | |
| 4000 | 7.809 (-1) | 2.098 (-1) | 9.324 (-3) | 6.195 (-6) | 1.391 (-24) | 2.734 (-11) | | | | | | | |
| 5000 | 7.808 (-1) | 2.097 (-1) | 9.324 (-3) | 2.500 (-4) | 3.172 (-16) | 6.616 (-7) | | | | | | | |
| 6000 | 7.796 (-1) | 2.094 (-1) | 9.323 (-3) | 2.361 (-3) | 3.802 (-11) | 2.999 (-4) | | | | | | | |
| 7000 | 7.728 (-1) | 1.996 (-1) | 9.278 (-3) | 8.482 (-3) | 3.258 (-8) | 9.858 (-3) | | | | | | | |
| 8000 | 7.553 (-1) | 1.742 (-1) | 9.106 (-3) | 1.465 (-2) | 7.772 (-7) | 4.677 (-2) | | | | | | | |
| 9000 | 7.316 (-1) | 1.385 (-1) | 8.846 (-3) | 1.847 (-2) | 4.639 (-6) | 1.025 (-1) | | | | | | | |
| 10,000 | 7.055 (-1) | 9.849 (-2) | 8.543 (-3) | 2.008 (-2) | 1.742 (-5) | 1.674 (-1) | | | | | | | |
| 11,000 | 6.791 (-1) | 5.754 (-2) | 8.225 (-3) | 1.934 (-2) | 5.885 (-5) | 2.357 (-1) | | | | | | | |
| 12,000 | 6.558 (-1) | 2.056 (-2) | 7.923 (-3) | 1.529 (-2) | 2.593 (-4) | 3.002 (-1) | | | | | | | |
| 13,000 | 6.427 (-1) | 1.883 (-3) | 7.736 (-3) | 7.440 (-3) | 3.243 (-3) | 3.370 (-1) | | | | | | | |
| 14,000 | 6.238 (-1) | 2.240 (-4) | 7.625 (-3) | 3.755 (-3) | 2.560 (-2) | 3.389 (-1) | 1.856 (-5) | 7.539 (-10) | 2.241 (-9) | 1.853 (-5) | 5.369 (-10) | 1.888 (-8) | 2.097 (-9) |
| 15,000 | 5.898 (-1) | 8.065 (-5) | 7.459 (-3) | 2.658 (-3) | 6.716 (-2) | 3.328 (-1) | 4.257 (-5) | 8.979 (-9) | 4.633 (-9) | 4.239 (-5) | 1.890 (-8) | 1.560 (-7) | 3.329 (-9) |
| 16,000 | 5.488 (-1) | 4.371 (-5) | 7.264 (-3) | 2.126 (-3) | 1.170 (-1) | 3.246 (-1) | 6.558 (-5) | 3.943 (-8) | 7.260 (-9) | 6.889 (-5) | 9.800 (-8) | 5.513 (-7) | 4.444 (-9) |
| 17,000 | 5.046 (-1) | 2.814 (-5) | 7.056 (-3) | 1.784 (-3) | 1.707 (-1) | 3.156 (-1) | 9.819 (-5) | 1.120 (-7) | 1.007 (-8) | 9.633 (-5) | 3.939 (-7) | 1.350 (-6) | 5.982 (-9) |
| 18,000 | 4.589 (-1) | 1.979 (-5) | 6.841 (-3) | 1.529 (-3) | 2.263 (-1) | 3.061 (-1) | 1.282 (-4) | 2.513 (-7) | 1.305 (-8) | 1.240 (-4) | 1.173 (-6) | 2.789 (-6) | 6.466 (-9) |
| 19,000 | 4.127 (-1) | 1.465 (-5) | 6.623 (-3) | 1.323 (-3) | 2.825 (-1) | 2.965 (-1) | 1.598 (-4) | 4.864 (-7) | 1.621 (-8) | 1.514 (-4) | 2.908 (-6) | 4.958 (-6) | 7.419 (-9) |
| 20,000 | 3.665 (-1) | 1.119 (-5) | 6.406 (-3) | 1.148 (-3) | 3.386 (-1) | 2.869 (-1) | 1.937 (-4) | 8.511 (-7) | 1.954 (-8) | 1.781 (-4) | 6.292 (-6) | 6.335 (-6) | 8.354 (-9) |
| 21,000 | 3.208 (-1) | 8.714 (-6) | 6.191 (-3) | 9.941 (-4) | 3.941 (-1) | 2.774 (-1) | 2.308 (-4) | 1.363 (-6) | 2.304 (-8) | 2.032 (-4) | 1.292 (-5) | 1.332 (-5) | 9.298 (-9) |
| 22,000 | 2.759 (-1) | 6.862 (-6) | 5.980 (-3) | 8.553 (-4) | 4.487 (-1) | 2.680 (-1) | 2.733 (-4) | 2.119 (-6) | 2.659 (-8) | 2.260 (-4) | 2.461 (-5) | 2.057 (-5) | 1.029 (-8) |
| 23,000 | 2.321 (-1) | 5.425 (-6) | 5.774 (-3) | 7.281 (-4) | 5.019 (-1) | 2.588 (-1) | 3.241 (-4) | 3.095 (-6) | 3.043 (-8) | 2.451 (-4) | 4.495 (-5) | 3.103 (-5) | 1.139 (-8) |
| 24,000 | 1.896 (-1) | 4.280 (-6) | 5.574 (-3) | 6.098 (-4) | 5.535 (-1) | 2.499 (-1) | 3.892 (-4) | 4.334 (-6) | 3.420 (-8) | 2.588 (-4) | 7.987 (-5) | 4.622 (-5) | 1.271 (-8) |
| 25,000 | 1.487 (-1) | 3.341 (-6) | 5.382 (-3) | 4.983 (-4) | 6.031 (-1) | 2.413 (-1) | 4.794 (-4) | 5.830 (-6) | 3.786 (-8) | 2.649 (-4) | 1.400 (-4) | 6.868 (-5) | 1.443 (-8) |
| 26,000 | 1.097 (-1) | 2.553 (-6) | 5.198 (-3) | 3.918 (-4) | 6.504 (-1) | 2.331 (-1) | 6.180 (-4) | 7.529 (-6) | 4.126 (-8) | 2.604 (-4) | 2.467 (-4) | 1.034 (-4) | 1.690 (-8) |

