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British Standard Aerospace Series: Schedule for

Tables relating to altitudes, airspeed and Mach numbers for use in aeronautical instrument design and calibration

Série aérospatiale. Plan normalisé des tables d'altitudes, vitesses de l'air et nombres de Mach utilisées pour la conception et l'étalonnage des instruments aéronautiques

Luft- und Raumfahrt-Reihe. Tabellen über Höhen, Fluggeschwindigkeiten und Machzahlen für die Konstruktion und Kalibrierung von aeronautischen Instrumenten

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Foreword

Over the years a number of pressure altitude and pressure airspeed tables have been published. The former differ from one another according to the temperature altitude convention adopted, and they have been identified by a particular 'Standard' or 'Model' atmosphere. The latter differ principally in the values assigned to the basic constants.

This revision of the British Standard has been prepared under the direction of the Aerospace Standards Committee and supersedes British Standard G 199 : 1967, which is withdrawn. Terminology has been rationalized to align with accepted international practice. New formulae have been included which enable individual calculations and table compilation to be made and additional tables have been included. Known errors in tables in the earlier issue of the standard have been corrected.

A series of tables is presented which can be used by all concerned in the aircraft instrument field and so eliminate any possible confusion. The altitude tables and altitude parameters where used in other tables are based on the now universally accepted ICAO Standard Atmosphere, 1964, which is identical to ISO 2533 over the tabulated altitude range. The airspeed tables and those where airspeed is a parameter are calculated from the de St. Venant and Rayleigh formulae, the values of the base constants being those of ICAO Document 7488/2, ISO 2533 and BS 350.

The tables are primarily for use in the aircraft instrument field and do not provide for other special interests, e.g. aerodynamics or space technology. The information is therefore not comprehensive and ranges are confined to probable aircraft requirements in the foreseeable future. Although the main purpose of the tables is for calibration work, sufficient information is given to enable the tables to be of assistance in instrument development and design.

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1 Scope

This British Standard provides a schedule of tables relating to altitudes, airspeeds and Mach numbers for use in aeronautical instrument design and calibration.

The size of the tables have been restricted and the units used for the various parameters have been kept to a minimum, namely, altitude in geopotential feet, pressures in millibars and inches of mercury, airspeed in knots, and temperature in degrees Celsius.

NOTE. Altitude measurements are based on the geopotential foot, and, in speed measurements where the 'knot' is involved, this is taken to mean one international nautical mile per hour.

2 Basis of tables

2.1 Notation and standard values

Altitude (geopotential) H

Free stream static pressure p_s

Atmospheric temperature lapse rate L

where

(a) $L = 6.50\ ^\circ C/1000\ m$ for $-3000\ ft \leqslant H < 36089\ ft$.

(b) $L = 0$ for $36089\ ft \leqslant H < 65617\ ft$.

(c) $L = 1.0\ ^\circ C/1000\ m$ for $65617\ ft \leqslant H \leqslant 105000\ ft$.

Free stream total pressure p_t

Total pressure behind normal shock wave at supersonic speeds p_p

Impact pressure q_c

defined by $q_c = p_t - p_s$ when $M \leqslant 1$

$= p_p - p_s$ when $M > 1$

Ratio of specific heats of air $\gamma = 1.4$ (exactly)

Specific gas constant $R^* = 287.0529\ m^2 \cdot K^{-1} \cdot s^{-2}$

NOTE. $R^* = R/\bar{M}$

where

R is the universal gas constant = $8.314315\ J \cdot K^{-1} \cdot mol^{-1}$ and

$\bar{M}$ is the mean molar mass of air = $28.9644\ g \cdot mol^{-1}$

Calibrated airspeed, in knots, V_c

True airspeed V_t

Mach number M

Density of air ρ

Speed of sound a

International knot $kn = 6076.1155\ ft/h$
(based on a nautical mile of 1852 m (exactly))

Temperature (in Kelvin) T

Temperature (in degrees Celsius) θ

Acceleration due to gravity g

Subscript o denotes standard value at zero altitude (from ICAO Document 7488/2)

$p_{so} = 1013.25$ mbar

$\rho_o = 1.2250\ kg/m^3$

$\theta_o = +15\ ^\circ C$

$T_o = 288.15\ K$

$a_o = 340.294\ m/s = 661.4786\ kn$

$g_o = 9.80665\ m/s^2 = 32.17405\ ft/s^2$

Free stream ambient air temperature T_s and θ_s

Temperature measured by aircraft sensor T_m and θ_m

Total temperature T_t and θ_t

Recovery factor of sensor r

where $r = \dfrac{5}{M^2}\left(\dfrac{T_m}{T_s} - 1\right)$

2.2 Pressure units

Pressures are given throughout the tables in millibars where 1 mbar = 100 Pa.

In tables 1 and 2 pressures are also given in inches of mercury (inHg), the relationship with millibars being as defined in BS 350, i.e.:

1 inHg = 0.0254 × 13595.1 × 9.80665 = 3386.39 Pa (33.8639 mbar)

To satisfy this relationship the mercury is assumed to be at 0 °C with a density of exactly 13595.1 kg/m^3 and to be under standard gravity conditions of 9.806 65 m/s^2 (see also BS 2520).

Table 8 gives conversion factors for pressures in terms of length of a column of water. The relationships are derived from the definition in BS 350, i.e.:

1 mmH_2O = 9.880665 Pa (0.0980665 mbar)

To satisfy this relationship it is assumed that the water is approximately + 4 °C with a uniform density of 1000 kg/m^3 (exactly) and under standard gravity conditions of 9.80665 m/s^2.

