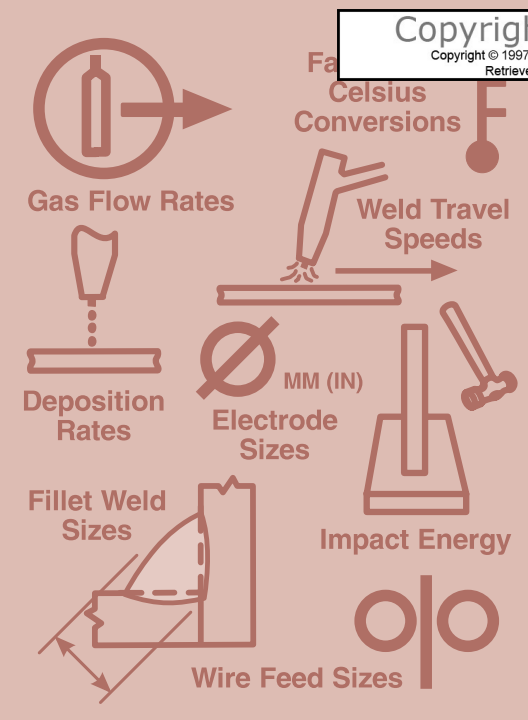

The Everyday Pocket Handbook on Metric Practices for the Welding Industry

Number 5 in a series

Compiled as a useful tool for on-the-job welding personnel by the AWS Product Development Committee

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Printed in the United States of America

American Welding Society

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Table 1—SI Units

SI consists of seven base units, two supplemental units, a series of derived units, and a series of prefixes for the formation of multiples of the various units.

Measure	Unit	Symbol
length	meter	m
mass	kilogram	kg
time	second	s
electric current	ampere	A
thermodynamic temperature	kelvin	K
luminous intensity	candela	cd
amount of substance	mole	mol
plane angle[1]	radian	rad
solid angle[1]	steradian	sr

[1]supplementary units

Table 2—Formulas for SI Derived Units

Measure	Unit	Symbol	Formula
acceleration—linear —angular	meter per second squared radian per second squared		m/s^2 rad/s^2
area	square meter		m^2
capacitance	farad	F	$A \cdot s/V$
conductivity (thermo)	watt per meter kelvin		$W/(m \cdot K)$
electric field strength	volt per meter		V/m
electromotive force	volt	V	W/A
electricity (quantity)	coulomb	C	$A \cdot s$
energy, work, heat, and impact strength	joule	J	$N \cdot m$
force	newton	N	$kg \cdot m/s^2$
frequency	hertz	Hz	s^{-1}
illumination	lux	lx	lm/m^2
inductance	henry	H	$V \cdot s/A$
luminous flux	lumen	lm	$cd \cdot sr$
magnetic flux	weber	Wb	$V \cdot s$
magnetic flux density, magnetic induction	tesla	T	Wb/m^2
power	watt	W	J/s
pressure, stress	pascal	Pa	N/m^2
resistance	ohm	Ω	V/A
velocity—linear angular	meter per second radian per second		m/s rad/s
volume	cubic meter		m^3

Table 3—Units Pertaining to Welding

Property	Unit	Symbol
area dimensions	square millimeter	mm^2
current density	ampere per square millimeter	A/mm^2
deposition rate	kilogram per hour	kg/h
electrical resistivity	ohm meter	$\Omega \cdot m$
electrode force	newton	N
flow rate (gas and liquid)	liter per minute	L/min
fracture toughness	meganewton meter$^{-3/2}$	$MN \cdot m^{-3/2}$
impact strength	joule	$J = N \cdot m$
linear dimensions	millimeter	mm
power density	watt per square meter	W/m^2
pressure (gas and liquid)	kilopascal	$kPa = 1000\ N/m^2$
pressure (vacuum)	pascal	$Pa = N/m^2$
tensile strength	megapascal	$MPa = 1\ 000\ 000\ N/m^2$
thermal conductivity	watt per meter kelvin	$W/(m \cdot K)$
travel speed	millimeter per second	mm/s
volume dimensions	cubic millimeter	mm^3
wire feed speed	millimeter per second	mm/s

Table 4—SI Prefixes

Exponential Expression	Multiplication Factor	Prefix	Symbol
10^{18}	1 000 000 000 000 000 000	exa	E
10^{15}	1 000 000 000 000 000	peta	P
10^{12}	1 000 000 000 000	tera	T
10^{9}	1 000 000 000	giga	G
10^{6}	1 000 000	mega	M
10^{3}	1000	kilo	k
10^{2}	100	hecto*	h
10	10	deka*	da
10^{-1}	0.1	deci*	d
10^{-2}	0.01	centi*	c
10^{-3}	0.001	milli	m
10^{-6}	0.000 001	micro	μ
10^{-9}	0.000 000 001	nano	n
10^{-12}	0.000 000 000 001	pico	p
10^{-15}	0.000 000 000 000 001	femto	f
10^{-18}	0.000 000 000 000 000 001	atto	a

*Nonpreferred. Prefixes should be selected in steps of 10^3.

