ThreeBond
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SI (International System of Units)

Introduction

People usually use the word “Weight” without any sense of consciousness. However, what kind of meaning do they use it for? If they use it for the meaning of mass, its representation must be “Mass”. This means that matters represented vaguely in the traditional unit systems are distinguished clearly. Specifically, kg represents unit of mass and N (Newton) represents unit of weight.

Weight is volume of gravity acting on the body, and it equals to the value of the multiplication of Mass and Gravity acceleration (g).

Movement toward SI system is rising for these years in the industry. The Ministry of International Trade and Industry (MITI) has issued the direction for supporting the transition to SI system in the measurement law. We at Three Bond have attempted to switch the measurement to SI system since November in 1990. However, actually SI system is not fully penetrated into the operations of our company.

For readers who are unfamiliar to SI system, this issue summarizes about SI mainly with relation to the products of our company.

Contents

1. About SI

1-1. About SI

Traditionally, each country in the world has used own unit system such as the metric system and the yard/pound system. Even with the metric system, MSK system, CGS system and Gravity system have been used in mixed up way. SI (International System of Units) unified these unit systems. Although it is called as SI units, it is not completely different from the traditionally used units. It is merely absolute unit of the metric system and expanded form of the traditional MSK units. However, use of Newton (N*1) and Pascal (Pa*2) as new unit name was started.

In addition, SI stands for " Système International d'Unités " in French and means "International System of Units".

*1: 1 N represents force that gives acceleration of 1m/s^2 to weight of 1kg.

*2: 1 Pa is used to represent unit of pressure or stress when force of 1 N is applied on the area of 1m^2.

1-2. Reasons why SI is required

Why is SI required? The reasons are as follows:

(1) SI is required since many of countries in the world adopt SI units.
It eliminates problems regarding unit on trading.

(2) It is more reasonable and convenient than the traditional units.
For instance, since only one unit represents volume of body, it eliminates confusion such as whether "kg" in this case is for volume or force.

Those are main reason of the transition to SI. Although those are true, it seems that disputes for adopting SI are not required, if all countries in the world including yard/pound countries adopt the metric system. However, the metric system itself has problems, too.

For instance, a problem exists on the unit of "kg". "kg" in MSK unit represents the unit of mass. However, even though the same metric system is used as a base unit, the industry used the weight unit system that uses weight kilograms that the gravity of the earth operates on the mass of 1kg. Therefore, "kg" was used for two units in different dimensions.

MSK system ----- kg

Gravity unit system ------ kg-m/s^2

Therefore, it was started that "kg" in the weight unit system was represented as "kgf", "kgw" or "kg weight" in order to distinguish "kg" of the weight unit system from "kg" of mass. (However, actually it seems that the cases using "kg" are still dominant.)

However, acceleration of gravity of the earth may vary place by place. Reasons of this are as follows.

(1) Centrifugal force of the earth is different by latitude.

(2) Gravitation varies according to altitude.

(3) Geology is different at center and surface of the earth.

Since earth is not a real sphere, it makes effect of the above 1 and 2 more significant. Generally, the acceleration of gravity becomes smaller as closing to the equator and as climbing higher the altitude.

The acceleration of gravity at specific places is referred in science encyclopedia as follows.

Place	Latitude	Altitude	*g*
Wakkanai	45 degree north	96m	9.806 22 m/s^2
Tokyo	35 degree north	28m	9.797 63 m/s^2
Miyakojima	24 degree north	30m	9.789 97 m/s^2
Quito	0 degree south	2815m	9.772 63 m/s^2
Showa Base	69 degree south	14m	9.825 25 m/s^2

SI information (your eyes only)

(1) If you buy a gold ingot of 1kg at Quito, the capital of Ecuador, and bring it to Showa base in the South Pole continent, it increases the weight about 5.4g. The value of the gold increases about 8,000 yen as gold price is 1,500 yen per gram. If you bring 100kg of gold, you would earn 800,000 yen. Why does such phenomenon happen? This is caused by the difference of gravity (g) as mentioned above. Gravity at the Showa base is 0.54 percent greater than at Quito. However, this story is true only if same spring scale is used at the both places. In order to avoid this, with the measurement law, actually, highly accurate spring scales and load cells must be compensated to the using geography.

