ENGINEERING STANDARDS

FOR

UNITS

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APPENDICES :

1. SCOPE

This Engineering Standard presents a system for units which is based on international system of units "SI".

The purpose of this publication is:

- to supplement the user's basic knowledge of the SI which is the only legal system for units in Iran and also to give SI Units and SI prefixes for decimal multiples and submultiples;

- to alert users to the fact that the Iranian Petroleum, Gas and Petrochemical Industries and their related companies have to do an ever-increasing proportion of their business in the SI system in future as the only legal system in Iran;

- to give conversion tables to facilitate conversions of units;

- to give some values and equivalents to be specifically used in oil industries as an appendix.

2. SOURCES AND REFERENCES

2.1 Sources

In preparation of this Standard, the following standards and publications have been considered:

ISO (INTERNATIONAL ORGANIZATION FOR STANDARDIZATION)

ISO 31/0 (1981)	"General Principles Concerning Quantities, Units and Symbols"
ISO 31/1 (1978)	"Quantities and Units of Space and Time"
ISO 31/2 (1978)	"Quantities and Units of Periodic and Related Phenomena"
ISO 31/3 (1978)	"Quantities and Units of Mechanics"
ISO 31/4 (1978)	"Quantities and Units of Heat"
ISO 31/5 (1979)	"Quantities and Units of Electricity and Magnetism"
ISO 31/6 (1980)	"Quantities and Units of Light and Related Electromagnetic"
ISO 31/7 (1978)	"Quantities and Units of Acoustics"
ISO 31/8 (1980)	"Quantities and Units of Physical Chemistry and Molecular Physics"
ISO 31/9 (1980)	"Quantities and Units of Atomic and Nuclear Physics"
ISO 31/10 (1980)	"Qauantities and Units of Nuclear Reactions and Ionizing Radiations"
ISO 31/11 (1978)	"Mathematical Signs and Symbols for use in the Physical Science and Technology"
ISO 31/12 (1981)	"Dimensionless Parameters"
ISO 31/13 (1981)	"Quantities and Units of Solid State Physics"
ISO 31 (Amendment 1) (1985)	"Quantities and Units"
ISO 1000 (1981)	"SI Units and Recommendations for the use of their Multiples and of Certain other Units"

OIML (ORGANIZATION INTERNATIONAL DE METROLOGY LEGAL)

OIML No. 2 (1978) "Legal Units of Measurement"

API (AMERICAN PETROLEUM INSTITUTE)

API Publ No. 2564 "Conversion of Operational and Process Measurement Units to the Metric (SI) System"

Oil Industry Conversion Factors by OPEC

3. WHAT IS SI?

SI is the official international abbreviation for the international system of units (Le Systeme International d'unites'). The SI is not the old centimeter-gram-second system, but a developed and modernized version of it.

SI consists of base units, derived units and units for dimensionless quantities. In addition, there are other units which are not a part of SI, but may be used together with SI units (called allowable non SI Units). The base units of SI by convention are regarded as being dimensionally independent. Derived units of SI are derived by dimensionally appropriate simple multiplications and divisions of the SI base units without the introduction of any numerical factors.

Thus the SI Unit of speed is the SI base unit of length divided by the SI base unit of time and the SI unit of kinetic energy is the SI base unit of mass multiplied by the square of the SI base unit of length and divided by the square of the SI base unit of time. Such a system of units is called "Coherent".

In any coherent system of units there is one, and only one unit for each quantity.

SI prefixes are used to form decimal multiples and submultiples of the SI Units.

3.1 Base Units: Definitions and Symbols

The base units of SI by convention are regarded as being dimensionally independent. The names and symbols of these units are respectively meter (symbol: m), kilogram (symbol: kg), second (symbol: s), Ampere (symbol: A), kelvin (symbol: K), mole (symbol: mol) and candela (symbol: cd).

As it is seen in the following definitions, all base units of SI except kilogram have been related to natural phenomena and considered unvarying and capable of being measured very accurately.

3.1.1 Metre (m): for length (also meter)

The meter is the length of the path traveled by light in vacuum during a time interval of 1/299 792 458 of a second.

3.1.2 Kilogram (kg): for mass

The kilogram is the unit of mass; it is equal to the mass of the international prototype of the kilogram. This prototype was sanctioned in 1889 by the first general conference of weights and measures and is kept at the international bureau of weights and measures at Sevres (in France).

3.1.3 Second (s): for time

The second is the duration of 9 192 631 770 periods of the radiation corresponding to the transition between the two hyperfine levels of the ground state of the cesium-133 atom.

3.1.4 Ampere (A): for electrical current

The Ampere is that constant current which, if maintained in two straight parallel conductors of infinite length, of negligible circular cross-section, and placed 1 meter apart in vacuum, would produce between these conductors a force equal to 2×10^{-7} newton per meter of length.

3.1.5 Kelvin (K): for thermodynamic temperature

The kelvin, unit of thermodynamic temperature, is the fraction 1/273.16 of the thermodynamic temperature of the triple point of water.

Note:

In addition to the thermodynamic temperature (symbol T), expressed in kelvin, use is also made of Celsius temperature (symbol: t) defined by the equation:

$t = T - To$

Where:

To = 273.15 K by definition. The unit "degree Celsius" is equal to the unit "Kelvin" but "degree Celsius" is a special name instead of "Kelvin" to express Celsius temperature. An interval or a difference of Celsius temperature may be expressed either in degrees Celsius or in Kelvins.

3.1.6 Mole (mol) : for amount of substance

The mole is the amount of substance of a system which contains as many as elementary entities as there are atoms in 0.012 kilogram of carbon 12 in the ground state.

Note:

When the mole is used, the elementary entities must be specified and may be atoms, molecules, ions, electrons, other particles, or specified groups of such particles.

3.1.7 Candela (cd): for luminous intensity

The candela is the luminous intensity in a given direction of a source which emits monochromatic radiation of frequency 540×10^{12} hertz and of which the radiant intensity in that direction is 1/683 watt per stradian.

3.2 Units for Dimensionless Quantities: Definitions and Symbols

In addition to the base units which are described in sub-clause 3.1 and there under, the SI does have two, purely geometrical units which are called units for dimensionless quantities. The names and symbols of these units are:

Radian (symbol: rad) and Stradian (symbol: sr).

3.2.1 Radian (rad): for plane angle

The radian is the plane angle between two radii which cuts off on the circumference of a circle an arc equal in length to the radius:

$$(1\ rad = \frac{1m}{1m} = 1\ )$$

3.2.2 Stradian (sr): for solid angle

The stradian is the solid angle, which having its vertex in the center of a sphere, cuts off an area of the surface of the sphere equal to that of a square with side of length equal to the radius of the sphere:

$$(1\ sr = \frac{1m^2}{1m^2})$$

3.3 Derived Units and Allowable Non - SI Units: Definitions and Symbols

Derived units are expressed algebraically in terms of base units and /or units of dimensionless quantities. Their symbols are obtained by means of mathematical signs of multiplication and divisions. For example, the unit for velocity is (m/s) and for angular velocity is (rad/s).

For some of the derived units, special names and symbols exist, which are listed in Table 1.

Note:

The use of mixed units compounded from different systems shall be avoided.

TABLE 1 - SPECIAL NAMES AND SY MBOLS FOR SOME DERIVED UNITS

QUANTITY	SPECIAL NAME OF DERIVED UNIT	SYMBOL	EXPRESSED IN TERMS OF BASE OR DERIVED UNITS
FREQUENCY	HERTZ	Hz	$1HZ = 1s^{-1}$
FORCE	NEWTON	N	$1N = 1kg.m/s^2$
PRESSURE, STRESS	PASCAL	Pa	$1Pa = 1N/m^2$
ENERGY, WORK AND QUANTITY OF HEAT	JOULE	J	1J = 1N.m
POWER	WATT	W	1W = 1J/s
ELECTRIC CHARGE (QUANTITY OF ELECTRICITY)	COULOMB	°C	1°C = 1A.s
ELECTRIC POTENTIAL POTENTIAL DIFFERENCE, TENSION, ELECTROMOTIVE FORCE	VOLT	V	1V = 1W/A
ELECTRIC CAPACITANCE	FARAD	F	1F = 1A.s/V
ELECTRIC RESISTANCE	OHM	Ω	1Ω = 1V/A
ELECTRIC CONDUCTANCE	SIEMENS	S	$1S = 1\Omega^{-1}$
FLUX OF MAGNETIC INDUCTION, MAGNETIC FLUX	WEBER	Wb	1Wb = 1V.s
MAGNETIC INDUCTION MAGNETIC FLUXDENSITY	TESLA	T	$1T = 1Wb/m^2$
INDUCTANCE	HENRY	H	1H = 1V.s/A
CELSUIS TEMPERATURE	DEGREE CELSIUS	°C	1°C = 1K
LUMINOUS FLUX	LUMEN	lm	1lm = 1cd.sr
ILLUMINANCE	LUX	lx	$1lx = 1lm/m^2$
ACTIVITY (OF A RADIONUCLIDE)	BECQUEREL	Bq	$1Bq = 1s^{-1}$
ABSORBED DOSE, SPECIFIC ENERGY IMPARTED, KERMA, ABSORBED DOSE INDEX	GRAY	Gy	1Gy = 1J/kg
DOSE EQUIVALENT	SIEVERT	Sv	1Sv = 1J/kg

There are a number of units which, while not a part of SI, but widely used even along with SI units. These units are known as allowable non-SI units. Examples are minute, hour, day and year as units of time (in addition to the second), and degree, minute and second of arc (in addition to radian), degree Celsius(°C) for temperature and temperature interval (instead of kelvin). Liter, ton, nautile mile and knot are some other examples for allowable non-SI units. The allowable non-SI units have been recognized by the Commite International des Poids et Mesures (CIPM) because of their practical importance or for use in specialized fields. Derived units and allowable non-SI units are given in the following sub-sub clauses:

Notes:

1) Definitions are given for identification and should not be construed as complete but the figures are exact.

2) Where two or more symbols are given for one quantity and no special distinction is made, they are on an equal footing. When a preferred symbol and a reserve symbol are given, the reserve symbol is in parentheses.

3) For further information see ISO 31/0 up to 31/13.

4) For exact definitions see OIML No. 2.

3.3.1 Quantities and units of space and time

	QUANTITY	SYMBOL OF QUANTITY	UNIT	SYMBOL OF UNIT	CONVERSION FACTOR	TYPE OF UNIT	DEFINITION	REMARKS
3.3.1.a	Plane angle	ε , β, γ,v,£,etc	radian	rad		dimension-less	see 3.2.1	
			degree	°	1°= 0.017 453 3 rad	allowable (non-SI)	1°=μ/180 rad	
			minute	/		allowable (non-SI)	1/ =1/60°	
			second	//		allowable (non-SI)	1// =1/60/	
			grade or gon	g	1g=μ/200 rad	allowable (non SI)	1g=μ/200 rad	not re-commended
3.3.1b	Solid angle	μ	stradian	sr		dimension-less	see 3.2.2	
3.3.1.c	Length Breadth Height Thickness Radius Diameter Length of path	l(L) b h dδ r d,D s	meter and its decimal multiples and sub multiples accor-ding to clause 4	m		base	see 3.1.1	mm is mostly used for all dimensions in diagrams and drawings (see clause 4) nmile to be used in navigation only. "in"may be used for threads, screws, nuts and diameter of pipes.
			angstrom	A°	1A°=0.1nm* (exactly)	allowable (non-SI)	1A=10^{-10}m	
			nautile mile inch	nmile in	1nmile=1852m (exactly)	allowable (non-SI) (non-SI)	1nmile=1852m	
3.3.1d	Area	A, (S) (for an element of area dδ is sometimes used)	square meter	m^2		derived	$1m^2$ is the area of a square with sides of length 1m	
			are	a	1a=$100m^2$ (exactly)	allowable (non-SI)	1a is the area of a square with sides of length 10m.	
			hectare	ha	1ha=10^4m^2 (exactly)	allowable (non-SI)	1 ha is the area of a square with sides of length 100m.	

*** See Clause 4 decimal multiples and submultiples of SI Units.**

3.3.1.e	Volume	V (for an element of volume dζ is sometimes used)	cubic meter	m^3		derived	$1m^3$ is the volume of a cube with edge of length 1m.	
			liter and some of decimal multiples and submultiples of liter like milli liter etc.	l or L		allowable (non-SI)	$1l=10^{-3}$ m^3 (exactly)	
			barrel	bbl	1bbl=0.158 987m^3	allowable (non SI) for oil volume	1bbl = 0.158 987 m^3	
3.3.1.f	Time Time interval Duration	t	second	s		base	see 3.1.3	
			minute	min	1min=60s (exactly)	allowable (non-SI)	1 min=60s	
			hour	h	1h=3600s (exactly)	allowable (non-SI)	1h=60min	
			day	d	1d=86400s (exactly)	allowable (non-SI)	1d= 24h	
			week month year			allowable (non-SI)	of the gregorian calendar.	
3.3.1.g	Angular velocity	ω	radian per second for other allowable units see 3.3.1.a and 3.3.1.f		rad/s	derived allowable (non-SI)	ω= dρ/dt 1 rad/s is the angular velocity of a body which, animated by a uniform rotation around a fixed axis, turns 1 radian in 1 second	
			rotation per second	n/s		allowable (non-SI)	n=2 £radian	
			rotation per minute	n/min		allowable (non-SI)		
			rotation per day	n/d		allowable (non-SI)		

3.3.1.h	Angular Acceleration	$\propto$	radian per second squared or other allowable units see 3.3.1a and 3.3.1f.	rad/s^2		derived allowable (non-SI)	x = dω/dt 1 rad/s^2 s the angular acceleration of a body which is animated by a rotation varying uniformly around a fixed axis, and whose angular velocity varies by 1 rad/s in 1 second.	
3.3.1.i	Velocity	u,v, ω,c	meter per second	m/s		derived	v= ds/dt 1 m/s is the speed of a body which, animated by a uniform movement, covers 1m in 1 second.	
			Kilometer per hour	km/h	1 km/h=0.277 778 m/s =1/3.6 m/s	allowable (non-SI)		
			knot	kn	1 kn=0.514 444m/s =1 nmile per hour	allowable (non-SI)		
3.3.1.j	Acceleration	a	meter per second	m/s^2		derived	a= dv/dt	
	Acceleration of free fall	g	gal (The gal is used only for the quantity g; in particular, the milligal is commonly used in geodesy.)	Gal	1 Gal=0.01 m/s^2	allowable (non-SI)		

3.3.2 Quantities and units of mass

	QUANTITY	SYMBOL OF QUANTITY	UNIT	SYMBOL OF UNIT	CONVERSION FACTOR	TYPE OF UNIT	DEFINITION	REMARKS
3.3.2.a	mass	m	kilogram and decimal multiples and submultiples of gram according to Clause 4	kg	—	base	See 3.1.2	
			ton and some of the decimal multiples and submultiples according to Clause 4	t	1t=1000 kg	allowable (non SI)		Also called in English, metric ton
			metric carat.	mc	$1mc=2\times10^{-4}$ kg	allowable (non SI)		Its use is authorized only for indicating the mass of precious stones
			atomic mass unit	u	$1u=1,66057\times10^{-27}$ kg(approximately)	allowable (non SI)	U:is equal to the fraction 1/12 of mass of an atom of the nucleide 12 C in the ground state.	
3.3.2.b	Density (mass density)	ρ	kilogram per cubic meter	kg/m^3		derived	1 kg/m^3 is the density of a homogeneous body having a mass of 1 kg and a volume of $1m^3$. Mass density is defined as mass divided by volume.	
			ton per cubic meter	t/m^3	$1t/m^3=1000$ $kg/m^3=1g/cm^3$	allowable (non SI)		ton per cubic meter is also called in English, metric ton per cubic meter.
			kilogram per liter	kg/1	1 kg/1=1000 $kg/m^3=1g/cm^3$	allowable (non SI)		

3.3.2.c	Relative density	d	This quantity is dimension-less				relative denity is the ratio of the density of a substance to the density of a referenc substanc under condi-tions that should be spe-cified for both substances.	
3.3.2.d	linear density	L	kilogram per meter	kg/m		derived	linear density is defined as mass divided by length. The kg/m is the linear density of a homogeneous body of uni-form section having a mass of 1 kg and length of 1 m.	
			tex	tex	1 tex=10^{-6} kg/m =1 g/km	allowable (non SI) (for textile filaments)		tex is used only for textile filameile
3.3.2.e	surface density	l_A,(L_s)	kilogram per square meter	kg/m^2		derived	Surface densi-ty is defined as mass divi-ded by area. 1 kg/m^2 is the surface density of a homogeneous body of uni-form thickness having a mass 1 kg and an area of 1 m^2.	

3.3.3 Quantities and units of mechanics

	QUANTITY	SYMBOL OF QUANTITY	UNIT	SYMBOL OF UNIT	CONVERSION FACTOR	TYPE OF UNIT	DEFINITION	REMARKS
3.3.3.a	Specific volume	v	cubic meter per kilogram	m^3/kg		derived	Specific volume is defined as volume divided by mass.	
3.3.3.b	Momentum	p	kilogram meter per second	kgm/s		derived	Momentum is defined as product of mass and velocity.	
3.3.3.c	Moment of momentum, angular	L	kilogram meter squared per second.	kgm^2/s		derived	The moment of momentum of particle about a point is equal to the vector product of the radius vector from this point to the particle and the momentum of the particle	
3.3.3.d	moment of inertia (dynamic moment of inertia)	I,J	kilogram meter squared	kgm^2		derived	The (dynamic) moment of inertia of a body about an axis is the sum(integral) of the products of its mass-elements and the squares of their distances from the axis.	

