METRIC UNITS TO U.S. CUSTOMARY UNITS
GENERAL PRIMER
California Department of Transportation

CONTENTS

I. Purpose

This Primer is the Department's basic guide for conversion from Metric units to U.S. Customary units. The tables and information contained herein serve as a primer or introduction to U.S. Customary units and conversion factors as well as some engineering considerations.

The Metric to English Transition Team developed the Primer. The Primer is a compilation of information from a number of reliable sources and reflects Team consensus. A preponderance of existing private and government publications deal exclusively with transition from U.S. Customary units to Metric units, not Metric to U.S. Customary. Metric to U.S. Customary transition is unique, hence the need for this Primer.

U.S. Customary units (a.k.a. "inch-pound" or "pound-inch" units) are defined by the National Institute of Standards and Technology (NIST). (*Web address:* http://ts.nist.gov/ts/htdocs/200/202/mpo_home.htm)

Users should become familiar with NIST and other equally reliable sources to obtain knowledge and skills exceeding the scope of this Primer. Appendix C of "Handbook 44 – 2004, Table 4" (available on the NIST web site) contains official U.S. Units of Measurement and Conversion Factors.

Another good resource is Caltrans Special Provision S8-M01. It contains material and product (Metric/English) substitutions for wire, re-bar, steel fasteners, sheet metal, pipe piles, concrete piling, timber and lumber, nails and spikes, and irrigation components.
(*Web address:* http://www.dot.ca.gov/hq/esc/oe/specifications/SSPs/99_04-SSPs/SSPIndex/)

Overall, be careful. Be confident of your sources and your methodology. Use sound engineering principles and judgement. Check your work.

II. U.S. Survey Foot

In 1893, the U.S. foot was legally defined as 1200/3937 meters. In 1959, a refinement was made to bring the foot into agreement with the definition used in other countries, i.e. 0.3048 meters. At the same time, it was decided that any data in feet derived from and published as a result of geodetic surveys within the U.S. would remain with the old standard, which is named the U.S. survey foot. The new length is shorter by exactly two parts in a million. (*Reference:* Federal Standard 376B, January 27, 1993)

The California Public Resources Code Section 8810 (below) is the legal basis for using the U.S. Survey Foot in California for state plane coordinates.

> 8810. The plane coordinates of a point on the earth's surface, to be used in expressing the position or location of the point in the appropriate zone of CCS27 or CCS83, shall consist of two distances, expressed in feet and decimals of a foot or meters and decimals of a meter. When the values are expressed in feet, the "U.S. Survey foot," (one foot = 1200/3937 meters) shall be used as the standard foot for CCS27 and CCS83. One of these distances, to be known as the "East x-coordinate," shall give the distance east of the Y axis; the other, to be known as the "North y-coordinate," shall give the distance north of the X axis. The Y axis of any zone shall be parallel with the central meridian of that zone. The X axis of any zone shall be at right angles to the central meridian of that zone.

TABLE 1 -- EXACT Conversion Factors

	When you know Metric	*Multiply by*	*To find* U.S. Survey Exact Value
Length	meter (m)	$^{3937}/_{1200}$	foot (ft)*
		$^{3937}/_{3600}$	yard (yd)
	millimeter (mm)	$^{3937}/_{100000}$	inch (in)
		$^{3937}/_{1200000}$	foot (ft)
	kilometer (km)	$^{39370}/_{12}$	foot (ft)
		$^{3937}/_{6336}$	mile (mi)
Area	square millimeter (mm^2)	$(^{3937}/_{100000})^2$	square inch (in^2)
		$(^{3937}/_{1200000})^2$	square foot (ft^2)
	square meter (m^2)	$(^{3937}/_{1200})^2$	square foot (ft^2)
		$(^{3937}/_{3600})^2$	square yard (yd^2)
		$\frac{(^{3937}/_{1200})^2}{43560}$	acre**
	square kilometer (km^2)	$(^{3937}/_{6336})^2$	square mile (mi^2)
		$\frac{(^{39370}/_{12})^2}{43560}$	acre
	hectare (ha)	$\frac{(^{3937}/_{12})^2}{43560}$	acre
		$\frac{(^{3937}/_{12})^2}{43560(640)}$	square mile (mi^2)***

