Some References on

Metric Information

Including a Chart on

All You Need to Know About Metric

NBS LC 1070
January 1977
Supersedes NBS Special Publication 389

U.S. DEPARTMENT OF COMMERCE
National Bureau of Standards

U.S. METRIC STUDY

See Page 5 for Ordering Information

The United States joined the worldwide trend toward adoption of the metric system of measurement with the enactment of the Metric Conversion Act of 1975. Several years prior to that action, the Congress asked the National Bureau of Standards to make a thorough investigation of the metric question. That investigation involved public hearings and surveys of almost every activity of our society—from education and the consumer to international trade and national security. The findings are given in the following summary and 12 detailed reports:

A METRIC AMERICA: A DECISION WHOSE TIME HAS COME (Summary Report to the Congress). D. V. DeSimone, NBS SP 345, 190 pages (July 1971), SD Stock No. SN 003-003-00884-2.	$2.70
INTERNATIONAL STANDARDS. R. D. Huntoon et al., NBS SP345-1, 145 pages (Dec. 1970), SD Stock No. SN 003-003-00731-5.	$1.70
FEDERAL GOVERNMENT: CIVILIAN AGENCIES. R. E. Clark and J. M. Tascher, NBS SP 345-2, 324 pages (July 1970), SD Stock No. SN 003-003-00824-9.	$3.20
COMMERCIAL WEIGHTS AND MEASURES. S. L. Hatos, NBS SP 345-3, 109 pages (July 1971), SD Stock No. SN 003-003-00859-1.	$1.75
THE MANUFACTURING INDUSTRY. L. E. Barbrow, Coordinator, NBS SP 345-4, 165 pages (July 1971), SD Stock No. SN 003-003-00825-7.	$1.95
NONMANUFACTURING BUSINESSES. E. D. Bunten and J. R. Cornog, NBS SP 345-5, 192 pages (Aug. 1971), SD Stock No. SN 003-003-00898-2.	$2.15
EDUCATION. B. D. Robinson, NBS SP 345-6, 209 pages (July 1971), SD Stock No. SN 003-003-00858-3.	$2.30
THE CONSUMER. B. D. Rothrock, NBS SP 345-7, 146 pages (July 1971), SD Stock No. SN 003-003-00864-8.	$1.75
INTERNATIONAL TRADE. G. F. Gordon, NBS SP 345-8, 181 pages, (Aug. 1971), SD Stock No. SN 003-003-00895-8.	$2.10
U.S. METRIC STUDY INTERIM REPORT: DEPARTMENT OF DEFENSE. D.V. DeSimone, NBS SP 345-9, 132 pages (June 1971), (Order as com 71-50305 from the National Technical Information Service, 5285 Port Royal Rd., Springfield, VA. 22151.)	$5.50 (from NTIS only)
A HISTORY OF THE METRIC CONTROVERSY IN THE UNITED STATES C. F. Treat, NBS SP 345-10, 306 pages (Aug. 1971), SD Stock No. SN 003-003-00879-6.	$3.05
ENGINEERING STANDARDS. R. D. Stiehler, NBS SP 345-11, 257 pages (July 1971), SD Stock No. SN 003-003-00835-4.	$2.70
TESTIMONY OF NATIONALLY REPRESENTATIVE GROUPS. J. V. Odom, Editor, NBS SP 345-12, 174 pages (July 1971), SD Stock No. SN 003-003-00865-6.	$2.00

NBS METRIC KIT

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______	Brief History of Measurement Systems with Chart of the Modernized Metric System, SP304A (SD Stock No. 003-003-01713-2)	$ .35 ea. $ 5.70 per 100
______	What About Metric, NBS CIS7 (SD STOCK No. SN 003-003-01688-8)	$ .35 ea. $23.00 per 100

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Special Publication 304A. Revised August 1976

Brief History of

MEASUREMENT SYSTEMS

with a Chart of the Modernized Metric System

"Weights and measures may be ranked among the necessaries of life to every individual of human society. They enter into the economical arrangements and daily concerns of every family. They are necessary to every occupation of human industry; to the distribution and security of every species of property; to every transaction of trade and commerce; to the labors of the husbandman; to the ingenuity of the artificer; to the studies of the philosopher; to the researches of the antiquarian, to the navigation of the mariner, and the marches of the soldier; to all the exchanges of peace, and all the operations of war. The knowledge of them, as in established use, is among the first elements of education, and is often learned by those who learn nothing else, not even to read and write. This knowledge is riveted in the memory by the habitual application of it to the employments of men throughout life."