3.3.3.e	Force	F	newton	N		derived	The resultant force acting on a body is equal to the rate of change of the momentum of the body 1N is that force which, when applied to a body having a mass of 1kg, gives it an acceleration of $1m/s^2$	kgf and kp is not recommended
			dyne	dyn	1 dyn=10^{-5}N (exactly)	allowable (non-SI)		
			kilogram force	kgf	1 kgf=1kp	allowable (non-SI)		
			kilopond	kp	=9.806 65 N	allowable (non-SI)		
	Weight	G,(P,W)	newton	N		derived	The weight of a body in a specified reference system is that force which, when applied to the body, would give it an acceleration equal to the local accele-ration of free fall in that reference system.	By mistake the units of mass are often used instead of newton.
3.3.3.f	Moment of force	M	newton meter	N.m		derived	The moment of a force about a point is equal to the vector product of the radius vector, from this point to any point on the line of action of the force and the force.	In elasticity, M is used for bending moment and T for twisting or torsional moment.
	torque, m-oment of a couple	T	newton meter	N.m		derived		

3.3.3.g	pressure	p	pascal	Pa	1Pa=1N/m^2	derived	Force divided by area. 1 pascal is the uniform pressure which when acting on a plane surface of 1 m^2, exercises per pendicularly to that surface a total force of 1 N.	Pascal is a special name for the newton per square meter.
	Normal stress	σ	bar	bar	1bar=10^5 Pa (exactly)	allowable (non SI)		
	Shear stress	τ	standard atmosphere	atm	1atm=101 325 Pa (exactly)	allowable (non SI)		not recommended
			meter water (conventional)	mH_2O	1mH_2O=9806.65 Pa (conventional)	allowable (non SI)		not recommended
			torr (conventional)	torr	1 torr=133.322 Pa (conventional)	allowable (non SI)	torr is mmHg	not recommended
3.3.3.h	linear strain (relative elongation)	e,ω					$\Sigma = \Delta 1/l_e$	
	Shear strain		These quantities are dimensionless				$\gamma = \Delta x/d$	Where Δ x is the parallel displacement of the upper surface with respect to the lower surface of a layer of thickness d.
	Volume strain (bulk strain)	v					$v = \Delta v/Vo$	Where Vo is volume in refe-rence state to be specified, and Δ v is increase in volume.

3.3.3.i	Viscosity (dynamic viscosity)	ζ (μ)	Pascal second	Pa.s		derived	1 Pa.S is the viscosity of a fluid in which the velocity under a shear stress of 1 Pa has a gradient of 1 m/s per meter perpen-dicular to the plane of shear	
			Poise	p	$1P=10^{-1}$ Pa.s	allowable (non-SI)		
			centi poise	cp	$1cp=10^{-3}$ Pa.s	allowable (non-SI)		
3.3.3.j	Kinematic viscosity	ν	square meter per second.	m^2/s		derived	$1m^2/s$ is the kinematic viscosity of a fluid with dy-namic viscosity 1Pa.s and density $1kg/m^3$	
			stokes	St	$1 St=10^{-4} m^2/s$	allowable (non-SI)		
			centi stokes	cSt	$10cst=10^{-6}$ m^2/s	allowable (non-SI)		
3.3.3.k	Work	W,(A)	Joule	J		derived	1J is the work done when the point of application of a force of 1N is displaced through a distance of 1m in the direction of the force.	Force multiplied by displa-cement in the direction of the force.
	Energy	E,(W)	Watt hour	W.h	$1W.h=3.6\times10^3$ J (exactly)	allowable (non-SI)	1W.h is the energy delivered in 1h by an energy source of 1W power.	

	Potential energy kinetic energy	Ep,V,ϕ Ek,K,T	electronvolt	eV	1eV =1.602 19×10^{-19}	allowable (non-SI)	1eV is the kinetic energy acquired by an electron in Passing through a potential difference of 1V in vacuo.	
			erg kilogram force meter kilopond meter	erg kgfm kpm	1erg=1dyn. cm =10^{-7}J (exactly) 1kgfm=1kpm =9.806 65 J	allowable (non-SI) allowable (non-SI)		kgfm and kpm is not recommended
3.3.3.l	Power	p	Watt	W		derived	Power is the rate of energy 1 watt is the power which gives rise to a production of energy equal to 1J per s.	Watt is special name for J/s.
				erg per second	1 erg/s=10^{-7} W (exactly)	allowable (non-SI)		
			horse power (cheval vapeur)	hp or cv	1cv=735.498 75W	allowable (non-SI)	1 hp=1 cv =75-kgm/s	not recommended
3.3.3.m	Mass flow rate	q_m	kilogram per second	kg/s		derived	Mass flow rate is the rate at which mass crosses a sur-face. 1kg/s is the mass flow rate of a uni-form flow such that a substan-ce having a mass of 1kg passes through the cross sect-ion considered in 1 S.	Due to the amount of quantity decimal multiples and submultiples of kg and allowable units of time interval are to be used instead of kg and S.

3.3.3.n	Volume flow rate	q_v	cubic meter per second	m^3/s		derived	Volume flow rate is the rate at which volume crosses a surface. 1 m^3/s is the volume flow rate of a uniform flow such that a substance having a volume of $1m^3$ passes through the cross section considered in 1 S.	Due to the amount of quantity decimal multiples and submultiples of m and allowable units of volume and time interval are to be used instead of "m" and "s".

3.3.4 Quantities and units of heat

	QUANTITY	SYMBOL OF QUANTITY	UNIT	SYMBOL OF UNIT	CONVERSION FACTOR	TYPE OF UNIT	DEFINITION	REMARKS
3.3.4.a	Thermodynamic temperature	T , 0	Kelvin	K		base	See 3.1.5	It is recommended that units of termodynamic and celsius temperature interval or difference should be expressed in kelvin(K) or in degrees celsius (°C). Other names and symbols such as"degree "deg" or "degree" should be abandoned.
	Celsius temperature	t , 0	degree celsius	C	t= T - To where To=273.15k	allowable (non-SI)	See 3.1.5 - Note	
3.3.4.b	Heat quantity of heat	Q	Joule	J		derived	For definition of joule see 3.3.3.K	For other units see also 3.3.3.K
			15°C calorie	cal15	1cal15=4.185 5J	allowable (non-SI)	1 cal15 is the amount of heat required to warm 1g of air-free water from 14.5°C to 15.5°C at a constant pressure of 101.325 kPa.	
			I.T. Calorie	calI.T.	1calI.T=4.186 8J 1McalI .T=1.163 KW.h (exactly)	allowable (non-SI)		I.T. calorie is the abbreviation for international table calorie (not recommended.
			thermo-chemical calorie	callth	1calth=4.184 J (exactly)	allowable (non-SI)		not recommended

3.3.4.c	Heat flow rate	ϕ	Watt	W		derived	For definition of watt see 3.3.3.l Heat flow rate is the rate of heat flow across a surface	
3.3.4d	Density of heat flow rate	q,φ	watt per square meter	W/m^2		derived	Density of heat flow rate is defined as heat flow rate divided by area.	
3.3.4.e	Thermal conductivity	χ ,(K)	watt per metre kelvin	W/(m.k)		derived	Thermal conductivity is density of heat flow rate divided by temperature gradient, 1 W/(m.k) is the thermal conductivity of a homogeneous body in which a difference of 1k between two parallel planes having a surface of $1m^2$ and which 1m apart produces between these planes a heat flow rate of 1w.	in most cases °C is used instead of k(kelvin).
			I.T.calorie per second centimetre kelvin	calI.T./ (s.cm.k)	1calI.T./ (s.cm.k) 1calI.T.=418. 68 W/(m.k) (exactly)	allowable (non-SI)		
			thermochemical calorie per second cen timetre kelvin.	calth/ 1 (s.cm.k) (exactly)	calth/(s.cm.k= 418.4 W/(m.k) (exactly)	allowable (non-SI)		
3.3.4.f	Thermal resistance	R	kelvin per watt	k/W		derived	Thermal resistance is temperature difference divided by heat flow rate.	in most cases °C is used instead of K(kelvin).

3.3.4g	Thermal conductance	G	watt per kelvin	W/k		derived	Thermal conductance is heat flow rate divided by temperature	In most cases °C is used instead of K(kelvin).
3.3.4h	heat capacity	C	Joule per kelvin	J/k		derived	When the temperature of a system is increased by dT as a result of addition of a small quantity of heat dQ1 the quantity dQ/dT is the heat capacity	This quantity is not completely defined unless the type of change is specified. Specific heat capacity .is heat capacity divided by mass.
3.3.4.i	Entropy	S	Joule per kelvin	J/k		derived	When a small quantity of heat dQ is received by a system the thermodynamic temperature of which is T, the entropy of the system is increased by dQ/T, provided that no irreversible change takes place in the system.	1J/K is the increase in the entropy of a system receiving a quantity of heat of 1J at the constant thermodynamic temperature of 1 k provided that no irreversible change takes place in the system.
3.3.4.J	Internal energy	U,(E)	Joule	J			for definition of joule see 2.3.3.k	
	Enthalpy	H,(I)	Joule	j			H=U+PV	
	Helmholtz free energy Helmholtz function	A,F	Joule	J			A=U-TS	

3.3.5 Quantities and units of electricity and magnetism

	QUANTITY	SYMBOL OF QUANTITY	UNIT	SYMBOL OF UNIT	CONVERSION FACTOR	TYPE OF UNIT	DEFINITION	REMARKS
3.3.5.a	Electric current	I	ampere	A		base	See 3.1.4.	
3.3.5.b	Electric charge quantity of electricity	Q	coulomb	C		derived	Electrical charge is the integral of electric current over time. The coulomb is the quantity of electricity carried in 1 s by a current of 1A.	
			ampere hour	A.h	1A.h=3.6 kC	allowable (non-SI)		
3.3.5.c	Electric potential Potential difference tension Electromotive force	V,? U,(V) E	Volt	V		derived	1 volt is the difference of electric potential between two points of a conducting wire carying a constant current of 1 A,when the power dissipated between these two points is equal to 1 W.	
3.3.5.d	Electric field strength	E,(K)	volt per metre	V/m		derived	Electric field strength is force, exerted by electric field on an electric point charge, divided by the electric charge. 1 V/m = 1 N/C	
3.3.5.e	Electric flux (flux of displacement)	?	coulomb	C		derived	The electric flux across a surface element is the scalar product of the surface element and the electric flux density. The unit of electric flux density is c/m^2 .	

3.3.5.f	Capacitance	C	farad	F		derived	Capacitance is defined as charge divided by potential difference. 1 farad is the capacitance of a capacitor between the plates of which there appears a difference of electric petential of 1V, when it is charged by a quantity of electricity of 1 C.	farad is an special name for C/V.
3.3.5.g	Permittivity permittivity of vacuum, electric constant	? ?o	farad per metre	F/m		derived	Permittivity is electric flux density divided by electric field strength.	
3.3.5.h	Relative permittivity	$?_r$	This quantity is dimensionless.	—		—	$?_r = ?/?_0$	
3.3.5.i	Magnetic field strength	H	ampere per metre	A/m		derived	The magnetic field strength is an axial vector quantity, the curl (rotation)of which is equal to the current density,including the displacement current. 1 A/m is the strength of the magnetic field produced in vacuum along the circumference of a circle of 1m circumference, by an electric current of 1A, maintained in a straight conductor of in finite length,of negligible circular cross section, forming the axis of the circle mentioned.	

3.3.5.j	Magnetic potential dif ference	U, U_m	ampere	A		derived	The magnetic potential dif ference between point 1 and point 2 is the line integral from 1 to 2 of the magnetic field strength.	
	Magnetomot- ive force	F, F_m	ampere	A		derived	F = ?Hd1	
	Current lin- kage	0	ampere	A		derived	Current linkage is the net electric conduction current- through a closed loop.	
3.3.5.k	Magnetic flux density, Magnetic in- duction	B	tesla	T		derived	The magnetic flux density is an axial vector quantity such that the force exerted on an element of current is equal to the vector product of this element and the magnetic flux density. 1 T is the uniform magnetic induction which,distributed normally over a surface of $1m^2$, 'produces across the surface a total magnetic flux of1 Wb. 1T=1N/(A.m) =1Wb/m2=1V.s/m^2	
3.3.5.l	Magnetic flux	Φ	weber	Wb		derived	The magnetic flux across a surface element is the scalar product of surface element and the magnetic flux density 1 Wb is the magnetic flux which,linking a circuit of 1 turn,would produce in it an electromotive force of 1 V,if it were reduced to zero at a uniform rate in 1 second. 1 Wb = 1 V.s	

3.3.5.m	Self inductance	L	henry	H		derived	Self inductance is defined as the magnetic flux through a loop. caused by the current in the loop,divided by this current. 1 henry is the electric inductance of a closed circuit in which an electromotive force of 1 volt is produced when the circuit varies uniformly at the rate of 1 ampere per second. 1N=1Wb/A=1V.S/A	
3.3.5.n	Permeability Permeability of vacuum	η η_o	henry per metre	H/m	$\eta o=4.10^{-7}$H/m	derived	Permeability is defined as the magnetic flux density divided by magnetic field strength. 1H/m =1 Wb/(A.m) =1 V.s/(A.m)	
3.3.5.o	Relative permeability	η_r	—	—		—	This quantity is dimensionless ηr=æ/ ηo	
3.3.5.p	Electromagnetic moment (magnetic moment)	m	ampere metre squared	$A.m^2$		derived	The electromagnetic moment is a vector quantity,the vector product of which with the magnetic flux density is equal to the torque.	
3.3.5.q	Magnetization	Hi,M	ampere per metre	A/m		derived	Hi = (B/ $\eta 0$) - H Where the H is magnetic field strength and B is magnetic flux density.	
3.3.5.r	Magnetic polarization	Bi,J	tesla	T		derived	Bi = B - ηoH $1T = 1Wb/m^2 = 1V.s/m^2$	
3.3.5.s	Electromagnetic energy density	w	Joule per cubic metre	J/m^3		derived	Electromagnetic field energy divided by volume.	
3.3.5.t	Resistance	R	ohm	Ω		derived	The resistance is defined as the electric potential difference divided by current when there is no electromotive force in the conductor. 1ê = 1 V/A	For the definition of ohm see OIML No.2
3.3.5.u	Conductance	G	siemens	S		derived	G= I/R	For the definition of siemens see OIML No.2

3.3.5.v	Resistivity	ϒ	ohm metre	Ω m		derived	The resistivity is defined as the electric field strength divided by current density when there is no electromotive force in the conductor.	
3.3.5.w	Conductivity	∂ σ	siemens per metre	S/m		derived	δ= 1/?	
3.3.5.x	Reluctance henry	R,R_m	reciprocal	H^{-1}		derived	Reluctance is defined as the magnetic potential difference divided by magnetic flux.	
3.3.5.y	Permeance	A,(P)	henry	H		derived	A=1/R_m	
3.3.5.z	Power	P	watt	W			1W = 1 J/s = 1 V.A	

3.3.6 Quantities and units of acoustics

	QUANTITY	SYMBOL OF QUANTITY	UNIT	SYMBOL OF UNIT	CONVERSION FACTOR	TYPE OF UNIT	DEFINITION	REMARKS
3.3.6.a	Period, Periodic time	T	second	S		base	Period is defined as time of one cycle.	
3.3.6.b	Frequency	f,ν	hertz	Hz		derived	f=1/T 1Hz is the frequency of a periodic phenomenon of which the period is 1 s.	
3.3.6.c	Angular frequency circular frequency pulsatance	ω	reciprocal second	s^{-1}			$\omega = 2\mu f$	
3.3.6.d	Wave length	λ	meter	m		base		
3.3.6.e	Circular wave number	K	reciprocal metre	m^{-1}			$K = 2\mu/\lambda = 2\mu\sigma$ Where å is the wave number $\sigma = 1/\lambda$	
3.3.6.f	Sound energy density	W,(Wa), (E)	Joule per cubic metre	J/m^3		derived	Sound energy density is defined as mean sound energy in a given volume divided by that volume.	
3.3.6.g	Sound energy flux Sound power	P,(Pa)	Watt	W		derived	Sound energy transferred in a certain time interval, divided by the duration of that interval	
3.3.6.h	Sound pressure level	Lp	decibel	dB		dimensionless	Lp =ln (P/P0)= ln 10.l g(P/P0) Where p and p0 are a given sound pressure and a reference pressure,respectively.1 dB is the sound pressure level when 10 lg(P/P0)=1	
3.3.6.i	Sound power level	Lp ,Lw	decibel	dB		dimensionless	Lp = 1/2 ln(P/P0) = 1/2 ln10. lg(P/P0) Where P and P0 are a given sound power and a reference power, respectively.	

3.3.7 Quantities and units of light and related electromagnetic radiation

This sub-sub clause contains a selection of quantities pertaining to light, many of which are also useful for the whole range of electromagnetic radiations. For light, mainly photometric quantities are given.