(2) Women who want to decrease their weight are gong to the moon or Mars.
Now a day, it is an era that people are going to space. If you must want to decrease your weight, it is recommended to go to the moon or Mars. A person whose weight is 50kg would be about 8.5kg on the moon, and about 19kg on the Mars. This is a true story like a dream that appearance is not changed, but weight is simply changed. Applicants, please ask NASA.

* Gravity on the moon and Mars is 0.17 and 0.38 respectively, normalized with earth's gravity as 1. (However, this is a story only where measuring weight with bathroom scales. Actual mass does not change.)

2. Status of SI transition

Usually, transition to SI will complete by executing following three steps.

First step: SI unit value will be written after traditional unit value with braces.
Example: 10 kgf { 98 N }

Second step: Traditional unit value will be written after SI unit value with braces.
Example: 100 N {10.2 kgf}

Third step: Only SI unit value will be written.
Example: 100 N

2-1. Status of foreign countries

(1) USA

USA legislated transition low to the metric system in 1975. However, present status is that the units in daily life have not been switched yet because of the opposition of public groups and the like. USA is far behind compared with European Community countries. However, in the law of comprehensive trade and commerce in 1988, USA included the clauses that obliged the use of the metric unit system, by the end of 1993 fiscal year, within the range that can be allowed and realized on the economy.

In addition, legislation of each state allows the use of both yard/pound unit and metric unit systems as units for trading.

Also, in many cases, it is obliged to indicate the yard/pound units together with the metric units if the packaged merchandise use the metric unit system.

However, there incorrigible opposition against SI exists in commerce area, labor unions, construction industry and etc. It is under harsh condition.

(2) France

France, advocating country of the metric unit system, quickly started to inhibit the use of non-metric unit systems in 1961. Finally, all non-SI units were expelled at the end of 1989. The country is already in the state of full SI system.

Moreover, SI is obliged in school education. Therefore, it could be said that France is one of most advanced countries.

(3) Germany

At the era Germany was separated, West Germany accorded to the direction of EC and started to inhibit the use of non-SI units in 1978. Then, legal measurement units are applied on the overall indication regarding measurement units, and measurements and measurement gauges that are used in the areas including commercial transaction, administration, public safety, public hearth and others.

Use of non-legal measurement units is allowed as long as legal measurement units are indicated together with them. However, the usage is limited until the end of 1999 according to the direction of EC.

2-2. Status in Japan

(1) Steel industry

In 1982, the steel industry started study of basic policy in order to correspond to SI transition. In 1985, it announced in advance to switch to SI in 1991, five years later from the announcement. Finally, whole steel industry simultaneously completed the transition to the third step in January 1991.

(2) Automobile industry

Since 1975, the society of automotive engineers of Japan established basic policy for applying SI to JASO (Japan Automobile Standards Organization) and started transition work to apply the first step of SI, by taking the opportunity, when new standards are specified in JASO and existing standards are revised. Then, application of the second step of SI was started on JASO specifications that would be specified and revised after 1985. It started transition to the third step from 1990.

(3) Test equipment industry

The test equipment industry was led by the steel industry and the automobile industry, and it provided their guideline. Status of SI transition is significantly different by each area of the industry. Figure 1 shows the status.

(4) School education

In this area, SI transition progressed quickly. Authorized textbooks for elementary schools introduced SI unit system from 1992, for junior high schools from 1993 and for high schools from 1994.