Altitude: 200,000 feet

TABLE III - GAS COMPOSITION BEHIND NORMAL-SHOCK WAVE

MOLE FRACTION CONCENTRATIONS

| $V_1$ | $N_2$ | $O_2$ | $A$ | $NO$ | $N$ | $O$ | $e$ | $N_2^+$ | $O_2^+$ | $NO^+$ | $N^+$ | $O^+$ | $O^-$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2000 | | | | | | | | | | | | | |
| 3000 | | | | | | | | | | | | | |
| 4000 | 7.809 (-1) | 2.088 (-1) | 9.324 (-3) | 5.242 (-6) | 7.424 (-25) | 2.207 (-11) | | | | | | | |
| 5000 | 7.808 (-1) | 2.087 (-1) | 9.324 (-3) | 2.309 (-4) | 2.679 (-16) | 6.807 (-7) | | | | | | | |
| 6000 | 7.796 (-1) | 2.085 (-1) | 9.322 (-3) | 2.261 (-3) | 3.890 (-11) | 3.415 (-4) | | | | | | | |
| 7000 | 7.725 (-1) | 1.930 (-1) | 9.272 (-3) | 8.081 (-3) | 3.265 (-8) | 1.109 (-2) | | | | | | | |
| 8000 | 7.545 (-1) | 1.727 (-1) | 9.091 (-3) | 1.368 (-2) | 7.120 (-7) | 5.001 (-2) | | | | | | | |
| 9000 | 7.306 (-1) | 1.365 (-1) | 8.825 (-3) | 1.707 (-2) | 4.084 (-6) | 1.070 (-1) | | | | | | | |
| 10.000 | 7.043 (-1) | 9.619 (-2) | 8.519 (-3) | 1.843 (-2) | 1.512 (-5) | 1.726 (-1) | | | | | | | |
| 11.000 | 6.779 (-1) | 5.509 (-2) | 8.199 (-3) | 1.759 (-2) | 5.131 (-5) | 2.412 (-1) | | | | | | | |
| 12.000 | 6.547 (-1) | 1.830 (-2) | 7.899 (-3) | 1.355 (-2) | 2.363 (-4) | 3.053 (-1) | | | | | | | |
| 13.000 | 6.423 (-1) | 1.341 (-3) | 7.727 (-3) | 6.113 (-3) | 3.615 (-3) | 3.389 (-1) | | | | | | | |
| 14.000 | 6.721 (-1) | 1.520 (-4) | 7.613 (-3) | 3.093 (-3) | 2.783 (-2) | 3.392 (-1) | 1.832 (-5) | 7.284 (-10) | 1.774 (-9) | 1.830 (-5) | 5.872 (-10) | 2.065 (-8) | 1.852 (-8) |
| 15.000 | 5.870 (-1) | 6.020 (-5) | 7.444 (-3) | 2.210 (-3) | 7.060 (-2) | 3.326 (-1) | 4.081 (-5) | 7.992 (-9) | 3.583 (-9) | 4.064 (-5) | 1.368 (-8) | 1.584 (-7) | 2.120 (-8) |
| 16.000 | 5.455 (-1) | 3.310 (-5) | 7.247 (-3) | 1.775 (-3) | 1.211 (-1) | 3.242 (-1) | 6.578 (-5) | 3.378 (-8) | 5.555 (-9) | 6.513 (-5) | 9.190 (-8) | 5.182 (-7) | 2.813 (-8) |
| 17.000 | 5.010 (-1) | 2.146 (-5) | 7.038 (-3) | 1.492 (-3) | 1.752 (-1) | 3.151 (-1) | 9.209 (-5) | 9.398 (-8) | 7.658 (-9) | 9.038 (-5) | 3.600 (-7) | 1.251 (-6) | 3.459 (-8) |
| 18.000 | 4.552 (-1) | 1.516 (-5) | 6.822 (-3) | 1.280 (-3) | 2.309 (-1) | 3.056 (-1) | 1.196 (-4) | 2.082 (-7) | 9.895 (-9) | 1.158 (-4) | 1.056 (-6) | 2.515 (-6) | 4.674 (-8) |
| 19.000 | 4.088 (-1) | 1.125 (-5) | 6.604 (-3) | 1.108 (-3) | 2.872 (-1) | 2.959 (-1) | 1.485 (-4) | 3.998 (-7) | 1.227 (-8) | 1.410 (-4) | 2.596 (-6) | 4.528 (-6) | 4.666 (-8) |
| 20.000 | 3.626 (-1) | 8.603 (-6) | 6.387 (-3) | 9.611 (-4) | 3.435 (-1) | 2.863 (-1) | 1.793 (-4) | 6.959 (-7) | 1.475 (-8) | 1.654 (-4) | 5.672 (-6) | 7.589 (-6) | 5.247 (-8) |
| 21.000 | 3.168 (-1) | 6.704 (-6) | 6.172 (-3) | 8.316 (-4) | 3.990 (-1) | 2.767 (-1) | 2.132 (-4) | 1.127 (-6) | 1.744 (-8) | 1.886 (-4) | 1.143 (-5) | 1.212 (-5) | 5.834 (-8) |
| 22.000 | 2.719 (-1) | 5.278 (-6) | 5.961 (-3) | 7.148 (-4) | 4.536 (-1) | 2.673 (-1) | 2.518 (-4) | 1.724 (-6) | 2.022 (-8) | 2.096 (-4) | 2.177 (-5) | 1.872 (-5) | 6.444 (-8) |
| 23.000 | 2.281 (-1) | 4.170 (-6) | 5.755 (-3) | 6.075 (-4) | 5.068 (-1) | 2.581 (-1) | 2.980 (-4) | 2.518 (-6) | 2.310 (-8) | 2.273 (-4) | 3.983 (-5) | 2.832 (-5) | 7.124 (-8) |
| 24.000 | 1.856 (-1) | 3.284 (-6) | 5.555 (-3) | 5.076 (-4) | 5.584 (-1) | 2.492 (-1) | 3.571 (-4) | 3.528 (-6) | 2.603 (-8) | 2.601 (-4) | 7.107 (-5) | 4.238 (-5) | 7.887 (-8) |
| 25.000 | 1.447 (-1) | 2.556 (-6) | 5.363 (-3) | 4.132 (-4) | 6.060 (-1) | 2.406 (-1) | 4.395 (-4) | 4.755 (-6) | 2.892 (-8) | 2.958 (-4) | 1.255 (-4) | 6.341 (-5) | 8.000 (-8) |
| 26.000 | 1.057 (-1) | 1.943 (-6) | 5.179 (-3) | 3.228 (-4) | 6.552 (-1) | 2.324 (-1) | 5.674 (-4) | 6.153 (-6) | 3.164 (-8) | 3.415 (-4) | 2.234 (-4) | 9.639 (-5) | 1.055 (-8) |