	QUANTITY	SYMBOL OF QUANTITY	UNIT	SYMBOL OF UNIT	CONVERSION FACTOR	TYPE OF UNIT	DEFINITION	REMARKS
3.3.7.a	Radiant energy	Q, W, (U,Qe)	Joule	J		derived	Radiant energy is energy emitted, transferred or received as radiation.	
3.3.7.b	Radiant power Radiant energy flux	P,ϕ (ϕ e)	Watt	W		derived	Radiant power is the power emitted, transferred or received as radiation. $\phi = f\ \phi\ \lambda\ d\ \lambda$	λis the wave length
3.3.7.c	Radiant energy fluence rate	φ , ψ	watt per square metre	W/m^2		derived	At a given point in space the radiant energy flux incident on a small sphere, divided by the cross sectional area of that sphere. $\phi = f\ \phi\ \chi\ d\ \lambda$	λ is the wave length
3.3.7.d	Luminous intensity	I,(Iv)	candela	cd		base	see 3.1.7	
3.3.7.e	Luminous flux	ϕ, (ϕv)	lumen	lm		derived	The luminous flux dϕ of a source of luminous intensity I in an element of solid angle dΩ is dϕ =IdΩ 1lm = 1cd.1sr 1 lm is the luminous flux emitted in the unit solid angle (steradian) by a uniform point source having a luminous intensity of 1 candela.	
3.3.7.f	Illuminance	E,(E_V)	lux	lx		derived	At a point of a surface,the luminous flux incident on an element of the surface,divided by the area of that element. E=?E?d? 1lx = $1lm/m^2$ 1 lx is illuminance of a surface receiving a luminous flux of 1 lumen uniformly distributed over $1m^2$ of the surface	

3.3.8 Quantities and units of physical chemistry and molecular physics

	QUANTITY	SYMBOL OF QUANTITY	UNIT	SYMBOL OF UNIT	CONVERSION FACTOR	TYPE OF UNIT	DEFINITION	REMARKS
3.3.8.a	Amount of substance	n,(ν)	mole	mol		base	see 3.1.6	
3.3.8.b	Molar mass	M	kilogr-am Per mole	kg/mol		derived	Molar mass is defined as mass divided by amount of substance.	
3.3.8.c	Molar volume	V_m	cubic metre per mole	m^3/mol		derived	Molar volume is defined as volume divided by amount of substance.	
3.3.8.d	Molar inter-nal energy	U_m, (E_m)	Joule per mole	J/mol		derived	Energy divided by amount of substance.	
3.3.8.e	Molar heat capacity	C_m	Joule per mole kelvin	J/(mol.k)		derived	Heat capacity divided by amount of substance.	
3.3.8.f	Concentrat-ion of substa-ance B(mole-basis)	C_B	mole per cubic meter mole per liter	mol/m^3 mol/l		derived allowable (non-SI)	Amount of substance of sub-stance B divided by the volume of mixture.	
3.3.8.g	Molarity of solute sub-stance B	b_B , mB	mole per kilogram	mol/kg		derived	The amount of substance of solute substance B in a solution divided by the mass of the solvent.	
3.3.8.h	Flow rate (mole basis)	q_m	mole per second, kilomole per second	mol/s kmol/s		derived allowable	The amount of substance which flows at time unit	kmol/s is often used
3.3.8.i	Electric dip-ole moment of molecule	P,u	colomb meter	C.m		derived	The electric dipole moment is a vector quantity,the vector product of which with the electric field strength is equal to the torque.	

3.3.8.J	Electric pol-arizability of a molecule	α	colomb metre squared per volt	$C.m^2/v$		derived	Induced electric dipole moment divided by electric field strength.	
3.3.8.k	Electrolytic conductivity	k,δ	siemens per meter	S/m		derived	The electrolytic current density divided by the electric field strength.	1S= l iT -1
3.3.8.l	Molar conductivity	A_m	siemens square metre per mole	$S.m^2/mol$			Conductivity divided by concentration.	

3.3.9 Quantities and units of radioactivity and ionizing radiation

	QUANTITY	SYMBOL OF QUANTITY	UNIT	SYMBOL OF UNIT	CONVERSION FACTOR	TYPE OF UNIT	DEFINITION	REMARKS
3.3.9.a	Reaction energy	Q	Joule	J		derived		
			electron-volt	eV	1eV=1.602189 2 10^{-19}J	allowable (non-SI)		
3.3.9.b	Cross section	δ	square metre	m^2		derived		
			barn	b	1b=$10^{-28}m^2$ (exactly)	allowable (non-SI)	1b=$10^{-28}m^2$ (exactly)	barn is used in nuclear and atomic physics only
	Total cross section	δtot, δt	square metre	m^2		derived		
			barn	b		allowable (non-SI)	1b=$10^{-28}m^2$ (exactly)	
3.3.9.c	Angular cross section	δ	square metre per stradian	m^2/sr		derived		Angular cross section is so-metimes called differential cross section.
			barn per stradian	b/sr	1b/sr=$10^{-28}m^2$/sr (exactly)	allowable (non-SI)	1b/sr=$10^{-28}m^2$/sr exactly	
3.3.9.d	Mobility	μ	square metre per volt second	m^2/(V.s)		derived	The average drift velocity imparted to a charged par-ticle in a medium by an electric field,divided by the electric field strength.	
3.3.9.e	Ion number density, Ion density	n^+,n^-	reciprocal cubic metre	m^{-3}		derived	The number of positive or negative ions in a volume element, divided by that element.	

3.3.9.f	Activity	A	becquerel	Bq		derived	Activity is the average number of spontaneo-us nuclear transitions from a particular energy state occurring in an amount of a radionuclide in a small time interval, divided by that interval. $1\ Bq = 1^{-1}s$ 1 Bq is the activity of a radioactive source in which one nuclear transformation or transition occurs per second.	
			curie	Ci	$1Ci=3.7\times10^{1}$ Bq (exactly)	allowable (non-SI)		
3.3.9g	Specific energy imparted	z	gray	Gy	1Gy=1J/kg	derived	For any ionizing radiation, the energy imparted to an eleme-nt of irradiated matter divided by the mass of this element. 1 Gy = 1 J/kg 1 Gy is dose absorbed in an element of matter of 1 kg mass to which the energy of 1 Joule is imparted by ionizing radiations whose ener-gy fluence is constant.	Gray is a special name for joule per kilogram to be used for this quantity.
3.3.9h	Absorbed dose	D	rad	rad	$1rad=10^{-2}$ Gy	allowable (non-SI)	Definition is the same as 3.3.9.g	
3.3.9.i	Dose equivale-nt	H	sievert rem	Sv rem	1Sv=1J/kg $1rm=10^{-2}$Sv	derived		sievert is a special name for J/kg to be used as SI unit for dose equivalent.
3.3.9.J	Absorbed dose rate	D^{0}	gray per second	Gy/s	1Gy/s=1W/kg	derived	1 Gy/s = 1 W/kg	
3.3.9.k	Exposure	X	rontgen	R	$1R=2.58x10^{-4}$ C/kg (exactly)	allowable (non-SI)	For X or gamma radiation,the total electric charge of the ions of one sign prod-uced when all the electrons liberated by photons in an element of air are stopped in air, divided by the mass of that element.	

3.3.9.l	Exposure rate	$\dot{X}$	coulomb per kilogram second	C/(kg.s)		derived	Exposure in a small interval, divided by that interval. $\dot{X} = dx/dt$	
			rontgen per second	R/s	1R/s=2.58x 10^{-4} C/(kg.s) (exactly)	allowable (non-SI)		
3.3.9.m	Atomic mass I.mass of electron II.mass of proton III.mass of neutron	 m_e m_p m_n	 kilogram and unified atomic mass unit	 kg u	 1u=1.660 565 5 10^{-27} kg	 allowable (non-SI)	 m_e =(5.485 802 6±0.000 002 1) x10^{-4} u m_p=(1.007 276 470±0.000 000011)u m_n =(1.008 665 012±0.000 000 037)u	For atomic mass unit, unified atomic mass unit(u) is always used and kg is not recommended.
3.3.9.n	Elementary charge	e	coulomb	C		derived base	The electric charge of a proton. e=(1.602 189 2 + 0.000 004 6) x10^{-19} C	

4. DECIMAL MULTIPLES AND SUBMULTIPLES OF SI UNITS AND RELATED PROVISIONS

The prefixes given in the following Table (Table 2) are used to form names and symbols of decimal multiples and submultiples of units. These multiples and submultiples are used only by base and derived and some allowable non-SI units.

The symbol of a prefix is considered to be combined with the single unit symbol* to which it is directly attached, forming with it a new symbol which can be raised to a positive or negative power, and which can be combined with other unit symbols to form symbols for compound units.

Examples:

$1\ cm^3 = (10^{-2}\ m)^3 = 10^{-6}\ m^3$
$1\ \mu s^{-1} = (10^{-6}\ s)^{-1} = 10^6\ s^{-1}$
$1\ mm^2/s = (10^{-3}\ m)^2/s = 10^{-6}\ m^2/s$

The symbol of the prefix must be placed before the symbol of unit without intermediate space and is recommended "if possible" to be printed in roman (upright) type.

Compound prefixes shall not be used such as mμm or MKm.

The choice of appropriate multiple and submultiple is governed by convenience, but anyhow those can usually be chosen so that the numerical values will be between 0.1 and 1000.

Examples:

1.2×10^4 *N can be written as 12 KN*
0.00396 m can be written as 3/96 mm
3.1×10^{-8}*s can be written as 31 ns*

However, in a table of values for the same quantities or in a discussion of such values within a given context, it will generally be better to use the same multiples for all items, even when some of the numerical values will be outside the range 0.1 to 1000.

*** Since the unit of mass in SI is kilogram (not gram), therefore exceptionally the names of the decimal multiples and submultiples of the unit of mass are formed by adding the prefixes to "gram" instead of "kilogram".**

In special cases it is better to use always the same prefix such as millimeter for dimensions in most mechanical engineering drawings.

In calculations it is recommended to use the SI prefixes of decimal multiples and submultiples instead of powers of 10. It will help to avoid error.

TABLE 2 - DECIMAL MULTIPLES AND SUBMULTIPLES OF SI UNITS

	PREFIX	SYMBOL OF PREFIX	FACTOR
Multiples	exa	E	10^{18}
	peta	P	10^{15}
	tera	T	10^{12}
	giga	G	10^{9}
	mega	M	10^{6}
	kilo	k	10^{3}
	hecto	h	10^{2}
	deca	da	10
Submultiples	deci	d	10^{-1}
	centi	c	10^{-2}
	milli	m	10^{-3}
	micro	μ	10^{-6}
	nano	n	10^{-9}
	pico	p	10^{-12}
	femto	f	10^{-15}
	atto	a	10^{-18}

5. GENERAL PROVISIONS

5.1 Provisions on SI Prefixes of Decimal Multiples and Submultiples

Provisions to be used on SI prefixes of decimal multiples and submultiples have been given in clause 4.

5.2 Rules and Recommendations for Writing of Unit Symbols

5.2.1 Unit symbols should remain unaltered in the plural, should be written without a final full stop (period) except for normal punctuation, e.g. at the end of a sentence and should be placed after the complete numerical value in the expression for a quantity, leaving a space between the numerical value and unit symbol.

Examples:

4 W NOT (4Ws) NOT (4W)

5.2.2 Unit symbols should generally be written in lower case letters except that the first letter is written in upper case when the name of the unit is derived from a proper name.

Examples:

m (meter) s (second) A (ampere) Wb (weber)

5.2.3 It is recommended "if possible" that unit symbols be printed in roman (upright) type (irrespective of the type used in the rest of the text).

The symbols for quantities "which are generally single letters of the Latin or Greek" are recommended to be printed in italic (sloping) type "if possible and irrespective of the type used in the rest of the text". But anyhow no recommendation is made or implied about the font of type in which symbols are to be printed.

5.2.4 When a compound unit is formed by multiplication of two or more units, this may be indicated in one of the following ways. N. m or N m. The last form may also be written without a space, provided that special care is taken when a symbol for one of the units is the same as the symbol for a prefix, e.g. mN means millinewton, not meter newton.

5.2.5 When a compound unit is formed by dividing one unit by another, this may be indicated in one of the following ways:

$\frac{m}{s}$, *m/s or* $m.s^{-1}$

In no case should more than one solidus (as in m/s) on the same line be included. In such a combination parentheses shall be inserted to avoid ambiguity. In complicated cases, negative power should be used.

Examples:

W/(m.K) for watt per meter kelvin
$W.m^{-2}$ *for watt per square meter*

5.3 Recommendation for Printing of Subscripts

When, in a given context, different quantities have the same letter symbol or when, for one quantity, different applications or different values are of interest, a distinction can be made by use of subscripts.

The following principles for the printing of subscripts are recommended:

A subscript that represents a symbol for a physical quantity is recommended "if possible" to be printed in italic (sloping) type. Other subscripts are recommended "if possible" to be printed in roman (upright) type.

5.4 Recommendations for Writing and Printing of Numbers

5.4.1 To facilitate the reading of numbers with many digits, these may be separated into suitable groups, preferably of three, counting from the decimal sign towards the left and the right; the groups should be separated by a small space but never by a comma, a point or by other means. For example: 9 192 631 770.

5.4.2 The preferred decimal sign is a dot on the line. For example: 1.25 (recommended) 1,25 (not recommended).

Note:

Use of a comma has been recommended by ISO as an alternative for decimal sign which is not recommended in IPS Standards.

5.4.3 If the magnitude of the number is less than unity, the decimal sign should be preceded by a zero. For example: **0.15.**

5.4.4 The use of superscripts for numbers with many digits is recommended. For example: **12 000 000 equals 12 × 10^6**.

5.4.5 The use of "E" notation is permitted for convenience because of inability of computers to print out or transmit superscripts. For example:

3.048×10^{-1} equals 3.048 E - 01
Similarly $9.290\,304 \times 10^{2}$ equals 9.290 304 E + 02

5.5 Multiplication of Numbers

The sign for multiplication of numbers is a cross (×). For example: **5 × 5**

5.6 Guide for the Rounding of Numbers

5.6.1 Rounding means replacing the magnitude of a given number by another number called the rounded number, selected from the sequence of integral multiples of a chosen rounding interval.

Examples:

1) rounding interval: 0.1
integral multiples: 12.1, 12.2, 12.3, 12.4, etc.

2) rounding interval: 10
integral multiples: 1 210, 1 220, 1 230, 1 240, etc.

5.6.2 If there is only one integral multiple nearest the given number, then that is accepted as the rounded number.

Examples:

1) rounding interval: 0.1

given number	rounded number
12. 223	12. 2
12. 251	12. 3
12. 275	12. 3

2) rounding interval: 10

given number	rounded number
1 222. 3	1 220
1 225. 1	1 230
1 227. 5	1 230

5.6.3 If there are two successive integral multiples equally near the given number, two different rules are in use.

RULE A: The even integral multiple is selected as the rounded number.

Examples:

1) rounding interval: 0.1

given number	rounded number
12. 25	12. 2
12. 35	12. 4

2) rounding interval: 10

given number	rounded number
1 225. 0	1 220
1 235. 0	1 240

RULE B: The higher integral multiple is selected as the rounded number.

Examples:

1) rounding interval: 0.1

given number	rounded number
12. 25	12. 3
12. 35	12. 4

2) rounding interval: 10

given number	rounded number
1 225. 0	1 230
1 235. 0	1 240

Note:

Rule A is generally preferable and of special advantage when treating, for example,series of measurements in such a way that the rounding errors are minimized.

Rule B is widely used in computers.

5.6.4 Rounding in more than one stage by the application of the rules given above may lead to errors; it is therefore recommended always to round in one step.

Example:

12.251 should be rounded to 12.3 and not first to 12.25 and then to 12.2.

5.6.5 The rules given above should be used only if no special criteria for the selection of the rounded number have to be taken into account. In cases where safety requirements or given limits have to be respected, it may for instance be advisable always to round in one direction.

6. CONVERSION FACTORS

Conversion factors are given in Table 3 to 12 to convert any specified unit to IPS preferred unit.

The Abbreviations used in Tables 3 to 12 are as below:

naut mi	for	nautile mile
yd	"	yard
ft	"	foot
ha	"	hectare
in	"	inch
mi	for	mile
cubem	"	cubic mile
bbl	"	barrel
gal	"	gallon
qt	"	quarter
pt	"	pint
ml	"	milliliter
deg	"	degree
min	"	minute
s or sec	"	second
rad	"	radian
sr	"	stradian
yr or a	"	year
h	"	hour

wk	"	week
cwt	"	hundred weight
lb	"	pound
oz	"	ounce
std	"	standard
mol	"	mole
atm	"	atmosphere
°F	"	Fahrenheit
°R	"	Rankine
dyn	"	dyne
m torr	"	milli torr
ppm	"	part per million
psi	"	pound per squared inch
ton or t	"	tonne
hp	"	horse power
ch or cv	"	cheval vapeur
cal	"	calorie
cal15	"	calorie at 15°C
calIT	"	international calorie
calth	"	thermochemical calorie
μ	"	micro

Note:
In the following Tables an asterisk(*) indicates that all following digits in the given conversion factor would be zero. If a conversion factor happens to end in several zero but does not have an asterisk, then any subsequent digits would not necessarily be zero.

TABLE 3 - CONVERSION TABLE FOR SPACE AND TIME

QUANTITY AND SI UNIT	MULTIPLY (A)	BY (B)	TO OBTAIN (C)
	A	B	C
Length m	naut mi mi	1.852 * 1.609 344 *	km
	chain link	20.116 8 * 0.201 168 *	m
	fathom yd ft	1.828 8 * 0.914 4 * 0.304 8 *	m
	in cm mil (thou)	25.4 * 10 * 0.0254 *	mm
	micron (μ)	1.0 *	μm
Length / Length m / m	ft/mi	0.189 393 9	m/km
Length / Volume m / m^3	ft/USgal ft/ft^3 ft/bbl	80.519 64 10.763 91 1.917 134	m/m^3
Area m^2	mi^2 .	2.589 988	km^2
	ha	10.000 *	m^2
	section acre	2.589 988 $\times 10^2$ 0.404 685 6	ha
	Yd^2 ft^2	0.836 127 4 9.290 304 * $\times 10^{-2}$	m^2
	in^2 cm^2	6.451 6 * $\times 10^2$ 100 *	mm^2
Area / Volume m^2 / m^3	ft^2/in^3	5.699 291 $\times 10^{-3}$	m^2/cm^3
Area / Mass m^2 / kg	cm^2/g	0.10 *	m^2/kg
Volume, m^3 Capacity	cubem (cubic mile acre.ft	4.168 182 1.233 482 $\times 10^3$	km^3 m^3
	yd^3	0.764 554 9	m^3
	bbl (42 USgal) ft^3	0.158 987 3 2.831 685 $\times 10^{-2}$	m^3

A Is any specified unit
B Is conversion factor
C Is IPS preferred unit (based on SI)

(to be continued)

TABLE 3 (Continued)

QUANTITY AND SI UNIT	MULTIPLY (A)	BY (B)	TO OBTAIN (C)
	A	B	C
Volume, m^3 Capacity (continued)	ft^3 UK gal	28.316 85 4.546 092 $\times 10^{-3}$ 4.546 092	litre = dm^3 m^3 litre
	US gal	3.785 412 $\times 10^{-3}$ 3.785 412	m^3 litre
	UK qt US qt	1.136 523 0.946 352 9	litre
	UK pt US pt	0.568 260 9 0.473 176 5	litre
	US fl oz UK fl oz in^3 ml	29.573 53 28.413 05 16.387 06 1	cm^3
Volume / Length (Linear Displacement) m^3/m	bbl/in bbl/ft ft^3/ ft US gal/ft	6.259 342 0.521 611 9 9.290 304 * $\times 10^{-2}$ 1.241 933 $\times 10^{-2}$	m^3/m
Plane angle rad	deg(°) min(/) sec(")	1.745 329 $\times 10^{-2}$ 2.908 882 $\times 10^{-4}$ 4.848 137 $\times 10^{-6}$	rad
Solid angle sr	sr	1	sr
Time s**	million years (MY) yr	1 1	Ma a
	wk	7.0	d
	h	60	min
	min	60	s
	millimicrosecond	1	ns

A Is any specified unit

B Is conversion factor

C Is IPS preferred unit (based on SI)

(**) In addition to the Basic SI Unit (second) existing time units may be used according to context, namely: minute, hour, day, week, month, year.

