METRIC GUIDE

FOR FEDERAL CONSTRUCTION

First Edition

The Construction Subcommittee
of the Metrication Operating Committee
of the
Interagency on Metric Policy

Published by the
NATIONAL INSTITUTE OF BUILDING SCIENCES
1201 L Street N.W.
Washington, D.C. 20005

Call 202-289-7800 for ordering information.

First printing, December 1991
Second printing, March 1992
Third printing, August 1992
Fourth printing, April 1993

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ACKNOWLEDGEMENTS

The Construction Subcommittee of the Interagency Council on Metric Policy's Metrication Operating Committee has prepared this guide to aid the federal agencies in implementing the metric system of measurement in the federal construction process.

I would like to express my appreciation to Arnold Prima of the Office of the Secretary of Defense, who first voiced a need for the guide and initiated its development; to William Brenner of the National Institute of Building Sciences, who wrote it; to Claret Heider, its editor; and to reviewers William Aird of the State Department, Valerie Antoine and Louis Sokol of the U.S. Metric Association, Bruce Barrow of the Defense Information Systems Agency, Maria Grazi Bruschi of the American Society of Civil Engineers, Ronald Clevenger of the Tennessee Valley Authority, Amitabha Datta of the General Services Administration, Troy Estes of the National Aeronautics and Space Administration, Luther Flouton of the Public Health Service, James Gross of the National Institute of Standards and Technology, Leslie Hegyi, Stan Jakuba of S.I. Jakub Associates, H. Leslie Simmons, Lee Schmidt of the U.S. Air Force, Clark Tufts and Gerald Underwood of the American National Metric Council, and Anthony Welch of the Federal Highway Administration.

I also would like to thank the many, many people who have given their time and energies over the years to developing the metric information on which the guide is based.

Finally, I would like to thank the Public Buildings Service of the General Services Administration, which provided the majority of funding for the guide's preparation.

Thomas R. Rutherford, PE
Chairman, Construction Subcommittee

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METRIC IS THE LAW

The Metric Conversion Act

The *Metric Conversion Act of 1975*, as amended by the *Omnibus Trade and Competitiveness Act of 1988*, establishes the modern metric system (System International or SI) as the preferred system of measurement in the United States. It requires that, to the extent feasible, the metric system be used in all federal procurement, grants, and business-related activities by September 30, 1992.

The Executive Order on Metric Usage

Executive Order 12770 (July 25, 1991), *Metric Usage in Federal Government Programs*, mandates that each federal agency:

- Make a transition to the use of metric units in government publications as they are revised on normal schedules or as new publications are developed.

- Work with other governmental, trade, professional, and private sector metric organizations on metric implementation.

- Formulate, approve, and implement a **Metric Transition Plan** by November 30, 1991, and provide it to the Secretary of Commerce.

The Metric Transition Plan is required to include:

The scope of the metric transition task and firm dates for all metric accomplishment milestones for 1991 and 1992,

Initiatives to enhance cooperation with industry as it voluntarily converts to the metric system, and

A schedule of activities to increase the understanding of the metric system through educational information and in publications.

- Designate a **Metric Executive** who is responsible for carrying out the Metric Transition Plan and preparing annual agency progress reports.

The Interagency Council on Metric Policy

To coordinate implementation of the *Metric Conversion Act* among the federal agencies, the Interagency Council on Metric Policy (ICMP) has been established under the Department of Commerce. The ICMP's working arm is the Metrication Operating Committee, which has 10 subcommittees, including one on construction.

The Construction Subcommittee

The task of the Construction Subcommittee is to facilitate the metrication of all federal construction, a $40 billion annual expenditure. During the summer of 1991, the Construction Subcommittee established a goal of *instituting the use of metric in the design of all new federal facilities by January 1994*.

To meet the requirements of the *Metric Conversion Act* and Executive Order 12770 and to help achieve this goal, the Construction Subcommittee has prepared this guide.

WHY METRIC?

Metric Is the International Standard

Developed at the time of the French Revolution, the metric system rapidly spread throughout Europe during the Napoleonic wars. It was promoted in the United States first by Thomas Jefferson and later by John Quincy Adams, but the federal government took no formal action on metric until 1866 when its use as a measurement system was legalized. In 1893, all standard U.S. measures were defined in terms of metric units. In 1902, Congressional legislation requiring the federal government to use metric exclusively was defeated by a single vote. Today, the United States is the last industrialized country to commit to metric.

The modern metric system was established by international agreement in 1960. It now is the standard international language of measurement and the system mandated by the *Metric Conversion Act* for use in the United States.

Metric Is Coherent

The modern metric system is coherent in that only one unit is used for each physical quantity and there are no conversion factors or constants to remember. The meter (and its decimal multiples), for example, is the single metric measure for length while its inch-pound system equivalents include the mil, the inch, the foot, the yard, the fathom, the rod, the chain, the furlong, and the mile, among others.

Metric's coherency, its simple base units, and its use of decimal arithmetic make it an especially logical and useful measurement system.

METRIC IN CONSTRUCTION

The Experience of Other Countries

There has been much speculation about the difficulty of converting to metric in the U.S. construction industry. The experience of the British, Australians, South Africans, and Canadians -- all of whom converted from the inch-pound system to metric in the past 20 years -- indicates otherwise:

- Metric conversion proved much less difficult than anticipated since most work is built in place.

- There was no appreciable increase in either design or construction costs, and conversion costs for most construction industry sectors were minimal or offset by later savings.

- The architecture/engineering community liked metric dimensioning since it was less prone to error and easier to use than feet and inches and since engineering calculations were faster and more accurate because there were no unit conversions and no fractions.

- Metric offered a one-time chance to reduce the many product sizes and shapes that have accumulated over the years but are no longer useful, thus saving production, inventory, and procurement costs.

- Architecture/engineering firms in these countries found that it took a week or less for staff members to learn to think and produce in metric, and most tradespeople took only a few hours to adapt.

Recent Developments in the United States

Several developments should make metric conversion in the United States construction industry easier:

- The use of computer-aided design and drafting systems continues to increase and almost all engineering and cost calculations now are performed on computers. Virtually all HVAC system controls are digitized. Computer-controlled manufacturing operations are now common. In each of these areas, the use of metric is greatly simplified.

- The codes and construction standards of two of the country's three model building code organizations (BOCA and SBCCI) and of NFPA and ASTM contain dual units (both inch-pound and metric) where measurements are specified. Many other standards-writing organizations have added metric measurements to their documents or are preparing to do so.

- The preliminary results of several recent General Services Administration metric pilot projects in the Philadelphia area indicate no increase in design or construction costs.

- American design and construction firms use metric routinely in foreign work with no reported problems.

- The costs of metric conversion in other U.S. industries have been far lower than expected, and the benefits greater. Total conversion costs were less than 1 percent of original estimates at General Motors, which now is fully metric. Rationalization of fastener sizes at IBM during metric conversion

reduced fastener part numbers from 38,000 to 4,000. The liquor industry reduced its container sizes from 53 to 7 after converting to metric.

Thus, Americans are increasingly exposed to metric in daily life and now take for granted many metric products. Without fanfare, the United States is moving toward a metric society.

International Competitiveness

For those sectors of the U.S. construction industry that export goods or services, metrication is vital:

- In 1990, U.S. non-lumber construction product exports totaled about $2.8 billion and imports totaled about $4.2 billion.

- Foreign billings for American architecture/engineering/ contracting firms amounted to $3.2 billion in 1989 with about a third of this from Europe.*

- The European Community, now the world's largest market, has specified that products with nonmetric labels will not be permitted for sale after 1992.

- The largest U.S. trading partners, Canada and Mexico, are now predominately metric countries.

- During the ongoing U.S.-Japanese Structural Impediments Initiative negotiations, the Japanese have identified nonmetric U.S. products as a specific barrier to the importation of U.S. goods.

Given this situation, some American manufacturers, such as Otis Elevator, are switching to metric to increase their international competitiveness and reduce their parts inventories. Others, such as the wood industry, have shipped exports in metric for many years.

Clearly, it is in the American construction industry's long-term interest to "go metric."

BASIC METRIC

Base Units

There are seven metric base units of measurement, six of which are used in design and construction. (The seventh, mole, is the amount of molecular substance and is used in physics.)

Quantity	Unit	Symbol
length	meter	m
mass*	kilogram	kg
time	second	s
electric current	ampere	A
temperature	kelvin	K
luminous intensity	candela	cd

* "Weight" in common practice often is used to mean "mass."

Celsius temperature (°C) is more commonly used than kelvin (K), but both have the same temperature gradients. Celsius temperature is simply 273.15 degrees warmer than kelvin, which begins at absolute zero. For instance, water freezes at 273.15 K and at 0 °C; it boils at 373.15 K and at 100 °C. To move between Celsius and kelvin, add or subtract 273.15.

Decimal Prefixes

Only two decimal prefixes are commonly used with the base units in design and construction:

Prefix	Symbol	Order of Magnitude	Expression
kilo	k	10^3	1000 (one thousand)
milli	m	10^{-3}	0.001 (one thousandth)

The prefixes mega (M) for one million (10^6), giga (G) for one billion (10^9), micro (m) for one millionth (10^{-6}), and nano (n) for one billionth (10^{-9}) are used in some engineering calculations.

Decimal prefixes to the tertiary power of 10 are preferred. The prefixes deci (d) for one tenth (10^{-1}), centi (c) for one hundredth (10^{-2}), deca (da) for ten (10^1), and hecto (h) for one hundred (10^2) have limited application in construction.

Plane and Solid Angles

The radian (rad) and steradian (sr) denote plane and solid angles. They are used in lighting work and in various engineering calculations. In surveying, the units degree (°), minute ('), and second (") continue in use.

Derived Units

Fifteen derived units with special names are used in engineering calculations:

Quantity	Name	Symbol	Expression
frequency	hertz	Hz	$Hz = s^{-1}$
force	newton	N	$N = kg \times m/s^2$
pressure, stress	pascal	Pa	$Pa = N/m^2$
energy, work, quantity of heat	joule	J	$J = N \times m$
power, radiant flux	watt	W	$W = J/s$
electric charge, quantity	coulomb	C	$C = A \times s$
electric potential	volt	V	$V = W/A$ or J/C
capacitance	farad	F	$F = C/V$
electric resistance	ohm	W	$W = V/A$
electric conductance	siemens	S	$S = A/V$ or W^{-1}
magnetic flux	weber	Wb	$Wb = V \times s$
magnetic flux density	tesla	T	$T = Wb/m^2$
inductance	henry	H	$H = Wb/A$
luminous flux	lumen	lm	$lm = cd \times sr$
illuminance	lux	lx	$lx = lm/m^2$

Liter, Hectare, and Metric Ton

The liter (L) is the measurement for liquid volume. The hectare (ha) is a metric measurement used in surveying. The metric ton (t) is used to denote large loads such as those used in excavating.

Pronunciation

candela	Accent the second syllable, can-**dell**-ah.
hectare	Accent the first syllable: **heck**-tare. The second syllable rhymes with **care**.
joule	Rhymes with **pool**.
kilometer	Accent the first syllable: **kill**-o-meter.
pascal	Rhymes with **rascal**.
siemens	Sounds like **seamen's**.

Rules for Writing Metric Symbols and Names

- Print unit symbols in upright type and in lower case except for liter (L) or unless the unit name is derived from a proper name.
- Print unit names in lower case, even those derived from a proper name.
- Print decimal prefixes in lower case for magnitudes 10^3 and lower (that is, k, m, m, and n) and print the prefixes in upper case for magnitudes 10^6 and higher (that is, M and G).
- Leave a space between a numeral and a symbol (write 45 kg or 37 °C, not 45kg or 37°C or 37° C).
- Do not use a degree mark (°) with kelvin temperature (write K, not °K).
- Do not leave a space between a unit symbol and its decimal prefix (write kg, not k g).
- Do not use the plural of unit symbols (write 45 kg, not 45 kgs), but do use the plural of written unit names (several kilograms).
- For technical writing, use symbols in conjunction with numerals (the area is 10 m^2); write out unit names if numerals are not used (carpet is measured in square meters). Numerals may be combined with written unit names in nontechnical writing (10 meters).
- Indicate the product of two or more units in symbolic form by using a dot positioned above the line ($kg \times m \times s^{-2}$).
- Do not mix names and symbols (write N×m or newton meter, not N×meter or newton×m).
- Do not use a period after a symbol (write "12 g", not "12 g.") except when it occurs at the end of a sentence.

Rules for Writing Numbers

- Always use decimals, not fractions (write 0.75 g, not ¾g).
- Use a zero before the decimal marker for values less than one (write 0.45 g, not .45 g).
- Use spaces instead of commas to separate blocks of three digits for any number over four digits (write 45 138 kg or 0.004 46 kg or 4371 kg). Note that this does not apply to the expression of amounts of money.
- In the United States, the decimal marker is a period; in other countries a comma usually is used.

Conversion and Rounding

- When converting numbers from inch-pounds to metric, round the metric value to the same number of digits as there were in the inch-pound number (11 miles at 1.609 km/mi equals 17.699 km, which rounds to 18 km).

- Convert mixed inch-pound units (feet and inches, pounds and ounces) to the smaller inch-pound unit before converting to metric and rounding (10 feet, 3 inches = 123 inches; 123 inches x 25.4 mm = 3124.2 mm; round to 3124 mm).

- In a "soft" conversion, an inch-pound measurement is mathematically converted to its exact (or nearly exact) metric equivalent. With "hard" conversion, a new rounded, rationalized metric number is created that is convenient to work with and remember.

Visualizing Metric

A few basic comparisons are worth remembering to help visualize metric:

- One millimeter is about 1/25 inch or slightly less than the thickness of a dime.
- One meter is the length of a yardstick plus about 3-1/3 inches.
- One gram is about the mass (weight) of a large paper clip.
- One kilogram is about the mass (weight) of a softbound model building code book (2.2 pounds).
- One liter is about the volume of a 4 inch cube (100 mm x 100 mm x 100 mm). One liter of water has a mass of 1 kilogram.
- One inch is just a fraction (1/64 inch) longer than 25 mm (1 inch = 25.4 mm; 25 mm = 63/64 inch).
- Four inches are about 1/16 inch longer than 100 mm (4 inches = 101.6 mm; 100 mm = 3-15/16 inches).
- One foot is about 3/16 inch longer than 300 mm (12 inches = 304.8 mm; 300 mm = 11-13/16 inches).
- Four feet are about 3/4 inch longer than 1200 mm (4 feet = 1219.2 mm; 1200 mm = 3 feet, 11¼ inches).

The metric equivalent of a typical 2-foot by 4-foot ceiling grid is 600 x 1200 mm, so metric ceiling tiles and lighting fixtures are about 3/8 inch smaller in one dimension and 3/4 inch smaller in the other.

- Similarly, the metric equivalent of a 4 by 8 sheet of plywood or drywall is 1200 x 2400 mm, so metric sheets are about 3/4 inch narrower and 1-1/2 inches shorter.

- "Rounding down" from multiples of 4 inches to multiples of 100 mm makes dimensions exactly 1.6 percent smaller and areas about 3.2 percent smaller. About 3/16 inch is lost in every linear foot.

References

The metric units in this guide are those adopted by the U.S. government (see the *Federal Register* of December 20, 1990; Federal Standard 376A, *Preferred Metric Units for Use by the Federal Government*; and PB 89-226922, *Metric Handbook for Federal Officials*). They are identical to the units in the following publications, which constitute the standard reference works on metric in the United States:

- ASTM E 621, *Standard Practice for Use of Metric (SI) Units in Design and Construction*,

- ANSI/IEEE 268, *American National Standard Metric Practice*, and

- ASTM E 380, *Standard Practice for the Use of the International System of Units (SI)*.

For editorial matters, also refer to:

- American National Metric Council, *Metric Editorial Guide* and

- U.S. Metric Association, *Metric Units of Measure and Style Guide*.

See the "Metric References" section of this guide for ordering information.

LENGTH, AREA, AND VOLUME

One metric unit is used to measure length, area, and volume in most design and construction work:

- meter (m).

Rules for Linear Measurement (Length)

- Use only the meter and millimeter in building design and construction.
- Use the kilometer for long distances and the micrometer for precision measurements.
- Avoid use of the centimeter.
- For survey measurement, use the meter and the kilometer.

Rules for Area

- The square meter is preferred.
- Very large areas may be expressed in square kilometers and very small areas, in square millimeters.
- Use the hectare (10 000 square meters) for land and water measurement only.
- Avoid use of the square centimeter.
- Linear dimensions such as 40 x 90 mm may be used; if so, indicate width first and height second.

Rules for Volume and Fluid Capacity

- Cubic meter is preferred for volumes in construction and for large storage tanks.
- Use liter (L) and milliliter (mL) for fluid capacity (liquid volume). One liter is 1/1000 of a cubic meter or 1000 cubic centimeters.
- Since a cubic meter equals one billion cubic millimeters, the cubic decimeter and cubic centimeter may be used in limited applications, since they are multiples of 1000 in volume measurement.

Area, Length, and Volume Conversion Factors

Quantity	From Inch-Pound Units	To Metric Units	Multiply by
Length	mile	km	1.609 344
	yard	m	0.914 4
	foot	m	0.304 8
		mm	304.8
	inch	mm	25.4
Area	square mile	km^2	2.590 00
	acre	m^2	4 046.856
		ha (10 000 m^2)	0.404 685 6
	square yard	m^2	0.836 127 36
	square foot	m^2	0.092 903 04
	square inch	mm^2	645.16
Volume	acre foot	m^3	1 233.49
	cubic yard	m^3	0.764 555
	cubic foot	m^3	0.028 316 8
	cubic foot	cm^3	28 316.85
	cubic foot	L (1000 cm^3)	28.316 85
	100 board feet	m^3	0.235 974
	gallon	L (1000 cm^3)	3.785 41
	cubic inch	cm^3	16.387 064
	cubic inch	mm^3	16 387.064

NOTE: Underline denotes exact number.

CIVIL AND STRUCTURAL ENGINEERING

The metric units used in civil and structural engineering are:

- meter (m)
- kilogram (kg)
- second (s)
- newton (N)
- pascal (Pa)

Rules for Civil and Structural Engineering

- There are separate units for mass and force.

- The kilogram (kg) is the base unit for mass, which is the unit quantity of matter independent of gravity.

- The newton (N) is the derived unit for force (mass times acceleration, or $kg \times m/s^2$). It replaces the unit "kilogram-force" (kgf), which should not be used.

- Do not use the joule to designate torque, which is always designated newton meter ($N \times m$).

- The pascal (Pa) is the unit for pressure and stress ($Pa = N/m^2$). The term "bar" is not a metric unit and should not be used.

- Structural calculations should be shown in MPa or kPa.

- Plane angles in surveying (cartography) will continue to be measured in degrees (either decimal degrees or degrees, minutes, and seconds) rather than the metric radian.

- Slope is expressed in nondimensional ratios. The vertical component is shown first and then the horizontal. For instance, a rise of one meter in four meters is expressed as 1:4. The units that are compared should be the same (meters to meters, millimeters to millimeters).

- For slopes less than 45°, the vertical component should be unitary (for example, 1:20). For slopes over 45°, the horizontal component should be unitary (for example, 5:1).

Civil and Structural Engineering Conversion Factors

Quantity	From Inch-Pound Units	To Metric Units	Multiply by
Mass	lb kip (1000 lb)	kg metric ton (1000 kg)	0.453 592 0.453 592
Mass/unit length	plf	kg/m	1.488 16
Mass/unit area	psf	kg/m^2	4.882 43
Mass density	pcf	kg/m^3	16.018 5
Force	lb kip	N kN	4.448 22 4.448 22
Force/unit length	plf klf	N/m kN/m	14.593 9 14.593 9
Pressure, stress, modulus of elasticity	psf ksf psi ksi	Pa kPa kPa MPa	47.880 3 47.880 3 6.894 76 6.894 76
Bending moment, torque, moment of force	ft-lb ft-kip	N×m kN×m	1.355 82 1.355 82
Moment of mass	lb×ft	kg×m	0.138 255
Moment of inertia	$lb \times ft^2$	$kg \times m^2$	0.042 140 1
Second moment of area	in^4	mm^4	416 231
Section modulus	in^3	mm^3	<u>16 387.064</u>

NOTE: Underline denotes exact number.

MECHANICAL ENGINEERING

The metric units used in mechanical engineering are:

- meter (m)
- kilogram (kg)
- second (s)
- joule (J)
- watt (W)
- kelvin (K) or degree Celsius (°C)
- pascal (Pa)
- radian (rad).
- newton (N)

Rules for Mechanical Engineering

- The joule (J) is the unit for energy, work, and quantity of heat. It is equal to a newton meter (N×m) and a watt second (W×s) and replaces a large number of inch-pound units.

- The watt (W) is both the inch-pound and metric unit for power and heat flow. It replaces horsepower, foot pound-force per hour, Btu per hour, calorie per minute, and ton of refrigeration.

- Moisture movement is expressed by the terms "vapor permeance" and "vapor permeability."

- The inch-pound unit "perm" continues to represent the degree of retardation of moisture movement. The lower the value, the greater the retardation.

- The newton (N) is the derived unit for force (mass times acceleration, or $kg \times m/s^2$). It replaces the unit "kilogram-force" (kgf), which should not be used.

Mechanical Engineering Conversion Factors

Quantity	From Inch-Pound Units	To Metric Units	Multiply by
Mass/area (density)	lb/ft^2	kg/m^2	4.882 428
Temperature	°F	K	5/9(°F -32) + 27-3.15
Energy, work, quantity of heat	kWh Btu ft×lbf	MJ J J	3.6 1 055.056 1.355 82
Power	ton (refrig) Btu/s hp (electric) Btu/h	kW kW W W	3.517 1.055 056 745.700 0.293 071
Heat flux	$Btu/(f^2×h)$	W/m^2	3.152 481
Rate of heat flow	Btu/s Btu/h	kW W	1.055 056 0.293 071 1
Thermal conductivity (k value)	$Btu/(ft^2×h×°F)$	W/(m×K)	1.730 73
Thermal conductance (U value)	$Btu/(ft^2×h×°F)$	$W/(m^2×K)$	5.678 263
Thermal resistance (R value)	$ft^2×h×°F/Btu$	$m^2×K/W$	0.176 110
Heat capacity, entropy	Btu/°F	kJ/K	1.899 1
Specific heat capacity, specific entropy	Btu/(lb×°F)	kJ/(kg×K)	4.186 8
Specific energy, latent heat	Btu/lb	kJ/kg	2.326
Vapor permeance	perm (23 °C)	$ng/(Pa×s×m^2)$	57.452 5
Vapor permeability	perm/in	ng/(Pa×s×m)	1.459 29
Volume rate of flow	ft^3/s cfm cfm	m^3/s m^3/s L/s	0.028 316 8 0.000 471 947 4 0.471 947 4
Velocity, speed	ft/s	m/s	0.3048
Acceleration	f/s^2	m/s^2	0.3048
Momentum	lb×ft/sec	kg×m/s	0.138 255 0
Angular momentum	$lb×ft^2/s$	$kg×m^2/s$	0.042 140 11
Plane angle	degree	rad mrad	0.017 453 3 17.453 3

Quantity	From Inch-Pound Units	To Metric Units	Multiply by
NOTE: Underline denotes exact number.			

ELECTRICAL ENGINEERING

The metric units used in electrical engineering are:

- meter (m)
- second (s)
- candela (cd)
- radian (rad)
- steradian (sr)
- ampere (A)
- coulomb (C)
- volt (V)
- farad (F)
- henry (H)
- ohm (W)
- siemens (S)
- watt (W)
- hertz (Hz)
- weber (Wb)
- tesla (T)
- lumen (lm)
- lux (lx)

Rules for Electrical Engineering

- There are no unit changes for electrical engineering except for the renaming of conductance from "mho" to siemens (S).

- The candela (cd) is the unit for luminous intensity and is already in common use; it replaces candle and candlepower.

- The lux (lx) is the unit for illuminance and replaces lumen per square foot and footcandle.

- Luminance is expressed in candela per square meter (cd/m^2) and replaces candela per square foot, footlambert, and lambert.

Electrical Engineering Conversion Factors

Quantity	From Inch-Pound Units	To Metric Units	Multiply by
Power, radiant flux	W	W	1 (same unit)
Radiant intensity	W/sr	W/sr	1 (same units)
Radiance	$W/(sr \times m^2)$	$W/(sr \times m^2)$	1 (same units)
Irradiance	W/m^2	W/m^2	1 (same units)
Frequency	Hz	Hz	1 (same value)
Electric current	A	A	1 (same unit)
Electric charge	A×hr	C	3600
Electric potential	V	V	1 (same unit)
Capacitance	F	F	1 (same unit)
Inductance	H	H	1 (same unit)
Resistance	W	W	1 (same unit)
Conductance	mho	S	100
Magnetic flux	maxwell	Wb	10^{-8}
Magnetic flux density	gamma	T	10^{-9}
Luminous intensity	cd	cd	1 (same unit)
Luminance	lambert cd/ft^2 footlambert	kcd/m^2 cd/m^2 cd/m^2	3.183 01 10.763 9 3.426 26
Luminous flux	lm	lm	1 (same unit)
Illuminance	footcandle	lx	10.763 9
NOTE: Underline denotes exact number.			

CONSTRUCTION TRADES

The metric units used in the construction trades are as follows. The term "length" includes *all* linear measurements (that is, length, width, height, thickness, diameter, and circumference).

	Quantity	Unit	Symbol
Surveying	length	kilometer, meter	km, m
	area	square kilometer hectare (10 000 m^2) square meter	km^2 ha m^2
	plane angle	degree (non-metric) minute (non-metric) second (non-metric)	° ' "
Excavating	length	meter, millimeter	m, mm
	volume	cubic meter	m^3
Trucking	distance	kilometer	km
	volume	cubic meter	m^3
	mass	metric ton (1000 kg)	t
Paving	length	meter, millimeter	m, mm
	area	square meter	m^2
Concrete	length	meter, millimeter	m, mm
	area	square meter	m^2
	volume	cubic meter	m^3
	temperature	degree Celsius	°C
	water capacity	liter (1000 cm^3)	L
	mass (weight)	kilogram, gram	kg, g
	cross-sectional area	square millimeter	mm^2
Masonry	length	meter, millimeter	m, mm
	area	square meter	m^2
	mortar volume	cubic meter	m^3
Steel	length	meter, millimeter	m, mm
	mass	metric ton (1000 kg) kilogram, gram	t kg, g

	Quantity	Unit	Symbol
Carpentry	length	meter, millimeter	m, mm
Plastering	length	meter, millimeter	m, mm
	area	square meter	m^2
	water capacity	liter (1000 cm^3)	L
Glazing	length	meter, millimeter	m, mm
	area	square meter	m^2
Painting	length	meter, millimeter	m, mm
	area	square meter	m^2
	capacity	liter (1000 cm^3) milliliter (cm^3)	L mL
Roofing	length	meter, millimeter	m, mm
	area	square meter	m^2
	slope	millimeter/meter	mm/m
Plumbing	length	meter, millimeter	m, mm
	mass	kilogram, gram	kg, g
	capacity	liter (1000 cm^3)	L
	pressure	kilopascal	kPa
Drainage	length	meter, millimeter	m, mm
	area	hectare (10 000 m^2) square meter	ha m^2
	volume	cubic meter	m^3
	slope	millimeter/meter	mm/m
HVAC	length	meter, millimeter	m, mm
	volume	cubic meter	m^3
	capacity	liter (1000 cm^3)	L
	airflow	meter/second	m/s
	volume flow	cubic meter/second liter/second	m^3/s L/s
	temperature	degree Celsius	°C
	force	newton, kilonewton	N, kN
	pressure	kilopascal	kPa
	energy, work	kilojoule, megajoule	kJ, MJ

	Quantity	Unit	Symbol
	rate of heat flow	watt, kilowatt	W, kW
Electrical	length	meter, millimeter	m, mm
	frequency	hertz	Hz
	power	watt, kilowatt	W, kW
	energy	megajoule kilowatt hour	MJ kWh
	electric current	ampere	A
	electric poten-tial	volt, kilovolt	V, kV
	resistance	ohm	W

DRAWINGS

Drawing Scales

- Metric drawing scales are expressed in nondimensional ratios.
- Nine scales are preferred: 1:1 (full size), 1:5, 1:10, 1:20, 1:50, 1:100, 1:200, 1:500, and 1:1000. Three others have limited usage: 1:2, 1:25, and 1:250.

Comparison Between Inch-Foot and Metric Scales

Inch-Foot Scales	Ratios	Metric Scales		Remarks
		Preferred	Other	
Full size	1:1	1:1		No change
Half full size	1:2		1:2	No change
4" = 1'-0" 3" = 1'-0"	1:3 1:4	1:5		Close to 3" scale
2" = 1'-0" 1-1/2" = 1'-0" 1" = 1'-0"	1:6 1:8 1:12	1:10		Between 1" and 1-1/2" scales
3/4" = 1'-0" 1/2" = 1'-0"	1:16 1:24	1:20	1:25	Between 1/2" and 3/4" scales Very close to 1/2" scale
3/8" = 1'-0" 1/4" = 1'-0" 1" = 5'-0" 3/16" = 1'-0"	1:32 1:48 1:60 1:64	1:50		Close to 1/4" scale
1/8" = 1'-0" 1" = 10'-0" 3/32" = 1'-0"	1:96 1:120 1:128	1:100		Very close to 1/8" scale
1/16" = 1'-0"	1:192	1:200		Close to 1/16" scale
1" = 20'-0"	1:240		1:250	Close to 1" = 20'-0"

Inch-Foot Scales	Ra-tios	Metric Scales		Remarks
		Preferred	**Other**	
1" = 30'-0" 1/32" = 1'-0" 1" = 40'-0"	1:360 1:384 1:480	1:500		Close to 1" = 40'-0" scale
1" = 50'-0" 1" = 60'-0" 1" = 1 chain 1" = 80'-0"	1:600 1:720 1:792 1:960	1:1000		

Metric Units Used on Drawings

- Use only one unit of measure on a drawing. Except for large scale site or cartographic drawings, the unit should be the millimeter (mm).

- Delete unit symbols but provide an explanatory note ("All dimensions are shown in millimeters" or "All dimensions are shown in meters").
- Whole numbers always indicate millimeters; decimal numbers taken to three places always indicate meters.

- Where modules are used, the recommended basic module is 100 mm, which is similar to the 4-inch module used in building construction (4 inches = 101.6 mm).

Drawing Sizes

- The ISO "A" series drawing sizes are preferred metric sizes for design drawings.

- There are five "A" series sizes:

  A0 1189 x 841 mm (46.8 x 33.1 inches)
  A1 841 x 594 mm (33.1 x 23.4 inches)
  A2 594 x 420 mm (23.4 x 16.5 inches)
  A3 420 x 297 mm (16.5 x 11.7 inches)
  A4 297 x 210 mm (11.7 x 8.3 inches)

- AO is the base drawing size with an area of one square meter. Smaller sizes are obtained by halving the long dimension of the previous size. All AO sizes have a height to width ratio of one to the square root of 2.

- Of course, metric drawings may be made on any size paper.

SPECIFICATIONS AND PUBLICATIONS

Specifications

All measurements in construction specifications should be stated in metric. Until existing specification systems are fully converted, the specifier may:

- Specify metric products. Check to see if the products to be specified are available in metric sizes.

- Refer to metric or dual unit codes and standards. ASHRAE, ASME, and ACI, among others, publish metric editions of some standards. Two of the country's three model code groups (BOCA and SBCCI) as well as ASTM and NFPA publish their documents with dual units (both metric and inch-pound measurements). In addition, most handicapped accessibility standards and a number of product standards are published with dual units. The metric measurements are virtually exact, "soft" numerical conversions that, over time, will be changed through the consensus process into rationalized, rounded "hard" metric dimensions. For now, use the "soft" metric equivalents.

See the "Metric References" section of this guide for sources of metric and dual unit codes and standards.

- Convert existing unit measurements to metric. Follow the conversion rules below.

Standards, Criteria, and Product Information

For organizations that publish construction standards, criteria, or product information:

- Review all active documents and develop a realistic conversion schedule.

- For most documents, the conversion to metric will be editorial; however, for complex documents, a parallel document or a metric appendix may have to be created and maintained for some time. For very simple documents with only a few measurements, footnotes may be sufficient.

- Follow the conversion rules below.

Conversion Rules

- Use ASTM E621, *Standard Practice for the Use of Metric (SI) Units in Building Design and Construction*, as a basic reference.

- Follow the rules for usage, conversion, and rounding in ASTM E380, *Standard Practice for Use of the International System of Units (SI)*, Sections 3 and 4, or ANSI/IEEE 268, *American National Standard Metric Practice*, Sections 3.5 and 4.

- Wherever possible, convert measurements to rounded, rationalized "hard" metric numbers. For instance, if anchor bolts are to be imbedded to a depth of 10 inches, the exact converted length of 254 mm might be rounded to either 250 mm (9.84 inches) or 260 mm (10.24 inches). The less critical the number, the "rounder" it can be, but ensure that allowable tolerances

or safety factors are not exceeded. When in doubt, stick with the exact "soft" conversion.

- Round to "preferred" metric numbers. While the preferred numbers for the "1 foot = 12 inches" system are, in order of preference, those divisible by 12, 6, 4, 3, 2 and 1, preferred metric numbers are, in order of preference, those divisible by 10, 5, 2 and 1 or decimal multiples thereof. NBS Technical Note 990, *The Selection of Preferred Metric Values for Design and Construction*, explains the concept of preferred numbers in detail and states in its foreword:

It is widely recognized that a transfer to a metric technical environment based upon a "soft conversion,"--that is, no change other than the description of the physical quantities and measurements in metric units--would cause considerable longer term problems and disadvantages due to the encumbrance of the resulting awkward numbers. The overall costs of soft conversion could greatly outweigh any savings due to its short term expediency.

[Technical Note 990] provides a rational basis for the evaluation and selection of preferred numerical values associated with metric quantities. Precedent has shown that the change to metric units can be accompanied by a change to preferred values at little or no extra cost, especially in specifications, codes, standards, and other technical data.

- Use hand calculators or software conversion programs that convert inch-pounds to metric. They are readily available and are indispensable to the conversion process. Simply check with any store or catalogue source that sells calculators or software.

- Be careful with the decimal marker when converting areas and volumes; metric numbers can be significantly larger than inch-pound numbers (a cubic meter, for instance, is one billion cubic millimeters).

MANAGEMENT AND TRAINING

The American National Metric Council and the U.S. Metric Association recommend the following management and training measures:

- Top level commitment. Top level management must provide a firm commitment to metric. This includes:

Announcing a formal metric policy,

Forming a metric committee, and

Appointing a metric coordinator to chair the committee and act as the organization's metric representative.

- Metrication schedule. Develop an organization-wide metrication schedule with milestones and a completion date.