Altitude: 270,000 feet

TABLE III - GAS COMPOSITION BEHIND NORMAL-SHOCK WAVE

MOLE FRACTION CONCENTRATIONS

| $V_1$ | $N_2$ | $O_2$ | $A$ | $NO$ | $N$ | $O$ | $e$ | $N_2^+$ | $O_2^+$ | $NO^+$ | $N^+$ | $O^+$ | $O^-$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2000 | | | | | | | | | | | | | |
| 3000 | | | | | | | | | | | | | |
| 4000 | 7.809 (-1) | 2.098 (-1) | 9.324 (-3) | 5.028 (-6) | 8.023 (-25) | 2.643 (-11) | | | | | | | |
| 5000 | 7.808 (-1) | 2.097 (-1) | 9.324 (-3) | 2.264 (-4) | 3.246 (-16) | 8.660 (-7) | | | | | | | |
| 6000 | 7.796 (-1) | 2.084 (-1) | 9.322 (-3) | 2.231 (-3) | 4.878 (-11) | 4.424 (-4) | | | | | | | |
| 7000 | 7.719 (-1) | 1.980 (-1) | 9.263 (-3) | 7.719 (-3) | 3.494 (-8) | 1.317 (-2) | | | | | | | |
| 8000 | 7.532 (-1) | 1.704 (-1) | 9.069 (-3) | 1.266 (-2) | 6.569 (-7) | 5.467 (-2) | | | | | | | |
| 9000 | 7.290 (-1) | 1.336 (-1) | 8.797 (-3) | 1.556 (-2) | 3.561 (-6) | 1.130 (-1) | | | | | | | |
| 10,000 | 7.025 (-1) | 9.299 (-2) | 8.488 (-3) | 1.663 (-2) | 1.292 (-5) | 1.793 (-1) | | | | | | | |
| 11,000 | 6.761 (-1) | 5.180 (-2) | 8.167 (-3) | 1.568 (-2) | 4.419 (-5) | 2.482 (-1) | | | | | | | |
| 12,000 | 6.532 (-1) | 1.546 (-2) | 7.870 (-3) | 1.164 (-2) | 2.295 (-4) | 3.116 (-1) | | | | | | | |
| 13,000 | 6.417 (-1) | 8.577 (-4) | 7.716 (-3) | 4.774 (-3) | 4.280 (-3) | 3.407 (-1) | | | | | | | |
| 14,000 | 6.197 (-1) | 1.097 (-4) | 7.598 (-3) | 2.154 (-3) | 3.089 (-2) | 3.393 (-1) | | | | | | | |
| 15,000 | 5.834 (-1) | 5.254 (-5) | 7.425 (-3) | 1.776 (-3) | 7.499 (-2) | 3.322 (-1) | 3.889 (-5) | 7.002 (-9) | 2.650 (-9) | 3.872 (-5) | 1.351 (-8) | 1.488 (-7) | 1.245 (-8) |
| 16,000 | 5.414 (-1) | 2.381 (-5) | 7.226 (-3) | 1.423 (-3) | 1.262 (-1) | 3.236 (-1) | 6.162 (-5) | 2.822 (-8) | 4.054 (-9) | 6.102 (-5) | 3.547 (-8) | 4.847 (-7) | 1.640 (-8) |
| 17,000 | 4.966 (-1) | 1.559 (-5) | 7.015 (-3) | 1.208 (-3) | 1.806 (-1) | 3.144 (-1) | 8.544 (-5) | 7.655 (-8) | 5.551 (-9) | 8.389 (-5) | 3.244 (-7) | 1.145 (-6) | 2.010 (-8) |
| 18,000 | 4.506 (-1) | 1.107 (-5) | 6.799 (-3) | 1.037 (-3) | 2.366 (-1) | 3.048 (-1) | 1.103 (-4) | 1.670 (-7) | 7.146 (-9) | 1.069 (-4) | 9.341 (-7) | 2.275 (-6) | 2.861 (-8) |
| 19,000 | 4.041 (-1) | 8.237 (-6) | 6.581 (-3) | 8.983 (-4) | 2.930 (-1) | 2.951 (-1) | 1.363 (-4) | 3.175 (-7) | 8.843 (-9) | 1.296 (-4) | 2.269 (-6) | 4.070 (-6) | 2.790 (-8) |
| 20,000 | 3.579 (-1) | 6.312 (-6) | 6.364 (-3) | 7.792 (-4) | 3.493 (-1) | 2.854 (-1) | 1.640 (-4) | 5.491 (-7) | 1.065 (-8) | 1.517 (-4) | 4.927 (-6) | 6.796 (-6) | 3.031 (-8) |
| 21,000 | 3.121 (-1) | 4.922 (-6) | 6.149 (-3) | 6.738 (-4) | 4.048 (-1) | 2.758 (-1) | 1.943 (-4) | 8.855 (-7) | 1.256 (-8) | 1.727 (-4) | 9.897 (-6) | 1.084 (-5) | 3.864 (-8) |
| 22,000 | 2.672 (-1) | 3.875 (-6) | 5.936 (-3) | 5.784 (-4) | 4.594 (-1) | 2.664 (-1) | 2.288 (-4) | 1.352 (-6) | 1.458 (-8) | 1.919 (-4) | 1.883 (-5) | 1.676 (-5) | 3.711 (-8) |
| 23,000 | 2.234 (-1) | 3.059 (-6) | 5.732 (-3) | 4.907 (-4) | 5.126 (-1) | 2.572 (-1) | 2.700 (-4) | 1.974 (-6) | 1.670 (-8) | 2.081 (-4) | 3.452 (-5) | 2.643 (-5) | 4.095 (-8) |
| 24,000 | 1.810 (-1) | 2.404 (-6) | 5.533 (-3) | 4.088 (-4) | 5.641 (-1) | 2.483 (-1) | 3.229 (-4) | 2.768 (-6) | 1.888 (-8) | 2.200 (-4) | 6.189 (-5) | 3.824 (-5) | 4.554 (-8) |
| 25,000 | 1.401 (-1) | 1.866 (-6) | 5.341 (-3) | 3.313 (-4) | 6.137 (-1) | 2.397 (-1) | 3.969 (-4) | 3.739 (-6) | 2.106 (-8) | 2.253 (-4) | 1.102 (-4) | 5.770 (-5) | 5.157 (-8) |
| 26,000 | 1.012 (-1) | 1.409 (-6) | 5.158 (-3) | 2.568 (-4) | 6.609 (-1) | 2.315 (-1) | 5.136 (-4) | 4.851 (-6) | 2.316 (-8) | 2.211 (-4) | 1.957 (-4) | 8.881 (-5) | 6.057 (-8) |