TABLE 4 - CONVERSION TABLE FOR MASS, AMOUNT OF SUBSTANCE

QUANTITY AND SI UNIT		MULTIPLY (A)	BY (B)	TO OBTAIN (C)
		A	B	C
Mass	kg	UK ton (long ton) US ton (short ton)	1.016 047 0.907 184 7	ton (t)
		q (quintal) UK cwt US cwt Slug lb	100 * 50.802 34 45.359 24 14.593 9 0.453 592 4	kg
		oz (troy) oz (av)	31.103 48 28.349 52	g
		grain	64.798 91	mg
Amount of substance	mol	lb mol g mol std m^3 (0°C,1 atm) ideal gas std m^3 (15°C,1atm) ideal gas std ft^3 (60°F,1atm) ideal gas	0.453 592 4 1.0 * $\times 10^{-3}$ 4.461 58 $\times 10^{-2}$ 4.229 32 $\times 10^{-2}$ 1.195 30 $\times 10^{-3}$	kmol

A Is any specified unit
B Is conversion factor
C Is IPS preferred unit (based on SI)

TABLE 5 - CONVERSION TABLE FOR CALORIFIC VALUE, HEAT, ENTROPY, HEAT (CAPACITY)

QUANTITY AND SI UNIT	MULTIPLY (A)	BY (B)	TO OBTAIN (C)
	A	B	C
W Calorific J/kg value (Mass basis)	Btu/lb	2.326 000 $\times 10^{-3}$ 2.326 000	MJ/kg kJ/kg = J/g
		6.461 112 $\times 10^{-4}$	kW.h/kg
	calth/g calth/lb	4.184 * 9.224 141 *	kJ/kg = J/g J/kg
Calorific J/mol value (Mole basis)	kcal/g mol	4.184 * $\times 10^{3}$	kJ/kmol
	Btu/lb mol	2.326 000 $\times 10^{-3}$ 2.326 000	MJ/kmol kJ/kmol
Calorific J/m^3 value (Volume basis solids & liquids)	therm/UK gal	2.320 800 $\times 10^{4}$ 2.320 800 $\times 10^{7}$	MJ/m^3 =kJ/dm^3 kJ/m^3
	Btu/US gal	2.787 163 $\times 10^{-4}$ 7.742 119 $\times 10^{-5}$	MJ/litre kWh/litre
	Btu/UK gal	2.320 800 $\times 10^{-4}$ M 6.446 667 $\times 10^{-5}$ k	Mj/litre Wh//litre
	Btu/ft^3	3.725 895 $\times 10^{-2}$ 1.034 971 $\times 10^{-2}$	MJ/m^3 kWh/m^3
	kcal/m^3	4.184 * $\times 10^{-3}$ 0.001 163	MJ/m^3 kWh/m^3
	cal/ml	4.184 *	MJ/m^3
	ft lbf/USgal	0.358 169 2	kJ/m^3
Calorific J/m^3 value (Volume Basis Gases)	cal/ml	4.184 *	MJ/m^3
	kcal/m^3	4.184 * $\times 10^{-3}$ 0.001 163	MJ/m^3 kWh/m^3
	Btu/ft^3	1.034 971 $\times 10^{-2}$ 3.725 895 $\times 10^{-2}$	kWh/m^3 MJ/m^3
Specific J/(kg.K) entropy	Btu/(lb.°R) cal/(g.K) kcal/kg. °C)	4.186 8 * 4.184 * 4.184 *	kJ/(kg.K)
Specific heat capacity (Mass Basis) J/(kg.K)	kWh/(kg.°C) Btu/(lb.°F) kcal/(kg.°C)	3.6 * $\times 10^{3}$ 4.186 8 * 4.184	kJ/(kg.°C)
Specific heat capacity (Mole Basis) J/(mol.K)	Btu/(lb.mol .°F) cal/(g.mol. °C)	4.186 8 * 4.184 *	Kj/(Kmol.°C)

A Is any specified unit
B Is conversion factor
C Is IPS preferred unit (based on SI)

TABLE 6 - CONVERSION TABLES FOR TEMPERATURE, PRESSURE, VACUUM

QUANTITY AND SI UNIT	MULTIPLY (A)	BY (B)	TO OBTAIN (C)
	A	B	C
Temperature K	°R **	5/9	K
K	°F	5/9(°F-32)	°C
Temperature (Difference) K	°F	5/9	°C
Temperature/Length (Geothermal Gradient) K/m	°F per 100ft	18.226 89 × 10^{-3}	K/m
Length/Temperature (Geothermal step)m/k	ft per °F	0.548 64 *	m/K
Pressure, N/m^2=Pa	bar	10* × 10^5	N/m^2 = Pa
	lb/in^2 (psi)	6.894 757 × 10^{-2}	
	atm (760 mmHg)	1.013 250 *	bar
	kgf/cm^2	0.980 665 0 *	
	inHg(at 60°F)	3.376 85 × 10	mbar
	mmHg or torr (at 0°C)	1.333 224	
	inH_2O (at 60°F)	2.488 4	
	mmH_2O(at 4 °C)	0.098 063 8	mbar
		98.063 8	µbar
	dyn/cm^2	1	
	µmHg or mtorr (at 0°C)	1.333 224	µbar
	in H_2O (at 60°F)	2.488 4 × 10^2	N/m^2= Pa

(**) Rankine is the absolute Fahrenheit Scale, where by absolute zero at - 459.69°F is equal to 0°R.

A Is any specified unit

B Is conversion factor

C Is IPS preferred unit (based on SI)

TABLE 7 - CONVERSION TABLE FOR DENSITY, VOLUME, CONCENTRATION, DOSAGE

QUANTITY AND SI UNIT	MULTIPLY (A)	BY (B)	TO OBTAIN (C)
	A	B	C
Density (Gases) kg/m^3	lb/ft^3	16.018 46 1.601 846 $\times 10^4$	kg/m^3 g/m^3
Density (Liquids) kg/m^3	lb/US gal lb/UK gal lb/ft^3	0.119 826 4 9.977 644 $\times 10^{-2}$ 1.601 846 $\times 10^{-2}$	 kg/litre $= kg/dm^3$
Density (Solids) kg/m^3	lb/ft^3	1.601 846 $\times 10^{-2}$	kg/litre
Specific volume (Gases) m^3/kg	ft^3/lb	6.242 796 $\times 10^{-2}$ 6.242 796 $\times 10^{-5}$	m^3/kg m^3/g
Specific volume (Liquids) m^3/kg	ft^3/lb UK gal/lb US gal/lb	62.427 96 10.222 41 8.345 404	 litre/kg
Specific volume (Mole basis) m^3/mol	litre/gmol $ft^3/lbmol$	1 6.242 796 $\times 10^{-2}$	1 $m^3/kmol$ $m^3/kmol$
Specific volume (Clay yield) m^3/kg	bbl/US ton bbl/UK ton	0.175 253 5 0.156 476 3	 m^3/t
Yield (Shale distillation) m^3/kg	bbl/US ton bbl/UK ton	1.752 535 $\times 10^2$ 1.564 763 $\times 10^2$	litre/t
	US gal/US ton US gal/UK ton	4.172 702 3.725 627	litre/t
Concentration (Mass/Mass) kg/kg	wt%	1.0 * $\times 10^{-2}$ 1.0 * $\times 10^{-5}$	kg/kg g/kg
	wt ppm	1	mg/kg
Concentration (Mass/Volume) kg/m^3	1b/bbl g/US gal g/UK gal	2.853 010 0.264 172 0.219 969 2	kg/m^3 or g/litre
	lb/1000 US gal lb/1000 UK gal grains/US gal	1.198 264 $\times 10^2$ 99.776 33 17.118 06	g/m^3 or mg/litre
	lb/1000 bbl mg/US gal	2.853 010 0.264 172 0	 g/m^3
	grains/100 ft^3	22.883 51	mg/m^3
Concentration (Volume/Volume) m^3/m^3	bbl/bbl ft^3/ft^3	1	m^3/m^3

A Is any specified unit
B Is conversion factor
C Is IPS preferred unit (based on SI)

(to be continued)

TABLE 7 (continued)
CONVERSION TABLE FOR DENSITY, VOLUME, CONCENTRATION, DOSAGE

QUANTITY AND SI UNIT	MULTIPLY (A)	BY (B)	TO OBTAIN (C)
	A	B	C
Concentration m^3/m^3 (Volume/Volume) (continued)	bbl/(acreft)	0.128 893 1	litre/m^3
	UK gal/ft^3 US gal/ft^3	1.605 437 $\times 10^2$ 1.336 806 $\times 10^2$	litre/m^3
	ml/US gal ml/UK gal	0.264 172 0 0.219 969 2	litre/m^3
	UK gal/1000 bbl US gal 1000 bbl UK pt/1000 bbl	28.594 03 23.809 52 3.574 253	cm^3/m^3
	Vol ppm	1 1.0 $\times 10^{-3}$	cm^3/m^3 litre/m^3
Concentration mol/m^3 (Mole/Volume)	lb mol/US gal lb mol/UK gal	1.198 264 $\times 10^2$ 99.776 44	kmol/m^3
	lb mol/ft^3 std ft^3 (60 °F. 1 atm) /bbl	16.018 46 7.518 21 $\times 10^{-3}$	kmol/m^3

A Is any specified unit
B Is conversion factor
C Is IPS preferred unit(based on SI)

TABLE 8 - CONVERSION TABLE FOR FACILITY THROUGHPUT, CAPACITY

QUANTITY AND SI UNIT	MULTIPLY (A)	BY (B)	TO OBTAIN (C)
	A	B	C
Concentration m^3/mol (Volume/Mole)	US gal/1000 std ft^3 (60°F/60°F)	3.166 91	
	bbl/million std ft^3 (60°F/60°F)	0.133 010	litre/kmol
Throughput kg/s (Mass basis)	million lb /yr	$4.535\ 924 \times 10^{2}$	
	UK ton/yr	1.016 047	t/a
	US ton/yr	0.907 184 7	
	UK ton/d	1.016 047	t/d
		$4.233\ 529 \times 10^{-2}$	t/h
	US ton/d	0.907 184 7	t/d
		$3.779\ 936 \times 10^{-2}$	t/h
	UK ton/h	1.016 047	
	US ton/h	0.907 184 7	t/h
	lb/h	0.453 592 4	kg/h
Throughput m^3/s (Volume basis)	bbl/d	0.158 987 3	m^3/d
		$6.624\ 471 \times 10^{-3}$	m^3/h
	ft^3/d	$1.179\ 869 \times 10^{-3}$	m^3/h
		$2.831\ 685 \times 10^{-2}$	m^3/d
	bbl/h	0.158 987 3	
	ft^3/h	$2.831\ 685 \times 10^{-2}$	m^3/h
	UK gal/h	$4.546\ 092 \times 10^{-3}$	m^3/h
	US gal/h	$3.785\ 412 \times 10^{-3}$	
	UK gal/min	0.272 765 5	m^3/h
	US gal / min	0.227 124 7	
	UK gal/min	4.546 092	litre/min
	US gal/min	3.785 412	
Throughput mol/s (Mole basis)	lb mol/h	0.453 592 4	kmol/h
		$1.259\ 979 \times 10^{-4}$	kmol/s

A Is any specified unit
B Is conversion factor
C Is IPS preferred unit (based on SI)

TABLE 9 - CONVERSION TABLE FOR FLOW RATE

QUANTITY AND SI UNIT	MULTIPLY (A)	BY (B)	TO OBTAIN (C)
	A	B	C
Flow rate kg/s (Mass basis)	UK ton/min US ton/min	16.934 12 15.119 74	kg/s
	UK ton/h US ton/h	0.282 235 3 0.251 995 8	kg/s
	UK ton/d US ton/d	1.175 980 $\times 10^{-2}$ 1.049 982 $\times 10^{-2}$	kg/s
	million lb /yr UK ton/yr US ton/yr	1.438 833 $\times 10^{-2}$ 3.221 864 $\times 10^{-5}$ 2.876 664 $\times 10^{-5}$	kg/s
	lb/s	0.453 592 4	kg/s
	lb/min	7.559 873 $\times 10^{-3}$	kg/s
	lb/h	1.259 979 $\times 10^{-4}$	kg/s
Flow rate m^3/s (Volume basis)	bbl/d ft^3/d	1.840 131 $\times 10^{-3}$ 3.277 413 $\times 10^{-4}$	litre/s
	bbl/h ft^3/h	4.416 314 $\times 10^{-2}$ 7.865 791 $\times 10^{-3}$	litre/s
	UK gal/h US gal/h	1.262 803 $\times 10^{-3}$ 1.051 503 $\times 10^{-3}$	litre/s
	US gal/min UK gal/min	7.576 820 $\times 10^{-2}$ 6.309 020 $\times 10^{-2}$	litre/s
	UK gal/min US gal/min	0.272 765 5 0.227 124 7	m^3/h
	ft^3/min ft^3/s	0.471 947 4 28.316 85	litre/s
Flow rate mol/s (Mole basis)	lb mol/s lb mol/h	0.453 592 4 1.259 979 $\times 10^{-4}$	kmol/s
Flow rate kg/(s.m) Length (Mole basis)	lb/s ft lb/h ft	1.488 164 4.133 789 $\times 10^{-4}$	kg/ (s.m)

A Is any specified unit
B Is conversion factor
C Is IPS preferred unit (based on SI)

(to be continued)

TABLE 9 (continued)
CONVERSION TABLE FOR FLOW RATE

QUANTITY AND SI UNIT	MULTIPLY (A)	BY (B)	TO OBTAIN (C)
	A	B	C
Flow rate/Length m^2/s	UK gal/- (min. ft)	2.485 833 $\times 10^{-4}$	
(Volume basis)	US gal/ (min. ft)	2.069 888 $\times 10^{-4}$	m^2/s
	UK gal/(h. in	4.971 667 $\times 10^{-5}$	m^2/s
	US gal/(h. in	4.139 776 $\times 10^{-5}$	
	UK gal/(h. ft	4.143 055 $\times 10^{-6}$	m^2/s
	US gal/(h ft	3.449 814 $\times 10^{-6}$	
Flow rate/Area (Mass basis)$kg/(s.m^2)$	$lb/(s.ft^2)$ $lb/(h.ft^2)$	4.882 428 1.356 230 $\times 10^{-3}$	$kg/(s.m^2)$
Flow rate/-Area (Volume basis) m/s	$ft^3/(s.ft^2)$	0.304 8 *	m/s
	$ft^3/(min.ft^2)$	5.08 * $\times 10^{-3}$	
	UK gal/(h. in^2)	1.957 349 $\times 10^{-3}$	m/s
	US gal/(h in2)	1.629 833 $\times 10^{-3}$	
	UKgal/(min ft^2)	8.155 621 $\times 10^{-4}$	m/s
	USgal/(min ft^2)	6.790 972 $\times 10^{-4}$	
	UK gal/(h. ft^2)	1.359 270 $\times 10^{-5}$	m/s
	US gal/(h. ft^2)	1.131 829 $\times 10^{-5}$	
Flow rate/Pressure drop (Productivity index) $m^3/(s.Pa)$	bbl/(d psi)	2.305 916 $\times 10^{-2}$ 2.305 916	$m^3/(d.kPa)$ $m^3/(d.bar)$

A Is any specified unit
B Is conversion factor
C Is IPS preferred unit (based on SI)

TABLE 10 - CONVERSION TABLE FOR ENERGY, WORK, POWER

QUANTITY AND SI UNIT	MULTIPLY (A)	BY (B)	TO OBTAIN (C)
	A	B	C
Energy, Work J	therm (British therm)	1.055 056 × 10^2 1.055 056 × 10^5 29.307 11	MJ kJ kWh
	thermie	4.186 8	MJ
	US ton_f mi	14.317 44	MJ
	hp h	1.013 9 2.684 520 2.684 520 × 10^3 0.745 699 9	ch.h MJ kJ kWh
	ch.h or CVh (metric horse power .h)	0.986 3 2.647 780 2.647 780 × 10^3 0.735 499 9	hp.h MJ kJ kWh
	kWh	3.6 * 3.6 * × 10^3	MJ kJ
	toe tons of oil equivalent (net)**	41.868 × 10^3	MJ
	tce tons of coal equivalent(net)**	29.307 × 10^3	MJ

**** Net value is the calorific value of a fuel, not taking into account the latent heat of condensation of the water vapor produced during combustion of the fuel.**

A Is any specified unit
B is conversion factor
C Is IPS preferred unit (based on SI)

(to be continued)