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2.3 Notes on the tables

2.3.1 *Table 1. Altitude* (range – 3000 ft to 105000 ft). The table conforms to the ICAO Standard Atmosphere 1964 (Geopotential altitude). For other altitude related quantities, reference should be made to ICAO Document 7488/2.

The table is based on the following formulae:

$$p_s = p_s^* \left\{ \frac{T_s^*}{T_s^* + L(H - H^*)} \right\}^{\frac{g_o}{LR^*}} \qquad L \neq 0 \qquad (1)$$

$$\log_{10} p_s = \log_{10} p_s^* - \log_{10} \exp \left\{ \frac{g_o}{R^* T_s^*} (H - H^*) \right\} \qquad L = 0 \qquad (2)$$

where p_s^*, T_s^*, H^* are datum values of these variables.

For the altitude range considered refer to equations (7) to (12).

$$T_s = T_s^* + L(H - H^*) \qquad L \neq 0 \qquad (3)$$

$$T_s = T_s^* \qquad L = 0 \qquad (4)$$

$$\frac{\rho}{\rho_o} = \frac{p_s}{p_o R^* T_s} \qquad (5)$$

$$\frac{a}{a_o} = \left(\frac{T_s}{T_o} \right)^{0.5} \qquad (6)$$

Numerically evaluated:

(a) – 3000 ft $\leqslant H \leqslant$ 36089 ft, $L = -6.50$ °C/1000 m or -1.9812 °C/1000 ft:

$$p_s = 1013.25 \left\{ \frac{288.15}{288.15 - (1.9812 \times 10^{-3} H)} \right\}^{-5.255879} \text{ mbar} \qquad (7)$$

$$T_s = \{288.15 - (1.9812 \times 10^{-3} H)\} \text{ K} \qquad (8)$$

(b) 36089 ft $\leqslant H <$ 65617 ft, $L = 0$:

$$p_s = \text{antilog}_{10} \{2.354729 - 2.087370 \times 10^{-5} (H - 36089)\} \text{ mbar} \qquad (9)$$

$$T_s = 216.65 \text{ K} \qquad (10)$$

(c) 65617 ft $\leqslant H \leqslant$ 105000 ft, $L = 1.0$ °C/1000 m or 0.3048 °C/1000 ft:

$$p_s = 54.7482 \left\{ \frac{216.65}{216.65 + 0.3048 \times 10^{-3} (H - 65617)} \right\}^{34.163215} \text{ mbar} \qquad (11)$$

$$T_s = 216.65 + 0.3048 \times 10^{-3} (H - 65617) \text{ K} \qquad (12)$$

NOTE. In the equations 7 to 12 inclusive the units of 'H' are in geopotential feet.

(d) At all altitudes:

$$\frac{\rho}{\rho_o} = \frac{p_s}{3.5164\, T_s} \qquad (13)$$

$$\frac{a}{a_o} = \left(\frac{T_s}{288.15} \right)^{0.5} \qquad (14)$$

In equations (13) and (14), substitution of T_s from equations (8), (10) or (12) gives standard atmosphere values.

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2.3.2 *Table 2. Calibrated airspeed* (range 0 kn to 1000 kn). Calibrated airspeed is defined as that airspeed which at standard sea level conditions would give the same impact pressure q_c (as defined in 2.1) as that existing in the aircraft.

The relationship between pressure and calibrated airspeed is obtained from the following equations:

Subsonic $\left(\text{i.e. } \frac{V_c}{a_o} \leqslant 1\right)$

$$q_c = P_{so}\left[\left\{1 + \frac{\gamma - 1}{2}\left(\frac{V_c}{a_o}\right)^2\right\}^{\frac{\gamma}{\gamma - 1}} - 1\right] \quad (15)$$

Supersonic $\left(\text{i.e. } \frac{V_c}{a_o} > 1\right)$

$$q_c = p_{so}\left[\frac{\gamma + 1}{2}\left(\frac{V_c}{a_o}\right)^2\left\{\frac{(\gamma + 1)^2\left(\frac{V_c}{a_o}\right)^2}{4\gamma\left(\frac{V_c}{a_o}\right)^2 - 2\gamma + 2}\right\}^{\frac{1}{\gamma - 1}} - 1\right] \quad (16)$$

Numerically evaluated:

Subsonic, $q_c = 1013.25\left\{(1 + 4.570865 \times 10^{-7} V_c^2)^{7/2} - 1\right\}$ mbar (17)

Supersonic, $q_c = 1013.25\left[\frac{3.0123255 \times 10^{-18} V_c^7}{(1.5998028 \times 10^{-5} V_c^2 - 1)^{5/2}} - 1\right]$ mbar (18)

2.3.3 *Table 3. Mach number* (range 0.16 to 4.0). The relationship between M and q_c/p_s is obtained from the following equations:

Subsonic ($M \leqslant 1$)

$$\frac{q_c}{p_s} = \left\{1 + \left(\frac{\gamma - 1}{2}\right) M^2\right\}^{\frac{\gamma}{\gamma - 1}} - 1 \quad (19)$$

Supersonic ($M > 1$)

$$\frac{q_c}{p_s} = \left(\frac{\gamma + 1}{2}\right) M^2\left\{\frac{(\gamma + 1)^2 M^2}{4\gamma M^2 - 2\gamma + 2}\right\}^{\frac{1}{\gamma - 1}} - 1 \quad (20)$$

Numerically evaluated:

Subsonic, $\frac{q_c}{p_s} = (1 + 0.2 M^2)^{7/2} - 1$ (21)

Supersonic, $\frac{q_c}{p_s} = \left\{\frac{166.92158 M^7}{(7M^2 - 1)^{5/2}}\right\} - 1$ (22)

The relationship between M and V_c is obtained by equating the common value q_c in equations (17) or (18) with that in equations (21) or (22), according to the magnitude of M and V_c/a_o; it will be noted that there is a condition where M can be > 1 while V_c/a_o is < 1.

