Metric Policy

1. Introduction

1.1 UL Standards & Engagement (ULSE) has traditionally employed the US inch-pound units (US Customary Units) as the preferred units of measurement in UL Standards. The use of this system of units was appropriate, as it reflected the level of understanding of the users of UL standards. In the late 1980s and early 1990s, ULSE took a proactive stance by polling each Industry Advisory Conference (IAC) and Industry Advisory Group (IAG) about the particular industry's readiness to move towards the International System of Units (SI). Some industries chose this option, and UL standards were converted to reflect metric requirements. However, most industries opted to maintain the traditional system. With the movement of the US towards a more metric system, and with the increased harmonization with standards using SI units, ULSE has recognized the need for a more visible stance regarding SI units.

1.2 This manual provides information on ULSE's policy regarding the use of SI units, as well as information on how to convert standards to include SI units.

1.3 Regardless of which system is used, a standard shall maintain consistency throughout the document, except as noted in 1.4. A standard incorporating SI units as the preferred unit of measurement should specify measurements in SI units throughout the standard. Similarly, if inch-pound units are the primary units of measurement, the standard should be written to include inch-pound units throughout the standard. This does not preclude the inclusion of Celsius requirements in a standard using inch-pound units.

1.4 Sometimes a UL standard may include one system of units, but may reference text in another standard based on another system of units. This practice is acceptable when converting to a single system would cause confusion.

2. Glossary

2.1 For the purpose of this document, the following definitions apply.

2.2 Binational Standard – A standard that has been submitted through the standards development process of, and is published by, ULSE and either the Canadian Standards Association (CSA) or the National Association of Standardization and Certification of the Electrical Sector (ANCE), and is governed by the *Procedures for Harmonizing ANCE/CSA/UL Standards.* See 3.3.

2.3 Hard Conversion – A change in dimensions or properties of an item into a new size that might or might not be interchangeable with the sizes used in the original measurement. A hard conversion is the result of "thinking metric." The standards writer must make the difficult determination of specifying suitable metric requirements. The advantages to this type of conversion are: (1) the specifications may mean more to the international users of the standard; (2) the standard is truly a metric standard; and (3) it is a good way to coordinate the units noted in multiple standards (for example, during harmonization). Hard conversions would be measured using metric tools.

2.4 IEC-Based Standard – A UL Standard that incorporates the complete text from the IEC standard, and is governed by the *Harmonization Manual for IEC-Based UL Standards.* This term also covers ISO-Based Standards. See 3.5.

2.5 Inch-Pound Units – The units of measurement used most commonly in the United States, and propagated throughout UL standards. The bases for these units are the inch, for length measurement, and the pound, for weight measurement.

2.6 SI Units – The units of measurement developed and maintained by the General Conference on Weights and Measures and intended as a basis for worldwide standardization of measurement units. SI stands for the *International System of Units*, and is a modern form of the metric system.

2.7 Soft Conversion – A direct mathematical conversion and involving a change in the description of an existing measurement but not in the actual dimension. A soft conversion is the result of taking the inch-pound unit and converting it to specify an approximately equivalent metric dimension (For example, converting 1 inch to 25 mm). The advantages to this type of conversion are: (1) there is little effect on manufacturers; (2) the conversion is just a restatement of the current requirement; and (3) the time to develop the new requirements will be minimized, as the conversion is simplified. Soft conversions would be measured using inch-pound measurement tools.

2.8 Standard Published with Other Organization – A standard that has been submitted through the standards development process of, and is published by ULSE, and one or more organizations, other than CSA or ANCE. For example, a standard published jointly by ULSE and ULC Standards falls into this category. See 3.4.

2.9 Traditional UL Standards – A standard that is published by ULSE, and is neither harmonized with another standard, nor based on another IEC or ISO standard. See 3.2.

2.10 Trinational Standard – A standard that is subject to the standards development process of, and is published by, ULSE, CSA, and ANCE, and is governed by the *Procedures for Harmonizing ANCE/CSA/UL Standards.* See 3.3.

3. Statement of Policy

3.1 General

3.1.1 A standard shall be consistent within itself with regard to the use or non-use of SI units. A standard written with inch-pound units as the base requirement shall use inch-pound units as the base requirement throughout the standard. A standard written with SI units as the base requirement shall use SI units as the base requirement throughout the standard.

3.1.2 The requirements of 3.1.1 do not preclude the use of Celsius requirements in a standard incorporating inch-pound units.

3.1.3 Sometimes a UL standard may include one system of units, but may reference text in another standard based on another system of units. This practice is acceptable when converting to a single system would cause confusion.

3.2 Traditional UL Standards

3.2.1 Historically, UL standards incorporate inch-pound units as the preferred unit of measurement. Except as noted in this manual, metric conversions shall be provided in parentheses for each unit specified.

