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МЕЖДУНАРОДНАЯ ОРГАНИЗАЦИЯ ПО СТАНДАРТИЗАЦИИ

Flight dynamics — Concepts, quantities and symbols —

Part 5: Quantities used in measurements

Mécanique du vol — Concepts, grandeurs et symboles —

Partie 5: Grandeurs utilisées dans les mesures

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work.

Draft International Standards adopted by the technical committees are circulated to the member bodies for approval before their acceptance as International Standards by the ISO Council. They are approved in accordance with ISO procedures requiring at least 75 % approval by the member bodies voting.

International Standard ISO 1151-5 was prepared by Technical Committee ISO/TC 20, *Aircraft and space vehicles*.

This second edition cancels and replaces the first edition (ISO 1151-5 : 1974), of which it constitutes an overall technical revision and to which sub-clause 5.7 has been added.

Users should note that all International Standards undergo revision from time to time and that any reference made herein to any other International Standard implies its latest edition, unless otherwise stated.

ISO 1151, *Flight dynamics — Concepts, quantities and symbols,* comprises, at present, seven parts:

Part 1: Aircraft motion relative to the air.

Part 2: Motions of the aircraft and the atmosphere relative to the Earth.

Part 3: Derivatives of forces, moments and their coefficients.

Part 4: Parameters used in the study of aircraft stability and control.

Part 5: Quantities used in measurements.

Part 6: Aircraft geometry.

Part 7: Flight points and flight envelopes.

ISO 1151 is intended to introduce the main concepts, to include the more important terms used in theoretical and experimental studies and, as far as possible, to give corresponding symbols.

In all the parts comprising ISO 1151, the term "aircraft" denotes a vehicle intended for atmosphere or space flight. Usually, it has an essentially port and starboard symmetry with respect to a plane. That plane is determined by the geometric characteristics of the aircraft. In that plane, two orthogonal directions are defined: fore-and-aft and dorsal-ventral. The transverse direction, on the perpendicular to that plane, follows.

When there is a single plane of symmetry, it is the reference plane of the aircraft. When there is more than one plane of symmetry, or when there is none, it is necessary to choose a reference plane. In the former case, the reference plane is one of the planes of symmetry. In the latter case, the reference plane is arbitrary. In all cases, it is necessary to specify the choice made.

Angles of rotation, angular velocities and moments about any axis are positive clockwise when viewed in the positive direction of that axis.

All the axis systems used are three-dimensional, orthogonal and right-handed, which implies that a positive rotation through $\pi/2$ around the x-axis brings the y-axis into the position previously occupied by the z-axis.

The centre of gravity coincides with the centre of mass if the field of gravity is homogeneous. If this is not the case, the centre of gravity can be replaced by the centre of mass in the definitions of ISO 1151; in this case, this should be indicated.

Numbering of sections and clauses

With the aim of easing the indication of references from a section or a clause, a decimal numbering system has been adopted such that the first figure is the number of the part of ISO 1151 considered.

Contents

Flight dynamics — Concepts, quantities and symbols —

Part 5: Quantities used in measurements

5.0 Introduction

This part of ISO 1151 deals with the quantities used in flight measurements.

ISO 2533, *Standard atmosphere,* is necessary as a reference document for the application of some items in this part of ISO 1151.

5.1 Fundamental characteristics of the atmosphere

Among the physical quantities characterizing the atmosphere at the point considered, the following are the most important.

No.	Term	Definition	Symbol
5.1.1	(Air) pressure	The pressure of the air at the point considered in the atmosphere, as measured by a perfect instrument, at rest relative to the air.	p
5.1.2	(Air) temperature	The thermodynamic temperature of the air at the point considered in the atmosphere, as measured by a perfect instrument, at rest relative to the air. NOTE — The thermodynamic temperature is still sometimes called the "absolute temperature".	T
5.1.3	(Air) density	The quotient of the mass of the air contained in an infinitesimal volume enclosing the point considered in the atmosphere by this volume.	ϱ
5.1.4	Relative (air) density	The ratio of the air density (5.1.3), at the point considered in the atmosphere, to a datum density. In general, this datum density is the density of air at mean sea level in the chosen standard atmosphere. Using the standard atmosphere specified in ISO 2533: $\sigma = \frac{\varrho}{\varrho_n}$ where $\varrho_n = 1{,}225\ \text{kg}\cdot\text{m}^{-3}$	σ