These prefixes should not be used for units of linear measurement, but may be used for higher order units. For example, the linear measurement, decimeter, is nonpreferred, but square decimeter is acceptable.

Table 5—Conversions for Common Welding Terms*

Property	To Convert From	To	Multiply By
area dimensions (mm^2)	$in.^2$ mm^2	mm^2 $in.^2$	$6.451\,600 \times 10^{2}$ $1.550\,003 \times 10^{-3}$
current density (A/mm^2)	A/in^2 A/mm^2	A/mm^2 $A/in.^2$	$1.550\,003 \times 10^{-3}$ $6.451\,600 \times 10^{2}$
deposition rate (kg/h)	lb/h kg/h	kg/h lb/h	$0.435\,924 \times 10^{-1}$ 2.204 623
electrical resistivity ($\Omega \cdot m$)	$\Omega \cdot cm$ $\Omega \cdot m$	$\Omega \cdot m$ $\Omega \cdot cm$	$1.000\,000 \times 10^{-2}$ $1.000\,000 \times 10^{2}$
electrical force (N)	pound-force kilogram-force N	N N lbf	4.448 222 9.806 650 $2.248\,089 \times 10^{-1}$
flow rate (L/min)	ft^3/h gallon per hour gallon per minute	L/min L/min L/min	$4.719\,474 \times 10^{-1}$ $6.309\,020 \times 10^{-2}$ 3.785 412
fracture toughness ($MN \cdot m^{-3/2}$)	$ksi \cdot in.^{1/2}$ $MN \cdot m^{-3/2}$	$MN \cdot m^{-3/2}$ $ksi \cdot in.^{1/2}$	1.098 843 $9.100\,477 \times 10^{-1}$
heat input (J/m)	J/in. J/m	J/m J/in.	$3.937\,008 \times 10$ $2.540\,000 \times 10^{-2}$

Table 5—Conversions for Common Welding Terms* (Continued)

Property	To Convert From	To	Multiply By
impact energy	foot pound-force	J	1.355 818
linear measurements (mm)	in.	mm	$2.540\,000 \times 10$
	ft	mm	$3.048\,000 \times 10^{2}$
	mm	in.	$3.937\,008 \times 10^{-2}$
	mm	ft	$3.280\,840 \times 10^{-3}$
power density ($W/\times m^2$)	$W/in.^2$	W/m^2	$1.550\,003 \times 10^{3}$
	W/m^2	$W/in.^2$	$6.451\,600 \times 10^{-4}$
pressure (gas and liquid) (kPa)	psi	kPa	6.894 757
	$lbf \cdot ft^2$	kPa	$4.788\,026 \times 10^{-2}$
	N/mm^2	kPa	$1.000\,000 \times 10^{3}$
	kPa	psi	$1.450\,377 \times 10^{-1}$
	kPa	$lbf \cdot ft^2$	$2.088\,543 \times 10$
	kPa	N/mm^2	$1.000\,000 \times 10^{-3}$
pressure (vacuum) (Pa)	torr (mm Hg at 0°C)	Pa	$1.333\,224 \times 10^{2}$
	micron (μm Hg at 0°C)	Pa	$1.333\,224 \times 10^{-1}$
	Pa	torr	$7.500\,617 \times 10^{-3}$
	Pa	micron	7.500 617
	bar	psi	$1.450\,377 \times 10^{1}$

Table 5—Conversions for Common Welding Terms* (Continued)

Property	To Convert From	To	Multiply By
tensile strength (MPa)	psi	MPa	$6.894\ 757 \times 10^{-3}$
	$lbf \cdot ft^2$	MPa	$4.788\ 026 \times 10^{-5}$
	N/mm^2	MPa	1.000 000
	MPa	psi	$1.450\ 377 \times 10^{2}$
	MPa	$lbf \cdot ft^2$	$2.088\ 543 \times 10^{4}$
	MPa	N/mm^2	1.000 000
thermal conductivity (W/[m · K])	cal/(cm · s° · C)	W/(m · K)	$4.186\ 800 \times 10^{2}$
travel speed, °R or wire feed speed (mm/s)	in./min	mm/s	$4.233\ 333 \times 10^{-1}$
	mm/s	in./min	2.362 205

*Preferred units are given in parentheses.