3.2.2 For some products, the manufacturers may desire to use metric units rather than inch-pound units in the standard. ULSE will accommodate such a request. In this case the metric unit would be given first, followed by the inch-pound conversion in parentheses.

3.2.3 The following wording shall be used in each traditional UL standard incorporating inch-pound units followed by metric units in parentheses, or incorporating metric units, followed by inch-pound units in parentheses (note that this text may be superseded by the current text entity of SGML, in which case the current text should be used):

X.X When a value for measurement is followed by a value in other units in parentheses, the first stated value is the requirement.

3.2.4 In some situations, the conversions may not be approximate, but may be such that compliance with either unit would address the requirement. For these standards, the following recommended wording should be used:

X.X When a value for measurement is followed by a value in other units, the use of either value will provide equivalent results in the application of the requirement.

3.2.5 When converting a requirement from the inch-pound system to the SI system of units, a hard conversion shall generally be used. Reasons for using a soft conversion include: a. Where trade practices dictate otherwise;

b. Where material is extracted from another standard and it is important that the requirements be the same;

c. Where dictated by industry practice; or

d. Where a hard conversion could impact safety.

3.3 Binational/Trinational Standards

3.3.1 In accordance with the *Procedures for Harmonizing ANCE/CSA/UL Standards*, all binational and trinational standards are required to be written using SI units as the base unit of measurement.

3.3.2 At the recommendation of the involved industry, inch-pound units may be provided for reference purposes, in accordance with the referenced procedures. These inch-pound units may be located in parentheses following the SI units, as an additional column in a table, or as an informative annex.

3.3.3 When inch-pound units are provided for informational purposes within a binational or trinational standard, the following recommended wording should be used:

X.X The values given in SI (metric) units are mandatory. Any other values given in inch-pound units, either in parentheses following the SI unit, or as an additional column in a table, or as an informative Annex, are for information only.

3.3.4 The Technical Harmonization Committee (THC) is responsible for determining the level of measurability of the SI unit. ULSE will verify suitability of the requirement. Using the soft conversion of the UL inch-pound unit may not be appropriate due to the inability to measure to the level of accuracy required.

3.3.5 When harmonizing the requirements of two or more standards, the use of hard metric conversions is recommended as a good way to coordinate the requirements of multiple standards.

3.4 Standards Published with Other Organizations

3.4.1 It is recommended that all standards co-published with other organizations be written using metric units as the base unit of measurement. The inch-pound units may be provided in parentheses for informational purposes. See also 3.3.5.

3.4.2 If the manufacturers desire to use inch-pound units rather than SI units, ULSE will accommodate such a request. In this case, the inch-pound unit should be given first, followed by the SI unit in parentheses.

3.4.3 The information provided in 3.2.3 and 3.2.4 applies to standards harmonized with other organization’s standards.

3.5 IEC-Based Standards

3.5.1 When adopting an IEC standard within a UL standard, the base units specified in the IEC standard, generally metric, shall be the base units for the UL standard.

3.5.2 If needed for reference purposes, an informative table providing equivalent inch-pound conversions may be provided in the UL IEC-based standard.

3.5.3 In accordance with the *Harmonization Manual for IEC-Based UL Standards*, ULSE may introduce deviations to the IEC text. In these cases, the deviations shall be introduced using the same base units. Except as noted in 3.5.4, a realistic and measurable SI unit shall be used.

3.5.4 A US deviation that is based on a ULSE requirement where the exact measurement is critical (such as an electrical spacing) may best be accomplished by using a soft conversion of the current ULSE requirement. This will allow the deviation to reflect the same requirement as would normally be required in the UL standard (and eliminate the need for an industry review of products certified to the UL requirement).

4. Converting to SI Units

4.1 US/SI Equivalence

4.1.1 Tables 4.1 and 4.2 provide the mathematical relationship between the inch-pound units and the SI units. The information included in Table 4.1 is listed alphabetically, while Table 4.2 includes units grouped by categories.

