Versatility of steel in sewer construction is typified by application of large diameter structural plate pipe.

Conversion Tables

INTRODUCTION - SYSTÈME INTERNATIONAL

Canada was converted to the Système International (SI) system of measurement. SI not only replaces the imperial system of measurement, it improves upon and supersedes older metric systems, once commonly used. It was approved for international application by 30 members of the International Organization for Standardization (ISO), including Canada and the United States of America, in June 1972.

SI BASE UNITS

There are seven base (Table 1) and two supplementary units (Table 2) in the Système International (SI)[1]. These are the basic units of measure for the whole system. All other SI units are formed by combining base and supplementary units through multiplication, division or a combination of both. Units formed are known as derived units.

Table C1 SI base units

Quantity	Name	Symbol
length	metre	m
mass	kilogram	kg
time	second	s
electric current	ampere	A
thermodynamic temperature	kelvin	K
amount of substance	mole	mol
luminous intensity	candela	cd

Table C2 SI supplementary units

Quantity	Name	Symbol
plane angle	radian	rad
solid angle	steradian	sr

DERIVED UNITS

General

Derived units are combinations of base units. For example, the SI unit for linear velocity is the metre divided by the second, and is shown symbolically as m/s (metres per second). The oblique stroke placed between symbols indicates that the first base unit is divided by the second base unit.

A dot placed midway between base unit symbols indicates that the units are multiplied. For example, a moment of force is expressed as newton metre, and written N•m. Where brackets occur in a symbol, this indicates that the bracketed portion is to be computed first.

Derived units with special names and symbols

Some derived units are used more frequently than others. It has been found convenient to give the most frequently used derived units their own names and symbols, to eliminate using lengthy names and symbols formed from the base units. For example, the unit for force, if expressed in terms of base units, would be "kilogram metre per second squared" ($kg•m/s^2$). In fact, it is called the "newton" and is expressed by the symbol "N". There are *15 derived units with special names and symbols,* and these are shown in Table 3.

Table C3 SI derived units with special names

Quantity	Name	Symbol	Expressed in terms of base and supplementary units
frequency	hertz	Hz	s^{-1}
force	newton	N	$m•kg•s^{-2}$
pressure, stress	pascal	Pa	$m^{-1}•kg•s^{-2}$
energy, work, quantity of heat	joule	J	$m^2•kg•s^{-2}$
power, radiant flux	watt	W	$m^2•kg•s^{-3}$
quantity of electricity, electric charge	coulomb	C	s•A
electric potential, potential difference, electromotive force	volt	V	$m^2•kg•s^{-3}•A^{-1}$
electric capacitance	farad	F	$m^{-2}•kg^{-1}•s^4•A^2$
electric resistance	ohm	Ω	$m^2•kg•s^{-3}•A^{-2}$
electric conductance	siemens	S	$m^{-2}•kg^{-1}•s^3•A^2$
magnetic flux	weber	Wb	$m^2•kg•s^{-2}•A^{-1}$
magnetic flux density	tesia	T	$kg•s^{-2}•A^{-1}$
inductance	henry	H	$m^2•kg•s^{-2}•A^{-2}$
luminous flux	lumen	lm	cd•sr
illuminance	lux	lx	$m^{-2}•cd•sr$

OTHER DERIVED UNITS

Derived units listed in Table 4, have names and symbols formed from base, supplementary, and derived SI units which have their own names and symbols. For example, the name and symbol for linear acceleration is formed from two base units, "metre per second squared" and is written m/s^2. The name and symbol for moment of force is formed from a derived unit and a base unit, i.e. "newton metre", (N•m).