Table 6—Length Conversions (inch to millimeter)
Inch and Millimeter Decimal Equivalents of Fractions of an Inch

1 in. = 25.4 mm. To convert in. to mm, multiply by 25.4. To convert mm to in., divide mm by 25.4.

Inch			Inch			Inch		
Fraction	Decimal	Millimeter	Fraction	Decimal	Millimeter	Fraction	Decimal	Millimeter
1/64	0.015 625	0.396 875	13/64	0.203 125	5.159 375	13/32	0.406 250	10.318 750
1/32	0.031 250	0.793 750	7/32	0.218 750	5.556 250	7/16	0.437 500	11.112 500
3/64	0.046 875	1.190 625	15/64	0.234 375	5.953 125	15/32	0.468 750	11.906 250
1/16	0.062 500	1.587 500	1/4	0.250 000	6.350 000	1/2	0.500 000	12.700 000
5/64	0.078 125	1.984 375	17/64	0.265 625	6.746 875	9/16	0.562 500	14.287 500
3/32	0.093 750	2.381 250	9/32	0.281 250	7.143 750	5/8	0.625 000	15.875 000
7/64	0.109 375	2.778 125	19/64	0.296 875	7.540 625	11/16	0.687 500	17.462 500
1/8	0.125 000	3.175 000	5/16	0.312 500	7.937 500	3/4	0.750 000	19.050 000
9/64	0.140 625	3.571 875	21/64	0.328 125	8.334 375	13/16	0.812 500	20.637 500
5/32	0.156 250	3.968 750	11/32	0.343 750	8.731 250	7/8	0.875 000	22.225 000
11/64	0.171 875	4.365 625	23/64	0.359 375	9.128 125	15/16	0.937 500	23.812 500
3/16	0.187 500	4.762 500	3/8	0.375 000	9.525 000	1	1.000 000	25.400 000

Table 6—Length Conversions (inch to millimeter) (Continued)
Inch and Millimeter Decimal Equivalents of Fractions of an Inch

1 in. = 25.4 mm. To convert in. to mm, multiply by 25.4. To convert mm to in., divide mm by 25.4.

Inch			Inch			Inch		
Fraction	Decimal	Millimeter	Fraction	Decimal	Millimeter	Fraction	Decimal	Millimeter
1-1/8	1.125 000	28.575 000	3-1/4	3.250 000	82.550 000	7-1/2	7.500 000	190.500 000
1-1/4	1.250 000	31.750 000	3-1/2	3.500 000	88.900 000	8	8.000 000	203.200 000
1-3/8	1.375 000	34.925 000	3-3/4	3.750 000	95.250 000	8-1/2	8.500 000	215.900 000
1-1/2	1.500 000	38.100 000	4	4.000 000	101.600 000	9	9.000 000	228.600 000
1-5/8	1.625 000	41.275 000	4-1/4	4.250 000	107.950 000	9-1/2	9.500 000	241.300 000
1-3/4	1.750 000	44.450 000	4-1/2	4.500 000	114.300 000	10	10.000 000	254.000 000
1-7/8	1.875 000	47.625 000	4-3/4	4.750 000	120.650 000	10-1/2	10.500 000	266.700 000
2	2.000 000	50.800 000	5	5.000 000	127.000 000	11	11.000 000	279.400 000
2-1/4	2.250 000	57.150 000	5-1/2	5.550 000	139.700 000	11-1/2	11.500 000	292.100 000
2-1/2	2.500 000	63.500 000	6	6.000 000	152.400 000	12	12.000 000	304.800 000
2-3/4	2.750 000	69.850 000	6-1/2	6.500 000	165.100 000	12-1/2	12.500 000	317.500 000
3	3.000 000	76.200 000	7	7.000 000	177.800 000	13	13.000 000	330.200 000

Table 7—Electrode Sizes (Approximate Equivalents)

in.	mm
0.030	0.8
0.035	0.9
0.040	1.0
0.045	1.1
1/16	1.6
5/64	2.0
3/32	2.4
1/8	3.2
5/32	4.0
3/16	4.8
1/4	6.4

Table 8—Fillet Weld Sizes (Approximate Equivalents)

Fillet Size (Approximate Equivalents)		Metric Fillet Size (Rational Series)[1]
in.	mm	mm
1/8	3	3
5/32	4	4
3/16	5	5
1/4	6	6
5/16	8	8
3/8	10	10
7/16	11	12
1/2	13	*
5/8	16	16
3/4	19	20
1	25	25

*No value is required in this interval for rational sizing.