- Metric organizations. Consider joining the American National Metric Council and the U.S. Metric Association.

- Metric publications. Begin a metric reference library. See the Metric References section of this guide.

- Training objectives. Write carefully worded, measurable training objectives with the goal of "enabling employees to perform their jobs with the same or greater degree of efficiency using metric."

- Define the learner population. Determine who needs to know metric and to what extent they need to know it. Some employees may require an in-depth working knowledge of metric whereas others may never need to know it at all. Most probably will need to know only a few metric units.

- Determine training needs. There are three kinds or levels of training:

Metric awareness training to help all employees overcome fear and resistance to change,

Management training to educate the people responsible for the transition to metric, and

Implementation training to teach specific metric skills to specific employees.

- Timing. Training should take place just prior to when an employee will use the new knowledge on the job; earlier training is ineffective.

- Train only as needed. Train only as necessary to meet the goal of "enabling employees to perform their jobs with the same or greater degree of efficiency using metric." Training is not a panacea, and massive training programs are wasteful. Often, training can be performed completely on-the-job.

- Train people to "think" metric. Link metric measurements to familiar objects. Avoid comparisons to inch-pounds as much as possible.

- Monitor the metrication program. Make sure training matches the organization's metric transition schedule. If something changes, adjust either the training or the schedule.

- Don't hide costs. There is a cost to metric conversion, both in time and money. Plan for it in advance, and monitor costs as transition takes place.

METRIC REFERENCES

American Concrete Institute (P.O. Box 19150, Detroit, MI 48219; phone 313-532-2600):

- ACI 318M-89/318RM-89, *Building Code Requirements for Reinforced Concrete and Commentary*. Metric edition of ACI 318-89/318R-89. $78.50.

- ACI 318.1M-89/318.1RM-89, *Building Code Requirements for Metric Structural Plain Concrete and Commentary*. Metric edition of ACI 318.1-89/318.1R-89. 14 pp. $14.95.

American Congress on Surveying and Mapping (5410 Grosvenor Lane, Suite 100, Bethesda, MD 20814; phone 301-493-0200):

- *Metric Practice Guide for Surveying and Mapping*. 11 pp. 1978. $10.00.

American Institute of Steel Construction (Metric Publications, One East Wacker Drive, Suite 3100, Chicago, IL 60601-2001; phone 312-670-5414):

- *Metric Properties of Structural Shapes with Dimensions According to ASTM A6M* (metric version of Part I of the *Manual of Steel Construction*). 92 pp.

- *Metric Conversion: Load and Resistance Factor Design Specification for Structural Steel Buildings*. 159 pp.

American National Metric Council (Washington, D.C.; phone 410-727-0882):

- *ANMC Metric Editorial Guide*. Fourth edition. 16 pp. $5.00.

- *SI Metric Training Guide*. 17 pp. $5.00.

- *Metrication and the Consumer*. $5.00.

- *Metrication for the Managers*. $15.00.

American National Standards Institute, Inc. (11 West 42nd St., New York, NY 10036; phone 212-642-4900):

- ANSI/IEEE 268, *American National Standard Metric Practice*. 48 pp. 1982. $52.50.

- ANSI/AWS A1.1, *Metric Practice Guide for the Welding Industry*. 1989. $20.00.

- ANSI/IEEE 945, *Preferred Metric Units for Use in Electrical and Electronics Science and Technology*. 1984. $45.00.

- ISO 1000, *SI Units and Recommendations for the Use of Their Multiples and Certain Other Units*. 1981. $48.00.

American Society for Testing and Materials (1916 Race St., Philadelphia, PA 19103; phone 215-299-5585):

- ASTM E380, *Standard Practice for Use of the International System of Units (SI)*. 35 pp. 1992. $23.00.

- ASTM E621, *Standard Practice for the Use of Metric (SI) Units in Building Design and Construction*. 37 pp. 1984. $23.00.

- ASTM E713, *Guide for Selection of Scales for Metric Building Drawings*. 3 pp. $15.00.

- ASTM E577, *Guide for Dimensional Coordination of Rectilinear Building Parts and Systems*. $15.00.

- ASTM E835, *Guide for Dimensional Coordination of Structural Clay Units, Concrete Masonry Units, and Clay Flue Linings*. $15.00

- All other ASTM standards are published in metric or with dual units.

American Society of Heating, Refrigerating, and Air-Conditioning Engineers (1791 Tullie Circle, N.E., Atlanta, GA 30329; phone 404-636-8400):

- *SI for HVAC&R*. 1986. 11 pp. Free on request.

- *Psychrometric Charts SI*. Charts 1 through 7. $10.00.

- *1991 Handbook -- HVAC Applications*. SI edition. $114.00.

- *1989 Handbook -- Fundamentals*. SI edition. $114.00.

- *1990 Refrigeration Handbook*. SI edition. $114.00.

- *1992 Handbook -- HVAC Systems and Equipment*. SI edition. $114.00.

American Society of Mechanical Engineers (22 Law Dr., Box 2300, Fairfield, NJ 07007; phone 1-800-834-2763 ext. 426):

- SI-1, *Orientation and Guide for Use of SI (Metric) Units*. 1982. $12.00.

- SI-2, *SI Units in Strength of Materials*. 14 pp. 1976. $12.00.

- SI-3, *SI Units in Dynamics*. 20 pp. 1976. $12.00.

- SI-4, *SI Units in Thermodynamics*. J. W. Murdock and L.T. Smith, eds. 55 pp. 1976. $12.00.

- SI-5, *SI Units in Fluid Mechanics*. J. W. Murdock and L.T. Smith, eds. 36 pp. 1976. $12.00.

- SI-6, *SI Units in Kinematics*. 14 pp. 1976. $12.00.

- SI-7, *SI Units in Heat Transfer*. J. W. Murdock, ed. 36 pp. 1977. $12.00.

- SI-8, *SI Units in Vibration*. 13 pp. 1976. $12.00.

- SI-9, *Guide for Metrication of Codes and Standards Using SI (Metric) Units*. 33 pp. 1980. $13.00.

- SI-10, *Steam Charts, SI (Metric) and U.S. Customary Units*. J.H. Potter, ed. 128 pp. 1976. $28.00.

- *ASME Steam Tables in SI (Metric) Units for Instructional Use*. 19 pp. 1977. No charge.

- All other ASME standards, except the *Boiler and Pressure Vessel Code*, are published either in separate SI editions or with dual units.

BSP Professional Books, Oxford, U.K. (available through the AIA Bookstore, 1735 New York Ave., Washington, D.C. 20006; phone 202-626-7475):

- *Neufert Architect's Data*. Ernst Neufert, author. 2d International (metric) Edition. 433 pp. 1980. $52.50.

Building Officials and Code Administrators International (4051 W. Flossmoor Rd., Country Club Hills, IL 60477-5795; phone 312-799-2300):

- *BOCA National Building, Fire, Mechanical, and Plumbing Codes*. All recent editions are published with dual units.

Canadian Standards Organization (178 Rexdale Blvd., Rexdale, Ontario M9W 1R3; phone 416-747-4044):

- CAN/CSA-Z234.2, *Canadian Metric Practice Guide*. 82 pp. 1989. $28.00 Canadian.

- CSA Special Publication Z372, *Metric Editorial Handbook*. 46 pp. 1980. $15.00 Canadian.

- CSA Special Publication Z351, *Glossary of Metric Units*. 57 pp. 1980. $13.00 Canadian.

R. S. Means Company (Box 800, Kingston, MA 02364; phone 617-585-7880):

- *Means Building Construction Cost Data*, Metric Edition.

National Fire Protection Association (1 Batterymarch Park, P.O. Box 9101, Quincy, MA 02269-9101; phone 1-800-334-3555):

- NFPA 101, *Life Safety Code*. Includes dual units. 1991. 327 pp. $33.75.

- NFPA 13, *Installation of Sprinkler Systems*. Includes dual units. 1991. 130 pp. $24.50.

- ANSI/NFPA 70, *National Electrical Code*. Includes dual units. 1993. 775 pp. $32.50.

- All other NFPA standards are published with dual units.

Southern Building Code Congress International, Inc. (900 Montclair Road, Birmingham, AL 35213-1206):

- *Standard Building Code*. The 1991 edition is published with dual units.

Underwriters Laboratories, Inc. (333 Pfingston Road, Northbrook, IL 60062; phone 708-272-8800):

- Virtually all UL standards contain dual units.

U.S. Government Printing Office (Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402; phone 202-783-3238):

- NIST Special Publication 330, 1991 Edition, *The International System of Units (SI)*. 56 pp. August, 1991. $3.50.

- NIST Special Publication 811, *Guide for the Use of the International System of Units*. Arthur O. McCoubrey, author. 34 pp. September, 1991. $2.50.

- "Metric Conversion Policy for Federal Agencies; Rule." 15 CFR Part 19, Subpart B. *Federal Register*, January 2, 1991.

- "Metric System of Measurement: Interpretation of the International System of Units for the United States; Notice. *Federal Register*, December 20, 1990.

U.S. Metric Association (10245 Andasol Avenue, Northridge, CA 91325; phone 818-363-5606):

- *Style Guide to the Use of the Metric System*. $3.00.

- *Freeman Training/Education Metric Materials List*. 1991. $38.00.

- *SI Metric Style Guide for Written and Computer Usage*. $2.00

- *Metric Vendor List*. $28.00.

Water Environment Federation (601 Wythe St., Alexandria, VA 22314; phone 703-684-2400):

- MO6, *Units of Expression for Wastewater Treatment Management*. 47 pp. $15.00.

John Wiley and Sons (Professional Reference and Trade Group, 605 Third Avenue, New York, NY 10158; phone 1-800-225-5945, ext. 2497):

- *The Architect's Studio Companion: Technical Guidelines for Preliminary Design*. Edward Allen and Joseph Iano, authors. Includes dual units. 468 pp. 1989. $52.95.

- *Wiley Engineer's Desk Reference*. S.I. Heisler, author. Includes dual units. 566 pp. 1984. $54.95.

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Metric Design Guide

General Services Adminstration
Design and Construction Division
Region 3 Philadelphia

Third Edition

October 1993

Design

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.State Roadway Plans
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Road Design/Ohio
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Acknowlegements

Introduction

Since issuance of the last version of this guide, SI has taken firm root in the US construction community.

For almost all Americans, there is now a project being planned or designed which will be built in metric within 1-2 hours of their home.

Many of us are located close to some of the projects already being constructed in metric.

Some of the largest federal and state projects are now being planned or designed in metric, and significant activities have begun at local levels.

It is highly probable that the type of project you are starting has already been designed in metric by another region, or another federal, state or local government.

At a minimum, something similar has been designed in metric, to answer your questions. The trick is locating the proper source, and obtaining material you need.

Through strong communication this can be achieved.

Now managing major metric construction projects, we reject assertions that metric design and construction are not feasible.

After January 1994, all GSA renovation and new construction projects shall be designed in metric.

We thank the private firms, contractors, government agencies, and individuals who provided feedback.

This document may be freely copied and distributed.

Our goals for this edition have been:

1. Give lessons learned on use of metric.
2. Minimize impact on design firms, contractors, and producers, while complying with the national directive of complete metric conversion.
3. Use private sector guidance wherever possible.
4. Convert to a metric thought process.

   Many regions have metric construction, and most others have done metric planning or designing, so basic material has been condensed or deleted.

   We have avoided using old units wherever possible.
5. Improve page efficiency, getting more on fewer pages, making it feasible to insert the document into every AE and construction bid package.
   This also reduces costs and conserves resources.

Most guidance is consistent with the previous edition.

This document supplements national policies. If it conflicts with them, those documents ofcourse govern.

WARNING Sample drawings and data are from many sources and are for the explicit purpose of showing good metric practice. They are not represented as current design criteria. Applicable codes and criteria should be consulted prior to design on projects.

Sample drawings are from US projects in design and construction, so drawings may be preliminary. Some drawings are from project add alternates, thus actual construction may vary from details shown.

We admit selecting only details or portions of details showing good

metric practice. Some details have been modified to delete inconsistent practice. Due to graphic modification, details may not be to scale indicated.

Based on project knowledge, we feel confident to design and build any road, sitework, or facilities project in metric, anywhere on American soil, at little to no cost impact, using the compromise approach established in this document.

As is unfair to project that the information in this document is of our doing only. We have tried to credit other sources for their metric experience.

As our leaders in the recent past simply resolved to place an American on the moon, and attained this through the sheer willpower and resolve of the American people, let us simply resolve to conclude the issue of metric conversion, for the national good.

Let us make the firm choices and gladly accept the effort required. We are looking for partners to move boldly and decisively with us in a direction that is very clear at this point.

Doing this will level the playing field for the next generation, the children and grandchildren in our families, so they may compete head on with other nations, without hindrance of an outdated system whose time has come.

In this edition, we have focused primarily on hard metric products commonly used in construction.

For a listing of firms that can fabricate or install these products, ie, construction firms that feel comfortable working in metric, see M1.

Products listed are made in USA, unless noted.

This directory is open to firms making metric products commonly used in federal construction.

Firms interested in being included may contact us.

Some firms listed minimum orders for products. These minimums will get smaller as we constantly buy metric products. If your order is half the minimum listed or more, we recommend you contact the manufacturer to determine their current interest.

We have deleted some product categories where obtaining metric products has not been a problem, and have given overall guidance to assist specifiers.

America recently regained its status as the world's largest exporter, and our firms are improving market share for many products.

Momentum is building in the American industrial machine, and an important component is use of SI.

Over the past year, we have spoken with thousands of manufacturers, designers, project managers, personnel in education, and representatives of construction firms.

The mood of the nation has shifted. There is a significant and growing body of people that realize that metric is a smart move for this country, and these individuals support the movement toward this system. There is ofcourse resistance.

The American construction community specifically though has responded to the challenge. We now track which contractors have done metric construction, which can build in metric with little difficulty, and which firms have already bid metric projects in this country. These results will appear regularly in M1.

While metric receives mixed initial review, many tradespeople prefer it after some learning period.

We have also encountered metric capability where we did not expect it.

We must conclude that original estimates of extensive effort to convert did not materialize.

When partnering between government and private industry is meaningfully applied, conversion to metric, and realization of the benefits of this system, are no more difficult than the introduction of any new technology or policy.

As the Federal landlord, we have frequent contact with many federal, state and municipal agencies.

Another document, M1, was developed to keep abreast of their metric conversion activities.

Title: M1, Metric Activity in US Construction

M1 is separate because metric projects and activities within government are changing rapidly, needing more frequent revision than design information.

M1 will be updated every few months.

M1 can be downloaded by interested parties from the Region 3 Bulletin Board Service: 215 656 6465

All regional specifications will soon be upgraded to conform to this document.

We welcome comments on this text.

Otto Schick
Tel (215) 656-5822
Fax (215) 656-5822

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Room 610
Philadelphia PA 19107

Philosophy

These three pages give our ideas on successful conversion while minimizing any costs involved.

There are 5 priority actions, ranked by importance:

1. M60
2. Strong Communication
3. Professional Rounding
4. Metric Codes and Criteria
5. Partnering with the Construction Community

1. M60 M60 is the most important action necessary for metric conversion, and takes the most courage to implement.

In many documents read, we have not seen a simple definition of success, of when an agency is metric.

This formula mirrors our progress.

M60 means "metric on 60 % of design this year".

With 60 % of design in the current fiscal year being done in metric, we feel all necessary momentum will be generated to permanently sustain conversion.

Example: A certain region, in this fiscal year, has 300 design projects, total of about $ 100 million.

If 60 %, or $ 60 million, is designed in metric, the entire organization will move to metric, and rapid development of group confidence takes place.

We select design as we view it as a largely irreversible process, without significant cost after a certain point. 60 was used since it represents a majority of the work.

The implications of this statement are significant.

Fewer projects can be selected as metric projects As few as 10 or 20 projects could combine from the design program can meet this M60 threshold. Then it is possible to work with a small group of architects or engineers who will run comparatively few projects, yet this engine will convert the entire organization. These people should generally be willing to work in metric.

We recommend that the M60 program be made up of medium to large size projects, the larger the better.

Anchor Effect This 60% block formed an anchor for our conversion effort. With many major projects being designed metric, a galvanizing effect occured to managers of small and medium sized jobs. They felt more confident to do metric projects, with x or y project going well in metric.

Combined Buying Power With major projects being done in metric, local suppliers are more willing to make changes to supply metric products. Some suppliers were reluctant to go metric without indication it would be worth it. With M60, this project block is often enough to show a sustained market.

This block can establish metric product availability, and lower order quantities. Ex, if a medium project needs 200 pieces of metric product x, some firms may not supply it. owever, with 200 now, and another 4000 documented through M60 over a few years, views may change considerably.

To gain this same amount of buying power, an organization may have to select perhaps 50 or 100 projects of smaller construction value, by far the more difficult route to becoming a metric organization.

On The Job Training M60 can make the organization metric as it brings the best metric training to the organization at about no cost. While only ten or fifteen staff run metric projects, we found many other people and divisions involved at stages (ex, reviewing designs or estimates, or in technical meetings). This framework introduces others to metric. Drawings, specs, estimates, appear in near finished format, developed by familiar faces, which enhances confidence.

A pool of metric experts is formed, the knowledge base grows quickly, and guides the organization.

Automatic Infrastructure When an group as ours simply decided to be metric, to meet M60, automatic needs were created for specs, criteria, codes, training devices, and other parts of metric infrastructure. Priorities are soon established. (ex, What specs to convert? This answered by seeing the 120 or 150 needed by the M60 program) A program becomes prepared for 100 % metric design. Items not needed by an M60 program may never have to be converted.

Partial Conversion Some will not wish to be a part of conversion. M60 allows projects to be developed in old units, for an interim period, if truly necessary.
In summary, we feel an organization can go metric almost surgically, highly successfully, by deciding to be metric, and meeting M60 in this fiscal year.

Related groups move after M60 action occurs. Design and construction firms trained workers. Builders and unions sought assistance. Suppliers made changes, and developed product literature.

In short, once an organization decides to be metric, all other activities fall into place.

Deciding to be a metric organization, ie M60, is by far the

most important activity in metric conversion.

This applies not only to government, but also to private and educational organizations.

Ex, Moving a college building program to M60 status would have more impact than courses in metric architecture alone. M60 creates a laboratory on campus, actual uses of SI. Many educators say if industry used SI, english would vanish from schools.

Rulers and posters create awareness, but M60 will move construction decisively to the SI system.

2. Strong Communication During much training, a major lesson learned, predictably, is that people feel much more confident to work in metric, when they know other projects nearby are being done in metric.

It makes a great difference to know in the next county, a $15 million building, or a $ 10 million interchange, is in design or construction in metric.

Most people know metric is here, but it galvanizes reality when projects, and exact locations, are known.

As metric coordinator, after starting the M60 program, the important task is letting those in and outside the region know the metric projects.

This can involve as little as a one page list, or a message on e-mail, as to what projects are being done.

The National Institute of Building Sciences (NIBS), Construction Metrication Council, manages conversion of US construction, involving agencies, producers, builders, and professional groups. The Task Force on Metric Projects is ideal to communicate your activities.

You can improve confidence of those around you to go metric by relaying your activity. New projects by nearby groups then enhance your ability to obtain metric products and may lower costs or minimum orders.

We recommend a 1-2 page Metric Project List, giving:

> All metric projects being done in your organization or region, construction value of each, and the status (planning, survey, design, construction)

This is the most powerful information you can have at your disposal as a metric coordinator.

We would give this to staff and the Task Force. If interested, please fax to either task force co-chair:

Otto Schick
Fax (215) 656-5836
Tel (215) 656-5822

Joe Sacco
Fax (703) 693-6934
Tel (703) 614-4879

3. Professional Rounding Over 90 % of products in construction today will not physically change during metric transition. We simply show dimensions in metric, ie, soft conversion.

These two terms help explain how to use 90 % soft metric products and still use round dimensions on projects. Examples from varied areas follow.

Product Dimension: size of an item not easily modified

Design Dimensions (dds): dimension that can be varied, often through fabrication or installation

Airports Concrete and soil have no dimension. Structures of them are

often governed by dds. Width of runways and taxiways and dimensions of clear zones, can often be hard metric. Imaginary surfaces may also be dds, if the airport is frontal layout, finger system, split finger, or other variety. Product dimensions for lighted runway and taxiway lights, beacons, wind indicators, guidance signs and gangplanks, can often be soft converted.

Bridges Rolled steel wide flanges to construct simple steel bridges are soft converted products, yet beam, girder, and lateral bracing lengths are dds which can be varied. Vertical bridge clearances are dds.

Environmental In water supply and waste treatment, components (ex, clarifiers or centrifuges) could be soft converted, yet structures for sedimentation tanks, grit chambers, sand filters, activated sludge process facilities, oxidation ponds, sludge thickening facilities involve many dimensions which can be rounded.

Facilities Rooms are often from centerline to centerline or face to face, if studs are hard or soft metric. Light switches are soft, but mounting heights are easily rounded. Ceiling heights are dds. Bar placements and wall thickness are dds. Slab to slab heights (ex, 5 m) are dds.

Conduit, alarm systems, motors, receptacles, switchgear, air handlers, boilers, pumps and valves will have product dimensions soft converted, but installation dimensions (ie, dds) are hard converted.

Marine Mooring posts, cleats, piles, fender systems, buoys, and precast breakwater units have product dimensions which could be soft converted. Yet turning basins, breakwaters, freight terminals, bulkhead wharfs, dolphins, fixed mooring berths, rock moles and trestles, have dimensions that are readily rounded.

Rail 136 RE rail and standard joint and tie components may be used in elevated high speed rail, with products soft converted, yet center to center for support piers could be hard, such as 25 m. Top and subballast thickness are dds, as well as right of way, such as 20 m each side. Frogs, spikes, and wood ties could probably be soft converted.

Water Engineering Prefabricated components in hydroelectric facilities may be soft converted, such as impulse or reaction turbines. Yet a primary product is concrete, so the dds such as height, thickness, spillway and intake tower dimensions, could be hard metric.

100 % Rule Over 90 % of current products will be used, but strive for 100 % hard design dimensions.

Most drawings show installation dimensions, which can be varied, often independent of product sizes.

Thus drawings will be mostly hard metric and make installation by our partners in the trades easier.

4. Metric Codes and Criteria

Criteria We recommend new or revised criteria for design (ex, handbooks, specs) be issued in metric only.

People no longer debate if or when, but realization of permanence emerges, and metric thinking begins.

Directives to go metric, along with issuance of dual dimensioned criteria, appear contradictory.

If the new ceiling height is 2700 mm, those with any experience will not forget this is about 9 feet.

Old documents propagate for years, even decades, and will bridge the

gap from metric to english as needed.

Codes Grade A metric codes would make metric design simpler and more desirable.

Ex, a code might state 44" (1118 mm) minimum width. While it is very helpful to have metric included, rounded design might lead to 1200 or 1150 being used.

The greatest improvement would be new dimensions in 100 and 50 mm sizes. Could 1100 be the new size? This is of course a professional judgement.

However, since rounded metric sizes are not in codes yet, many still use english sizes during daily speech. Grade A codes would greatly assist metric transition.

Fortunately, many code sizes are lengths, which when converted usually get smaller, and offer many little cost savings. Ex, from above, if 1100 is possible, small savings would appear over many situations.

5. Partnering with the Construction Community Construction firms have little time to prepare bids for a project. This pressure increases on a metric project.

Prepare your community with:

1) Reference Material
2) Clarity on Hard Metric
3) Advance Notice

Reference material reveals what you obtained from months of metric design. This document may be a good first step. List other suppliers you have found.

At pre-bid meetings, identify the hard metric products. Explain most products are the same as previously used.

Advance notice means alerting local groups, unions and societies of forthcoming metric projects.

In summary, from our experience with metric, we feel we could design and build about any project in this country, completely in the metric system, using this compromise philosophy.

From discussions with builders nationwide and talks with managers on metric projects, we could provide 10 firms to bid any metric project over $ 500,000, almost anywhere in the United States.

January 1994 is feasible for all construction in our country to be designed in metric, utilizing techniques established in this document.

The design and construction projects now being done in metric indicate to us this is possible.

Usage

Metric Slang From PCs, CAD and fax, from Seatac to the Keys, the Alcan, the Lone Star, the Bay Area, and the Beltway, slang is part of our vibrant culture.

Americans are efficient and we like things fast. Our people will brand the SI system with our personality and make it our own.

While perhaps controversial, we do not discourage this, as we feel a verbally modified system will be more quickly accepted in society at large.

Smooth and catchy words such as nada are easily incorporated into our daily speech.

The critical issue is that SI be implemented, and that everyone is clear what the new expressions mean.

Few are confused when five kilos, a non-SI term, instead of five kilograms, are referred to.

This information shows techniques from daily usage, but is not represented as preferred metric practice.

mmoc We have seen the term "mmoc" on drawings, to mean mm on center. (ex, Fasten every 600 mmoc)

The "x" can verbally represent "hundred millimeters".

(ex, "five x", vs "five hun-dred mill-i-met-ers", 2 vs 7 syllables) This can be very efficient for lengths up to 10 meters (ex, 5 x, 12 x, 52 x, 78 x).

Even fractions can be verbally faster using x. (Ex, point five x, vs. fif-ty mill-i-met-ers)

This also helps people to use 100 mm increments.

"x" does not conflict with any other SI symbols.

Modular Products such as ceiling tiles, access floor, light fixtures, and carpet tiles, have few standard sizes. We often use shorted names for 100 mm increments. 5 x 5 is 500 x 500, 6 x 6 is 600 x 600, etc.

Centimeters While not used in drawings and specs, they are used in other countries in day to day life. We sometimes call them "c's" (pronounced "seas"). (ex, the report was about 2 seas thick)

This technique was used earlier with cc's for volume.

Pascals "k-p-a" is often said instead of kilopascals, and "m-p-a" instead of megapascals.

Mass Megagram (Mg), equal to 1000 kg, is SI, and is our choice for large masses. (ex, rebar, steel, gravel)

We like to call them "meg". (ex, eighty meg of rebar)

This is already used by people in daily speech, such as a 25 meg hard drive.

We hear metric ton used, but we find it slow, and it can be confusing, since people often drop metric and say only tons, even when metric tons are meant. Micrometers are often shown as "um" since the micro character can be hard to use on many keyboards.
(ex, 25 um means 25 micrometers)

Superscripts can be cumbersome, and are often avoided in correspondence, using only the number.

> 2500 m3 means 2500 cubic meters.
> 1100 g/m2 means 1100 grams per square meter.

Rule of 3's For Meters Many say, no matter how many classes attended, they will never have a feel for meters. The rule of 3's can help, and is fairly accurate.

Feet times three, move decimal left one digit.

50 feet, times 3 = 150, move decimal, 15 m
20 feet x 3 = 60, yields 6 m

Rule of 4's For Hectares This rule can help develop a general feel for converting commonly used acres to hectares (ha), or hecters, as many pronounce it.

Multiply acres times 4, move decimal left one digit.

30 acres x 4 = 120. Move decimal yields 12 hectares.
10 acres x 4 = 40, yields 4 ha.

Rule of 10's For Square Meters

Square Feet divided by 10 = Square Meters

500,000 SF divided by 10 = 50,000 m2

For diehard fans of the old system, who can not bring themselves to use meters, the ideal transition unit may be the metric foot, equal to 300 mm, or 0.3 m.

So the 8 foot ditch becomes 8 metric feet, or 2.4 m.

Drawings

Good drawing practice is demonstrated on the sample drawings in this document.

Centimeters shall not to be used.

Dual dimensions shall not be used. Example, 200 mm (7-7/8")

Dual dimensions are a complete waste of time in construction documents. When english units are there, readers use them and ignore the metric.

Use preferred scales:
1:1 1:2 1:5 1:10 1:20 1:50 1:100 1:200 1:500 1:1000

Many state DOTs use 1:250 for urban plan sheets.

ISO Paper Sizes are the standard international paper sizes, and are often available within a few weeks, anywhere in our country, from domestic sources.

Many state and federal agencies, such as Army Corps, Huntsville Division, are now using them.

We are now generating designs in this region around A1 size. Designs are to now use ISO sizes, see below.
The Government Printing Office now stocks A4 paper for purchase by other agencies.

Many state highway groups have adopted A1 as their standard drawing size.

A0 1189 x 841
A3 420 x 297
A1 841 x 594
A4 210 x 297
A2 594 x 420

Specifications

Several questioned our use of mm for large dimensions. In response, we have utilized both m and mm in specifications in the interim period, and have found little difficulty or confusion using either.

Our new general rule is to use m or mm, whichever you prefer. Examples:

Concrete to be 200 mm thick. (0.2 m could be used)

Clearance shall be 1500 mm. (1.5 m could be used)

This practice differs from drawing usage where mm are used exclusively in many areas.

In specifications, the unit (ex, m or mm) is almost always present. Little room exists for confusion. On drawings, using mm eliminates the need to write m or mm, and eliminates decimal usage for all but large scale civil and road design drawings.

Centimeters should not be used. A small class of items reference standards using cm or cm2, such as fire ratings for some products. These areas only, which account for less than 2 % of specification references, should make reference to cm or cm2.

It is recommended that each region establish a directory of pure SI specifications, as we have done, and not mix SI and english specifications.

It is also not recommended to have both metric and english in a guide specification section, as this requires spec writers to edit english out of the document.

Nominal Technique Many spec references can effectively use nominal mass, nominal volume, or nominal length technique. Ex, if 1 gallon of product x is required (or, 3.785 L) the spec could be rewritten using nominal volume, requiring 4 L (+/- 0.25 L). People can then say 4 L when referencing this item, yet still allow current product to be submitted.

Rounding

Having seen many metric drawings, and seeing the downstream effect, we feel rounding of design dimensions is a very high priority.

Too many review comments on metric projects state that we do not prefer bar spacings at 305 mm on center, or base plate dimensions of 460 x 460, and similar items.

The professional rounding concept helped, but we have developed a simpler, but firmer stance on this issue.

The Rachet: 100 50 10 5 1

The rachet is a five level priority system, 100 being highest priority, which requires justification to move down one rachet. (ex, to move from 100 to 50)

Thus design dimensions, created in ones mind, should be increments of 100 mm, unless solid reasons exist to move down a rachet to design in 50 mm increments.

Room sizes in new construction and renovation are ofcourse in 600 mm increments unless not possible.

The rachet applies most directly to design dimensions, which are smaller than room dimensions, such as 3600 x 4800, but larger than product dimensions, such as
92 mm metal stud sizes, which are often fixed.

Examples: bathroom stall widths, bathroom component mounting heights, concrete wall thickness, window dimensions, base plate sizes, parking stall widths, cabinet widths, counter heights, slab thickness, door louver and window sizes, ductwork sizes, shelf spacing, railing heights and on center dimensions, landscape installation dimensions, etc.

Critics have indicated this is not always possible, which we know. But increments of 100 and 50 mm should now become the baseline for project design, with 10 and 5 mm increments used only as required.

Simple Mathematical Rounding shall not be used.

Ex, A design dimension simply converted to 3658 mm.

Professional Rounding shown below, takes simple mathematical rounding, adds professional judgment.

Step 1. Convert The Dimension Mathematically A pavement width in some codes becomes 914 mm.

Step 2. Select A Replacement Dimension (Use Rachet)
1000 would be the preferred replacement.
950 would be used only with justification.
900 would offend the code and could not be used.

For non code dimensions, smaller dimensions in increments of 100 might be selected.

Ex, custom cabinets are to be built to a width that converts to 508 mm. 500 would be the probable choice, and would be permitted if this were not a code or exact required dimension.

Codes and Standards

About 90 % of codes and standards needed by us to do design are available today in metric.

Many not in metric are being converted now.

Codes and standards have not hindered renovation or new construction designs in metric to date.

Documents listed below are now being extensively used in metric design projects of every sort.

For codes or standards not in metric, rounding techniques have been proven sufficient.

The missing component to full metric conversion in United States construction is the implementation of metric design projects in the federal, state, local and private design communities.

Only this full implementation will create the need to continually improve metric codes and standards.

These are sample documents where most of the text, or the entire text, contain SI/english or pure SI data.

AASHTO Standard Specs. for Structural Supports for Highway Signs, Luminaires, and Traffic Signals (1985), including revisions to 1991, have SI data.

Construction Manual for Highway Bridges and Incidental Structures has SI in many areas.

Standard Specs for Highway Bridges contain SI data and formulas in appendix E.

Standard Specs for Transportation Materials, now contain SI, in Parts 1 and 2. Many tests use SI only. Many standards are identical to ASTM standards, most of which now contain SI data.

ACI 318M, 318.1M available, which are SI versions.

ACSM Amer Congress on Surveying and Mapping Metric Practice Guide was recently reissued.

AFPA Amer Forest and Paper Assn First LRFD manual and next National Design Spec will have SI.

AIA Graphic Standards, has SI chapter. Masterspec will be available in metric shortly.

AISC LRFD Spec and Properties of Structural Shapes are in SI version. Metric Database for ASD and LRFD available. Manual of Steel Constr to be SI in 1994.

ASHRAE All handbooks available in SI.

ASME Most ASME standards contain SI data.

ASTM ASTM Standards in Building Codes contain SI in almost every standard.

AWS AWS standards contain SI data.
BOCA National Building, Fire Prevention, Mechanical and Plumbing Codes have SI.

CSI CSI Spectext has SI. Other CSI publications contain SI or are being converted now.

CSSB Cedar Shake and Shingle Bureau WA, New Roof Construction manual comes in SI version.
Michael Westfall (206) 453-1323

IES Illumination Engineering Society Handbooks contain SI data.

KCMA Kitchen Cabinet Mfrs Assn A161.1, Recommended Performance and Construction Standards for Kitchen and Vanity Cabinets now has SI. KCMA reports exporting firms do so in SI units.

NEBB National Environmental Balancing Board Fundamentals, Air Systems, and Hydronic Systems guides available in SI.

NFPA Almost all standards now have SI. Examples:

NFPA 13 Installation of Sprinkler Systems
NFPA 20 Installation of Centrifugal Fire Pumps
NFPA 24 Private Fire Service Mains
NFPA 70 National Electric Code
NFPA 101 Life Safety Code

SBC Standard Building Code has SI. 1994 versions of Fire, Plumbing and Mechanical will have SI.

SMACNA All SMACNA publications now being converted to contain SI data.

UBC 1994 versions of Building, Fire, Mechanical, and Plumbing will have SI.

UL Many UL standards contain SI units.

Architecural / Block

Hard metric block has 12.5 block per m2.

Metric block has been installed on US projects.

Standard mortar joint for brick and block is 10 mm.

Sizes: 90, 140, 190 thick, 190 x 390 face

Some metric block are being supplied using molds borrowed from sources that already owned them, eliminating mold purchase costs.

See other national policy on this issue.