JOHN QUINCY ADAMS
Report to the Congress, 1821

Weights and measures were among the earliest tools invented by man. Primitive societies needed rudimentary measures for many tasks: constructing dwellings of an appropriate size and shape, fashioning clothing, or bartering food or raw materials.

Man understandably turned first to parts of his body and his natural surroundings for measuring instruments. Early Babylonian and Egyptian records and the Bible indicate that length was first measured with the forearm, hand, or finger and that time was measured by the periods of the sun, moon, and other heavenly bodies. When it was necessary to compare the capacities of containers such as gourds or clay or metal vessels, they were filled with plant seeds which were then counted to measure the volumes. When means for weighing were invented, seeds and stones served as standards. For instance, the "carat," still used as a unit for gems, was derived from the carob seed.

As societies evolved, weights and measures became more complex. The invention of numbering systems and the science of mathematics made it possible to create whole systems of weights and measures suited to trade and commerce, land division, taxation, or scientific research. For these more sophisticated uses it was necessary not only to weigh and measure more complex things—it was also necessary to do it accurately time after time and in different places. However, with limited international exchange of goods and communication of ideas, it is not surprising that different systems for the same purpose developed and became established in different parts of the world—even in different parts of a single continent.

The English System

The measurement system commonly used in the United States today is nearly the same as that brought by the colonists from England. These measures had their origins in a variety of cultures—Babylonian, Egyptian, Roman, Anglo-Saxon, and Norman French. The ancient "digit," "palm," "span," and "cubit" units evolved into the "inch," "foot," and "yard" through a complicated transformation not yet fully understood.

Roman contributions include the use of the number 12 as a base (our foot is divided into 12 inches) and words from which we derive many of our present weights and measures names. For example, the 12 divisions of the Roman "pes," or foot, were called *unciae*. Our words "inch" and "ounce" are both derived from that Latin word.

The "yard" as a measure of length can be traced back to the early Saxon kings. They wore a sash or girdle around the waist—that could be removed and used as a convenient measuring device. Thus the word "yard" comes from the Saxon word "gird" meaning the circumference of a person's waist.

Standardization of the various units and their combinations into a loosely related system of weights and measures sometimes occurred in fascinating ways. Tradition holds that King Henry I decreed that the yard should be the distance from the tip of his nose to the end of his thumb. The length of a furlong (or furrow-long) was established by early Tudor rulers as 220 yards. This led Queen Elizabeth I to declare, in the 16th century, that henceforth the traditional Roman mile of 5 000 feet would be replaced by one of 5 280 feet, making the mile exactly 8 furlongs and providing a convenient relationship between two previously ill-related measures.

Thus, through royal edicts, England by the 18th century had achieved a greater degree of standardization than the continental countries. The English units were well suited to commerce and trade because they had been developed and refined to meet commercial needs. Through colonization and dominance of world commerce during the 17th, 18th,

THE MODERNIZED metric system

The International System of Units-SI

is a modernized version of the metric system established by international agreement. It provides a logical and interconnected framework for all measurements in science, industry, and commerce. Officially abbreviated SI, the system is built upon a foundation of seven base units, plus two supplementary units, which appear on this chart along with their definitions. All other SI units are derived from these units. Multiples and submultiples are expressed in a decimal system. Use of metric weights and measures was legalized in the United States in 1866, and since 1893 the yard and pound have been defined in terms of the meter and the kilogram. The base units for time, electric current, amount of substance, and luminous intensity are the same in both the customary and metric systems.

COMMON CONVERSIONS

Accurate to Six Significant Figures

Symbol	When You Know Number Of	Multiply by	To Find Number Of	Symbol
in	inches	[A]25.4	[B]millimeters	mm
ft	feet	[A]0.3048	meters	m
yd	yards	[A]0.9144	meters	m
mi	miles	1.609 34	kilometers	km
yd^2	square yards	0.836 127	square meters	m^2
	acres	0.404 686	[C]hectares	ha
yd^3	cubic yards	0.764 555	cubic meters	m^3
qt	quarts (lq)	0.946 353	[D]liters	L
oz	ounces (avdp)	28.349 5	grams	g
lb	pounds (avdp)	0.453 592	kilograms	kg
°F	degrees Fahrenheit	[A]5/9 (after subtracting 32)	degrees Celsius	°C
mm	millimeters	0.039 370 1	inches	in
m	meters	3.280 84	feet	ft
m	meters	1.093 61	yards	yd
km	kilometers	0.621 371	miles	mi
m^2	square meters	1.195 99	square yards	yd^2
ha	[C]hectares	2.471 05	acres	
m^3	cubic meters	1.307 95	cubic yards	yd^3
L	[D]liters	1.056 69	quarts (lq)	qt
g	grams	0.035 274 0	ounces (avdp)	oz
kg	kilograms	2.204 62	pounds (avdp)	lb
°C	degrees Celsius	[A]9/5 (then add 32)	degrees Fahrenheit	°F

[A] exact

[B] for example, 1 in = 25.4 mm, so 3 inches would be $(3\text{ in})(25.4\ \frac{\text{mm}}{\text{in}}) = 76.2\text{ mm}$

[C] hectare is a common name for 10 000 square meters

[D] liter is a common name for fluid volume of 0.001 cubic meter

Note: Most symbols are written with lower case letters; exceptions are units named after persons for which the symbols are capitalized. Periods are not used with any symbols.