Standards & Engagement

Table 4.1
Alphabetical Listing of Conversions

To convert from	To	Multiply by
acre-foot	Cubic meter (m^3)	1 233.5
ampere hour	Coulomb (C)	3 600
atmosphere, standard	Pascal (Pa) Kilopascal (kPa)	1.013 25 E+05 101.325
atmosphere, technical (1 kgf/cm^2)	Pascal (Pa) Kilopascal (kPa)	9.806 65 E+04 98.066 5
Bar	Pascal (Pa) Kilopascal (kPa)	1.0 E+05 100
barrel (oil, 42 US gallons)	Cubic meter (m^3) liter (L)	0.158 987 3 158.987 3
British thermal unit (Btu) (International Table)	joule (J)	1 055. 056
British thermal unit (Btu) (thermochemical)	joule (J)	1 054. 350
Btu foot per hour square foot degree Fahrenheit (Btu·ft/(h·ft^2·°F)	watt per meter kelvin [W/(m·K)]	1. 730 735
Btu inch per hour square foot degree Fahrenheit [Btu·in/(h·ft^2·°F)]	watt per meter kelvin [W/(m·K)]	0.144 227 9
Btu per cubic foot (Btu/ft^3)	joule per cubic meter (J/m^3)	3.725 895 E+04
Btu per degree Fahrenheit (Btu/°F)	joule per kelvin (J/K)	1 899.101
Btu per hour (Btu/h)	watt (W)	0.293 071 1
Btu per hour square foot [Btu/(h·ft^2)]	watt per square meter (W/m^2)	3.154 591

To convert from	To	Multiply by
Btu per hour square foot degree Fahrenheit [Btu/(h·ft^2·°F)]	watt per square meter kelvin [W/(m^2·K)]	5.678 263
Btu per pound (Btu/lb)	joule per kilogram (J/kg)	2 326
Btu per pound degree Fahrenheit [Btu/(lb·°F)]	joule per kilogram kelvin [J/(kg·K)]	4 186.8
Btu per second (Btu/s)	watt (W)	1 055. 056
Btu per square foot (Btu/ft^2)	joule per square meter (J/m^2)	1.135 653 E+04
bushel (US dry)	Cubic meter (m^3)	0.035 239 07
calorie per square centimeter second [cal/(cm^2·s)]	watt per square meter (W/m^2)	4.184 E+04
candela per square inch (cd/in^2)	Candela per square meter (cd/m^2)	1 550.003
Centimeter of water	Pascal (Pa)	98.066 5
circular mil	Square millimeter (mm^2)	5.067 075 E-04
cubic foot (ft^3)	Cubic meter (m^3)	0.028 316 85
cubic foot per minute (cfm)	Cubic meter per second (m^3/s) liter per second (L/s)	4.719 474 E-04 0.471 947 4
cubic foot per second (ft^3/s)	Cubic meter per second (m^3/s)	0.028 316 85
cubic inch (in^3)	Cubic meter (m^3)	1.638 706 4 E-05
cubic inch per minute (in^3/min)	Cubic meter per second (m^3/s)	2. 731 177 E-07
cubic yard (yd^3)	Cubic meter (m^3)	0.764 554 9
cubic yard per minute (yd^3/min)	Cubic meter per second (m^3/s)	0. 012 742 58
cup (US)	Cubic meter (m^3) liter (L) milliliter (mL)	2.366 E-04 0.236 6 236.6

To convert from	To	Multiply by
Degree	Radian (rad)	$\pi/180$ = 0.017 453 29
degree Fahrenheit (°F) (interval)	Degree Celsius (°C)	0.555 555 6
degree Fahrenheit (°F) (temperature)	Degree Celsius (°C)	$t_{°C}=(t_{°F}-32)/1.8$
degree Fahrenheit hour per Btu (°F·h/Btu)	Kelvin per watt (K/W)	1.895 634
degree Fahrenheit square foot hour per Btu (°F·ft^2·h/Btu)	Kelvin square meter per watt (K·m^2/W)	0.176 110 2
degree Fahrenheit square foot hour per Btu inch [°F·ft^2·h/(Btu·in)]	Kelvin meter per watt (K·m/W)	6.933 472
faraday (based on carbon 12)	Coulomb (C)	9.648 531 E+04
foot	Meter (m)	0.304 8
foot of water	Pascal (Pa) Kilopascal (kPa)	2 989.07 2. 989 07
foot per hour (ft/h)	Meter per second (m/s)	8.466 667 E-05
foot per minute (ft/min)	Meter per second (m/s)	0.005 08
foot per second (ft/s)	Meter per second (m/s)	0.304 8
foot per second squared (ft/s^2)	Meter per second squared (m/s^2)	0.304 8
foot pound-force (ft·lbf) (torque)	Newton meter (N·m)	1.355 818
foot pound-force (ft·lbf) (energy)	joule (J)	1.355 818
foot pound-force per hour (ft·lbf/h)	watt (W)	3.766 161 E-04
foot pound-force per minute (ft·lbf/min)	watt (W)	0.022 596 97
foot pound-force per second (ft·lbf/s)	watt (W)	1.355 818
gallon (Imperial)	Cubic meter (m^3)	4.546 09 E-03