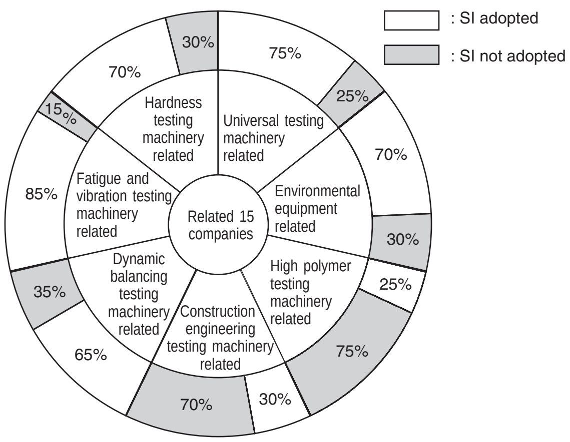


Figure 1. Shipping status of SI adopted testing machinery, that are manufactured by companies belonging to Japan Testing Machinery Association (By May 1991)
(Excerpted from “Methodology for carrying SI transition forward”)

3. Structure of SI

SI structure is as follows.

- SI
  - SI units
    - Base units (7)
    - Auxiliary units (2)
    - Derived units
      - Derived units with special names
      - Other derived units
  - Prefixes (16) and "integral times power of 10" for SI units

Table 1. Base units

Measure	Unit name	Unit symbol	Definition
Length	meter	m	One meter is the length of the path traveled by light in a vacuum during the time interval of 1/299 792 458 of a second.
Mass	kilogram	kg	Kilogram (not weight and not force) is the unit of mass and one kilogram equals to the mass of the international prototype kilogram.
Time	second	s	One second is the duration of exactly 9 192 631 770 periods of the radiation corresponding to the transition between two hyperfine levels of the ground state of the cesium-133 atom.
Electrical current	ampere	A	One ampere is the constant current which, if maintained in two straight parallel conductors, of infinite length and negligible cross-section, placed 1 meter apart in a vacuum, would produce a force between these conductors equal to 2×10^{-7} newtons per meter of length.
Thermodynamic temperature	kelvin	K	Kelvin is the fraction 1/273.16 of the thermodynamic temperature at the triple point of water
Amount of substance	mole	mol	One mole is the same number of elementary entities ([2]) as number of atoms in 0.012 kilograms of pure carbon-12, or substance amount of the system structured by a set of elementary entities (limited on the one which its organization is clarified.), using specific particles or the mass of particles.
Luminous intensity	candela	cd	One candela is the luminous intensity, in a given direction, of a source that emits monochromatic radiation of frequency 540×10^{12} Hertz and that has a radiant intensity in that direction of 1/683 watt per steradian

Table 2. Auxiliary units

Quantity	Unit name	Unit symbol	Definition
Angle	radian	rad	One radian is the angle subtended at the center of a circle by an arc of the circumference equal in length to the radius of the circle.
Solid angle	steradian	sr	One steradian is the solid angle subtended at the center of a sphere of radius r by a portion of the surface of the sphere having an area of square of the radius (r^2).

Table 3. Prefixes

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

4. Usage of SI

Usage of SI is described in JIS Z8202 and 8203, and Three Bond operates them with the criteria as following.

4-1. Usage of unit symbols

1) Typeface and notation

Typeface should be upright Roman type and a half or one character space should be placed between number and unit symbol. In addition, a large letter should be used only for the first character of the unit that is derived from proper noun, and all others should be small letters.

- Typeface usage is prescribed according to JIS Z8202.

  Upright Roman
  Unit symbols Examples: m, s, Pa, N

  Italic
  Volume symbols Examples: *a*, *b*, *c*, *d*...

- Writing numeric values should be standard to group decimal digits in three and insert a space of 1/4 character between groups. Yet if word processing or other device in use does not have such function, it is allowed to omit a space or a space of 1/2 character. However, it is not allowed to separate with comma or other delimiters.

  Example: 1 kgf/m^3=9.806 65 Pa

2) Period

It is never allowed to append periods to unit symbols in any cases.

		(Correct)	(Wrong)
Example:	Revolutions per minute	rpm	r.p.m.
	Viscosity	Pa•s	Pa.s

3) Plural form

Even if numbers indicating volume is plural, the symbol should not be changed.