Limits of V_c of 100 kn (lower) and 1000 kn (upper) have been set in compiling the tables.

The static pressure adopted for the various altitudes conform to the ICAO International Standard Atmosphere (ISA) 1964.

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2.3.4 *Table 4.1 to 4.9. Truc airspeed.* These nine tables have been limited by a V_c envelope with a minimum V_c of 150 kn and a maximum at each altitude which would give a probable maximum of M at that altitude, with a ceiling of $M = 4.0$.

For each of the nine altitudes, M and V_t are tabled, for the seven free stream temperatures ISA − 30°C, ISA − 20°C, ISA − 10°C, ISA, ISA + 10°C, ISA + 20°C, ISA + 30°C, and for a series of values V_c.

The relationship between V_c and M is given in **2.3.3.** V_t is obtained from M by the equation:

$$V_t = Ma_o\left(\frac{T_s}{T_o}\right)^{0.5} = M\,661.4786\left(\frac{\theta_s + 273.15}{288.15}\right)^{0.5} = 38.967854\,M\,T_s^{0.5}\ \text{kn} \qquad (23)$$

The relation between measured temperature θ_m and free stream static temperature θ_s is:

$$\frac{\theta_m + 273.15}{\theta_s + 273.15} = 1 + 0.2rM^2 \qquad (24)$$

In order to limit the extent of the tables, a recovery factor of 1 has been assumed throughout. The value of θ_m thus calculated, becomes θ_t, the total temperature.

The static pressure and temperature adopted for the various altitudes conform to the ICAO International Standard Atmosphere (ISA) 1964.

2.3.5 *Table 5. Variation of speed of sound with temperature.* Variations of the ratio a/a_o is tabled for temperatures ranging from − 73 °C to + 45 °C, calculated from:

$$\frac{a}{a_o} = \left(\frac{T_s}{T_o}\right)^{0.5} = \left(\frac{\theta_s + 273.15}{288.15}\right)^{0.5} \qquad (25)$$

2.3.6 *Table 6. Variation of the ratio of total free stream temperatures with Mach number.* (Implied sensor recovery factor of 1.) Measured temperature T_m is related to free stream temperature T_s by the equation:

$$T_m = T_s\left\{1 + r\left(\frac{\gamma - 1}{2}\right)M^2\right\} \qquad (26)$$

If $r = 1$, T_m becomes T_t, total temperature, so we have:

$$\frac{T_t}{T_s} = 1 + 0.2\,M^2 = \frac{\theta_t + 273.15}{\theta_s + 273.15} \qquad (27)$$

The table can also be used to compute T_m/T_s, for a known recovery factor other than 1. Equation (27) may be expressed as:

$$\frac{T_m}{T_s} = 1 + 0.2rM^2 \quad (\text{for } M \leqslant 1) \qquad (28)$$

Hence, if the value of $\sqrt{r}\,M$ is calculated, and the table is entered in the 'M' column for this value, the T_t/T_s column will give the corresponding value of T_m/T_s.

NOTE. When $M > 1$ and known recovery factor other than 1 then:

$$\frac{T_m}{T_s} = \left\{2\gamma M^2 - (\gamma - 1)\right\}\left\{\frac{2 + (\gamma - 1)M^2}{(\gamma + 1)^2 M^2}\right\}\left[1 + r\frac{(\gamma - 1)}{2}\left\{\frac{1 + \frac{(\gamma - 1)}{2}M^2}{\gamma M^2 - \frac{(\gamma - 1)}{2}}\right\}\right]$$

2.3.7 *Table 7. Ratio of impact pressure to static pressure.* Variation of the ratio q_c/p_s is tabled for values of M from 0.100 to 4.000, calculated from equations (21) and (22). (See **2.3.3.**)

2.3.8 *Table 8. Relationship of various pressure units.* These values have been derived from BS 350; units in terms of length of a column of mercury or water being defined therein. (See also **2.2.**)