TABLE 10 (continued)
CONVERSION TABLE FOR ENERGY, WORK, POWER

QUANTITY AND SI UNIT		MULTIPLY (A)	BY (B)	TO OBTAIN (C)
		A	B	C
Energy, Work (continued)	J	Btu	1.055 056 2.930 711 × 10^{-4}	kJ kWh
		cal_{15} cal_{IT} cal_{th} ft lb_f J	4.185 5 × 10^{-3} 4.186 8 * × 10^{-3} 4.184 * × 10^{-3} 1.355 818 × 10^{-3} 1.0 * × 10^{-3}	kJ
		erg	1.0 * × 10^{-7}	J
Impact energy	J	kgf m lbf ft	9.806 650 * 1.355 818	J
Work/Length	J/m	US tonf mi /ft	46.973 22	MJ/m
Surface energy	J/m^2	erg/cm^2	1.0 *	mJ/m^2
Specific impact Energy	J/m^2	$kgf\ m/cm^2$ $lbf\ ft/in^2$	9.806 650 * 2.101 522 × 10^{-1}	J/cm^2
Power	W	million Btu/h ton of refrigeration	0.293 071 1 3.516 853	MW KW
		Btu/s	1.055 056	kW
		hydraulic horse power-hhp hp (electric)	0.746 043 0.746 *	kW
		hp(550 ft lbf/s ch or CV	0.745 699 9 0.735 499 9	kW
		Btu/min ft lbf/s	1.758 427 ×10^{-2} 1.355 818 ×10^{-3}	kW
		kcal/h Btu/h ft lbf/min	1.162 222 0.293 071 1 2.259 697 ×10^{-2}	W
Power/Area Heat flow unit hfu (Geothermics)	W/m^2	$Btu/(s\ ft^2)$ $cal/(h\ cm^2)$ $Btu/(h\ ft^2)$	11.356 53 1.162 222 ×10^{-2} 3.154 591 ×10^{-3}	kW/m^2
		µcal/ $(s\ cm^2)$	41.84 *	mW/m^2

A Is any specified unit
B is conversion factor
C Is IPS preferred unit (based on SI)

(to be continued)

TABLE 10 (continued)
CONVERSION TABLE FOR ENERGY, WORK, POWER

QUANTITY AND SI UNIT	MULTIPLY (A)	BY (B)	TO OBTAIN (C)
	A	B	C
Heat release W/m^3 Rate, Mixing power	hp/ft^3 $cal/(h\ cm^3)$	26.334 14 1.162 222	kW/m^3
	$Btu/(s\ ft^3)$ $Btu/(h\ ft^3)$	37.258 95 1.034 971 $\times 10^{-2}$	kW/m^3
Heat generation unit-hgu (Radioactive rocks)	$cal/s\ cm^3$	4.184 * $\times 10^6$	W/m^3
Cooling duty W/W (Machinery)	Btu/bhp h	0.393 014 8	W/kW
Specific fuel consumption kg/J (Mass basis)	lb/(hp h)	0.168 965 9	mg/J or kg/MJ
Specific fuel consumption m^3/J (Volume basis)	m^3/kWh	2.777 778 $\times 10^2$	litre/MJ
	US gal/(hp.h)	1.410 089	litre/MJ
	UKpt/(hp.h)	0.211 680 6 0.762 050 4	litre/MJ litre/kWh
Fuel consumption (Automotive) m^3/m	UK gal/mi US gal/mi	2.824 807 $\times 10^2$ 2.352 146 $\times 10^2$	litre/100 km
	mi/US gal mi/UK gal	0.425 143 7 0.354 006 4	km/litre

A Is any specified unit
B Is conversion factor
C Is IPS preferred unit(based on SI)

TABLE 11 - CONVERSION TABLE FOR MECHANIC

QUANTITY AND SI UNIT		MULTIPLY (A)	BY (B)	TO OBTAIN (C)
		A	B	C
Velocity (Linear), Speed	m/s	knot mi/h	1.852 * 1.609 344 *	km/h
		ft/s ft/min	0.304 8 * 5.08 * $\times 10^{-3}$	m/s
		ft/h ft/d in/s in/min	8.466 667 $\times 10^{-2}$ 3.527 778 $\times 10^{-3}$ 25.4 * 0.423 333 3	mm/s
Reciprocal velocity	s/m	s/ft	3.280 840	s/m
Corrosion rate mm/a		in/yr(ipy)	25.4 *	mm/a
Rotational frequency	rev/s	rev/min	1.666 667 $\times 10^{-2}$	rev/s
Acceleration (Linear)	m/s^2	ft/s^2 $gal(cm/s^2)$	0.304 8 * 1.0 * $\times 10^{-2}$	m/s^2
Momentum	kg.m/s	lb ft/s	0.138 255 0	kg.m/s
Force	N	UK tonf US tonf	9.964 016 8.896 443	KN
		kgf(kp) lbf	9.806 650 * 4.448 222	N
		pdl (paundal) dyn	1.382 500 $\times 10^{2}$ 1.0 * $\times 10^{-2}$	mN
Bending moment, Torque	Nm	US tonf ft	2.711 636	kN.m
		kgf m lbf ft pdl ft (poundal.ft) lbf in	9.806 650 * 1.355 818 * 4.214 011 $\times 10^{-2}$ 0.112 984 8	N.m
Bending moment/Length	N.m/m	lbf ft/in kgf m/m lbf in/in	53.378 66 9.806 650 * 4.448 222	N.m/m
Moment of inertia	$kg.m^2$	$lb\ ft^2$	4.214 011 $\times 10^{-2}$	$kg.m^2$

A Is any specified unit
B Is conversion factor
C Is IPS preferred unit (based on SI)

(to be continued)

TABLE 11 (continued)
CONVERSION TABLE FOR MECHANICS

QUANTITY AND SI UNIT	MULTIPLY (A)	BY (B)	TO OBTAIN (C)
	A	B	C
Moment of section (Second moment of area) m^4	in4	41.623 14	cm^4
Stress N/m^2(Pa)	US tonf/in^2 kgf/mm^2 US ton/ft^2 lbf/in^2 (psi)	13.789 51 9.806 650 * 9.576 052 $\times 10^{-2}$ 6.894 757 $\times 10^{-3}$	N/mm^2
	lbf/ft^2 (psf) dyn/cm^2	4.788 026 $\times 10^{-2}$ 0.10 *	kN/m^2(kPa) N/m^2(Pa)
Yield Point, Gel strength (Drilling fluid)	,$lbf/100\ ft^2$	47.880 26	N/m^2(Pa)
Mass/Length kg/m	lb/ft	1.488 164	kg/m
Mass/Area kg/m^2 Structural loading, Bearing capacity (Mass basis)	US ton/ft^2 lb/ft^2	9.764 855 4.882 428	t/m^2 kg/m^2
Section modulus m^3	in^3	16.387	cm^3

A Is any specified unit
B Is conversion factor
C Is IPS preferred unit (based on SI)

TABLE 12 - CONVERSION TABLE FOR TRANSPORT PROPERTIES

QUANTITY AND SI UNIT	MULTIPLY (A)	BY (B)	TO OBTAIN (C)
	A	B	C
Diffusivity m^2/s	ft^2/s	9.290 304 * $\times 10^4$	mm^2/s
	cm^2/s	100 *	
	ft^2/h	25.806 4 *	
Thermal resistance $K\ m^2/W$	°C m^2h/kcal	8.604 208 $\times 10^2$	°C m^2/kW
	°F ft^2 h/Btu	1.761 102 $\times 10^2$	
Heat flux W/m^2	(Btu/h)/ft^2	3.154 591 $\times 10^{-3}$	kW/m^2
Thermal conductivity W/(m.K)	(cal/s)/ cm^2.°C/cm	4.184 * $\times 10^2$	W/(m.°C)
	(Btu/h)/ft^2 °F/ft	1.730 735	
	kcal/h.m^2 °C /m	1.162 222	W/(m.°C)
	Btu/h.ft^2 °F/in	0.144 227 9	
	cal/h.cm^2 °C/cm	0.116 222 2	
Heat transfer coefficient W/(m^2.K)	cal/s.cm^2 °C	41.84 *	kW/(m^2.°C)
	Btu/s.ft^2 °F	20.441 75	
	cal/h.cm^2 °C	1.162 222 $\times 10^{-2}$	
	Btu/h ft^2 °F	5.678 263 $\times 10^{-3}$	
Heat transfer coefficient (continued)	Btu/h.ft^2°R	5.678 263 $\times 10^{-3}$	kW/(m^2.K)
	kcal/h m^2°C	1.162 222 $\times 10^{-3}$	kW/(m^2.°C)
Volumetric heat, transfer coefficient W/(m^3.K)	Btu/s.ft^3°F	67.066 11	kW/(m^3.°C)
	Btu/h.ft^3°F	1.862 947 $\times 10^{-2}$	
Surface tension N/m	dyn/cm	1	mN/m
Viscosity (Dynamic) N.s/m^2	lbf s/in^2	6.894 757 $\times 10^3$	N.s/m^2
	lbf s/ft^2	47.880 26	
	kgf s/m^2	9.806 650 *	N.s/m^2
	lb/ft.s	1.488 164	
	dyn s/cm^2	1.0	N.s/m^2
	cp (centipoise)	1.0 * $\times 10^{-3}$	
	lb/ft.h	4.133 789 $\times 10^{-4}$	

A Is any specified unit
B Is conversion factor
C Is IPS preferred unit (based on SI)

(to be continued)

TABLE 12 (continued)
CONVERSION TABLE FOR TRANSPORT PROPERTIES

QUANTITY AND SI UNIT	MULTIPLY (A)	BY (B)	TO OBTAIN (C)
	A	B	C
W Viscosity m^2/s (Kinematic)	ft^2/s	$9.290\ 304 * \times 10^4$	
	in^2/s	$6.451\ 6 * \times 10^2$	mm^2/s
	m^2/h	$2.777\ 778 \times 10^2$	
	cm^2/s	$1.0 * \times 10^2$	mm^2/s
	ft^2/h	$25.806\ 4 *$	
	cst (centistoke)	1	mm^2/s
Permeability m^2	darcy	0.986 923 3	µm2
	millidarcy	$9.869\ 233 \times 10^{-4}$	

A Is any specified unit
B Is conversion factor
C Is IPS preferred unit (based on SI)

APPENDICES

APPENDIX A
COMMONLY USED QUANTITIES AND UNITS IN TECHNOLOGY

Examples of decimal multiples and sub-multiples of some SI Units and allowable units which commonly used in technology are given in this Appendix.

Different Clauses of this Appendix are concerned with various sectors of technology.

Quantity	SI unit	Selection of multiples of the SI unit	Units outside the SI which are never. theless recognized by the CIPM as having to be retained either because of their practical importance of because of their use in specialized fields		Remarks, and information about units used in special fields
			Units	Multiples of units given in column 5	
angle (plane angle_	rad (radian)	 mrad urad	° (degree) (minute) (second)		If the radian is not used, the units degree (or grade for gon) may be used. Decimal subdivisions of degree are preferable to minute and second for most applications. grade (θ) or gon, 18 = 1 gon = $\frac{\pi}{200}$ rad
sotid sngle	sr (steradian)				
length	 m (metre)	km cm mm µm nm pm fm			1 international nautical mile = 1852 m inch may be use for threads, screw, nuts and diameter of pipe in IPS.
ares	m^2	km^2 dm^2 cm^2 mm^2			ha (hectare), 1 ha = 10^4 m^2 a (are), 1 a = 10^2 m^2
volume	m^3	 dm^3 cm^3 mm^3	 LL" (litre)	hl 1 hl = 10^{-1} m^3 cl 1 cl = 10^{-5} m^3 ml 1 ml = 10^{-6} m^3 = 1 cm^3	In 1964, the Conference Generale des Poids at Mesures declared that the name Litre (1) may be used as a special name for the cubic decimetre (dm^3) and advised against the use of the name litre for high-precision measurements.
thime	 s (second)	 ms µs ns	d (day) h (hour) min (minute)		Other units such as week, month and year (a) are in common use.
angular velocity	rad/s				
velocity	m/s			km/h 1 km/h = $\frac{1}{3,6}$ m/s	1 knot = 0,514 444 m/s
acceleration	m/s^2				
frequency	 Hz (hertz)	THz GHz MHz kHz			
rotational frequency	s^{-1}		min^{-1}		The designations "revolution per minute" (r/min) and "revolution per second" (r/s) are widely used for rotational frequency in specifications on rotating machinery".

A . 2 - COMMONLY USED QUANTITIES AND UNITS OF MECHANICS

Quantity	SI unit	Selection of multiples of the SI unit	Units outside the SI which are never. theless recognized by the CIPM as having to be retained either because of their practical importance of because of their use in specialized fields		Remarks, and information about units used in special fields
			Units	Multiples of units given in column 5	
mass	kg (kilogram)	g m µg	t (ton)		
density (mass density)	kg/m^3	Mg/m^3 or kg/dm^3 or g/cm^3	t/m^3 or kg/l	g ml g	
linear density	kg/m	mg/m			1 tex = 10^{-5} kg/m The unit tex is used for textile filaments.
momentum	kgm/s				
moment of momentum, angular momentum	$kg\ m^2/s$				
moment of inertia	kgm^2				
force	N (newton)	MN kN mN µN			
moment of force	Nm	MN m kN m mN m µN m			
pressure	pa (pascal)	GPa MPa kPa mPa µPa	bar	moar µbar	1 bar = 10^5 Pa
normal stress	pa or N/m^2	GPa MPa N/mm^2 kPa			
viscosity (dynamic)	Pas	mPa's			P (poise) 1 cP = 1 mPa's
kinematic viscosity	m^2/s	mm^2/s			St (stokes) 1 cSt = 1 mm^2/s
surface tension	N/m	mN/m			
energy, work	J (joule)	EJ PJ TJ GJ MJ kJ mJ	eV (electronvolt)	Gev Mev kev	The units W h, kW h, MW h, GW h and Tw h are used in the field of consumption of electrical energy. The units keV. MeV and GeV are used in atomic and nuclear physics and in accelerator technology.
power	W (watt)	DW MW kW mW µW			

A . 3 - COMMONLY USED QUANTITIES AND UNITS OF HEAT

Quantity	SI unit	Selection of multiples of the SI unit	Units outside the SI which are never. theless recognized by the CIPM as having to be retained either because of their practical importance of because of their use in specialized fields		Remarks, and information about units used in special fields
			Units	Multiples of units given in column 5	
thermo. dynamic temperature	K (kelvin)				
Celsius temperature	°C (degree Celsius)[31]				The Celsius temperature t is equal to the difference $t = T - T_o$ between two thermodynamic temperatures T_o and T where $T_o = 273, 15$ k.
temperature interval	K				For temperature interval, °C may be used instead of k.
linear expansion coefficient	K^{-1}				
heat, quantity of heat	J	EJ PJ TJ GJ MJ kJ mJ			
heat flow rate	W	kW			
thermal conductivity	W/ (m.K)				
conefficient of heat transfer	$W/(m^2.K)$				
heat capacity	J/K	kJ/K			
specific heat capacity	J/(kg.K)	kJ/(kg.K)			
entropy	J/K	kJ/K			
specific entropy	J/(kg.K)	kJ/(kg.K)			
specific internal energy	J/kg	MJ/kg kJ/kg			
specific latent heat	J/kg	MJ/kg kJ/kg			

A . 4 - COMMONLY USED QUANTITIES AND UNITS OF ELECTRICITY AND MAGNETISM

Quantity	SI unit	Selection of multiples of the SI unit	Units outside the SI which are never. theless recognized by the CIPM as having to be retained either because of their practical importance of because of their use in specialized fields		Remarks, and information about units used in special fields
			Units	Multiples of units given in column 5	
electric current	A (ampere)	kA mA μA nA pA			
electric charge. quantity of electricity	C (coulomb)	kC μC nC pC			1 A.h = 3,6 kC
volume density of charge. charge density	C/m^3	C/mm^3 MC/m^3 or C/cm^3 kC/m^3 mC/m^3 $\mu C/m^3$			
surface density of charge	C/m^2	MC/m^2 or C/mm^2 C/cm^2 kC/m^2 mC/m^2 $\mu C/m^2$			
electric field strength	V/m	MV/m kV/m or V/mm V/cm mV/m μV/m			
electric potential potential difference (tension) electromotive force	V (volt)	M/V kV mV μV			
electric flux density, displacement	C/m^2	C/cm^2 kC/m^2 mC/m^2 $\mu C/m^2$			
electric flux. (flux of displacement)	C	MC kC mC			
capacitance	F (farad)	mF μF nF pF			
permittivity	F/m	μF/m nF/m pF/m			

A . 4 - (continued)

Quantity	SI unit	Selection of multiples of the SI unit	Units outside the SI which are never. theless recognized by the CIPM as having to be retained either because of their practical importance of because of their use in specialized fields		Remarks, and information about units used in special fields
			Units	Multiples of units given in column 5	
electric polarization	C/m^2	C/cm^2 kC/m^2 mC/m^2 $\mu C/m^2$			
electric dipole moment	C.m				
curtent density	A/m^2	Ma/m^2 or A/mm^2 A/cm^2 kA/m^2			
linear current density	A/m	kA/m or A/mm A/cm			
mangnetic field strength	A/m	kA.m or A/mm A/cm			
magnetic potential difference	A	kA mA			
magnetic flux density, magnetic induction	T (tesla)	mT μT nT			
magnetic flux	Wb (weber)	mWb			
magnetic vector potential	Wb/m	kWb/m or Wb/mm			
self inductance mutual inductance	H (henry)	mH μH nH pH			
permeability	H/m	μH/m nH/m			
electuomagnetic moment, (magnetic moment)	$A.m^2$				
magnetization	A/m	kA/m or A/mm			
magnetic polarization	T	mT			
magnetic dipole moment	$N/m^2/A$ or Wb.m				

A . 4 - (continued)

Quantity	SI unit	Selection of multiples of the SI unit	Units outside the SI which are never. theless recognized by the CIPM as having to be retained either because of their practical importance of because of their use in specialized fields		Remarks, and information about units used in special fields
			Units	Multiples of units given in column 5	
resistance (to direct current)	Ω (ohm)	GΩ MΩ kΩ mΩ μΩ			
conductance to direct current)	S (siemens)	kS mS μs			
resistivity	Ω.m	GΩ.m MΩ.m kΩ.m Ω.cm mΩ.m μΩ.m nΩ.m			$\mu\Omega.cm = 10^{-8}\ \Omega.m$ $\frac{\Omega.mm^2}{m} = 10^{-6}\ \Omega.m = \mu\Omega.m$ are also used.
conductivity	S/m	MS/m kS/m			
reluctance	H^{-1}				
permeance	H				
impedance (complex impedance) modulus of impedance, (impedance) reactance resistance	Ω	MΩ kΩ mΩ			
admittance (complex admittance) modulus of admittance. (admittance) susceptance conductance	S	kS mS μS			
power		TW GW MW kW mW μW nW			in electric power technology, active power is expressed in watts (W), apparent power in voltamperes (v.A) and reactive power in vars (var).