Altitude: 280,000 feet

## TABLE III - GAS COMPOSITION BEHIND NORMAL-SHOCK WAVE

MOLE FRACTION CONCENTRATIONS

| $V_1$ | $N_2$ | $O_2$ | $A$ | $NO$ | $N$ | $O$ | $e$ | $N_2^+$ | $O_2^+$ | $NO^+$ | $N^+$ | $O^+$ | $O^-$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2000 | | | | | | | | | | | | | |
| 3000 | | | | | | | | | | | | | |
| 4000 | 7.809 (-1) | 2.096 (-1) | 9.324 (-3) | 5.028 (-6) | 1.090 (-24) | 3.589 (-11) | | | | | | | |
| 5000 | 7.808 (-1) | 2.097 (-1) | 9.324 (-3) | 2.264 (-4) | 4.408 (-16) | 1.176 (-6) | | | | | | | |
| 6000 | 7.785 (-1) | 2.083 (-1) | 9.321 (-3) | 2.221 (-3) | 6.478 (-11) | 5.936 (-4) | | | | | | | |
| 7000 | 7.711 (-1) | 1.966 (-1) | 9.251 (-3) | 7.350 (-3) | 3.733 (-8) | 1.569 (-2) | | | | | | | |
| 8000 | 7.517 (-1) | 1.678 (-1) | 9.046 (-3) | 1.165 (-2) | 6.009 (-7) | 5.972 (-2) | | | | | | | |
| 9000 | 7.272 (-1) | 1.305 (-1) | 8.767 (-3) | 1.412 (-2) | 3.060 (-6) | 1.194 (-1) | | | | | | | |
| 10,000 | 7.007 (-1) | 8.963 (-2) | 8.455 (-3) | 1.494 (-2) | 1.097 (-5) | 1.863 (-1) | | | | | | | |
| 11,000 | 6.742 (-1) | 4.839 (-2) | 8.133 (-3) | 1.389 (-2) | 3.793 (-5) | 2.553 (-1) | | | | | | | |
| 12,000 | 6.517 (-1) | 1.267 (-2) | 7.842 (-3) | 9.854 (-3) | 2.144 (-4) | 3.177 (-1) | | | | | | | |
| 13,000 | 6.409 (-1) | 5.302 (-4) | 7.705 (-3) | 3.572 (-3) | 5.173 (-3) | 3.420 (-1) | | | | | | | |
| 14,000 | 6.170 (-1) | 7.364 (-5) | 7.583 (-3) | 1.834 (-3) | 3.423 (-2) | 3.392 (-1) | | | | | | | |
| 15,000 | 5.797 (-1) | 2.978 (-5) | 7.406 (-3) | 1.417 (-3) | 7.959 (-2) | 3.218 (-1) | 3.692 (-5) | 6.066 (-9) | 1.935 (-9) | 3.676 (-5) | 1.322 (-8) | 1.433 (-7) | 7.167 (-10) |
| 16,000 | 5.371 (-1) | 1.697 (-5) | 7.205 (-3) | 1.150 (-3) | 1.314 (-1) | 3.230 (-1) | 5.752 (-5) | 2.333 (-8) | 2.923 (-9) | 5.696 (-5) | 7.882 (-8) | 4.497 (-7) | 9.378 (-10) |
| 17,000 | 4.921 (-1) | 1.121 (-5) | 6.993 (-3) | 9.711 (-4) | 1.862 (-1) | 3.135 (-1) | 7.900 (-5) | 6.173 (-8) | 3.976 (-9) | 7.760 (-5) | 2.900 (-7) | 1.042 (-6) | 1.145 (-9) |
| 18,000 | 4.459 (-1) | 8.003 (-6) | 6.776 (-3) | 8.351 (-4) | 2.423 (-1) | 3.040 (-1) | 1.013 (-4) | 1.326 (-7) | 5.098 (-9) | 9.831 (-5) | 8.197 (-7) | 2.047 (-6) | 1.342 (-9) |
| 19,000 | 3.994 (-1) | 5.976 (-6) | 6.558 (-3) | 7.235 (-4) | 2.988 (-1) | 2.943 (-1) | 1.247 (-4) | 2.497 (-7) | 6.296 (-9) | 1.188 (-4) | 1.969 (-6) | 3.636 (-6) | 1.532 (-9) |
| 20,000 | 3.531 (-1) | 4.587 (-6) | 6.341 (-3) | 6.274 (-4) | 3.551 (-1) | 2.846 (-1) | 1.495 (-4) | 4.290 (-7) | 7.575 (-9) | 1.388 (-4) | 4.245 (-6) | 6.050 (-6) | 1.717 (-9) |
| 21,000 | 3.074 (-1) | 3.580 (-6) | 6.126 (-3) | 5.422 (-4) | 4.106 (-1) | 2.750 (-1) | 1.766 (-4) | 6.891 (-7) | 8.940 (-9) | 1.577 (-4) | 8.498 (-6) | 9.636 (-6) | 1.908 (-9) |
| 22,000 | 2.625 (-1) | 2.819 (-6) | 5.916 (-3) | 4.649 (-4) | 4.651 (-1) | 2.655 (-1) | 2.072 (-4) | 1.050 (-6) | 1.039 (-8) | 1.751 (-4) | 1.616 (-5) | 1.494 (-6) | 2.096 (-9) |
| 23,000 | 2.188 (-1) | 2.223 (-6) | 5.710 (-3) | 3.967 (-4) | 5.183 (-1) | 2.564 (-1) | 2.439 (-4) | 1.532 (-6) | 1.193 (-8) | 1.900 (-4) | 2.968 (-5) | 2.269 (-6) | 2.308 (-9) |
| 24,000 | 1.764 (-1) | 1.744 (-6) | 5.511 (-3) | 3.270 (-4) | 5.697 (-1) | 2.474 (-1) | 2.810 (-4) | 2.151 (-6) | 1.353 (-8) | 2.010 (-4) | 5.348 (-6) | 3.432 (-6) | 2.562 (-9) |
| 25,000 | 1.356 (-1) | 1.349 (-6) | 5.318 (-3) | 2.638 (-4) | 6.193 (-1) | 2.389 (-1) | 3.572 (-4) | 2.912 (-6) | 1.517 (-8) | 2.061 (-4) | 8.602 (-6) | 5.224 (-6) | 2.887 (-9) |
| 26,000 | 9.666 (-2) | 1.012 (-6) | 5.136 (-3) | 2.028 (-4) | 6.664 (-1) | 2.307 (-1) | 4.631 (-4) | 3.780 (-6) | 1.677 (-8) | 2.021 (-4) | 1.757 (-4) | 8.151 (-6) | 3.393 (-9) |