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Table 1. Altitude

Altitude (geopotential) H	Static pressure p_s		Temperature θ	$\Delta H/\Delta p_s$	Density ratio ρ/ρ_0	$\left(\frac{\rho}{\rho_0}\right)^{0.5}$	Speed of sound ratio a/a_0	Pressure ratio p_s/p_{s0}
ft	mbar	inHg	°C	ft/mbar				
−3000	1128.029	33.3107	20.94	25.04	1.0908	1.0444	1.0103	1.1133
−2500	1108.201	32.7252	19.95	25.40	1.0752	1.0369	1.0086	1.0937
−2000	1088.657	32.1480	18.96	25.77	1.0598	1.0295	1.0069	1.0744
−1500	1069.393	31.5791	17.97	26.14	1.0446	1.0221	1.0051	1.0554
−1000	1050.406	31.0185	16.98	26.53	1.0296	1.0147	1.0034	1.0367
−900	1046.641	30.9073	16.78	26.60	1.0266	1.0132	1.0031	1.0330
−800	1042.888	30.7964	16.58	26.68	1.0236	1.0117	1.0027	1.0293
−700	1039.145	30.6859	16.39	26.76	1.0206	1.0103	1.0024	1.0256
−600	1035.413	30.5757	16.19	26.84	1.0177	1.0088	1.0021	1.0219
−500	1031.692	30.4658	15.99	26.91	1.0147	1.0073	1.0017	1.0182
−400	1027.982	30.3563	15.79	26.99	1.0118	1.0059	1.0014	1.0145
−300	1024.283	30.2471	15.59	27.07	1.0088	1.0044	1.0010	1.0109
−200	1020.595	30.1381	15.40	27.15	1.0059	1.0029	1.0007	1.0072
−100	1016.917	30.0295	15.20	27.23	1.0029	1.0015	1.0003	1.0036
0	1013.250	29.9212	15.00	27.31	1.0000	1.0000	1.0000	1.0000
100	1009.594	29.8133	14.80	27.39	0.9971	0.9985	0.9997	0.9964
200	1005.948	29.7056	14.60	27.47	0.9942	0.9971	0.9993	0.9928
300	1002.313	29.5983	14.41	27.55	0.9913	0.9956	0.9990	0.9892
400	998.689	29.4913	14.21	27.63	0.9883	0.9942	0.9986	0.9856
500	995.075	29.3845	14.01	27.71	0.9855	0.9927	0.9983	0.9821
600	991.472	29.2782	13.81	27.80	0.9826	0.9912	0.9979	0.9785
700	987.880	29.1721	13.61	27.88	0.9797	0.9898	0.9976	0.9750
800	984.298	29.0663	13.42	27.96	0.9768	0.9883	0.9972	0.9714
900	980.727	28.9608	13.22	28.04	0.9739	0.9869	0.9969	0.9679
1000	977.166	28.8557	13.02	28.12	0.9711	0.9854	0.9966	0.9644
1100	973.615	28.7508	12.82	28.21	0.9682	0.9840	0.9962	0.9609
1200	970.075	28.6463	12.62	28.29	0.9654	0.9825	0.9959	0.9574
1300	966.546	28.5421	12.42	28.37	0.9625	0.9811	0.9955	0.9539
1400	963.027	28.4381	12.23	28.46	0.9597	0.9796	0.9952	0.9504
1500	959.518	28.3345	12.03	28.54	0.9568	0.9782	0.9948	0.9470
1600	956.019	28.2312	11.83	28.63	0.9540	0.9767	0.9945	0.9435
1700	952.531	28.1282	11.63	28.71	0.9512	0.9753	0.9941	0.9401
1800	949.054	28.0255	11.43	28.80	0.9484	0.9738	0.9938	0.9366
1900	945.586	27.9231	11.24	28.88	0.9456	0.9724	0.9934	0.9332
2000	942.129	27.8210	11.04	28.97	0.9428	0.9710	0.9931	0.9298
2100	938.682	27.7193	10.84	29.05	0.9400	0.9695	0.9928	0.9264
2200	935.245	27.6178	10.64	29.14	0.9372	0.9681	0.9924	0.9230
2300	931.819	27.5166	10.44	29.23	0.9344	0.9666	0.9921	0.9196
2400	928.402	27.4157	10.25	29.31	0.9316	0.9652	0.9917	0.9163
2500	924.996	27.3151	10.05	29.40	0.9289	0.9638	0.9914	0.9129
2600	921.600	27.2148	9.84	29.49	0.9261	0.9623	0.9910	0.9095
2700	918.214	27.1148	9.65	29.58	0.9233	0.9609	0.9907	0.9062
2800	914.838	27.0151	9.45	29.67	0.9206	0.9595	0.9903	0.9029
2900	911.472	26.9158	9.25	29.75	0.9179	0.9580	0.9900	0.8996
3000	908.117	26.8167	9.06	29.84	0.9151	0.9566	0.9896	0.8962