[1]Rational size that would be selected for original design work rather than converting existing U.S. customary units.

Table 9—Welding Travel and Wire Feed Speeds (inches per minute to millimeters per second)

1 in./min = 0.423 mm/s. To convert in./min to mm/s, multiply by 0.423. To convert mm/s to in./min, divide by 0.423.

Find the number to be converted in the center (**boldface**) column. If converting mm/s, read the in./min equivalent in the column headed "in./min." If converting in./min, read the mm/s equivalent in the column headed "mm/s."

mm/s		in./min	mm/s		in./min	mm/s		in./min
1.69	**4**	9.46	16.92	**40**	94.56	84.60	**200**	472.81
2.54	**6**	14.18	19.04	**45**	106.38	93.06	**220**	520.09
3.38	**8**	18.91	21.15	**50**	118.20	101.52	**240**	567.38
4.23	**10**	23.64	25.38	**60**	141.84	109.98	**260**	614.66
5.08	**12**	28.37	29.61	**70**	165.48	118.44	**280**	661.94
5.92	**14**	33.10	33.84	**80**	189.13	126.90	**300**	709.22
6.77	**16**	37.83	38.07	**90**	212.77	135.36	**320**	756.50
7.61	**18**	42.55	42.30	**100**	236.41	143.82	**340**	803.78
8.46	**20**	47.28	50.76	**120**	283.69	152.28	**360**	851.06
10.58	**25**	59.10	59.22	**140**	330.97	160.74	**380**	898.34
12.69	**30**	70.92	67.68	**160**	378.25	169.20	**400**	945.63
14.81	**35**	82.74	76.14	**180**	425.53			

Table 10—Deposition Rates (pounds per hour to kilograms per hour)

1 lb/h = 0.45 kg/h. To convert lb/h to kg/h, multiply by 0.45. To convert kg/h to lb/h, divide by 0.45.

Find the number to be converted in the center (**boldface**) column. If converting lb/h, read the kg/h equivalent in the column headed "kg/h." If converting kg/h, read the lb/h equivalent in the column headed "lb/h."

lb/h		kg/h	lb/h		kg/h	lb/h		kg/h
4.44	**2**	0.9	48.89	**22**	9.9	133.33	**60**	27.0
8.89	**4**	1.8	53.33	**24**	10.8	144.44	**65**	29.25
13.33	**6**	2.7	57.78	**26**	11.7	155.56	**70**	31.50
17.78	**8**	3.6	62.22	**28**	12.6	166.67	**75**	33.75
22.22	**10**	4.5	66.67	**30**	13.5	177.78	**80**	36.0
26.67	**12**	5.4	77.78	**35**	15.75	188.89	**85**	38.25
31.11	**14**	6.3	88.89	**40**	18.0	200.00	**90**	40.50
35.56	**16**	7.2	100.00	**45**	20.25	211.11	**95**	42.75
40.00	**18**	8.1	111.11	**50**	22.50	222.22	**100**	45.0
44.44	**20**	9.0	122.22	**55**	24.75			

Table 11—Gas Flow Rates (cubic feet per hour to liters per minute)

1 ft^3/h = 0.4719 L/min. To convert ft^3/h to L/min, multiply by 0.4719. To convert L/min to ft^3/h, divide by 0.4719.

Find the number to be converted in the center (**boldface**) column. If converting ft^3/h, read the L/min equivalent in the column headed "L/min." If converting L/min, read the ft^3/h equivalent in the column headed "ft^3/h."

ft^3/h		L/min	ft^3/h		L/min
8.5	**4**	1.9	59.3	**28**	13.2
12.7	**6**	2.8	63.6	**30**	14.2
17.0	**8**	3.8	67.8	**32**	15.1
21.2	**10**	4.7	72.0	**34**	16.0
25.4	**12**	5.7	76.3	**36**	17.0
29.7	**14**	6.6	80.5	**38**	17.9
33.9	**16**	7.6	84.8	**40**	18.9
38.1	**18**	8.5	89.0	**42**	19.8
42.4	**20**	9.4	93.2	**44**	20.8
46.6	**22**	10.4	97.5	**46**	21.7
50.9	**24**	11.3	101.7	**48**	22.7
55.1	**26**	12.3	106.0	**50**	23.6

Table 12—Impact Energy (foot pounds force to joules)

1 ft lb = 1.356 J. To convert from ft lb to J, multiply by 1.356. To convert from J to ft lb, divide by 1.356.