A . 5 - COMMONLY USED QUANTITIES AND UNITS OF LIGHT AND RELATED ELECTROMAGNETIC RADIATIONS

Quantity	SI unit	Selection of multiples of the SI unit	Units outside the SI which are never. theless recognized by the CIPM as having to be retained either because of their practical importance of because of their use in specialized fields		Remarks, and information about units used in special fields
			Units	Multiples of units given in column 5	
wavelength	m	μm nm pm			A(angstrom). 1 A = 10^{-10} m = 0,1 nm = 10^{-4} μm
radiant energy	J				
radiant power, radiant energy flux	W				
radiant intensity	W/sr				
radiance	W/(sr.m^2)				
radiant exitance	W/m^2				
irradiance	W/m^2				
luminous intensity	cd (candela)				
luminous fluc	lm (lumen)				
quantity of light	lm.s				1 lm.h = 3600 lm.s
luminance	cd/m^2				
luminous exitance	lm/m^2				
illuminance	lx (lux)				
light exposure	lx.s				
luminous efficact	lm/W				

A . 6 - COMMONLY USED QUANTITIES AND UNITS OF ACOUSTIC

Quantity	SI unit	Selection of multiples of the SI unit	Units outside the SI which are never. theless recognized by the CIPM as having to be retained either because of their practical importance of because of their use in specialized fields		Remarks, and information about units used in special fields
			Units	Multiples of units given in column 5	
period periodic time	s	 ms µs			
frequency	 Hz	MHz kHz			
wavelength	m	 mm			
density (mass density)	kg/m^3				
static pressure (instantaneous) sound pressure	pa	 mpa µpa			
(instantaneous) sound particle velocity	m/s	mm/s			
(instantaneous) volume flow rate, volume velocity	m^3/s				
velocity of sound	m/s				
sound energy flux. sound power	W	kW mW µW pW			
sound intensity	W/m^2	 mW/m^2 mW/m^2 pW/m^2			
specific acoustic impedance	pa.s/m				
acoustic impedance	$pa.s/m^3$				
mechanical impedance	N.s/m				
sound pressure level					dB (decibel)
sound power level					dB
sound reduction index, sound transmission loss					dB
equivalent absorption area of a surface or object	m^2				
reverberation time	s				

A . 7 - COMMONLY USED QUANTITIES AND UNITS O F PHYSICAL CHEMISTRY AND MOLECULAR PHYSICS

Quantity	SI unit	Selection of multiples of the SI unit	Units outside the SI which are never. theless recognized by the CIPM as having to be retained either because of their practical importance of because of their use in specialized fields		Remarks, and information about units used in special fields
			Units	Multiples of units given in column 5	
amount of substance	mol (mole)	kmol mmol μmol			
molar mass	kg/mol	g/mol			
molar volume	m^3/mol	dm^3/mol cm^3/mol	l/mol		
molar internal energy	J/mol	kJ/mol			
molar heat capacity	J/(mol.K)				
molar entropy	J/(mol.K)				
concentration of substance B, amount-of-substance concentration of substance B	mol/m^3	mol/dm^3 or kmol/m^3	mol/l		
molality of solute substance B	mol/kg	mmol/kg			
diffusion coefficient	m^2/s				
thermal diffusion coefficient	m^2/s				

VALUES AND EQUIVALENTS TO BE SPECIFICALLY USED IN OIL INDUSTRIES

APPENDIX B
CALORIFIC EQUIVALENTS OF COAL, OIL, NATURAL GAS AND ELECTRICITY

to from	coal 10^3 tons	oil 10^3 tons	oil 10^6 litres	oil 10^3 litres	oil b/d	natural gas 10^9 litres	electricity GWh
	multiply by						
Coal: 1.000 metric tons	1.0	0.70	0.78	4.9	13.4	0.84	8.14
Oil:							
1,000 metric tons	1.43	1.0	1.11	7.0	19.1	1.20	11.63
1,000 kilolitres	1.29	0.9	1.0	6.0	17.2	1.08	10.47
1,000 barrels	0.204	0.143	0.159	1.0	2.74	0.172	1.66
1 barrel per day	0.075	0.052	0.058	0.365	1.0	0.063	0.61
Natural gas: 1 million cu m (or 1 gigalitre)	1.19	0.83	0.92	5.80	15.9	1.0	9.65
Electricity:							
1 Gigawatt hour	0.123	0.086	0.0955	0.60	1.65	0.104	1.0

Note:

The above mentioned equivalents are based on the following unit values: coal, 7.0 teracalories per 1,000 ton; oil, 10.0 teracalories (net) per 1,000 tons, or 9.0 teracalories (net) per 1,000 kiloliter; natural gas, 8.3 teracalories (net) per gigaliter; electricity, 860 teracalories per terawatt hour.

The difference between the "net" and the "gross" calorific value of a fuel is the latent heat of condensation of the water vapour produced during combustion of the fuel. For coal and oil net calorific value is five per cent less than gross; for most forms of natural and manufactured gas the difference is nine to ten per cent, while for electricity there is no difference. The use of net calorific value is consistent with European Community practice. However, Japanese and North American official energy balances are regularly published in terms of gross heat content.

APPENDIX C
ENERGY EQUIVALENT OF NATURAL GAS

TO convert

to from	10^6 tce/yr	10^6 cu ft/d natural gas	1×10^9 Nm^3/yr natural gas	b/d oe	10^{12} cu ft/yr natural gas	10^6 kWh/yr	10^6 th/yr	TJ/yr	10^9 Nm^3/y Groningeng (8,400 kca)
multiply by									
1×10^6 tce/yr	1	74.896	0.7329	12,913	0.02734	8.012	6,891	28,843	0.8202
100×10^6 cu ft/d natural gas	1.3352	100	0.9785	17,241	0.0365	10,697	9,201	38,510	1,095
1×10^9 Nm^3/yr natural gas	1.3645	102.2	1	17,620	0.0373	10.932	9,403	39,356	1.119
1×10^4 barrels/d oil equivalent	0.7744	58	0.5675	10×10^3	0.0212	6,204	5,336	22,336	0.635
1×10^{12} cu ft/yr natural gas	36.58	2,740	26.808	472,367	1	293,071	252,074	1.055×10^6	30
1×10^6 kWh/yr	0.1248×10^{-3}	9.348×10^{-3}	91.47×10^{-6}	1.6118	3.4×10^{-6}	1	0.8601		102.4×10
1×10^6 thermies/yr	0.1451×10^{-3}	10.87×10^{-3}	0.1064×10^{-3}	1.8739	3.97×10^{-6}	1.1626	1	4.186	119.1×10
1×tj/yr	34.67×10^{-6}	2.597×10^{-3}	25.41×10^{-6}	0.4477	0.9478×10^{-6}	0.2778	0.2389	1	28.44×10
1×10^9 Nm^3/yr Groningen gas (8,400 kcal)	1.2193	91.3	0.894	15,746	0.0333	9,769	8,403	35,169	1

Notes:

1) To use for 1×10^6 ton oe, multiply the top line by 1.57 and the first column by 0.64.

2) Gas heating value: 1,000 BTU/cuft (9400 kcal/Nm^3, 37.3 MJ/cum (st), 39.4 MJ/Nm^3). Adjust for different heat content by scaling as appropriate.

3) Tce is tons of coal equivalent.

4) Oe is oil equivalent.

APPENDIX D
ELECTRICAL OUTPUT

oil equivalent metric tons per Gigawatt hour		oil equivalent barrels per Gigawatt hour		oil equivalent kilolitres per Gigawatt hour	
@ 100 % efficiency	86	@ 100 % efficiency	601	@ 100 % efficiency	96
@ 40 % efficiency	215	@ 40 % efficiency	1,503	@ 40 % efficiency	239
@ 35 % efficiency	246	@ 35 % efficiency	1,717	@ 35 % efficiency	273
@ 30 % efficiency	287	@ 30 % efficiency	2,003	@ 30 % efficiency	319
@ 25 % efficiency	344	@ 25 % efficiency	2,404	@ 25 % efficiency	382
@ 20 % efficiency	430	@ 20 % efficiency	3,005	@ 20 % efficiency	478

oil equivalent metric tons per Gigawatt hour		energy equivalent Teracalories per Gigawatt hour		energy equivalent billion BTU per Gigawatt hour	
@ 100 % efficiency	122.8	@ 100 % efficiency	0.860	@ 100 % efficiency	3.412
@ 40 % efficiency	307.1	@ 40 % efficiency	2.150	@ 40 % efficiency	8.530
@ 35 % efficiency	350.9	@ 35 % efficiency	2.457	@ 35 % efficiency	9.748
@ 30 % efficiency	409.3	@ 30 % efficiency	2.867	@ 30 % efficiency	11.373
@ 25 % efficiency	491.2	@ 25 % efficiency	3.440	@ 25 % efficiency	13.648
@ 20 % efficiency	614.0	@ 20 % efficiency	4.330	@ 20 % efficiency	17.060

APPENDIX E
VOLUME / MASS / HEATING VALUES OF FUELS

	Specific gravity	bbl/ton	BTU/UK gal	BTU/lb	kcal/kg	10^6 BTU/bbl	10^6 kcal/bbl	boe/bbl
Propane	0.501	12.790		21,500	11,943	3.795	0.956	0.654
Butane	0.579	11.060		21,140	11,742	4.315	1.088	0.744
Motor gasoline	0.732	8.740	148,000	20,160	11,200	5.176	1.304	0.892
Kerosene	0.780	8.213	156,000	20,000	11,110	5.456	1.377	0.941
Vaporising oil	0.823	7.783	163,000	19,800	11,000	5.701	1.442	0.983
Gas oil	0.840	7.625	164,000	19,500	10,835	5.736	1.445	0.988
Fuel oils	0.850	7.536	165,660	19,490	10,830	5.794	1.460	0.999
"	0.860	7.448	166,840	19,400	10,780	5.835	1.470	1.006
"	0.870	7.362	168,080	19,320	10,730	5.878	1.481	1.013
"	0.880	7.278	169,310	19,240	10,690	5.921	1.492	1.021
"	0.890	7.196	170,440	19,150	10,640	5.961	1.502	1.028
"	0.900	7.116	171,640	19,070	10,590	6.002	1.513	1.035
"	0.910	7.038	172,730	18,980	10,540	6.041	1.522	1.042
"	0.920	6.961	173,800	18,890	10,490	6.078	1.532	1.048
"	0.930	6.887	174,860	18,800	10,440	6.115	1.541	1.054
"	0.940	6.813	175,890	18,710	10,390	6.151	1.550	1.061
"	0.950	6.741	176,910	18,620	10,340	6.187	1.559	1.067
"	0.960	6.671	177,910	18,530	10,290	6.222	1.568	1.073
"	0.970	6.602	178,890	18,440	10,240	6.256	1.577	1.079
"	0.980	6.535	179,860	18,350	10,190	6.290	1.585	1.084
"	0.990	6.469	180,800	18,260	10,140	6.323	1.593	1.090
"	1.000	6.404	181,730	18,170	10,090	6.356	1.602	1.096

Note:

The above mentioned heating values are gross values and gross value is the heating value of a fuel taking into account the latent heat of condensation of the water vapour produced during combustion of the fuel.

APPENDIX F
MASS / VOLUME EQUIVALENTS FOR LPG BULK

	bbl/ton	ton/yr LPG	ton/yr fuel oil	b/d fuel oil	106 cu ft/d natural gas	109 cu m/yr natural gas
Propane	12.44	293,408	341,844	6,084	38.18	0.374
Propylene	12.10	301,653	341,488	6,078	38.14	0.373
isoButane	11.19	326,184	372,943	6,637	41.65	0.408
n-Butane	10.80	337,962	387,104	6,889	43.23	0.423
n-Pentane	10.50	347,619	389,465	6,931	43.49	0.426
C^4	10.00	365,000	406,235	7,230	45.37	0.444
C_3/C^4	10.90	334,862	383,417	6,824	42.82	0.419
	11.67	312,768	361,247	6,429	40.35	0.395

1) Fuel oil: 18,500 BTU/lb

2) Natural gas heating value: 1,000 BTU/cu ft (9,400 kcal/Nm^3).

3) C_4 = 75 percent wt n-Butane, 25 percent wt isoButane.
C3/C4 = 50 percent wt Propane, 50 percent wt C_4 as above.

APPENDIX G
GAS FACTORS FOR METHANE

To convert

from \ to	it liq	cu ft liq	cu ft gas	cu m liq	l liq	cu m gas	therm	thermie
	multiply by							
long ton liquid	1	84.56	52,886	2.394	2,394	1,419.7	535.2	13,491
cu feet liquid	0.01183	1	625.43	0.02831	28.31	16.789	6.329	159.54
million cu feet gas*	18.91	1,599	1×10^{6}	45.27	45,270	26,847	10,121	255,115
cu m liquid	0.4177	35.315	22,090	1	1,000	593	223.55	5,635.2
litres liquid	417.7×10^{-6}	35.315×10^{-3}	22.09	1×10^{-3}	1	593×10^{-3}	223.55×10^{-3}	5.6352
billion cu m gas**	704,374	59.56×10^{6}	37.25×10^{9}	1.686×10^{6}	1.686×10^{6}	1×10^{9}	0.377×10^{9}	9.503×10^{9}
million therms	1,868	157,958	98.79×10^{6}	4,472	4.472×10^{6}	2.652×10^{6}	1×10^{6}	25.21×10^{6}
million thermies	74.12	6,268	3.92×10^{6}	177.44	177.44×10^{3}	105,228	39.669	1×10^{6}

* cu ft measured at 60°F, 14,696 lbf/sq in, dry.

** cu m measured at 0°C, 760 mm Hg, dry.

Notes:

1) The above factors are based on the properties of pure methane. Liquefied natural gas will vary in composition according to the presence of heavier hydrocarbons in the gas stream.

2) Therm = 100,000 BTU.

3) Thermie = 3,966.9 BTU.

4) Lt is long ton.

APPENDIX H
FACTORS FOR OTHER PETROLEUM PRODUCTS

	metric tons per				long tons per			
producy	cu m	1,000 lmp gal	1,000 Us gal	bbl	cu m	1,000 lmp gal	1,000 US gal	bbl
Liquefied petroleum gas*	0.5403	2.4548	2.0441	0.0859	0.5313	2.4107	2.0089	0.0845
Aviation spirit	0.7304	3.3186	2.7634	0.1161	0.7184	3.2997	2.7143	0.1142
Natural gasoline	0.7404	3.3640	2.8012	0.1177	0.7283	3.3080	2.7545	0.1158
Motor spirit	0.7404	3.3640	2.8012	0.1177	0.7283	3.3080	2.7545	0.1158
Kerosene/iet fuel	0.8104	3.6823	3.0662	0.1288	0.7972	3.6205	3.0223	0.1267
Distillate fuel oils	0.8704	3.9550	3.2933	0.1383	0.8563	3.8973	3.2366	0.1361
Lubricating oils	0.9005	4.0914	3.4069	0.1431	0.8858	4.0268	3.3571	0.1408
Fuel oils n.o.s.**	0.9105	4.1369	3.4447	0.1447	0.8956	4.0759	3.3839	0.1423
Residual fuel oils	0.9505	4.3187	3.5962	0.1510	0.9350	4.2500	3.5446	0.1487
Road oil/asphalt	1.0405	4.7278	3.9368	0.1653	1.0236	4.6563	3.8795	0.1627

	cu m per		bbl per		US gal per		lmp gal per	
product	metric ton	It***	metric ton	It	metric ton	It	metric ton	It
Liquefied petroleum gas*	1.8519	1.8816	11.6482	11.8352	489.2254	497.0775	407.3687	413.9069
Aviation spirit	1.3699	1.3918	8.6162	8.7545	361.8818	367.6900	301.3321	306.1684
Natural gasoline	1.3514	1.3730	8.4998	8.6362	356.9911	362.7208	297.2597	302.0307
Motor spirit	1.3514	1.3730	8.4998	8.6362	356.9911	362.7208	297.2597	302.0307
Karosene/iet fuel	1.2346	1.2544	7.7652	7.8898	326.1376	331.3721	271.5686	275.9272
Distillate fuel oils	1.1494	1.1679	7.2296	7.3456	303.6437	308.5172	252.8383	256.8964
Libricating oils	1.1111	1.1289	6.9886	7.1008	293.5216	298.2326	244,4098	248.3326
Fuel oils n.o.s.**	1.0989	1.1165	6.9118	7.0227	290.2958	294.9551	241.7238	245.6035
Residual fuel oils	1.0526	1.0695	6.6208	6.7270	278.0720	282.5351	231.5453	235.2616
Road oil/asphalt	0.9615	0.9770	6.0478	6.1448	254.0067	258.0835	211.5065	214.9012

***** **50/50 Butane/Propane mixture.**

****** **Not otherwise specified.**

******* **Long ton.**

APPENDIX I

CRUDE OIL

API GRAVITY TO SPECIFIC GRAVITY;