Altitude: 290,000 feet

## TABLE III - GAS COMPOSITION BEHIND NORMAL-SHOCK WAVE

MOLE FRACTION CONCENTRATIONS

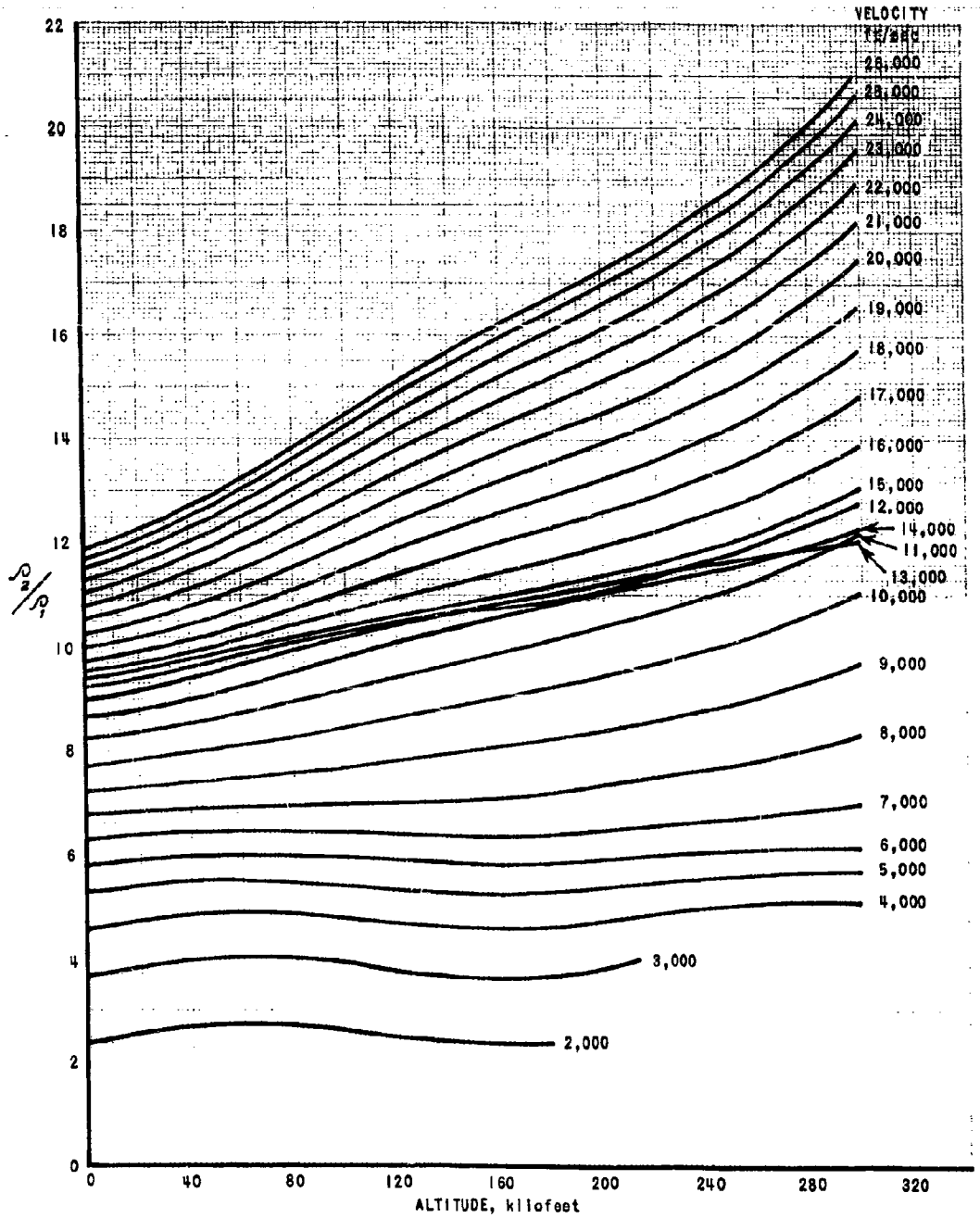
| $V_1$ | $N_2$ | $O_2$ | $A$ | $NO$ | $N$ | $O$ | $e$ | $N_2^+$ | $O_2^+$ | $NO^+$ | $N^+$ | $O^+$ | $O^-$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2000 | | | | | | | | | | | | | |
| 3000 | | | | | | | | | | | | | |
| 4000 | 7.809 (-1) | 2.098 (-1) | 9.324 (-3) | 5.028 (-6) | 1.479 (-24) | 4.873 (-11) | | | | | | | |
| 5000 | 7.808 (-1) | 2.097 (-1) | 9.324 (-3) | 2.263 (-4) | 5.984 (-16) | 1.597 (-6) | | | | | | | |
| 6000 | 7.795 (-1) | 2.082 (-1) | 9.320 (-3) | 2.208 (-3) | 8.540 (-11) | 7.933 (-4) | | | | | | | |
| 7000 | 7.702 (-1) | 1.952 (-1) | 9.236 (-3) | 6.963 (-3) | 3.884 (-8) | 1.842 (-2) | | | | | | | |
| 8000 | 7.502 (-1) | 1.653 (-1) | 9.022 (-3) | 1.070 (-2) | 5.421 (-7) | 6.475 (-2) | | | | | | | |
| 9000 | 7.255 (-1) | 1.275 (-1) | 8.739 (-3) | 1.279 (-2) | 2.643 (-6) | 1.255 (-1) | | | | | | | |
| 10.000 | 6.988 (-1) | 8.637 (-2) | 8.424 (-3) | 1.340 (-2) | 9.265 (-6) | 1.930 (-1) | | | | | | | |
| 11.000 | 6.724 (-1) | 4.510 (-2) | 8.102 (-3) | 1.229 (-2) | 3.250 (-5) | 2.621 (-1) | | | | | | | |
| 12.000 | 6.504 (-1) | 1.012 (-2) | 7.816 (-3) | 8.273 (-3) | 2.088 (-4) | 3.232 (-1) | | | | | | | |
| 13.000 | 6.400 (-1) | 3.268 (-4) | 7.696 (-3) | 2.820 (-3) | 6.254 (-3) | 3.429 (-1) | | | | | | | |
| 14.000 | 6.143 (-1) | 4.980 (-5) | 7.568 (-3) | 1.528 (-3) | 3.765 (-2) | 3.390 (-1) | | | | | | | |
| 15.000 | 5.760 (-1) | 2.094 (-5) | 7.387 (-3) | 1.133 (-3) | 8.412 (-2) | 3.312 (-1) | 3.493 (-5) | 5.204 (-9) | 1.409 (-9) | 3.478 (-5) | 1.276 (-8) | 1.369 (-7) | 4.118 (-10) |
| 16.000 | 5.330 (-1) | 1.214 (-5) | 7.185 (-3) | 9.233 (-4) | 1.365 (-1) | 3.223 (-1) | 5.358 (-5) | 1.917 (-8) | 2.104 (-9) | 5.308 (-5) | 7.204 (-8) | 4.149 (-7) | 5.855 (-10) |
| 17.000 | 4.877 (-1) | 8.087 (-6) | 6.972 (-3) | 7.816 (-4) | 1.915 (-1) | 3.129 (-1) | 7.296 (-5) | 4.956 (-8) | 2.844 (-9) | 7.170 (-5) | 2.575 (-7) | 9.440 (-7) | 6.516 (-10) |
| 18.000 | 4.414 (-1) | 5.800 (-6) | 6.755 (-3) | 6.729 (-4) | 2.478 (-1) | 3.032 (-1) | 9.303 (-5) | 1.050 (-7) | 3.635 (-9) | 9.037 (-5) | 7.155 (-7) | 1.835 (-6) | 7.621 (-10) |
| 19.000 | 3.949 (-1) | 4.344 (-6) | 6.536 (-3) | 5.831 (-4) | 3.043 (-1) | 2.934 (-1) | 1.140 (-4) | 1.958 (-7) | 4.480 (-9) | 1.088 (-4) | 1.701 (-6) | 3.240 (-6) | 8.686 (-10) |
| 20.000 | 3.486 (-1) | 3.340 (-6) | 6.319 (-3) | 5.057 (-4) | 3.606 (-1) | 2.837 (-1) | 1.362 (-4) | 3.344 (-7) | 5.387 (-9) | 1.268 (-4) | 3.043 (-6) | 5.372 (-6) | 9.722 (-10) |
| 21.000 | 3.029 (-1) | 2.609 (-6) | 6.105 (-3) | 4.367 (-4) | 4.161 (-1) | 2.741 (-1) | 1.604 (-4) | 5.351 (-7) | 6.359 (-9) | 1.440 (-4) | 7.269 (-6) | 8.547 (-6) | 1.076 (-9) |
| 22.000 | 2.581 (-1) | 2.054 (-6) | 5.894 (-3) | 3.741 (-4) | 4.706 (-1) | 2.647 (-1) | 1.877 (-4) | 8.138 (-7) | 7.402 (-9) | 1.598 (-4) | 1.381 (-5) | 1.324 (-5) | 1.183 (-9) |
| 23.000 | 2.148 (-1) | 1.619 (-6) | 5.689 (-3) | 3.162 (-4) | 5.236 (-1) | 2.555 (-1) | 2.203 (-4) | 1.187 (-6) | 8.516 (-9) | 1.735 (-4) | 2.543 (-5) | 2.021 (-5) | 1.300 (-9) |
| 24.000 | 1.721 (-1) | 1.268 (-6) | 5.491 (-3) | 2.619 (-4) | 5.751 (-1) | 2.466 (-1) | 2.622 (-4) | 1.669 (-6) | 9.696 (-9) | 1.837 (-4) | 4.605 (-5) | 3.074 (-5) | 1.440 (-9) |
| 25.000 | 1.310 (-1) | 9.769 (-7) | 5.299 (-3) | 2.102 (-4) | 6.245 (-1) | 2.381 (-1) | 3.215 (-4) | 2.265 (-6) | 1.092 (-8) | 1.885 (-4) | 8.343 (-5) | 4.720 (-5) | 1.626 (-9) |
| 26.000 | 9.249 (-2) | 7.285 (-7) | 5.116 (-3) | 1.603 (-4) | 6.716 (-1) | 2.298 (-1) | 4.175 (-4) | 2.959 (-6) | 1.215 (-8) | 1.849 (-4) | 1.550 (-4) | 7.469 (-5) | 1.808 (-9) |