To convert from	To	Multiply by
	liter (L)	4.546 09
gallon (US)(231 in^3)	Cubic meter (m^3) liter (L)	3.785 412 E-03 3.785 412
gallon (US) per day	Cubic meter per second (m^3/s) liter per second (L/s)	4.381 264 E-08 4.381 264 E-05
gallon (US) per minute (gpm)	Cubic meter per second (m^3/s) liter per second (L/s)	6.309 020 E-05 0.063 090 20
gallon (US) per horsepower hour	Cubic meter per joule (m^3/J)	1.410 089 E-09
Horsepower (550 ft·lbf/s)	watt (W)	745. 699 9
inch	Meter (m)	0.025 4
inch of mercury	Pascal (Pa) Kilopascal (kPa)	3386.39 3.386 39
inch of water	Pascal (Pa)	249.089
inch ounce-force	Newton meter (N·m) Millinewton meter (mN·M)	7.61 552 E-03 7.061 552
inch pound-force (in·lbf)	Newton meter (N·m)	0.112 984 8
mil (0.001 in)	Meter (m) Millimeter (mm)	2.54 E-05 0.025 4
mil (angle)	Radian (rad) Degree (°)	$2\pi/6400$= 9.817 477 E-04 0.056 25
mile, nautical	Meter (m)	1 852
mile, US statute	Meter (m)	1 609.347
mile per gallon (US)(mpg)	Meter per cubic meter (m/m^3) Kilometer per liter (km/L)	4.251 437 E+05 0.425 143 7
mile per hour	Meter per second (m/s) kilometer per hour (km/h)	0.447 04 1.609 344
mile per minute	meter per second (m/s)	26.822 4
millibar	pascal (Pa)	100

To convert from	To	Multiply by
	kilopascal (kPa)	0.1
millimeter of mercury	pascal (Pa)	133.322 4
minute (arc)	radian (rad)	2.908 882 E-04
ohm circular-mil per foot	ohm meter (Ω·m) ohm square millimeter per meter ($\Omega \cdot mm^2/m$)	1.662 426 E-09 0.001 662 426
ounce	cubic meter (m^3) milliliter (mL)	2.957 353 E-05 29.573 53
ounce-force	newton (N)	0.278 013 9
ounce per square foot (oz/ft^2)	kilogram per square meter (kg/m^2)	0.305 151 7
ounce per square yard (oz/yd^2)	kilogram per square meter (kg/m^2)	0.033 905 75
pint (US dry)	cubic meter (m^3) liter (L)	5.506 1 E-04 0.550 61
pint (US liquid)	cubic meter (m^3) liter (L)	4.731 76 E-04 0.473 176
pound (avoirdupois)	kilogram (kg)	0.453 592 37
pound (troy or apothecary)	kilogram (kg)	0.373 241 7
pound-force	newton (N)	4.448 222
pound-force foot (lbf·ft) (torque)	newton meter (N·m)	1.355 818
pound-force per foot (lbf/ft)	newton per meter (N/m)	14.593 90
pound-force per inch (lbf/in)	newton per meter (N/m)	175.126 8
pound-force per pound (lbf/lb)	newton per kilogram (N/kg)	9.806 65
pound-force per square foot (lbf/ft^2)(psf)	pascal (Pa)	47.880 26
pound-force per square inch (lbf/in^2) (psi)	pascal (Pa) kilopascal (kPa)	6 894. 757 6.894 757
pound-force second per	pascal second (Pa·s)	47.880 26

To convert from	To	Multiply by
square foot (lbf·s/ft^2)		
pound-force second per square inch (lbf·s/in^2)	pascal second (Pa·s)	6 894. 757
pound per cubic foot (lb/ft^3)	kilogram per cubic meter (kg/m^3)	16.018 46
pound per cubic inch (lb/in^3)	kilogram per cubic meter (kg/m^3)	2.767 990 E+04
pound per cubic yard (lb/yd^3)	kilogram per cubic meter (kg/m^3)	0.593 276 4
pound per foot (lb/ft)	kilogram per meter (kg/m)	1.488 164
pound per foot hour [lb/(ft·h)]	pascal second (Pa·s)	4.133 789 E-04
pound per gallon (US)(lb/gal)	kilogram per cubic meter (kg/m^3) kilogram per liter (kg/L)	119.826 4 0.119 826 4
pound per hour (lb/h)	kilogram per second (kg/s)	1.259 979 E-04
pound per inch (lb/in)	kilogram per meter (kg/m)	17.857 97
pound per minute (lb/min)	kilogram per second (kg/s)	0.007 559 873
pound per square foot	kilogram per square meter (kg/m^2)	4.882 428
pound per horsepower hour [lb/(hp·h)]	kilogram per joule (kg/J)	1.689 659 E-07
pound per yard (lb/yd)	kilogram per meter (kg/m)	0.496 054 6
quart (US dry)	cubic meter (m^3) liter (L)	0.001101 221 1.101 221
quart (US liquid)	cubic meter (m^3) liter (L)	9.463 529 E-04 0.946 352 9
revolution	radian (rad)	2π = 6.283 185
revolution per minute (rpm)	radian per second (rad/s)	$2\pi/60$ = 0.104 719 8
second	radian (rad)	4.84 137 E-06
slug	kilogram (kg)	14.593 90