Table C4 SI derived units without special names

Quantity	Description	Symbol	Description of base units
area	square metre	m^2	
volume	cubic metre	m^3	
speed – linear	metre per second	m/s	
– angular	radian per second	rad/s	indicated
acceleration – linear	metre per second squared	m/s^2	by
– angular	radian per second squared	rad/s^2	symbol
wave number	1 per metre	m^{-1}	
density, mass density	kilogram per cubic metre	kg/m^3	
concentration (amount of substance)	mole per cubic metre	mol/m^3	
specific volume	cubic metre per kilogram	m^3/kg	
luminance	candela per square metre	cd/m^2	
dynamic viscosity	pascal second	$Pa\cdot s$	$m^{-1}\cdot kg\cdot s^{-1}$
moment of force	newton metre	$N\cdot m$	$m^2\cdot kg\cdot s^{-2}$
surface tension	newton per metre	N/m	$kg\cdot s^{-2}$
heat flux density, irradiance	watt per square metre	W/m^2	$kg\cdot s^{-3}$
heat capacity, entropy	joule per kelvin	J/K	$m^2\cdot kg\cdot s^{-2}\cdot K^{-1}$
specific heat capacity, specific entropy	joule per kilogram kelvin	$J/(kg\cdot K)$	$m^2\cdot s^{-2}\cdot K^{-1}$
specific energy	joule per kilogram	J/kg	$m^2\cdot s^{-2}$
thermal conductivity	watt per metre kelvin	$W/(m\cdot K)$	$m\cdot kg\cdot s^{-3}\cdot K^{-1}$
energy density	joule per cubic metre	J/m^3	$m^{-1}\cdot kg\cdot s^{-2}$
electric field strength	volt per metre	V/m	$m\cdot kg\cdot s^{-3}\cdot A^{-1}$
electric charge density	coulomb per cubic metre	C/m^3	$m^{-3}\cdot s\cdot A$
surface density of charge, flux density	coulomb per square metre	C/m^2	$m^{-2}\cdot s\cdot A$
permittivity	farad per metre	F/m	$m^{-3}\cdot kg^{-1}\cdot s^4\cdot A^2$
current density	ampere per square metre	A/m^2	indicated
magnetic field strength	ampere per metre	A/m	by symbol
permeability	henry per metre	H/m	$m\cdot kg\cdot s^{-2}\cdot A^{-2}$
molar energy	joule per mole	J/mol	$m^2\cdot kg\cdot s^{-2}\cdot mol^{-1}$
molar entropy, molar heat capacity	joule per mole kelvin	$J/(mol\cdot K)$	$m^2\cdot kg\cdot s^{-2}\cdot K^{-1}\cdot mol^{-1}$
radiant intensity	watt per steradian	W/sr	$m^2\cdot kg\cdot s^{-3}s\cdot r^{-1}$

NON-SI UNITS USED WITH THE SI

Some non-SI Units are used with SI, usually for one of four reasons:–

- The unit is beyond human control, e.g. the day.
- The use of the unit is so ingrained internationally that the disruption resulting from a change would far outweigh any benefits gained. Examples of such units are minutes and hours, degrees of arc, etc.
- The unit has a very limited and well-defined use, e.g. the parsec, a unit of stellar distance.
- The unit is being retained for a limited time until a satisfactory replacement has been formulated.

Table C5 Non-SI units

Condition of use	Unit	Symbol	Value in SI units
Permissible universally with SI	minute	min	1 min = 60 s
	hour	h	1 h = 3600 s
	day	d	1 d = 86400 s
	degree (of arc)	°	1° = (π/180) rad
	minute (of arc)	'	1' = (π/10800) rad
	second (of arc)	"	1" = (π/648000) rad
	litre	L	1 L = 1 dm^3
	tonne	t	1 t = 10^3 kg
	degree Celsius	°C	
Permissible in specialized fields	electronvolt	eV	1 eV = 0.160219 aj
	unit of atomic mass	u	1 u = 1.66053 x 10^{-27} kg
	astronomical unit		1 AU = 149.600 Gm
	parsec	pc	1 pc = 30857 Tm
Permissible for a limited time	nautical mile		1 nautical mile = 1852 m
	knot	kn	1 nautical mile per hour = (1852/3600) m/s
	ångström	Å	1 Å = 0.1 nm = 10^{-10} m
	are	a	1 a = 10^2 m^2
	hectare	ha	1 ha = 10^4 m^2
	bar	bar	1 bar = 100 kPa
	standard atmosphere	atm	1 atm = 101.325 kPa

MULTIPLES AND SUBMULTIPLES

In SI, a consistent method of multiplying or dividing units exists for all types of measurement. The multiplying factors are shown in Table 6. Prefixes are employed attached to the unit to indicate multiples or sub-multiples of the unit, and a corresponding symbol is attached to the unit symbol.