Altitude: 300,000 feet

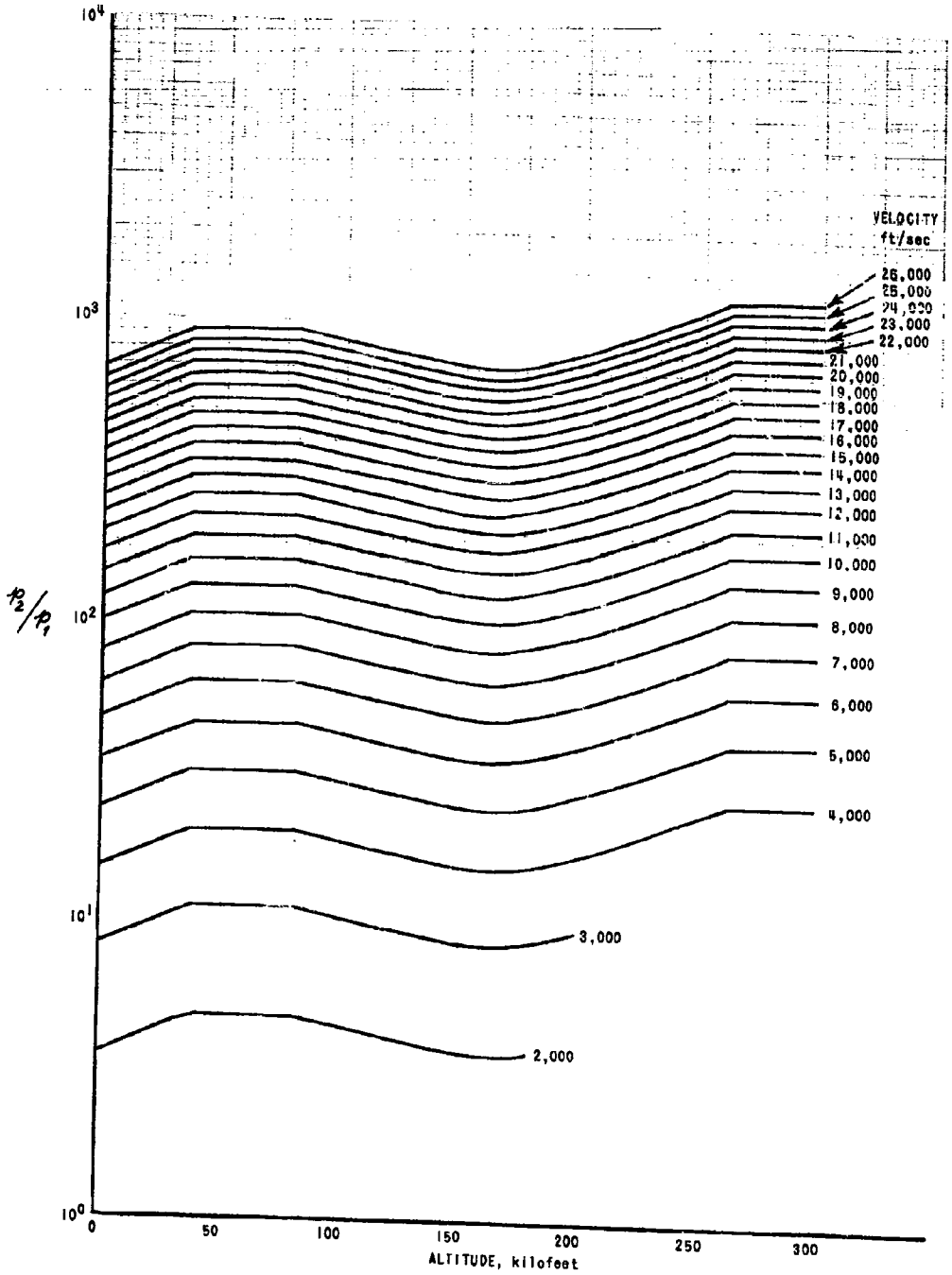
## TABLE III - GAS COMPOSITION BEHIND NORMAL-SHOCK WAVE

MOLE FRACTION CONCENTRATIONS

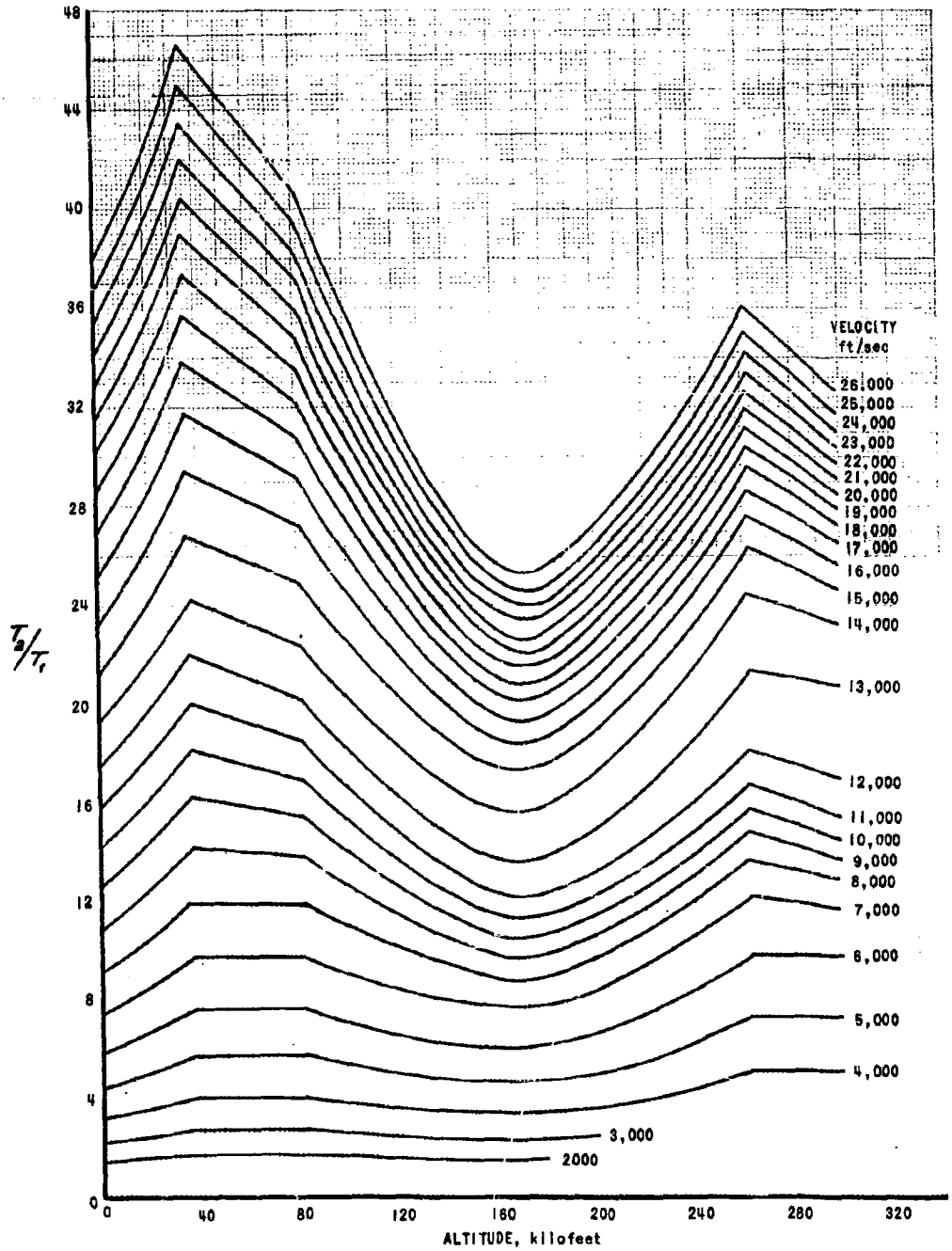
| $V_1$ | $N_2$ | $O_2$ | $A$ | $NO$ | $N$ | $O$ | $e$ | $N_2^+$ | $O_2^+$ | $NO^+$ | $N^+$ | $O^+$ | $O^-$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2000 | | | | | | | | | | | | | |
| 3000 | | | | | | | | | | | | | |
| 4000 | 7.808 (-1) | 2.098 (-1) | 9.324 (-3) | 5.064 (-6) | 2.087 (-24) | 6.756 (-11) | | | | | | | |
| 5000 | 7.808 (-1) | 2.097 (-1) | 9.324 (-3) | 2.271 (-4) | 8.279 (-16) | 2.191 (-6) | | | | | | | |
| 6000 | 7.794 (-1) | 2.081 (-1) | 9.319 (-3) | 2.195 (-3) | 1.126 (-10) | 1.061 (-3) | | | | | | | |
| 7000 | 7.692 (-1) | 1.936 (-1) | 9.224 (-3) | 6.564 (-3) | 3.953 (-8) | 2.139 (-2) | | | | | | | |
| 8000 | 7.487 (-1) | 1.627 (-1) | 8.989 (-3) | 9.800 (-3) | 4.832 (-7) | 6.979 (-2) | | | | | | | |
| 9000 | 7.237 (-1) | 1.244 (-1) | 8.711 (-3) | 1.156 (-2) | 2.251 (-6) | 1.315 (-1) | | | | | | | |
| 10,000 | 6.970 (-1) | 8.316 (-2) | 8.394 (-3) | 1.200 (-2) | 7.789 (-6) | 1.994 (-1) | | | | | | | |
| 11,000 | 6.706 (-1) | 4.189 (-2) | 8.072 (-3) | 1.085 (-2) | 2.782 (-5) | 2.686 (-1) | | | | | | | |
| 12,000 | 6.491 (-1) | 7.828 (-3) | 7.793 (-3) | 8.864 (-3) | 2.087 (-4) | 3.282 (-1) | | | | | | | |
| 13,000 | 6.390 (-1) | 2.014 (-4) | 7.688 (-3) | 2.164 (-3) | 7.540 (-3) | 3.434 (-1) | | | | | | | |
| 14,000 | 6.114 (-1) | 3.385 (-5) | 7.553 (-3) | 1.208 (-3) | 4.114 (-2) | 3.386 (-1) | | | | | | | |
| 15,000 | 5.724 (-1) | 1.476 (-5) | 7.369 (-3) | 9.053 (-4) | 8.859 (-2) | 3.307 (-1) | 5.295 (-5) | 4.423 (-9) | 1.023 (-9) | 3.280 (-5) | 1.218 (-8) | 1.297 (-7) | 2.854 (-10) |
| 16,000 | 5.290 (-1) | 8.689 (-6) | 7.165 (-3) | 7.413 (-4) | 1.414 (-1) | 3.216 (-1) | 4.982 (-5) | 1.566 (-8) | 1.510 (-9) | 4.936 (-5) | 6.531 (-8) | 3.608 (-7) | 3.046 (-10) |