Architectural / Brick

75 modular metric per m2, 50 metric jumbo per m2.

BIA says most member firms can supply metric brick. Metric brick has been used on US projects.

Metric modular is most common:
90 x 57 x 190
Jumbo brick is also popular:
90 x 90 x 190

Three modular courses with 10 mm joints rounds to 200 mm. Two jumbo courses equals 200.

Brick should be specified in metric whether ASTM C216 or ASTM C62 / AASHTO M114 is used.
Weepholes mostly spaced in 100 mm sizes. (ex, 600)

Architectural / Carpet

Most firms have the dies and can or do make metric tile. It is usually not stocked. Minimum orders go from no minimum to several hundred square meters. Most said as industry goes metric, minimums would drop and premiums would shrink or be eliminated.

Most common sizes are 500 x 500 and 600 x 600.

Our projects are now specifying hard metric tile sizes.

Architectural / Ceiling Systems

Many design and construction projects, both renovation and new construction, are using the 600 x 600 system.

Many facilities with 2 x 2 grids are not adversely affected by use of new 600 x 600 grids, since coordination between grids, window mullions, and other architectural elements is often not maintained through years of renovation.

With hard metric ceilings, room dimensions can be multiples of 600 mm, giving clean, rounded dimensions

to construction personnel for layout.

Architectural / Doors

A popular size is 900 x 2100, especially in interior partitions. 1000 x 2100 is sometimes being used.

Public Works Canada often uses 950 x 2150, with a 50 mm frame, matching 2200 block coursing.

Based on project feedback, and ease of obtaining hard metric sizes, all of our projects are now using hard metric door and frame sizes.

Louvers and glass should be in hard metric dimensions, such as 300 x 300, 450 x 450, etc.

Thickness Most architects soft convert door thickness and are using nominal 45 mm as standard.

Frames Almost all door frame section dimensions are being rounded to the nearest 1 mm. (ex, 13, 25, 41, 50, 80 mm) Lengths and widths match hard metric door sizes and should be hard metric. (ex, 900 x 2100)

Architectural / Drywall

Sheet width is 1200. Standard stud spacing is 400.

Thicknesses are the same to minimize production impact. Most architects show these as 13 and 16 mm on drawings, instead of the exact 12.7 and 15.9 mm.

Minimum orders vary by firm. Partial truckload orders are available, but most firms indicated one truckload as a minimum order. We have now approved metric drywall submittals and will soon begin installation.

We feel many projects using 500-2000 m2 should be able to feasibly obtain it. The range of 2000 m2 or more should have no difficulty.

Architectural / Elevators

We propose capacities be specified to the next lowest 50 kg. (ex, 4000 lb = 1816 kg. Specify as 1800 kg)

Signage in the elevator would show 1800 kg only.

Most mfrs can make hard metric platforms. We feel it is not critical, and recommend allowing standard sizes.

Specifying 50 mm platform sizes is preferred, but allow standard english platform sizes to be submitted.

(ex, 5'7 x 7' platform = 1702 x 2134. Specify as 1700 x 2100, but approve the standard english size)

Note: Code and criteria requirements may restrict this approach and must be considered on each project.

Speeds should be in m/s, shown to 2 digits.
(ex, 0.64 m/s, 0.51 m/s)

Thus mfrs supply standard product, and rounded numbers appear in specs, drawings, and to the public.

Architectural / Glass

ASTM C1036 gives metric sizes for flat glass, heat absorbing glass, and wired glass. Glass shall now be specified in mm only. Thicknesses for Type 1, Transparent Flat Glass: 1, 1.5, 2, 2.5, 2.7, 3, 4, 5, 5.5, 6, 8, 10, 12, 16, 19, 22, 25, 32

Architectural / Landscaping

Products should be specified in rounded increments. We recommend the following, wherever possible:

Inches x 25 = mm (ex, 2 inch x 25 = 50 mm)

This should be used for description of existing landscaping, as well as new items.

Architectural / Lighting Fixtures

Most common sizes are 600 x 600 and 600 x 1200. Many firms say it is easier to supply 600 x 600, since U tubes do not restrict housing sizes from being made slightly smaller.

Architecural / Lumber

AFPA recommends the designations often used in Canada. Products are not changed. This chart gives actual mm-nominal inches.
(ex, 38 x 89 replaces 2 x 4)

38-2 63-3 89-4 114-5
140-6 165-7 184-8 210-9
235-10 260-11 286-12
337-14 387-16

Our experience shows people use mm dimensions in exact layout work only, such as layout of cabinetry, but verbally they still use 2 x 6, 2 x 10, etc.

Architectural / Plywood

Many firms often make metric plywood, and others can make many grades, thicknesses, and panel sizes.

Most firms prefer one truckload as the minimum order, which can generally include different thicknesses.

It generally takes 2-3 weeks for delivery. Costs will be comparable to english sizes.

Projects using plywood should specify metric sheets.

Thickness is the same to minimize production impact. Standard are 12.7 and 19.05 mm, commonly given nominal thicknesses on drawings (ex, 19 mm)

While it may sound contrary to the spirit of conversion, suppliers indicated they should decide the least costly way to supply metric sheets.

Many mills cut 4 x 8's to smaller sheets for furniture. They say 20-50 metric sheet orders could be cut locally from 4 x 8 to 1200 x 2400 for less than fabricating it and shipping it from a major mill across the country, until 1200 x 2400 becomes commonly available. We focus on specifying stud spacing and allow industry to innovate supply methods.

Architectural / Renovation

Renovation is more difficult than new construction, metric or english.

The difficulty of metric renovation can be minimized through use of the following and other techniques.

Examples are simplifed to demonstrate the principles.

<u>One Bad Rule</u> This technique can be utilized to minimize awkward metric numbers. Any existing space dimension, no matter how awkward, can be developed as a series of clean, rounded metric numbers, combined with one awkward metric number.

Ex, if two existing walls are located 12 043 mm apart on a renovation project, this could be laid out as:

1400 + 3600 + 4200 + 1200 + one bad, or 1643

This is ofcourse simplified, but it is a noble goal in renovation, and if the majority of situations utilize this technique, the awkward numbers can be minimized.

Off The Wall Technique In addition, if the first four dimensions above are such that the spaces can be laid out off one wall, the 1643 will not be used, although it will probably be checked initially to confirm overall accuracy.

Ex, 1400 + 3600 + 4200 + 1200 = 10400

With this approach the layout work is all done in rounded metric units off one wall, and the 1643 is a floating dimension. Layout is done to the maximum of 10400 only, all with clean numbers.

Metric Core Technique With the same example above, our space of 12043, we can use the metric core technique.

If either wall is to have stud and drywall applied, we can take up the slack to establish a hard metric core. If we use 92 mm metal studs, 16 GWB, and move the stud 35 mm out from the existing wall, we establish a 143 mm floating zone. A rounded, 11900 dimension is now established as the metric core.

Equal Technique If both walls are to receive drywall facing, we can use 92 studs and 16 GWB both sides, plus indicate an equal distance from each existing wall to the metal stud, to create a total metric core of 11800. The equal distance would be 13.5 mm equal on each side, making 121.5 each side, times 2 equals 243, leaving 11800. The 13.5 could be shown only as Equal on drawings.

Soffit Technique In some facilities, we utilize soffit ceiling techniques to take up the awkward difference around the edge, so we can utilize hard metric ceilings. In our example, 18 metric 600 mm ceiling tiles, plus a 100 mm border, would give 11 m. An equal soffit space of 521.5 would work nicely as a border, and would equal our 12043 dimension.

The majority of dimensions involved with renovation or new construction involve new dimensions. Ex, no one is reconstructing a bay spacing in an existing building, since it already exists. The frequently utilized dimensions in renovation consist of dimensions which can be stated in rounded, hard metric dimensions to a large degree.

Architectural / Roofing

Use m2 for areas, instead of the 2 previous units.

State membrane thickness in mm only. Lap widths should be even mm. (ex, 100, 150 mm)

Architectural / Sheet Metal

We have found very little difficulty showing dimensions in mm thickness only in specifications.

While several people indicated it would be simpler to leave gage, we feel specifying mm thickness eliminates all confusion, and still allows standard products to be supplied, since specifications give minimum thickness.

Our projects are now moving toward showing minimum thickness in mm only.

We recommend specifying in even 1 or 0.1 mm thickness wherever possible. (ex, 1 mm, 1.6 mm)

Most overseas references we see also utilize either
1 or 0.1 mm increments.

From our research, hard metric sheet metal is obtainable, even in smaller quantities.

Architectural / Slope

There is benefit to using % for slope.

Rule: Percent x 10 = mm/m (mm per meter drop)

Ex: 2 % x 10 = 20 mm/m, 45 % = 450 mm/m

We recommend using % instead of ratios (ex, 1:12), wherever possible.

Architectural / Stone

Stone, such as granite and marble, should be specified in hard metric (ex, 30, 50 mm thick, or 100 x 300)

We have contacted many domestic companies able to produce required hard metric stone sizes.

Architectural / Studs

We have seen several conversion systems, and propose to call common metal studs by these nominal mm sizes, which closely align with the dimensions in the standard: 42 64 92 102 153 mm

A 22 mm hat channel for furring is also common.

Architectural / Woodwork

Custom casework, such as cabinets, built-in benches, shelves, security desks, and judges benches, should be developed in hard metric to the fullest degree possible.

Dimensions should follow the rachet technique.

Cabinets Many cabinet widths we have seen are shown as increments of 50 mm. (ex, 450, 500 mm wide)

Lockers in childcare have been seen as 250 mm wide.

Civil / Concrete

Concrete is now being widely specified throughout the country in MPa. Strengths are stated in 5 MPa increments: 20, 25, 30, 35, 40, 45, 50, etc.

20, 25 and 30 MPa are the most common.

ACI 318 M, metric version, should now be used.

Slump Limits on metric projects always use 10 or 5 mm increments. (ex, 75, 80, 90 mm)

Some Canadian documents state increments of 10 mm are to be used. (ex, 80, 90, 100 mm)

Civil / Concrete Pipe

ACPA states concrete pipe can now be specified using hard metric ASTM and AASHTO standards, as is currently done in Canada.

Reinforced concrete pipe is now being specified on our projects as ASTM C76M / AASHTO M170M.

Current C76 RCP will meet the hard metric standard, as tolerances were set in the hard metric standard to accept current product.

Nonreinforced concrete pipe will be specified as ASTM C14M / AASHTO M86M.

C76M sizes:300 375 450 525 600 675 750 825 900 1050 1200 1350 1500 1650 1800 1950 2100 2250 2400 mm

C14M sizes: 100 150 200 250 300 375 450 525 600 675 750 825 900

Civil / Geotech

Geotech reports shall be SI units only, and equally importantly, shall be in rounded SI units. Bearing and side frictions values shall be in MPa, rounded to 1 or 0.1 MPa increments wherever possible.

Failure to state bearing values in even MPa will cause english values to be utilized throughout the project. Example: Conversion of an english value to 1.437 MPa will not cause people to use this number, whereas rounding to 1.4 or 1.5 MPa, if technically possible, produces a number easy enough to incorporate into common daily use.

Show anticipated settlements in even mm sizes. Location plans and boring plates shall be to metric scales, and shall have metric graphic scales only.

Soil profiles and boring logs shall show even meter depth increments only. Bearing value contours shall be in meters. Describe boring equipment, such as barrels and hammers, in SI units only.

Civil / GIS

Many Geographic Information Systems and AM/FM systems for mapping, gas, electric, and water distribution mgmt, wastewater systems, and other infrastructure elements, will operate in SI.

Delta Data MS, offers AGIS, Adv Geographic Informatn System, which runs in SI. (601) 799-1813

ESRI CA, produces ARC/INFO, a market leader in the GIS market as well as the utility market, which will work completely in metric. (909) 793-2853 x 1375

Facility Mapping Systems CA, produces several software packages that operate in metric:
FMS/AC Municipal
(DPW and Planning)
FMS/AC Public Works
(infrastructure mgmt)
FMS/AC Utility
(electric, gas, water systems)
Gregg Smith
(800) 442-3674
(415) 381-1750

Intergraph AL, produces GIS software that can run in metric. John Hacker (205) 730-1705

Scott and Scott Systems WA, a prominent electrical utility GIS software producer, offers DMS/G, which can operate in a metric environment.
Susan Varga (800) 325-1494
(206) 441-1804

Our sources also indicate the Global Positioning Satellite (GPS) system is already in metric.

Civil / Infrastructure

We have had contact with many firms able to build infrastructure projects in metric. (ex, waste water and water treatment plants) We are placing this material in the next M1 version.

Civil / Reinforcement

Availability of metric rebar will be variable over the next 1-2 years. Minimum orders vary significantly.

All projects shall now specify hard metric rebar.

Projects let to construction during low supply periods shall, as a concession to our friends in industry, utilize the rebar substitution developed by the Reinforcing Steel Inst of Canada (RSIC), until the formal CRSI system is issued, which we will immediately adopt.

Claim of lack of availability should be backed up by a comprehensive industry product search.

RSIC used M suffixs (ex, 20M) to avoid confusion, which we will use. Recent CRSI material uses this.

Metric rebar is made by a few producers, and others indicated they will produce it. To assist US

firms, limit number of metric bars to the fewest possible per job.

Several DOTs (MO TX VA) and other engineers, were concerned over lack of a metric bar for the No 4.

Canadians had significant discussion on whether 12M should have been added. Through the years, it was decided to stay with the existing series.

Survey From an 8/93 survey of state rebar conversion and metric activity, 19 DOTs had incorporated metric bar into criteria (ex, standard drawings and specs) or would do so within 6 months. (AK AL CA DE FL IA IL KS KY LA MD MS NC OK PA TX VA VT WA)

Three states were not sure if it would be incorporated into criteria within 6 months. 14 states said it would not be incorporated within the next 6 months. 14 states did not respond.

Subsequent discussions have verified that many of the 6 month projections have been realized.

Size	Diam (mm)	Area (mm2)	Size	Diam (mm)	Area (mm2)
3	9.52	71	10M	11.3	100
4	12.70	129	15M	16.0	200
5	15.87	200	20M	19.5	300
6	19.05	284	25M	25.2	500
7	22.22	387	30M	29.9	700
8	25.40	510	35M	35.7	1000
9	28.65	645	45M	43.7	1500
10	32.25	819	55M	56.4	2500
11	35.81	1006			
14	43.00	1452			
18	57.32	2581			

Welded Wire Fabric WRI is currently developing a series of hard metric wire diameters. Many firms make their own dies and can make any size diameter. Some firms, mostly those with newer variable step spacing equipment such as EVG, Schlotter, or BSG, are able to produce metric spacing (ex, 150 x 150), but minimum orders are significant, ranging from about 15 Mg to much higher minimum orders. Look to WRI for shortly forthcoming metrication guidance.

Civil / Roads

Road Design States are roughly divided on use of km or 100 meter stations. AASHTO recommends km stations. Projects may use either at this time.

Use AASHTO Standard R1, equal to ASTM E380, for metric practice.

Federal Highway Administration directed that all construction using federal funds after October 1996 must be designed using the metric system.

The state response has been decisive in many areas, as many states have established dates earlier than that, setting dates in 1995, after which their highway construction will be metric.

Many major state and local highway projects starting now or in the near future are being done in metric.

Federal, state, and local agencies are already doing metric road and bridge design, with some already in or near construction.

Most states have begun converting standard drawings and specifications to metric. See M1 for details.

See the Road Design Data section for more detail.

Right of Way (R/W) Critical issues appear to be public response to SI, and legal acceptance. Our site acquisitions, ie r/w purchases, should use technique 1 below, unless not possible, then use technique 2:

1. Hard Metric Only: 100 m
2. Hard Metric / Soft English: 100 m (328.08')

With method 2, when SI is used exclusively, english can be deleted and numbers will be even metric.

This ofcourse applies only to site acquisitions of uniform geometry (ex, long stretchs of 100 m wide r/w) For site acquisitions of uneven geometry, SI and english dimensions will often involve uneven numbers.
We use AASHTO 1993 Guide To Metric Conversion, for geometric design values, lane and shoulder widths, curb heights, sight distances, curvatures, other material. Phone Orders: AASHTO (202) 624-5800

Civil / Sitework

Sitework, such as location and placement of utility feeds, is among the easier portions of work to do in metric. Surveyors already work in decimal units, and most field personnel indicated switching to metric involved little if any effort.

Our regional electronic surveying and mapping equipment provides data in metric. Many states also utilize electronic data measurement (EDM) equipment which almost always can work in metric units.

Civil / Surveying

Two primary agencies producing survey data are National Geodetic Survey (NGS) and US Geological Survey (USGS). SI database information is available.

NGS horizontal and vertical control point network has been SI since 1983. Benchmark elevations are meters.

UTM and State Plane Coordinates Systems are metric.

Almost 40 states have adopted metric in their state plane coordinate systems.

Project Data Most engineers are now using meters for survey elevations, contour intervals, and large scale site drawings. Feel free to use m or mm.

Convert benchmarks from feet to m or mm.
Ex, 314.15 feet becomes 95.753 m (95 753 mm)

Smart Technique We have seen large mapping scales use SI symbols. 1:2000 was written as 1:2k, 1:5,000,000 as 1:5M.

Electrical

Conduit will not physically change by switching to metric. It becomes classified by a nominal mm size.

There has been significant discussion among our partners at NEMA and in the conduit manufacturing field regarding designations of various conduit types.

Most important is these products will be physically identical. Look to NEMA for future guidance.

Wire Size Almost all cable firms contacted make metric sizes for export, or can make them. Minimum orders vary.

Projects with medium and larger wire requirements may wish to start using international sizes, where permitted by governing codes and criteria.

Many projects have begun to refer to existing sizes by mm2 dimensions, to become familiar with mm2 scale.

These are mm2 equivalents with detailed rounding. In some cases, rounding to nearest 0.1, 1, or more mm2 may be feasible. Use professional judgement.

AWG-mm2 22-0.506 20-0.517 18-0.82 16-1.31 14-2.08 12-3.31 10-5.26 9-6.6 8-8.37 7-10.6
6-13.30 5-16.8 4-21.15 3-26.66 2-33.63 1-42.41 1/0-53.48 2/0-67.44 3/0-85.03 4/0-107.2

kcm-mm2 250-126.68 300-152.01 350-177.35 400-202.68 450-228.0 500-253.4 550-278.7 600-304.0 650-329.4 700-354.7 750-380.0
800-405.4 900-456.0 1000-506.7 1100-557.4 1200-608.1 1250-633.4 1300-658.7 1400-709.4 1500-760.1 1600-810.7 1700-861.4 1800-912.1 1900-962.7 2000-1013.4

ASTM B682 gives metric sizes. Common sizes are:

0.5, 0.75, 1, 1.5, 2.5, 4, 6, 10, 16, 25, 35, 50, 70, 95, 120, 150, 185, 240, 300 mm2

Fiber Optics It was falsely reported in the last edition that fiber optic cables would be soft converted. Most cables are made to metric dimensions, so these will be specified in hard metric. (ex, 125 um fiber cable)

Illumination levels are in lux (lx). Specify lux values using the rachet technique, where feasible and allowed by criteria. 1 FC ~ 10 lx; thus rounding a few lx may have little impact.

Environmental

The environmental field has been progressive regarding SI. Many regulations have been metric for years.

Based on review of commonly used environmental data, projects shall now specify metric only.

Estimating

Time We find metric design and construction take the same number of months as english projects. No adjustments have been made to time expectations.

Cost Estimating shall be done in metric units only.

Design Costs There will be no change to the standard design fee charts used to calculate design costs.

Now that 1) specs are SI 2) SI estimating tools are offered 3) criteria is SI 4) most codes and standards have SI 5) sample drawings exist for most items, we cannot justify uniform premiums for metric design.

Construction Costs Bids to date have not shown detectable premiums for metric. No additional funds are being allocated for metric construction.

We would welcome comparing detailed cost analysis which yields results contrary to this conclusion.

Estimating Tools are offered by many prominent firms.

Building System Design GA, offers metric estimating software.
Larry Hendrix (404) 876-4700

Cost Engineering Technologies NJ, offers a metric database. Kenneth Browne (201) 335-1707

MCASES Gold, DOD database, operates in metric.

MC2 (MC Squared) TN, offers a metric database.
Billy Telford (901) 346-9880

R.S. Means MA, (800) 448-8182, offers metric estimating handbooks. Database available in late 1993.

Timberline OR, offers a metric database.
Ann Kenkel, Curtis Peltz
(503) 626-6775

US Softcost GA, offers their Success metric database.
Louis Parkins, John Williams (800) 955-1385

Mechanical / General Fasteners

With major sectors of US industry now using metric fasteners extensively, there is virtually no

fastener that is not obtainable in mm sizes.

It is hard to imagine a well known manufacturer that does not stock, regularly make, or have the capability to produce metric products.

Thomas Register has hundreds of firms under Metric Fasteners, Metric Screws, and Metric Bolts.

IFI offers guides of fastener types and producers. Most firms in the division 4/5, covering some common construction fasteners, indicate metric ability. IFI Metric Fastener Standards (530 pg) has technical data, selection hints. IFI, (216) 241-1482

Many pieces of mechanical and electrical equipment already use both metric and english fasteners.

Metric fasteners use M numbers. (M10 x 40 is nominal 10 mm diameter, 40 mm length)

Some states already stock some metric nuts and bolts. (ex, Colorado Department of Transportation)

To conserve paper, we will not list the over 150 firms that stock or produce general metric fasteners. We will list suppliers only for fasteners often used in construction, which are not stock items yet.

The following two charts provide information on fasteners. Our source cautioned that the material is several years old and is soon to be revised, so standards references should be confirmed prior to specification of products.

Conclusion Our projects are now using metric socket head cap screws, set screws, hex bolts, and similar items, whenever needed, in any quantity. These have been stock for years and available at about the same cost.

Mechanical / Anchor Bolts

All new projects are specifying metric anchor bolts (ex, L, J, and U bolts). ASTM F568 gives metric chemical and mechanical data for carbon steel anchor bolts and studs, and references ANSI dimensional standards. No metric version of A307 is planned.

ISO Metric Grades as given in ISO 898 and ASTM F568, should be used. Many anchor bolts are made from low carbon steel grades, such as ISO classes 4.6, 4.8, and 5.8.

Many firms indicated no minimum order quantity, but some stated there would be premiums related to set up costs for very small orders.

Preferred Diameters From material we have seen, it appears preferred nominal diameters for items such as anchor bolts and threaded rod, would be as shown below.

Reference individual standards prior to specification.

Sizes are given between M5 and M45, as these are commonly used sizes in construction.

1: = 1st preference, 2: = 2nd preference, etc.

Fastener Data 1Fastener Data 2
Mechanical / HVAC

Air Flow out of grilles and diffusers should be rounded to even increments of 5 or 10 L/s, wherever possible.

Ductwork (Round, Rigid) Most designers are showing hard metric diameters. (ex, 250, 300)

Ductwork (Round, Flexible) Many designers are showing flexible round duct in hard metric sizes, but accepting soft metric during construction. (ex, 200, 250)

Ductwork (Rectangular) Use 50 and 100 mm sizes,
(ex, 500 x 1000, 250 x 350) unless not possible.

Equipment We regularly receive updated catalogs from producers that have added metric data to their catalogs or literature. Where this did not exist, we have had no difficulty receiving modified data on a project, or obtaining a bond paper supplement.

Schedules To think metric, flow rates, pressures, thermal powers, and other criteria on schedules should be rounded wherever possible.

The 1 % Analysis provides a useful technique.

Ex 1, A fan flowrate converts to 8,022 L/s.
1% is +/- 80.22 L/s. This fan could possibly be shown as minimum 8000 L/s (8 m3/s) and is easier and faster to say.

Ex 2, A pump flow converts to 75.7 L/s. 1 % of this is 0.757 L/s. 75 L/s could possibly be used.

It is important to note that in some cases codes or design criteria may not allow this liberty. In other cases however, 2 or 3 % analysis may be feasible, and could lead to rounded, easily spoken numbers.

Temperature People will rarely speak in decimal degrees. (ex, 23.8 degrees C). All mechanical schedule temperatures, design temperatures, leaving and entering temperatures, and others shall be stated in even Celcius (ex, 5, 12, 25, and 40 degrees C) unless not possible.

New construction projects shall use Celcius only.

Renovation projects where new control systems are being installed, should use Celcius.

HVAC calculations shall be in SI to the fullest extent possible.

Thermal Ratings for boilers and chillers should be specified in even nominal MW or kW increments to the largest degree possible:
(Ex, 500 kW, 0.9 MW, 3.5 MW)

Pipe Steel pipe (ASTM A53) and copper tube sizes (ASTM B88) will not physically change by switching to the metric system. They are now classified by new nominal mm sizes.

ASTM B88M, hard metric copper tube sizes, should not yet be utilized.

Schedule designations remain the same (example: Schedule 40, and type K,L,M)

The Mechanical Task Group, under leadership of ASME, recently recommended use of 18 mm for 5/8, instead of the 16 stated in the last guide. All other designations remain the same.

Metric pipe designations are:

15 18 20 25 32 40 50 65 80 90 100 125 150 mm

Over 150, inch x 25 = mm (24 " x 25 = 600 mm)

Units Use units from the ASHRAE SI Guide.

Structural

The primary lesson learned is design dimensions must be rounded dimensions. Bar spacing, wall and slab thickness, and similar dimensions, shall be even mm (100, 250, 400 mm) not conversions. (ex, 305 mm)

Calculations End results of structural calculations, and all summary data shall be SI. Calculations shall be SI to the fullest degree feasible.

Cambers State in even mm. (ex, 20, 22 mm)

Floor Load capacity is specified in kPa.

Significant hinderance to use of kPa has been allowing dual dimensions. No feel for kPa is acquired unless kPa only are used.

Our typical office rating is 5 kPa: with 4 kPa and
1 kPa components. Drawings and calculations should reflect these numbers only.

In existing facilities, it is preferred to convert values to exact kPa and round to next lowest 0.1 kPa, unless strong reasons exist not to use this method.

Ex 1, A load capability exactly converts to 9.58 kPa. Round to 9.5 kPa. This is rounded, easy to remember, less than 1 % error.

Ex 2, at Richmond VA Federal Building renovation:

"Existing Structure Allowable Live Load Per Original 1959 Building Plans Are As Follows:
Lobbies, Stairs, and Corridors- 4.8 kPa, Toilets-2.9 kPa, All Other Areas 3.8 kPa"

Situations needing mass loading might use the following rounded, slightly conservative, rule:

kPa x 100 = kg/m2 (5 kPa x 100 = 500 kg/m2)

Steel Deck thicknesses are being soft converted
(ex, 38 mm).

Structural Steel shall be specified in SI only, such as 250 MPa. Shapes shall be specified according to the millimeter sizes and dimensions in ASTM A6M.

Welds are shown in even mm sizes. (ex, 5, 6 mm)

Wind Pressures are given in Pa.

Wind Speeds are most frequently given in m/s.

Preparation

Standard regional procedure is as follows:

Internal Preparation Project managers starting a metric project receive:

1)
2)
3) 1 hour metric design orientation course
4) Metric / english tape measure (if needed)

Most people (except field inspectors) use tape measures infrequently after a few months of daily metric usage.

Metric training cannot have the same training effect as immersion into metric design or construction.

We did not purchase metric conversion calculators.

External Preparation For Design Firms, Construction Managers, and Real Estate Developers

1. Provide this design guide to staff members

2. Metric experience can only be a plus, as federal, state, and local government projects increasingly go metric. To obtain experience, consider using metric for other government or private projects.

3. The architectural and engineering communities have in general responded favorably to metric conversion. We have not provided wholesale training to all firms that commonly do business with us. We provide detailed consultation (~ 2 hours if needed) once firms sign contracts and are about to start design.

External Preparation for Product Manufacturers Contacts with product manufacturers should now always discuss available metric products and literature, although many have been exposed through projects.

Submissions have unfortunately been returned for resubmittal based on lack of understanding of the firmness of this requirement. This can be avoided by thorough communication.

This design guide
Metric scale

Construction Firms, Construction Personnel Agencies like New York State Department of Transportation are working with local AGC chapters to alert contractors of upcoming metric activities. Our construction management firms have helped us by also contacting AGC, unions, other construction related groups, to advise of upcoming metric projects.

Design Policy

Selection of pilot projects is an important factor in whether a metric project will be successful. All projects need not be done in metric now.

National policy requires all projects be in metric after January 1994. Our regional policy, in place since January 1992, shall remain prior to that time.

As our major capitol project designs have been metric for some time, the vast majority of all major project construction dollars in 1994 will be metric.

Regional Design Policy All renovation and new construction projects of $ 500,000 or more, shall be done completely in metric.

All specifications for new construction lease projects shall be metric. The same firms that provide construction services to developers on lease projects perform construction for us in direct federally funded projects.

Projects under $ 500,000 may be done in SI, based of feasability. About half of our projects under $500,000 are currently selected for metric design.

Feasability of doing projects below $ 500,000 is based on the number of hard metric products used. Small projects using mainly soft metric products can usually be easily done in metric.

Very small projects under $50,000 are generally not being done in metric yet.

Timeframe To Convert Projects To Metric
Our past year reinforces earlier policy: It is fully feasible to convert medium and large projects to metric up to about 25-30 % design completion. This can be up to about 40 % for smaller projects.

For CAD drawings, it is usually easy to convert to SI and select similar metric structure dimensions.

Many projects nationwide, at the federal, state, and local levels, have now been converted to metric up to the 30% design stage, with success.

CAD While regional policy requires all projects be 100 % CAD, projects are being done nationwide in metric in freehand format with little difficulty.

AE / CM Advertisements

As required for the past 2 years, advertisements for Architectural/Engineering (AE) or Construction Management (CM) services shall be as follows:

1. State areas in m2 only. (ex, The new building will be approximately 40,000 net square meters)

2. Each announcement shall state: "This project will be designed and built entirely in metric units."

3. For A/E firm announcements, including term contracts, this is a required evaluation factor:

   "Familiarity with SI and ability to design in SI units." This will typically be 10-15 % of the evaluation.

   Each responding firm must continue to submit a one page summary of their SI experience, familiarity with SI, and ability to design in SI units.

   Metric experience though is not mandated.

   Almost half of the 500 largest US design firms, which design many of our medium and large scale projects, did overseas work last year, much of which was SI.

   Based on our experience though, size of firm has not been a determining factor. Many small, medium, and large firms are producing high caliber metric designs.

4. For CM (Construction Manager) ads, including term CMs, this remains an evaluation factor:

   "Familiarity with SI and ability to perform required services in SI units." A one page summary must also be submitted. (similar to above)

5. Each CBD announcement shall state:

   "The GSA Region 3 Metric Design Guide is available free to bidders upon request.

Construction Advertisements

Advertisements for construction projects shall:

1. State project area in m2 only.

2. State "This project was designed in metric. Inspection will take place in metric. Submittals must be provided in metric units.

3. State: "The GSA Region 3 Metric Design Guide is available free to bidders upon request.

Note: The Metric Design Guide can be a good orientation document, which can contribute to the overall project success. Bidders will be able to ask better questions at the prebid conference if this guide is available to them in advance."

AE / CM Scope Guidance

AE scope guidance can be stated as follows:

Design on this project shall take place in conformance with M2, The GSA Region 3 Metric Design Guide.

Submittals

To assist manufacturers with metric conversion, we recommend the following submittal classes be utilized.

Classes should be supplemented for each project.

Please contact us regarding detail of items listed here.

There is gray area in this classification system.

Our guiding principle is that if a construction firm makes an honest, good faith effort to comply with metric guidance, then we should work with them and allow minor variations where needed to promote the greater goal of smooth, overall transition.

We would generally encourage project managers to push non-essential submittals into class 3 wherever feasible.

Class 1. Drawings That Must Be Metric Only English units are not permitted on these submittals. Drawings must use metric scales. In general, any drawing that is job specific, and is custom generated for this project, must be in metric only. These are some samples:

.All Floorplans
.Reflected Ceiling Drawings
.Stairwell Erection Drawings
.Foundation Wall Drawings
.Concrete / Rebar Installation Drawings
.Sitework Drawings
.Sheeting and Shoring Plans
.Steel Erection / Fabrication Drawings and Details
. Precast Manhole Drawings
. Door Schedules
. Wall Paneling Drawings
. Caisson Details
. Millwork drawings
. Cabinet Work Details
. Toilet Room Details
. Ductwork Submittals
. Pipe Installation Drawings
. HVAC Schedules
. Switchgear Drawings
. Electrical Component Layout Drawings
. Signage Drawings

Class 2. Data That Must Be Metric Only Following types of items must be submitted in SI only.

Primarily, any data generated specifically for this project must be submitted in SI only.

. Concrete Design Mixes
. Concrete Test Data
. Core Bore Depths and Data
. Aggregate Mixes Must Show Metric Sieves
. Mechanical Air and Water Flow or Balancing Data
. Environmental or Hazardous Material Data
. Most Test Data of various natures
. Other data generated for this project, not in bound, preprinted catalogs or publications.

To absolutely minimize the time and cost impact of metric conversion, we have recommended an additional class of submittal data.

This allows us to meet the national mandate of complete metric conversion, while allowing the extensive body of technical information to be fully converted over a period of a few years.

We understand that the time and cost associated with sudden conversion of handbooks and product literature can be significant, and have attempted to avoid that.

Class 3. Metric Supplement Required
Requires existing pre-printed literature to be supplemented to show conformance with requirements stated in the specification or on drawings.

Supplements can be:

1. Bond Paper Supplement
2. Handwritten Or Typed On Existing Literature
3. Other Approved Method

Examples:

Steel Deck Data The entire product literature does not need to be converted, only those numbers sufficient to show that the sizes submitted are those sizes required (such as 38 mm, etc). The bond paper supplement would state the 1.5 inch deck is equal to 38 mm.

Epoxy Adhesive Literature must only show conformance with requirements specifically shown in the specs.

Preprinted Mechanical / Electrical Equipment Catalogs need not be converted. However, conformance with specified and scheduled flowrates, pressures, temperatures, thermal output rates, etc, must be demonstrated.

Physical dimensions of mechanical and electrical equipment shown on project specific installation drawings are Class 1, and must show metric only.

Typical eqpmt: Boilers, AHUs, Chillers, Terminal Units, Pumps, Exhaust Fans, Switchgear, Pumps, Transformers, UPS systems, Fire Alarm Eqpmt, etc.

.Elevator Component Data
.Bathroom Component Details
.Mini-Blind Data
.Roof Hatch Sizes
.Metal Ceiling Grid Data
.Access Floor Tile Data
.Plumbing Fixture Data
.Metal Stud Data
.Structural Bolt Data
.Paint Literature
.Formwork Release Agent Data
.Valve, Pipe, and Fittings Data

We have found that a major portion of firms supplying submittal data already have their data available in either metric only or dual dimensioned format.