Example:– If the original unit is a metre (m), when multiplied by 1000 it becomes a kilometre (km). When divided by 1000 it becomes a millimetre (mm). Similarly, a newton multiplied by 1000 becomes a kilonewton (kN) and, when divided by 1000 it becomes a millinewton (mN).

Table C6 SI prefixes

Multiplying factor	SI prefix	SI symbol
1 000 000 000 000 = 10^{12}	tera	T
1 000 000 000 = 10^{9}	giga	G
1 000 000 = 10^{6}	mega	M
1 000 = 10^{3}	kilo	k
100 = 10^{2}	hecto	h
10 = 10^{1}	deca	da
0.1 = 10^{-1}	deci	d
0.01 = 10^{-2}	centi	c
0.001 = 10^{-3}	milli	m
0.000 001 = 10^{-6}	micro	μ
0.000 000 001 = 10^{-9}	nano	n
0.000 000 000 001 = 10^{-12}	pico	p
0.000 000 000 000 001 = 10^{-15}	femto	f
0.000 000 000 000 000 001 = 10^{-18}	atto	a

Note: The SI prefixes in Table 6, as applied to linear measurement, are as shown in Table 7.

Table C7 Metric linear measure units

SI unit	Symbol	Equivalent in metres
terrametre	Tm	1 000 000 000 000
gigametre	Gm	1 000 000 000
megametre	Mm	1 000 000
kilometre	Km	1 000
hectometre	hm	100
decametre	dam	10
metre	m	1
decimetre	dm	0.1
centimetre	cm	0.01
millimetre	mm	0.001
micrometre	μm	0.000 001
nanometre	nm	0.000 000 001
picometre	pm	0.000 000 000 001
femtometre	fm	0.000 000 000 000 001
attometre	am	0.000 000 000 000 000 001

ENGINEERING CONVERSION UNITS

It is useful to have conversion units to simplify calculations when working between the Imperial and Système International units. Table 8 has been specifically designed to include those units most likely to be encountered in engineering calculations relevant to this handbook. The basis for this table is "Table VII: Table of Units", contained in the *Industry Practice Guide for SI Metric Units in the Canadian Iron & Steel Industry*[2].

