NEW ZEALAND METEOROLOGICAL SERVICE

Technical Information Circular No. 103

Pressure and Density Altitudes

The following notes, tables and graphs are provided for convenient reference in expressing air pressures and air densities in terms of pressure altitudes and density altitudes in the I.C.A.O. standard atmosphere.

TIC 103

(M.A.F. Barnett)
DIRECTOR

N.Z. Meteorological Service,
P.O. Box 722,
WELLINGTON.

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Pressure and Density Altitudes

For many purposes it is convenient to identify conditions in the actual atmosphere with altitudes in a hypothetical standard atmosphere at which those conditions occur.

In aviation work it is the I.C.A.O. Standard Atmosphere (I.S.A.) that is commonly used, and many aircraft performance tables and graphs relate to conditions in this atmosphere. Values of a number of atmospheric parameters in this atmosphere are tabulated in I.C.A.O. Document 7488 "Manual of I.C.A.O. Standard Atmosphere". It should be noted that some of these values differ slightly from those in the older I.C.A.N. and N.A.C.A. standard atmospheres.

Pressure Altitude

An air pressure may be expressed as a "pressure altitude", which is altitude in the hypothetical I.S.A. at which air would have this particular pressure.

Meteorologists customarily refer their upper air data to isobaric surfaces identified by their pressures in millibars, but these isobaric surfaces can easily be identified by their pressure altitudes. Thus the 500 mb surface, for example, has a constant I.S.A. pressure altitude of 18289 feet, regardless of the variations in its geometric height or geopotential.

Appended are two sheets of tables giving

(1) corresponding pressures and pressure altitudes, with related air temperatures in the I.S.A., for a selection of commonly used values, and

(2) corresponding values of pressure and pressure altitude for intervals of 10 mb and of 1000 feet.

Density Altitude

An air density may be expressed as a "density altitude", i.e. the altitude in the hypothetical I.S.A. at which the air would have that particular density.

The density of dry air depends on its pressure and temperature. Water vapour however is less dense than dry air, so that the density of moist air at a particular pressure and temperature is less than the density of dry air under the same conditions. In practice it is convenient to base density calculations on a fictitious "virtual temperature", proceeding then as for dry air. This virtual temperature is obtained by increasing the true temperature of the air by an amount dependent on the humidity.

The virtual temperature increment for saturated air is shown in various tables, e.g. Smithsonian Meteorological Tables (Sixth Edition, Table 72). When the relative humidity is less than 100% the virtual temperature increment is reduced correspondingly. Thus for a relative humidity of 80% the increment would be 4/5 of the value tabulated for saturated air.

Some values of virtual temperature increment for saturated air are:

Virtual Temperature Increment (°C) for Saturated Air

Temperature	Air Pressure (mb)					
(°C)	1000	900	800	700	600	500
40	9.0	10.1	11.4	13.0		
35	6.7	7.5	8.5	9.7		
30	5.0	5.5	6.2	7.1		
25	3.6	4.0	4.5	5.2		
20	2.6	2.9	3.3	3.8	4.4	5.3
15	1.9	2.1	2.3	2.7	3.1	3.8
10	1.3	1.5	1.7	1.9	2.2	2.7
5	0.9	1.0	1.2	1.3	1.5	1.8
0	0.6	0.7	0.8	0.9	1.1	1.3
-5	0.4	0.5	0.5	0.6	0.7	0.9
-10	0.3	0.3	0.4	0.4	0.5	0.6
-15	0.2	0.2	0.2	0.3	0.3	0.4
-20	0.1	0.1	0.2	0.2	0.2	0.2

A convenient method for obtaining a close approximation to the appropriate virtual temperature increment (in °C) is to take one sixth of the numerical value of the humidity mixing ratio (expressed in the customary manner as parts per thousand). This humidity mixing ratio may for example be read from the dew point curve plotted on a tephigram. Thus air with a pressure of 999 mb, temperature of 25.0°C, and a dew point of 23.0°C (for which the humidity mixing ratio is 18 parts per thousand) would have a virtual temperature of 25.0 + 1/6(18), or 28.0°C; its density altitude would therefore be 2000 feet.

It should be noted that where the density altitude of an airfield is required, as for the calculation of length of take-off run under the conditions prevailing, the density computation must be based on virtual temperature and airfield level pressure, not the pressure artificially adjusted to sea level.

Appended are:

(1) a graph for deriving density altitude from air pressure and virtual temperature, covering the values commonly attained at low-level airfields, and

(2) a reproduction of a tephigram marked to show the density altitudes corresponding to various pressures and virtual temperatures.