| 17,000 | 4.835 (-1) | 5.836 (-6) | 6.951 (-3) | 6.289 (-4) | 1.957 (-1) | 3.121 (-1) | 8.728 (-5) | 3.959 (-8) | 2.029 (-9) | 6.616 (-5) | 2.272 (-7) | 8.518 (-7) | 3.684 (-10) |
| 18,000 | 4.371 (-1) | 4.205 (-6) | 6.734 (-3) | 5.420 (-4) | 2.530 (-1) | 3.024 (-1) | 8.532 (-5) | 8.275 (-8) | 2.585 (-9) | 8.298 (-5) | 6.213 (-7) | 1.640 (-6) | 4.213 (-10) |
| 19,000 | 3.906 (-1) | 3.158 (-6) | 6.515 (-3) | 4.699 (-4) | 3.096 (-1) | 2.926 (-1) | 1.041 (-4) | 1.530 (-7) | 3.181 (-9) | 9.962 (-5) | 1.462 (-6) | 2.878 (-6) | 4.987 (-10) |
| 20,000 | 3.443 (-1) | 2.433 (-6) | 6.298 (-3) | 4.074 (-4) | 3.659 (-1) | 2.829 (-1) | 1.240 (-4) | 2.599 (-7) | 3.822 (-9) | 1.159 (-4) | 3.118 (-6) | 4.757 (-6) | 5.486 (-10) |
| 21,000 | 2.986 (-1) | 1.902 (-6) | 6.084 (-3) | 3.516 (-4) | 4.214 (-1) | 2.733 (-1) | 1.456 (-4) | 4.143 (-7) | 4.514 (-9) | 1.314 (-4) | 6.192 (-6) | 7.559 (-6) | 6.062 (-10) |
| 22,000 | 2.538 (-1) | 1.497 (-6) | 5.874 (-3) | 3.009 (-4) | 4.758 (-1) | 2.639 (-1) | 1.700 (-4) | 6.290 (-7) | 5.261 (-9) | 1.458 (-4) | 1.176 (-5) | 1.172 (-5) | 6.655 (-10) |
| 23,000 | 2.102 (-1) | 1.179 (-6) | 5.669 (-3) | 2.539 (-4) | 5.288 (-1) | 2.547 (-1) | 1.989 (-4) | 9.172 (-7) | 6.068 (-9) | 1.583 (-4) | 2.170 (-5) | 1.795 (-5) | 7.808 (-10) |
| 24,000 | 1.679 (-1) | 9.217 (-7) | 5.471 (-3) | 2.097 (-4) | 5.801 (-1) | 2.458 (-1) | 2.362 (-4) | 1.291 (-6) | 6.834 (-9) | 1.679 (-4) | 3.950 (-5) | 2.746 (-5) | 8.073 (-10) |
| 25,000 | 1.272 (-1) | 7.077 (-7) | 5.280 (-3) | 1.675 (-4) | 6.295 (-1) | 2.372 (-1) | 2.891 (-4) | 1.758 (-6) | 7.849 (-9) | 1.726 (-4) | 7.222 (-5) | 4.255 (-5) | 9.087 (-10) |
| 26,000 | 8.840 (-2) | 5.243 (-7) | 5.098 (-3) | 1.266 (-4) | 6.766 (-1) | 2.290 (-1) | 3.761 (-4) | 2.305 (-6) | 8.785 (-9) | 1.693 (-4) | 1.362 (-4) | 6.832 (-5) | 1.067 (-9) |