We can provide sample acceptable submittals to government agencies for virtually any product.

01 Tools

Metric tape measures are available.

Some construction firms are using metric only tapes.

Federal agencies can buy 10 ft/3.3 m tape measures on GSA schedule. Product # 5210-00-086-4988, under $5.

Lufkin Tools NC, makes metric tape measures. (919) 362 7511

Stanley Tools CT, makes metric measures.

32-156 (5 m) 32-
33-443 (10 m) 33-

Carl Lickwar, Alan G. Martin (203) 225-5111

Metric framing squares have also been ordered from Stanley by the US Public Health Service.

Stanley Hand Tools CT,(800) 262-2161

US Tape VA, makes metric tape measures, steel tapes, and derrick tapes.
W. S. Spotswood (703) 256-1500

Scales Metric scales are available:
Staedtler-Mars Model 987-18-1
Alvin Model 117 PM
Charvoz Model 30-1261

Contact your local graphic arts supply store to order.

NOTE: These metric scales are made overseas, as are most inch size Architect scales available today.

03 Rebar

Atlantic Steel GA, can make A615M bar.
R.S. Mellum (404) 897-4505

Birmingham Steel AL, produces metric bar in their Salmon Bay Steel subsidiary, and can produce it in their IL, AL, and MS facilities.
Robert Wilson, H.A. Hilton (205) 985-9290

Salmon Bay Steel stocks rebar in 10-35 mm. Minimum order is about 20 Mg, or one truckload, which can consist of different sizes, and can be shipped anywhere in the country. Facility ships rebar overseas regularly.
Chuck James, Paul Cmorey
(800) 677-1012

Cascade Steel OR, currently makes 10-35 mm. 45 and 55 mm might require some lead time. When sizes are in stock, minimum order is about 20 Mg, or one truckload, which can be mixed sizes.
Glen Peterson (503) 472-4181
x3307
Dennis Lauber (503) 434-3275

Florida Steel FL, can produce A615M bar.
Has production in FL, NC, and TN.
Don Ballard, Don Haney
(813) 251-8811

Marion Steel OH, can make A615M but is not able to make 45 and 55 mm.
Gerry Lehrke, Michael Johnson (614) 383-4011

New Jersey Steel NJ, has made metric rebar, can make A615M rebar.
Gary Giovannetti, Elaine Skiba
(908) 721-6600

North Star Steel MN, has made metric before, can produce A615M sizes in their MN and IA facilities.
Michael Hanson (612) 688-1719
Wm Pepper (612) 731-5644

Nucor Steel UT, can make A615M rebar.
R. Wayne Jones (801) 458-3961

Parker Steel OH, can supply A615M rebar. Plans are being made to provide stock to handle any size order.
Paul Goldner (800) 333-4140

Thomas Steel IL, has made metric bar, can make A615M.
Edward Koper, Jerry Wenzel
(708) 257-7701

04 Block / CMU

Many firms can supply hard metric block. Unless otherwise stated, there will generally be lead time and cost impact to this product. See GSA national policy on this issue.

Adams Products can make metric block. Several hundred block orders are acceptable.

Adams Products NC,
Buddy Ray (919) 467-2218

Adams Products NC,
Cheryl Gaw (919) 488-4120

Adams Products NC,
Betty Hughes (919) 523-5136

Amcor Block UT, can make metric block.
Gayland Smith (801) 295-5470

Basalite CA, can supply.
Jim Mayer (916) 678-1901

Betco Block is supplying metric block to GSA. Minimum order is 150 m2. Current project Betco is supplying is using about 1600 m2 (20,000 block)

Betco Block MD,
Scott Harper (301) 654-2312

Betco Block NY,
Steve Nagel (518) 756-2125

Betco Block VA,
Robert Carmody (703) 591-2770

Buehner Block UT, can supply the metric block.
Ron Hoffmann, Kent Mortensen
(801) 467-5456

Burns and Russell MD,
Michelle McVey (800) 638-3188

Clarkes Block GA, can supply.
L.E. Wells (912) 234-3436

Colorado Concrete Mfg CO, can supply metric block.
Karl Dolder, Thor Kaumeyer
(719) 390-5477

Concrete Mold Components CA, can supply molds.
Maurice Alhadeff (213) 636-7534

Dagostino Building Blocks NY
Ken Dagostino (518) 374-3116

Elco PA, can produce metric block. Several hundred block orders acceptable.
Walter Albright (717) 274-3661

Featherlight Building Products TX, can produce metric block. Wade Albritton, H.V. Moss
(512) 472-2424

Fizzano Masonry PA, has indicated ability to supply for VA project in Philadelphia.
(215) 833-1100

Goria Enterprises NC, can make metric block.
Ken Mayo (919) 375-5821

Grand Blanc Cement MI, can supply metric block.
Can supply metric molds, all shapes.
Michael Hicks, Ron Hunt
(800) 875-7500

Hagerstown Block MD
(301) 733-3510

E.P. Henry NJ, can supply hard metric block.
Stephen Reale, Mariane Anzaldo
(609) 845-6200

Adolph Jandris MA,
Tony Raila (508) 632-0089

Jewell Concrete Products TX, can make metric block.
Several hundred block orders are acceptable.
Walter Grisham (817) 772-3440 Tom Call (903) 592-0752

Marquart Block IA, can supply hard metric block.
John Thiele, Scott Shimp

(319) 233-8421

Miller Materials MO, can make metric block. Several hundred block orders are acceptable.
Charles Kreutzer (816) 444-2244

Mission Masonry CO, supplied metric block to the GSA Denver facility.
(303) 841-6089

Phoenix Inc MD
John Cissel, Don Bowers
(301) 698-4010

Plasticrete CT,
Joe Rescigno (800) 243-6934

Proudfoot Corp CT, has made metric molds in the past, can supply metric sizes.
Michael Thompson, James Loseth
(203) 459-0031

Reading Rock Inc OH
Stan Bass (513) 874-2345

Sherman Int'l AL,
Dannie Rodgers (205) 252-6900

Southern Brick & Block VA,
Ron Peters (804) 353-6681
Superlite Block AZ, can make. Several hundred block orders acceptable.
John Graves (602) 352-3500

Trenwyth Industries PA, makes many metric block sizes.
Linda Adcock (800) 233-1924

Tricon Enterprises MA
Monica Maracaccio (508) 697-6112

04 Block / Glass

Pittsburgh Corning PA, makes metric glass block. Several patterns. 190 x 190 mm (80 or 100 thick)
Robert McMarlin (412) 327-6100

05 Anchor Bolts

These firms can provide metric anchor bolts, threaded road, and similar material.

Archer Engineering IL, no minimum quantity.
Ron Lanie (312) 247-3501

Atwood Industries OH, no minimum order. Premium on smaller quantities.
Jeff Mueller, James Mraz
(800) 362-2059

Fansteel Mfg IA, lists metric threads can be obtained on their anchor bolt products.
(800) 394-7091

High Point Fasteners NJ, no minimum quantity.
Ted Brace (201) 293-3411

Hilti OK, offers their HSL metric expansion anchors in M8, M10, M12, M16, M20, and M24.
XXX Dick Wollmenshauzser
(800) 879-6000

Kenneth Lilly Fasteners DE, no minimum quantity.
Gary Lilly, Roland Sharp
(800) 433-1815

Midstate Bolt and Screw MI, no minimum quantity.
Herb Sommers, Kevin Bloss
(800) 482-0867

O'Brien Iron Works CA, no minimum quantity.
Richard Schulba, Richard Kotalik
(510) 685-5300

Piping Technology TX, $ 35 minimum order.
Marion McKnight, Aundrela Durham
(713) 731-0030

R and R Engineering IN, minimum 500 pieces.
Mike Melott, Ralph Amos
(317) 536-2263

Richmond Screw Anchor TX, no minimum order, premium on orders of 100 bolts or less.
Leroy Caldwell (817) 589-2091

Stanley Industries MI, can supply metric anchor bolts and threaded rod.
Mr. Cash (800) 253-BOLT

Steel Products/Massillon OH, minimum $ 50 order. Colin Petrovich, Dan Alvarez

(800) 874-2658

Sullivan Bolt CA, can make metric anchor bolts.
(800) 423-4287

Threadline Products NC, no minimum quantity.
Lenore Lemmond, Larry Stanley (704) 523-5870
Vulcan Threaded Products AL, minimum order is 10 bolts.
Jim Murdock (800) 633-3432

Wayne Bolt MI, no minimum quantity.
Joe or Mike Wojcik
(800) 521-2207

05 Nuts

These firms can supply nuts for anchor bolts and common construction fasteners.

Century AL, can supply metric nuts. $50 minimum order.
Lynda Oakley (205) 772-7300

Coloc TX, can makes up to M60 nuts. Many grades. $50 minimum order.
Dick Ingram (903) 848-8411

Fasteners and Metal Products MA, can supply metric nuts. No minimum.
Tom Hatzis (617) 489-0414

Midwest Bolt and Supply MO, can supply metric nuts.
$ 25 minimum.
Bill Thate (816) 842-7880

North Texas Bolt & Nut TX, a distributor, can supply metric nuts, $ 35 minimum order.
John Ricard (214) 647-0608

Quality Bolt LA, can provide orders in the $ 200-300 range. Pat McGrail
(504) 465-0297

Samson Industries AZ, can supply. $ 25 minimum. Brian Saxton, Christine Gruice
(602) 581-8082

05 Steel Plate

Metric steel plate is available from US mfrs, and is being specified in hard metric on our projects.

Most firms indicated metric plate is usually not stocked, and would require some additional lead time. Many of these firms could also be consulted for hard metric sheet metal purchase.

Many firms indicated however that no order would be too small to supply, such as an order for 5 or 10 base plates, however premiums would apply to smaller orders. Many grades can be supplied.

Many of these firms also fabricate.

We can provide data on what standard sizes of plate are being specified in government projects.

Sample firms that stock metric thickness plate, or are able to supply or produce it:

Accro-Met NC, can supply in 6-150 mm.
Steve Ferguson (800) 543-4755

Alloy and Carbon Steel Co NJ, no minimum quantity.
Gail Ferranti (908) 613-9150

Concord Steel OH, no minimum order.
Paul Vesey (216) 372-2030

Excel Bridge Mfg CA, can obtain steel plate and fabricate products in any metric dimension.
Craig Vasquez (310) 944-0701

Gulf States Steel AL, has made metric plate before. No minimum order.
Lester Bridges (800) 423-0004

Hardox Corp PA, no minimum order, but small orders would have longer lead times.
Tom Sullivan (800) 666-0092

High Steel Structures PA, one of the largest heavy plate steel fabricators in the nation, can provide plate, bearings, structural shape lengths and geometries, bolts, and other items, fabricated in hard metric. No minimum order.
Doug Winner (717) 293-4099

Hub Inc, Energy and Process Div GA, can handle small and large orders, has full cutting and milling capability.
Marc Capallo (404) 723-7531

Johnston and Jennings IL, has supplied metric plate before, can supply maximum 600 mm thickness. No minimum order. John Violet
(708) 757-5375

Leeco Steel Products IL, stocks some A572M metric plate. Can supply any size/thickness in A572M or other grades.
Sales Department (800) 621-4366

Metalmart CA, has supplied metric plate. Stocks some, can supply many other thicknesses.
Hank Morin (800) 888-7766

Mills Alloy Steel OH, can supply metric plate.
Dave Gilbert (800) 326-6455

Parker Steel OH, can supply metric plate and many other structural shapes, as well as bar and sheet stock.
Paul Goldner (800) 383-4140

Pioneer Steel MI, no minimum order. Facilities in AL, MI, and TN. Rob Beves (800) 999-9440

Skorr Steel NY, stainless steel plate only.
Joe Piela (718) 386-9577

Stainless Specialties TX, no minimum quantity. Supplies carbon, stainless and nickel alloy plate.
Has supplied metric plate before.
Robert Caudillo (713) 840-0444

Universal Fabricators WV, can supply metric plate.
Mike O'Connor (800) 394-1385

United States Steel can provide a chart showing their standard metric plate thicknesses (6-160 mm). They indicate their mill prices are generally the same as their prices for equivalent english sizes.

05 Structural Bolts

Many firms can produce A325M/M164M, and A490M/M253M bolts. Some can make ASTM A394M, galvanized metric transmission tower bolts.

Metric bolts may now be utilized on all projects.

Some firms indicated they could supply metric bolts at small quantities, but premiums primarily related to set up costs, would be associated.

See also bolt data in Road Design Data / Louisiana.

Aetna Screw Products IL, can make A325M and A490M. Frank or Joe Valerio (708) 647-9555

Atwood Industries OH, can supply A325M and A490M, as well as other metric bolts.
James Mraz, Jeff Mueller
(800) 362-2059

Bennett Bolt Works NY, $ 100 minimum order.
Ron Merrill NY (315) 689-3981
Vince Ruggerio OH (216) 979-9813

Cold Heading Co MI, can make metric bolts.
Bill Deason, Tom Paull
(313) 923-7800

CWR Manufacturing NY
Fay Cluett (315) 437-1030

Detroit Heading MI, can also make A394M.
Roger Palmer, Kevin Stanisz
(313) 925-8138

Haydon Bolts PA (215) 537-8700
Richard Giusti (215) 537-8700

Holo-Chrome CT Skip Gallo

Huck Int'l TX, makes A325M and A490M product. Larry Chipman, Chuck Schultz (800) 388-4825

Kenneth Lilly Fasteners DE, can supply A325M and A490M. Gary Lilly, Roland Sharp
(800) 433-1815

Lake Erie Screw OH
Steve Vass (216) 521-1800

Metric and Multistandard Components NY, can supply A325M and A490M bolts. Also supplies other metric bolts.
Roger Stilman (800) 431-2792

Mid-West Fabricating OH
Vaughn Doss (614) 969-4411

National Bolt NY, minimum order is 500 bolts.
M.D. Strauss (800) 992-6587

Nucor Fastener Div IN, minimum order is one keg per size.
Cecil Couch, Peter Kasper
(800) 955-6826

Ohio Rod Products IN, states that metric is available upon request.
(812) 689-6565

Steel Products/Massillon OH, $1000 minimum order.
Colin Petrovich, Dan Alvarez
(800) 874-2658

Sullivan Bolt CA, is able to make metric bolts.
(800) 423-4287

United Steel and Fasteners IL, no minimum quantity. Premium on smaller orders.
Perri Guerino, Bob Fiorio
(708) 250-0900

Wayne Bolt MI, no minimum quantity.
Joe or Mike Wojcik
(800) 521-2207

06 Lumber

Oregon Overseas Timber OR
currently manufactures metric lumber sizes for export, thickness 27-76 mm, width 75-280 mm
Jim Curran (503) 347-4419

Vanport Mfg OR
90% of production is in hard metric for Japanese and other export markets.
Thicknesses 27-120 mm Widths 45-360 mm
Wayne Geist (503) 663-4466

06 Plywood

Metric plywood can now be used for items like housing, barracks, sheathing or formwork applications.

Amer-Ply NJ, can supply metric sheets. No minimum order quantity.
Mr. Matthew (908) 352-8111

Boise-Cascade ID, has made metric before, can supply metric.
Jan Blechschmidt (206) 572-8300

Champion International WA, makes metric sheet sizes and thicknesses. Metric available for underlayment, sheathing, and sanded products. Metric concrete form panels can be ordered. Minimum order is 1 truckload. Jim DiStefano (206) 572-8300 (form panels)
Steve Williams (206) 572-8300 (plywood, western)
Jim Clark, TN (901) 731-4550 (plywood, southern)

Furman Lumber MA, can supply metric from their usual suppliers.
Chris Hemingway (508) 670-3800
Offices: CT FL GA MD NJ NY PA TX VA

Multnomah OR, can supply 50-100 piece orders.
Paul Brooks, Anne Snyder
(503) 297-4738

Murphy Plywood OR, can make metric plywood.
John Murphy, Mark Gryziec
(503) 459-3225

Oregon Strand Board OR, can make metric engineering panels, similar to plywood, at no additional cost. Minimum order is one truckload.
Joe Maliszewski (503) 466-5177

Potlatch WA, has exported metric, can make metric sizes. C.D. Whitney, Mac Ryerse
(509) 328-0930

Roseburg Forest Products OR, makes 6-19 mm thick plywood, can make metric sheets. Makes other metric wood building products. Min. order is 1 truckload.
Dave Adams, Kevin Barry
(503) 679-3311

Stone Forest Industries, OR, currently produces both metric dimensional and thickness plywood. This firm could produce about two pressloads minimum order (about 60 sheets) but premiums would apply to small orders of this size.
Lain Osborn, Tom Clow
(800) 541-6906

Vancouver Standard
has made metric sizes, can make metric sizes.
Generally makes AC and higher grade.
Ken Trimbell, Bill Sparks
(800) 367-0038

Other firms indicated on the telephone they were able to make metric plywood, but we did not receive detailed data from them in time for publication.

07 Curtainwalls

These are obtainable in hard metric. This means panel length and width can be any size. Panel extrusions may be hard to change, and may need to be specified in soft metric.

Howard Industries, FL, a major windowall mfr, has done foreign work, can make metric sizes.
Bob Voigt or Joe Sixto
(305) 888-1521

Profile Systems, MO, subsidiary of the Maune Company, can make hard metric sizes.
Grant Maune (800) 962-8100

Kalwell Corporation, NH, a major curtainwall producer, can make hard metric sizes.
Bruce Keller (800) 258-9777

Kawneer Company, GA, a major manufacturer, has been making metric for overseas for years, and can make any metric size.
Enrique Morales, Int'l Sales Mgr (703) 433-2711
Edward Bugg, Asst Engrg Mgr (703) 433-2711

07 Insulation

Several firms indicated ability to fabricate insulation board in hard metric sizes. Our projects are now specifying these.

08 Doors / Metal

Acme Steel Door NY
Jack Teich (718) 384-7800

Allied Steel Products FL, no minimum.
Bill Desin (305) 624-3333

American Steel Products NY
can make any size metric door.
Hank (516) 293-7100

Amweld Building Products OH
Has made metric before, can make metric sizes.
Mike Scott, Fred Bloom Jr (216) 527-4385

Ceco Door IL, a major mfr, can make any hard metric size.
Norb Bruzan (312) 242-2000

Duolock OR, major aluminum products mfr, can make any metric size.
Clem Grant (800) 678-0566

SW Fleming CA MA PA SC
William Strong (800) 263-7515

Howard Industries FL, has made metric, can make metric sizes. Bob Voigt, Joe Sixto
(305) 888-1521

Republic Builders Products TN
Jim Jackson (901) 352-3383

Stanley Door Systems MI
Mark Goldstein (313) 528-1400

Steelcraft Mfg Co OH, no minimum order.
Makes metric sizes now, exports to many countries.
Bill Ball, Claud Frederick (513) 745-6400

Tex-Steel Corp TX, no minimum order.
George Maldonado (512) 423-0912

08 Doors / Wood

Many other door manufacturers indicated ability to supply metric doors but did not respond with detailed information prior to publication.

California Millworks CA, $10,000 minimum.
Dave Gerken (805) 294-2345

Eagle Plywood and Door Mfr NJ, no minimum.
Tony Schifano (908) 769-7650

Marlite OH, can produce.
Donald Sweitzer (216) 343-6621

Michigan Birch Door MI, minimum order is 6 doors.
Roger Eger (313) 949-2020

Mohawk Flush Doors PA, no minimum.
Don Enigk (717) 473-3557

Vancouver Door WA
Gary Geppert (206) 845-9581

08 Windows

Alenco Commercial Group TX, major window mfr, can make metric sizes.
Harold Chilton (409) 823-6557

Andersen Windows Commercial Group MN, exports, has SI literature available.
Craig Johnson (612) 439-5150

Caradco IL, can make any size metric window.
Roy Szyhowski (217) 893-4444

Desco Company Desmet SD, can produce metric sizes.
Cindy Albrecht (605) 854-9126

Marmet Corporation WI, can make any size metric window.
Brent Schepp 715) 845-5242

Marvin Windows MN, has made and can make metric sizes.
Dan McKinnon (218) 386-1430

Optimum Windows, Bronx NY, can produce hard metric sizes. Candido Perez (212) 991-0700

Peerless Commercial Window Division MO, can make any metric size.
Tony Grossi (913) 432-2232

Pella Windows IA, can make any size metric window.
Cheryl Waits (515) 628-1000

09 Carpet

Collins and Aikman, is able to supply metric size tiles.

Interface GA, has dies to supply metric tiles. No minimum, but premiums on orders from 1 to 100 m2 orders. Scott Landa
Kathy Kerby (800) 336-0225

Milliken GA, has dies and makes metric size tiles.

Shaw PA, makes 500 x 500 and 600 x 600 for overseas clients. Can supply to US for 25 m2 minimum orders.
David Vita (800) 424-7429 x 8459
Russ Riehm x 2064

09 Ceiling Systems

Armstrong World Industries PA, makes metric. Usually no added cost or lead time for metric sizes.
Dan Kennard (717) 396-2684
Deb Kantner x 3045

Capaul Architectural Acoustics IL, can make metric sizes.
Tom Stanton (distributor) (410) 234-0010

Celotex Corporation FL, a major tile mfr, offers an entire product line of hard metric sizes.
George Mitchell (813) 873-4027

Chicago Metallic Corp IL, makes metric grids.
Craig Trotier (800) 323-7164

National Rolling Mills PA, makes metric sizes.
Rich Mattioni (215) 644-6700

Steel Ceilings OH, can make metric perforated and unperformated accoustical metal ceiling panels in steel, aluminum, and stainless.
Lou Heil (614) 622-4655

USG Interiors IL, makes metric sizes.
William Nelson (312) 606-5358
David Vanosdall (312) 606-3804

09 Drywall

Celotex FL,
George Mitchell (813) 873-4027

Centex American Gypsum NM, minimum order is generally one truckload (~2000 m2) dependent on job location and production status at time of order.
Lex Dominey (800) 545-6302

Domtar Gypsum MI, has made, and will supply in less than one truckload increments if premium is paid. George Shortreed
Jim Hanser (313) 930-4700

Georgia Pacific GA
Bronwyn Dawkins (404) 521-4000

James Hardie Gypsum NV, can supply in 2000 m2 minimum orders.
Todd Thomas (310) 787-6950
Alex Beaman (800) 995-0950 x210

National Gypsum NC, can make, has not yet fixed their minimum order.
Kurt Withrock (704) 365-7475
David Drummond (704) 364-7474

Temple Inland TX, can make.
Jim Rush (800) 231-6060

USG Interiors IL, can make. See USG names above.

09 Floor Tile

Burke CA, makes 500 x 500.
(408) 297-3500

Freudenberg MA, makes 1000, 500, 250 mm tiles.
Joe King (508) 689-0530

Gerbert PA, makes 300 x 300.
(717) 299-5035

Roppe OH, makes 500 tile.
(800) 537-9527

10 Access Floor

Following firms make 600 x 600 access floor.

C-TEC Inc MI,
Don Heeney (616) 243-2211

Interstitial Systems IL,
Bill Collier (708) 691-8600

Tate Access Floors MD, Lida Poole, Victor Sainato
(410) 799-4200

USG Interiors / Donn IL
William Nelson (312) 606-5358
David Vanosdall (312) 606-3804

Interface GA, commonly known for carpet, also makes access floor domestically. Only size is 500 x 500. Heights are lower than traditional heights, and are intended for wire management applications.
Lew Engle, Peter LePage
(800) 336-0225

14 Elevators

A recent elevator project bid, requiring submittals and construction in metric, was bid by several well known producers. Project is now in construction.

The ability of US producers to provide drawings and data in metric is essentially unanimous. We have discussed metrication with both US firms and many of their Canadian operations, and find consistent practice.

Dover NC, can provide metric drawings for US work.

Montgomery IL, has done metric for overseas, most Canada jobs are metric, can do metric for US work.

Otis Elevator CT, can do US work in metric. New designs are often hard metric and have have started to use hard metric fasteners.

Schindler NJ, can provide drawings in metric for elevator, escalator, and moving walk equipment. Escalator products made in NC are produced in metric.

15 Air Diffusers and Grilles

Acutherm CA, mfr of VAV air distribution devices, can make metric sizes.
Jim Kline (510) 428-1064

Aireguide FL, a large air products mfr, can make 80-90 % of its products in metric sizes.
Daryl Gray (305) 888-1631

Carnes WI, a large mfr, often makes metric sizes.
Dick Laughlin (608) 845-6411

Donco Air Products IA, can make light troffer, slot, and lay-in diffusers up to 1500 mm long.
Ron Jansen, Marc Vanedgrift (515) 488-2211

Duralast LA, can make its diffuser product in
600 x 600. Ron Vinson (distributor) (504) 837-2346

J & J Register TX, can make hard sizes.
Chris Smith (915) 852-9111

Juniper Industries NY, has made, and can make metric size diffusers and grilles.
Steve Liebermann (718) 326-2546

Krueger Inc AZ, can make metric sizes.
Steve Bowser (602) 622-7601

Reliable Metal Products AL, part of Hart & Cooley, can make 90 % of its products in metric sizes.
John Bowers (205) 684-3621

Rock Island Register IL, can make its diffuser in
600 x 600.
John Howarth (309) 788-5611

Sommerville Metalcraft IL, can produce metric grilles and diffusers.
Paul Moehling (800) 654-3124

Thermo Kinetics SC, can make metric grilles and diffusers. No extra cost. Terry Rutledge
(803) 277-8080

Titus Products TX, major mfr of grilles and diffuser products, indicates a number of products now available in metric sizes. Dave Loren (214) 699-1030

Trane has begun to offer metric data on their VAV products.

15 Mechanical Equipment

Many major manufacturers of mechanical equipment already have metric literature on their products, are converting literature and product data to metric, or have committed to do so for US metric projects.

American Standard
Ansul Fire Protection
Aurora Pump
Baltimore Air Coil
Carrier Corporation
Central Sprinkler

Dunham-Bush
Hurst Boiler
ITT Bell Gossett
Landis and Gyr Powers
Liebert, current catalog has metric.
Loren Cook Company
Marley Cooling Tower
McQuay
Trane Company
York

16 Conductors

These firms either have made metric conductors before, or are able to make them.

Americable AR, produces mm2 sizes, and can supply for US projects. (sizes 0.5 to 300 mm2)
Noubar Sarkissian (800) 643-1516

American Flexible Conduit MA, has made metric before, can produce mm2 sizes.
Glenn Stewart (800) 225-8588

Kerite Company CT, can produce mm2 sizes. (203) 888-2591

Okonite Company NJ, can produce.
Jim Kushner (201) 825-0300

Pacific Electricord CA, stocks some 0.75, 1, and 1.5 mm2 product. Can produce other sizes.
Donna Tovey (310) 532-6600

Pirelli Cable NJ, has made mm2 sizes, can produce.
Tony Tremonte (800) 845-8507

Rome Cable NY, has made mm2 size, can produce.
Jan Visser (315) 337-3000

Triangle Wire RI, has made mm2 sizes, can produce.
Hilliard Huggins (401) 729-5400

Southwire Company GA, has made mm2 sizes, can produce.
Sid Ticker (404) 832-4242

16 Lighting Fixtures

We recommend that selection of fixtures be limited to the high volume, commonly used lay-in fixtures, since industry is concerned that the effort associated with converting all products to metric over a short period of time would be difficult, as tooling requires resources and time to construct.

Allan Lighting NJ, can supply lensed and parabolic 600 x 600 and 600 x 1200 fixtures. Electronic ballasts or other are available. 10-20 fixture orders are acceptable.
Howard Komish (908) 964-6885

ALP Lighting IL, which supplies louvers and lenses to many major US mfrs, can produce these products in any required metric size. ALP has supplied louvers to Germany and England in metric sizes.
Don Michels (312) 774-9550

American Fluorescent IL, can produce the 600 x 600 and 600 x 1200 fixtures. Electronic ballasts available. Parabolic and lensed available. Minimum order is about 500 fixtures. Gary Stabelfeldt (708) 249-5970

Bieber Lighting Corporation CA, can make both
600 x 600 and 600 x 1200 hard metric fixtures. 18 cell parabolics, electronic ballasts, are available. Minimum order will be about 50 fixtures.
Bob Bieber (800) 243-2375
(213) 776-4744

C.W. Cole & Co CA, can make both 600 x 600 and 600 x 1200 hard metric light fixtures. Parabolic and lensed. Electronic ballasts are available.
Minimum orders are about 20 fixtures.
Frank Dayley, Jose Lopez
(818) 443-2473

Day-O-Lite Manufacturing RI, can produce the
600 x 600 and 600 x 1200 fixtures. Electronic ballasts available, parabolic and lensed available. No minimum order quantity.
Arthur Goldstein (401) 467-8232

Hasco Electric Corp CT, can produce both the
600 x 600 and 600 x 1200 fixtures. Parabolic, lensed, and electronic ballasts available. Minimum order is about 20 fixtures.
Anthony Varbaro (203) 531-9400

H & H Fixture MO, can produce both the 600 x 600 and 600 x 1200 fixture. Electronic ballasts available. 5-10 fixture orders acceptable.

H.E. Williams MO, is currently making plans to be able to produce the hard metric fixtures. The firm is interested in hearing project inquiries, and may be able to supply these products in the near future.
Ron Snyder, Gary Fagg

Holcor IL, can produce 600 x 600 and 600 x 1200 fixtures. Electronic ballasts or other are available. 5-10 fixture orders acceptable.
Mark Nelson, Kathy Dykstra (312) 376-9780

Holophane OH, can provide the 600 x 600 and
600 x 1200 fixtures. Parabolic or lensed available. Electronic ballasts available. Holophane has quoted hard metric inquiries before. Minimum order is probably about 100 fixtures.
Bob Catone (614) 345-9631

Lithonia GA, one of the largest US lay-in mfrs, produces hard metric fixtures in its SP, SP(air), Paramax, and Optimax products.
West Coast: Marcus Cone
(818) 965-0711

Louisville Lamp Company KY, is able to supply both the 600 x 600 and 600 x 1200 fixture. Electronic ballasts, parabolics, lensed fixtures available. No minimum quantity.
Mike Davidson (502) 964-4094

Lumispec PA, can produce both 600 x 600 and 600 x 1200 hard metric fixtures. Parabolics, lensed, and electronic ballasts available. Minimum order is about 30 fixtures.
Eric Papougenis (215) 228-3830

Mark Lighting NJ, has made metric fixtures before, can supply both the 600 x 600 and 600 x 1200. Minimum order is about 50 fixtures.
George Miller (201) 939-0880

Midwest Chandelier KS, is now supplying hard metric 600 x 1200 parabolic and lensed fixtures to GSA projects. Prices are generally comparable to english size costs. Minimum order is 50 fixtures.
Tom Lefkovitz, Doug Pasternak (913) 281-1100

Morlite Equipment PA,
(814) 774-9631

Prudential Lighting CA, can make both the 600 x 600 and the 600 x 1200 fixture. Company only produces lensed products, such as lensed troffers. Parabolics are not offered. Electronic ballasts available. Minimum order about 75 fixtures.
Tammy Swaim (213) 746-0360

Simkar Lighting PA, has produced and can supply 600 x 600 and 600 x 1200 fixtures. Parabolics, electronic ballasts, are offered. Premiums on small orders such as 10-20 fixtures.
Robert McCully (215) 831-7700

Solar Kinetics TX, is able to provide the 600 x 600 and 600 x 1200 fixtures. Electronic ballasts available.
Sandy McCrea (214) 556-2376

USI / Columbia Lighting WA, the second largest fluorescent fixture producer in the country, often produces hard metric sizes, can supply 600 x 600 and 600 x 1200, and can make almost any size metric fixture. Lead times would not normally exceed 8-10 weeks.
Mark Johnson, Fred Smith
(509) 924-7000

Wellmade Metal Products CA, is able to produce both
600 x 600 and 600 x 1200 hard metric fixtures. Parabolics or lensed are available. Electronic ballasts are available. Minimum order is about 100 fixtures.
Bernie Shane (510) 562-1878

Acknowlegments

Black and Veatch MO
Brecher Associates PA
BRR Associates PA
CRSS Architects
Daroff Design PA
Dubois and King VT
DWL Architects AZ
Geddes Brecher Qualls Cunningham PA
Gehman + Associates VA
Gilbane Building Company
Hayes Seay Mattern Mattern VA
Heery Program Management
Holmes and Narver CA
Martin Marietta Energy Systems TN
Pahl Pahl Pahl CO
Simpson Gumpertz Heger MA
Skidmore Owings Merrill DC
Square D
Sverdrup Technology MD
The Kling Lindquist Partnership PA
3D/International

Our many helpful friends in corporations, and provincial and federal agencies in Canada.

The many US federal, state, and local agencies that provided input and assistance.

Others who have assisted us, and who we have negligently, but unintentionally, failed to mention.Standard Graphic Design Data:

1. Titles for drawings shall be 25 mm from top edge.
2. Left and right margins shall be 30 mm.
3. Text should preferably start 40 mm from top edge.
4. Bottom margin should be minimum 20 mm.

Volume 1, Issue 1 May 1992

FACTS ABOUT METRIC IN CONSTRUCTION

Welcome to the first issue of *Metric in Construction*. You may have heard about federal construction "going metric." Here are the facts:

Metric is the Law

In 1988, federal law mandated the metric system as the preferred system of measurement in the United States and required that metric be used in all federal procurement, grants, and business-related activities to the extent feasible by September 30, 1992. The intent of the law is to make the United States more competitive in international trade by bringing its measurement system into line with that of the rest of the world, which now is virtually all metric.

Last July, President Bush signed Executive Order 12770, *Metric Usage in Federal Government Programs*, which requires federal agencies to develop specific timetables and milestones for the transition to metric.

Federal agencies involved in construction generally have agreed to institute the use of metric in the design of all federal construction by January 1994.

Federal construction represents a big chunk of the nation's $400 billion-a-year construction industry. According to *Engineering News-Record*, 1992 federal appropriations for construction (including grants and aid to states) total about $35 billion.

To date, over $600 million in federal metric work is being readied for design award or is in the design stage now (see page 3).

Other Countries Have Converted With Minimal Problems

The British, Australians, South Africans, and Canadians all converted from the inch-pound system to metric during the past 20 years and encountered only minimal problems in converting the construction industry. In fact, the conversion proved much less difficult than anticipated since much work is built in place and most manufactured components can be used without dimensional change.

There was no appreciable increase in either design or construction costs, and conversion costs for most construction industry sectors were minimal or offset by later savings. Design firms found that it took a week or less for staff to begin thinking and producing in metric; most tradespeople adapted in only a few hours.

The architecture/engineering community preferred metric dimensioning since it was less prone to error and easier to use than feet and inches. Engineering calculations were faster and more accurate because there were no unit conversions and no fractions.

Metric offered a one-time chance to reduce the many product sizes and shapes that had accumulated over the years but were no longer useful, thus saving production, inventory, and procurement costs.