* Exact, by definition of U.S. Survey foot, Section 8810, State of California Public Resources Code (CPRC).
U.S. Survey foot is $^{1200}/_{3937}$ meter (exactly). This value is accurate for any number of significant digits.
Other values shown in Table 1 derive from the U.S. Survey definition and are exact on the same basis.
Note: Most conversion calculators use the International definition of "1 foot = 0.3048 meters (exactly)."
The International foot is shorter by a difference of 2 parts per million (see Example 1 below).

EXAMPLES:

1) A typical "EASTING" in a state plane coordinate zone is 2,000,000.00 meters, which contains 9 significant digits.
YES (U.S. Survey): 2,000,000.00 meters x ($^{3937}/_{1200}$) foot per meter = 6,561,666.67 feet
NO (International): 2,000,000.00 meters x ($^{1}/_{0.3048}$) foot per meter = 6,561,679.79 feet
Difference -13.12 feet

2) An area is 22,353 hectares, which contains 5 significant digits.
Calculation: 22,353 ha x $\frac{(^{3937}/_{12})^2}{43560(640)}$ mi^2 per ha = 86.30507028 mi^2
Rounding to nearest 1,000th of a square mile yields a value of 86.305 mi^2

Note: It is important to use a calculator capable of carrying out the calculation to the required number of digits.
Otherwise, internal rounding errors will occur.
Both calculations for the examples above were performed using a Microsoft EXCEL spreadsheet.

** Acre = 43,560 square feet.

***Square mile = 640 acres.

III. Generalized Conversion Tables

TABLE 2 -- APPROXIMATE Conversion Factors (**4** Significant Digits)

	When you know **Metric**	***Multiply by***	***To find*** **U.S. Customary**
Length	millimeter (mm)	**0.03937**	inch (in)
		0.003281	foot (ft)
	meter (m)	**3.281**	foot (ft)
		1.094	yard (yd)
	kilometer (km)	**3,281**	foot (ft)
		0.6214	mile (mi)
Area	square millimeter (mm^2)	**0.001550**	square inch (in^2)
		0.00001076	square foot (ft^2)
	square meter (m^2)	**10.76**	square foot (ft^2)
		1.196	square yard (yd^2)
		0.0002471	acre
	square kilometer (km^2)	**0.3861**	square mile (mi^2)
		247.1	acre
	hectares (ha)	**2.471**	acre
		0.003861	square mile (mi^2)
Volume	milliliter (mL)	**0.03381**	fluid ounce (fl oz)
	liter (L)	**1.057**	quart (qt)
		0.2642	gallon (gal)
		61.02	cubic inch (in^3)
		0.03531	cubic foot (ft^3)
	cubic meter (m^3)	**35.31**	cubic foot (ft^3)
		1.308	cubic yard (yd^3)
		0.0008107	acre foot (acre ft)
Mass/Weight	milligram (mg)	**0.00003527**	ounce (oz)
	gram (g)	**0.03527**	ounce (oz)
		0.002205	pound (lb)
	kilogram (kg)	**2.205**	pound (lb)
		0.001102	ton (2,000 lb)
	metric ton (1,000 kg)	**1.102**	ton (2,000 lb)
		2.205	kip (1,000 lb)
	kilogram per meter (kg/m)	**0.6720**	pound per linear foot (plf)
	kilogram per square meter (kg/m^2)	**0.2048**	pound per square foot (psf)
Mass/Density	kilogram per cubic meter (kg/m^3)	**0.06243**	pound per cubic foot (pcf)
		1.686	pound per cubic yard (lb/yd^3)
Velocity	kilometer per hour (km/h)	**0.6214**	mile per hour (mph)
	meter per second (m/s)	**3.281**	foot per second (fps)
Acceleration	meter per second per second (m/s^2)	**3.281**	foot per second per second (ft/s^2)
Force	newton (N)	**0.2248**	pound (lb)
	kilonewton(kN)	**0.2248**	kip (1,000 lb)
Pressure/Stress	pascal (Pa)	**0.02089**	pound per square foot (psf)
	kilopascal (kPa)	**0.02089**	kip per square foot (ksf)
		0.1450	pound per square inch (psi)
	megapascal (MPa)	**0.1450**	kip per square inch (ksi)
Moment/Torque	newton-meter (N-m)	**0.7376**	foot-pounds (ft-lb)
	kilonewton-meter (kN-m)	**0.7376**	foot-kip (ft-kip)
Power	watt (W) or (J/s) or (N-m/s)	**0.7376**	foot-lb per second (ft-lb/s)
		0.001341	horsepower (hp)
Moment of Mass	kilogram-meter (kg-m)	**7.233**	pound-foot (lb-ft)
Moment of Inertia	$kilogram\text{-}meter^2$ ($kg\text{-}m^2$)	**23.73**	$pound\text{-}foot^2$ ($lb\text{-}ft^2$)
Second Moment of Area	$millimeter^4$ ($mm^{4)}$	**0.000002403**	$inch^4$ (in^4)
Section Modulus	$millimeter^3$ (mm^3)	**0.00006102**	$inch^3$ (in^3)
Temperature (exact)	Degree Celcius (^oC)	**$F=(Cx^9/_5)+32$**	Degree Fahrenheit (^oF)