Find the number to be converted in the center (**boldface**) column. If converting ft lb, read the J equivalent in the column headed "J." If converting J, read the ft lb equivalent in the column headed "ft lb."

ft lb		J	ft lb		J	ft lb		J
3.687	**5**	6.780	22.124	**30**	40.680	41.298	**56**	75.936
5.900	**8**	10.848	23.599	**32**	43.392	42.773	**58**	78.648
7.375	**10**	13.560	25.074	**34**	46.104	44.248	**60**	81.360
8.850	**12**	16.272	26.549	**36**	48.816	45.723	**62**	84.072
10.324	**14**	18.984	28.024	**38**	51.528	47.198	**64**	86.784
11.062	**15**	20.340	29.498	**40**	54.240	48.673	**66**	89.496
11.799	**16**	21.696	30.973	**42**	56.952	50.147	**68**	92.208
13.274	**18**	24.408	32.449	**44**	59.664	51.622	**70**	94.920
14.749	**20**	27.120	33.923	**46**	62.376	53.097	**72**	97.632
16.224	**22**	29.832	35.398	**48**	65.088	54.572	**74**	100.344
17.699	**24**	32.544	36.873	**50**	67.800	56.047	**76**	103.056
19.174	**26**	35.256	38.348	**52**	70.512	57.522	**78**	105.768
20.649	**28**	37.968	39.823	**54**	73.224	58.997	**80**	108.480

Table 13—Pressure and Stress Equivalents (pounds force per square inch to Kilopascals and thousand pounds force per square inch to Megapascals)

1 psi = 6894.757 Pa. To convert psi to pascals, multiply the psi value by $6.894\,757 \times 10^3$.
To convert pascals to psi, divide the pascal value by $6.894\,757 \times 10^3$.

*psi or *ksi	0	1	2	3	4	5	6	7	8	9
	*kPa or *MPa									
0	0.0000	6.8948	13.7895	20.6843	27.5790	34.4738	41.3685	48.2633	55.1581	62.0528
10	68.9476	75.8423	82.7371	89.6318	96.5266	103.4214	110.3161	117.2109	124.1056	131.0004
20	137.8951	144.7899	151.6847	158.5794	165.4742	172.3689	179.2637	186.1584	193.0532	199.9480
30	206.8427	213.7375	220.6322	227.5270	234.4217	241.3165	248.2113	255.1060	262.0008	268.8955
40	275.7903	282.6850	289.5798	296.4746	303.3693	310.2641	317.1588	324.0536	330.9483	337.8431
50	344.7379	351.6326	358.5274	365.4221	372.3169	379.2116	386.1064	393.0012	399.8959	406.7907
60	413.6854	420.5802	427.4749	434.3697	441.2645	448.1592	455.0540	461.9487	468.8435	475.7382
70	482.6330	489.5278	496.4225	503.3173	510.2120	517.1068	524.0015	530.8963	537.7911	544.6858
80	551.5806	558.4753	565.3701	572.2648	579.1596	586.0544	592.9491	599.8439	606.7386	613.6334
90	620.5281	627.4229	634.3177	641.2124	648.1072	655.0019	661.8967	668.7914	675.6862	682.5810
100	689.4757									

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*This table may be used to obtain SI equivalents of values expressed in psi or ksi. SI values are usually expressed in kPa when original value is in psi and in MPa when original value is in ksi.

This table may be extended to values below 1 or above 100 psi (or ksi) by manipulation of the decimal point and addition. For example, 0.9 psi = 6.205 281 Pa (decimal moved two places to the left), or 120 ksi = 827.371 MPa (decimal moved one place to the right).

Table 14—Conversions for Fahrenheit Celsius Temperature Scales

°F = 9/5 °C + 32. °C = 5/9 (°F – 32)

Find the number to be converted in the center (**boldface**) column. If converting Fahrenheit degrees, read the Celsius equivalent in the column headed "°C" on the left. If converting Celsius degrees, read the Fahrenheit equivalent in the column headed "°F" on the right.

