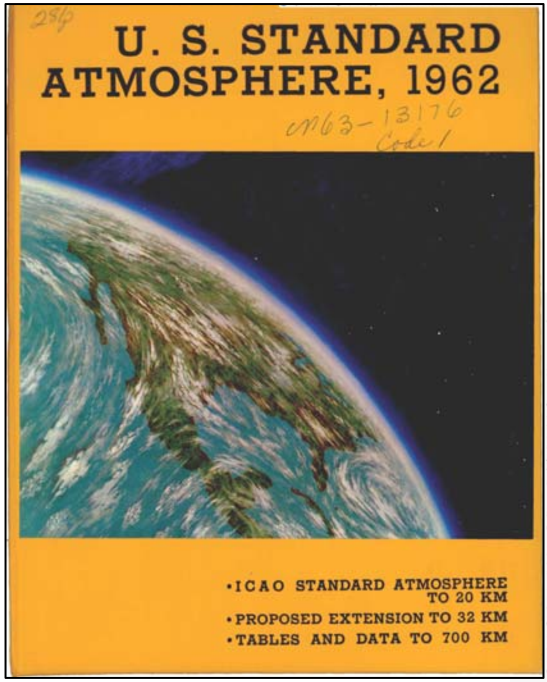

U. S. STANDARD ATMOSPHERE, 1962

286

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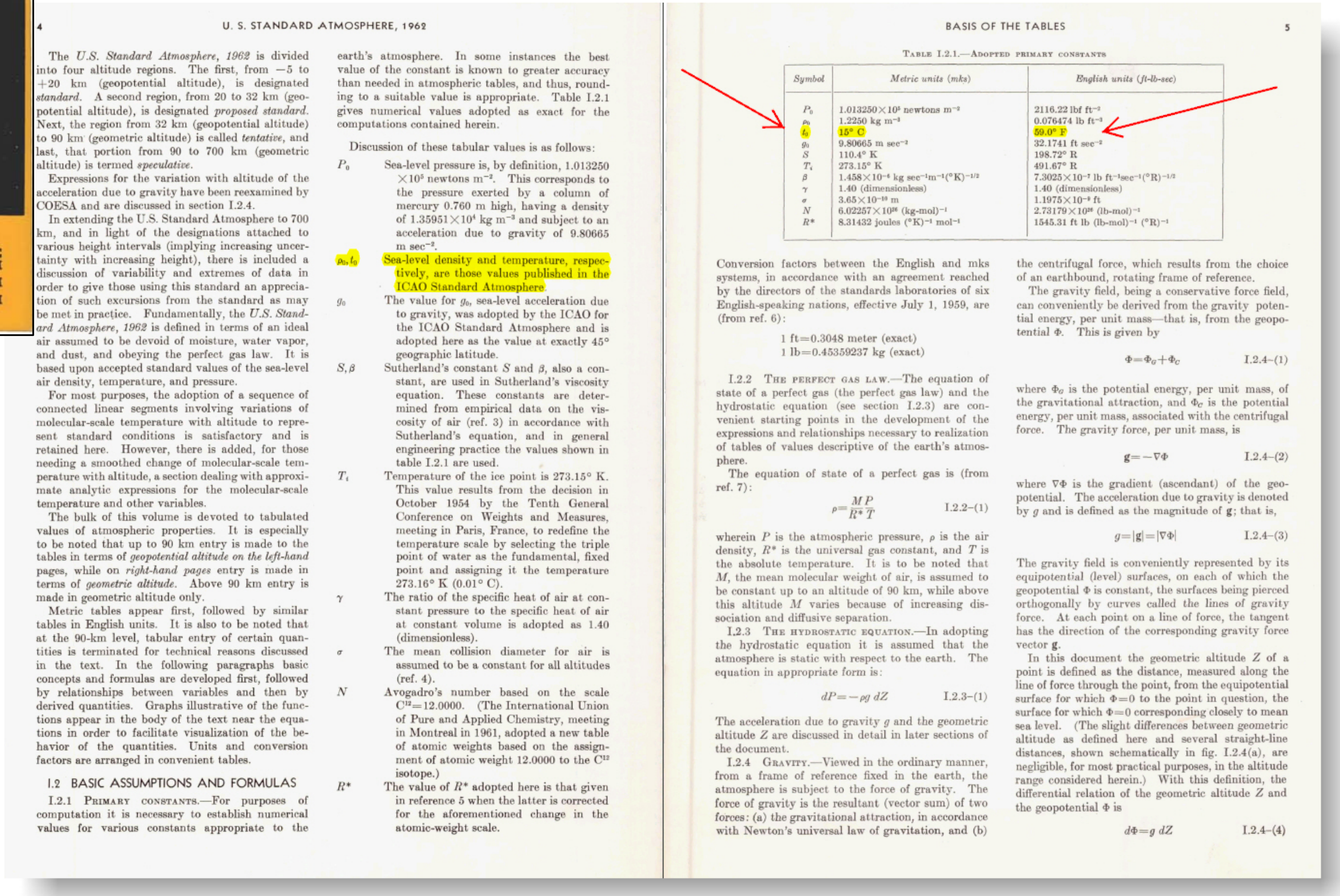
- ICAO STANDARD ATMOSPHERE TO 20 KM
- PROPOSED EXTENSION TO 32 KM
- TABLES AND DATA TO 700 KM