Refer to Handbook 44, Table 4, for official U.S. Standards and Conversion Factors
at the National Institute of Standards and Technology web site:
http://ts.nist.gov/ts/htdocs/200/202/mpo_home.htm

TABLE 3 -- RATIONALIZED Speed

METRIC	U.S. CUSTOMARY	
	soft	hard*
km/h	mph	
20	12.43	15
30	18.64	20
40	24.86	25
50	31.07	30
		35
60	37.28	40
70	43.50	45
80	49.71	50
90	55.92	55
100	62.14	60
		65
110	68.35	70
120	74.57	75
130	80.78	80

*2001 AASHTO--Geometric Design of Highways and Streets, Exhibit 2-29.
Note that there are no hard metric equivalents for 35 mph and 65 mph.
This Table is intended for general referencing only. It is recommended that design values be developed independently in U.S. Customary units. Therefore, it is advised to work entirely in one system and not attempt to convert directly between the two systems.

Example: Minimum Merging Taper Length for Temporary Traffic Control

Formula for speeds of 70 km (45 mph) or more is L=WS/1.6 (L=WS)
"L" for 65 mph = WS = 12 feet x 65mph = 780 feet

Formula for speeds of 65 km (40 mph) or less is
L=WSS/155 (WSS/60)
"L" for 35 mph = WSS/60 = 12 feet x $(35\ mph)^2/60$ = 245 feet