		(Correct)	(Wrong)
Example:	Time	h	hrs

4) Product of units

When a new unit is formed by multiplication of multiple units, following notation should be used.

Example: N•m or Nm
(Both are acceptable; the former style is easy to understand.)

[Note] When using m, it should be carefully used to avoid confusion between meter as a unit and milli as a prefix.

5) Quotient of units

When a new unit is formed by quotient of multiple units, following notation should be used.

Example: $\frac{m}{s}$ m/s m•s^{-1}

But, with the notation that uses slash, multiple slashes should not be used within representation of a unit. Plus or minus exponent, or brackets should be used for units with complex configuration.

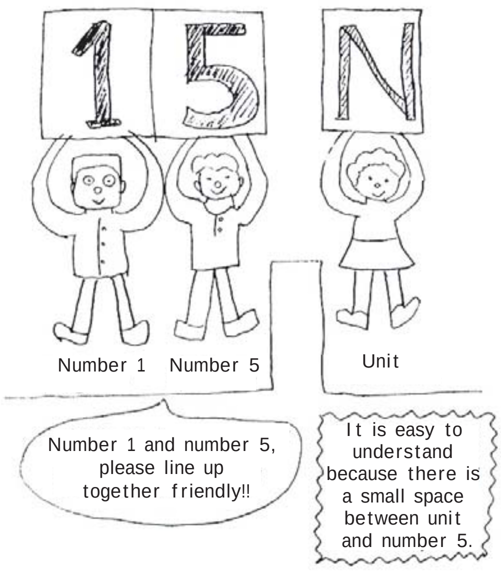
	(Correct)	(Wrong)
Example:	m/s^2 or m•s	m/s/s
	cal/(cm•s•°C)	cal/cm/s/°C

6) Appended characters

It is not allowed to append any character to unit symbols. If it is required to distinguish meaning of a symbol, appended characters should be placed on the volume symbol, or they should be separated from the unit symbol and bracketed.

Example: *P* abs = 3 Mpa 3 Mpa [abs]
--- Absolute pressure

P gage = 5 Mpa 5 Mpa [gage]
--- Gage pressure



4-2. Usage of prefixes

1) Typeface and notation

Typeface should be upright Roman type and a half or one character space should be placed between number and prefix, and no spaces should be placed between prefix and unit symbol.

	(Correct)	(Wrong)
Example:	10 MPa	10MPa, 10M Pa, 10 M Pa

2) Prefix selection

Even though a prefixes can be selected to generate an arbitrary measure unit, principally it should be selected so that the volume number represented by the unit is fell between 0.1 and 1 000.

However, this may not be applied if the same measure is listed on one table and it accords to the practices.

Example: 15 000 mPa•s

3) Duplicated prefixes

It is not allowed to use multiple prefixes duplicated.

Example: Do not use mμm (milli-micro meter). Instead, use nm (nano-meter).

4) Exclusive use of prefix without unit is not allowed

		(Correct)	(Wrong)
Example:	Quantity per volume	10^6/m^3	M/m^3
Example:	Coefficient of linear thermal expansion	5×10^{-5}/°C	50 μ/°C

5) Prefix for kilogram

Base unit of mass (kg) has already a prefix. Therefore, prefix should be appended to gram.

Example: 10^{-6} kg should be not μkg, but mg.
10 000 kg should be 10 Mg or 10 t.

6) Meaning of integral times power of 10

If exponent that represents integral times power of 10 is appended to a unit with a prefix, the exponent is also effective to the prefix.

Example: 1 km^2=(10^3 m)^2=10^6 m^2≠10^3 m^2

7) Application to synthesized derived unit

Only one prefix can be used for the derived units synthesized by multiplication or quotient.

However, kg on denominator may not be considered as symbol (kg) with prefix.

	(Correct)	(Wrong)
Example:	300 mN/m	300 μN/cm
Example:	kJ/kg can be used.	

4-3. Conversion methods

When converting numeric values, it is necessary to keep number of effective columns as exactly same as numbers before and after the conversion.