Table C8 Engineering conversion units

Name	SI units	Imperial units	Equivalent metric units	Factors by which values must be multiplied to convert from: Imperial to metric	Metric to imperial
acceleration (gravitational)	m/s²	ft/s²	m/s²	3.084×10^{-1}	3.208 84
area	m²	in.²	mm² or	6.4516×10^{2}	$1.550\ 00 \times 10^{-3}$
see also section			cm²	6.4516	$1.550\ 00 \times 10^{-1}$
properties		ft²	m²	$9.290\ 30 \times 10^{-2}$	1.076 39 x 10
		yd²	m²	$8.361\ 27 \times 10^{-1}$	1.195 99
		acre	ha	$4.046\ 86 \times 10^{-1}$	2.471 05
		mile²	km²	2.589 99	$3.861\ 02 \times 10^{-1}$
area per unit length	m²/m	in.²/in.	mm²/mm	2.540 00 x 10	$3.937\ 01 \times 10^{-2}$
		in.²/ft	mm²/mm	2.116 67	$4.724\ 41 \times 10^{-1}$
		in.²/ft	mm²/m	$2.116\ 67 \times 10^{3}$	$4.724\ 41 \times 10^{-4}$
bearing capacity, soils	N/m²	lbf/in.²	kN/m²	6.894 76	$1.450\ 38 \times 10^{-1}$
		lbf/ft²	kN/m²	$4.788\ 03 \times 10^{-2}$	2.088 54 x 10
		tonf/ft²	kN/m²	9.576 06 x 10	$1.042\ 27 \times 10^{-2}$
bending moment	N-m	lbf in.	Nm	$1.129\ 85 \times 10^{-1}$	8.850 75
		lbf ft	Nm	1.355 82	$7.375\ 62 \times 10^{-1}$
coating thickness	m	in.	mm	2.54 x 10	$3.937\ 01 \times 10^{-2}$
		mil or thou	μm	2.54 x 10	$3.937\ 01 \times 10^{-2}$
coating weight	kg/m²	oz/ft²	g/m²	$3.051\ 52 \times 10^{2}$	$3.277\ 06 \times 10^{-3}$
corrosion rate					
mass per area unit time	g/(m²•s)	oz/(ft²•a)	g/(m²•a)	$3.051\ 52 \times 10^{2}$	$3.277\ 06 \times 10^{-3}$
depth per unit time	m/s	mil/a	μm/a	2.54 x 10	$3.937\ 01 \times 10^{-2}$
density	kg/m³	g/cm³	kg/m³	1.0×10^{3}	1.0×10^{-3}
mass density		lb/in.³	kg/m³	$2.767\ 99 \times 10^{4}$	$3.612\ 73 \times 10^{-5}$
		lb/ft³	kg/m³	1.601 85 x 10	$6.242\ 80 \times 10^{-2}$
		lb/gal	kg/litre	$9.977\ 64 \times 10^{-2}$	1.002 24 x 10
density equivalent to		lb/ft³	N/m³	$1.570\ 88 \times 10^{2}$	$6.365\ 86 \times 10^{-3}$
determine force		lb/ft³	kN/m³	$1.570\ 88 \times 10^{-1}$	6.365 86
flow					
volume basis	m³/s	ft³/s	m³/s	$2.831\ 68 \times 10^{-2}$	3.531 47 x 10
		ft³/min	m³/min or	$2.831\ 68 \times 10^{-2}$	3.531 47 x 10
			m³/h	1.699 01	$5.885\ 78 \times 10^{-1}$
		ft³/h	m³/h	$2.831\ 68 \times 10^{-2}$	3.531 47 x 10
		gal(Cdn)/s	litres/s	4.546 09	$2.199\ 69 \times 10^{-1}$
		gal(Cdn)/min	litre/min	4.546 09	$2.199\ 69 \times 10^{-1}$
		gal(Cdn)/h	litre/h	4.546 09	$2.199\ 69 \times 10^{-1}$
		gal(US)/s	litre/s	3.785 41	$2.641\ 72 \times 10^{-1}$
		gal/m	m³/s	$7.576\ 80 \times 10^{-5}$	$1.319\ 80 \times 10^{4}$
		ft³/s	L/s	2.831 68 x 10	$3.531\ 47 \times 10^{-2}$
		gal/m	L/s	$7.576\ 80 \times 10^{-2}$	1.319 80 x 10

Table C8 Engineering conversion units (continued)

