Designation: D 2506 – 80 (Reapproved 1989)

An American National Standard

Standard Terminology Relating to Solid Rocket Propulsion[1]

This standard is issued under the fixed designation D 2506; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 These symbols and definitions provide nomenclature for those parameters of common usage associated with solid rocket propulsion. In the interest of common understanding and standardization, consistent word usage is encouraged to help eliminate the major barrier to effective technical communication, particularly in the case of words having economic importance.

2. Significance and Use

2.1 Significant terms are grouped into major categories which have generally accepted meanings. Within each major category, significant terms are given definite meanings, symbols, and definitions. The following criteria determine acceptability of a term for inclusion:

2.1.1 The term is of interest to solid propulsion workers.

2.1.2 The term has a specific application or has been subject to misunderstanding or misuse.

2.1.3 The term is not adequately defined for general use in any standard dictionary.

2.1.4 Terms are used in current systems.

DEFINITION OR DESCRIPTION OF TERMS

3. Geometry—Linear dimensions shall be expressed in feet or inches, including any decimal parts, and abbreviated as ft or in. Angular dimensions shall be expressed in degrees and decimal parts of a degree, for example, 15.23 deg.

3.1 *Area of Propellant Burning Surface* (A_b).

3.2 *Flow Area at Nozzle Exit Plane* (A_e).

3.3 *Flow Area at Grain Port* (A_p).

3.4 *Flow Area at Nozzle Throat* (A_t).

3.5 *Web Thickness of Propellant* (w).

3.6 *Nozzle Divergence Half-Angle* (α).

3.7 *Nozzle Convergence Half-Angle* (β).

4. Impulse (I)—Impulse shall be expressed as pounds-force-seconds (lbf·s). A numeral in the subscript to I indicates the time elapsed from zero time. The numeral may be changed to suit the application.

4.1 *Action Time Impulse* (I_a)—The area under the "thrust action time" portion of the thrust-time record.

4.2 *Burning Time Impulse* (I_b)—The area under the "thrust burning time" portion of the thrust-time record.

4.3 *Propellant Specific Impulse* (I_{sp})—This symbol is used only in general reference to propellant specific impulse or in reporting nonstandard corrected values of I_{spd} (Notes 1 and 2). All numerical values must be accompanied by specification of the following assumptions:

4.3.1 Chamber pressure (P_c),

4.3.2 Ambient pressure (P_{amb}),

4.3.3 Nozzle area expansion ratio (E) and whether or not this is optimum, and

4.3.4 Nozzle divergence half-angle (α).

NOTE 1—Use the same time interval and propellant mass assumptions as for I_{spd}; therefore, do not report a numerical value of I_{sp} without also reporting the corresponding value of I_{spd}.

NOTE 2—With the only exception of $I°_{sps}$, all reported values of propellant specific impulse must be accompanied by a statement of the assumptions made in calculating a theoretical value, or a statement of the existing motor conditions and assumptions in obtaining a measured or corrected value. A degree sign (°) indicates a theoretical value, not a value that has been obtained from or derived from the results of a motor firing. In stating the assumptions or motor conditions, or both, a shorthand notation may be used if no confusion will result. For example, a measured propellant specific impulse of 241.6 lbf·s/lbm over the 25 psia action time from a motor operating at 1230 psia, exhausting to 11.6 psia with an expansion ratio of 9.8, a nozzle divergence angle of 17.5 deg, and an expended mass of 3563 lbm may be abbreviated as follows:

$$I_{spd}(1230/11.6,\ 9.8,\ 17.5°,\ {}_{a0.25p,}m_m - m_{bo} = 3563) = 241.6 \text{ lbf·s/lbm}$$

4.4 *Theoretical Propellant Specific Impulse* ($I°_{sp}$), calculated from propellant thermodynamic properties. All numerical values must be accompanied by specification of the following assumptions:

4.4.1 Chamber pressure (P_c)

4.4.2 Ambient pressure (P_{amb}),

4.4.3 Nozzle area expansion ratio (E) and whether or not this is optimum,

4.4.4 Nozzle divergence half-angle (α),

4.4.5 Assumption of frozen or equilibrium exit composition, and

4.4.6 Physical state of exhaust condensables.

4.5 *Measured (Delivered) Propellant Specific Impulse* (I_{spd}), calculated from data from an actual motor firing. All numerical values must be accompanied by specification of the following motor conditions:

4.5.1 Chamber pressure (P_c),

4.5.2 Ambient pressure (P_{amb}),

4.5.3 Nozzle area expansion ratio (E),

4.5.4 Nozzle divergence half-angle (α),

4.5.5 Time interval used for impulse determination, and

4.5.6 Propellant mass assumption.

4.6 *Theoretical Delivered Propellant Specific Impulse* ($I°_{spd}$), calculated from propellant thermodynamic properties assuming the same motor conditions reported for I_{spd} with the added specifications of either frozen or equilibrium exit composition and physical state of exhaust condensables. One

[1] These definitions are under the jurisdiction of ASTM Committee F-7 on Aerospace Industry Methods and are the direct responsibility of Subcommittee F07.02 on Propellant Technology.

Current edition approved Oct. 31, 1980. Published March 1981. Originally published as D 2506 – 66 T. Last previous edition D 2506 – 70 (1980).