TABLE 4 -- RATIONALIZED Fractional Inch

	inch (soft)	**fractional inch (hard) with corresponding decimal equivalent**											
	decimal	**64th**	decimal	**32nd**	decimal	**16th**	decimal	**8th**	decimal	**4th**	decimal	**half**	decimal
1 mm	*0.03937*	**3**	0.04688	**1**	0.03125								
2 mm	*0.07874*	**5**	0.07813	**3**	0.09375	**1**	0.06250						
3 mm	*0.1181*	**8**	0.1250	**4**	0.1250	**2**	0.1250	**1**	0.1250				
4 mm	*0.1575*	**10**	0.1563	**5**	0.1563								
5 mm	*0.1969*	**13**	0.2031	**6**	0.1875	**3**	0.1875						
6 mm	*0.2362*	**15**	0.2344	**8**	0.2500	**4**	0.2500	**2**	0.2500	**1**	0.2500		
7 mm	*0.2756*	**18**	0.2813	**9**	0.2813								
8 mm	*0.3150*	**20**	0.3125	**10**	0.3125	**5**	0.3125						
9 mm	*0.3543*	**23**	0.3594	**11**	0.3438								
10 mm	*0.3937*	**25**	0.3906	**13**	0.4063	**6**	0.3750	**3**	0.3750				
11 mm	*0.4331*	**28**	0.4375	**14**	0.4375	**7**	0.4375						
12 mm	*0.4724*	**30**	0.4688	**15**	0.4688								
13 mm	*0.5118*	**33**	0.5156	**16**	0.5000	**8**	0.5000	**4**	0.5000	**2**	0.5000	**1**	0.5000
14 mm	*0.5512*	**35**	0.5469	**18**	0.5625	**9**	0.5625						
15 mm	*0.5906*	**38**	0.5938	**19**	0.5938								
16 mm	*0.6299*	**40**	0.6250	**20**	0.6250	**10**	0.6250	**5**	0.6250				
17 mm	*0.6693*	**43**	0.6719	**21**	0.6563	**11**	0.6875						
18 mm	*0.7087*	**45**	0.7031	**23**	0.7188								
19 mm	*0.7480*	**48**	0.7500	**24**	0.7500	**12**	0.7500	**6**	0.7500	**3**	0.7500		
20 mm	*0.7874*	**50**	0.7813	**25**	0.7813								
21 mm	*0.8268*	**53**	0.8281	**26**	0.8125	**13**	0.8125						
22 mm	*0.8661*	**55**	0.8594	**28**	0.8750	**14**	0.8750	**7**	0.8750				
23 mm	*0.9055*	**58**	0.9063	**29**	0.9063								
24 mm	*0.9449*	**60**	0.9375	**30**	0.9375	**15**	0.9375						
25 mm	0.9843	**63**	0.9844	**31**	0.9688	**16**	1.0000	**8**	1.0000	**4**	1.0000	**2**	1.0000

IV. English Standard

TABLE 5 -- U.S. CUSTOMARY Conversion Factors

REMEMBER THESE

Length	mil	inch	foot	yard
1 mil		0.001		
1 inch	1,000		$^1/_{12}$	
1 foot		12		$^1/_3$
1 yard		36	3	
1 mile			5,280	1,760

Area	in^2	ft^2	yd^2	acre
1 ft^2	144			
1 yd^2		9		
1 mi^2				640
1 acre		43,560	4,840	

Volume	fluid ounce	pint	quart	gallon	in^3	ft^3
1 fluid ounce		$^1/_{16}$				
1 pint	16		$^1/_2$	$^1/_8$		
1 quart	32	2		$^1/_4$		
1 gallon	128	8	4		231	0.1337
1 ft^3					1,728	
1 yd^3						27
1 acre foot				325,853.38		

Weight	ounce	pound
1 pound	16	
1 ton		2,000

Density	lb/ft^3	lb/gal
water (50°F)	62.4	8.34

Velocity	fps
1 mph	1.4667
60 mph	88
speed of light	186,282.3971 mps

Flowrate	cfs
1 mgd	1.55
1,000 gpm	2.23

Acceleration	ft/s^2
earth gravity	32.174

Energy	ft-lb
1 BTU	778

Power	ft-lb/s	watt
1 hp	550	746

Table 6
Computer Aided Design & Drafting Standards for U.S. Customary Units (English) Plans

1. Stationing for Plan Sheets shall be based on 100-feet per station (major station tick mark) with annotation at full 100-feet stations. See the table below for minor station tick mark intervals for U.S. Customary units.

   Stationing for Preliminary Drawings shall also be based on 100-feet per station but with annotation at full 500-feet stations for both: 1" = 200' and 1" = 400'. The 100-foot station shall serve as the minor tick mark interval.

   Stationing shall be shown to the hundredth of a foot.

   The typical length of a minor station tick mark (in a MicroStation design file) is 3.5 feet at 1" = 50', 1.4 feet at 1" = 20' and 7.0 feet at 1" = 100'. Major station tick marks are twice the length of the minor station tick mark.