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DATA FOR SELECTED LEVELS IN ICAO STANDARD ATMOSPHERE

Press. mb	Height feet	Temp. °C	Height 1000 ft	Press. mb	Temp. °C
1013	0	15.0	0	1013	15.0
1000	364	14.3	5	843	5.1
900	3,243	8.6	10	697	- 4.8
850	4,781	5.5	15	572	-14.7
800	6,394	2.3	20	466	-24.6
700	9,882	- 4.6	25	376	-34.5
600	13,801	-12.3	30	301	-44.4
500	18,289	-21.2	35	238	-54.3
400	23,574	-31.7	40	188	-56.5
300	30,065	-44.6	45	147	-56.5
250	33,999	-52.4	50	116	-56.5
226	36,089	-56.5	55	91	-56.5
200	38,662	-56.5	60	72	-56.5
150	44,647	-56.5			
100	53,083	-56.5			
70	60,504	-56.5			

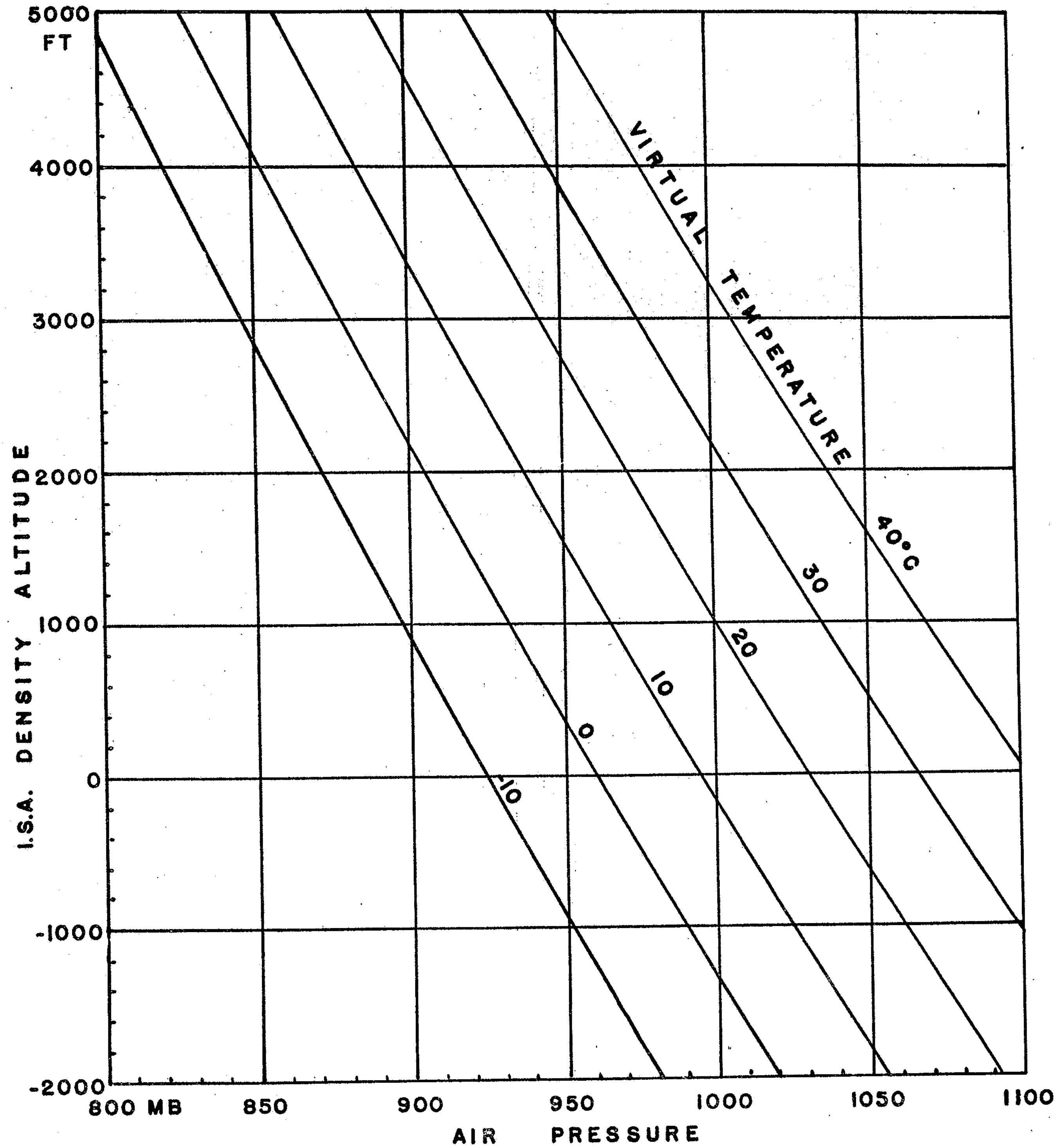
(Based on ICAO Doc. 7488)

HEIGHTS (100 gp.feet) AS FUNCTIONS OF PRESSURE (mb) IN ICAO STANDARD ATMOSPHERE

mb	00	10	20	30	40	50	60	70	80	90
					hundreds feet					
000							637	605	557	553
100	531	511	493	476	461	446	433	420	409	397
200	387	376	367	358	349	340	332	324	316	308
300	301	293	286	280	273	266	260	254	248	242
400	236	230	224	219	213	208	203	198	193	188
500	183	178	173	169	164	160	155	151	146	142
600	138	134	130	126	122	118	114	110	106	103
700	99	95	92	90	84	81	77	74	71	67
800	64	61	57	54	51	48	45	42	39	35
900	32	29	26	24	21	18	15	12	9	6
1000	4	1	-2	-5	-7	-10				