To convert from	To	Multiply by
square foot (ft^2)	square meter (m^2)	0.092 903 04
square foot per hour (ft^2/h)	square meter per second (m^2/s)	2.580 64 E-05
square inch (in^2)	square meter (m^2)	6.451 6 E-04
square mile	square meter (m^2)	2.589 988 E+06
square yard (yd^2)	square meter (m^2)	0.836 127 4
tablespoon	cubic meter (m^3) milliliter (mL)	1.479 E-05 14.79
teaspoon	cubic meter (m^3) milliliter (mL)	4.929 E-06 4.929
ton of refrigeration (12000 Btu/h)	watt (W)	3 517
watt hour	joule (J)	3 600
watt per square inch (W/in^2)	watt per square meter (W/m^2)	1 550. 003
yard	meter (m)	0.914 4

Table 4.2
Measurement Characteristic Listing of Conversions

To convert from	To	Multiply by
	Angle	
Degree	Radian (rad)	$\pi/180$ = 0.017 453 29
Mil	Radian (rad) Degree (°)	$2\pi/6400$ = 9.817 477 E-04 0.056 25
Minute (arc)	Radian (rad)	2.908 882 E-04
Revolution	Radian (rad)	2π = 6.283 185
Second	Radian (rad)	4.848 137 E-06
	Length	
Foot	Meter (m)	0.304 8
Inch	Meter (m)	0.025 4
Mil (0.001 in)	Meter Millimeter	2.54 E-05 0.025 4
Mile, nautical	Meter (m)	1 852
Mile, US statute	Meter (m)	1 609.347
Yard	Meter (m)	0.9144
	Area	
Circular mil	Square meter (m^2) Square millimeter (m^2)	5.067 075 E-10 5.067 075 E-04
Square foot (ft^2)	Square meter (m^2)	0.092 903 04
Square inch (in^2)	Square meter (m^2)	6.451 6 E-04
Square mile	Square meter (m^2)	2.589 988 E+06
Square yard (yd^2)	Square meter (m^2)	0.836 127 4
	Volume (Includes Capacity)	
Acre-foot	Cubic meter (m^3)	1 233.5
Barrel (oil, 42 US gallons)	Cubic meter (m^3) Liter (L)	0.158 987 3 158.987 3
Bushel (US)	Cubic meter (m^3)	0.035 239 07
Cubic foot (ft^3)	Cubic meter (m^3)	0.028 316 85
Cubic inch (in^3)	Cubic meter (m^3)	1.638 706 4 E-05
Cubic yard (yd^3)	Cubic meter (m^3)	0.764 554 9
Cup (US)	Cubic meter (m^3) Liter (L) Milliliter (mL)	2.366 E-04 0.236 6 236.6
Gallon (Imperial)	Cubic meter (m^3) Liter (L)	4.546 09 E-03 4.546 09
Gallon (US) (231 in^3)	Cubic meter (m^3) Liter (L)	3.785 412 E-03 3.785 412
Pint (US dry)	Cubic meter (m^3) Liter (L)	5.506 1 E-04 0.550 61

Pint (US liquid)	Cubic meter (m^3) Liter (L)	4.731 76 E-04 0.473 176
Quart (US dry)	Cubic meter (m^3) Liter (L)	0.001 101 221 1.101 221
Quart (US liquid)	Cubic meter (m^3) Liter (L)	9.463 529 E-04 0.946 352 9
Tablespoon	Cubic meter (m^3) Milliliter (mL)	1.479 E-05 14.79
Teaspoon	Cubic meter (m^3) Milliliter (mL)	4.929 E-06 4.929
Velocity (Includes Speed)		
Foot per hour (ft/h)	Meter per second (m/s)	8.466 667 E-05
Foot per minute (ft/min)	Meter per second (m/s)	0.005 08
Foot per second (ft/s)	Meter per second (m/s)	0.304 8
Mile per hour	Meter per second (m/s) Kilometer per hour (km/h)	0.447 04 1.609 344
Mile per minute	Meter per second (m/s)	26.822 4
Revolution per minute (rpm)	Radian per second (rad/s)	$2\pi /60$ = 0.104 719 8
Acceleration		
Foot per second squared	Meter per second squared (m/s^2)	0.304 8
Cubic foot per minute (cfm)	Cubic meter per second (m^3/s) Liter per second (L/s)	4.719 474 E-04 0.471 947 4
Cubic foot per second (ft^3/s)	Cubic meter per second (m^3/s)	0.028 316 85
Cubic inch per minute (in^3/min)	Cubic meter per second (m^3/s)	2.731 177 E-07
Cubic yard per minute (yd^3/min)	Cubic meter per second (m^3/s)	0.012 742 58
Gallon (US) per day	Cubic meter per second (m^3/s) Liter per second (L/s)	4.381 264 E-08 4.381 264 E-05
Gallon (US) per minute	Cubic meter per second (m^3/s) Liter per second (L/s)	6.309 020 E-05 0.063 090 20
Mass		
Pound (avoirdupois)	Kilogram (kg)	0.453 592 37
Pound (troy or apothecary)	Kilogram (kg)	0.373 241 7
Slug	Kilogram (kg)	14.593 90
Mass per Unit Time (Includes Flow)		
Pound per hour (lb/h)	Kilogram per second (kg/s)	1.259 979 E-04
Pound per minute (lb/min)	Kilogram per second (kg/s)	0.007 559 873