Example: When converting 95kgf (two effective columns) to SI, round off the forth effective columns of the converting coefficient 9.806 65. It results 9.81. Multiply this number with 95 to:

95×9.81 N=931.95 N=930 N.

It is necessary to round off the third column of the resulted number in multiplication and obtain 930 N with two effective columns.

1) Viscosity

150 cP=150 mPa•s
1 500 cP=1.5 Pa•s
15 000 cP=15 Pa•s

Note: However, if number of effective columns is specified clearly, it is possible to indicate as 1.50, 15.0 Pa•s and the like.

2) Pressure

95 kgf/cm^3=95×9.81×10^4 Pa
=9.3×10^6 Pa
=9.3 MPa

3) Shearing strength of bonding

150 kgf/cm^3=150×9.807×10^4 Pa
=14.71×10^6 Pa
=14.7 MPa
(In case of the number of effective columns of 150 are three.)

4) Peeling strength

12 kgf/25mm=12×9.81×40 N/m
=4 707 N/m
=4.7 kN/m

(In case of peeling strength, the denominator changes from 25mm to m.)

5) Loosening torque

320 kgf•cm=320×9.81×10^{-2} N•m
=31 N•m

(In case of the number of effective columns is two.)

6) Thermal conductivity

2.5×10^{-3} cal/(cm•s•°C)

This is a case of ThreeBond 1225. Because unit of cal/(cm•s•°C) is not listed on the conversion table, as first step, convert it to the unit of kcal/(cm•h•°C) listed on the conversion table, then convert to SI.

2.5×10^{-3} cal/(cm•s•°C)
=2.5×10^{-3}×10^{-3}×10^{2}×3 600 kcal/(m•h•°C)
=2.5×10^{-3}×10^{-3}×10^{2}×3 600×1.16 W/(m•K)
=1.0 W/(m•K) Note: Instead of K, °C is acceptable.

7) Hardness

Hardness is not a physical quantity. It is similar to expedient industrial indexes. Therefore, it is a non-unit number and has no unit.
(Excepted from “Future unit — What is SI? —” issued by Japanese Standards Association)

8) Impact strength

It is necessary to pay attention on the conversion, because unit of impact strength is different depending on measurement method.

(1) Charpy impact strength
1 kgf•cm/cm^2=0.98 kJ/m^2

(2) Izod impact strength
1 kgf•cm/cm=9.8 J/m

While there exist drop weight and Dupont testers for impact strength of paint, none of them does not have unit.

9) Coefficient of linear thermal expansion

Coefficient of thermal expansion has two categories: volume thermal expansion and linear thermal expansion coefficient. If coefficient of thermal expansion is referred, it indicates the linear thermal expansion generally. However, in order to avoid misunderstanding, it is recommended to use the term “Linear thermal expansion coefficient”. In both SI and conventional units, it is represented by the same unit measure of /°C. Thus, because of its small numbers, it is indicated by exponentiation such as 10^{-5}.

Example: 5.5×10^{-5}/°C

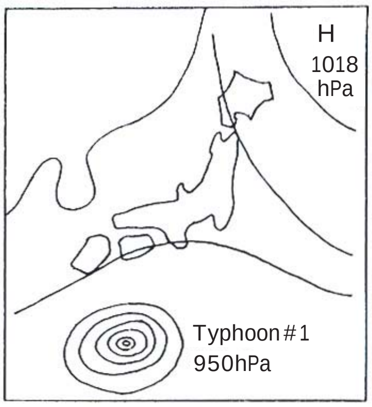
SI information

SI unit has been used in industries, but also it starts to penetrate into our daily life. An article shown below was appeared on Mainichi newspaper on February 1.

> On the day of 31st of the month, The Meteorological Agency announced to change the notation of unit for atmospheric pressure from millibar (mb) to hectopascal (hPa). This is an action to join to the international unified unit and will proceed in official on December 1st of this year.