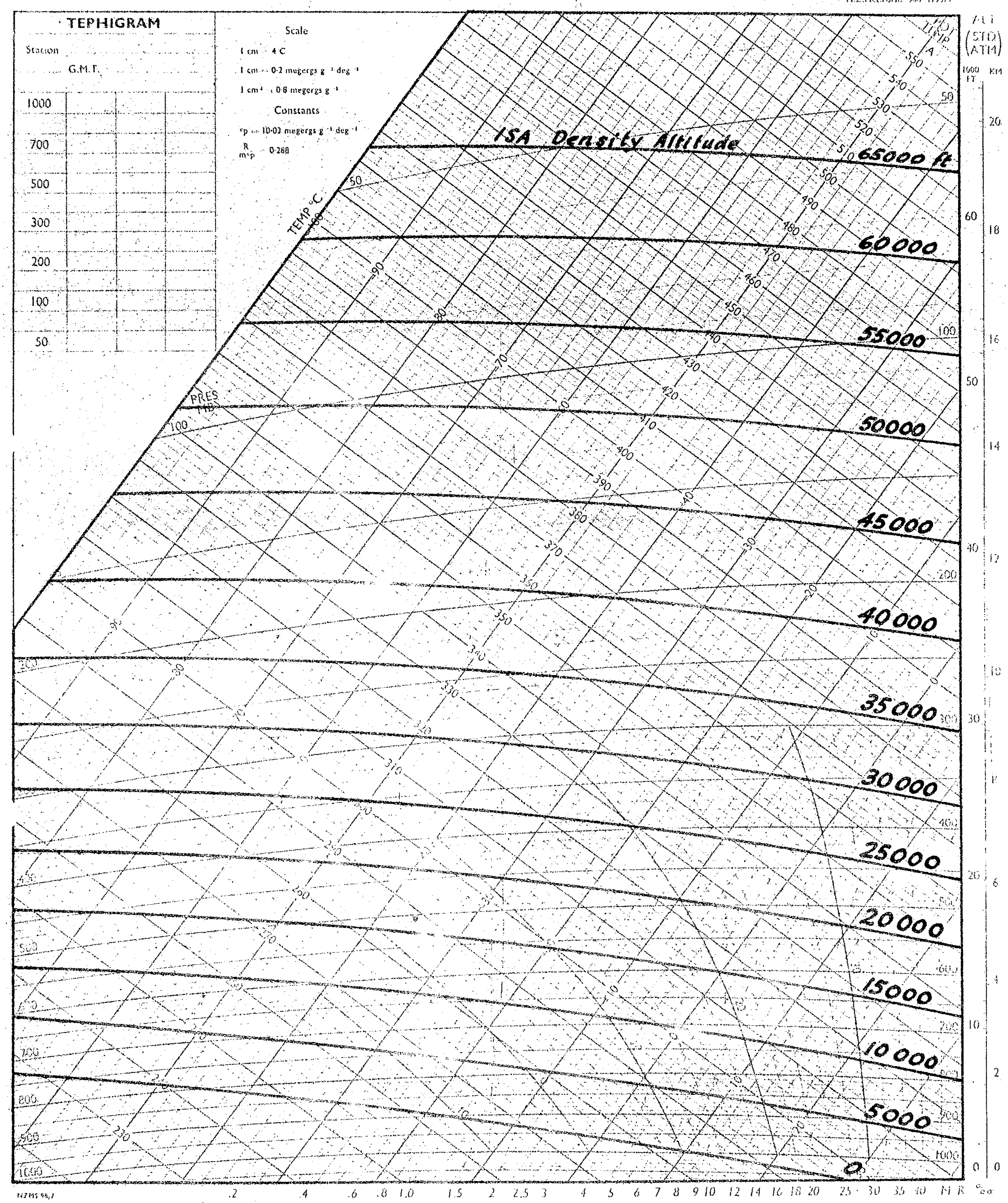
PRESSURES (mb) AS FUNCTIONS OF HEIGHT (1000 gp.feet) IN ICAO STANDARD ATMOSPHERE

1000 ft	0	1	2	3	4	5	6	7	8	9
					millibars					
0	1013	977	942	908	875	843	812	782	753	724
10	697	670	644	619	595	572	549	527	506	485
20	466	446	428	410	393	376	360	344	329	315
30	301	287	274	262	250	238	227	217	206	197
40	188	179	170	162	155	147	141	134	128	122
50	116	110	105	100	96	91	87	83	79	75
60	72	68	65	62	59	56				



5000 FT
4000
3000
2000
1000
0
-1000
-2000
I.S.A. DENSITY ALTITUDE
800 MB
850
900
950
1000
1050
1100
AIR PRESSURE
VIRTUAL TEMPERATURE
40°C
30
20
10
0
-10

N.Z.Met.Form 906 (1957)



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