Mass per Unit Length		
Pound per foot (lb/ft)	Kilogram per meter (kg/m)	1.488 164
Pound per inch (lb/in)	Kilogram per meter (kg/m)	17.857 97
Mass per Unit Area		
Ounce per square foot (oz/ft^2)	Kilogram per square meter (kg/m^2)	0.305 151 7
Ounce per square yard (oz/yd^2)	Kilogram per square meter (kg/m^2)	0.033 905 75
Pound per square foot	Kilogram per square meter (kg/m^2)	4.882 428
Mass per Unit Volume (Includes Density and Mass Concentration)		
Pound per gallon (US) (lb/gal)	Kilogram per cubic meter (kg/m^3) Kilogram per liter (kg/L)	119.826 4 0.119826 4
Pound per cubic foot (lb/ft^3)	Kilogram per cubic meter (kg/m^3)	16.018 46
Pound per cubic inch (lb/in^3)	Kilogram per cubic meter (kg/m^3)	2.767 990 E+04
Pound per cubic yard (lb/yd^3)	Kilogram per cubic meter (kg/m^3)	0.593 276 4
Force		
Ounce-force	Newton (N)	0.278 013 9
Pound-force	Newton (N)	4.448 222
Force per Unit Length		
Pound-force per foot	Newton per meter (N/m)	14.593 90
Pound-force per inch	Newton per meter (N/m)	175.126 8
Thrust to Mass Ratio		
Pound-force per pound	Newton per kilogram (N/kg)	9.806 65
Bending Moment or Torque		
Foot pound-force	Newton meter (N·m)	1.355 818

Pressure or Stress (Force per Unit Area)		
Atmosphere, standard	Pascal (Pa) Kilopascal (kPa)	1.013 25 E+05 101.325
Atmosphere, technical (1 kgf/cm^2)	Pascal (Pa) Kilopascal (kPa)	9.806 65 E+05 98.066 5
Bar	Pascal (Pa) Kilopascal (kPa)	1.0 E+05 100
Centimeter of water	Pascal (Pa)	98.066 5
Foot of water	Pascal (Pa) Kilopascal (kPa)	2 989.07 2.989 07
Inch of mercury	Pascal (Pa) Kilopascal (kPa)	3 386.39 3.386 39
Inch of water	Pascal (Pa)	249.089
Millibar	Pascal (Pa) Kilopascal (kPa)	100 0.1
Millimeter of mercury	Pascal (Pa)	133.322 4
Pound-force per square foot (psf)	Pascal (Pa)	47.880 26
Pound-force per square inch (psi)	Pascal (Pa) Kilopascal (kPa)	6 894.757 6.894757
Viscosity		
Pound-force second per square foot	Pascal second (Pa·s)	47.880 26
Pound force second per square inch	Pascal second (Pa·s)	6 894.757
Pound per foot hour	Pascal second (Pa·s)	4.133 789 E-04
Square foot per hour	Square meter per second (m^2/s)	2.580 64 E-05
Energy and Work		
British Thermal Unit (BTU) (International Table)	Joule (J)	1 055.056
British Thermal Unit (BTU)	Joule (J)	1 054.350
Foot pound-force	Joule (J)	1.355 818
Watthour	Joule (J)	3 600
Energy per Unit Area Time		
Watt per square inch	Watt per square meter (W/m^2)	1 550.003
Power		
Foot pound-force per hour	Watt (W)	3.766 161 E-04
Foot pound-force per minute	Watt (W)	0.022 596 97
Foot pound-force per second	Watt (W)	1.355 818
Horsepower (550 ft·lbf/s)	Watt (W)	745.699 9