Metric Conversion Is Readily Achievable

The use of computer-aided design and drafting systems continues to increase, and most engineering and cost calculations are performed on computers. Virtually all HVAC system controls are digitized, and computer-controlled manufacturing operations are now common. In each of these areas, computers make switching between the inch-pound system and the metric system simple.

The codes of two of the country's three model code organizations, BOCA and SBCCI, and the standards of NFiPA and ASTM feature dual units (inch-pound and metric) where measurements are specified. Many other organizations have added metric measurements to their standards or are in the process of doing so.

The preliminary results of several recent General Services Administration metric pilot projects in the Philadelphia area indicate no increase in design or construction costs.

American design and construction firms use metric routinely in foreign work with no reported problems.

The costs of metric conversion in other U.S. industries have been far lower than expected and the benefits, greater. Total conversion costs were less than 1 percent of original estimates at General Motors, which now is fully metric. Rationalization of fastener sizes at IBM during metric conversion reduced the number of fasteners from 38,000 to 4,000. The liquor industry reduced the number of container sizes from 53 to 7 after converting to metric.

International Competition Demands Metric

For those sectors of the U.S. construction industry that export goods or services, metrication is vital.

In 1990, U.S. non-lumber construction product exports totaled about $2.8 billion and imports totaled about $4.2 billion.

The foreign billings of American architecture/engi-neering/contracting firms amounted to $3.2 billion in 1989 with about a third of this from Europe.

The European Community, now the world's largest market, has specified that products with nonmetric labels will not be permitted for sale after 1992.

The largest U.S. trading partners, Canada and Mexico, are now predominantly metric countries.
In the ongoing U.S.-Japanese Structural Impediments Initiative negotiations, the Japanese have identified nonmetric U.S. products as a specific barrier to the importation of U.S. goods.

Some American manufacturers, such as Otis Elevator, are switching to metric to increase their international competitiveness and reduce their parts inventories. Other sectors of the construction community, such as the wood industry, have shipped exports in metric for many years.

Even without the federal impetus, there is a growing consensus that it is in the American construction industry's long-term interest to "go metric."

Metric Guide Available

To help the construction industry learn about converting to metric, the National Institute of Building Sciences has published a 34-page booklet called the *Metric Guide for Federal Construction*. The guide includes:

-An introduction to metric

-A primer on metric usage for architects, engineers, and the trades

-Requirements for metric drawings and specifications

-Guidance on metric management and training

-A complete list of available metric construction references

To order the guide, send $15 ($12 for NIBS members) to Metric Guide, NIBS Publications Department, 1201 L Street, N.W., Suite 400, Washington, D.C. 20005, or use your VISA or Mastercard by calling (202) 289-7800.

FEDERAL METRIC PROJECTS

A number of federal projects with a total estimated cost of over $600 million are being readied for design award or are in the design stage now.

GENERAL SERVICES ADMINISTRATION ($300-400 million)--A variety of new and rehabilitation projects:

Arizona--Border station
Colorado--Federal warehouse, Denver
District of Columbia--GSA headquarters, Southeast Federal Center
Florida--Federal courthouse, Tampa
Maryland--Social Security Administration operations building, Woodlawn; appraisers store, Baltimore
New Jersey--U.S. courthouse, Trenton
Pennsylvania--Department of Veterans Affairs regional headquarters, Philadelphia; Byrne/Green Federal Complex, Philadelphia; mechanical/electrical upgrade project, Philadelphia; federal building, Harrisburg
Vermont--Border station
Virginia--Federal building in Richmond, U.S. courthouse, Richmond; Federal Executive Institute, Charlottesville
West Virginia--Federal building, Beckley

DEPARTMENT OF STATE ($200 million)--Various foreign embassy projects

NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY (up to $50 million)--Various projects at NIST facilities in Gaithersburg, Maryland, and Denver, Colorado

ARMY CORPS OF ENGINEERS ($30-40 million)--Eight projects in Arizona, Arkansas, Kentucky, Louisiana, Maryland, New York, and Virginia

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION ($10 million)--Various NASA projects throughout United States

OFFICE OF SECRETARY OF DEFENSE (up to $1 million)--Various projects, Arlington, Virginia

YOUR BODY METRICS

Your approximate height in centimeters:

Add a zero to your height in inches, divide by four, and add 3 cm. (For an exact conversion, multiply your height in inches by 2.54 cm.)

Your height:___'___" = ___" add a 0 = ____ ÷ 4 = ___ + 3 cm = ___ cm

Your approximate weight in kilograms:

Divide your weight by two, then subtract 10% more. (For an exact conversion, multiply your weight by 0.454 kg.)

Your weight: ___ lbs ÷ 2 = ___ - 10% (___) = ___ kg

AISC METRIC PUBLICATIONS

Two new publications are available in draft form from the American Institute of Steel Construction:

- *Metric Properties of Structural Shapes with Dimensions According to ASTM A6M.* A 92-page metric version of Part 1 of the *Manual of Steel Construction.* $10.00

- *Metric Conversion: Load and Resistance Factor Design Specification for Structural Steel Buildings.* A 159-page metric version of the September 1, 1986 *LRFD Specification.* $10.00

Send a check or money order to Metric Publications, AISC, One East Wacker Drive, Suite 3100, Chicago, Illinois 60601-2001, or use your VISA or Mastercard by calling (312) 670-5414.

Metric in Construction is the newsletter of the Construction Metrication Council of the National Institute of Building Sciences, Washington, D.C.

CONSTRUCTION METRICATION COUNCIL

National Institute of Building Sciences
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Washington, D.C. 20005
Telephone--202-289-7800, Fax--202-289-1092

Metric in Construction is a bimonthly newsletter published by the Construction Metrication Council to inform the building community about metrication in U.S. construction. The Construction Metrication Council was created by the National Institute of Building Sciences to provide industry-wide, public and private sector support for the metrication of federal construction and for the adoption and use of the metric system of measurement as a means of increasing the international competitiveness, productivity, and quality of the U.S. construction industry.

The National Institute of Building Sciences is a nonprofit, nongovernmental organization authorized by Congress to serve as an authoritative source on issues of building science and technology.

The Council is an outgrowth of the Construction Subcommittee of the Metrication Operating Committee of the federal Interagency Council on Metric Policy. The Construction Subcommittee was formed in 1988 to further the objectives of the 1975 *Metric Conversion Act*, as amended by the 1988 *Omnibus Trade and Competitiveness Act*. To foster effective private sector participation, the activites of the subcommittee were transferred to the Council in April 1992. The Council is supported by funds from contributing federal agencies.

Membership in the Council is open to all public and private organizations and individuals with a substantial interest in and commitment to the Council's purposes. For membership information, contact the Council at the above address.

Volume 1, Issue 2 July-August 1992

METRIC Q & A

The last issue presented some basic facts about metric in construction. This issue answers the most common questions we receive.

Is the federal government really serious about metric? Metric is mandated by federal law and presidential executive order. Although some agencies are moving faster than others, they all are in the process of converting. Without a doubt, government is "going metric."

How does this affect the construction industry? The buying power of the government is enormous. By the mid-1990s, most federal construction as well as state and local work tied to federal grants and programs will be designed and built in metric.

The construction industry is primarily a domestic industry. Why does it have to convert? The federal law is intended to increase America's competitiveness. Some basic construction products like brick, block, and concrete are made and used locally, but a surprisingly large number are or can be exported (e.g., glass, coatings, finishes, fasteners, structural steel, wood and wood composites and most electrical, HVAC, mechanical, plumbing, and conveying equipment). American A/E/C services, which have been exported worldwide for decades, also represent an important part of the industry's revenues.

If construction goes metric, won't that eliminate one more barrier to imported products? Yes, but the alternative is restricting our products and services to within our own boundaries while the rest of the world goes about its business and excludes us.

What is the construction industry's response to metric? In general, it is positive. After all, we all read the newspapers and know we have to improve our inter-national competitive position. So the message from the industry is: "We understand the need to change--just don't drag it out."

How about the trade unions? They are not yet really involved in metric, but when we talk to the individual trades, they say, "Tell us what you want and we'll build it!"

Do designers like metric? Most prefer it, especially those who have used it. No more dimension strings made up of fractions, inches, and feet; with metric it's all millimeters. And no more dealing with a multitude of conversion factors. For example, which has a higher thermal output, a 22 million Btu/hour boiler or a 1000 ton chiller? With metric, you can tell instantly: the boiler is 6.4 MW and the chiller is 3.5 MW.

Does the Council have a policy on construction documents? One was adopted by consensus last fall. For construction drawings, only metric units may be used. Placing both inch-pound and metric units on drawings increases dimensioning time, doubles the chance for errors, makes drawings more confusing, and delays the learning process since people "see" only the units they know. Our policy on specifications is similar except that wherever the use of an inch-pound measure serves to clarify an otherwise unfamiliar metric measure, the inch-pound unit may be placed in parentheses after the metric.

Can metric be used on rehab projects? People who have used metric in rehab work say it's essentially no different from using foot-pound units. Tradesmen still must install new products in spaces not built for them. And metric has one advantage--making field measurements is faster and less error-prone because unit conversions are eliminated.

Where are we with product manufacturers? About 95% of construction products will not need to change since they are not modular or panelized. They simply will be "soft converted"--relabeled in metric. A 2-3/4 x 4-1/2 inch wall switch face plate will be relabeled 70 x 115 mm and a 10 horsepower motor, 7460 W.

But how about modular products? Most will undergo "hard conversion"--their dimensions will change to new rounded metric numbers. Suspended ceiling grids will convert to 600 x 600 mm or 600 x 1200 mm. Drywall, plywood, and rigid insulation will change to 1200 mm widths, but their thicknesses will remain the same to eliminate the need for recalculating fire and acoustic ratings and U-values. Raised access flooring will go to 600 x 600 mm. Brick will become 90 x 57 x 190 mm and block will become 190 x 190 x 390 mm; both will use 10 mm mortar joints and be laid in 600 mm modules.

What happens to the traditional 2-by-4 wood stud? As we all know, "2-by-4" is a nominal name, not a finished size. Neither wood studs nor other framing lumber will change in cross-section, but they will be spaced at 400 mm instead of 16 inches--about 1/4 inch closer together. Batt insulation installed between studs might not change in width; instead, there will be more of a "friction fit."

Are there other products in the same category? Yes. A 2-inch pipe has neither an inside nor an outside diameter of 2 inches. A 24-inch I-beam contains no actual 24-inch dimension. These products won't change sizes either; they'll just be relabeled. Perhaps they eventually will get new nominal names such as 50 mm pipe or 600 mm beams but it's too early to tell. With or without new names, the metrication process won't be affected.

Does the Council have a policy on product conversion? Our policy is that each product manufacturer must decide if and when to change its products to rounded or "hard" metric numbers. Some never will need to change. For instance, current dimensions of freestanding plumbing fixtures are just fine for metric bathrooms. Hard conversion or soft, if you design in metric, label in metric and build in metric, you're metric.

So "going metric" in construction won't be so bad? Everyone who has gone through the conversion process says it was much easier than expected. Still, there will be problems and we shouldn't minimize them. Construction, however, is a problem-solving process and, on a scale of construction problems from one to ten with ten being the hardest, metric conversion is about a two.

Are there resources to help me out? See the back page of this newsletter for a list or call the Council with specific questions. Remember though, few resources beyond a thorough knowledge of the conversion process and a firm commitment to "go metric" are needed.

FEDERAL METRIC PROJECTS REACH
$1 BILLION

Federal metric projects with a total estimated cost of about $1 billion are being readied for design award or are in the design or construction stage now.

The **General Services Administration** is conducting a variety of new and rehabilitation projects approaching $700 million:

- **Arizona**--border station
- **Colorado**--federal warehouse, Denver
- **District of Columbia**--GSA headquarters, Southeast Federal Center
- **Florida**--federal courthouse, Tampa
- **Maryland**--Social Security Administration operations building, Woodlawn; appraisers store, Baltimore
- **Missouri**--federal courthouse, Kansas City; federal courthouse, St. Louis
- **New Jersey**--U.S. courthouse, Trenton
- **Pennsylvania**--Department of Veterans Affairs regional headquarters, Philadelphia; Byrne/Green Federal Complex, Philadelphia; mechanical/electrical upgrade project, Philadelphia; federal building, Harrisburg
- **Vermont**--border station
- **Virginia**--federal building in Richmond, U.S. courthouse, Richmond; Federal Executive Institute, Charlottesville
- **West Virginia**--federal building, Beckley

The **Department of Health and Human Services** is investing approximately $2 million in various projects for the National Institutes of Health and the Indian Health Service.

The **Department of State** has under way various foreign embassy projects totaling approximately $200 million.

The **National Aeronautics and Space Administration** is undertaking various projects throughout the United States with a value of $14 million.

The **National Institute of Standards and Technology** is in the process of awarding a large multiyear A/E services contract for various projects at NIST facilities in Gaithersburg, Maryland, and Denver Colorado. Work is planned to be in metric and design fees be as high as $50 million. More about this project in the next issue.

The **Office of the Secretary of Defense** is planning up to $1 million in various projects in Arlington, Virginia.

The **U.S. Army Corps of Engineers** has eight projects in Arizona, Arkansas, Kentucky, Louisiana, Maryland, New York, and Virginia with a total value of $30 to $40 million.

The **Smithsonian Institution** is planning a $40 million collections research center in Suitland, Maryland.

METRIC RESOURCES

- Available from the Publications Department, National Institute of Building Sciences, 1201 L St., N.W., Washington DC 20005; phone 202-289-7800 (bulk orders are available at a discount):

Metric Guide for Federal Construction (34 pg, $15). Written specifically for the construction industry and reviewed by metric experts throughout the country. Includes a background on the federal metric laws, facts on metric in construction, an introduction to metric units, a primer on metric usage for architects, engineers, and the trades, requirements for metric drawings and specifications, guidance on metric management and training, and a listing of current metric construction references.

GSA Metric Design Guide, second draft edition (78 pg loose-leaf, $8, $5 if ordered with above guide). Interim design guide developed by GSA for use by federal project managers and their A/Es. Contains practical architectural, civil, structural, mechanical, and electrical design information, a list of available "hard" metric products, sample drawings, and related reference information.

- Available from the AIA Bookstore, 1735 New York Ave., Washington, DC 20006; phone 202-626-7475:

Nufert Architect's Data, 2d International Edition ($52). The European e-quivalent to the **AIA Graphic Standards**. All measurements in metric.

The Architect's Studio Companion; Technical Guidelines for Preliminary Design ($44.95). Includes dual units.

- **Wiley Engineer's Desk Reference** ($54.95). John Wiley & Sons, Professional Reference and Trade Group, 605 Third Ave., New York N.Y. 10158; phone 1-800-225-5945, Ext. 2497. Includes dual units.

- **Metric Practice Guide for Surveying and Mapping** ($10). American Congress of Surveying and Mapping, 5410 Grosvenor Lane, Suite 100, Bethesda, Md. 20814; phone 301-493-0200.

- Available for $114 each; American Society of Heating, Refrigeration, and Air-Conditioning Engineers, 1791 Tullie Circle, N.E., Atlanta GA 30329; phone 404-636-8400: **ASHRAE 1991 Handbook--HVAC Applications**, SI Edition; **1989 Handbook -- Fundamentals**, SI Edition; **1990 Refrigeration Handbook**, SI Edition; **1992 Handbook--HVAC Systems and Equipment**. All with dual units.

- **ACI 318M-89/318RM-89, Building Code Requirements for Reinforced Concrete and Commentary** ($70). American Concrete Institute, Box 19150, Detroit MI 48219; phone 313-532-2600. Metric edition of ACI 318.

- Available in draft form for $10 each; American Institute of Steel Construction, Metric Publications, AISC, One E. Wacker Dr., Suite 3100, Chicago, Illinois 60601-2001; 312-670-5414:

Metric Properties of Structural Shapes with Dimensions According to ASTM A6M (92 pg). Metric version of Part 1 of the **Manual of Steel Construction**.

Metric Conversion: Load and Resistance Factor Design Specification for Structural Steel Buildings (159 pg). Metric version of the September 1, 1986 **LRFD Specification.**

- **Metric-X**. Orion Development Corporation, Box 2323, Merrifield, VA 22116-2323; phone 1-800-992-8170; single user copies $24.95; site/network copies available, discounts for bulk orders. Quick and friendly metric conversion software for use with any IBM-compatible computer. Converts length, area, liquid and dry volume, mass, force, energy, velocity, pressure, power, temperature, acceleration, and wavelength.

- **1992 Means Building Construction Cost Data**, Metric Edition ($65). R. S. Means Company, Box 800, Kingston MA 02364; phone 617-585-7880). Prototype metric edition of Means' cost estimating handbook. Complete metric edition for 1993 should be available this fall. Means also offers metric cost estimating seminars.

- **All About Metric** ($500) MMEI Corp., 2247 Lexington Pl., Livermore CA 94550; phone 510-449-8992. Three-tape video training package by the U.S. Metric Association and MMEI Corp. Covers the background of the metric system, government/industry transition, everyday metric units, and rules for metric usage. Accompanying reference manual includes conversion tables and other information. Instructor's manual contains lesson tips, test questions, illustrations suitable for use as masters for overhead projector transparencies.

- **SI Metric for the Workplace** ($2195). Workplace Training, 520 North Arm Dr., Orono MN 55364; phone 612-472-2564. Six-tape video/workbook courseware. Provides in-depth metric training for business and industry professionals. Includes an introduction to metric, units of measure, reading/ writing rules, limits/fits/toler ances, metric conversion.

SI FACTS: Length

Where would engineering be without a gooddefinition of length? Probably caught somewhereshort of inventing the wheel. The SI systemoffers a unit for length called the meter (m).The meter has been defined as the wavelengthof the radiation from a krypton-86 atom andis equal to 3.2808398 ft. For conversion, thefactor 3.28 can be used.For shorter lengths, the meter is dividedinto 1000 parts or millimeters (mm);25.4 mm = 1 inch. For *nontechnical* purposes,centimeters (1 m = 100 cm) may be used, butdecimeters (1 m = 10 dm) should always be avoided.For larger dimensions, use kilometers (1000 m = 1 km),not hectometers (100 m = 1 hm) or dekameters(10 m = 1 dam). There are 1.609344 km in a U.S. statute mile.

Problem: A boiler tube has a 3-inch diameter. What is its diameter in millimeters?

Solution: 3 in. x 25.4 mm/in. = 76.2

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Volume 1, Issue 3 September-October 1992

METRIC MANAGEMENT AND TRAINING

How should design and construction firms, product manufacturers, code officials, and others in the construction industry prepare for metric? The American National Metric Council and the U.S. Metric Association recommend the following management and training measures, which apply to organizations large and small:

Provide top level commitment. Top level management must provide a firm commitment to metric. This includes: announcing a formal metric policy, forming a metric committee, and appointing a metric coordinator to chair the committee and act as the organization's metric representative.

Set milestones. Establish a realistic, organization-wide metrication schedule with milestones and a completion date.

Collect information. Begin a metric reference library. See the July-August issue of this newsletter for a list of metric construction references or refer to the more complete list in the *Metric Guide to Federal Construction*.

Develop training objectives. Write carefully worded, measurable training objectives with the goal of "**enabling employees to perform their jobs with the same or greater degree of efficiency using metric.**"

Define the learner population. Determine who needs to know metric and to what extent they need to know it. Some employees may require an in-depth working knowledge of metric whereas others may never need to know it at all. Most probably will need to know only a few metric units.

Determine training needs. There are three kinds or levels of training: metric awareness training to help all employees overcome fear and resistance to change, management training to educate the people responsible for the transition to metric, and implementation training to teach specific metric skills to specific employees.

Train at the right time. Training should take place just prior to when an employee will use the new knowledge on the job; **earlier training is ineffective.**

Train only as needed. Train only as necessary to meet the goal of "enabling employees to perform their jobs with the same or greater degree of efficiency using metric." Training is not a panacea, and massive training programs are wasteful. **Often, training can be performed completely on-the-job.**

Train people to "think" metric. Link metric measurements to familiar objects. Avoid converting to inch-pound units as much as possible. For linear measurements use dual unit tape measures (see "Metric References" below).

Monitor the metrication program. Make sure training matches the organization's metric transition schedule. If something changes, adjust either the training or the schedule.

Don't hide costs. There is a cost to metric conversion, both in time and money. Plan for it in advance, and monitor costs as transition takes place.

General metric publications and materials are available from the U.S. Metric Association, 10245 Andasol Avenue, Northridge, CA 91325, phone 818-368-7443, and the American National Metric Council, 1735 North Lynn Street, Suite 950, Arlington, VA 22209-2022, phone
703-524-2007.

Stan Jakuba, a metric management and training consultant in Hartford, Connecticut, and a member of the Construction Metrication Council, contributed to this article. He can be reached at 203-521-7924.

METRIC RESOURCES

Dual unit tape measures. The use of dual unit tape measures is considered one of the best ways to learn metric on the job because they provide a quick and easy means of "visualizing" linear dimensions in metric. Stanley Tools, Lufkin, U.S. Tape, Starrett Tools, and others make dual unit tape measures. Check larger hardware stores or call Stanley Tools at 1-800-262-2161, Lufkin at 912-362-7511, or U.S. Tape at 703-256-1500.

Metric drawing scales. Metric architect and engineer scales are available from graphic arts supply stores. Popular models are the Staedtler-Mars 987-18-1, Alvin 117 PM, and Charvoz 30-1261.

Metric plumbing template. A metric plumbing template is available from American Standard. Call Ms. Barbara Munson at 703-841-9585.

Metric guides. Two metric guides are available from the Publications Department, National Institute of Building Sciences (NIBS), 1201 L St., N.W., Suite 400, Washington DC 20005; phone 202-289-7800 (bulk orders are available at a discount):

Metric Guide for Federal Construction (34 pg, $15). Written specifically for the construction industry and reviewed by metric experts throughout the country. Includes a background on the federal metric laws, facts on metric in construction, an introduction to metric units, a primer on metric usage for architects, engineers, and the trades, requirements for metric drawings and specifications, guidance on metric management and training, and a listing of current metric construction references.

GSA Metric Design Guide, second draft edition (78 pg loose-leaf, $8, $5 if ordered with above guide). Interim design guide developed by GSA for use by federal project managers and their A/Es. Contains practical architectural, civil, structural, mechanical, and electrical design information, a list of available "hard" metric products, sample drawings, and related reference information.

Both guides also are available in electronic form on the Construction Criteria Base (CCB), a large database of construction criteria and standards on optical disk. For more information about the CCB, call NIBS at the above number.

FEDERAL METRIC PROJECTS GAIN MOMENTUM

The **General Services Administration**, which serves as the "federal landlord," now has over $1 billion in metric projects in the planning, design, or construction stages.

The **National Institute of Standards and Technology** is planning about $1 billion in facilities work for its campuses in Gaithersburg, Maryland, and Denver, Colorado. Work is scheduled to be in metric.

Most of the **Department of Energy**'s $8.2 billion Super Collider project will be constructed in metric.

Two new **Smithsonian Institution** facilities with a total cost of over $150 million will be built in metric.

The **Army Corps of Engineers**, **Air Force**, **Office of the Secretary of Defense**, **NASA**, and the Public Health Service are conducting over $60 million in metric pilot projects with significantly more work in planning.

The $400-$500 million **Defense Medical Facilities** program for FY 95 is scheduled to be in metric.

The **Department of State** continues to build in metric with current projects totaling $275 million.

BASIC METRIC

There are seven metric base units of measurement, six of which are used in design and construction. (The seventh, mole, is the amount of molecular substance and is used in physics.)

Quantity	**Unit (Symbol)**
length	meter (m)
mass	kilogram (kg)
time	second (s)
electric current	ampere (A)
temperature	k (K)
luminous intensity	candela (cd)

Note that "weight" in common practice often is used to mean "mass."

Celsius temperature (°C) is more commonly used than kelvin (K), but both have the same temperature gradients. Celsius temperature is simply 273.15 degrees warmer than kelvin, which begins at absolute zero. For instance, water freezes at 273.15 K and at 0 °C; it boils at 373.15 K and at 100 °C. To move between Celsius and kelvin, add or subtract 273.15.

VISUALIZING METRIC

A few basic comparisons that help in visualizing metric are well worth remembering:

- One millimeter (mm) is about 1/25 inch or slightly less than the thickness of a dime.

- One meter (m) is the length of a yardstick plus about 3-1/3 inches.

- One gram (g) is about the mass (weight) of a large paper clip.

- One kilogram (kg) is about the mass (weight) of a softbound model building code book (2.2 pounds).

- One liter (L) is about the volume of a 4 inch cube (100 mm x 100 mm x 100 mm)--a little over one quart. One liter of water has a mass of 1 kilogram.

- One inch is just a fraction (1/64 inch) longer than 25 mm (1 inch = 25.4 mm; 25 mm = 63/64 inch).

- Four inches are about 1/16 inch longer than 100 mm (4 inches = 101.6 mm; 100 mm = 3-\15/16 inches).

- One foot is about 3/16 inch longer than 300 mm (12 inches = 304.8 mm; 300 mm = 11-13/16 inches).

- Four feet are about 3/4 inch longer than 1200 mm (4 feet = 1219.2 mm; 1200 mm = 3 feet, 11¼ inches).

- The metric equivalent of a typical 2-foot by 4-foot ceiling grid is 600 x 1200 mm, so metric ceiling tiles and lighting fixtures are about 3/8 inch smaller in one dimension and 3/4 inch smaller in the other.

- Similarly, the metric equivalent of a 4 by 8 sheet of plywood or drywall is 1200 x 2400 mm so metric sheets are about 1-1/2 inches shorter and 3/4 inch narrower.

- "Rounding down" from multiples of 4 inches to multiples of 100 mm makes dimensions exactly 1.6 percent smaller and areas about 3.2 percent smaller. About 3/16 inch is lost in every linear foot.

METRIC MODULES AND GRIDS

The basic metric module is 100 mm (about 4 inches; see above). Submodules in preferred order are 50 mm (about 2 inches), 25 mm (about 1 inch), 20 mm, 10 mm, and 5 mm. Multimodules in preferred order are 300 mm (about 1 foot), 600 mm (about 2 feet), 1200 mm (about 4 feet), 3000 mm (about 10 feet), and 6000 mm (about 20 feet). For buildings, the metric planning grid is usually 600 mm.

METRIC DRAWING SCALES

Metric scales are true ratios and are the same for both architectural and engineering drawings. Preferred scales are:

1:1	Same as full size
1:5	Close to 3" = 1'-0"
1:10	Between 1" = 1'-0" and 1-1/2" = 1'-0"
1:20	Between 1/2" = 1'-0" and 3/4" = 1'-0"
1:50	Close to 1/4" = 1'-0"
1:100	Close to 1/8" = 1'-0"
1:200	Close to 1/16" = 1'-0"
1:500	Close to 1" = 40'-0"
1:1000	Close to 1" = 80'-0"

METRIC FACTS: Area

How wide? How long? From these questions we get area. The metric unit for area is the square meter (m^2). It is one of the system's simpler derived units. Derived units are those made from a combination of one or more of the seven base units. The square meter is the area enclosed by a square with 1-meter sides. It is equal to 10.76 square feet. But the square meter is too large for much mechanical engineering work so the square millimeter (mm^2) is used. To translate this into customary units, 1 in^2 = 645.16 mm^2. For areas much larger than the square meter, the square kilometer is used (km^2). There are 2.59 km^2 in a square mile.

Problem: What is the approximate cross-sectional area in square meters of a rectangular duct that measures 4 ft x 5 ft?

Solution: 4 ft x 5 ft = 20 ft^2 20 ft^2 x (1 m^2/10.76 ft^2) = 1.86 m^2

Metric in Construction is the newsletter of the Construction Metrication Council of the National Institute of Building Sciences, Washington, D.C. Reproduction and distribution of its contents is encouraged provided the Council receives attribution. Copies of previous newsletters are available upon request.

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Metric in Construction is a bimonthly newsletter published by the Construction Metrication Council to inform the building community about metrication in U.S. construction. The Construction Metrication Council was created by the National Institute of Building Sciences to provide industry-wide, public and private sector support for the metrication of federal construction and to promote the adoption and use of the metric system of measurement as a means of increasing the international competitiveness, productivity, and quality of the U.S. construction industry.

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Membership in the Council is open to all public and private organizations and individuals with a substantial interest in and commitment to the Council's purposes. The Council meets monthly in Washington, D.C.; publishes the *Metric Guide to Federal Construction* and this bimonthly newsletter; and coordinates a variety of industry metrication task groups. For membership information, call the Council at the above phone number.

Volume 1, Issue 4 November-December 1992

WHAT WILL CHANGE AND WHAT WILL STAY THE SAME? Part I

This is the first part of a twopart summary of salient metric conversion issues discussed by the Construction Metrication Council to date.

DRAWINGS

What will change
- Unitsfrom feet and inches to millimeters for all building dimensions and to meters for large site plans and civil engineering drawings; meters are always carried to one, two, or three decimal places.
- Drawing scalesfrom inchfractionstofeet (e.g. 1/2" = 1'0") to true ratios (e.g., 1:20).
- Drawing sizesto the ISO "A" seriesAO (1189 x 841 mm, 46.8 x 33.1 inches); A1 (841 x 594 mm, 33.1 x 23.4 inches); A2 (594 x 420 mm, 23.4 x 16.5 inches); A3 (420 x 297 mm, 16.5 x 11.7 inches); A4 (297 x 210 mm, 11.7 x 8.3 inches). Of course, metric drawings can be made on any size paper.

What will stay the same
- Drawing contents

Never use dual units (both inchpound and metric) on drawings. It increases dimensioning time, doubles the chance for errors, makes drawings more confusing, and delays the learning process. Centimeters are not used in construction.

SPECIFICATIONS

What will change
- Units of measurefrom feetinches to millimeters for linear dimensions, from square feet to square meters for area, and from cubic yards to cubic meters for volume (except use liters for fluid volumes).

What will stay the same
- Everything else

Do not use dual units in specifications except when the use of an inchpound measure serves to clarify an otherwise unfamiliar metric measure; then place the inch-pound unit in parentheses after the metric. For example, "7460 W (10 horsepower)." All unit conversions should be **checked by a professional** to ensure that rounding does not exceed allowable tolerances.

FLOOR LOADS

What will change
- Floor load designationsfrom "psf" to kilograms per square meter (kg/m^2) or kilonewtons per square meter (kN/m^2).

What will stay the same
- Floor load requirements

In common practice, kilograms per square meter are used for floor loads because many live and dead loads (furniture, filing cabinets, construction materials, etc.) are measured in kilograms. However, kilonewtons per square

meter (kN/m^2) or their equivalent, kilopascals (kPa), are used for structural calculations.

CONSTRUCTION PRODUCTS

About 95% of construction products won't change size since they are not modular or panelized. They simply will be "soft converted"relabeled in metric. A 23/4 x 41/2 inch wall switch face plate will be relabeled 70 x 115 mm and a 30 gallon tank, 114 L. Modular products will undergo "hard conversion"their dimensions will change to new rounded metric numbers as shown below.

"2BY4" STUDS AND OTHER "2BY" FRAMING (both wood and metal)

What will change
- Spacingfrom 16" to 400 mm, and 24" to 600 mm

What will stay the same
- Cross sections

"2by4s" may keep their nominal name, or perhaps they'll be relabeled a nominal 50 x 100 mm or a more exact size.

DRYWALL, PLYWOOD, AND RIGID INSULATION

What will change
- Widthfrom 4'0" to 1200 mm
- Heightfrom 8'0" to 2400 mm, 10'0" to 3000 mm

What will stay the same
- Thicknesses, so fire, acoustic, and thermal ratings won't have to be recalculated

Metric drywall is readily available, but with a possible cost penalty for small orders. Metric plywood and rigid insulation may not be available at this time.

BATT INSULATION

What will change
- Widthfrom 16" and 24" nominal to 400 mm and 600 mm nominal ***or*** no changethere just will be more of a "friction" fit

What will stay the same
- Thickness, so thermal ratings won't have to be recalculated

DOORS

What will change
- Height from 6'8" to 2050 or 2100 mm and from 7'0" to 2100 mm
- Width from 2'6" to 750 mm, from 2'8" to 800 mm, from 2'10' to 850 mm, from 3'0" to 900 or 950 mm, and from 3'4" to 1000 mm.

What will stay the same
- Door thicknesses
- Door materials and hardware

For commercial work, doors can be ordered in any size since they are normally customfabricated.

CEILING SYSTEMS

What will change
- Grids and layin ceiling tile, air diffusers, and lighting fixtures from 2' x 2' to 600 x 600 mm and from 2' x 4' to 600 x 1200 mm

What will stay the same
- Grid profiles, tile thicknesses, air diffuser capacities, florescent tubes, and means of suspension

RAISED FLOOR SYSTEMS

What will change
- Grids and layin floor tilefrom 2' x 2' to 600 x 600 mm

What will stay the same
- Grid profiles, tile thicknesses, and means of support

HVAC CONTROLS

What will change
- Temperature unitsfrom Fahrenheit to Celsius

What will stay the same
- All other parts of the controls

Controls are now digital so temperature conversions can be made with no difficulty.

Part II will be published in the next issue

FEDERAL METRIC PROJECTS KEEP GROWING

The **Army Corps of Engineers** has over $50 million in pilot projects under way and more largescale projects are about to be announced. Corps metric overseas projects total about $525 million.

The **General Services Administration** now has about $1.5 billion in metric projects in the planning, design, or construction stages. All work designed after January 1994 will be in metric.

Most of the **Department of Energy**'s $8.2 billion Super Collider project is being constructed in metric.

Two new **Smithsonian Institution** facilities with a total cost of over $150 million will be built in metric.

The **Air Force**, **Office of the Secretary of Defense**, **NASA**, and the **Public Health Service** are conducting over $30 million in metric pilot projects with significantly more work in planning. All Air Force work designed after January 1994 will be in metric.

The $400-$500 million **Defense Medical Facilities** program for FY 95 is scheduled to be in metric.

Indications are that the massive $1 billion **Pentagon** renovation will be conducted in metric.

The **Department of State** continues to build in metric with current projects totaling $275 million.

METRIC RESOURCES

- Available from the Publications Department, National Institute of Building Sciences, 1201 L St., N.W., Washington DC 20005; phone 202-289-7800 (bulk orders are available at a discount):

Metric Guide for Federal Construction (34 pg, $15). Written specifically for the construction industry and reviewed by metric experts throughout the country. Includes a background on the federal metric laws, facts on metric in construction, an introduction to metric units, a primer on metric usage for architects, engineers, and the trades, requirements for metric drawings and specifications, guidance on metric management and training, and a listing of current metric construction references.