Name	SI units	Imperial units	Equivalent metric units	Factors by which values must be multiplied to convert from: Imperial to metric	Metric to imperial
force	N	lbf	N	4.44822	$2.248\,09 \times 10^{-1}$
		lbf	kN	$4.448\,22 \times 10^{-3}$	$2.248\,09 \times 10^{2}$
		tonf	kN	8.896 44	$1.124\,04 \times 10^{-1}$
		kgf	N	9.806 65	$1.019\,72 \times 10^{-1}$
force per unit length	N/m	lbf/ft	N/m	$1.459\,39 \times 10$	$6.852\,18 \times 10^{-2}$
		lbf/ft	kN/m	$1.459\,39 \times 10^{-2}$	$6.852\,18 \times 10$
		lbf/in.	N/m	$1.751\,27 \times 10^{2}$	$5.710\,15 \times 10^{-3}$
		lbf/in.	kN/m (N/mm)	$1.751\,27 \times 10^{-1}$	5.710 15
linear measurement	m	mil	μm	2.54×10	$3.937\,01 \times 10^{-2}$
		in.	mm	2.54×10	$3.397\,01 \times 10^{-2}$
		ft	mm	3.084×10^{2}	$3.280\,84 \times 10^{-3}$
		ft	m	3.084×10^{-1}	3.280 84
		statute mi	km	1.609 35	$6.213\,71 \times 10^{-1}$
		nautical mi	km	1.853	$5.396\,65 \times 10^{-1}$
mass	kg	lb(avdp)	kg	$4.535\,92 \times 10^{-1}$	2.204 62
mass per unit area	kg/m^2	lb/ft^2	kg/m^2	4.882 43	$2.084\,16 \times 10^{-1}$
mass per unit length	kg/m	lb/ft	kg/m	1.488 16	$6.719\,69 \times 10^{-1}$
modulus of elasticity	Pa	lbf/in.^{2}	MPa (N/mm^2)	$6.894\,76 \times 10^{-3}$	$1.450\,38 \times 10^{2}$
pressure (stress)	Pa	lbf/in.^{2}	kPa	6.894 76	$1.450\,38 \times 10^{-1}$
		lbf/ft^2	kPa	$4.788\,03 \times 10^{-2}$	$2.088\,54 \times 10$
		$tonf/ft^2$	kPa	$9.576\,05 \times 10$	$1.044\,27 \times 10^{-2}$
		N/mm^2	MPa	1.00	1.00
section properties:					
first moment of area, modulus of section, S	m^3	in.^{3}	mm^3	$1.638\,71 \times 10^{4}$	$6.102\,37 \times 10^{-5}$
second moment of area, moment of inertia, I	m^4	in.^{4}	mm^4	$4.162\,31 \times 10^{5}$	$2.402\,51 \times 10^{-6}$
section properties per unit length:					
modulus of section per unit length	m^3/m	in.^{3}/in.	mm^3/mm	$6.451\,60 \times 10^{2}$	1.55×10^{-3}
		in.^{3}/ft	mm^3/mm	$5.376\,35 \times 10$	1.86×10^{-2}
		in.^{3}/ft	mm^3/m	$5.376\,35 \times 10^{4}$	1.86×10^{-5}
moment of inertia per unit length	m^4/m	in.^{4}/in.	mm^4/mm	$1.638\,71 \times 10^{4}$	$6.102\,37 \times 10^{-5}$
		in.^{4}/ft	mm^4/mm	$1.365\,59 \times 10^{3}$	$7.322\,85 \times 10^{-4}$
		in.^{4}/ft	mm^4/m	$1.365\,59 \times 10^{6}$	$7.322\,85 \times 10^{-7}$

Table C8 Engineering conversion units (continued)

Name	SI units	Imperial units	Equivalent metric units	Factors by which values must be multiplied to convert from: Imperial to metric	Metric to imperial
stress (see pressure)					
temperature – customary	°C	°F	°C (Celsius)	(5/9)(°F – 32)	(9/5) °C + 32
torque (see bending moment					
velocity	m/s	ft/s	m/s	3.084×10^{-1}	3.280 84
volume	m^3	ft^3	m^3	$2.831\ 68 \times 10^{-2}$	$3.351\ 47 \times 10$
		yd^3	m^3	$7.645\ 55 \times 10^{-1}$	1.307 95
		gal (Cdn)	L	4.546 09	$2.199\ 69 \times 10^{-1}$
		ft^3	dm^3	$2.831\ 68 \times 10$	$3.531\ 47 \times 10^{-2}$
		dm^3	L	1.00	1.00
		$in.^3$	L	1.6387×10^{-2}	6.1024×10
Young's modulus (see modulus of elasticity)					

MISCELLANEOUS INFORMATION

Ice and Snow

1 cubic metre of ice at 0°C weighs 920 kg; 1 kilogram of ice a 0°C has a volume of 0.00109 cubic metres = 1.09×10^6 cubic millimetres.