5.2 Geometric and geopotential altitudes

No.	Term	Definition	Symbol
5.2.1	Geometric altitude (with respect to sea level)	A quantity, the modulus of which is equal to the distance between the point considered and the mean sea level. This quantity is positive for points above mean sea level.	h or Z_g NOTE — Where there is no possibility of confusion with Z (1.5.2), the subscript "g" may be omitted.
5.2.2	Geopotential altitude	The geopotential altitude of a point P, of geometric altitude h(P) (5.2.1), is given by the relationship: $H = \frac{1}{g_n} \int_0^{h(P)} g(h) \, dh$ where $g(h)$ is the acceleration of free fall defined in the standard atmosphere specified in ISO 2533 as a function of the geometric altitude h (5.2.1); g_n is the standard acceleration of free fall (g_n = 9,806 65 $m \cdot s^{-2}$ according to ISO 2533). The integral is calculated along the vertical passing through point P.	H

5.3 Equivalent altitudes related to a standard atmosphere

The definition of a number of quantities of interest in flight measurements depends on the concept of a standard atmosphere. Such an atmosphere is assumed to comprise a perfect gas, of known molar mass, in aerostatic equilibrium.

The laws of variation of temperature and composition of the gas with geopotential altitude (5.2.2) are chosen according to convention; the laws of variation with geopotential altitude of the different physical parameters which characterize the standard atmosphere adopted are then deduced.

No.	Term	Definition	Symbol
5.3.1	Pressure altitude	The geopotential altitude (5.2.2) at which, in the chosen standard atmosphere, the pressure is equal to the air pressure (5.1.1) at the point considered.	H_p
5.3.2	Temperature altitude	The geopotential altitude (5.2.2) at which, in the chosen standard atmosphere, the temperature is equal to the air temperature (5.1.2) at the point considered.	H_T
5.3.3	Density altitude	The geopotential altitude (5.2.2) at which, in the chosen standard atmosphere, the density is equal to the air density (5.1.3) at the point considered.	H_ϱ

NOTE — Similar definitions to those given in 5.3.1 to 5.3.3 can be drawn up by analogy using the geometric altitude; the corresponding symbols are: h_p, h_T, h_ϱ.

5.4 Physical quantities related to motion of the aircraft in the atmosphere

The determination of the velocity and altitude of the aircraft requires the definition of physical quantities relative to the motion of a point in the atmosphere. It is assumed that the atmosphere is not disturbed by the presence of the moving point.

No.	Term	Definition	Symbol
5.4.1	(Static) pressure	The air pressure (5.1.1) at a point of the atmosphere coincident with the instantaneous position of the moving point.	p_s NOTE — Where there is no possibility of confusion, the subscript "s" may be omitted.
5.4.2	(Static) temperature	The air temperature (5.1.2) at a point of the atmosphere coincident with the instantaneous position of the moving point.	T_s NOTE — Where there is no possibility of confusion, the subscript "s" may be omitted.
5.4.3	(Static) density	The air density (5.1.3) at a point of the atmosphere coincident with the instantaneous position of the moving point.	ϱ_s NOTE — Where there is no possibility of confusion, the subscript "s" may be omitted.
5.4.4	Total pressure	The pressure of the air brought to rest, relative to the moving point, by an isentropic process (adiabatic and reversible).	p_i or p_t
5.4.5	Total pressure behind a normal shock	The pressure of the air brought to rest, relative to the moving point, by an isentropic process (adiabatic and reversible) downstream of a normal shock.	p'_i or p'_t
5.4.6	Pitot pressure	The pressure of the air brought to rest, relative to the moving point, — by an isentropic process in subsonic flow; — by an isentropic process downstream of a normal shock in supersonic flow. NOTE — Subsonic: $p_p = p_i = p_t$ Supersonic: $p_p = p'_i = p'_t$	p_p
5.4.7	Total temperature	The thermodynamic temperature of the air brought to rest, relative to the moving point, by an adiabatic process. NOTE — The thermodynamic temperature is still sometimes called the "absolute temperature".	T_i or T_t
5.4.8	Kinetic pressure	The quantity having the dimension of a pressure and equal to half the product of the air density ϱ (5.1.3) and the square of the speed V (1.3.1) of the point relative to the air: $q = \frac{\varrho}{2} V^2$	q

NOTE — In some countries, terms are used for the following differences:

$p_i - p_s$ or $p_t - p_s$

$p_p - p_s$

(See the table in the annex.)