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- Available from the AIA Bookstore, 1735 New York Ave., Washington, DC 20006; phone 202-626-7475:

Nufert Architect's Data, 2d International Edition ($52). The European equivalent to the **AIA Graphic Standards**. All measurements in metric.

The Architect's Studio Companion; Technical Guidelines for Preliminary Design ($44.95). Includes dual units.

- **Wiley Engineer's Desk Reference** ($54.95). John Wiley & Sons, Professional Reference and Trade Group, 605 Third Ave., New York N.Y. 10158; phone 1-800-225-5945, Ext. 2497. Includes dual units.

- **Metric Practice Guide for Surveying and Mapping** ($10). American Congress of Surveying and Mapping, 5410 Grosvenor Lane, Suite 100, Bethesda, Md. 20814; phone 301-493-0200.

- Available for $114 each; American Society of Heating, Refrigeration, and AirConditioning Engineers, 1791 Tullie Circle, N.E., Atlanta GA 30329; phone 404-636-8400: **ASHRAE 1991 Handbook-HVAC Applications**, SI Edition; **1989 Handbook Fundamentals**, SI Edition; **1990 Refrigeration Handbook**, SI Edition; **1992 Handbook-HVAC Systems and Equipment**. All with dual units.

- **ACI 318M89/318RM89, Building Code Requirements for Reinforced Concrete and Commentary** ($70). American Concrete Institute, Box 19150, Detroit MI 48219; phone 313-532-2600. Metric edition of ACI 318.

- Available in draft form for $10 each; American Institute of Steel Construction, Metric Publications, AISC, One E. Wacker Dr., Suite 3100, Chicago, Illinois 60601-2001; 312-670-5414:

Metric Properties of Structural Shapes with Dimensions According to ASTM A6M (92 pg). Metric version of Part 1 of the **Manual of Steel Construction**.

Metric Conversion: Load and Resistance Factor Design Specification for Structural Steel Buildings (159 pg). Metric version of the September 1, 1986 **LRFD Specification**.

- **MetricX**. Orion Development Corporation, phone 1-800-992-8170; single user copies $24.95; site/network copies available, discounts for bulk orders. Metric conversion software for use with IBMcompatible computers.

ConvertFile Conversion Utility. Vidtrak Technologies Co., phone 216-762-5141; $29.95. Metric conversion software for use with IBMcompatible computers.

- **1992 Means Building Construction Cost Data**, Metric Edition ($65). R. S. Means Company, Box 800, Kingston MA 02364; phone 6175857880). Prototype metric edition of Means' cost estimating handbook. Complete metric edition for 1993 should be available this fall. Means also offers metric cost estimating seminars.

- **All About Metric** ($500) MMEI Corp., 2247 Lexington Pl., Livermore CA 94550; phone 510-449-8992. Threetape video training package by the U.S. Metric Association and MMEI Corp. Covers the background of the metric system, government/industry transition, everyday metric units, and rules for metric usage. Accompanying reference manual includes conversion tables and other information. Instructor's manual contains lesson tips, test questions, illustrations suitable for use as masters for overhead projector transparencies.

- **SI Metric for the Workplace** ($2195). Workplace Training, 520 North Arm Dr., Orono MN 55364; phone 612-472-2564. Sixtape video/workbook courseware.

Provides indepth metric training for business and industry professionals. Includes an introduction to metric, units of measure, reading/writing rules, limits/fits/tolerances, metric conversion.

Metric poster. Blackhawk Metric Supply Inc., phone 815-389-2850. Attractive wall poster that shows common metric measures. $8 each; discounts for bulk orders.

METRIC FACTS: Volume

How much does it hold? In metric, the unit for volume is the cubic meter (m^3). Cubic meter is a multiple of the base metric unit, meter. The cubic meter is the volume enclosed by a cube with 1 meter sides. This is a large volume, equal to 35.3 cubic feet. The more popular metric unit for fluid capacity is the liter (1 liter = 1.06 US quarts). A liter is equal to exactly 1 cubic decimeter. A milliliter is equal to a cubic centimeter.

In technical work, the cubic millimeter (mm^3) should be used for small volumes. One $m^3 = 10^9$ mm^3 and 16.387 mm^3 = 1 in^3.

Problem: A rectangularly shaped tank measures 6 ft x 7 ft x 4 ft. How many cubic meters of liquid will it hold when filled?

Solution: (6 ft) x (7 ft) x (4 ft) x 1 $m^3/35.3$ ft^3 = 4.75 m^3

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WHAT WILL CHANGE AND WHAT WILL STAY THE SAME?

Part II

This is the second part of a two-part summary of salient metric conversion issues discussed by the Construction Metrication Council in 1992.

BRICK

What will change

- Standard brick to 90 x 57 x 190 mm
- Mortar joints from 3/8" and 1/2" to 10 mm
- Brick module from 2' x 2' to 600 x 600 mm

What will stay the same

- Brick and mortar composition

Of the 100 or so brick sizes currently made, 5 to 10 are within a millimeter of a metric brick so the brick industry will have no trouble supplying metric brick.

CONCRETE BLOCK

What will change

- Block sizes to 190 x 190 x 390 mm
- Mortar joints from 1/2" to 10 mm
- Block module from 2' x 2' to 600 x 600 mm

What will stay the same

- Block and mortar composition

Metric block sizes are distinctly different (3/8 inch shorter in the long dimension) from current block sizes. The block industry will have to buy new mold components.

SHEET METAL

What will change

- Designation from "gage" to millimeters

What will stay the same

- Thickness

In specifications, use millimeters only or millimeters with the gage in parentheses.

CONCRETE

What will change

- Strength designation from "psi" to megapascals, rounded to the nearest 5 Mpa

What will stay the same

- Strength requirements

REBAR

What will change

- Bar sizes may change to metric per ASTM A615M, A616M, A617M, and A706M

What will stay the same

- Everything else

GLASS

What will change

- Cut sheet dimensions from feet-inches to millimeters

What will stay the same

- Sheet thickness, which is already in millimeters

ELECTRICAL CONDUIT

What will change

- Nominal conduit designations from inches to millimeters

What will stay the same

- Conduit cross sections

ELECTRICAL WIRE

What will change

- Nothing at this time

What will stay the same

- Existing American Wire Gage (AWG) sizes

PIPE AND TUBING

What will change

- Nominal pipe and tubing designations from inches to millimeters
- Threads to metric sizes

What will stay the same

- Pipe and tubing cross sections

Pipe and tubing sizes are the same in much of the world, but their names vary as do thread sizes.

STRUCTURAL STEEL

What will change

- Section designations from inches to millimeters and from pounds per foot to kilograms per meter
- Bolts, to metric diameters and threads per ASTM A325M and A490M

What will stay the same

- Cross sections

Nominal section designations may change to metric but their dimensions will remain the same. For instance, a 24-inch section may be called a 600 mm section.

STATUS OF FEDERAL METRIC CONSTRUCTION

The following information was presented at the November 1992 meeting of the Construction Metrication Council by representatives of federal agencies.

General Services Administration (GSA)

- Design work for metric pilot projects has gone smoothly with no significant problems. Designers report that they find metric units easier to work with after a short adjustment period.
- Cost estimating in metric has been the most critical issue because estimators' data bases are in inch-pound units. New GSA metric cost estimating forms will help estimators make the adjustment.
- GSA construction will be completely metric within two or three years. Small projects with shorter design times probably will lead the bigger projects into construction even though design of the bigger projects started first.
- The Denver warehouse project is in construction now and work is going smoothly. Workmen are using dual-unit measuring tapes.
- The metric versions of Masterspec Divisions 1, 15, and 16 have been put on the NIBS CD-ROM Construction Criteria Base.

GSA, National Capitol Region

- Design work on the new FBI field office building in Washington, D.C., will be completed in September 1993 with occupancy scheduled for about mid-1996. The 8-story, 52 760 m² reinforced concrete frame building has an estimated cost of about $57 million.
- Design work on a new Federal Protective Service field office building will be completed in 1994 with occupancy scheduled for late 1995. The 3-story, 16 850 m² building has an estimated cost of about $37 million.
- Construction of a small building designed by in-house staff in metric is about 40 percent complete with no problems to date.

GSA Region 3, Philadelphia

- The following publications have been completed: draft Region 3 metric version of PBS PQ-100, *Facilities Standards for the Public Building Service*; the metric interim Region 3 version of the *U.S. Courts Design Guide*; and the metric version of the *Border Station Design Guide*.
- Construction has begun on the renovation of 4 floors of an 8-story federal building in Baltimore, Maryland. Work is in metric. The construction award was 15 percent below the government cost estimate (in line with bids in recent non-metric projects) so there has been no detectable cost premium for using metric on this job to date.
- About $100 million in metric construction will be advertised in FY 1993.
- Region 3 has converted 65 of the most commonly used Masterspec sections (in addition to Divisions 1, 15, and 16) and 50 more will be completed in January 1993 (the AIA will convert the balance later in 1993). Region 3 is aiding other federal agencies in converting their specifications.
- GSA continues to receive metric literature from product manufacturers. A recent arrival: information on hard metric resilient floor and carpet tile.
- January 1994 is viewed as a feasible date for doing all GSA work over $1 million in metric.

Army Corps of Engineers

- Six metric pilot projects with a total program value of $28 million are now under way. Overseas Corps metric projects total about $525 million. Ten U.S. building projects with a total value of about $100 million have been selected for the FY 1995 metric construction program.

Naval Facilities Engineering Command (NAVFAC)

- NAVFAC is preparing a metric transition and implementation plan for Navy construction. NAVFAC does all its overseas work in metric. For the past year NAVFAC has been converting its specifications and criteria to metric as they are updated. A separate metric edition is being created for each document.

Air Force

- The Air Force has two metric pilot projects in planning, two being bid, and one in construction. There have been no problems to date with these projects. All overseas Air Force projects are in metric. Each major Air Force command is to have one military construction project in metric under way by January 1994.

Office of the Secretary of Defense

- Five small Washington area projects are being designed in metric. The first phase of the multiyear, $1 billion Pentagon renovation is planned to be in metric.

Coast Guard

- The Coast Guard's Facilities Standards Section has a metric transition plan that begins in 1995 and is to be completed in 1997. The *Shore Facilities Standards Manual* contains a prototype metric multi-mission station and the *Space Components Standards Manual* includes metric units. A metric coordinator for shore facilities construction is being selected.

Department of the Treasury

- Treasury has a three-phase metric transition plan. In Phase I, building drawings will be put on CAD and their dimensions converted to metric. In Phase II (FY 1993), A/Es will be notified that all future plans, specifications, and related construction documents must be prepared in metric. In Phase III (FY 1994), all work will be performed in metric.

Department of State

- State is doing all of its design work in metric. It is receiving help from GSA on finding U.S. suppliers for metric or metric-labeled products. A/E guidelines are being changed to require all contract deliverables to be in metric.

Department of Agriculture

- The Facilities Management Division plans to be completely metric by 1995. A $500,000 metric construction project is due to be completed by July 1993. It came in below the government cost estimate. Two additional metric projects will be completed in 1994, and all projects will be in metric after 1995.

U.S. Forest Service

- The Division of Engineering plans to follow the Federal Highway Administration's (FHWA) metrication schedule requiring all construction to be in metric after October 1, 1996. Design work is being started in metric.

National Science Foundation (NSF)

- All proposals for grants, cooperative agreements, and contracts submitted to NSF are required to be in metric as are all related reports, publications, and correspondence.

Internal Revenue Service (IRS)

- CRSS Architects has completed the working draft of the new IRS *Regional Service Centers Design Criteria Manual*, which contains metric units.

Federal Highway Administration

- The FHWA metric conversion plan was approved in 1991. September 30, 1996 is the target date for full conversion of the agency's annual $16 billion construction program.
- FHWA is working closely with the AASHTO metric task force. The University of Alabama is preparing the AASHTO *Guide to Metric Conversion* for release in March 1993. Highway signage is the most controversial issue; an advanced notice of proposed rulemaking on signage plans will be published in the *Federal Register* in 1993.
- FHWA is developing a one-day metric training course for federal and state highway agency personnel that will begin in mid-1993. FHWA Region 9 (California, Nevada, Arizona, and Hawaii) held a metric coordinating meeting in November; other regions plan to hold similar meetings.

National Aeronautics and Space Administration (NASA)

- The NASA physical plant is worth about $15 billion and its annual design and construction budget is $500 million. Each of the 12 NASA centers

selected a metric pilot project last November for the 1994 construction program. Projects total $17 million.
- A two-day seminar was held last July to review the status of the pilot projects and to conduct metric cost estimating training. A meeting will be held in mid-1993 to review the pilot project results. If they are going well, the number of pilot projects will be doubled in 1994. If the 1994 projects go well, NASA construction will go 100 percent metric in 1995.

Department of Labor

- The Employment and Training Administration (ETA) focuses on Job Corps programs. Its metric transition plan includes the development of a pilot curriculum for teaching metric at two Job Corps centers by the end of 1993; if successful, metric will be taught at all centers by the end of 1994. A steering group will meet monthly to review the progress of the metric transition program.
- In 1993, ETA will require engineering support contractors to use dual units in facilities and site surveys and utilization studies. In 1994, ETA will have its contract documents prepared in dual units; if these are successful, they will be changed to metric-only.

Tennessee Valley Authority (TVA)

- The corporate design and development staff is planning to design its first metric building in 1993. The facilities services group is gearing up to use metric in facilities modification work. Some parts of the TVA already make extensive use of metric equipment.

Small Business Administration (SBA)

- All procedures, regulations, and publications are being reviewed for conversion to metric. Video training tapes on metric will be circulated to SBA offices in early 1993.
- A new publication, *Converting to Metric: A Guide for Small Business*, and a one-page handout, *Focus on the Facts: Converting to Metric*, have been recently published.

Department of Energy (DOE)

- DOE's metric transition plan was published in April 1992 and set January 1994 as the target for all major construction projects to be in metric. All non-metric work first must be cleared by a waiver from the appropriate Assistant Secretary.
- In May 1992 the DOE metric construction working group met in Washington. Project managers were eager to begin work in metric. All new and revised DOE standards will include metric units. DOE will show preference for non-government standards that are in metric. Revisions of DOE design criteria to include metric begin in November 1992. Some agency programs will go metric immediately without pilot projects and will rely on requests for proposals for metric services and surveys of available metric products and equipment.
- DOE controls many of the facility and equipment standards in the *Code of Federal Regulations* and will convert them metric in the next revision cycle.
- Equipment for DOE's $8.2 billion Super Collider project is primarily in metric. Tunnels and buildings were started prior to metric conversion and therefore are being built using inch-pound units. The Yucca Mountain nuclear waste repository will have 22 km of tunnels bored in metric dimen-

sions. Its related MRS interim storage facility will be built primarily in metric.

Public Health Service

- Several small metric pilot projects are under way. Project planning documents are being converted to metric. Facilities reports to the Department of Health and Human Services are beginning to be submitted in metric.

National Institute of Standards and Technology (NIST)

- Approximately $110 million in new and renovated laboratory facility projects at the NIST Gaithersburg, Maryland, and Boulder, Colorado, campuses most likely will be built in metric. This is the first phase of an extensive 10-year program to modernize and expand NIST facilities.
- The Metric Program Office has prepared a six-panel metric style guide to augment the American National Metric Council's *Metric Editorial Guide*.

Federal Bureau of Prisons

- Metric transition guidelines are being prepared for the Design and Construction Branch by an A/E consultant. The bureau is committed to the January 1994 date for the construction of new facilities in metric. Several pilot projects are being considered for 1993. Project managers are "raring to go" metric.

Central Intelligence Agency

- All design and construction documents are being converted to dual units. Designers and contractors working for the agency have been positive about metric conversion.

Department of the Interior (DOI)

- DOI agencies involved in construction are the Bureau of Reclamation, the Fish and Wildlife Service, the National Park Service, the Bureau of Land Management, and the Bureau of Indian Affairs. Each is in a different stage of metric transition.
- The Bureau of Land Management is conducting a $50 thousand metric pilot project at La Ventana.
- The National Park Service has a $1 million pilot project under way at the Thurmond Depot in New River Gorge, West Virginia.
- The Fish and Wildlife Service is adding dual units to its specifications and criteria.
- In 1978, the Bureau of Reclamation began construction of a $260 million desalinization plant in Yuma, Arizona. It was designed and built in metric because so much of the technology was foreign. The plant is the largest of its kind in the world and is now about 50 percent operational. No problems associated with the use of metric have been reported. The Bureau of Reclamation undertakes many overseas projects, all of which are built in metric. Included is a $40 million project at Aswan, Egypt.

The Smithsonian Institution

- The Smithsonian metric transition plan has three objectives: the use of metric in daily operations, especially procurement; the education of the Smithsonian staff; and the incorporation of metric in all public programs. A new requisitions handbook will be released that will require the use of metric units.

- All planning and design work will be conducted in metric after January 1994. The $25 million National Museum of the American Indian Suitland Facility will be designed in metric, with design beginning in February 1993. The $77 million National Museum of the American Indian also will be designed in metric. The A/E is being selected.
- An Institution-wide accessibility master plan is being prepared in metric.

Naval Sea Systems Command

- The new LX amphibious assault ship will be a metric and inch-pound hybrid. About 100 other ship building projects are being constructed in metric. Some offices have converted all specifications and drawings to metric. The Navy's implementation of metric has been uneven but work is being performed in metric in many areas.

National Oceanic and Atmospheric Administration (NOAA)

- NOAA went metric on October 1, 1992, and is actively pro-metric. Procurement guidelines mandate that all new procurement actions be made in metric. Exceptions for non-metric procurements must be submitted in writing. NOAA has requested that GSA use metric to build the new $32 million National Climate Data Center in Asheville, North Carolina.

Architect of the Capitol

- The Architect of the Capitol plans to construct future buildings in metric even though none are being considered by Congress at this time.

National Institutes of Health (NIH)

- A $1 million addition to the primate building at NIH is being designed in metric. A/E contractors have been alerted that after January 1994 new work will be performed in metric. In 1992, the Division of Engineering Services provided metric orientation training to all its managers and supervisors. The balance of the 670 person staff will be trained over the next few months.

Department of Housing and Urban Development (HUD)

- There has been little official movement toward metric by the agency but there is interest in "retailing" metric to the states and cities through the HUD grants program. The revised HUD guide specifications being prepared by CHK Architects and Planners include dual units, with metric units listed first.

$8.5 BILLION IN METRIC CONSTRUCTION

Here are the January 1993 totals, by agency, for federal metric projects in the planning, design, and construction stages:

	$ Million
Army Corps of Engineers (domestic and overseas)	653
Bureau of Land Management	under 1
Bureau of Reclamation (domestic only)	260
Department of Agriculture	under 1
Department of Energy (Super Collider only)	6000
General Services Administration	1281

NASA.....17
NAVFAC (overseas).....65
National Institute of Standards and Technology.....110
National Park Service.....1
Office of the Secretary of Defense.....1
Public Health Service.....1
Smithsonian Institution.....103
Air Force.....5

ATTENTION FEDERAL CONSTRUCTION MANAGERS

Please submit information about your federal metric programs to Joe Sacco at the Pentagon, 703-614-4879.

Joe is maintaining a database of metric projects, products, and findings. He can help you and you can help others smooth the way for metric.

METRIC FACTS: Velocity

How fast will it go? The metric measure applied to questions of velocity is the meter per second (m/s). It is made up of the base units meter and second. One meter per second is equal to 3.281 feet per second.

The meter per second should be used in engineering calculations except for very low velocities where the millimeter per second (mm/s) may be used.

Problem: The water velocity in a boiler tube is 7 ft/sec. What is this velocity in m/s?

Solution: (7 ft/1 s) x (1 m/3.281 ft) = 2.1 m/s.

Metric in Construction is the newsletter of the Construction Metrication Council of the National Institute of Building Sciences, Washington, D.C. Copies of previous newsletters are available upon request.

CONSTRUCTION METRICATION COUNCIL

National Institute of Building Sciences
1201 L Street, N.W., Suite 400
Washington, D.C. 20005
Telephone 202-289-7800; Fax 202-289-1092

Metric in Construction is a bimonthly newsletter published by the Construction Metrication Council to inform the building community about metrication in U.S. construction. The Construction Metrication Council was created by the National Institute of Building Sciences to provide industry-wide, public and private sector support for the metrication of federal construction and to promote the adoption and use of the metric system of measurement as a means of increasing the international competitiveness, productivity, and quality of the U.S. construction industry.

The National Institute of Building Sciences is a nonprofit, nongovernmental organization authorized by Congress to serve as an authoritative source on issues of building science and technology.

The Council is an outgrowth of the Construction Subcommittee of the Metrication Operating Committee of the federal Interagency Council on Metric Policy. The Construction Subcommittee was formed in 1988 to further the objectives of the 1975 *Metric Conversion Act*, as amended by the 1988 *Omnibus Trade and Competitiveness Act*. To foster effective private sector participation, the activities of the subcommittee were transferred to the Council in April 1992.

Membership in the Council is open to all public and private organizations and individuals with a substantial interest in and commitment to the Council's purposes. The Council meets monthly in Washington, D.C.; publishes the *Metric Guide for Federal Construction* and this bimonthly newsletter; and coordinates a variety of industry metrication task groups. For membership information, call the Council at the above phone number.

Volume 2, Issue 2 March-April 1993

METRIC RESOURCES

Metric conversion is largely a paper--and software--change. Codes, standards, handbooks, manufacturers' literature, advertising, and software are being prepared in metric. Here are some of the most requested metric resources.

Metric Construction Guides

National Institute of Building Sciences (Publications Department, 1201 L St., N.W., Suite 400, Washington DC 20005; phone 202-289-7800):

- *Metric Guide for Federal Construction.* Written by NIBS specifically for the construction industry and reviewed by metric experts throughout the country. Includes background on the federal metric laws; facts on metric in construction; an introduction to metric units; a primer on metric usage for architects, engineers, and the trades; requirements for metric drawings and specifications; guidance on metric management and training; and a list of current metric construction references. 34 pp. $15.00 (including shipping and handling).

- *GSA Metric Design Guide.* Interim design guide developed by the General Services Administration (GSA) for use by federal project managers and their A/Es. Contains practical architectural, civil, structural, mechanical, and electrical design information; a list of available "hard" metric products; sample drawings; and related reference information. 77 pp. $8.00; $5.00 if ordered with the above *Metric Guide for Federal Construction.*

General Metric Information

American National Metric Council (Washington, DC; phone 410-727-0882 for publications):

- *ANMC Metric Editorial Guide.* $5.00; bulk discounts available.
- *SI Metric Training Guide.* $5.00.
- *Metrication and the Consumer.* $5.00.
- *Metrication for the Manager.* $15.00.

Society of Automotive Engineers (400 Commonwealth Dr., Warrendale, PA 15096-0001; phone 412-776-4841):

- *Metric (SI) in Everyday Science and Engineering.* A well written, concise, and very practical guide to understanding metric in depth. By Stan Jakuba. 1993. $26.00.

U.S. Metric Association (10245 Andasol Ave., Northridge, CA 91325; phone 818-363-5606):

- *Style Guide to the Use of the Metric System.* $3.00; bulk discounts available.
- *SI Metric Style Guide for Written and Computer Usage.* $2.00; bulk discounts available.
- *Freeman Training/Education Metric Materials List.* $38.00.
- *Metric Vendor List.* $28.00.

Blackhawk Metric Supply Inc. (Box 543, South Beloit, IL 61080; phone 815-389-2850):

- *Metric poster*. Attractive four-color chart that shows common metric units and their logical relationships. $8 each; discounts for bulk orders.

Design

American Institute of Architects (AIA Bookstore, 1735 New York Ave., N.W., Washington, DC 20006; phone 202-626-7475. All but the *AIA Pocket Metric Guide* are published by John Wiley & Sons, Professional Reference and Trade Group, 605 Third Ave., New York, NY 10158; phone 1-800-225-5945, ext. 2497):

- *AIA Pocket Metric Guide*. Available in June 1993.
- *Architectural Graphic Standards*. A metric edition is not due for several years, but current editions include a comprehensive section on metric conversion.
- *The Architect's Studio Companion: Technical Guidelines for Preliminary Design*. By Edward Allen and Joseph Iano. Includes dual units. 468 pp. 1989. $52.95.
- *Architectural Detailing: Function, Constructabililty, and Aesthetics*. By Edward Allen. Includes dual units. 1993. Available with *Architect's Studio Companion* as a set for $87.50.
- *Fundamentals of Building Construction: Materials and Methods*. By Edward Allen. Includes dual units. $59.95.
- *Neufert Architect's Data*. Ernst Neufert. Second International (metric) Edition (Germany). 433 pp. 1980. $52.50.
- *Wiley Engineer's Desk Reference*. By S. I. Heisler. Includes dual units. 566 pp. 1984. $54.95.

Cost Estimating

R. S. Means Company (Box 800, Kingston, MA 02364; phone 617-585-7880):

- *Means Building Construction Cost Data, 1993*. Metric edition. $94.95.

Specifications

American Institute of Architects (1735 New York Ave., N.W., Washington, DC 20006; phone 1-800-424-5080):

- *AIA MASTERSPEC* will contain dual units by late this summer.

Construction Specifications Institute (601 Madison St., Alexandria, VA 22314-1791; phone 703-684-0300):

- *CSI SPECTEXT* contains dual units. All other CSI publications contain dual units or are being converted now.

Building Codes

Building Officials and Code Administrators International (4051 W. Flossmoor Rd., Country Club Hills, IL 60477-5795; phone 312-799-2300):

- *BOCA National Building, Fire Prevention, Mechanical, and Plumbing Codes*. All editions are published with dual units.

International Conference of Building Officials (5360 South Workman Mill Rd., Whittier, CA 90601; phone 310-699-0541):

- *Uniform Building, Fire, Mechanical, and Plumbing Codes*. The 1994 editions will be published with dual units.

National Fire Protection Association (1 Batterymarch Park, Box 9101, Quincy, MA 02269-9101; phone 1-800-344-3555):

- NFPA 101, *Life Safety Code*. All NFPA documents are published with dual units. 1991. $33.75

Southern Building Code Congress International, Inc. (900 Montclair Rd., Birmingham, AL 35213-1206; phone 205-591-1853):

- *Standard Building Code*. The 1991 edition is published with dual units. The *Standard Fire, Plumbing, and Mechanical Codes* will be published with dual units in 1994.

Standards

American National Standards Institute, Inc. (11 W. 42nd St., New York, NY 10036; phone 212-642-4900):

- ANSI/IEEE 268, *American National Standard Metric Practice*. 1992. $52.50.
- ANSI/AWS A1.1, *Metric Practice Guide for the Welding Industry*. $20.00.
- ANSI/IEEE 945, *Preferred Metric Units for Use in Electrical and Electronics Science and Technology*. $45.00.
- ISO 1000, *SI Units and Recommendations for the Use of Their Multiples and Certain Other Units*. $48.00.
- Many other ANSI standards are available in metric; check with ANSI.

American Society for Testing and Materials (1916 Race St., Philadelphia, PA 19103; phone 215-299-5585):

- ASTM E380, *Standard Practice for Use of the International System of Units (SI)*. 35 pp. 1992. $23.00.
- ASTM E621, *Standard Practice for the Use of Metric (SI) Units in Building Design and Construction*. 37 pp. 1984. $23.00.
- ASTM E713, *Guide for Selection of Scales for Metric Building Drawings*. 3 pp. $15.00.
- ASTM E577, *Guide for Dimensional Coordination of Rectilinear Building Parts and Systems*. $15.00.
- ASTM E835, *Guide for Dimensional Coordination of Structural Clay Units, Concrete Masonry Units, and Clay Flue Linings*. $15.00.
- All other ASTM standards are published in metric or with dual units.

Underwriters Laboratories, Inc. (333 Pfingston Rd., Northbrook, IL 60062; phone 708-272-8800):

- Virtually all UL standards contain dual units.

Civil

American Congress on Surveying and Mapping (5410 Grosvenor Lane, Suite 100, Bethesda, MD 20814; phone 301-493-0200):

- *Metric Practice Guide for Surveying and Mapping*. 11 pp. 1978. $10.00.

American Association of State and Highway Transportation Officials (444 N. Capital St., N.W., Suite 225, Washington DC 20001; phone 202-624-5800):

- *Guide to Metric Conversion*. Available in mid-May 1993.
- *Standard Specifications for Transportation Materials*. Two-volume set. Includes dual units. $115.00.

Wood

American Forest and Paper Association (formerly National Forest Products Association; 1250 Connecticut Ave., N.W., Washington, DC 20036; phone 202-463-2700:

- *Lumber and Wood Products Metric Planning Package*. 1978. Currently being revised.

National Particleboard Association (18928 Premiere Ct., Gaithersburg, MD 20879; phone 301-670-0604):

- Metric units currently are being added to the APA/ANSI standards for particleboard and medium-density fiberboard.

Hardwood Plywood Manufacturers Association (Box 2789, Reston, VA 22090-2789; phone 703-435-2900):

- *Interim Voluntary Standard for Hardwood and Decorative Plywood*. Includes dual units. 24 pp. 1992. $10.00.

Steel

American Institute of Steel Construction (Metric Publications, 1 E. Wacker Dr., Suite 3100, Chicago, IL 60601-2001; phone 312-670-5414):

- *Metric Properties of Structural Shapes with Dimensions According to ASTM A6M*. Metric version of Part I of the *Manual of Steel Construction*. $10.00.
- *Metric Conversion: Load and Resistance Factor Design Specification for Structural Steel Buildings*. $10.00.
- *Manual of Steel Construction, Metric Edition*. To be published in 1994.

American Welding Society (550 N.W. LeJeune Rd, Box 35104, Miami, FL 33135; phone 305-443-9353):

- All AWS standards include dual units.

Industrial Fasteners Institute (1105 East Ohio Building, 1717 E. 9th St., Cleveland, OH 44114; phone 216-241-1482):

- *Metric Fastener Standards*. $60.00.

Concrete

American Concrete Institute (Box 19150, Detroit, MI 48219; phone 313-532-2600):

- ACI 318M-89/318RM-89, *Building Code Requirements for Reinforced Concrete and Commentary*. Metric edition of ACI 318-89/318R-89. $70.00.

- ACI 318.1M-89/318.1RM-89, *Building Code Requirements for Metric Structural Plain Concrete and Commentary*. Metric edition of ACI 318.1-89/318.1R-89. $11.50.

Mechanical and Electrical

American Society of Heating, Refrigerating, and Air-Conditioning Engineers (1791 Tullie Circle, N.E., Atlanta, GA 30329; phone 404-636-8400):

- *SI for HVAC&R*. 1986. 11 pp. Free on request.
- *Psychrometric Charts SI*. Charts 1 through 7. $10.00.
- *1991 Handbook -- HVAC Applications*. SI edition. $114.00.
- *1989 Handbook -- Fundamentals*. SI edition. $114.00.
- *1990 Refrigeration Handbook*. SI edition. $114.00.
- *1992 Handbook -- HVAC Systems and Equipment*. SI edition. $114.00.
- All ASHRAE standards are published in metric or with dual units. ASHRAE plans to discontinue the use of inch-pound units by the year 2000.

American Society of Mechanical Engineers (22 Law Dr., Box 2300, Fairfield, NJ 07007; phone 1-800-843-2763 ext. 426):

- SI-1, *Orientation and Guide for Use of SI (Metric) Units*. 1982. $12.00.
- SI-2, *SI Units in Strength of Materials*. 14 pp. 1976. $12.00.
- SI-3, *SI Units in Dynamics*. 20 pp. 1976. $12.00.
- SI-4, *SI Units in Thermodynamics*. 55 pp. 1976. $12.00.
- SI-5, *SI Units in Fluid Mechanics*. 36 pp. 1976. $12.00.
- SI-6, *SI Units in Kinematics*. 14 pp. 1976. $12.00.
- SI-7, *SI Units in Heat Transfer*. 36 pp. 1977. $12.00.
- SI-8, *SI Units in Vibration*. 13 pp. 1976. $12.00.
- SI-9, *Guide for Metrication of Codes and Standards Using SI (Metric) Units*. 33 pp. 1980. $13.00.
- SI-10, *Steam Charts, SI (Metric) and U.S. Customary Units*. Edited by J. H. Potter. 128 pp. 1976. $28.00.
- All other ASME standards, except the *Boiler and Pressure Vessel Code*, are published either in separate SI editions or with dual units.

National Environmental Balancing Bureau (1385 Piccard Dr., Rockville, MD 20850; phone 301-977-3698):

- *Fundamentals*, *Air Systems*, and *Hydronic Systems* guides. Available in metric editions.

National Fire Protection Association (1 Batterymarch Park, Box 9101, Quincy, MA 02269-9101; phone 1-800-344-3555):

- NFPA 13, *Installation of Sprinkler Systems*. Includes dual units. 1991. $24.50.
- ANSI/NFPA 70, *National Electrical Code*. Includes dual units. 1993. $32.50.
- All other NFPA standards are published with dual units.

Sheet Metal and Air Conditioning Contractors National Association (4201 Lafayette Center Dr., Chantilly, VA 22021; phone 703-803-2980):

- All SMACNA publications are being converted to dual units.

Water Environment Federation (601 Wythe St., Alexandria, VA 22314; phone 703-684-2400):

- Manual of Practice No. 6, *Units of Expression for Wastewater Treatment Management*. 47 pp. $15.00.

Product Manufacturing

Association for Manufacturing Technology, The (7901 Westpark Dr., McLean, VA 22102-4269; phone 703-893-2900):

- *Guidelines for Metric Conversion in Machine Tool and Related Industries*. $15.00.

Dual Unit Tape Measures

Dual unit tape measures are all that will be needed for most job-site work. They are readily available at larger hardware stores or directly from **Stanley Tools** (1-800-262-2161), **Lufkin** (912-362-7511), or **U.S. Tape** (703-256-1500).

Metric Scales and Templates

Metric scales are available from graphic arts supply stores. Popular models are **Staedtler-Mars** 987-18-1, **Alvin** 117 PM, and **Charvoz** 30-1261. A metric plumbing template is available from **American Standard**; call Ms. Barbara Munson at 703-841-9585.

Metric Calculator

Sharp Instrument Company (Van Schaack Premium Group, 4747 W. Peterson, Chicago, IL 60646; phone 312-736-5600):

- *Sharp Model EL-344G Metric Calculator*. Converts linear dimensions, areas, volumes, liquids, pressures, and masses with two keystrokes. Very handy for simple conversions. Under $20.00.

Metric Conversion Software

Orion Development Corporation (Box 2323, Merrifield, VA 22116-2323; phone 1-800-992-8170):

- *Metric-X*. Metric conversion software for use with any IBM-compatible computer. Single user copies $24.95; site/network copies available; discounts for bulk orders.

Vidtrack Technologies Co. (540 S. Main St., Suite 941, Akron, OH 44311-1010; phone 216-762-5141):

- *ConvertFile Conversion Utility*. Metric conversion software for use with IBM-compatible computers. $29.95.