Temperature		
Degree Fahrenheit (°F)	Degree Celsius (°C)	$t_{^\circ C}=(t_{^\circ F}-32)/1.8$
Degree Fahrenheit (°F)	Kelvin (K)	$T_K = (t_{^\circ F} + 459.67)/1.8$
Temperature Interval		
Degree Fahrenheit (°F)	Kelvin (K)	0.555 555 6
Degree Fahrenheit (°F)	Degree Celsius (°C)	0.555 555 6
Thermal Energy		
British thermal unit (BTU) (International Table	Joule (J)	1 055.056
Heat Flow Rate		
BTU per hour	Watt (W)	0.293 071 1
BTU per second	Watt (W)	1 055.056
Ton of refrigeration (12000 BTU/h)	Watt (W)	3 517
Density of Heat Flow Rate		
BTU per hour square foot	Watt per square meter (W/m^2)	3.154 591
BTU per second square foot	Watt per square meter (W/m^2)	1.135 653 E+04
Thermal Conductivity		
BTU foot per hour square foot degree Fahrenheit [$BTU/(h \cdot ft^2 \cdot {^\circ F})$]	Watt per square meter kelvin [$W/(m^2 \cdot K)$]	5.678 263
BTU inch per hour square foot degree Fahrenheit	Watt per meter kelvin [$W/(m \cdot K)$]	0.144 227 9
Coefficient of Heat Transfer		
BTU foot per hour square foot degree Fahrenheit [$BTU \cdot Ft/h \cdot ft^2 \cdot {^\circ F}$]	Watt per meter kelvin [$W/(m \cdot K)$]	1. 730 735
Thermal Resistance		
Degree Fahrenheit hour per BTU	Kelvin per watt (K/W)	1.895 634
Thermal Diffusivity		
Square foot per hour	Square meter per second (m^2/s)	2.580 64 E-05

Heat Capacity and Entropy		
BTU per degree Fahrenheit	Joule per kelvin (J/K)	1 899.101
Specific Heat Capacity		
BTU per pound degree Fahrenheit	Joule per kilogram kelvin [J/(kg·K)]	4 186.8
Density of Heat		
BTU per square foot	Joule per square meter (J/m^2)	1.135 653 E+04
Internal Energy		
BTU per cubic foot	Joule per cubic meter (J/m^3)	3.725 895 E+04
BTU per pound	Joule per kilogram (J/kg)	2 326
Fuel Consumption		
Gallon (US) per horsepower hour	Cubic meter per joule (m^3/J)	1.410 089 E-09
Mile per gallon (US) (mpg)	Meter per cubic meter (m/m^3) Kilometer per liter (km/L) Liter per 100 kilometers (L/100km)	4.251 437 E+05 0.425 143 7 divide 235.215 by the number of miles per gallon
Pound per horsepower hour	Kilogram per joule (kg/J)	1.689 659 E-07
Electricity and Magnetism		
Ampere hour	Coulomb (C)	3 600
Faraday (based on Carbon 12)	Coulomb (C)	9.648 531 E+04
Ohm circular-mil per foot	Ohm square millimeter per meter $\Omega \cdot mm^2/m$)	0.001 662 426
Light		
Candela per square inch	Candela per square meter (cd/m^2)	1 550.003

4.2 Establishing the Requirement

4.2.1 Issues to Consider

4.2.1.1 When establishing a new value for a requirement, the following issues should be considered:

a. Safety impact (for example, will a slightly reduced spacing affect the level of safety of the product?)
b. Test equipment (what limitations are introduced by the existing test equipment?)
c. Measurement ability (how accurately can the available test equipment measure the specification?)
d. Tooling issues (would the manufacturer need to retool in order to manufacture the product according to the new specifications?)
e. Parts supplier issues (would component manufacturers or other parts suppliers need to make changes in order to meet the new specifications?)

f. Impact on industry (would the manufacturer need to redesign the product to meet the new specifications?)

4.2.1.2 Although much of the burden of converting to SI units will likely fall on the Standards Department, it is important that the Conformity Assessment Services (CAS) Staff be involved in the decisions as noted in 4.2.1.1. The CAS Staff will be responsible for verifying that the values listed are measurable.

4.2.2 All Standards

4.2.2.1 Pipe dimensions shall be stated using the US size designation. The many factors of wall thickness, material specifications, threads, and tolerances shall be covered by referencing the appropriate ASTM, ASME, ANSI, or other standard. Metric trade numerical designations are:

a. 1/2 = 16;
b. 3/4 = 21;
c. 1 = 27;
d. 1 1/4 = 35;
e. 1 1/2 = 41;
f. 2 = 53;
g. 2 1/2 = 63;
h. 3 = 78;
i. 3 1/2 = 91; and
j. 4 = 103.