5.5 Measurement of quantities related to motion of the aircraft in the atmosphere

On the basis of the measurements of pressure and temperature taken on board the aircraft, the quantities defined in 5.4 can be determined. However, these measurements are affected by two types of errors:

a) errors due to the aerodynamic field of the aircraft, to the shape and orientation of the pressure or temperature probes, etc.;

b) errors due to the measuring system installed on board the aircraft (sensors, transducers, transmission, pneumatic delays, coding systems, reading errors, etc.).

The correction of the second type of errors deals with measurement problems in general. On the other hand, the specific character of errors of the first type leads to the definition of characteristic quantities existing at the input of the measuring probes for pressure and temperature installed on board the aircraft.

NOTE – In the symbols for 5.5.1 to 5.5.7, the subscript "b" shall be retained or replaced by an alphanumeric index characteristic of the measuring probe considered.

No.	Term	Definition	Symbol
5.5.1	Input static pressure	The pressure existing at the input of the probe for static pressure (5.4.1).	p_{sb}
5.5.2	Static error	The difference between the input static pressure (5.5.1) and the static pressure (5.4.1): $dp_s = p_{sb} - p_s$	dp_s
5.5.3	Coefficient of static error	The static error (5.5.2) divided by the kinetic pressure (5.4.8): $K_{ps} = \frac{dp_s}{q}$	K_{ps}
5.5.4	Input pitot pressure	The pressure existing at the input of the probe for pitot pressure (5.4.6).	p_{pb}
5.5.5	Pitot pressure error	The difference between the input pitot pressure (5.5.4) and the pitot pressure (5.4.6): $dp_p = p_{pb} - p_p$	dp_p
5.5.6	–	The difference between the input pitot pressure (5.5.4) and the input static pressure (5.5.1): $\Delta p = p_{pb} - p_{sb}$	Δp
5.5.7	Input total temperature	The thermodynamic temperature existing at the location of the probe for total temperature (5.4.7).	T_{ib} or T_{tb}

5.6 Speeds and indicated Mach number

No.	Term	Definition	Symbol
5.6.1	Calibrated airspeed	The airspeed (1.3.1) the aircraft would have at sea level in a standard atmosphere as specified in ISO 2533, for the same value of difference between the pitot pressure (5.4.6) and the static pressure (5.4.1) as that existing at the moment considered. Its value is given by the following theoretical relationships: a) If $V_c \leqslant \sqrt{\gamma R T_n} = a_n = 340{,}294\ \text{m}\cdot\text{s}^{-1}$, then $p_p - p_s = p_n \left[\left(1 + \frac{\gamma - 1}{2}\frac{V_c^2}{\gamma R T_n}\right)^{\gamma/(\gamma-1)} - 1\right]$ b) If $V_c > \sqrt{\gamma R T_n} = a_n = 340{,}294\ \text{m}\cdot\text{s}^{-1}$, then $p_p - p_s = p_n \left\{\left(\frac{\gamma + 1}{2}\frac{V_c^2}{\gamma R T_n}\right)^{\gamma/(\gamma-1)} \left[1 + \frac{2\gamma}{\gamma + 1}\left(\frac{V_c^2}{\gamma R T_n} - 1\right)\right]^{1/(1-\gamma)} - 1\right\}$ where, according to convention, γ (sometimes written as κ) = 1,400 R = 287,052 87 $\text{J}\cdot\text{K}^{-1}\cdot\text{kg}^{-1}$ p_n = 101 325 Pa T_n = 288,15 K These formulae are used to calibrate airspeed indicators. NOTE — a_n, p_n and T_n are, respectively, the standard values of the speed of sound, pressure and thermodynamic temperature, at mean sea level.	V_c
5.6.2	Indicated airspeed	The airspeed obtained at the output of a measuring system, calculated as a calibrated airspeed (5.6.1), but using pressure indications available at the input of the computer incorporated in the system.	V_i
5.6.3	Equivalent airspeed	The product of the airspeed (1.3.1) and the square root of the relative air density (5.1.4): $V_e = V\sqrt{\sigma}$	V_e