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Table 1. *(continued)*

Altitude (geopotential) H	Static pressure p_s		Temperature t	$\Delta H/\Delta p_s$	Density ratio ρ/ρ_0	$\left(\frac{\rho}{\rho_0}\right)^{0.5}$	Speed of sound ratio a/a_0	Pressure ratio p_s/p_{s0}
ft	mbar	inHg	°C	ft/mbar				
3100	904.771	26.7179	8.86	29.93	0.9124	0.9552	0.9893	0.8929
3200	901.435	26.6194	8.66	30.02	0.9097	0.9538	0.9889	0.8896
3300	898.109	26.5211	8.46	30.11	0.9069	0.9523	0.9886	0.8864
3400	894.793	26.4232	8.26	30.20	0.9042	0.9509	0.9882	0.8831
3500	891.487	26.3256	8.07	30.29	0.9015	0.9495	0.9879	0.8798
3600	888.191	26.2283	7.87	30.38	0.8988	0.9481	0.9875	0.8766
3700	884.905	26.1312	7.67	30.48	0.8961	0.9466	0.9872	0.8733
3800	881.629	26.0345	7.47	30.57	0.8934	0.9452	0.9868	0.8701
3900	878.362	25.9380	7.27	30.66	0.8908	0.9438	0.9865	0.8669
4000	875.105	25.8418	7.08	30.75	0.8881	0.9424	0.9862	0.8637
4100	871.859	25.7460	6.88	30.84	0.8854	0.9410	0.9858	0.8605
4200	868.621	25.6504	6.68	30.94	0.8828	0.9396	0.9855	0.8573
4300	865.394	25.5551	6.48	31.03	0.8801	0.9381	0.9851	0.8541
4400	862.176	25.4600	6.28	31.12	0.8774	0.9367	0.9848	0.8509
4500	858.968	25.3653	6.08	31.22	0.8748	0.9353	0.9844	0.8477
4600	855.770	25.2709	5.89	31.31	0.8722	0.9339	0.9841	0.8446
4700	852.581	25.1767	5.69	31.41	0.8695	0.9325	0.9837	0.8414
4800	849.402	25.0828	5.49	31.50	0.8669	0.9311	0.9834	0.8383
4900	846.233	24.9892	5.29	31.60	0.8643	0.9297	0.9830	0.8352
5000	843.073	24.8959	5.09	31.69	0.8617	0.9283	0.9827	0.8320
5500	827.416	24.4336	4.10	32.18	0.8487	0.9212	0.9809	0.8166
6000	811.996	23.9782	3.11	32.67	0.8359	0.9143	0.9792	0.8014
6500	796.809	23.5298	2.12	33.18	0.8232	0.9073	0.9774	0.7864
7000	781.854	23.0881	1.13	33.69	0.8106	0.9004	0.9756	0.7716
7500	767.126	22.6532	0.14	34.21	0.7983	0.8935	0.9739	0.7571
8000	752.624	22.2250	−0.85	34.75	0.7860	0.8866	0.9721	0.7428
8500	738.344	21.8033	−1.84	35.29	0.7739	0.8797	0.9703	0.7287
9000	724.285	21.3881	−2.83	35.84	0.7620	0.8729	0.9686	0.7148
9500	710.443	20.9794	−3.82	36.41	0.7502	0.8661	0.9668	0.7012
10000	696.817	20.5770	−4.81	36.98	0.7385	0.8593	0.9650	0.6877
11000	670.198	19.7909	−6.79	38.17	0.7156	0.8459	0.9614	0.6614
12000	644.408	19.0294	−8.77	39.40	0.6932	0.8326	0.9579	0.6360
13000	619.429	18.2917	−10.76	40.68	0.6713	0.8193	0.9543	0.6113
14000	595.239	17.5774	−12.74	42.01	0.6500	0.8062	0.9507	0.5875
15000	571.820	16.8858	−14.72	43.40	0.6292	0.7932	0.9470	0.5643
16000	549.152	16.2164	−16.70	44.85	0.6090	0.7804	0.9434	0.5420
17000	527.218	15.5687	−18.68	46.35	0.5892	0.7676	0.9397	0.5203
18000	505.998	14.9421	−20.66	47.92	0.5699	0.7549	0.9361	0.4994
19000	485.476	14.3361	−22.64	49.55	0.5511	0.7424	0.9324	0.4791
20000	465.633	13.7501	−24.62	51.26	0.5328	0.7299	0.9287	0.4595
21000	446.451	13.1837	−26.61	53.03	0.5150	0.7176	0.9250	0.4406
22000	427.915	12.6363	−28.59	54.89	0.4976	0.7054	0.9213	0.4223
23000	410.006	12.1075	−30.57	56.82	0.4807	0.6933	0.9175	0.4046
24000	392.710	11.5967	−32.55	58.84	0.4642	0.6813	0.9138	0.3876
25000	376.009	11.1035	−34.53	60.94	0.4481	0.6694	0.9100	0.3711