2. Scales:

	English	Minor Station Tick Mark Interval (For English)
Detail Sheets:		
	1/8" =1'	
	3/16"=1'	
	1/4" =1'	
	3/8" =1'	
	1/2" =1'	
	3/4" =1'	
	1" =1'	
	1" =2'	
	1" =5'	
Plan Sheets:		
	1" =10'	
	1" =20'	25 ft (If necessary)
	1" =40'	50 ft
	1" =50' base scale	50 ft
	1" =100'	50 ft
Preliminary Drawings:		
	1" =200'	100 ft
	1" =400'	100 ft

3. Profile Sheets:

Vertical to horizontal scale ratios producing profile grade line plots steeper than 1:1 should be avoided. Scale ratio of H/V = 10 is most commonly used.

Type of Conditions	English	
	Horizontal	Vertical
Rural sections in hilly or mountainous terrain	1" = 100'	1" = 10'
Rural or Urban with gentle rolling terrain	1" = 50'	1" = 5'
Rural or Urban with level terrain	1" = 20'	1" = 2'

4. Earthwork cross section plotting scales for U.S. customary units are:

Rural	1" = 10'
Urban	1" = 5'

Cross section intervals shall not be greater than 50 feet. Maintain the same scale for all cross sections for one alignment. The horizontal (H) and vertical (V) scales should be the same.

5. Contour Intervals:

For U.S. customary units, the index contour line will be every fifth contour and will be a heavier weight than the intermediate contour lines.

English		
	Contours	
Scale	Index	Intermediate
1" = 20'	5 ft	1 ft
1" = 50'	10 ft	2 ft
1" = 100'	20 ft	4 ft
1" = 200'	50 ft	10 ft
1" = 400'	100 ft	20 ft

6. Miscellaneous:

- Pavement cross slope and superelevation shall continue to be shown as percent.
- Angular measurement will retain the Degree-Minute-Second convention.
- Dual Units shall not be allowed on any Contract Plans. All survey information will be expressed in English units.
- Side slopes shall be expressed in a non-dimensional ratio. The horizontal component shall always be shown first and then the vertical component (X:Y). When a side slope becomes steeper than 1:1, the horizontal component shall be shown as a fraction ($^{3}/_{4}$:1).

V. Soft and Hard Conversion

SOFT CONVERSION – A soft conversion is the U.S. Customary equivalent to the corresponding metric number.

Example #1 (soft conversion)

The distance between two bolt holes on a steel-plate washer is 230 mm. Calculation: 230 mm x 0.03937 in/mm = 9.055 inches.

Example #2 (soft conversion)

The diameter of a certain bolt hole is 11 millimeters. The hole accommodates a 10-millimeter diameter bolt. Calculation: 11 mm x 0.03937 in/mm = 0.4331 inch, and 10 mm x 0.03937 in/mm = 0.3937 inch.

Example #3 (soft conversion)

The width of a standard traffic lane is 3.6 meters. Calculation: 3.6 m x 3.281 ft/m = 11.8 feet.

Example #4 (soft conversion)

The size of a federal W20-1 ROAD WORK AHEAD sign is 1500 millimeters x 1500 millimeters. Calculation: 1500 mm x 0.03937 in/mm = 59.06 inches.

HARD CONVERSION-- A hard conversion is a new rounded (or rationalized) U.S. Customary number that is different from its corresponding metric number. The decision to use a hard number varies from application to application. It should be a well-thought-out, conscious decision to make a hard conversion. In many cases, the decision to use a hard number is due primarily to predetermined industry or Department standards or policies. Transition problems can occur as the result of poor judgement when converting to hard numbers. See Examples 5 to 10 below.

Example #5 (hard conversion)

In Example #1 (above) the engineer might want to specify 9 inches between bolt holes instead of 9.055 inches. The new rationalized dimension will be 0.055 inch less than its corresponding metric dimension. The engineer will have to consider the impact (if any) of a lesser dimension. The need for precision, interchangeable replacement parts, or ease of fabrication may be considerations whether to use a new (hard) number.

