International System of Units (SI) [Part 1]

(According to JIS Z 8203 "SI units and recommendations for the use of their multiples and of certain other units" and Z 8202 "Quantities and units")

■ Origin of the term SI (International System of Units)

SI stands for Système International d'Unités in French (International System of Units in English), an internationally accepted official abbreviation.

■ Purpose and historical background of the SI

The Metre Convention was signed in 1875 to oversee the keeping of metric system as a unified international system of units. Then, the metric system had more than ten variations, losing its consistency. At the 9th General Conference on Weights and Measures (Conférence Générale des Poids et Mesures: CGPM) in 1948, a resolution was adopted "to use a unified system of units in all fields". The International Committee for Weights and Measures (Comité International des Poids et Mesures: CIPM) of the treaty organization started a process to establish a unified system and determined the framework of the SI in 1960. In 1973, the International Organization for Standardization (ISO) developed the standard ISO 1000, which describes SI units and recommendations for the use of them, leading to global adoption of the system. In Japan, a policy to introduce SI units into JIS through the following three phases was determined in 1972; the introduction of SI units into JIS progressed rapidly.

First phase: Use of conventional units followed by SI units	e.g. 1 kgf [9.8 N]
Second phase: Use of SI units followed by conventional units	e.g. 10 N {1.02 kgf}
Third phase: Use of SI units only	e.g. 10 N

The Measurement Act in Japan was fully revised in 1992 and enacted in 1993 to unify statutory measurement units into SI units. Under the new Measurement Act, a transition period of up to seven years was granted before the exclusive use of SI units for "pressure" and "moment of force" in the field of hydraulics, and the period expired on September 30, 1999. Since October 1, 1999, it has been mandatory to use SI units as statutory measurement units for transactions and certifications. Commercially available pressure gauges are in SI units. The units used in this catalogue are SI units.

All units used in this catalogue are SI units as applicable in the third phase of the SI implementation process.

■ Structure of SI units and JIS Z 8203

- JIS Z 8203
  - S I
    - SI Units
      - Base Units (7)
      - Supplementary Units (2)
      - Derived Units
        - Derived Units with Special Names (19)
        - Other Derived Units
    - Prefixes (20) and Decimal Multiples of SI units
  - Important Non-SI Units Accepted for Use with SI Units

● Base Units

Quantity	Base Unit	
	Name	Symbol
Length	meter	m
Mass	kilogram	kg
Time	second	s
Electric Current	ampere	A
Thermodynamic Temperature	kelvin	K
Amount of Substance	mole	mol
Luminous Intensity	candela	cd

● Supplementary Units

Quantity	Supplementary Unit	
	Name	Symbol
Plane Angle	radian	rad
Solid Angle	steradian	sr

● Prefixes

Prefixes are used to form decimal multiples of SI units.

Unit Multiplier	Prefix	
	Name	Symbol
10^{24}	yotta	Y
10^{21}	zetta	Z
10^{18}	exa	E
10^{15}	peta	P
10^{12}	tera	T
10^{9}	giga	G
10^{6}	mega	M
10^{3}	kilo	k
10^{2}	hecto	h
10	deka	da
10^{-1}	deci	d
10^{-2}	centi	c
10^{-3}	milli	m
10^{-6}	micro	μ
10^{-9}	nano	n
10^{-12}	pico	p
10^{-15}	femto	f
10^{-18}	atto	a
10^{-21}	zepto	z
10^{-24}	yocto	y

● Non-SI units accepted for use with SI units

Quantity	Unit Name	Unit Symbol
Time	minute hour day	min h d
Plane Angle	degree minute second	° ′ ″
Volume	liter	l, L★
Mass	metric ton	t

★The letter “L” may be used as the symbol for liter, when the symbol “l” for liter might be confused with any other character (as a general rule, Yuken uses “L”).

● Units accepted for use with SI units for usefulness in special fields

Quantity	Unit Name	Unit Symbol
Energy	electronvolt	eV
Atomic Mass	atomic mass unit	u
Distance	astronomical unit	AU
	parsec	pc
Fluid Pressure	bar	bar

● Derived units

Derived units are expressed algebraically in terms of base units and supplementary units (by means of the mathematical symbols of multiplication and division) in the International System of Units.