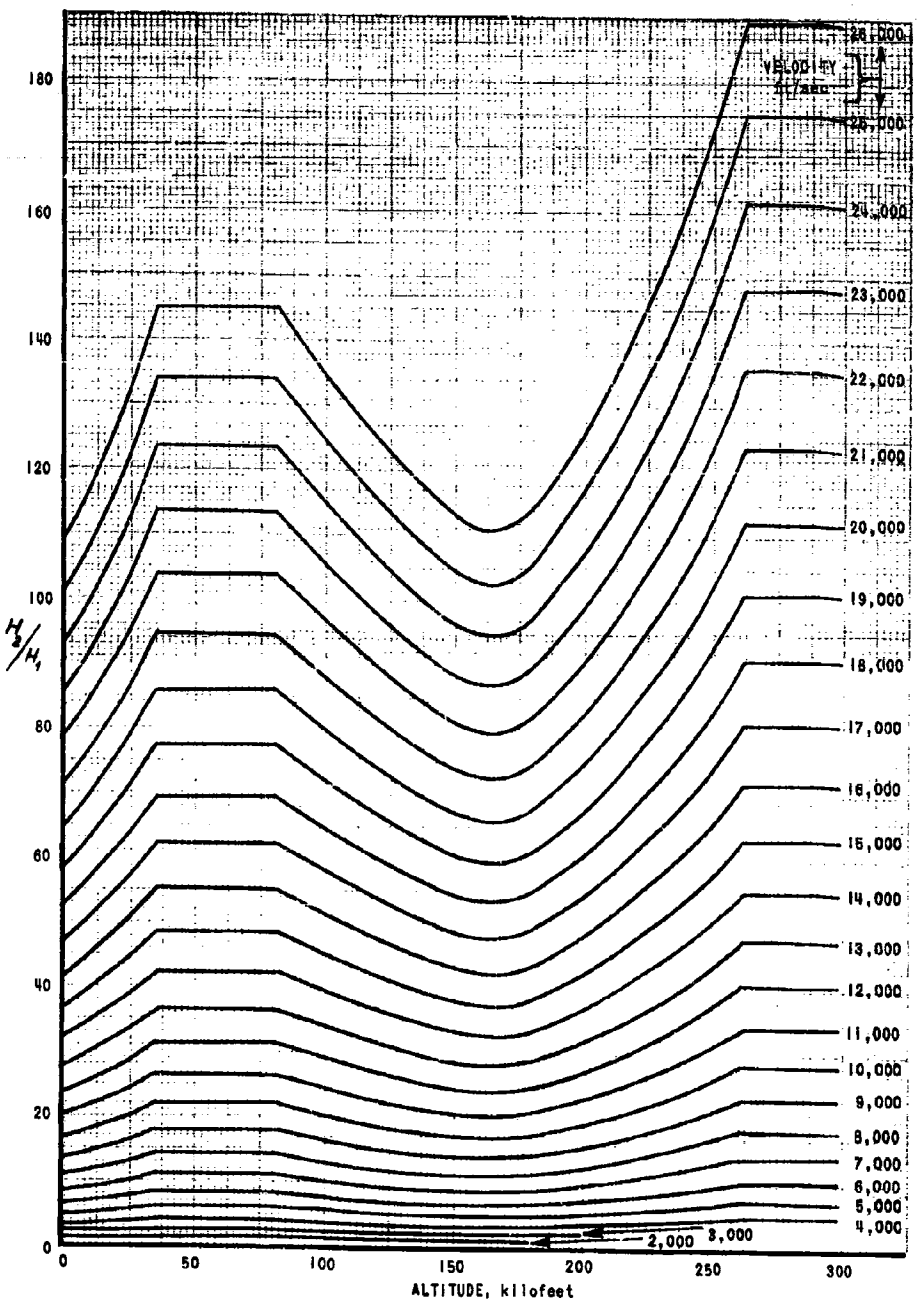

Graph I DENSITY RATIO AS A FUNCTION OF ALTITUDE



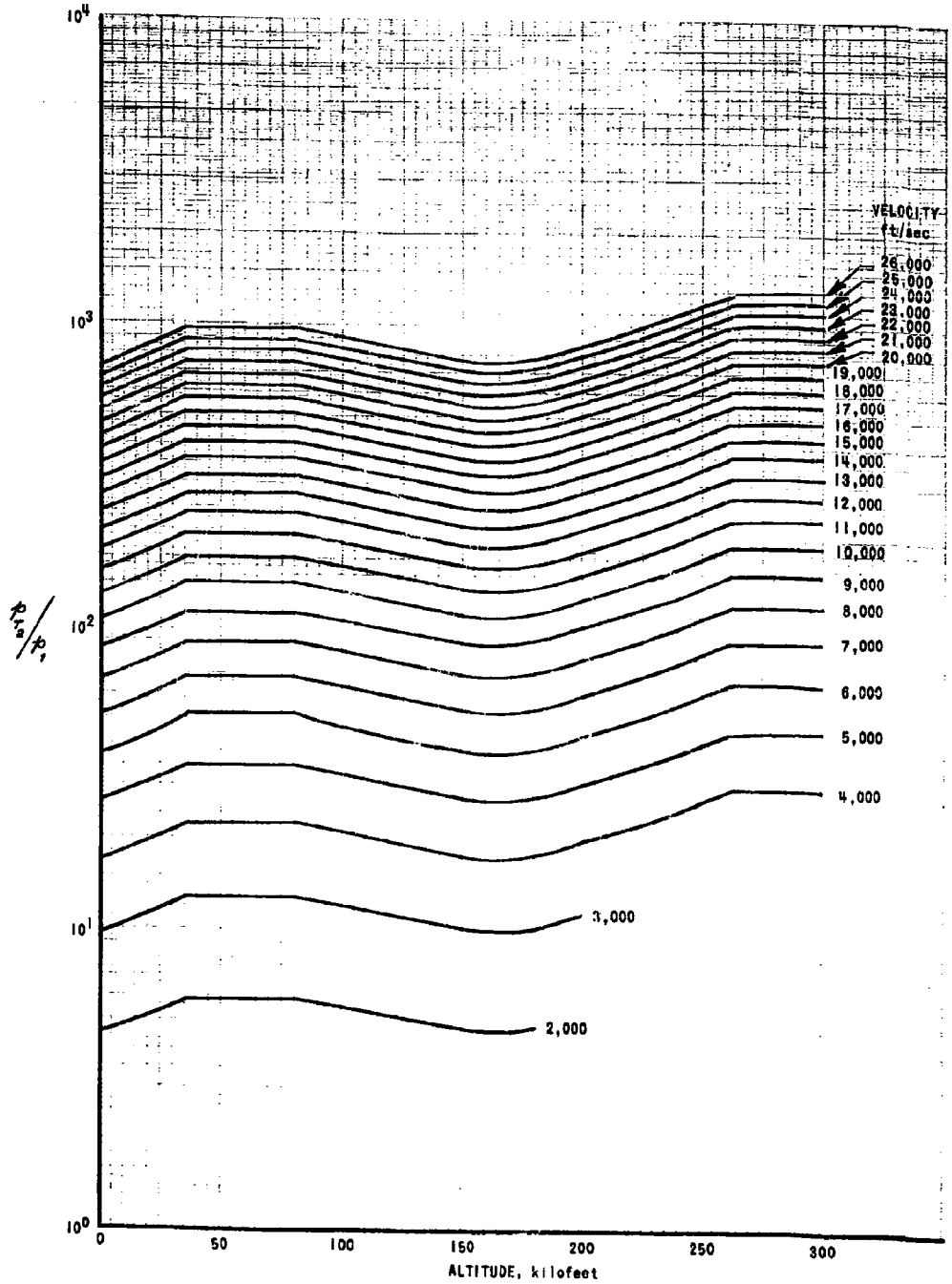

Graph 2 PRESSURE RATIO AS A FUNCTION OF ALTITUDE



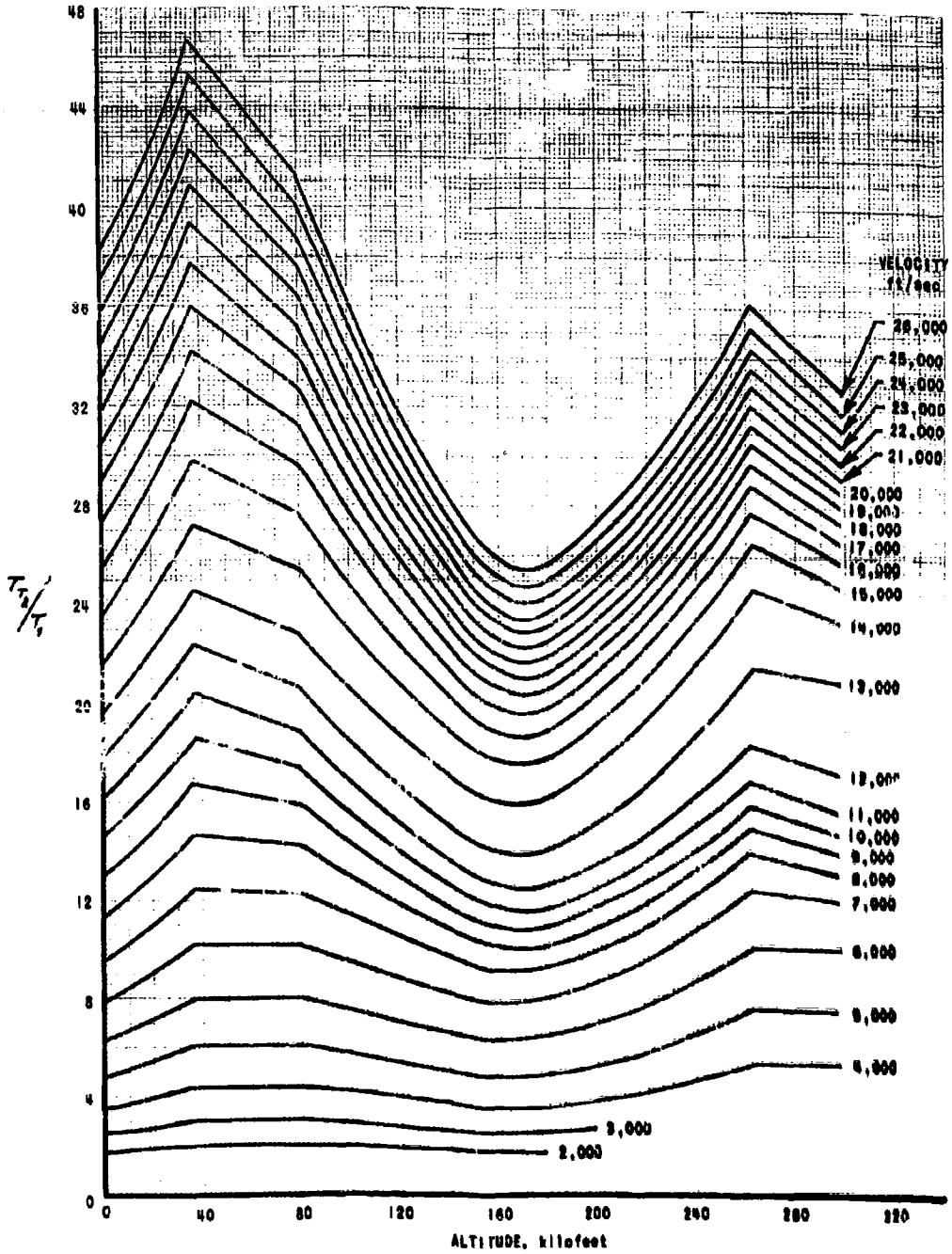

Graph 3 TEMPERATURE RATIO AS A FUNCTION OF ALTITUDE




Graph 4 ENTHALPY RATIO AS A FUNCTION OF ALTITUDE




Graph 5 STAGNATION-POINT PRESSURE RATIO AS A FUNCTION OF ALTITUDE




Graph 6 STAGNATION-POINT TEMPERATURE AS A FUNCTION OF ALTITUDE