1 cubic metre of fresh snow, according to humidity of atmosphere, weighs 80 to 190 kilograms. 1 cubic metre of snow moistened and compacted by rain weighs 240 to 800 kilograms.

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General Tables

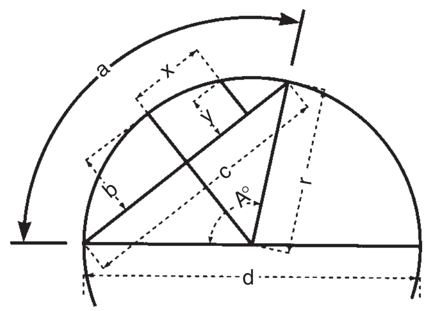
Table G1 Properties of the Circle*

Circumference of Circle of Dia 1 = π = 3.14159265

Circumference of Circle = $2\pi r$

Dia of Circle = Circumference × 0.31831

Diameter of Circle of equal periphery as square	= side	× 1.27324
Side of Square of equal periphery as circle	= diameter	× 0.78540
Diameter of Circle circumscribed about square	= side	× 1.41421
Side of Square inscribed in Circle	= diameter	× 0.70711



Arc, $a = \frac{\pi r A°}{180} = 0.017453\, r A°$

Angle, $A = \frac{180°\, a}{\pi r} = 57.29578 \frac{a}{r}$

Radius, $r = \frac{4b^2 + c^2}{8b}$ Diameter, $d = \frac{4b^2 + c^2}{4b}$

Chord, $c = 2\sqrt{2br - b^2} = 2r \sin\frac{A°}{2}$

Rise, $b = r - 1/2\sqrt{4r^2 - c^2} = \frac{c}{2}\tan\frac{A°}{4} = 2r\sin^2\frac{A}{4}$

Rise, $b = r + y - \sqrt{r^2 - x^2}$ $y = b - r \quad \sqrt{r^2 - x^2}$ $x = \sqrt{r^2 - (r + y - b)^2}$

π = 3.14159265, log = 0.4971499

$\frac{1}{\pi}$ = 0.3183099, log = $\bar{1}$.5028501

π^2 = 9.8696044, log = 0.9942997

$\frac{1}{\pi^2}$ = 0.1013212, log = $\bar{1}$.0057003

$\sqrt{\pi}$ = 1.7724539, log = 0.2485749

$\sqrt{\frac{1}{\pi}}$ = 0.5641896, log = $\bar{1}$.7514251

$\frac{\pi}{180}$ = 0.0174533, log = $\bar{2}$.2418774

$\frac{180}{\pi}$ = 57.2957795, log = 1.7581226

*From Carnegie's "Pocket Companion."

Table G2

Canadian Standard Thicknesses[1] for Corrugated Steel Pipe			
Nominal Thickness[2] (mm)	Minimum (mm)	Maximum (mm)	Weight (mass)[3] (kg/m^2)
1.0	0.87	1.13	7.8
1.3	1.15	1.45	10
1.6	1.42	1.78	13
2.0	1.82	2.18	16
2.8	2.60	3.00	22
3.5	3.27	3.73	27
4.2	3.97	4.43	33

[1] Thickness is based on CSA G401-93
[2] Nominal thickness includes base metal and metallic coating
[3] Weight is based on nominal thickness

Table G3

Canadian Standard Thicknesses[1] for Structural Plate Corrugated Steel Pipe			
Nominal Thickness[2] (mm)	Minimum (mm)	Maximum (mm)	Weight (mass)[3] (kg/m^2)
3.0	2.70	3.30	24
4.0	3.70	4.30	31
5.0	4.70	5.60	39
6.0	5.70	6.60	47
7.0	6.70	7.70	55

[1] Thickness is based on CSA G401-93
[2] Nominal thickness is the base metal thickness excluding zinc coating
[3] Weight is based on nominal thickness