MULTIPLES AND PREFIXES

These Prefixes May Be Applied To All SI Units[E]

Multiples and Submultiples		Prefixes	Symbols
1 000 000 000 000 000 000	= 10^{18}	exa (ĕx´ a)	E
1 000 000 000 000 000	= 10^{15}	peta (pĕt´ a)	P
1 000 000 000 000	= 10^{12}	tera (tĕr´ a)	T
1 000 000 000	= 10^{9}	giga (jĭ´ ga)	G
1 000 000	= 10^{6}	mega (mĕg´ a)	M
1 000	= 10^{3}	kilo (kĭl´ ō)	k
100	= 10^{2}	hecto (hĕk´ tō)	h
10	= 10^{1}	deka (dĕk´ a)	da
Base Unit 1	= 10^{0}		
0.1	= 10^{-1}	deci (dĕs´ ĭ)	d
0.01	= 10^{-2}	centi (sĕn´ tĭ)	c
0.001	= 10^{-3}	milli (mĭl´ ĭ)	m
0.000 001	= 10^{-6}	micro (mī´ krō)	μ
0.000 000 001	= 10^{-9}	nano (năn´ ō)	n
0.000 000 000 001	= 10^{-12}	pico (pē´ kō)	p
0.000 000 000 000 001	= 10^{-15}	femto (fĕm´ tō)	f
0.000 000 000 000 000 001	= 10^{-18}	atto (ăt´ tō)	a

[E] apply to gram in case of mass

National Bureau of Standards
Special Publication 304A (Revised August 1976)
For sale by the Superintendent of Documents U.S. Government Printing Office Washington D.C. 20402 SD Stock No 003-003-017132 Price 50 cents

REFERENCES

NBS Special Publication 330, Latest Edition, International System of Units (SI), available by purchase from the Superintendent of Documents Government Printing Office Washington, D.C. 20402 SD Stock No 003-003-01326-9 Price 80 cents

American National Standard for Metric Practice Z210 1, available by purchase from the American National Standards Institute, 1430 Broadway N Y N Y 10018

SI Units and Recommendations for the Use of Their Multiples and of Certain Other Units available by purchase from the American National Standards Institute 1430 Broadway N Y N Y 10018, order as ISO Standard 1000

U.S. DEPARTMENT OF COMMERCE
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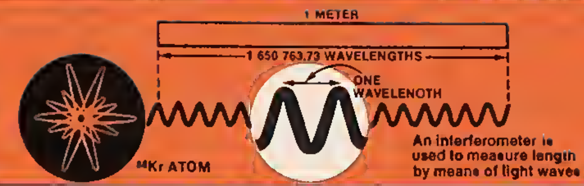
SEVEN BASE UNITS

meter-m LENGTH

The mater is defined as 1 650 763.73 wavelengths in vacuum of the orange-red line of the spectrum of krypton-86.



The SI unit of area is the square meter (m^2).

The SI unit of voluma is the cubic matar (m^3). The liter (0.001 cubic mater), although not an SI unit, is commonly used to measure fluid volume.

kilogram-kg MASS

Tha standard for tha unit of mass* the kilogram, is a cylinder of platinum-iridium alloy kept by the Intarnational Bureau of Weights and Maasures at Paris. A duplicate in the custody of tha National Bureau of Standards sarvas as the mass standard for tha United States. This is the only base unit still defined by an artifact.

* "Weight" is a commonly used term for "mass."

The SI unit of force is the nawton (N). One newton is tha force which, when applied to a 1-kilogram mass, will give the kilogram mass an acceleration of 1 (meter par second) per second.

1 N = 1 kg·m/s²

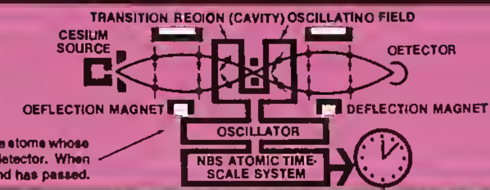
The SI unit for pressure is the pascal (Pa).
1 Pa = 1 N/m²

Tha SI unit for work and energy of any kind is the joule (J).
1 J = 1 N·m

The SI unit for power of any kind is the watt (W).
1 W = 1 J/s

second-s TIME

The second is defined as the duration of 9 192 631 770 cycles of the radiation associated with a specified transition of the cesium-133 atom. It is realized by tuning an oscillator to tha resonanca frequency of cesium-133 atoms as they pass through a system of magnets and a resonant cavity into a detector.