MCB Enterprises (Box 6563, Huntington Beach, CA 92615-6563; phone 714-647-5534):

- *Metric Calc!* Metric conversion software in both DOS and Windows versions. $49.95.

CAD and Engineering Software

The two largest CAD vendors, **Autodesk** and **Intergraph**, allow the user to work in either inch-pound or metric units. Many structural and mechanical design

programs have metric capability, too. Before you purchase any new computer software, **make sure it has provisions for metric.**

Metric Videotapes

Workplace Training (520 N. Arm Dr., Orono, MN 55364; phone 612-472-2564):

- *SI Metric for the Workplace.* Six-tape video/workbook courseware. Provides in-depth metric training for business and industry professionals. Includes an introduction to metric, units of measure, reading/writing rules, limits/fits/tolerances, and metric conversion. $2195.

MMEI Corporation (2247 Lexington Pl., Livermore, CA 94550; phone 510-449-8992):

- *All About Metric.* Three-tape video training package that covers the background of the metric system, government/industry transition, everyday metric units, and rules for metric usage. Accompanying refer ence manual includes conversion tables and other information. Instructor's manual contains lesson tips, test questions, illustrations suitable for use as masters for overhead projector transparencies. $500. Also available through the U.S. Metric Association (see page 1).

Many other metric resources are available. Help speed the conversion process by promoting metric in the organizations to which you belong. Remember: English is the international language of business and metric is the international language of measurement. So let's all pitch in and "go metric."

Facts: Linear Acceleration How long will it take to get up speed? The opposite of linear acceleration is, of course, a reduction in speed. In metric, both are expressed in meters/second/second (m/s^2). Acceleration is easily understood if it is thought of as the rate of change of velocity. When a body is accelerating, it is adding units of velocity each second. The most commonly observed display of linear acceleration is that of a falling object which accelerates due to the force of gravity. The international standard acceleration of gravity (as defined by the 1901 General Conference on Weights and Measures) is 9.806 m/s^2, which in customary units is 32.17 ft/sec^2, so the conversion factor is 3.281.

Problem: A machine part goes from a standstill to 50 ft/sec in 3 seconds. What is its average acceleration expressed in metric units?

Solution: 50 ft/sec x 1/3s x m/3.281 ft = 5.08 m/s^2 By Oscar Fisher; used with the permission of the American Society of Mechanical Engineers.

$9 BILLION

This is the current amount of federal construction in the planing, design, and construction stages.

Metric in Construction is the newsletter of the Construction Metrication Council of the
National Institute of Building Sciences, Washington, D.C. Copies of previous newsletters are available upon request.

THE CONSTRUCTION TRADES

Here are the metric units that will be used by the construction trades. The term "length" includes all linear measurements--length, width, height, thickness, diameter, and circumference.

	Quantity	Unit	Symbol
Surveying	length	kilometer, meter	km, m
	area	square kilometer hectare (10 000 m^2) square meter	km^2 ha m^2
	plane angle	degree (non-metric) minute (non-metric) second (non-metric)	° ' "
Excavating	length	meter, millimeter	m, mm
	volume	cubic meter	m^3
Trucking	distance	kilometer	km
	volume	cubic meter	m^3
	mass	metric ton (1000 kg)	t
Paving	length	meter, millimeter	m, mm
	area	square meter	m^2
Concrete	length	meter, millimeter	m, mm
	area	square meter	m^2
	volume	cubic meter	m^3
	temperature	degree Celsius	°C
	water capacity	liter (1000 cm^3)	L
	mass (weight)	kilogram, gram	kg, g
	cross-sectional area	square millimeter	mm^2

$10+ BILLION IN METRIC

So much federal metric work is under way that estimating the total has become difficult. Virtually all agencies have some metric projects in the design stage or beyond. More and more are moving aggressively as they find that metrication is readily achievable.

- The Army Corps of Engineers expects to have all of its *Guidespecs* converted by this fall and has formed a Senior Executive Service committee to implement metric in all Corps programs. A number of metric pilot projects are under way and many more are in planning.
- All new GSA design work will be in metric after this October. The agency recently completed construction of a metric-based pilot project in Denver. It came in under budget and there were no appreciable metric-related problems in either the design or construction stages.
- The Federal Highway Administration is maintaining its schedule for the metrication of highway construction by October 1996. States are preparing for the change to metric now, and many have pilot projects under way. Annual federal highway outlays are about $16 billion; these funds will stimulate billions more in state and local metric construction dollars.
- Other federal agencies hard at work on conversion include the Air Force, the Navy, NASA, the Smithsonian Institution, and the Departments of Veterans Affairs, Energy, Health and Human Services, Commerce, Interior, and Agriculture.

Virtually all federal construction--about $40 billion annually--will be designed and built in metric by late in this decade. Spurred by federal grant programs, state and municipal construction also may be predominantly metric by that time.

The private sector is doing its share. Codes, standards, trade, and professional organizations are converting their remaining non-metric documents and beginning to prepare their constituents for the change to metric. Product manufacturers are beginning to convert their product literature.

You can help speed the process by promoting metric in the organizations to which you belong. **Remember, English is the international language of business and metric is the international language of measurement.**

	Quantity	Unit	Symbol
Masonry	length	meter, millimeter	m, mm
	area	square meter	m^2
	mortar volume	cubic meter	m^3
Steel	length	meter, millimeter	m, mm
	mass	metric ton (1000 kg) kilogram, gram	t kg, g
Carpentry	length	meter, millimeter	m, mm
Plastering	length	meter, millimeter	m, mm
	area	square meter	m^2
	water capacity	liter (1000 cm^3)	L
Glazing	length	meter, millimeter	m, mm
	area	square meter	m^2
Painting	length	meter, millimeter	m, mm
	area	square meter	m^2
	capacity	liter (1000 cm^3) milliliter (cm^3)	L mL
Roofing	length	meter, millimeter	m, mm
	area	square meter	m^2
	slope	millimeter/meter	mm/m
Plumbing	length	meter, millimeter	m, mm
	mass	kilogram, gram	kg, g
	capacity	liter (1000 cm^3)	L
	pressure	kilopascal	kPa
Drainage	length	meter, millimeter	m, mm
	area	hectare (10 000 m^2) square meter	ha m^2
	volume	cubic meter	m^3
	slope	millimeter/meter	mm/m

	Quantity	Unit	Symbol
HVAC	length	meter, millimeter	m, mm
	volume	cubic meter	m^3
	capacity	liter (1000 cm^3)	L
	airflow	meter/second	m/s
	volume flow	cubic meter/second liter/second	m^3/s L/s
	temperature	degree Celsius	°C
	force	newton, kilonewton	N, kN
	pressure	kilopascal	kPa
	energy, work	kilojoule, megajoule	kJ, MJ
	rate of heat flow	watt, kilowatt	W, kW
Electrical	length	meter, millimeter	m, mm
	frequency	hertz	Hz
	power	watt, kilowatt	W, kW
	energy	megajoule kilowatt hour	MJ kWh
	electric current	ampere	A
	electric potential	volt, kilovolt	V, kV
	resistance	ohm	Ω

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HIGHWAYS

Federal funds help build and maintain almost 1.5 million kilometers (922,000 miles) of our nation's roads and highways--about a quarter of the U.S. total. Combined federal and state construction expenditures for this work are about $20 billion annually with 80 percent paid by the federal government and the balance paid by the states. After 1996, all federally aided and federally funded highway construction will be in metric as indicated in the following Federal Highway Administration (FHWA) timetable:

FEDERAL HIGHWAY METRIC TRANSITION TIMETABLE:

Prepare metric conversion plan - **October 1991**

Initiate revision of laws and regulations that are barriers to metric conversion - **1991**

Complete conversion of FHWA manuals, documents, and publications - **1994**

Complete conversion of FHWA data collection and reporting processes - **1995**

Issue construction contracts in metric units only - **September 30, 1996**

Although many federal agencies have set a goal of converting their construction to metric in January 1994, the 1996 date adopted by the FHWA allows the states, which perform the actual highway work except on federally owned land, sufficient time to prepare for metric conversion. This is particularly important in light of the long lead times that larger highway projects require.

Here, in abridged form, are the answers to commonly asked questions about highway metrication. Taken from a June 1993 FHWA metric fact sheet, the questions and answers illustrate the complexity of the conversion process and FHWA's firm commitment to meeting the 1996 deadline.

Q What is meant by metric plans, specifications, and cost estimates (PS&Es)? Do all measurements have to be in metric or can certain designated numbers remain in inch-pounds or can dual units be used?

A All PS&Es are to be in metric units exclusively after September 30, 1996. While special situations may be considered on a case-by-case basis, it is expected that the states are currently taking necessary actions in their project activities to ensure that projects advertised for construction after this date are being developed in metric. General exceptions will not be granted. Specific exceptions will have to be justified--for example, if circumstances are beyond the state's control due to unforeseen delays in right-of-way acquisition or environmental clearances, an exemption would be considered.

Q Will structural and hydraulic design calculations have to be in metric? These are not transmitted with the PS&E package.

A Eventually, all highway engineering and reference manuals will be in metric, so it seems reasonable to expect that calculations requiring the use of data from tables and equations in these manuals will be also in metric. Working in inch-pounds units and then converting to metric defeats the purpose of

learning the metric system and creates an environment that is prone to confusion and errors.

Q Have any states put out metric PS&Es? If so, can the other states be provided with examples and a description of problems and difficulties that had to be overcome? Does Canada have standard designs, computer software, and other aids we can use?

A The Florida Department of Transportation (DOT) will contract for a large metric project in August. The Kentucky DOT has a metric project 10.5 kilometers (6.5 miles) long to be let in the near future. The Federal Lands Highway Office completed several metric projects in the 1970s. The Puerto Rico Department of Public Works has been doing metric projects exclusively for a long time. Canada has been very helpful in providing information about metrication and we are consulting with a number of their highway officials.

Q Will the FHWA require certain items to be in hard metric units or will this be left up to the states?

A The FHWA expects states to follow metric standards adopted by the American Association of State Highway Transportation Officials (AASHTO), the industry, and the FHWA. To the extent practical, units should be hard converted.

Q Will dimensions have to be shown in metric for rehabilitation projects? How about replacement of inch-pound parts such as bolts?

A When reasonable and practical, all dimensions should be in metric. Showing two different methods of measurement only creates confusion. In the replacement of inch-pound parts such as bolts, common sense should dictate the action.

Q Will the FHWA insist on a hard conversion for all plans authorized for bids after September 30, 1996, including plans previously designed in inch-pound units, or can a state soft convert inch-pound plans on the shelf and those caught in unique circumstances just prior to September 30?

A The FHWA's implementation schedule calls for projects authorized after September 30, 1996, to be in metric units. While the use of rational metric units resulting from hard conversion is desired, it is not mandated. Due to the 5-year lead time provided, the FHWA does not expect states to have a significant number of inch-pound projects still to be let after September 30, 1996. If an exception is not warranted, as previously discussed, soft conversion will be acceptable.

Q What about research reports? Is there a policy on metrication for university-performed research?

A According to instructions issued by the FHWA's Office of Contracts and Procurement, contracts awarded by the FHWA after October 1, 1992, require that all technical reports provide metric units with inch-pound units in parentheses. This is consistent with the FHWA's Metric Conversion Policy, published in the *Federal Register* on June 11, 1992, which requires that, after FY 1992, all new and revised FHWA technical publications be in metric units and that, after FY 1993, the use of dual units should be avoided except in specific cases where such use is deemed beneficial.

Q Has it been determined that metric construction will cost more initially than inch-pound construction?

A No. Based on experience so far there has been no appreciable increase in costs due to metrication. The Services Administration has over $1.5 billion in design and construction contracts and they claim no cost increases due to metrication. Countries that have changed to metric in recent times (e.g., Canada, Australia, Great Britain, and South Africa) also indicate no appreciable increase.

Q Will the FHWA adopt the *Guide to Metric Conversion* published by the American Association of State Highway and Transportation Officials (AASHTO) or will changes be recommended? What is the timetable for acceptance of the *Guide*?

A The FHWA has representation on the AASHTO Metric Task Force and was provided the opportunity to review and comment on the *Guide* during its development process. We are unaware of any items in the guide that the FHWA disagrees with. The *Guide* is designed to help the state highway agencies responsible for implementing their individual conversion plans.

Q What is the length of a survey station in metric, 100 meters or 1 kilometer?

A The metric length of a survey station for highway purposes is 1 kilometer. The Federal Lands Highway Office is using 1 kilometer. The AASHTO *Interim Selected Metric Values for Geometric Design Guide* states that the AASHTO Geometric Design Task Force concurs with the AASHTO Subcommittee on Construction's recommendation of stationing on a 1 kilometer basis.

Q The FHWA Metric Conversion Plan shows that pavement design standards will be hard converted by the end of FY 1995. What does this mean? Does the state highway agency's pavement design program have to provide a metric design thickness? Does project design support documentation for PS&Es authorized after September 30, 1996, have to be in metric?

A The AASHTO *Guide for Design of Pavement Structures* was recently revised but the revision did not include metric units. Currently, there are no specific dates set by AASHTO for a metric version of the *Guide*. After September 30, 1996, however, plans must show pavement thicknesses in metric units.

Q Does the FHWA have a current estimated completion date for modifying or coordinating modification of the following software programs to metric: WSPRO, HEC2, TR-20, and TR-55?

A The WSPRO hydraulics program is being revised by a consultant to include metric and should become available in the summer of 1994. The HEC2 is a Corps of Engineers hydraulics program and already is available in metric. The TR-20 and TR-55 are Soil Conservation Service programs that are not scheduled for conversion at this time.

Q Will state highway agency and metropolitan planning organization air conformity models and analysis methods need to be in metric?

A Air conformity models and analysis methods are being revised to meet new air quality requirements. These programs should be available in both inch-pounds and metric units within a year or so.

Q Will the FAA's regulations governing airway-highway clearance be revised to metric to coincide with the FHWA's metric conversion dates?

A Currently, the FAA is revising their design guides for airport development. The guides include airway-highway clearances. All guides will be in dual units by 1997 and in metric-only units by 1999.

Q The notice of proposed rulemaking for the ISTEA (Intermodal Surface Transportation Efficiency Act of 1991) Management Systems does not have metric references. Are these systems required to be developed in metric?

A Each program office responsible for individual Management Systems has been reminded to issue specific instructions for metric implementation to the field offices as soon as possible.

For more information about the FHWA's metric conversion activities, contact Al Benet at 202-366-4631. To obtain a copy of the AASHTO *Guide to Metric Conversion* ($13.00, including shipping and handling), call AASHTO's publications department at 202-624-5809.

METRIC FACTS: DENSITY

Which is heavier, a pound of feathers or a pound of lead? This childish question probably marked the first encounter with the concept of density for many people. For engineers, the concept is one that is used almost daily.

Density is defined as mass per unit volume. There have been many ways of expressing this concept in different measurement systems over the years. Fortunately, in metric there is only one combinatio of units that should be used and that is kilogram per cubic meter, kg/m^3. For conversion purposes, there are 2.205 pounds per kilogram and 264.2 U.S. liquid gallons per cubic meter.

Problem:

A sample of No. 6 fuel oil has a density of 7.95 lb/gal. Express this in metric units.

Solution:

$7.95\ lb/gal \times kg/2.205\ lb \times 264.2\ gal/m^3 = 952.6\ kg/m^3$

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Volume 2, Issue 5 September-October 1993

PIPE

Pipe is one of the most ubiquitous products in construction. It is made of a wide variety of materials, including galvanized steel, black steel, copper, cast iron, concrete, and various plastics such as ABS, PVC, CPVC, polyethylene, and polybutylene, among others.

But like wood 2-by-4s which are not really 2 inches by 4 inches, pipe is identified by "nominal" or "trade" names that are related only loosely to actual dimensions. For instance, a 2-inch galvanized steel pipe has an inside diameter of about 2-1/8 inches and an outside diameter of about 2-5/8 inches. It is called "2-inch pipe" only for the sake of convenience.

Since few, if any, pipe products have actual dimensions that are in even, round inch-pound numbers, there is no need to convert them to even, round metric numbers. Instead, only their *names* will change--from inch-pound to metric. *Pipe cross sections will not change*. Fittings, flanges, couplings, valves, and other piping components will be renamed in like manner as will pipe threads.

Here are the inch-pound names for pipe products (called NPS or "nominal pipe size") and their metric equivalents (called DN or "diameter nominal"). The metric names conform to International Standards Organization (ISO) usage and apply to all plumbing, natural gas, heating oil, drainage, and miscellaneous piping used in buildings and civil works projects.

NPS	DN	NPS	DN
1/8"	6 mm	8"	200 mm
3/16"	7 mm	10"	250 mm
1/4"	8 mm	12"	300 mm
3/8"	10 mm	14"	350 mm
1/2"	15 mm	16"	400 mm
5/8"	18 mm	18"	450 mm
3/4"	20 mm	20"	500 mm
1"	25 mm	24"	600 mm
1-1/4"	32 mm	28"	700 mm
1-1/2"	40 mm	30"	750 mm
2"	50 mm	32"	800 mm
2-1/2"	65 mm	36"	900 mm
3"	80 mm	40"	1000 mm
3-1/2"	90 mm	44"	1100 mm
4"	100 mm	48"	1200 mm
4-1/2"	115 mm	52"	1300 mm
5"	125 mm	56"	1400 mm
6"	150 mm	60"	1500 mm

(For pipe over 60 inches, use 1 inch equals 25 mm)

The following examples show how inch-pound names for pipe products are converted to metric designations. By changing their names and referring to the appropriate specification, existing pipe products and thread sizes can be specified in metric.
- In a specification, 1-1/2-inch, 2-inch, 4-inch, and 6-inch pipe are shown as DN40, DN50, DN100 and DN150 pipe.

Comment: The specification will further elaborate, for example, that "Pipe sizes DN50 or less are to be black steel per ASTM A135, Schedule 40, and threaded per ASME B1.20.1. Pipe sizes greater than DN50 are to be black steel per ASTM A135, Schedule 10, and roll grooved." By specifying the appropriate manufacturing standard, the pipe's actual inside diameter (ID), outside diameter (OD), and material are assured.

- An installation standard calling for all pipe threads to be per ASME B1.20.1 remains unchanged.

Comment: The NPT (National Standard Pipe Taper) pipe thread form is the same but its name is converted; for example, 1/2-inch NPT becomes DN15 NPT.

- An installation standard calling for the use of a minimum 2-inch drain valve is revised to indicate the use of a minimum DN50 drain valve.

Comment: Since the 2-inch size is actually a nominal pipe size (NPS), it is converted to a nominal metric size (DN) as opposed to using the conversion of 1 inch equals 25.4 mm.

- A 2-inch Class 150 malleable iron 90° elbow per ASME B16.3 is designated as a DN50 Class 150 malleable iron 90° elbow per ASME B16.3.

Comment: Pipe fittings manufactured to ASME B16.3 are threaded with ASME B1.20.1 pipe threads. Therefore, a DN50 90° elbow will have DN50 NPT pipe threads. The term "Class 150", which refers to a pressure rating, remains unchanged (since the term does not designate an inch-pound increment from which it was derived, it can be used with metric nomenclature).

- A 6-inch × 6-inch × 4-inch, Class 125, Grade A, reducing tee per ASME B16.1 is designated a DN150 × DN150 × DN100, Class 125, Grade A, reducing tee per ASME B16.1.

Comment: All product dimensions covered by ASME B16.1 remain unchanged.

- A 1/2-14 NPT thread per ASME B1.20.1 is designated DN15-14 NPT per ASME B1.20.1.

Comment: In the above designation, "14" refers to 14 threads per inch. Since the term does not designate an inch-pound increment from which it was derived, it can be used with metric nomenclature. It is interesting to note that IS0 7, which is a recognized international pipe thread standard, refers to the number of threads per 25.4 mm, or 1 inch.

The material for this article was developed by the Mechanical Task Group of the Construction Metrication Council, National Institute of Building Sciences. Examples were provided by Roger Wilkins of Grinnell Corporation.

CONCRETE MASONRY BLOCK

In the transition to metric, most construction products (like pipe) will not change size--they simply will be relabeled in metric units. Only products that must fit together in a modular grid are logical candidates for "hard" metric conversion--that is, an actual dimensional change. Such products include drywall, plywood and other wood-based panels, suspended ceiling components, raised flooring, tile, brick, and block.

The manufacturers of most of these products can readily supply hard metric sizes, but the concrete masonry block industry has said it will have difficulty. This industry is composed primarily of small producers with a marketing radius of from 60 to 300 km. Hard metric conversion would require that they buy new mold boxes, which cost in the range of from $10,000 to $20,000 apiece--a large capital investment for small firms that have been hit by the economic downturn.

In response to these problems, the General Services Administration (GSA) has modified its *Metric Design Guide* (July 1993) to permit the use of either conventional inch-pound block or metric block. The *Guide* states:

> Masonry walls have a critical wall thickness for fire resistance and compressive strength. Beyond this, it is not important what dimension the height and width of a masonry unit is except for appearance, the ability to accommodate metric window and door openings, having even coursing for ties and round dimensions between openings for ease of builder measurement, and the weight of the unit for lifting. Project requirements should be limited to these factors with total competitive pricing determining the dimensioning.

Metric modular block is 190 by 190 by 390 mm. This equates to 7-1/2 by 7-1/2 by 15-3/8 inches. Conventional [inch-pound] modular block is 194 by 194 by 397 mm, quite similar to metric block.

While the Construction Metrication Council advocates a timely and complete change to metric, its policy calls for each industry to convert to hard metric when it is economically feasible to do so. Because of the cost of hard conversion in the block industry, the Council endorses GSA's policy of

permitting the use of either inch-pound or metric concrete masonry block, as project requirements dictate.

METRIC PUBLICATIONS

The following metric publications are available from the Publications Department, National Institute of Building Sciences (NIBS), 1201 L St., N.W., Suite 400, Washington DC 20005; phone 202-289-7800. Major credit cards and phone orders are accepted and prices include shipping and handling.

GSA Metric Design Guide (July 1993). Developed for federal project managers and their architect/engineer contractors, the GSA guide contains practical architectural, civil, structural, mechanical, and electrical design information; a list of available "hard" metric product manufacturers; and related reference information. $8.00 ($5.00 if ordered with the *Metric Guide for Federal Construction* described below).

Metric Guide for Federal Construction. Written specifically for the construction industry and reviewed by metric experts throughout the country, the *Metric Guide* includes a background on federal metric laws; facts about metric in construction; an introduction to metric units; a primer on metric usage for architects, engineers, and the trades; requirements for metric drawings and specifications; guidance on metric management and training; and a listing of current metric construction references. $15.00.

Both guides are available in electronic form on the NIBS **Construction Criteria Base** (CCB), a large database of construction criteria and standards on optical disk. For more information about the CCB, call or write NIBS.

Metric (SI) in Everyday Science and Engineering. A clear, authoritative, and easy-to-read text on the use of the metric system written by one of the foremost metric trainers in the United States, Stan Jakuba. This book should be owned by everyone with a serious interest in metric. Call the NIBS Publications Department for more information.

The bimonthly metric newsletter, ***Metric in Construction***, is available from NIBS at no charge. Write or fax (***do not call***) NIBS (the fax number is 202-289-1092). Include only the words "Metric newsletter" and your ***most concise*** mailing address. Please, one subscription per office. Phone orders will not be accepted.

METRIC FACTS: FORCE

How much force will it take to get up to speed? What force will be exerted on the foundation? The metric answers to these questions are expressed in ***newtons*** (N). The newton is defined as the force that when applied to a free mass of 1 kilogram (kg) will impart an acceleration of 1 meter per second per second (kg m/s^2). One of the many advantages of metric is that it uses a different unit for mass (kg) than it uses for force (N), thus reducing the mass-force-weight confusion.

The customary unit for force is the poundal and the conversion is 7.233 poundals per newton. On the earth at sea level, a mass of one kilogram will produce a force on its support of 9.806 newtons.

Problem:
A crane on the earth at sea level lifts a mass of 500 kilograms. What force in newtons is imposed on the crane?

Solution:
500 kg × (9.806 N/kg) = 4903 N

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METRICATION ACTIVITIES IN U.S. CODES, STANDARDS, PROFESSIONAL, AND TRADE ORGANIZATIONS

The Construction Metrication Council recently asked a broad sample of U.S. codes, standards, professional, and trade organizations--including all of the major ones--to report on their current metrication activities.

Here is a summary of their reports. The term "hard metric" denotes the conversion of inch-pound units to new, rounded, easy-to-use metric measurements. "Soft metric" denotes the mathematical conversion of inch-pound units to metric measurements with little or no rounding. References to "SI" denote "Standard International," the formal term for what the Council simply refers to as "metric."

American Association of State Highway Transportation Officials (AASHTO). In June, AASHTO published the *Guide to Metric Conversion* for use by states in meeting the Federal Highway Administration's (FHWA) mandate that all federally aided highway projects after October 1996 be built in metric. An AASHTO metric task force, with funds provided by the federal Transportation Research Board, is establishing a metric information clearinghouse and an electronic bulletin board to help the states set uniform metric procedures and standards. Recently, AASHTO requested additional funds from the Transportation Research Board for converting its technical standards and computer software to metric.

- **Air-Conditioning and Refrigeration Institute (ARI).** ARI's metric policy states that each ARI section is to adopt an international standard within one year of publication or explain why such a standard cannot be adopted. To assist in this process, ARI has issued a new guidance document, *Use of SI Units in ARI Standards*.

- **American Consulting Engineers Council (ACEC).** At ACEC's Fall Conference, a new metric policy was proposed that includes the development of an active program for encouraging members to prepare for metrication and empowering staff to support member metrication needs. The conference included a special session on metrication. ACEC has printed numerous articles about metrication in its publications, sells the NIBS *Metric Guide to Federal Construction*, and promotes the *Metric in Construction* newsletter to its members.

- **American Concrete Institute (ACI).** ACI has supported the voluntary conversion to metric since 1987. Two of its principal publications, *Building Code Requirements for Reinforced Concrete* and *Building Code Requirements for Plain Concrete*, are available in metric editions. ACI is considering a timetable for converting its remaining documents to hard metric as early as 1998.

- **American Concrete Pipe Association (ACPA).** The concrete pipe industry has been involved in metrication since the early 1970s. To date, 22 American Society for Testing and Materials (ASTM) standards on concrete pipe have been issued in metric units. ACPA is revising its design manuals, handbooks, software, and marketing materials to include metric by 1996. Meanwhile, it is encouraging concrete pipe manufacturers to develop new design drawings, revise promotional materials, modify purchasing, update records, and train plant personnel to mark products in metric units.

- **American Congress on Surveying and Mapping (ACSM).** ACSM first published the *Metric Practice Guide for Surveying and Mapping* in 1978. To date, about 20 states have adopted legislation to permit the use of the metric system as the basis for their state plane coordinate systems. The recent FHWA mandate to produce surveys and maps for highway design and construction in the metric system has heightened interest in metric. The September-October 1993 *ACSM Bulletin* carried two articles about metric conversion.

- **American Forest and Paper Association (AFPA).** AFPA is about to issue a new edition of the *Metric Planning Package for the Wood Products Industry*. First published in the 1970s, it includes industry recommendations for metric conversion. The 1996 edition of the *National Design Specification for Wood Construction* will include metric units as will the *LRFD for Engineered Wood Construction.* Metric units will be added to other AFPA publications as appropriate.

- **American Institute of Architects (AIA).** AIA's policy supporting metric goes back to the 1940s. It is now printing an *AIA Pocket Metric Guide* to promote metrication in the architectural field. A metric version of *MASTERSPEC* is virtually complete and will be available by the end of the year. Metric units are being added incrementally to *Architectural Graphic Standards* and a complete metric edition is being considered for the tenth edition, which could be published as early as 1996.

- **American Institute for Hollow Structural Sections (AIHSS).** AIHSS recently completed two metric guides for use by its members: *Summary of Presentation Factors and Procedures for Determining Properties of Square and Rectangular HHS/Structural Steel Tubing from U.S. Customary Units to Metric Units* and *Recommendations for Soft Conversion of Dimensions of Square, Rectangular, and Round HSS/Structural Steel Tubing from U.S. Customary Units to Metric Units*. Both documents apply to structural steel components specified in ASTM A500.

- **American Institute of Steel Construction (AISC).** AISC recently published the *Metric Properties of Structural Shapes with Dimensions According to ASTM A6M*, first issued last year in draft form. A complete metric edition of the *LRFD Manual of Steel Construction* will be available in late 1994.

AISC is working with the Industrial Fasteners Institute to develop a policy on the metrication of structural steel bolts.

- **American Iron and Steel Institute (AISI).** AISI members who ship mill products to the construction market support the activities of the Construction Metrication Council. Basic steel mill products are available today in metric sizes and voluntary consensus standards for these products are available through ASTM and other organizations. AISI is working closely with allied trade organizations to help implement metric and is developing metric engineering aids for steel bridge design as well as adding metric units to its design manual for coldformed steel structures.

- **American Public Works Association (APWA).** APWA has adopted a policy in support of metric conversion that reflects a growing interest in metric among its members. A session on metrication was held at the Public Works Congress and Exposition in San Francisco last spring and was well received. APWA has

included two major articles on metric in its monthly magazine and presently is drafting *A Public Works Guide to Metrication* that provides a background on the metric system, reasons for converting, metric conventions, and guidelines for a smooth transition.

- **American National Standards Institute (ANSI).** In October, ANSI adopted a policy stating that units of the modernized metric system (SI) are the preferred units of measurement in American National Standards. To facilitate implementation of this policy, ANSI has formed a Task Group on Metrication to encourage and assist ANSI member organizations in converting their standards. The task group first met in September and is open to interested parties.

- **American Society of Civil Engineers (ASCE).** ASCE has supported use of the metric system since 1876. Its most recent metric policy, adopted in 1991, states that ASCE will actively support the metrication of civil engineering practice and research, implement the use of metric units in all ASCE publications, and encourage civil engineering schools to stress the use of metric in instruction. Since January 1993, ASCE has mandated that metric be included as the primary unit in all new and revised standards with no other units being required. ASCE regularly includes metric articles in its periodicals, provides metric literature at its conferences, and has a Committee on Metrication with over 90 members.

- **American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE).** ASHRAE's four handbooks are available in both inch-pound and metric editions. Its 80-plus standards contain metric units as do the proceedings of its semiannual meetings and conferences. Goal 15 of ASHRAE's strategic plan states that ASHRAE will implement a policy on and promote utilization of metric units by the HVAC&R and allied industries. Objective 15.1 is to develop and implement a plan that will promote and assist the HVAC&R and allied industries in implementing the use of metric units by the year 2000 and Objective 15.2 is to develop and implement a plan to use only metric units in ASHRAE publications by the year 2000.

- **American Society of Mechanical Engineers (ASME).** ASME supports a national program of metric conversion. All ASME standards contain metric units except the *Boiler and Pressure Vessel Code*, which is being converted now. ASME has set a target date of 1998 for the publication of its codes and standards only in metric. ASME provides staff support to the Mechanical Task Group of the Construction Metrication Council.

- **American Society for Testing and Materials (ASTM).** ASTM requires the use of metric in all its standards. Currently, 38 technical committees are developing standards in hard metric and another 7 are in the process of converting to hard metric. In total, approximately 1600 ASTM standards use only metric units, 3500 use metric as the primary unit, and the remaining 3000 use metric as the secondary unit. Recently, ASTM and the Institute of Electrical and Electronics Engineers (IEEE) have begun negotiations to merge their two metric standards, ASTM E380-93, *Standard Practice for the Use of International Units*, and ANSI/IEEE 268, *American National Standard Metric Practice*.

- **American Water Works Association (AWWA).** AWWA has undertaken a program to convert its publications and other documents to metric by January 1997. Metric units have been added to many of AWWA's 120 water supply product and

procedural standards, whose increasing usage on an international basis makes metrication a timely issue.

- **Architectural Precast Association (APA).** APA supports the Precast/Prestressed Concrete Institute's recommendations on metric conversion. APA members, who make nonstructural architectural precast cladding, view metrication favorably and generally foresee no problems in producing in metric.

- **Associated Builders and Contractors (ABC).** ABC is using its national publications and training programs to inform and educate members about metric. During the past year, all ABC's publications--*Monthly Regulatory Update, ABC Today*, and *Heavy/Highway Report*--have carried articles on metric. ABC's craft training manuals for electricians, millwrights, pipefitters, welders, carpenters, plumbers, sheet metal workers, metal building assemblers, and instrumentation control mechanics incorporate metric in their core curricula.

- **Associated General Contractors of America (AGC).** AGC formed a metric task force in 1992. Many AGC members are large contractors who have experience in metric and foresee no problems in using it. AGC regularly provides copies of the *Metric in Construction* newsletter to two of its large committees and several AGC chapters. Two sessions on metric were held at AGC's annual conference in Las Vegas last spring.

- **Brick Institute of America (BIA).** BIA has adopted a metric policy stating that it: (1) supports conversion to metric units of measure as an inevitable action; (2) will continue to provide information in both metric and inch-pound units, as it has since 1978; (3) encourages all brick manufacturers and distributors to publish their product literature and other design data in equivalent metric versions or with both inch-pound and metric units; (4) will work with brick manufacturers to promote the use and manufacture of modular metric sizes through its technical, marketing, and informational publications; (5) will continue to work with the federal government and within the codes and standards organizations to provide masonry codes, standards, and specification in correct metric units; and (6) encourages the training of bricklayers in vocational programs in the use of the metric system as it relates to brick masonry. In addition, BIA anticipates the publication of a new *Technical Notes* on modular metric brick.

- **Concrete Reinforcing Steel Institute (CRSI).** CRSI has undertaken several metric initiatives during the past year. It presented 20 seminars in key cities across the United States on the metrication of reinforced concrete design and construction. Four more seminars are planned for the first half of 1994. CRSI has initiated the development of several metric design and detailing aids including printed metric bar cards and a computer program, DEVLAPM, for determining development and lap splice lengths for metric reinforcing bars. Metric versions of a wall bar chart will be completed by the end of this year and a metric version of the CRSI *Manual of Standard Practice* is being prepared. CRSI will begin converting its other technical publications and design aids in 1994. Lately, CRSI staff has been responding to a significant number of inquiries about metric.

- **Construction Specifications Institute (CSI).** In February 1992, CSI instituted a policy of adding metric units to its new and revised documents

and publications, although *SPECTEXT*, the Master guide specification owned by the Construction Science Research Foundation (CSRF), has always contained metric units. Last year, metric units were added to CSI's *Manual of Practice* and they are now being added to CSI's *SpecGUIDEs*. CSI is encouraging manufacturers to convert their *SPEC-DATA* and *MANU-SPEC* product data sheets to metric. CSI's magazine, *Construction Specifier*, began using metric as the primary unit in June 1992 and features a monthly column on metrication. CSI's monthly newsletter, *NEWSDigest*, regularly features metric updates.