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Table 1. *(continued)*

Altitude (geopotential) H	Static pressure p_s		Temperature θ	$\Delta H/\Delta p_s$	Density ratio ρ/ρ_0	$\left(\frac{\rho}{\rho_0}\right)^{0.5}$	Speed of sound ratio a/a_0	Pressure ratio p_s/p_{s0}
ft	mbar	inHg	°C	ft/mbar				
26000	359.888	10.6275	−36.51	63.15	0.4325	0.6576	0.9062	0.3552
27000	344.331	10.1681	−38.49	65.45	0.4173	0.6460	0.9024	0.3398
28000	329.324	9.7249	−40.47	67.85	0.4025	0.6344	0.8986	0.3250
29000	314.850	9.2975	−42.45	70.37	0.3881	0.6230	0.8948	0.3107
30000	300.896	8.8854	−44.44	73.00	0.3741	0.6117	0.8909	0.2970
31000	287.447	8.4883	−46.42	75.75	0.3605	0.6004	0.8870	0.2837
32000	274.489	8.1056	−48.40	78.63	0.3473	0.5893	0.8832	0.2709
33000	262.007	7.7371	−50.38	81.65	0.3345	0.5783	0.8793	0.2586
34000	249.990	7.3822	−52.36	84.82	0.3220	0.5674	0.8753	0.2467
35000	238.423	7.0406	−54.34	88.13	0.3099	0.5567	0.8714	0.2353
36000	227.293	6.7120	−56.32	91.61	0.2981	0.5460	0.8675	0.2243
36089	226.323	6.6833	−56.50	91.93	0.2971	0.5450	0.8671	0.2234
37000	216.627	6.3970	−56.50	96.04	0.2844	0.5332	0.8671	0.2138
38000	206.462	6.0968	−56.50	100.77	0.2710	0.5206	0.8671	0.2038
39000	196.773	5.8107	−56.50	105.73	0.2583	0.5082	0.8671	0.1942
40000	187.539	5.5380	−56.50	110.94	0.2462	0.4962	0.8671	0.1851
41000	178.739	5.2781	−56.50	116.40	0.2346	0.4844	0.8671	0.1764
42000	170.351	5.0305	−56.50	122.13	0.2236	0.4729	0.8671	0.1681
43000	162.357	4.7944	−56.50	128.15	0.2131	0.4616	0.8671	0.1602
44000	154.738	4.5694	−56.50	134.46	0.2031	0.4507	0.8671	0.1527
45000	147.477	4.3550	−56.50	141.08	0.1936	0.4400	0.8671	0.1455
46000	140.556	4.1506	−56.50	148.02	0.1845	0.4295	0.8671	0.1387
47000	133.960	3.9558	−56.50	155.31	0.1758	0.4193	0.8671	0.1322
48000	127.674	3.7702	−56.50	162.96	0.1676	0.4094	0.8671	0.1260
49000	121.683	3.5933	−56.50	170.98	0.1597	0.3997	0.8671	0.1201
50000	115.972	3.4247	−56.50	179.40	0.1522	0.3902	0.8671	0.1145
51000	110.530	3.2640	−56.50	188.24	0.1451	0.3809	0.8671	0.1091
52000	105.343	3.1108	−56.50	197.50	0.1383	0.3719	0.8671	0.1040
53000	100.400	2.9648	−56.50	207.23	0.1318	0.3630	0.8671	0.0991
54000	95.689	2.8257	−56.50	217.43	0.1256	0.3544	0.8671	0.0944
55000	91.198	2.6931	−56.50	228.14	0.1197	0.3460	0.8671	0.0900
56000	86.919	2.5667	−56.50	239.37	0.1141	0.3378	0.8671	0.0858
57000	82.840	2.4463	−56.50	251.16	0.1087	0.3298	0.8671	0.0818
58000	78.952	2.3315	−56.50	263.52	0.1036	0.3219	0.8671	0.0779
59000	75.247	2.2221	−56.50	276.50	0.0988	0.3143	0.8671	0.0743
60000	71.716	2.1178	−56.50	290.11	0.0941	0.3068	0.8671	0.0708
61000	68.351	2.0184	−56.50	304.40	0.0897	0.2995	0.8671	0.0675
62000	65.143	1.9237	−56050	319.38	0.0855	0.2924	0.8671	0.0643
63000	62.086	1.8334	−56.50	335.11	0.0815	0.2855	0.8671	0.0613
64000	59.173	1.7474	−56.50	351.61	0.0777	0.2787	0.8671	0.0584
65000	56.396	1.6654	−56.50	368.92	0.0840	0.2721	0.8671	0.0557
65617	54.748	1.6167	−56.50	380.03	0.0719	0.2681	0.8671	0.0540
66000	53.750	1.5872	−56.38	387.29	0.0705	0.2655	0.8673	0.0530
67000	51.231	1.5128	−56.08	406.91	0.0671	0.2591	0.8679	0.0506
68000	48.833	1.4420	−55.77	427.49	0.0639	0.2528	0.8686	0.0482
69000	46.550	1.3746	−55.47	449.08	0.0608	0.2466	0.8692	0.0459
70000	44.377	1.3105	−55.16	471.73	0.0579	0.2406	0.8698	0.0438

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Table 1. *(concluded)*

Altitude (geopotential) H	Static pressure p_s		Temperature θ	$\Delta H/\Delta p_s$	Density ratio ρ/ρ_0	$\left(\frac{\rho}{\rho_0}\right)^{0.5}$	Speed of sound ratio a/a_0	Pressure ratio p_s/p_{s0}
ft	mbar	inHg	°C	ft/mbar				
71000	42.309	1.2494	−54.86	495.48	0.0551	0.2348	0.8704	0.0418
72000	40.339	1.1912	−54.55	520.40	0.0525	0.2291	0.8710	0.0398
73000	38.464	1.1358	−54.25	546.53	0.0500	0.2235	0.8716	0.0380
74000	36.678	1.0831	−53.94	573.94	0.0476	0.2181	0.8722	0.0362
75000	34.978	1.0329	−53.64	602.68	0.0453	0.2129	0.8728	0.0345
80000	27.615	0.8155	−52.12	768.67	0.0355	0.1885	0.8758	0.0273
85000	21.837	0.6448	−50.59	978.75	0.0279	0.1670	0.8788	0.0216
90000	17.296	0.5107	−49.07	1244.20	0.0220	0.1482	0.8818	0.0171
95000	13.721	0.4052	−47.54	1579.06	0.0173	0.1315	0.8848	0.0135
100000	10.902	0.3219	−46.02	2000.83	0.0136	0.1168	0.8878	0.0108

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Table 2. Calibrated airspeed