Why is the unit of hectopascal selected, but kilopascal (kPa)? The reasons are:

1. Quantity value number on the conventional millibar can be used as it is.
   1 013 mb=1 013 hPa
2. It has been used already in twelve major countries such as Germany, French, etc.



Unit of atmospheric pressure is
hPa.

5. Conversion rates and name of SI units from key units of conventional unit systems to SI units

Measure	Conventional unit	Rate when converting conventional units to SI units	SI unit symbol	SI unit name
Length	μ (micron)	10^{-6}	m	meter
		1	μm	micrometer
	Å (angstroem)	10^{-10}	m	meter
Volume	cc	10^{-6}	m^3	cubic meter
		1	mL	millilitter
Acceleration	G	9.806 65	m/s^2	meter per second per second
Frequency	c/s, c	1	Hz	hertz
Force	kgf, kg	9.806 65	N	newton
Moment force (toque)	kgf•cm	$9.806\ 65\times10^{-2}$	N•m	newtonmeter
Pressure	kgf/cm^2	$9.806\ 65\times10^{4}$	Pa	pascal
	mmH_2O	9.806 65	Pa	pascal
	atm	$1.013\ 25\times10^{5}$	Pa	pascal
	mmHg	$1.333\ 22\times10^{2}$	Pa	pascal
	Torr	$1.333\ 22\times10^{2}$	Pa	pascal
Stress	kgf/cm^2	$9.806\ 65\times10^{4}$	Pa	pascal
Energy	kgf•m	9.806 65	J	joule
Work	erg	1×10^{-7}	J	joule
Work rate, Power	kgf•m/s	9.806 65	W	watt
	PS	735.499	W	watt
Calorific value	cal	4.186 05 (measurement law)	J	joule
Viscosity	cP	1×10^{-3}	Pa•s	pascal-second
		1	mPa•s	millipascal-second
	P	1×10^{-1}	Pa•s	pascal-second
		1×10^{2}	mPa•s	millipascal-second
Dynamic viscosity	cSt	1×10^{-6}	m^2/s	square meter per second
	St	1×10^{-4}	m^2/s	

6. Table of conversion rates for the units that have problem on conversion to SI units

(Units inside bold lines are SI units.)

Force	N	dyn	Kgf
	1	1×10^{5}	$1.019\ 72\times10^{-1}$
	1×10^{-5}	1	$1.019\ 72\times10^{-6}$
	9.806 65	$9.806\ 65\times10^{5}$	1

Viscosity	Pa•s	cP	P
	1	1×10^{3}	1×10
	1×10^{-3}	1	1×10^{-2}
	1×10^{-1}	1×10^{2}	1

Notes: 1 P=1 dyn•s/cm^2=1 g/cm•s,
1 Pa•s=1 N s/m^2, 1 cP=1 mPa•s

Stress	Pa or N/m^2	MPa or N/mm^2	Kgf/mm^2	kgf/cm^2
	1	1×10^{-6}	$1.019\ 72\times10^{-7}$	$1.019\ 72\times10^{-5}$
	1×10^{6}	1	$1.019\ 72\times10^{-1}$	$1.019\ 72\times10$
	$9.806\ 65\times10^{6}$	9.806 65	1	1×10^{2}
	$9.806\ 65\times10^{4}$	$9.806\ 65\times10^{-2}$	1×10^{-2}	1

Dynamic viscosity	m^2/s	cSt	St
	1	1×10^{6}	1×10^{4}
	1×10^{-6}	1	1×10^{-2}
	1×10^{-4}	1×10^{2}	1