AND VOLUME PER UNIT MASS BY API DEGREES

API 15.56/15.56°C	sp gr 15.56/15.56°C	US barrels per long ton	US barrels per metric ton	cubic metres per long ton	cubic metres per metric ton
10.0	1.0000	6.4041	6.3030	1.01729	1.00123
10.5	0.9965	6.4265	6.3250	1.02085	1.00472
11.0	0.9930	6.4490	6.3472	1.02443	1.00825
11.5	0.9895	6.4717	6.3695	1.02803	1.01180
12.0	0.9861	6.4946	6.3920	1.03166	1.01537
12.5	0.9826	6.5176	6.4146	1.03532	1.01897
13.0	0.9792	6.5400	6.4367	1.03887	1.02246
13.5	0.9759	6.5625	6.4588	1.04245	1.02599
14.0	0.9725	6.5852	6.4812	1.04606	1.02954
14.5	0.9692	6.6080	6.5037	1.04969	1.03311
15.0	0.9659	6.6302	6.5255	1.05321	1.03657
15.5	0.9626	6.6534	6.5483	1.05689	1.04020
16.0	0.9593	6.6758	6.5704	1.06046	1.04371
16.5	0.9561	6.6985	6.5927	1.06406	1.04725
17.0	0.9529	6.7213	6.6151	1.06768	1.05081
17.5	0.9497	6.7434	6.6369	1.07119	1.05427
18.0	0.9465	6.7665	6.6596	1.07486	1.05788
18.5	0.9433	6.7889	6.6816	1.07841	1.006138
19.0	0.9402	6.8114	6.7038	1.08199	1.06490
19.5	0.9371	6.8341	6.7262	1.08560	1.06845
20.0	0.9340	6.8569	6.7487	1.08923	1.07202
20.5	0.9309	6.8799	6.7712	1.09288	1.07562
21.0	0.9279	6.9022	6.7932	1.09642	1.07910
21.5	0.9248	6.9255	6.8161	1.10012	1.08274
22.0	0.9218	6.9481	6.8383	1.10370	1.08627
22.5	0.9188	6.9708	6.8607	1.10731	1.08982
23.0	0.9159	6.9927	6.8823	1.11079	1.09325
23.5	0.9129	7.0157	6.9048	1.11445	1.09684
24.0	0.9100	7.0379	6.9268	1.11797	1.10032
24.5	0.9071	7.0603	6.9488	1.12153	1.10381
25.0	0.9042	7.0837	6.9718	1.12525	1.10748
25.5	0.9013	7.1064	6.9941	1.12885	1.11102
26.0	0.8984	7.1292	7.0166	1.13247	1.11458
26.5	0.8956	7.1512	7.0382	1.13596	1.11802
27.0	0.8927	7.1742	7.0609	1.13963	1.12163
27.5	0.8899	7.1975	7.0838	1.14332	1.12526
28.0	0.8871	7.2199	7.1059	1.14688	1.12877
28.5	0.8844	7.2424	7.1281	1.15046	1.13229
29.0	0.8816	7.2651	7.1504	1.15407	1.13584
29.5	0.8788	7.2880	7.1729	1.15770	1.13941
30.0	0.8762	7.3099	7.1945	1.16119	1.14285
30.5	0.8735	7.3331	7.2172	1.16486	1.14646
31.0	0.8708	7.3553	7.2391	1.16839	1.14994
31.5	0.8681	7.3787	7.2622	1.17211	1.15360
32.0	0.8654	7.4012	7.2843	1.17569	1.15712

$$API = \frac{141.5}{\text{spgr } 15.56\ ^\circ C / 15.56\ ^\circ C} - 131.5$$

spgr = specific gravity

15.56 °C ≈ 60° F

to be continued

APPENDIX I (continued)

API 15.56/15.56°C	sp gr 15.56/15.56°C	US barrels per long ton	US barrels per metric ton	cubic metres per long ton	cubic metres per metric ton
32.5	0.8628	7.4239	7.3067	1.17929	1.16066
33.0	0.8602	7.4457	7.3281	1.18275	1.16407
33.5	0.8576	7.4686	7.3507	1.18639	1.16765
34.0	0.8550	7.4917	7.3734	1.19006	1.17126
34.5	0.8524	7.5139	7.3952	1.19359	1.17473
35.0	0.8498	7.5372	7.4182	1.19729	1.17838
35.0	0.8473	7.5597	7.4403	1.20085	1.18189
36.0	0.8448	7.5822	7.4625	1.20444	1.18541
36.5	0.8423	7.6049	7.4848	1.20804	1.18896
37.0	0.8398	7.6266	7.5062	1.21150	1.19237
37.5	0.8373	7.6496	7.5288	1.21515	1.19596
38.0	0.8348	7.6728	7.5516	1.21882	1.19957
38.5	0.8324	7.6960	7.5745	1.22251	1.20320
39.0	0.8299	7.7183	7.5964	1.22605	1.20669
39.5	0.8275	7.7407	7.6184	1.22961	1.21019
40.0	0.8251	7.7632	7.6406	1.23319	1.21371
40.5	0.8227	7.7859	7.6629	1.23679	1.21726
41.0	0.8203	7.8097	7.6854	1.24041	1.22082
41.5	0.8179	7.8316	7.7079	1.24405	1.22441
42.0	0.8155	7.8547	7.7306	1.24772	1.22801
42.5	0.8132	7.8767	7.7523	1.25122	1.23146
43.0	0.8109	7.8989	7.7741	1.25474	1.23492
43.5	0.8086	7.9224	7.7972	1.25847	1.23859
44.0	0.8063	7.9448	7.8193	1.26203	1.24210
44.5	0.8040	7.9673	7.8415	1.26561	1.24562
45.0	0.8017	7.9900	7.8638	1.26921	1.24917
45.5	0.7994	8.0128	7.8863	1.27284	1.25274
46.0	0.7972	8.0358	7.9088	1.27648	1.25632
46.5	0.7949	8.0588	7.9316	1.28015	1.25993
47.0	0.7927	8.0808	7.9532	1.28364	1.26336
47.5	0.7905	8.1029	7.9749	1.28715	1.26682
48.0	0.7883	8.1264	7.9980	1.29087	1.27049
48.5	0.7861	8.1487	8.0200	1.29443	1.27398
49.0	0.7839	8.1724	8.0434	1.29819	1.27769
49.5	0.7818	8.1938	8.0644	1.30158	1.28103
50.0	0.7796	8.2178	8.0880	1.30539	1.28478
50.5	0.7775	8.2394	8.1092	1.30882	1.28815
51.0	0.7753	8.2623	8.1318	1.31247	1.29174
51.5	0.7732	8.2854	8.1546	1.31614	1.29536
52.0	0.7711	8.3074	8.1762	1.31963	1.29879
52.5	0.7690	8.3307	8.1992	1.32334	1.30244
53.0	0.7669	8.3529	8.2210	1.32686	1.30591
53.5	0.7649	8.3752	8.2429	1.33040	1.330939
54.0	0.7628	8.3990	8.2663	1.33418	1.31310
54.5	0.7608	8.4202	8.2872	1.33755	1.31642

$$\text{API} = \frac{141.5}{\text{spgr } 15.56\ ^\circ\text{C} / 15.56\ ^\circ\text{C}} - 131.5$$

spgr = specific gravity

15.56 °C ≈ 60° F

to be continued

APPENDIX I (continued)

API 15.56/15.56°C	sp gr 15.56/15.56°C	US barrels per long ton	US barrels per motric ton	cubic metres per long ton	cubic metres per metric ton
55.0	0.7587	8.4442	8.3018	1.34136	1.32017
55.5	0.7567	8.4656	8.3319	1.34476	1.32353
56.0	0.7547	8.4885	8.3544	1.34840	1.32711
56.5	0.7527	8.5115	8.3771	1.35206	1.33071
57.0	0.7507	8.5347	8.3999	1.35574	1.33433
57.5	0.7487	8.5566	8.4215	1.35922	1.33775
58.0	0.7467	8.5800	8.4445	1.36294	1.34141
58.5	0.7447	9.6035	8.4677	1.36667	1.34509
59.0	0.7428	8.6244	8.4882	1.36999	1.34835
59.5	0.7408	8.6482	8.5116	1.37377	1.35207
60.0	0.7389	8.6707	8.5338	1.37734	1.35559
60.5	0.7370	8.6933	8.5560	1.38093	1.35912
61.0	0.7351	8.7160	8.5784	1.38454	1.36268
61.5	0.7332	8.7389	8.6009	1.38817	1.36625
62.0	0.7313	8.7618	8.6235	1.39182	1.36984
62.5	0.7294	8.7835	8.6448	1.39526	1.37322
63.0	0.7275	8.8067	8.6676	1.39895	1.37685
63.5	0.7256	8.8300	8.6906	1.40265	1.38050
64.0	0.7238	8.8520	8.7122	1.40614	1.38394
64.5	0.7219	8.8741	8.7339	1.40965	1.38739
65.0	0.7201	8.8978	8.7573	1.41342	1.39109
65.5	0.7183	8.9201	8.7792	1.41696	1.39458
66.0	0.7165	8.9425	8.8013	1.42053	1.39809
66.5	0.7146	8.9651	8.8235	1.42411	1.40162
67.0	0.7128	8.9878	8.8458	1.42771	1.40516
67.5	0.7111	9.0105	8.8682	1.43132	1.40872
68.0	0.7093	9.0334	8.8908	1.43496	1.41230
68.5	0.7075	9.0564	8.9134	1.43861	1.41590
69.0	0.7056	9.0796	8.9362	1.44229	1.41951
69.5	0.7040	9.1013	8.9575	1.44574	1.42290
70.0	0.7022	9.1246	8.9805	1.44945	1.42655
70.5	0.7005	9.1465	9.0021	1.45293	1.42998
71.0	0.6988	9.1685	9.0237	1.45642	1.43342
71.5	0.6970	9.1922	9.0471	1.46019	1.43713
72.0	0.6953	9.2145	9.0689	1.46372	1.44060
72.5	0.6936	9.2384	9.0925	1.46752	1.44435
73.0	0.6919	9.2609	9.1146	1.47109	1.44786
73.5	0.6902	9.2834	9.1368	1.47468	1.45139
74.0	0.6886	9.3061	9.1591	1.47828	1.45493
74.5	0.6869	9.3273	9.1800	1.48164	1.45824
75.0	0.6852	9.3518	9.2041	1.48554	1.46207
75.5	0.6836	9.3732	9.2251	1.48893	1.46541
76.0	0.6819	9.3963	9.2479	1.49260	1.46903
76.5	0.6803	9.4195	9.2708	1.49269	1.47266
77.0	0.6787	9.4412	9.2921	1.49974	1.47605

$$\text{API} = \frac{141.5}{\text{spgr } 15.56\ ^\circ\text{C} / 15.56\ ^\circ\text{C}} - 131.5$$

spgr = specific gravity

15.56 °C ≈ 60° **F**

to be continued

APPENDIX I (continued)

API 15.56/15.56°C	sp gr 15.56/15.56°C	US barrels per long ton	US barrels per motric ton	cubic metres per long ton	cubic metres per metric ton
77.5	0.6770	9.4647	9.3152	1.50346	1.47972
78.0	0.6754	9.4865	9.3367	1.50694	1.48314
79.0	0.6738	9.5102	9.3600	1.51070	1.48684
79.5	0.6722	9.5323	9.3818	1.51421	1.49030
	0.6706	9.5545	9.4036	1.51774	1.49377
80.0	0.6690	9.5785	9.4273	1.52155	1.49752
80.5	0.6675	9.5992	9.4476	1.52484	1.50076
81.0	0.6659	9.6235	9.4715	1.52869	1.50455
81.5	0.6643	9.6461	9.4938	1.53229	1.50809
82.0	0.6628	9.6688	9.5161	1.53590	1.51164
82.5	0.6612	9.6917	9.5386	1.53953	1.51521
83.0	0.6597	9.7129	9.5595	1.54289	1.51852
83.5	0.6581	9.7377	9.5839	1.54683	1.52240
84.0	0.6566	9.7591	9.6049	1.55023	1.52575
84.5	0.6551	9.7805	9.6261	1.55364	1.52910
85.0	0.6536	9.8039	9.6491	1.55736	1.53276
85.5	0.6521	9.8274	9.6722	1.56109	1.53643
86.0	0.6506	9.8492	9.6936	1.56455	1.53984
86.5	0.6491	9.8729	9.7170	1.56831	1.54354
87.0	0.6476	9.8949	9.7386	1.57180	1.54698
87.5	0.6461	9.9188	9.7621	1.57560	1.55072
88.0	0.6446	9.9410	9.7840	1.57913	1.55419
88.5	0.6432	9.9633	9.8059	1.58267	1.55767
89.0	0.6417	9.9856	9.8279	1.58622	1.56117
89.5	0.6403	10.0081	9.8501	1.58979	1.56469
90.0	0.6388	10.0326	9.8742	1.59368	1.56851
90.5	0.6374	10.0534	9.8946	1.59699	1.57176
91.0	0.6360	10.0762	9.9171	1.60061	1.57533
91.5	0.6345	10.0991	9.9396	1.60424	1.57891
92.0	0.6331	10.1221	9.9622	1.60790	1.58250
92.5	0.6317	10.1452	9.9850	1.61157	1.58612
93.0	0.6303	10.1665	10.0059	1.61495	1.58944
9305	0.6289	10.1898	10.0289	1.61865	1.59309
94.0	0.6275	10.2132	10.0519	1.62237	1.59675
94.5	0.6261	10.2367	10.0750	1.62611	1.60042
95.0	0.6247	10.2584	10.0964	1.62955	1.60381
95.5	0.6233	10.2821	10.1197	1.63332	1.60752
96.0	0.6220	10.3040	10.1412	1.63679	1.61094
96.5	0.6206	10.3279	10.1648	1.64059	1.61468
97.0	0.6193	10.3479	10.1845	1.64377	1.61781
97.5	0.6179	10.3721	10.2083	1.64761	1.62159
98.0	0.6166	10.3943	10.2302	1.65114	1.62506
98.5	0.6152	10.4187	10.2521	1.65469	1.62858
99.0	0.6139	10.4391	10.2742	1.65825	1.63206
99.5	0.6126	10.4616	10.2964	1.66183	1.63558
100.	0.6112	10.4863	10.3207	1.66575	1.63944

$$\text{API} = \frac{141.5}{\text{spgr } 15.56\ ^\circ\text{C} / 15.56\ ^\circ\text{C}} - 131.5$$

spgr = specific gravity

15.56 °C ≈ 60° **F**

to be continued

APPENDIX J
CRUDE OIL PRODUCTION RATES

API b/d	10°	15°	20°	25°	30°	34°	40°	45°	50°
	metric tons.yr								
1.00	57.9089	55.9344	54.0845	52.3538	50.7332	49.5023	47.7711	46.4152	45.1286
1.10	63.6998	61.5279	59.4929	57.5891	55.8065	54.4525	52.5482	51.0567	49.6414
1.20	69.4907	67.1213	64.9014	62.8245	60.8798	59.4028	57.3253	55.6983	54.1543
1.30	75.2816	72.7147	70.3098	68.0599	65.9532	64.3530	62.1025	60.3398	58.6672
1.40	81.0725	78.3082	75.7183	73.2953	71.0265	69.3032	66.8796	64.9813	63.1800
1.50	86.8634	83.9016	81.1267	78.5307	76.0998	74.2535	71.6567	69.6228	67.6929
1.60	92.6543	89.4951	86.5352	83.7660	81.1731	79.2037	76.4338	74.2644	72.2057
1.70	98.4452	95.0885	91.9436	89.0014	86.2464	84.1539	81.2109	78.9059	76.7186
1.80	104.2361	100.6819	97.3521	94.2368	91.3198	89.1041	85.9880	83.5474	81.2315
1.90	110.0270	106.2754	102.7605	99.4722	96.3931	94.0544	90.7651	88.1889	85.7443
2.00	115.8179	111.8688	108.1690	104.7075	101.4664	99.0046	95.5422	92.8304	90.2572
2.10	121.6088	117.4623	113.5774	109.9429	106.5397	103.9548	100.3193	97.4720	94.7700
2.20	127.3997	123.0557	118.9859	115.1783	111.6130	108.9051	105.0965	102.1135	99.2829
2.30	133.1905	128.6491	124.3943	120.4137	116.6864	113.8553	109.8736	106.7550	103.7957
2.40	138.9814	134.2426	129.8028	125.6490	121.7597	118.8055	114.6507	111.3965	108.3086
2.50	144.7723	139.8360	135.2112	130.8844	126.8330	123.7558	119.4278	116.0380	112.8215
2.60	150.5632	145.4295	140.6197	136.1198	131.1198	128.7060	124.2049	120.6796	117.3343
2.70	156.3441	151.0229	146.0281	141.3552	136.9796	133.6562	128.9820	125.3211	121.8472
2.80	162.1450	156.6164	151.4366	146.5906	142.0530	138.6064	133.7591	129.9626	126.3600
2.90	167.9359	162.2098	156.8450	151.8259	147.1263	143.5567	138.5362	134.6041	130.8729
3.00	173.7268	167.8032	162.2535	157.0613	152.1996	148.5060	143.3134	139.2457	135.3858
3.10	179.5177	173.3967	167.6619	162.2967	157.2729	153.4571	148.0905	143.8872	139.8986
3.20	185.3086	178.9901	173.0704	167.5321	162.3462	158.4074	152.8676	148.5287	144.4115
3.30	191.0995	184.5836	178.4788	172.7674	167.4196	163.3576	157.6447	153.1702	148.9243
3.40	196.8904	190.1770	183.8873	178.0028	172.4929	168.3078	162.4218	157.8117	152.4372
3.50	202.6813	195.7704	189.2957	183.2382	177.5662	173.2581	167.1989	162.4533	157.9500
3.60	208.4722	201.3639	194.7042	188.4736	182.6395	178.2083	171.2083	167.0948	162.4629
3.70	214.2630	206.9573	200.1126	193.7089	187.7128	183.1585	176.7531	171.7363	166.9758
3.80	220.0539	212.5508	205.5211	198.9443	192.7862	188.1087	181.5302	176.3778	171.4886
3.90	225.8448	218.1442	210.9295	204.1797	197.8595	193.0590	186.3074	181.0194	176.0015
4.00	231.6357	223.7376	216.3380	209.4151	202.9328	198.0092	191.0845	185.6609	180.5143
4.10	237.4266	229.3311	221.7464	214.6504	208.0061	202.9594	195.8616	190.3024	185.0272
4.20	243.2175	234.9245	227.1549	219.8858	213.0794	207.9097	200.6387	194.9439	189.5401
4.30	249.0084	240.5180	232.5633	2251212	218.1528	212.8599	205.4158	199.5854	194.0529
4.40	254.7993	246.1114	237.9718	230.3566	223.2261	217.8101	210.1929	204.2270	198.5658
4.50	260.5902	251.7049	243.3802	235.5920	228.2994	222.7604	214.9700	208.8685	203.0786
4.60	266.3811	257.2983	248.7887	240.8273	233.3727	227.7106	219.7471	213.5100	207.5915
4.70	272.1720	262.8917	254.1971	246.0627	238.4460	232.6608	224.5243	218.1515	212.1044
4.80	277.9629	268.4852	259.6056	251.2981	243.5194	237.6110	229.3014	222.7931	216.6172
4.90	283.7538	270.0786	265.0140	256.5335	248.5927	242.56.13	234.0785	227.4346	221.1301
5.00	289.5447	279.6721	270.4225	261.7688	253.6660	247.5115	238.8556	232.0761	225.6429
5.10	295.3356	285.2655	275.8309	267.0042	258.7393	252.4617	243.6327	236.7176	230.1558
5.20	301.1264	290.8589	281.2393	272.2396	263.8126	257.4120	248.4098	241.3591	234.6686
5.30	306.9173	296.4524	286.6478	277.4750	268.8860	262.3622	253.1869	246.0007	239.1815
5.40	312.7082	302.0458	292.0562	282.7103	273.9593	267.3124	257.9640	250.6422	243.6944
5.50	318.4991	307.6393	297.4647	287.9457	279.0326	272.2627	262.7411	255.2837	248.2072

to be continued

APPENDIX J (continued)