Calibrated airspeed V_c	Dynamic pressure q_c		$\Delta V_c/\Delta q_c$	Calibrated airspeed V_c	Dynamic pressure q_c		$\Delta V_c/\Delta q_c$
kn	mbar	inHg	kn/mbar	kn	mbar	inHg	kn/mbar
5	0.041	0.0012	61.687				
10	0.162	0.0048	30.841	71	8.195	0.2420	4.319
15	0.365	0.0108	20.558	72	8.428	0.2489	4.259
20	0.649	0.0192	15.415	73	8.665	0.2559	4.200
25	1.013	0.0299	12.329	74	8.904	0.2629	4.142
30	1.460	0.0431	10.271	75	9.147	0.2701	4.086
31	1.559	0.0460	9.939	76	9.394	0.2774	4.032
32	1.661	0.0490	9.628	77	9.644	0.2848	3.979
33	1.766	0.0522	9.335	78	9.896	0.2922	3.927
34	1.875	0.0554	9.060	79	10.153	0.2998	3.877
35	1.987	0.0587	8.800	80	10.412	0.3075	3.827
36	2.102	0.0621	8.555	81	10.675	0.3152	3.780
37	2.221	0.0656	8.323	82	10.942	0.3231	3.733
38	2.343	0.0692	8.104	83	11.211	0.3311	3.687
39	2.468	0.0729	7.895	84	11.484	0.3391	3.642
40	2.596	0.0767	7.697	85	11.760	0.3473	3.599
41	2.728	0.0805	7.509	86	12.040	0.3555	3.556
42	2.862	0.0845	7.329	87	12.323	0.3639	3.515
43	3.000	0.0886	7.158	88	12.609	0.3723	3.474
44	3.142	0.0928	6.995	89	12.898	0.3809	3.434
45	3.286	0.0970	6.838	90	13.191	0.3895	3.396
46	3.434	0.1014	6.689	91	13.487	0.3983	3.358
47	3.585	0.1059	6.546	92	13.787	0.4071	3.320
48	3.740	0.1104	6.409	93	14.089	0.4161	3.284
49	3.897	0.1151	6.278	94	14.396	0.4251	3.248
50	4.058	0.1198	6.151	95	14.705	0.4342	3.214
51	4.222	0.1247	6.030	96	15.018	0.4435	3.179
52	4.390	0.1296	5.913	97	15.334	0.4528	3.146
53	4.561	0.1347	5.801	98	15.654	0.4623	3.113
54	4.735	0.1398	5.693	99	15.977	0.4718	3.081
55	4.912	0.1451	5.589	100	16.303	0.4814	3.049
56	5.093	0.1504	5.488	101	16.632	0.4912	3.019
57	5.276	0.1558	5.391	102	16.965	0.5010	2.988
58	5.464	0.1613	5.298	103	17.302	0.5109	2.959
59	5.654	0.1670	5.207	104	17.641	0.5209	2.929
60	5.848	0.1727	5.120	105	17.984	0.5311	2.901
61	6.045	0.1785	5.035	106	18.331	0.5413	2.873
62	6.245	0.1844	4.953	107	18.681	0.5516	2.845
63	6.448	0.1904	4.874	108	19.034	0.5621	2.818
64	6.655	0.1965	4.797	109	19.390	0.5726	2.792
65	6.865	0.2027	4.722	110	19.750	0.5832	2.766
66	7.079	0.2090	4.650	111	20.113	0.5939	2.740
67	7.295	0.2154	4.580	112	20.480	0.6048	2.715
68	7.515	0.2219	4.512	113	20.850	0.6157	2.690
69	7.739	0.2285	4.446	114	21.223	0.6267	2.666
70	7.965	0.2352	4.382	115	21.600	0.6379	2.642

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Table 2. *(continued)*

Calibrated airspeed V_c	Dynamic pressure q_c		$\Delta V_c/\Delta q_c$	Calibrated airspeed V_c	Dynamic pressure q_c		$\Delta V_c/\Delta q_c$
kn	mbar	inHg	kn/mbar	kn	mbar	inHg	kn/mbar
116	21.980	0.6491	2.619	161	42.644	1.2593	1.860
117	22.364	0.6604	2.595	162	43.183	1.2752	1.848
118	22.751	0.6718	2.573	163	43.726	1.2912	1.836
119	23.141	0.6834	2.550	164	44.273	1.3074	1.824
120	23.535	0.6950	2.529	165	44.822	1.3236	1.812
121	23.932	0.7067	2.507	166	45.376	1.3400	1.801
122	24.333	0.7185	2.486	167	45.933	1.3564	1.789
123	24.737	0.7305	2.465	168	46.494	1.3730	1.778
124	25.144	0.7425	2.444	169	47.058	1.3896	1.767
125	25.555	0.7546	2.424	170	47.626	1.4064	1.756
126	25.969	0.7669	2.404	171	48.197	1.4233	1.745
127	26.387	0.7792	2.384	172	48.772	1.4402	1.734
128	26.808	0.7916	2.365	173	49.350	1.4573	1.723
129	27.233	0.8042	2.346	174	49.932	1.4745	1.713
130	27.660	0.8168	2.327	175	50.518	1.4918	1.702
131	28.092	0.8296	2.309	176	51.107	1.5092	1.692
132	28.527	0.8424	2.291	177	51.700	1.5267	1.682
133	28.965	0.8553	2.273	178	52.296	1.5443	1.672
134	29.407	0.8684	2.255	179	52.896	1.5620	1.662
135	29.852	0.8815	2.238	180	53.500	1.5798	1.652
136	30.300	0.8948	2.221	181	54.107	1.5978	1.642
137	30.752	0.9081	2.204	182	54.718	1.6158	1.632
138	31.208	0.9216	2.187	183	55.332	1.6340	1.623
139	31.667	0.9351	2.171	184	55.950	1.6522	1.613
140	32.129	0.9488	2.155	185	56.572	1.6706	1.604
141	32.595	0.9625	2.139	186	57.197	1.6890	1.595
142	33.064	0.9764	2.123	187	57.826	1.7076	1.585
143	33.537	0.9903	2.107	188	58.459	1.7263	1.576
144	34.013	1.0044	2.092	189	59.095	1.7451	1.567
145	34.493	1.0186	2.077	190	59.735	1.7640	1.558
146	34.976	1.0328	2.062	191	60.379	1.7830	1.549
147	35.463	1.0472	2.047	192	61.026	1.8021	1.541
148	35.953	1.0617	2.033	193	61.677	1.8213	1.532
149	36.447	1.0763	2.018	194	62.331	1.8406	1.524
150	36.944	1.0909	2.004	195	62.989	1.8601	1.515
151	37.444	1.1057	1.990	196	63.651	1.8796	1.507
152	37.949	1.1206	1.977	197	64.317	1.8993	1.498
153	38.456	1.1356	1.963	198	64.986	1.9190	1.490
154	38.967	1.1507	1.950	199	65.659	1.9389	1.482
155	39.482	1.1659	1.936	200	66.335	1.9589	1.474
156	40.000	1.1812	1.923	201	67.016	1.9790	1.466
157	40.522	1.1966	1.910	202	67.700	1.9992	1.458
158	41.047	1.2121	1.898	203	68.387	2.0195	1.450
159	41.576	1.2277	1.885	204	69.079	2.0399	1.442
160	42.108	1.2435	1.873	205	69.774	2.0604	1.435