Example #6 (hard conversion)

Industry standards dictate sizes for hardware, therefore it is not practical to use a soft conversion as in Example #2 (above) because these sizes may not be commercially available.
From “Table 4 -- Rationalized Fractional Inch”,

Bolt Hole Diameter: 11 mm (0.4331 inch) ≈ $^{7}/_{16}$ inch (0.4375 inch)
Bolt Diameter: 10 mm (0.3937 inch) ≈ $^{25}/_{64}$ inch (0.3906 inch),
$^{13}/_{32}$ inch (0.4063 inch), or $^{3}/_{8}$ inch (0.3750 inch)

Three possible bolt sizes for Example #6 will work. The required mechanical properties of the bolt, tolerances and or availability of certain bolt sizes may be deciding factors in selecting the appropriate bolt size. Three eighths of an inch is a common bolt size.

Example #7 (hard conversion)

In Example #3 (above), the Department has predetermined that the standard width for a new traffic lane is 12 feet.

Example #8 (hard conversion)

In Example #4 (above) the FHWA has predetermined that the standard size for the W20-1 sign is 60 inches x 60 inches.

Example #9 (hard conversion)

The width of excavation/backfill is 1 meter or 3 feet.

Example #10 (hard conversion)

The distance of a steel bar to the edge of concrete is 50 mm or 2 inches, 75 mm or 3 inches.

VI. Rounding, Significant Digits and Accuracy

Rounding

Rule #1 -- When the first digit discarded is less than 5, the last digit retained is not changed.

Example #11

1.00 m x 3.281 ft/m = 3.281 feet – Round to 3.28 feet
1 m x 3.281 ft/m = 3.281 feet – Round to 3 feet
75 mm x 0.03937 = 2.953 inches – Round to 2.95 inches

Rule #2 -- When the first digit discarded is greater than 5 or is a 5 followed by at least one digit other than 0, add 1 to the last digit retained.

Example #12

50 mm x 0.03937 in/mm = 1.969 inches – Round to 1.97 inches

Rule#3 -- When the first digit discarded is exactly 5 followed only by zeros, the digit retained should be rounded upward if it is odd. Make no adjustment if it is an even number.

Example #13

a) The number 4,365,000 rounded to three significant digits is 4,360,000.
b) The number 4,355,000 rounded to three significant digits is 4,360,000.

Rule #4 – When making conversions, if the first digit of the resultant “inch-pound” value is equal to or greater than the first significant digit of the metric value, consider rounding the “inch-pound” value to the same number of significant digits as there are in the metric value.

Example #14

1.0 m x 3.281 ft/m = 3.381 feet
Since 3 is greater than 1 – Round to 3.3 feet

Rule #5 – When making conversions, if the first significant digit of the resultant “inch-pound” value is smaller than the first significant digit of the metric value, consider rounding to one more significant digit.

Example #15

a) 9.0 meters x 3.281 ft/m = 29.52 feet
Since 2 is less than 9 – Round to 29.5 feet
b) 75 mm x 0.03937 in/mm = 2.953 inches
Since 2 is less than 7 – Round to 2.95 inches

Significant Digits

Rule #6 -- All non-zero digits (1-9) are significant.

Rule #7 -- Zeros are significant unless:

a) They are to the right of a number and to the left of the decimal point.
b) They are to the left of a number.

Example #16

Number	Significant Digits
200	1
20	1
2	1
0.2	1
0.02	1
0.002	1
0.0020	2
210	2
21.0	3
210.0	4
207.302	6
200.000	6

Rule #8 -- Zeros may indicate either a specific value or an order of magnitude.

Example #17

a) The population of the United States in 1970, rounded to thousands, was 203,185,000. The six left-hand digits are significant (including the zero), each measuring a specific value. The three right-hand zeros indicate that the number is most likely to the nearest thousand.

b) Laypersons usually express the speed of light as 186,000 miles per second. The three zeros are not measurements at all. The zeros are placeholders to the left of the decimal point to indicate order of magnitude. The speed is actually closer to 186,282.3971 miles per second.