TABLE 1 Common Dimensional Systems with Corresponding Unit and Gravitational Conversion Factors[A]

	System Name	Primary Units	Force, F	Mass, M	Length, L	Time, T	Standard Gravitational Acceleration—Earth, g_o	Gravitational Conversion Factor, g_c
U.S. Customary Units	Absolute	MLT	pdl = lbm·ft/s^2	lbm	ft	s	32.1740 ft/s^2	1
	Gravitational	FLT	lbf	slug = lbf·s^2/ft	ft	s	32.1740 ft/s^2	1
	Engineering or technical	FMLT	lbf	lbm	ft	s	32.1740 ft/s^2	32.1740 lbm·ft/lbf·s^2
Metric Units	Absolute	MLT	dyne = gm·cm/s^2	gm	cm	s	980.665 cm/s^2	1
	Gravitational	FLT	gf	gf·s^2/cm	cm	s	980.665 cm/s^2	1

[A] Abbreviations: F = force, M = mass, L = length, T = time; lbf = pound-force, lbm = pound-mass, gf = gram-force; gm = gram-mass, pdl = poundal, ft = foot; cm = centimetre, s = second

should use $I°_{spd}$ only when it can be compared to an available I_{spd}. If no I_{spd} is available, use $I°_{sp}$ instead of $I°_{spd}$.

4.7 *Standard Deliverable Propellant Specific Impulse* (I_{sps})—A value of I_{spd} corrected to the following standard conditions (Notes 3 and 4):

4.7.1 Chamber pressure P_c = 1000 psia,

4.7.2 Ambient pressure P_{amb} = 14.7 psia,

4.7.3 Nozzle area expansion ratio E = optimum, and

4.7.4 Nozzle divergence half-angle α = 0.

NOTE 3—These conditions are implied in the symbol I_{sps} and need not be stated in reporting numerical values. Use the same time interval and propellant mass assumptions as for I_{spd}; therefore, do not report I_{sps} without also reporting the corresponding I_{spd}.

NOTE 4—For further discussion of the derivation of these criteria, see ASTM Recommended Practice D 2508, for Solid Rocket Propellant Specific Impulse Measurements.[2]

4.8 *Standard Theoretical Propellant Specific Impulse* ($I°_{sps}$) calculated from propellant thermodynamic properties. The physical state of exhaust condensables must be specified. The following standard conditions are implied in the symbol $I°_{sps}$ and need not be stated in reporting numerical values:

4.8.1 Chamber pressure P_c = 1000 psia,

4.8.2 Ambient pressure P_{amb} = 14.7 psia,

4.8.3 Nozzle area expansion ratio E = optimum,

4.8.4 Nozzle divergence half-angle α = 0, and

4.8.5 Equilibrium exit composition.

4.9 *Quarter-Second Impulse* ($I_{0.25l}$)—The impulse developed in the first quarter of a second after zero time.

NOTE 5—Other threshold values would be shown by alteration of the numerical subscript. The letter "l" never appears in a subscript; the number "1" often does, and should be read as such.

4.10 *Total Impulse* (I_{tot})—The total area under the thrust-time record.

5. Mass (m)—Mass shall be expressed as pounds mass (lbm).

NOTE 6—Concerning proper treatment of the concepts and terminology involving force, mass, weight and gravity, refer to American National Standard Letter Symbols for Rocket Propulsion (Y10.14), American National Standards Institute, 1430 Broadway, New York, N. Y. 10018.

[2] *Annual Book of ASTM Standards*, Vol 15.03.

5.1 *Mass at Burnout* (m_{bo})—The mass of the motor, including any unburned slivers, at completion of propellant burning.

5.2 *Motor Gross Mass* (m_m)—The motor gross mass including propellant, liner, case, nozzle, and igniter (if attached).

5.3 *Propellant Mass* (m_p)—The mass of the propellant charge excluding igniter propellant.

6. Pressure (P)—Pressure shall be expressed as absolute pressure and indicated as psia. All pressures defined in this standard are static pressures. A bar ($^-$) over the symbol P denotes an average value ($\bar{P}_a$). A numeral in the subscript to P indicates a fixed pressure threshold level. The number indicates the threshold level divided by 100, and may be changed to suit the application.

6.1 *Action Time Average Chamber Pressure* ($\bar{P}_a$)—The average pressure between the initial and final 10 percent maximum pressure levels on the pressure-time record.

6.2. *Thrust Action Time Average Chamber Pressure* ($\bar{P}_{af}$)—The average pressure between the initial and final 10 percent maximum thrust levels on the thrust-time record.

6.3 *Ambient Barometric Pressure* (P_{amb})—The existing static pressure due to the surrounding atmosphere.

6.4 *Average Chamber Pressure Between 100 lbf Levels* ($\bar{X}_{a1f}$)—The average pressure between the initial and final 100 lbf levels on the thrust-time record.

6.5 *Average Chamber Pressure Between 100 psia Levels* ($\bar{P}_{a1p}$)—The average pressure between the initial and final 100 psia levels on the pressure-time record.

6.6 *Burning Time Average Chamber Pressure* ($\bar{P}_b$)—The average pressure between the initial 10 percent maximum pressure level and the web burnout point of maximum curvature on the pressure-time record (see Note 7).

6.7 *Thrust Burning Time Average Chamber Pressure* ($\bar{P}_{bf}$)—The average pressure between the initial 10 percent maximum thrust level and the web burnout point of maximum curvature on the thrust-time record.

6.8 *100 lbf Burning Time Average Chamber Pressure* ($\bar{P}_{b1f}$)—The average pressure between the initial 100 lbf level and the web burnout point of maximum curvature on the thrust-time record (Note 5).

6.9 *100 psia Burning Time Average Chamber Pressure* ($\bar{P}_{b1p}$)—The average pressure between the initial 100 psia level and the web burnout point of maximum curvature on