Quelle: https://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/19630003300.pdf

Seite 4 und 5
(.pdf-Seite 20 und 21)



The *U.S. Standard Atmosphere, 1962* is divided into four altitude regions. The first, from −5 to +20 km (geopotential altitude), is designated *standard*. A second region, from 20 to 32 km (geopotential altitude), is designated *proposed standard*. Next, the region from 32 km (geopotential altitude) to 90 km (geometric altitude) is called *tentative*, and last, that portion from 90 to 700 km (geometric altitude) is termed *speculative*.

Expressions for the variation with altitude of the acceleration due to gravity have been reexamined by COESA and are discussed in section I.2.4.

In extending the U.S. Standard Atmosphere to 700 km, and in light of the designations attached to various height intervals (implying increasing uncertainty with increasing height), there is included a discussion of variability and extremes of data in order to give those using this standard an appreciation of such excursions from the standard as may be met in practice. Fundamentally, the *U.S. Standard Atmosphere, 1962* is defined in terms of an ideal air assumed to be devoid of moisture, water vapor, and dust, and obeying the perfect gas law. It is based upon accepted standard values of the sea-level air density, temperature, and pressure.

For most purposes, the adoption of a sequence of connected linear segments involving variations of molecular-scale temperature with altitude to represent standard conditions is satisfactory and is retained here. However, there is added, for those needing a smoothed change of molecular-scale temperature with altitude, a section dealing with approximate analytic expressions for the molecular-scale temperature and other variables.

The bulk of this volume is devoted to tabulated values of atmospheric properties. It is especially to be noted that up to 90 km entry is made to the tables in terms of *geopotential altitude on the left-hand pages*, while on *right-hand pages* entry is made in terms of *geometric altitude*. Above 90 km entry is made in geometric altitude only.

Metric tables appear first, followed by similar tables in English units. It is also to be noted that at the 90-km level, tabular entry of certain quantities is terminated for technical reasons discussed in the text. In the following paragraphs basic concepts and formulas are developed first, followed by relationships between variables and then by derived quantities. Graphs illustrative of the functions appear in the body of the text near the equations in order to facilitate visualization of the behavior of the quantities. Units and conversion factors are arranged in convenient tables.

I.2 BASIC ASSUMPTIONS AND FORMULAS

I.2.1 PRIMARY CONSTANTS.—For purposes of computation it is necessary to establish numerical values for various constants appropriate to the earth's atmosphere. In some instances the best value of the constant is known to greater accuracy than needed in atmospheric tables, and thus, rounding to a suitable value is appropriate. Table I.2.1 gives numerical values adopted as exact for the computations contained herein.

Discussion of these tabular values is as follows:

P_0	Sea-level pressure is, by definition, 1.013250×10^5 newtons m^{-2}. This corresponds to the pressure exerted by a column of mercury 0.760 m high, having a density of 1.35951×10^4 kg m^{-3} and subject to an acceleration due to gravity of 9.80665 m sec^{-2}.
ρ_0, t_0	Sea-level density and temperature, respectively, are those values published in the ICAO Standard Atmosphere.
g_0	The value for g_0, sea-level acceleration due to gravity, was adopted by the ICAO for the ICAO Standard Atmosphere and is adopted here as the value at exactly 45° geographic latitude.
S, β	Sutherland's constant S and β, also a constant, are used in Sutherland's viscosity equation. These constants are determined from empirical data on the viscosity of air (ref. 3) in accordance with Sutherland's equation, and in general engineering practice the values shown in table I.2.1 are used.
T_i	Temperature of the ice point is 273.15° K. This value results from the decision in October 1954 by the Tenth General Conference on Weights and Measures, meeting in Paris, France, to redefine the temperature scale by selecting the triple point of water as the fundamental, fixed point and assigning it the temperature 273.16° K (0.01° C).
γ	The ratio of the specific heat of air at constant pressure to the specific heat of air at constant volume is adopted as 1.40 (dimensionless).
σ	The mean collision diameter for air is assumed to be a constant for all altitudes (ref. 4).
N	Avogadro's number based on the scale $C^{12}=12.0000$. (The International Union of Pure and Applied Chemistry, meeting in Montreal in 1961, adopted a new table of atomic weights based on the assignment of atomic weight 12.0000 to the C^{12} isotope.)
R^*	The value of R^* adopted here is that given in reference 5 when the latter is corrected for the aforementioned change in the atomic-weight scale.