Rule #9 -- Any digit (including zeros) necessary to define the specific value or quantity is significant.

Example #18

The value 540,000 meters has two significant digits if originally expressed to the nearest 10,000 meters (i.e., 5.4×10^5), or three significant digits if originally expressed to the nearest 1,000 meters (i.e., 5.40×10^5).

Rule #10 -- When adding or subtracting, the answer must contain no significant digits to the right of the least precise number.

Example #19

Round numbers in column 1 one significant digit to the right of the least precise number and take the sum as shown in column 2.

163,000,000	163,000,000
217,885,000	217,900,000
96,432,768	96,400,000
477,317,768	477,300,000

Round the total to 477,000,000 as called for by the rule.

Rule #11 -- When multiplying or dividing, the product or quotient should contain no more significant digits than the number with the fewest significant digits used in the multiplication or division.

Example #20

113.2 x 1.43 = 161.876 -- Round to 162 because 1.43 has three significant digits.
113.2 / 1.43 = 79.1608 -- Round to 79.2 for the same reason.

Accuracy

It is essential to use good judgement in estimating the accuracy required in conversions. Always establish intended accuracy beforehand as a guide to how many digits to retain in calculations. In abstract mathematical work the number 2 means exactly 2. It means nothing more and nothing less. In engineering terms, the value of 2 means somewhere between 1.5 and 2.5. Or, it may be a very accurate value of 2, expressed as "2.0000."

Rule #12 -- When converting integral values of units, consider the implied or required accuracy of the integral value to be converted.

Example #21

The value "50 m" may represent 49.5m, 50.0 m, 50.5 m or 50.00 m, etc.

Rule #13 -- Converted values should round to the minimum number of significant digits to maintain the required accuracy afterward. Do not retain more digits than is appropriate for the situation.

Example #22

A length of 1,100 meters (3,609 feet) originally expressed to the nearest 100 meters lies somewhere between 1,050 meters (3,445 feet) and 1,150 meters (3,773 feet). Rounding to 3,600 feet (i.e., 2 significant digits) would be appropriate. If originally expressed to the nearest 10 meters, the result lies somewhere between 1,095 meters (3,593 feet) and 1,105 meters (3,625 feet). Rounding to 3,610 feet (i.e., 3 significant digits) would be appropriate.

Rule #14 – Handle a stated limit such as "not more than" or "at least" to not violate the limit after the conversion. Rounding must be in the direction that does not violate the limit.

Example #23

"At least 9.2 meters wide" requires a width of at least 30.2 feet, or at least 31 feet. A width of 30 feet violates the requirement by 0.2 feet.

Rule #15 -- When converting, multiply a value by a more accurate factor than required, then round appropriately afterward.

Example #24

The value 15.6 m^3 has three significant digits (i.e., 1-5-6), so the conversion factor should have at least four significant digits. Calculation: 15.6 m^3 x 35.31 ft^3/m^3 = 550.836 ft^3, then rounding to three significant digits yields a value of 551 ft^3.

Rule # 16 – Round converted dimensions to a minimum number of significant digits so the unit of the last place is equal to or smaller than its conversion.

Example #25

The interior panel length of a formed panel sign is 1214 mm ± 3 mm, which convert to 47.80 inches and 0.12 inch respectively (see Rule #4 and Rule #5). Therefore, try 47.80 inches ± 0.12 inch for the converted values. Checking: 1214 mm lies between 1211 mm (47.68 inches) and 1217 mm (47.91 inches). No Good -- since 47.80 inches ± 0.12 inch lies between 47.68 inches and 47.92 inches (i.e., 49.92 > 49.91). Use: 47.80 inches ± 0.10 inch to keep within limits.

VII. Technical and Specification Writing Conventions for U.S. Customary Units

The following rules are conventions used in technical writing or specifications. Contract plans and standard plans use separate conventions (not covered here).