- **Council of American Building Officials (CABO).** CABO is made up of the three model code organizations--BOCA, SBCCI, and ICBO. The BOCA *National Codes* have included metric units since 1975. SBCCI added metric units to its *Standard Building Code* in 1991 and will add them to the balance of its codes 1994. ICBO will add metric units to its *Uniform Codes* in 1994. Metric will be added to the *CABO One- and Two-Family Dwelling Code* in 1995. CABO is secretariat to the ANSI A117.1 accessibility code, which has contained metric units since its inception. All three model code organizations support the Construction Metrication Council and have published articles about metrication in their magazines.

- **Gypsum Association.** The Gypsum Association has no policy on metrication but notes that many of its member manufacturers can provide hard metric gypsum products now.

- **Hardwood Plywood and Veneer Association (HPVA).** Last year, HPVA revised its *Interim Voluntary Standard for Hardwood and Decorative Plywood* to include metric units. Now it is adding metric to its other two standards, ANSI/HPMA LHF, *American National Standard for Laminated Hardwood Flooring*, and DFV-1 *Voluntary Standard for Sliced Decorative Wood Face Veneer*.

- **Institute of the Ironworking Industry (III).** III reports that the International Association of Bridge Structural and Ornamental Iron Workers recently published a 100-page apprentice and journeyman student guide titled *Metrics for Ironworkers*.

- **Instrument Society of America (ISA).** ISA produces instrument and control systems standards for the HVAC and industrial process industries in the United States and abroad. ISA supports federal metrication efforts and believes that the country's adoption of metric will increase its global competitiveness. All new and recently revised ISA standards express measurements in metric units.

- **International Association of Plumbing and Mechanical Officials (IAPMO).** IAPMO is incorporating metric units in its standards and other publications and is adding metric to the 1994 edition of its plumbing code, published by ICBO as the *Uniform Plumbing Code*.

- **International Concrete Repair Institute (ICRI).** ICRI regularly informs its members about the progress of construction metrication through its *Concrete Repair Bulletin* and uses metric units in its publications.

- **Kitchen Cabinet Manufacturers Association (KCMA).** KCMA supports metric conversion and encourages its members to add metric to their product

literature. Its cabinet standard, ANSI/KCMA A161.1, *Recommended Performance & Construction Standards for Kitchen and Vanity Cabinets*, includes metric units.

- **Mechanical Contractors Association of America (MCAA).** MCAA publishes information about metric conversion in its newsletter and participates in the Mechanical Task Group of the Construction Metrication Council.

- **National Association of Architectural Metal Manufacturers (NAAMM).** NAAMM is adding metric units to its standards and does not foresee any significant problems in the conversion of architectural metal products to metric.

- **National Fire Protection Association (NFPA).** NFPA codes and standards have included metric units since the 1970s. Converting measurements to hard metric will require the submittal of proposals through the standards-making process.

- **National Glass Association (NGA).** The glass industry is international and most NGA members work in metric now. Since the making of float glass is computer controlled, it can be produced in any size and thickness. NGA's *Glass Magazine* published one of the first construction industry articles on metric in February 1992.

- **National Particleboard Association (NPA).** NPA recently issued a revised version of its standard, ANSI A208.1-1993, *Particleboard*, in hard metric. During the conversion process, the number of particleboard grades was reduced from 19 to 12.

- **National Roofing Contractors Association (NRCA).** NRCA has approved a policy to support metric conversion in the roofing industry and to implement the use of metric units in all NRCA publications, manuals, programs, research, and instructional materials. NRCA's metric committee has made the following recommendations: get news of federal metrication activities into the hands of members, emphasize that metric conversion will not be as difficult as it may seem, and implement metric educational programs. The committee also is exploring the kinds of metric tools and devices it should recommend to its members.

- **National Society of Professional Engineers (NSPE).** NSPE has supported metric conversion since the 1970s. After passage of the 1988 amendments to the *Metric Usage Act*, NSPE extended its support to federal metrication efforts and instituted a program to increase metric awareness among its members. NSPE routinely answers queries about metric received through its state chapter computer network.

- **National Stone Association (NSA).** NSA has an active information program to help its members prepare for metric conversion. After discussing metrication in several forums, NSA has concluded that there will be no significant impact on the stone industry. Stone products are typically specified by gradations determined through sieve analysis. Testing sieves are in metric sizes now with nominal inch-pound names provided for current use; therefore, the gradation of products will not change, just the units in the specification. The industry's equipment suppliers are for the most part international and their equipment is predominantly metric. The only remaining task is the conversion of computer software used by quarry operators for weighing and invoicing trucks so their weights can be recorded in kilograms and metric tons.

- **North American Insulation Manufacturers Association (NAIMA).** NAIMA regularly sends its member companies information on federal metrication activities. Many NAIMA members have international operations and make metric products now.

- **Portland Cement Association (PCA).** PCA's metric policy states that all publications, videotapes, slide sets, and computer programs will be developed to include metric units. Metric has been added to most of PCA's recently updated publications and its concrete design computer programs have metric capability now.

- **Precast/Prestressed Concrete Institute (PCI).** PCI supports the FHWA's metric conversion policy as it applies to precast/prestressed concrete bridge products. PCI advocates an initial soft conversion by rounding all dimensions to the nearest 5 mm, followed over time by a hard conversion. All new PCI publications include metric units and a metric edition of PCI's *Design Handbook* is being considered for publication in 1996.

Metric in Construction is the newsletter of the Construction Metrication Council of the National Institute of Building Sciences, Washington, D.C. Copies of previous newsletters are available upon request.

METRIC FACTS: MASS

For everyday purposes, *mass* means *weight*, but there is a difference. Weight is a relative term, dependent on the force of gravity (that is, weight is really a measure of force) and mass is an absolute term. Thus, on the moon you would only weigh about a sixth of what you do on earth, but in both places you would have exactly the same mass.

Is the difference between mass and weight important in construction? No, except in some aspects of engineering. Still, the proper metric term is ***mass*** and the metric unit for expressing mass is the ***kilogram***.

There are 2.205 pounds in a kilogram. The metric ton (t) is 1000 kilograms.

Problem: What is the mass in kilograms of a 27 pound casting?

Solution: 27 lb × 1 kg/2.205 lb = 12.24 kg

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Metric in Construction is a bimonthly newsletter published by the Construction Metrication Council to inform the building community about metrication in U.S. construction. The Construction Metrication Council was created by the National Institute of Building Sciences to provide industry-wide, public and private sector support for the metrication of federal construction and to promote the adoption and use of the metric system of measurement as a means of increasing the international competitiveness, productivity, and quality of the U.S. construction industry.

The National Institute of Building Sciences is a nonprofit, nongovernmental organization authorized by Congress to serve as an authoritative source on issues of building science and technology.

The Council is an outgrowth of the Construction Subcommittee of the Metrication Operating Committee of the federal Interagency Council on Metric Policy. The Construction Subcommittee was formed in 1988 to further the objectives of the 1975 *Metric Conversion Act*, as amended by the 1988 *Omnibus Trade and Competitiveness Act*. To foster effective private sector participation, the activities of the subcommittee were transferred to the Council in April 1992.

Membership in the Council is open to all public and private organizations and individuals with a substantial interest in and commitment to the Council's purposes. The Council meets monthly in Washington, D.C.; publishes the *Metric Guide for Federal Construction* and this bimonthly newsletter; and coordinates a variety of industry metrication task groups. For membership information, call the Council at the above phone number.

The Council is grateful to the following private contributors: The Kling-Lindquist Partnership; Smith, Hinchman, and Grylls Associates; and Raytheon Engineers and Constructors.

JANUARY 1994

Almost two years ago, federal agency construction representatives met and voted to set a goal of designing all new projects in metric by January 1994. The reports herein--presented at the November 1993 meeting of the Construction Metrication Council--show that most agencies have met that goal, some even have exceeded it, and the remainder are not far behind.

Federal construction represents a big chunk of the nation's construction industry. Federal appropriations for construction, including grants and aid to states, now total over $50 billion. To date, about $20 billion in federal metric work is being readied for design award or is in the design or construction stage. By 1996, this figure will approach the $50 billion federal total, not including billions more in state and local matching funds.

Such large expenditures will expose a significant portion of the U.S. construction industry to metric. No one will want to work with two different systems of measurement for very long, so chances are that U.S. construction will convert predominantly to metric within the next five to ten years.

Metrication will bring more than efficiency and better quality control to construction: *it will benefit every American by helping our nation compete more effectively in the global marketplace*.

Here are the federal agency reports:

- **General Services Administration**. The General Services Administration (GSA) officially will begin all new design work in metric as of January 1994; however, many metric projects already are under way. Projects in the design stage include three new U.S. courthouses in St. Louis, Missouri, Tampa, Florida, and Kansas, border stations in Vermont and Texas, a Census Bureau computer center in Maryland, and a FBI regional office building in Washington, D.C.

Currently out for bid is a Department of Veterans Affairs data center building in Philadelphia, Pennsylvania. Projects under construction include the renovation of a federal office building in Richmond, Virginia, the renovation of the GSA Appraiser's Store in Baltimore, Maryland, and a border station in New York. Completed projects include a GSA warehouse in Denver, Colorado, a border station in Arizona, and a mechanical plant addition in Washington, D.C. The total value of these and a number of smaller projects is over $600 million.

To date, there have been no significant problems associated with the use of metric. A side benefit of conversion is that it has caused GSA to re-examine the premises behind many of its technical documents and to clarify and strengthen them.

GSA's metric construction experience indicates that the thoughtful use of rounded dimensions on construction drawings significantly helps field personnel in their work and gives them a positive attitude toward metric. Wherever possible rounded metric dimensions should be used.

- **General Services Administration, Philadelphia Region**. GSA's Philadelphia Region is building all new projects in metric. The 44 000 m^2, $70 million

Department of Veterans Affairs Data Center in Philadelphia, Pennsylvania, has gone to bid and will be built as an all-metric job. The $15 million Richmond, Virginia, project, a gut rehab of a 10-story federal office building, was awarded about 20 percent under budget (in line with current non-metric GSA projects). It is an all-metric job and is proceeding smoothly at about 20 percent completion.

The Philadelphia Region's *M2: Metric Design Guide, Third Edition*, was released in October and may be obtained by calling 215-656-5822. It contains many new manufacturer listings for metric products and specifies minimum order quantities. The region also has contacted approximately 100 contractors with annual billings of over $50 million to inquire about their ability to bid on metric jobs. Most have responded positively, convincing the region that GSA can get a minimum of 10 competitive bids on a metric project anywhere in the country. Based on this finding and bidding experience to date, the region believes that large projects can be designed and built in metric with no cost premium if a common sense approach to metric is taken as advocated in its *Guide*.

The region has informal contacts with a large number of non-federally funded organizations that are converting to metric such as the Port Authority of New York and New Jersey, various state and local governments, and several corporations. It also has news about a number of non-federal metric efforts that are in the planning or design stage now.

- **GSA National Capitol Region**. GSA's National Capitol Region is designing all major new Washington area projects in metric. The office of Skidmore, Owings, and Merrill recently completed metric design documents that are about to be released for bid for a $57 million FBI Regional Office building. Metric projects in the planning and design stages include a Census Bureau computer center ($28 million), the Southeast Federal Center complex (a $148 million GSA office building, a $95 million Corps of Engineers building, and $88 million in infrastructure work), the renovation of the Department of Interior building ($106 million), and a complex for the Food and Drug Administration (between $200 and 850 million). In addition, all new mechanical condition surveys and prospectus development studies are being prepared in metric.

- **Army Corps of Engineers**. Last year, the Corps of Engineers selected 14 metric pilot projects with a total value of $124 million. Two are in construction, one is pending construction award, five are in the concept design or definition stage, and six have been delayed for budgetary reasons. Overseas metric work totaled about $600 million for 1993 and is expected to reach $1 billion in 1994. All new Corps facilities will be designed in metric after January 1994 to the extent economically and technically feasible. One Corps division and two districts are considering going "all metric" at this time.

A metric edition of the Corps' *Guide Specifications* was completed in October and all new and revised publications, criteria, manuals, and standard designs are being published in metric. The Corps is developing two metric training courses, each consisting of video tapes and training books for use at the field level. The first course focuses on providing a basic understanding of metric and the second, on the specifics of metric design and construction.

Corps representatives recently met with a number of large contractors from the Associated General Contractors of America who said that if the Corps is converting to metric, they would prefer that it do so immediately without a

transition period where both inch-pound and metric projects would co-exist and cause confusion.

- **Naval Facilities Engineering Command.** The goal of the Naval Facilities Engineering Command is to implement metric fully as a way of doing business. A metric version of its *Guide Specifications* is nearing completion. Beginning in 1994, metric will be added to all planning and design criteria updates. Computer systems and databases also are being converted to metric.

The Navy builds all its overseas projects in metric and currently is preparing a domestic construction metrication plan. Meanwhile, one field division is moving ahead with several metric pilot projects.

- **Air Force.** The Air Force has 12 metric military construction projects in progress that range in cost from $1.2 to $14.2 million. Eleven are in design and one is in construction. It also has a number of metric operations and maintenance projects, several of which are complete. There have been no significant problems associated with the use of metric to date.

- **Office of the Secretary of Defense.** The Corps of Engineers is using metric in the design of the first phase of the multiyear, $1.2-billion Pentagon renovation program. All other Pentagon construction and repair projects are being designed and built in metric. Several have been completed to date, all very successfully.

- **Department of State.** The Department of State's overseas construction work has always been metric. In July 1992, its Foreign Buildings Operations established a metric-only policy for construction documents. Good progress toward that goal was reported at a November 1993 meeting to review metric implementation problems and achievements.

- **Department of Agriculture.** Department of Agriculture policy states that beginning in fiscal year 1994, new projects shall be designed in metric. Drawings and specifications are to be metric-only and cost estimates are to be completed in both inch-pounds and metric. Metric products will be used whenever practical and metric modules will be used for determining bay sizing and floor-to-floor heights.

- **U.S. Forest Service.** The Minerals and Geology Group is converting to metric in fiscal year 1994 and will be metric-only in fiscal year 1995. The Engineering Group plans to be metric-only by fiscal year 1997. All engineering publications have included metric units for several years. A metrication task group monitors and encourages metric conversion service-wide.

- **Federal Highway Administration (FHWA).** All federal and federally-aided highway construction--as much as $25 billion annually--will be built in metric after September 30, 1996. Since most highway work is performed by the states, state highway agencies are preparing for the transition now. Currently, the majority of states are surveying in metric, many are designing in metric, and several have metric projects under construction.

The highway construction industry appears ready to begin building in metric but there are still some concerns in the utility and railroad industries, which at times become involved in road widenings and other right-of-way work.

Interim FHWA metric deadlines are 1994 for the conversion of manuals, documents, and publications and 1995 for the conversion of data collection and

reporting processes. Only metric units are being used in internal correspondence and research reports, and to the extent possible in external correspondence.

In May 1993, the American Association of State Highway Transportation Officials (AASHTO) published the *Guide to Metric Conversion*, a document designed to help the states convert their highway programs to metric. AASHTO is converting the balance of its standards and software programs to metric now and is working with the Transportation Research Board and Texas A&M to establish a metric information clearinghouse.

No decision has been made yet about highway signage. This is not a construction issue and is being treated as a separate concern.

The National Highway Institute (NHI) has developed a one-day metric training course, Metric (SI) Training for Highway Agencies, for use by state and local highway departments. The morning session focuses on units and rules of application and the afternoon session is devoted to solving typical metric design problems.

The North Carolina Department of Transportation is hosting the AASHTO-FHWA National Metric Conference in Raleigh, North Carolina, from January 31 through February 3.

- **National Aeronautics and Space Administration.** In 1993, NASA designed 11 projects, ranging in value from $1 to $4 million, in metric. Three have been awarded, all under budget, and the other eight are out for bid. No significant problems have been encountered to date. Based on the positive experience of these projects, 31 fiscal year 1995 projects with an aggregate value of $45 million are being readied for or are now in design. If they go well, NASA will design its fiscal year 1996 and later projects in metric.

Working with the Army and Navy, NASA has nearly completed the metrication of its SPECSINTACT construction documents system.

- **Department of Labor.** In 1993, the Department of Labor's Employment and Training Administration formed a steering group to monitor metrication progress and completed a metric facility survey and utilization study. Two metric pilot projects are being considered for fiscal year 1994. If they are successful, all subsequent projects will be built in metric.

- **Department of Energy (DOE).** DOE is conducting a $400-million study at Yucca Mountain, Nevada, to evaluate the site's potential as a high level waste repository. The study is being performed in metric and involves boring a tunnel 18 km long and 7.3 m in diameter. Other DOE metric projects include a monitored retrievable storage facility for spent commercial reactor fuel ($1 billion) and a multipurpose storage canister system (estimated at $5 billion).

DOE's power marketing administrations are identifying projects for metrication and should be able to meet the January 1994 goal of designing all new work in metric. Currently, the Bonneville Power Administration is constructing two $22-million substations in metric. The decision to use metric was made after the design-build contracts for the two projects were awarded; nevertheless, there has been no cost penalty associated with metric. Bonneville also is designing a control center in metric and the contract will be awarded in February.

Most of DOE's national laboratories are implementing metric construction plans. The $25-million, 3800-m² laboratory for the Human Geome Project at Lawrence Livermore Laboratory will be built in metric.

DOE's metric executive recently issued a memorandum to all programs and operations offices reminding them that projects initiated after January 1, 1994, are to be designed in metric.

- **National Institute of Standards and Technology (NIST).** Over $500 million in new and renovated laboratory facilities at NIST's Gaithersburg, Maryland, and Boulder, Colorado, campuses are being designed in metric in a phased, multiyear program. Meanwhile, a $1-million hazardous material handling facility is being built in metric as a pilot project. NIST's internal design and construction group expects to be fully converted to metric in 1995.

- **Central Intelligence Agency (CIA).** The CIA began using metric in its construction activities in 1992, first as the secondary unit and, beginning in 1993, as the primary unit. Inch-pounds units will be dropped in the near future and all CIA design and construction documents will specify products and materials only in metric. Design contractors had no difficulty using metric and construction contractors adjusted to it once metric became the primary unit.

- **Department of the Interior.** The Bureau of Reclamation will begin collecting data and designing all projects in metric in January 1994. In 1993, it completed 26 metric specifications. A $300-million desalting plant for the Colorado River at the United States-Mexico border, under construction in phases since 1978, has been built primarily in metric.

The Bureau of Land Management will begin designing all new projects in metric in January 1994. In the past year, it designed three metric projects: the La Ventana Arch Project in New Mexico, the Las Vegas Federal Interagency Resource Complex in Nevada, and the San Pedro National Conservation Area Visitor Center in Arizona.

The Fish and Wildlife Service continues to use dual units in its drawings and specifications because so many of its projects are small and located in remote areas.

The National Park Service is developing a metric implementation plan for its Denver Service Center that includes the procurement of metric design aids, the conversion of existing guidelines and guide specifications, and a program for metric training. At least four metric projects are being considered for fiscal year 1994 although funding is uncertain: Independence National Historical Park (a 10-year, $110 million project), the Depew and Raymondsill projects in the Delaware Water Gap National Recreation Area (about $750,000), the McCreery project at New River Gorge National River, and a project for the Ozark National Scenic Riverway.

- **Bureau of Indian Affairs (BIA).** BIA is building two road construction projects in metric in the Phoenix area. Its metric transition planning is complete and all future projects will be built in metric.

- **Indian Health Service (IHS).** IHS envisions full use of the metric system in early 1994. Metric projects now in design include the Quarters Units at Belcourt, North Dakota; a youth regional treatment center at

Portland-Spokane, Washington; and a health center at White Earth, Minnesota. Future metric projects include, among others, a hospital at Fort Defiance, Arizona; a health center at Fort Belknap, Montana; and a youth regional treatment center at Aberdeen-Chief Gall, South Dakota.

The IHS *Technical Handbook for Health Facilities* and *Health Facilities Planning Manuals* are being converted to metric. In addition, IHS is preparing seminars and training programs for use in increasing employee awareness and understanding of the metric system.

- **The Smithsonian Institution.** The Smithsonian's annual construction budget is approximately $100 million for projects nationwide. Virtually all design work beginning in fiscal year 1994 will be in metric. A number of small metric projects are proceeding smoothly through design now and a $162-million master plan is being prepared in metric.

The Suitland Cultural Resources Center (13 000 m²) for the planned Museum of the American Indian (24 060 m²) also is under design. Its structural grid is 9 m by 9 m to accommodate display loading requirements. The museum itself, the last major structure to be built on the Mall in Washington, D.C., also will be built in metric and is awaiting design award.

A plan is being developed to field-verify the dimensions of the Smithsonian's existing buildings as part of a process to update building CADD files. The revised files will be in metric. Metric also is being implemented in the Smithsonian's public programs and all new exhibit signage.

- **Naval Sea Systems Command (NAVSEA).** The LX amphibious assault ship is the first major Navy ship acquisition program to be built in metric. Fifty smaller NAVSEA programs reported using metric last year, including those involving new boats and service craft. Such programs use many of the same construction products as buildings, particularly structural steel.

The Naval Air Systems Command, the Space and Naval Warfare Systems Command, and the Marine Corps have a total of 37 other metric programs including those for aircraft, jet engines, electronic systems, battle tanks, assault vehicles, and watercraft.

- **Department of Veterans Affairs (VA).** The VA is implementing metric on selected medical and nonmedical facilities around the country. The $170-million, 79 000 m²-medical center planned for Brevard County, Florida, is scheduled to be designed in metric. It is VA's goal to implement metric aggressively while not incurring significant additional construction costs.

- **Architect of the Capitol (AOC).** AOC maintains and operates the Capitol Complex consisting of the U.S. Capitol building, the House office buildings, the Senate office buildings, the Library of Congress buildings, and the Supreme Court building. Metric has been used for all in-house design and renovation projects for over a year. Although no new capitol complex buildings are planned at this time, all future work will be in metric.

- **National Institutes of Health (NIH).** NIH's Division of Engineering Services has provided metric awareness training to its 650 employees as well as to NIH procurement personnel and small construction contractors. As a result, attitudes towards metric are very positive. Beginning in January 1994, all new NIH design work will be in metric.

- **Coast Guard.** The Coast Guard has three metric pilot projects under way with a total value of $13.4 million, about 10 percent of its 1993 construction budget. It is converting its architectural programs and space standards to metric.

- **Tennessee Valley Authority (TVA).** TVA is promoting metric conversion through employee training, correspondence, the purchase of goods and services, and selected engineering and construction projects. Current metric pilot projects include buildings at four power plant sites and a new transmission and substation line.

This year, TVA mailed a Supplier of Preference Questionnaire to 4000 supply firms and manufacturers asking about their ability to supply metric products. Response has been excellent.

- **Public Health Service (PHS).** Since October 1993, all new federally funded PHS projects have been designed in metric. Beginning in January 1995, all new federally assisted construction projects will be built in metric unless design work was under way prior to January 1994.

As new planning and construction documents are created or updated, PHS is converting them exclusively to metric.

- **Department of Housing and Urban Development (HUD).** HUD published a notice in the September 8, 1993, *Federal Register* outlining its metrication policy and activities. The agency is creating a Metric Policy Committee, chaired by the Assistant Secretary of Policy Development and Research, a Metric Coordinating Committee, and, as necessary, interdepartmental metric work groups. All program offices are reviewing their operations to determine appropriate changes and drawing up plans to implement them.

- **Bureau of Prisons.** The Bureau of Prisons is distributing metric information to its six regions. Although the entire agency is experiencing the strains of rapid growth, metrication is beginning to take hold. Currently, the Bureau has $2 billion in construction planned or under way and all new projects starting after January 1994 will be designed in metric.

- **Department of the Treasury.** Treasury plans to require all new projects to be designed in metric after January 1994. Existing plans for the Main Treasury Building and the Annex Building are being transferred to CADD and will be converted to metric by the end of fiscal year 1994.

Metric in Construction is the newsletter of the Construction Metrication Council of the National Institute of Building Sciences, Washington, D.C. Copies of previous newsletters are available upon request.

The Philadelphia Region of the General Services Administrration is seeking information about current metric projects in the design or construction stages. Please direct responses to Otto Schick:
Phone -- (215) 656-5822
Fax -- (215) 656-5836

SEVEN METRIC CASE STUDIES

The National Institute of Building Sciences recently completed a preliminary case study report for the Army Corps of Engineers, the General Services Administration, and the Department of Veterans Affairs on seven federal metric projects. As of the report's publication in January 1994, three projects were in design, one was out for bid, one was under construction, and two had been completed. The report's findings are as follows:

Design Costs. The design fees for two of the seven metric projects examined were slightly higher than they would have been had the projects been non-metric. In both cases, the fee increases were granted because government standards had not yet been converted to metric and the architect/engineer had to make the necessary conversions. Fee increases also may be justified when projects are changed from inch-pounds to metric after design work has begun.

Construction Costs. It is premature to draw firm conclusions about construction costs since only three of the seven projects have been awarded to date. Two were well below the government cost estimate, following a bid pattern similar to that for current non-metric projects. The third, located in a remote area, was awarded slightly above the government cost estimate. These cursory data appear to indicate that market conditions play a much greater role in determining construction costs than does conversion to metric.

The Metric Learning Curve. An additional effort was required on the part of designers and builders to use metric, resulting in a temporary reduction in productivity until everyone "got up to speed." Specifying and using metric required extra time, care, and attention to detail. Rethinking familiar practices, particularly in the early stages of a project, was necessary and time had to be allowed for this.

After the initial learning period, however, the advantages of metric became evident: it was easier to use and resulted in fewer errors. As the construction industry becomes accustomed to working in metric, there may be a net increase in productivity.

Although it was not critical to have someone with metric experience on the project team, it helped. Experienced personnel gave everyone more confidence in making the many small decisions involved in the conversion process and their guidance reduced the impact of conversion on productivity, project costs, and schedules. On one project, for instance, the contractor's superintendent had previous metric experience and was able to help subcontractors interpret construction documents and prepare shop drawings.

Project Selection. An organization's initial metric projects should be as large as possible because large projects provide time for everyone on the job to learn metric thoroughly (in fact, they cannot avoid learning it). Large projects also provide the volume orders required to purchase metric products without a cost premium. Small projects may not offer these advantages. The cutoff point varies depending on the nature of the project, but the GSA Philadelphia Region indicates that projects of a few hundred thousand dollars often can be executed in metric without difficulty. Projects under one hundred thousand dollars also are feasible if they do not require the small amounts of metric materials (e.g., block or drywall) that could carry a premium price.

Architectural Design. Architects had little difficulty learning to design in metric. The preparation of specifications, however, took more time and effort because the availability of metric products had to be researched and non-metric product specifications had to be converted. As architectural firms convert their in-house specification systems and product manufacturers convert their literature, this problem should disappear.

Structural Engineering. There were no reported problems in the area of structural design. Some firms performed calculations using inch-pounds, converted the answers to metric, and then completed the structural details.

Mechanical Engineering. There were no reported problems in the area of mechanical design. A number of firms reported using mechanical design software programs that performed calculations in metric.

Cost Estimating. A conversion error in an early cost estimate for one project was the only reported problem associated with cost estimating.

Computer-aided Design and Drafting. Computer-aided design and drafting (CADD) programs were reported to be quite useful in producing metric drawings since CADD allows users to work in metric scales and units. CADD also allows designers to evaluate alternative approaches to rounding from inch-pound to metric dimensions.

Metric Guidance Documents. The National Institute of Building Sciences' (NIBS) *Metric Guide For Federal Construction* and the General Services Administration's *Metric Design Guide* were the two most commonly used guidance documents. The GSA guide was cited as being particularly useful to designers and project managers.

Codes and Standards. Few problems were encountered in this area since most codes and standards contain metric units. In one case, a building inspector was reluctant to review metric plans. In another, it was found that a set of requirements was based on tests of inch-pound assemblies, which resulted in the need for extra research on the part of the specifier.

Trade Union Training. On one of the large projects, government representatives are helping the local trade unions begin metric training before the project goes to bid. On the job, the metric training responsibility will be assigned to the general contractor's project safety office with little or no additional cost to the project anticipated. Similar outreach efforts are recommended whenever possible and consideration should be given to requiring them in the general conditions of the contract.

Metric Tools. Metric measuring tapes were not provided to the trades on one project, causing confusion and delays. Provision should be made to ensure that metric tools are always available. On one project, the contractor supplied the metric measuring tapes and insisted that metric terms be used in all job-site discussions.

Reverse Conversion. A mistake by a contractor in converting metric dimensions back to inch-pounds led to a significant ordering error on one project. Continuous effort is needed to eliminate unnecessary reverse conversions in the field.

Shop Drawings. Government project managers consistently demanded metric-only submittals for shop drawings. A slightly higher rate of shop drawing rejections and a significant number of metric-related mark-ups have been reported. In a few instances, subcontractors submitted metric shop drawings but used drawings with dual notations in the field. A metric orientation program for subcontractors prior to the beginning of the job can reduce such problems.

Converting and Rounding Numbers. When rounding metric numbers, the effects of repeating a rounded dimension over a large area must be considered since the cumulative effect of such rounding may be significant. Lack of care in rounding also may lead to errors in shop drawings and in-place work. There are no rules of thumb to replace the need for attention to details and rechecking calculations. The designers and builders who devoted special attention to such details avoided problems.

Building Products. Some project participants were concerned that metric modular products (brick, block, drywall, plywood, suspended ceiling components, and floor tile) might not be available locally or be produced by enough manufacturers to promote competitive bidding. However, all product availability concerns were resolved without causing project delays or increasing costs.

A limited number of metric construction products may cost more due to a relatively low level of competition or production capacity. It is best to deal with this issue by contacting suppliers during the design stage to ensure that the products being considered are locally available. The GSA Philadelphia Region's *M2: Metric Design Guide*, Third Edition, contains a listing, by manufacturer, of metric products and associated minimum order requirements.

Some concern was expressed regarding whether to allow contractors to substitute soft metric for hard metric products. Experience has shown that most hard metric materials are readily available and that substitutions should not be allowed unless there will be a clear and overriding benefit to the government.
Building product data often are available in metric. Some manufacturers who produce for both the domestic and foreign markets have metric data available. Others have begun to add metric data to their catalogs and advertising literature. Discussions with manufacturers during the development of product specifications help ensure a competitive supply of metric components.

Effective communication among designers, managers, contractors, subcontractors, and manufacturers and the identification of critical metric dimensions will reduce requests for changes in product specifications during construction.

Systems Furniture. Office furniture systems are manufactured in inch-pound modules but will work in metric layouts if care is taken in choosing the appropriate module sizes. Problems can be minimized by avoiding shortcuts and checking calculations.

Utilities. Local government and utility records are not maintained in metric units and local authorities may require submittals in inch-pound units. On one project, there was some resistance to reviewing metric drawings, but no problems were reported on the other projects.

Clients and Tenants. Clients and tenants often have difficulty understanding space requirements when metric is used. Allow for the extra time needed to assist them in this regard.

Federal Commitment. Many study participants emphasized the need for the federal government to show an unequivocal commitment to metric. Only a strong federal commitment will provide the necessary incentive for the construction industry to convert rapidly to metric.

Positive Approach. A positive approach to metric construction seems to work best. It involves:

- Making a firm commitment to learning metric,

- Choosing projects of significant size,

- Using available CADD technology,

- Conveying a positive message about metric to all project personnel and constantly reinforcing it,

- Providing metric orientation for construction trades,

- Accepting the increase in effort needed to ascend the metric learning curve,

- Devoting extra attention to details and checking calculations, and

- Requiring metric-only usage in the provisions of all design and construction contracts.

Canadian Metrication. The Canadian construction industry converted to metric in the late 1970s. It found that the conversion process was much less difficult than anticipated and that there were no appreciable cost penalties associated with the change.

[The above findings are excerpted from *Seven Metric Construction Case Studies: Preliminary Assessment*. The full report is available for $12 (including shipping and handling) from the National Institute of Building Sciences, 1201 L St., N.W., Suite 400, Washington, D.C. 20005; phone 202-289-7800. Major credit cards and phone orders are accepted. Also available from NIBS are the *Metric Guide for Federal Construction* ($15) and the *M2: Metric Design Guide*, Third Edition ($12), both mentioned herein.]

METRIC FACTS: PRESSURE AND STRESS In the inch-pound system, pressure and stress areexpressed in many ways, including pounds per square inch (psi), inches of mercury, and inches of water. In the metric system, the unit for pressure and stress is the ***pascal*** (rhymes with rascal). One pascal is defined as the force of one newton exerted over an area of one square meter. In symbolic language, this is shown as $Pa = N/m^2$.

One psi equals 6894 pascals. Since the pascal is such a small unit, pressure and stress are often given in kilopascals (kPa) or megapascals (MPa).

Problem: The operating pressure in a boiler is 125 psi. Express this in pascals with a convenient prefix.

Solution: $125\ lb/in^2 \times 6894\ Pa/lb/in^2 \times k/1000 = 892\ kPa$

By Oscar Fisher; used with the permission of the American Society of Mechanical Engineers.

Metric in Construction is the newsletter of the Construction Metrication Council of the National Institute of Building Sciences, Washington, D.C. Reproduction and distribution of its contents is encouraged provided the Council receives attribution. Copies of previous newsletters are available upon request.

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Metric in Construction is a bimonthly newsletter published by the Construction Metrication Council to inform the building community about metrication in U.S. construction. The Construction Metrication Council was created by the National Institute of Building Sciences to provide industry-wide, public and private sector support for the metrication of federal construction and to promote the adoption and use of the metric system of measurement as a means of increasing the international competitiveness, productivity, and quality of the U.S. construction industry.

The National Institute of Building Sciences is a nonprofit, nongovernmental organization authorized by Congress to serve as an authoritative source on issues of building science and technology.

The Council is an outgrowth of the Construction Subcommittee of the Metrication Operating Committee of the federal Interagency Council on Metric Policy. The Construction Subcommittee was formed in 1988 to further the objectives of the 1975 *Metric Conversion Act*, as amended by the 1988 *Omnibus Trade and Competitiveness Act*. To foster effective private sector participation, the activities of the subcommittee were transferred to the Council in April 1992.

Membership in the Council is open to all public and private organizations and individuals with a substantial interest in and commitment to the Council's purposes. The Council meets bimonthly in Washington, D.C.; publishes the *Metric Guide for Federal Construction* and this bimonthly newsletter; and coordinates a variety of industry metrication task groups. It is funded primarily by contributions from federal agencies. For membership information, call the Council at the above phone number.

The Council is grateful to the following private contributors: The Kling-Lindquist Partnership; Smith, Hinchman, and Grylls Associates; and Raytheon Engineers and Constructors; and the Associated General Contractors of America.