Notes: 1 St=1 cm^2/s, 1 cSt=1 mm^2/s

Pressure	Pa	kPa	MPa	bar	kgf/cm^2	atm	mmH$_2$O	mmHg or Torr
	1	1×10^{-3}	1×10^{-6}	1×10^{-5}	1.01972×10^{-5}	9.86923×10^{-6}	1.01972×10^{-1}	7.50062×10^{-3}
	1×10^{3}	1	1×10^{-3}	1×10^{-2}	1.01972×10^{-2}	9.86923×10^{-3}	1.01972×10^{2}	7.50062
	1×10^{6}	1×10^{3}	1	1×10	1.01972×10	9.86923	1.01972×10^{5}	7.50062×10^{3}
	1×10^{5}	1×10^{2}	1×10^{-1}	1	1.01972	9.86923×10^{-1}	1.01972×10^{4}	7.50062×10^{2}
	9.80665×10^{4}	9.80665×10	9.80665×10^{-2}	9.80665×10^{-1}	1	9.67841×10^{-1}	1×10^{4}	7.35559×10^{2}
	1.01325×10^{5}	1.01325×10^{2}	1.01325×10^{-1}	1.01325	103323	1	1.03323×10^{4}	7.60000×10^{2}
	9.80665	9.80665×10^{-3}	9.80665×10^{-6}	9.80665×10^{-5}	1×10^{-4}	9.67841×10^{-5}	1	7.35559×10^{-2}
	1.33322×10^{2}	1.22222×10^{-1}	1.33322×10^{-4}	1.33322×10^{-3}	1.35951×10^{-3}	1.31579×10^{-3}	1.35951×10	1

Notes: 1 Pa=1 N/m^2

Work•Energy• Calorific value	J	kW•h	kgf•m	kcal
	1	$2.777\ 78\times10^{-7}$	$1.019\ 72\times10^{-1}$	$2.388\ 89\times10^{-4}$
	3.600×10^{6}	1	$3.670\ 98\times10^{5}$	$8.600\ 0\times10^{2}$
	9.806 65	$2.724\ 07\times10^{-6}$	1	$2.342\ 70\times10^{-3}$
	$4.186\ 05\times10^{3}$	$1.162\ 79\times10^{-3}$	$4.268\ 58\times10^{2}$	1

Notes: 1 J=1 W•s, 1J=1 N•m
1 cal=4.186 05 J (by Measurement law)

Coefficient of thermal conductive	W/(m•K)	kcal/(h•m•°C)
	1	$8.600\ 0\times10^{-1}$
	1.162 79	1

Notes: 1 cal=4.186 05 J
(by measurement law)

Work rate (Power, Motive force) Thermal flow	W	kgf•m/s	PS	kcal/h
	1	$1.019\ 72\times10^{-1}$	$1.359\ 62\times10^{-3}$	$8.600\ 0\times10^{-1}$
	9.806 65	1	$1.333\ 33\times10^{-2}$	8.43371
	$7.355\ \ \times10^{2}$	$7.5\ \ \times10$	1	$6.325\ 29\times10^{2}$
	1.162 79	$1.185\ 72\times10^{-1}$	$1.580\ 95\times10^{-3}$	1

Notes: 1 W=1 J/s, PS:
1 PS=0.735 5 kW (by enforcement law of Measurement law)
1 cal=4.186 05 J (by Measurement law)

Coefficient of thermal transfer	W/(m^2•K)	kcal/(h•m^2•°C)
	1	$8.600\ 0\times10^{-1}$
	1.162 79	1

Notes: 1 cal=4.186 05 J
(by measurement law)

Specific heat capacity	J/(kg•K)	kcal/(kg•°C) cal/(g•°C)
	1	$2.388\ 89\times10^{-4}$
	$4.186\ 05\times10^{3}$	1

Notes: 1 cal=4.186 05 J
(by Measurement law)

Epilogue

In this issue of Technical News, outlines of SI were introduced. We hope you could understand them well.

SI has deep relations to our daily life through force, energy and the like.

It will take some time to switch to SI from the conventional units that we have used perfectly. However, once familiarized with the representation of the second step, it is quite easy to enter the third step, which is the representation used only SI. We believe this could be done without any resistance.

First, try to use SI. Thereafter, you will have intimateness to SI and can have controls over SI. We hope this issue helps you.

Reference documents and standards

[Reference documents]

Step forward transition toward SI, (1991), The Japanese Standards Association

Dictionary for utilizing SI units, (1979), The Japanese Standards Association

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