°C		°F	°C		°F	°C		°F	°C		°F
–129	**–200**	–328	4.4	**40**	104	93	**200**	392	482	**900**	1652
–118	**–180**	–292	10.0	**50**	122	99	**210**	410	510	**950**	1742
–107	**–160**	–256	15.6	**60**	140	100	**212**	414	538	**1000**	1832
–96	**–140**	–220	21.1	**70**	158	121	**250**	484	566	**1050**	1922
–84	**–120**	–184	26.7	**80**	176	149	**300**	572	593	**1100**	2012
–73	**–100**	–148	32.2	**90**	194	177	**350**	662	621	**1150**	2102
–62	**–80**	–112	37.8	**100**	212	204	**400**	752	649	**1200**	2192
–51	**–60**	–76	43	**110**	230	232	**450**	842	677	**1250**	2282
–40	**–40**	–40	49	**120**	248	260	**500**	932	704	**1300**	2372
–34	**–30**	–22	54	**130**	266	288	**550**	1022	732	**1350**	2462
–29	**–20**	–4	60	**140**	284	316	**600**	1112	760	**1400**	2552
–23	**–10**	14	66	**150**	302	343	**650**	1202	788	**1450**	2642
–17.8	**0**	32	71	**160**	320	371	**700**	1292	816	**1500**	2732
–12.2	**10**	50	77	**170**	338	399	**750**	1382			
–6.7	**20**	68	82	**180**	356	427	**800**	1472			
–1.1	**30**	86	88	**190**	374	454	**850**	1562			

Table 15—Heat Input (kilojoules per inch to kilojoules per meter)

1 kJ/in. = 39.37 kJ/m. To convert kJ/in. to kJ/m, multiply by 39.37. To convert kJ/m to kJ/in., divided by 39.37.

For ready reference for kJ/in. to kJ/m:				For ready reference for kJ/m to kJ/in.:			
kJ/in.	kJ/m	kJ/in.	kJ/in.	kJ/in.	kJ/m	kJ/in.	kJ/m
10	393.70	60	2362.20	10.16	400	60.96	2400
15	590.55	65	2559.05	15.24	600	66.04	2600
20	787.40	70	2755.90	20.32	800	71.12	2800
25	984.25	75	2952.75	25.40	1000	76.20	3000
30	1181.10	80	3149.60	30.48	1200	81.28	3200
35	1377.95	85	3346.45	35.56	1400	86.36	3400
40	1574.80	90	3543.30	40.64	1600	91.44	3600
45	1771.65	95	3740.15	45.72	1800	96.52	3800
50	1968.50	100	3937.00	50.80	2000	101.60	4000
55	2165.35			55.88	2200		

Why SI Units?

This pocket handbook contains the accepted definition of the International System of Units (SI) as contained in the pertinent American National Standards Institute (ANSI) and International Standards Organization (ISO) documents.

The United States is one of the *very few countries* left using the U.S. customary measurement system. The world is now a global market. There will be many more conversions to SI units as U.S. companies compete in the world market.

SI is a modernized system of measurement. It was formally established in 1960 as the International System of Units, and is officially recognized by all industrial nations. It has features that make it superior to the U.S. customary system and to other metric systems. The advantages to be derived from these features require familiarity with the SI units to recognize the simplicity of their usage.

An absolute system has several advantages, the greatest of which is simplicity of calculation. For example, in SI units, a force of one newton gives a mass of one kilogram an acceleration of one meter per second squared. Confusion arises in the United States because the pound is used for either force or mass.

Coherence is the characteristic that relates any derived unit to any other, or to the base units from which it is formed, without the use of conversion factors. In SI units, a force of one newton applied through a distance of one meter does work equivalent to one joule, which equals

the work produced by one watt of power in one second.

Another desirable characteristic of SI is its use of only one unit for each physical quantity. The SI units of force, energy and power are the same regardless of whether the process is mechanical, electrical or thermal. Power, whether in engines or air conditioners, is measured in watts. By contrast, the U.S. customary system has nine commonly used units for area, twenty-five units for energy, twenty-six units for length, and so on.

SI is a decimal system, and thus, easier to use because it is easier to work in multiples of ten and in decimal notation than in the fractions and decimalized fraction equivalents common to the customary U.S. system.

The above combination of features makes SI an excellent system, suitable for all kinds of measurements. Though there remain areas that can and no doubt will be improved, SI is practical for universal application and is rapidly becoming the commonly used world measurement system.