TABLE I.2.1.—ADOPTED PRIMARY CONSTANTS

Symbol	*Metric units (mks)*	*English units (ft-lb-sec)*
P_0	1.013250×10^5 newtons m^{-2}	2116.22 lbf ft^{-2}
ρ_0	1.2250 kg m^{-3}	0.076474 lb ft^{-3}
t_0	15° C	59.0° F
g_0	9.80665 m sec^{-2}	32.1741 ft sec^{-2}
S	110.4° K	198.72° R
T_i	273.15° K	491.67° R
β	1.458×10^{-6} kg $sec^{-1}m^{-1}(°K)^{-1/2}$	7.3025×10^{-7} lb $ft^{-1}sec^{-1}(°R)^{-1/2}$
γ	1.40 (dimensionless)	1.40 (dimensionless)
σ	3.65×10^{-10} m	1.1975×10^{-9} ft
N	6.02257×10^{26} (kg-mol)$^{-1}$	2.73179×10^{26} (lb-mol)$^{-1}$
R^*	8.31432 joules $(°K)^{-1}$ mol^{-1}	1545.31 ft lb (lb-mol)$^{-1}$ $(°R)^{-1}$

Conversion factors between the English and mks systems, in accordance with an agreement reached by the directors of the standards laboratories of six English-speaking nations, effective July 1, 1959, are (from ref. 6):

1 ft=0.3048 meter (exact)
1 lb=0.45359237 kg (exact)

I.2.2 THE PERFECT GAS LAW.—The equation of state of a perfect gas (the perfect gas law) and the hydrostatic equation (see section I.2.3) are convenient starting points in the development of the expressions and relationships necessary to realization of tables of values descriptive of the earth's atmosphere.

The equation of state of a perfect gas is (from ref. 7):

$$\rho=\frac{M}{R^*}\frac{P}{T} \qquad \text{I.2.2–(1)}$$

wherein P is the atmospheric pressure, ρ is the air density, R^* is the universal gas constant, and T is the absolute temperature. It is to be noted that M, the mean molecular weight of air, is assumed to be constant up to an altitude of 90 km, while above this altitude M varies because of increasing dissociation and diffusive separation.

I.2.3 THE HYDROSTATIC EQUATION.—In adopting the hydrostatic equation it is assumed that the atmosphere is static with respect to the earth. The equation in appropriate form is:

$$dP=-\rho g\, dZ \qquad \text{I.2.3–(1)}$$

The acceleration due to gravity g and the geometric altitude Z are discussed in detail in later sections of the document.

I.2.4 GRAVITY.—Viewed in the ordinary manner, from a frame of reference fixed in the earth, the atmosphere is subject to the force of gravity. The force of gravity is the resultant (vector sum) of two forces: (a) the gravitational attraction, in accordance with Newton's universal law of gravitation, and (b) the centrifugal force, which results from the choice of an earthbound, rotating frame of reference.

The gravity field, being a conservative force field, can conveniently be derived from the gravity potential energy, per unit mass—that is, from the geopotential Φ. This is given by

$$\Phi=\Phi_G+\Phi_C \qquad \text{I.2.4–(1)}$$

where Φ_G is the potential energy, per unit mass, of the gravitational attraction, and Φ_C is the potential energy, per unit mass, associated with the centrifugal force. The gravity force, per unit mass, is

$$\mathbf{g}=-\nabla\Phi \qquad \text{I.2.4–(2)}$$

where $\nabla\Phi$ is the gradient (ascendant) of the geopotential. The acceleration due to gravity is denoted by g and is defined as the magnitude of $\mathbf{g}$; that is,

$$g=|\mathbf{g}|=|\nabla\Phi| \qquad \text{I.2.4–(3)}$$

The gravity field is conveniently represented by its equipotential (level) surfaces, on each of which the geopotential Φ is constant, the surfaces being pierced orthogonally by curves called the lines of gravity force. At each point on a line of force, the tangent has the direction of the corresponding gravity force vector $\mathbf{g}$.

In this document the geometric altitude Z of a point is defined as the distance, measured along the line of force through the point, from the equipotential surface for which $\Phi=0$ to the point in question, the surface for which $\Phi=0$ corresponding closely to mean sea level. (The slight differences between geometric altitude as defined here and several straight-line distances, shown schematically in fig. I.2.4(a), are negligible, for most practical purposes, in the altitude range considered herein.) With this definition, the differential relation of the geometric altitude Z and the geopotential Φ is

$$d\Phi=g\, dZ \qquad \text{I.2.4–(4)}$$