Rule #1 -- Spell out U.S. Customary units. Do not use abbreviations or symbols, except as noted. Use numerals for measurements, sizes, and quantities. Use a non-breaking space between the number and the unit. To create a non-breaking space, use “shift, ctrl and space.”

Examples:
12 pounds *not:* 12 lb. or 12#.
24 inches *not:* 24 in. or 24".

Exceptions:
1. GPM, GPH, psi, psig, RPM, CFM, CFS, F, C.
2. Degree symbol, ° (for temperature only)
3. Inch and foot symbols when used with multiple dimensions (e.g. 12" x 24"). Do not use a space between a number and a symbol. Do not mix units. Use the multiplication cross symbol (x), not the word "by."
4. Those shown in a standard collegiate dictionary.
5. In Tables (use symbols).
6. In formulas, (e.g. 12" x 24") use non-breaking spaces.

Rule #2 -- Use words at the beginning of a sentence.

Examples:
Eight hours of labor constitutes a full day of work.
Thirty minutes before installation . . .

Rule #3 -- In text, indicate a range that includes the endpoints by using the words "from" and "to." Do not use a dash. Use units for both numbers in a range.

Example:
from 10 inches to 14 inches *not:* from 10 to 14 inches

Rule #4 -- Use singular form on unit when number is one or less; plural form when number is greater than one. Express decimals with numerals and not with words.

Examples:
0.067 foot *not:* 0.067 feet
5 feet *not:* 5 foot
1.055 feet *not:* 1.055 foot
0.1 *not:* one-tenth

Rule #5 -- Write "linear foot" to express a quantity is one or less and "linear feet" for quantities greater than one.

Example:
0.5 linear foot *not:* 0.5 linear feet, lineal foot

Rule #6 -- Use "0" as a placeholder in front of a decimal for numbers less than one.

Example:
0.565 pounds per square inch *not:* .565 pounds per square inch

Rule #7 -- Use singular form of a unit with a non-breaking hyphen when used as a modifier. To create a non-breaking hyphen, use “shift, ctrl and hyphen.”

Examples:
6-inch bolt
5-yard touchdown

Rule #8 -- Do not use an ordinal designator with a fraction when using as a modifier.

Example:
¾-inch steel plate *not:* ¾th-inch steel plate

Rule #9 -- If expressions combine different units, do not use a hyphen.

Example:
5 feet 5½ inches *not:* 5 feet - 5½ inches

Rule #10 -- Use "per" to express a ratio.

Example:
5 feet per second *not:* 5 feet/second

Rule #11 -- For tolerences, use the "±" and not "+/-". Also, use the units for both the measurement and the tolerence.

Example:
24.2 kips per square inch ± 5 kips per square inch
not: 24.2 ± 5 kips per square inch, 24.2 kips +/- 5 kips per square inch

Rule #12 -- Spell out "percent."

Example:
100 percent *not:* 100%

Rule #13 -- Do not capitalize units:

Example:
100 yards *not:* 100 Yards

Rule #14 -- This rule applies to Standard Specifications only. Use whole numbers and fractions together without a separating space or hyphen. If a high degree of accuracy is needed, decimals for fractional parts of U.S. Customary units are allowed. Do not mix fractions and decimals within a specification or table.

Example:
2½ inches *not:* 2 ½ inches, 2-½ inches, 2.5 inches

Rule #15 -- Do not use symbols for fractions in SSPs. Use full-sized text for fractions and non-breaking space or non-breaking hyphen as applicable.

Examples:
1/4, 1/2, 3/4 *not:* ¼, ½, ¾

Rule #16 -- Use commas in the thousands place for U.S. Customary numbers.

Example:
31,000 *not:* 31 000
17,900 *not:* 17 900

Rule #17 -- Use “weight” or “size” appropriately to replace “mass” in the Standards Specifications and SSPs.

Rule #18 -- Reference slope ratios as 2:1 (horizontal to vertical).