4.2.2.2 Sheet metal thickness shall be stated in decimal unit minimums in inches, followed by the minimum equivalent thicknesses in millimeters in parentheses. Unless used by the industry involved, the MSG or other gage designations shall not be included.

4.2.2.3 The thickness of electrical insulation, coatings, or the like, shall be given in their decimal unit minimums rather than nominal dimensions. The minimum average and the minimum at any point may be needed in some cases.

4.2.3 Standards Using SI Base Units

4.2.3.1 Avoid defining requirements in terms of SI units that are not practically measurable or do not reflect the accuracy contemplated by the original requirement (For example, 32.675 mm is not an easily measureable quantity).

4.2.3.2 In the example of spacings or measurements, it is recommended that values be set using 5 mm increments to make measurement easier and more repeatable.

4.2.3.3 In general, the following may be used as a guideline in converting from inch-pound units to SI units:

a. For dimensions given in decimal form (for example, 0.500 inch, 1.250 inch, etc.) the conversion to millimeters shall be to one less decimal place (for example, to 12.70 mm, 31.75 mm, etc.).
b. For dimensions given in a form for which the millimeter equivalent is less than 100 mm (for example, 2 inches, 1-3/8 inches, 1/2 inch, etc.), the conversion to millimeters shall be to the first decimal place (for example, to 50.8 mm, 34.9 mm, 12.7 mm, etc.).
c. For dimensions given in a form for which the millimeter equivalent is greater than 100 but less than 1000 mm (for example, 6 inches, 8 inches, 24 inches, 28-1/2 inches, etc.), the conversion to millimeters shall be to the nearest whole millimeter (for example, 152 mm, 203 mm, 610 mm, 724 mm, etc.)
d. For dimensions given in a form for which the millimeter equivalent is greater than 1000 mm (for example, 40 inches, 48 inches, 72 inches, etc.), the dimension may be replaced by a dimension in feet or feet and inches, if possible (for example, 3 feet 4 inches, 4 feet, 6 feet, etc.), then converted to a dimension in meters given to the nearest hundredth place (for example, 1.02 m, 1.22 m, 1.83 m, etc.).

5. Style and Usage

5.1 Spelling

5.1.1 For a UL only standard, or a binational or trinational standard, the US spelling for the SI terms shall be used, for example, meter and liter.

5.1.2 For a standard harmonized with an IEC standard, the spelling used in the IEC standard shall be used. This most likely will result in the following spelling types: metre and litre.

5.2 Symbols

5.2.1 In the SI System, symbols represent units, such as m for meter. Because unit symbols are not abbreviations, they shall be written according to the rules noted in 5.2.2 – 5.2.7. The proper symbols for the units of measurement are noted in the table in 4.1.

5.2.2 Symbols shall be noted in roman (upright) type, regardless of the type style used in the surrounding text.

5.2.3 Symbols shall not be altered in the plural (for example, 5 mm, not 5 mms).

5.2.4 The SI symbol shall not be followed by a period except when used at the end of a sentence.

5.2.5 Other than Liter which is symbolized by L, all letter unit symbols shall be written in lowercase letters, unless the unit name has been derived from a proper name, in which case the first letter is capitalized (for example, Pa).

5.2.6 When the value for a quantity is expressed as a numerical value and a unit symbol, a space shall be left between them. For example, write 25 mm, not 25mm. There shall be no space between the number and the symbols for degree and minute. For example, write 25°C, not 25 °C.

5.2.7 Symbols, and not abbreviations, shall be used for units. For example, use A, not amp, to represent ampere.

5.3 Prefixes

5.3.1 Prefixes shall be written in uppercase or lowercase letters as noted in Table 5.1.

Table 5.1
Prefix Definitions

Multiplication Factor	**Prefix**	**Symbol**
10^9	giga	G
10^6	mega	M
10^3	kilo	k
10^{-2}	centi	c
10^{-3}	milli	m
10^{-6}	micro	µ

5.3.2 The SI prefixes shall be used to indicate orders of magnitude. An SI prefix shall never be used alone.

5.3.3 The prefix directly precedes the SI symbol. No space shall be left between the prefix and the unit symbols. For example, 1000 meters would be symbolized by 1 km.

6. References

6.1 The following publications were used as sources for this manual. These documents may be used for additional information on the use of SI units.

IEEE/ASTM SI 10-1997, Standard for Use of the International System of Units (SI): The Modern Metric System (Revision and Resignation of ANSI/IEEE Std 268-1992 and ASTM E380).

CAN/CSA Z234.1-89, Canadian Metric Practice Guide, General Instruction No. 1 R(1995)

NIST Special Publication 330, The International System of Units (SI), 1991 Edition

Contact Patricia Sena, Standards Accreditations Manager, (Patricia.A.Sena@ul.org) with questions or concerns regarding the Metric Policy for UL Standards & Engagement.