● Derived units expressed in terms of SI base units

Quantity	Derived Unit	
	Name	Symbol
Area	square meter	m^2
Volume	cubic meter	m^3
Speed, Velocity	meter per second	m/s
Acceleration	meter per second squared	m/s^2
Wavenumber	reciprocal meter	m^{-1}
Density	kilogram per cubic meter	kg/m^3
Current Density	ampere per square meter	A/m^2
Magnetic Field Strength	ampere per meter	A/m
(Amount-of-substance) Concentration	mole per cubic meter	mol/m^3
Specific Volume	cubic meter per kilogram	m^3/kg
Luminance	candela per square meter	cd/m^2

● Derived units with special names

Quantity	Derived Unit		
	Name	Symbol	Definition
Frequency	hertz	Hz	s^{-1}
Force	newton	N	$kg·m/s^2$
Pressure, Stress	pascal	Pa	N/m^2
Energy, Work, Amount of Heat	joule	J	N·m
Amount of Work Done Per Time, Motive Power, Electrical Power	watt	W	J/s
Electric Charge, Amount of Electricity	coulomb	C	A·s
Electric Potential, Potential Difference, Voltage, Electromotive Force	volt	V	W/A
Capacitance	farad	F	C/V
Electric Resistance	ohm	Ω	V/A
(Electric) Conductance	siemens	S	A/V
Magnetic Flux	weber	Wb	V·s
Magnetic Flux Density, Magnetic Induction	tesla	T	Wb/m^2
Inductance	henry	H	Wb/A
Celsius Temperature	degree celsius/degree	℃	
Luminous Flux	lumen	lm	cd·sy
Illuminance	lux	lx	lm/m^2
Activity Referred to a Radionuclide	becquerel	Bq	S^{-1}
Absorbed Dose	gray	Gy	J/kg
Dose Equivalent	sievert	Sv	Gy

International System of Units (SI) [Part 3]

Data Sheet

■ Use of SI units

Space and Time

Quantity	SI Unit	Decimal Multiple Unit
Plane Angle	rad (radian)	mrad μrad
Solid Angle	sr (steradian)	
Length, Width, Height, Thickness, Radius, Diameter, Length of Path Traveled, Distance	m (meter)	km dm cm mm μm nm pm
Area	m^2 (square meter)	km^2 dm^2 cm^2 mm^2
Volume	m^3 (cubic meter)	dm^3 cm^3 mm^3
Time	s (second)	ks ms μs ns
Angular Velocity	rad/s (radian per second)	
Speed, Velocity	m/s (meter per second)	
Acceleration	m/s^2 (meter per second squared)	

Periodic and Related Phenomena

Quantity	SI Unit	Decimal Multiple Unit
Frequency	Hz (hertz)	THz GHz MHz kHz
Rotational Speed, Revolutions	s^{-1} (per second)	

Dynamics

Quantity	SI Unit	Decimal Multiple Unit
Mass	kg (kilogram)	Mg g mg μg
Density, Concentration	kg/m^3 (kilogram per cubic meter)	mg/m^3 or kg/dm^3 or g/cm^3
Moment of Inertia	$kg \cdot m^2$ (kilogram meter squared)	
Force	N (newton)	MN kN mN μN
Moment of Force	N·m (newton meter)	MN·m kN·m mN·m μN·m
Pressure	Pa (pascal)	GPa MPa kPa mPa μPa
Stress	(pascal or newton per square meter) Pa or N/m^2	GPa, MPa or N/mm^2, kPa
Viscosity	Pa·s (pascal second)	mPa·s
Kinematic Viscosity	m^2/s (square meter per second)	mm^2/s
Work, Energy, Amount of Heat	J (joule)	TJ GJ MJ kJ mJ
Power, Amount of Work Done Per Unit of Time	W (watt)	GW MW kW mW μW
Flow Rate	m^3/s (cubic meter per second)	

Heat

Quantity	SI Unit	Decimal Multiple Unit
Thermodynamic Temperature	K (kelvin)	
Celsius Temperature	°C (degree Celsius or degree)	
Temperature Interval, Temperature Difference	K or °C	
Amount of Heat	J (joule)	TJ GJ MJ kJ mJ
Heat Flow Rate	W (watt)	kW
Thermal Conductivity	W/(m·K)	
Coefficient of Heat Transfer	$W/(m^2 \cdot K)$	
Specific Heat Capacity	J/(kg·K)	kJ/(kg·K)

Electricity and Magnetism

Quantity	SI Unit	Decimal Multiple Unit
Electric Current	A (ampere)	kA mA μA nA pA
Electric Potential, Electric Potential Difference, Voltage, Electromotive Force	V (volt)	MV kV mV μV
(Electric) Resistance (Direct Current)	Ω (ohm)	GΩ MΩ (Remarks) MΩ is also referred to as megohm. kΩ mΩ μΩ
(Active) Electric Power	W (watt)	TW GW MW kW mW μW nW

Sound

Quantity	SI Unit	Decimal Multiple Unit
Frequency	Hz (hertz)	GHz MHz kHz
Sound Pressure Level*		

*This SI unit is not provided by ISO 1000-1973 and ISO 31 Part 7-1978, but JIS adopts and specifies dB (decibel) as a unit accepted for use with SI units.