API / b/d	10°	15°	20°	25°	30°	34°	40°	45°	50°
	metric tons/yr								
5.60	324.2900	313.2327	302.8731	293.1811	284.1059	277.2129	267.5183	259.9252	252.7201
5.70	330.0809	318.8261	308.2816	298.4165	289.1792	282.1631	272.2954	264.5667	257.2329
5.80	335.8718	324.4196	313.6900	303.6519	294.2526	287.1133	277.0725	269.2083	261.7458
5.90	341.6627	330.0130	319.0985	308.8872	299.3259	292.0636	281.8496	273.8498	266.2587
6.00	347.4536	335.6065	324.5069	314.1226	304.3992	297.0138	286.6267	278.4913	270.7715
6.10	353.2445	341.1999	329.9154	319.3580	309.4725	301.9640	291.4038	283.1328	275.2844
6.20	359.0354	346.7933	335.3238	324.5934	314.5458	306.9143	296.1809	287.7744	279.7972
6.30	364.8263	352.3868	340.7328	329.8287	319.6192	311.8645	300.9580	292.4159	284.3101
6.40	370.6172	357.9802	346.1407	335.0641	324.6925	316.8147	305.7352	297.0574	288.8229
6.50	376.4081	363.5737	351.5492	340.2995	329.7658	321.7650	310.5123	301.6989	293.3358
6.60	382.1990	369.1671	356.9576	345.5349	334.8391	326.7152	315.2894	306.3404	297.8487
6.70	387.9898	374.7606	362.3661	350.7702	339.9124	331.6654	320.0665	310.9820	302.3615
6.80	393.7807	380.3540	367.7745	356.0056	344.9858	336.6156	324.8436	315.6235	306.8744
6.90	399.5716	385.9474	373.1830	361.2410	350.0591	341.5659	329.6207	320.2650	311.3872
7.00	405.3625	391.5409	378.5914	366.4764	355.1324	346.5161	334.3978	324.9065	315.9001
7.10	411.1534	397.1343	383.9999	371.7118	360.2057	351.4663	339.1749	329.5481	320.4130
7.20	4169443	402.7278	389.4083	376.9471	365.2790	356.4166	343.9520	334.1896	324.9258
7.30	422.7352	408.3212	394.8168	382.1825	370.3524	361.3668	348.7292	338.8311	329.4387
7.40	428.5261	413.9146	400.2252	387.4179	375.4257	366.3170	353.5063	343.4726	333.9515
7.50	434.3170	419.5081	405.6337	392.6533	380.4990	371.2673	353.2834	348.1141	338.4644
7.60	440.1079	425.1015	411.0421	397.8886	385.5723	376.2175	363.0605	352.7557	342.9773
7.70	445.8988	430.6950	416.4506	403.1240	390.6456	381.1677	367.8376	357.3972	347.4901
7.80	451.6897	436.2884	421.8590	408.3594	395.7190	386.1179	372.6147	362.0387	352.0030
7.90	457.4806	441.8818	427.2675	413.5948	400.7923	391.0682	377.3918	366.6802	356.5158
8.00	463.2715	447.4753	432.6759	418.8301	405.8656	396.0184	382.1689	371.3218	361.0287
8.10	469.0624	453.0687	438.0844	424.0655	410.9389	400.9686	386.9461	375.9633	365.5415
8.20	474.8532	458.6622	443.4928	429.3009	416.0122	405.9189	391.7232	380.6048	370.0544
8.30	480.6441	464.2556	448.9013	434.5363	421.0856	410.8691	396.5003	385.2463	374.5673
8.40	486.4350	469.8491	454.3097	439.7717	426.1589	415.8193	401.2774	389.8878	379.0801
8.50	492.2259	475.4425	459.7182	445.0070	431.2322	420.7696	406.0545	394.5294	383.5930
8.60	498.0168	481.0359	465.1266	450.2424	436.3055	425.7198	410.8316	399.1709	388.1058
8.70	503.8077	486.6294	470.5351	455.4778	441.3788	430.6700	415.6087	403.8124	392.6187
8.80	509.5986	492.2228	475.9435	460.7132	446.4522	435.6202	420.3858	408.4539	397.1316
8.90	515.3895	497.8163	481.3520	465.9485	451.5255	440.5705	425.1629	413.0955	401.6444
9.00	521.1804	503.4097	486.7604	471.1839	456.5988	445.5207	429.9401	417.7370	406.1573
9.10	526.9713	509.0031	492.1689	476.4193	461.6721	450.4709	434.7172	422.3785	410.6701
9.20	532.7622	514.5966	497.5773	481.6547	466.7454	455.4212	439.4943	427.0200	415.1830
9.30	538.5531	520.1900	502.9858	486.8900	471.8188	460.3714	444.2714	431.6615	419.6958
9.40	544.3440	525.7835	508.3942	492.1254	476.8921	465.3216	449.0485	436.3031	424.2087
9.50	550.1349	531.3769	513.8027	497.3608	481.9654	470.2719	453.8256	440.9446	428.7216
9.60	555.9257	536.9703	519.2111	502.5962	487.0387	475.2221	458.6027	445.5861	433.2344
9.70	561.7166	542.5638	524.6196	507.8315	492.1120	480.1723	463.3798	450.2276	437.7473
9.80	567.5075	548.1572	530.0280	513.0669	497.1853	485.1225	498.1570	454.8691	442.2601
9.90	572.2984	553.7507	535.4365	518.3023	502.2587	490.0728	472.9341	459.5107	446.7730

APPENDIX K

CRUDE OIL
BARRELS OF OIL PER DAY AS LONG TONS PER YEAR

API / b/d	10°	15°	20°	25°	30°	34°	40°	45°	50°
	metric tons/yr								
1.00	56.9947	55.0511	53.2311	51.5267	49.9323	48.7206	47.0167	45.6821	44.4158
1.10	62.6942	60.5562	58.5542	56.6794	54.9255	53.5927	51.7184	50.2503	48.8574
1.20	68.3937	66.0614	63.8773	61.8321	59.9187	58.4647	56.4200	54.8185	53.2989
1.30	740932	71.5665	69.2004	66.9848	64.9120	63.3368	61.1217	59.3867	57.7405
1.40	79.7926	77.0716	74.5235	72.1374	69.9052	68.2088	65.8234	63.9549	62.1821
1.50	85.4921	82.5767	79.8466	77.2901	74.8984	73.0809	70.5250	68.5232	66.6237
1.60	91.1916	88.0818	85.1697	82.4428	79.8917	77.9530	75.2267	73.0914	71.0652
1.70	96.8911	93.5869	90.4928	87.5955	84.8849	82.8250	79.9284	77.6596	75.5068
1.80	102.5905	99.0920	95.8159	92.7481	89.8781	87.6971	84.6300	82.2278	79.9484
1.90	108.2900	104.5971	101.1390	97.9008	94.8713	92.5691	89.3317	86.7960	84.3900
2.00	113.9895	110.1023	106.4621	103.0535	99.8646	97.4412	94.0334	91.3642	88.8316
2.10	119.6889	115.6074	111.7852	108.2062	104.8578	102.3133	98.7351	95.9324	93.2731
2.20	125.3884	121.1125	117.1083	113.3588	109.8510	107.1853	103.4367	100.5006	97.7147
2.30	131.0879	126.6176	122.4314	118.5115	114.8443	112.0574	108.1384	105.0688	102.1563
2.40	136.7874	132.1227	127.7545	123.6642	119.8375	116.9294	112.8401	109.6370	106.5979
2.50	142.4868	137.6278	133.0776	128.8169	124.8307	121.8015	117.5417	114.2053	111.0395
2.60	148.1863	143.1329	138.4007	133.9695	129.8239	126.6736	122.2434	118.7735	115.4810
2.70	153.8858	148.6381	143.7238	139.1222	134.8172	131.5456	126.9451	123.3417	119.9226
2.80	159.5853	154.1432	149.0469	144.2749	139.8104	136.4177	131.6467	127.9099	124.3642
2.90	165.2847	159.6483	154.3701	149.4276	144.8036	141.2897	136.3484	132.4781	128.8058
3.00	170.9842	165.1534	159.6932	154.5802	149.7979	146.1618	141.0501	137.0463	133.2473
3.10	176.6837	170.6585	165.0163	159.7329	154.7901	151.0339	145.7518	141.6145	137.6889
3.20	182.3832	176.1636	170.3394	164.8856	159.7833	155.9059	150.4534	146.1827	142.1305
3.30	188.0826	181.6687	175.6625	170.0383	164.7765	160.7780	155.1551	150.7509	146.5721
3.40	193.7821	187.1738	180.9856	175.1909	169.7698	165.6500	159.8568	155.3191	151.0137
3.50	199.4816	192.6790	186.3087	180.3436	174.7630	170.5221	164.5584	159.8874	155.4552
3.60	205.1811	198.1841	191.6318	185.4963	179.7562	175.3942	169.2601	164.4556	159.8968
3.70	210.8805	203.6892	196.9549	190.6490	184.7494	180.2662	173.9618	169.0238	164.3384
3.80	216.5800	209.1943	202.2780	195.8016	189.7427	185.1383	178.6634	173.5920	168.7800
3.90	222.2795	214.6994	207.6011	200.9543	194.7359	190.0103	183.3651	178.1602	173.2215
4.00	227.9790	220.2045	212.9242	206.1070	199.7291	194.8824	188.0668	182.7284	177.6631
4.10	233.6784	225.7096	218.2473	211.2597	204.7224	199.7545	192.7684	187.2966	182.1047
4.20	239.3779	231.2147	223.5704	216.4123	209.7156	204.6265	197.4701	191.8648	186.5463
4.30	245.0774	236.7199	228.8935	221.5650	214.7088	209.4986	202.1718	196.4330	190.9879
4.40	250.7768	242.2250	234.2166	226.7177	219.7020	214.3706	206.8735	201.0013	195.4294
4.50	256.4763	247.7301	239.5397	231.8704	224.6953	219.2427	211.5751	205.5695	199.8710
4.60	262.1758	253.2352	244.8628	237.0230	229.6885	224.1148	216.2768	210.1377	204.3126
4.70	267.8753	258.7403	250.1859	242.1757	234.6817	228.9868	220.9785	214.7059	208.7542
4.80	273.5747	264.2454	255.5090	247.3284	239.6750	233.8589	225.6801	219.2741	213.1957
4.90	279.2742	269.7505	260.8322	252.4810	244.6682	238.7309	230.3818	223.8423	217.6373
5.00	284.9737	275.2556	266.1553	257.6337	249.6614	243.603	235.0835	228.4105	222.0789
5.10	290.6732	280.7608	271.4784	262.7864	254.6546	248.4751	239.7851	232.9787	226.5205
5.20	296.3726	286.2659	276.8015	267.9391	259.6479	253.3471	244.4868	237.5469	230.9621
5.30	302.0721	291.7710	282.1246	273.0917	264.6411	258.2192	249.1885	242.1151	235.4036
5.40	307.7716	297.2761	287.4477	278.2444	269.6343	263.0912	253.8901	246.6834	239.8452
5.50	313.4711	302.7812	292.7708	283.3971	274.6276	267.9633	258.5918	252.2516	244.2868

to be continued

APPENDIX K (continued)

API b/d	10°	15°	20°	25°	30°	34°	40°	45°	50°
	metric tons/yr								
5.60	319.1705	308.2863	298.0939	288.5498	279.6208	272.8354	263.2935	255.8198	248.7284
5.70	324.8700	313.7914	303.4170	293.7024	284.6140	277.7074	267.9952	260.3880	253.1699
5.80	330.5695	319.2966	308.7401	298.8551	289.6072	282.5795	272.6968	264.9562	257.6115
5.90	336.2690	324.8017	314.0632	304.0078	294.6005	287.4515	277.3985	269.5244	262.0531
6.00	341.9684	330.3068	319.3863	309.1605	299.5937	292.3236	282.1002	274.0926	266.4947
6.10	347.6679	335.8119	324.7094	314.3131	304.5869	297.1957	286.8018	278.6608	270.9363
6.20	353.3674	341.3170	330.0325	319.4658	309.5802	302.0677	291.5035	283.2290	275.3778
6.30	359.0668	346.8221	335.3556	324.6185	314.5734	306.9398	296.2052	287.7972	279.8194
6.40	364.7663	352.3272	340.6787	329.7712	319.5666	311.8118	300.9068	292.3655	284.2610
6.50	370.4658	357.8323	346.0018	334.9238	324.5598	316.6839	305.6085	296.9337	288.7026
6.60	376.1653	363.3375	351.3249	340.0765	329.5531	321.5560	310.3102	301.5019	293.1442
6.70	381.8647	368.8426	356.6480	345.2292	334.5463	326.4280	3150119	306.0701	297.5857
6.80	387.5642	374.3477	361.9712	350.3189	339.5395	331.3001	319.7135	310.6383	302.0273
6.90	393.2637	379.8528	367.2943	355.5345	344.5328	336.1721	324.4152	315.2065	306.4689
7.00	398.9632	385.3579	372.6174	360.6872	349.5260	341.0442	329.1169	319.7747	310.9105
7.10	411.1534	397.1343	383.9999	371.7118	360.2057	351.4663	339.1749	329.5481	320.4130
7.20	416.9443	402.7278	389.4083	376.9471	365.2790	356.4166	343.9520	334.1896	324.9258
7.30	422.7352	408.3212	394.8168	382.1825	370.3524	361.3668	348.7292	338.8311	329.4387
7.40	428.5261	413.9146	400.2252	387.4179	375.4257	366.3170	353.5063	343.4726	333.9515
7.50	434.3170	419.5081	405.6337	392.6533	380.4990	371.2673	358.2834	348.1141	338.4644
7.60	440.1079	425.1015	411.0421	397.8886	385.5723	376.2175	363.0605	352.7557	342.9773
7.70	445.8988	430.6950	416.4506	403.1240	390.6456	381.1677	367.8376	357.3972	347.4901
7.80	451.6897	436.2884	421.8590	408.3594	395.7190	386.1179	372.6147	362.0387	352.0030
7.90	457.4806	441.8818	427.2675	413.5948	400.7923	391.0682	377.3918	366.6802	356.5158
8.00	463.2715	447.4753	432.6759	418.8301	405.8656	396.0184	382.1689	371.3218	361.0287
8.10	469.0624	453.0687	438.0844	424.0655	410.9389	400.9686	386.9461	375.9633	365.5415
8.20	474.8532	458.6622	443.4928	429.3009	416.0122	405.9189	391.7232	380.6048	370.0544
8.30	480.6441	464.2556	448.9013	434.5363	421.0856	410.8691	396.5003	385.2463	374.5673
8.40	486.4350	469.8491	454.3097	439.7717	426.1589	415.8193	401.2774	389.8878	379.0801
8.50	492.2259	475.4425	459.7182	445.0070	431.2322	420.7696	406.0545	394.5294	383.5930
8.60	498.0168	481.0359	465.1266	450.2424	436.3055	425.7198	410.8316	399.1709	388.1058
8.70	503.8077	486.6294	470.5351	455.4778	441.3788	430.6700	415.6087	403.8124	392.6187
8.80	509.5986	492.2228	475.9435	460.7132	466.4522	435.6202	420.3858	408.4539	397.1316
8.90	515.3895	497.8163	481.3520	465.9485	451.5255	440.5705	425.1629	413.0955	401.6444
9.00	521.1804	503.4097	486.7604	471.1839	456.5988	445.5207	429.9401	417.7370	406.1573
9.10	526.9713	509.0031	492.1689	476.4193	461.6721	450.4709	434.7172	422.3785	410.6701
9.20	532.7622	514.5966	497.5773	481.6547	466.7454	455.4212	439.4943	427.0200	415.1830
9.30	538.5531	520.1900	502.9858	486.8900	471.8188	460.3714	444.2714	431.6615	419.6958
9.40	544.3440	525.7835	508.3942	492.1254	476.8921	465.3216	449.0486	436.3031	424.2087
9.50	550.1349	531.3769	513.8027	497.3608	481.9654	470.2719	453.8256	440.9446	428.7216
9.60	555.9257	536.9703	519.2111	502.5962	487.0387	475.2221	458.6027	445.5861	433.2344
9.70	561.7166	542.5638	524.6196	507.8315	492.1120	480.1723	463.3798	450.2276	437.7473
9.80	567.5075	548.1572	530.0280	513.0669	497.1853	485.1225	468.1570	454.8691	442.2601
9.90	572.2984	553.7507	535.4365	518.3023	502.2587	490.0728	472.9341	459.5107	446.7730