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Table 2. *(continued)*

Calibrated airspeed V_c	Dynamic pressure q_c		$\Delta V_c/\Delta q_c$	Calibrated airspeed V_c	Dynamic pressure q_c		$\Delta V_c/\Delta q_c$
kn	mbar	inHg	kn/mbar	kn	mbar	inHg	kn/mbar
206	70.473	2.0811	1.427	256	110.272	3.2563	1.119
207	71.175	2.1018	1.420	257	111.167	3.2828	1.114
208	71.882	2.1227	1.412	258	112.067	3.3093	1.109
209	72.592	2.1436	1.405	259	112.970	3.3360	1.104
210	73.306	2.1647	1.397	260	113.878	3.3628	1.099
211	74.023	2.1859	1.390	261	114.789	3.3897	1.095
212	74.744	2.2072	1.383	262	115.705	3.4168	1.090
213	75.469	2.2286	1.376	263	116.624	3.4439	1.085
214	76.198	2.2501	1.369	264	117.548	3.4712	1.080
215	76.931	2.2718	1.362	265	118.476	3.4986	1.076
216	77.667	2.2935	1.355	266	119.408	3.5261	1.071
217	78.407	2.3154	1.348	267	120.343	3.5537	1.066
218	79.151	2.3373	1.341	268	121.283	3.5815	1.062
219	79.899	2.3594	1.334	269	122.227	3.6094	1.057
220	80.650	2.3816	1.327	270	123.175	3.6374	1.052
221	81.405	2.4039	1.321	271	124.127	3.6655	1.048
222	82.164	2.4263	1.314	272	125.084	3.6937	1.044
223	82.927	2.4488	1.308	273	126.044	3.7221	1.039
224	83.694	2.4715	1.301	274	127.008	3.7506	1.035
225	84.464	2.4942	1.295	275	127.977	3.7792	1.030
226	85.239	2.5171	1.288	276	128.950	3.8079	1.026
227	86.017	2.5401	1.282	277	129.926	3.8367	1.022
228	86.799	2.5632	1.276	278	130.907	3.8657	1.017
229	87.585	2.5864	1.269	279	131.892	3.8948	1.013
230	88.374	2.6097	1.263	280	132.882	3.9240	1.009
231	89.168	2.6331	1.257	281	133.875	3.9533	1.005
232	89.965	2.6567	1.251	282	134.873	3.9828	1.000
233	90.766	2.6803	1.245	283	135.874	4.0124	0.996
234	91.571	2.7041	1.239	284	136.880	4.0421	0.992
235	92.380	2.7280	1.233	285	137.890	4.0719	0.988
236	93.193	2.7520	1.227	286	138.904	4.1018	0.984
237	94.010	2.7761	1.222	287	139.923	4.1319	0.980
238	94.830	2.8003	1.216	288	140.945	4.1621	0.976
239	95.655	2.8247	1.210	289	141.972	4.1924	0.972
240	96.483	2.8491	1.204	290	143.003	4.2229	0.968
241	97.315	2.8737	1.199	291	144.039	4.2535	0.964
242	98.151	2.8984	1.193	292	145.078	4.2841	0.960
243	98.992	2.9232	1.188	293	146.122	4.3150	0.956
244	99.836	2.9481	1.182	294	147.170	4.3459	0.952
245	100.683	2.9732	1.177	295	148.222	4.3770	0.948
246	101.535	2.9983	1.171	296	149.278	4.4082	0.945
247	102.391	3.0236	1.166	297	150.339	4.4395	0.941
248	103.251	3.0490	1.160	298	151.404	4.4710	0.937
249	104.115	3.0745	1.155	299	152.474	4.5025	0.933
250	104.982	3.1001	1.150	300	153.547	4.5342	0.930
251	105.854	3.1259	1.145	301	154.625	4.5661	0.926
252	106.729	3.1517	1.139	302	155.707	4.5980	0.922
253	107.609	3.1777	1.134	303	156.794	4.6301	0.919
254	108.493	3.2038	1.129	304	157.884	4.6623	0.915
255	109.380	3.2300	1.124	305	158.980	4.6947	0.911

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