Data Sheet
International System of Units (SI)

International System of Units (SI) [Part 4]

■ SI unit conversion factors table

(Shaded columns [ ] represent SI units.)

● Force

N Newton	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

● Moment of inertia

N·m Newton meter	kgf·m
1	0.101 972
9.807	1

Note) 1 N·m = 1 kg•m²/s²

● Pressure

Pa pascal	bar	kgf/cm²	atm	mmH_2O	mmHg or Torr
1	1×10^{-5}	$1.019\ 72\times10^{-5}$	$9.869\ 23\times10^{-6}$	$1.019\ 72\times10^{-1}$	$7.500\ 62\times10^{-3}$
1×10^{5}	1	1.019 72	$9.869\ 23\times10^{-1}$	$1.019\ 72\times10^{4}$	$7.500\ 62\times10^{2}$
$9.806\ 65\times10^{4}$	$9.806\ 65\times10^{-1}$	1	$9.678\ 41\times10^{-1}$	1×10^{4}	$7.355\ 59\times10^{2}$
$1.013\ 25\times10^{5}$	1.013 25	1.033 23	1	$1.033\ 23\times10^{4}$	$7.600\ 00\times10^{2}$
9.806 65	$9.806\ 65\times10^{-5}$	1×10^{-4}	$9.678\ 41\times10^{-5}$	1	$7.355\ 59\times10^{-2}$
$1.333\ 22\times10^{2}$	$1.333\ 22\times10^{-3}$	$1.359\ 51\times10^{-3}$	$1.315\ 79\times10^{-3}$	$1.359\ 51\times10$	1

Note) 1 Pa = 1 N/m²

● Stress

Pa pascal	MPa or N/mm² Megapascal or newton per square milimeter	kgf/mm²	kgf/cm²
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

● Viscosity

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

Note) 1 P = 1 dyn•s/cm² = 1 g/cm•s
1 Pa•s = 1 N•s/m², 1 cP = 1 mPa•s

● Work, energy, amount of heat

J joule	kW·h	kgf·m	kcal
1	$2.777\ 78\times10^{-7}$	$1.019\ 72\times10^{-1}$	$2.388\ 89\times10^{-4}$
$3.600\ \ \times10^{6}$	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

Note) 1 J = 1 W•s, 1 W•h = 3,600 W•s
1 cal = 4.186 05 J (according to the Measurement Act)

● Kinematic viscosity

m²/s square meter per second	cSt	St
1	1×10^{6}	1×10^{4}
1×10^{-6}	1	1×10^{-2}
1×10^{-4}	1×10^{2}	1

Note) 1 cSt = 1 mm²/s, 1 St = 1 cm²/s

● Power (amount of work done per unit of time or motive power)

kW kilowatt	kgf·m/s	PS	kcal/h
1	$1.019\ 72\times10^{2}$	1.359 62	$8.600\ 0\ \times10^{2}$
$9.806\ 65\times10^{-3}$	1	$1.333\ 33\times10^{-2}$	8.433 71
$7.355\ \ \times10^{-1}$	$7.5\ \ \times10$	1	$6.325\ 29\times10^{2}$
$1.162\ 79\times10^{-3}$	$1.185\ 72\times10^{-1}$	$1.580\ 95\times10^{-3}$	1

Note) 1 W = 1 J/s, PS: French horsepower
1 PS = 0.735 5 kW (according to the Act for Enforcement of the Measurement Act)
1 cal = 4.186 05 J (according to the Measurement Act)

● Thermal conductivity

W/(m•K) watt per meter kelvin	kcal/(h·m·℃)
1	$8.600\ 0\times10^{-1}$
1.162 79	1

Note) 1 cal = 4.186 05 J (according to the Measurement Act)

● Temperature

$T_1 = T_2 + 273.15$
$T_3 = 1.8\ T_2 + 32$

- T_1: Thermodynamic temperature — K (kelvin)
- T_2: Celsius temperature — °C (degree)
- T_3: °F

● Specific heat capacity

J/(kg•K) joule per kilogram kelvin	kcal/(kg·℃) cal/(g·℃)
1	$2.388\ 89\times10^{-4}$
$4.186\ 05\times10^{3}$	1

Note) 1 cal = 4.186 05 J (according to the Measurement Act)

● Coefficient of heat transfer

W/(m²•K) watt per meter squared kelvin	kcal/(h·m²·℃)
1	$8.600\ 0\times10^{-1}$
1.162 79	1

Note) 1 cal = 4.186 05 J (according to the Measurement Act)