Schematic diagram of an atomic beam spectrometer or "clock." Only those atoms whose magnetic moments are "flipped" in the transition region reach the detector. When 9 192 631 770 oscillations have occurred, the clock indicates one second has passed.

The number of periods or cycles per second is called frequency. The SI unit for frequency is the hertz (Hz). One hertz equals one cycle per second.

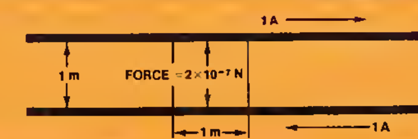
The SI unit for speed is the mater per sacond (m/s).

The SI unit for acceleration is the (mater per second) per second (m/s²).

Standard frequencies and correct time are broadcast from WWV, WWVB, and WWVH, and stations of the U.S. Navy. Many shortwave receivers pick up WWV and WWVH, on frequencies of 2.5, 5, 10, 15, and 20 megahertz.

ampere-A ELECTRIC CURRENT

The ampere is defined as that current which, if maintained in each of two long parallel wires separated by one meter in free space, would produce a forca between the two wires (due to thair magnetic fialds) of 2×10^{-7} newton for each meter of length.

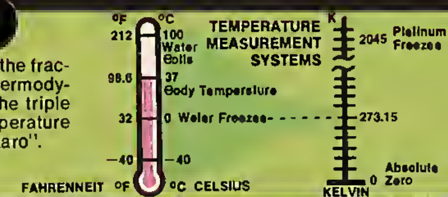


The SI unit of voltage is the volt (V).
1 V = 1 W/A

The SI unit of electric resistance is the ohm (Ω).
1 Ω = 1 V/A

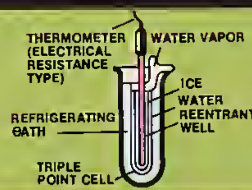
kelvin-K TEMPERATURE

The kelvin is defined as the fraction 1/273.16 of the thermodynamic temperature of the triple point of water. The temperature 0 K is called "absolute zaro".



On the commonly used Celsius temperature scale, watar freezes at about 0 °C and boils at about 100 °C. The °C is defined as an interval of 1 K, and the Celsius temperature 0 °C is defined as 273.15 K.

1.8 Fahrenheit degrees are equal to 1.0 °C or 1.0 K; the Fahrenhait scale uses 32 °F as a temperature corresponding to 0 °C.



The standard temperature at the triple point of water is provided by a special cell, an evacuated glass cylinder containing pure water. When the cell is cooled until a mantle of ice forms around the reentrant well, the temperature at the interface of solid, liquid, and vapor is 273.16 K. Thermometers to be calibrated are placed in tha reentrant well.

mole-mol AMOUNT OF SUBSTANCE

The mole is the amount of substance of a system that contains as many elementary entities as there are atoms in 0.012 kilogram of carbon 12.

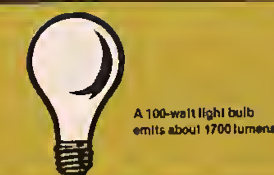
When the mole is used, the elementary entities must be specified and may be atoms, molecules, ions, electrons, other particles, or specified groups of such particles.

The SI unit of concentration (of amount of substance) is the mole per cubic meter (mol/m³).

candela-cd LUMINOUS INTENSITY

The candela is defined as the luminous intensity of 1/600 000 of a square meter of a blackbody at the temperature of freezing platinum (2045 K).

The SI unit of light flux is the lumen (lm). A source having an intensity of 1 candela in all directions radiates a light flux of 4 π lumens.



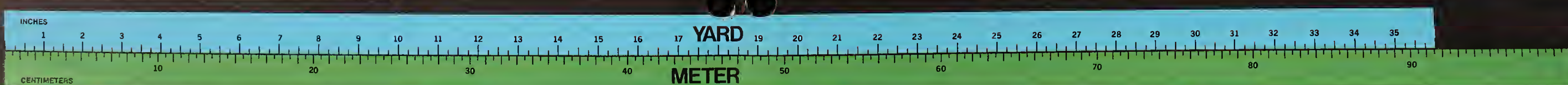
TWO SUPPLEMENTARY UNITS

radian-rad PLANE ANGLE

The radian is the plane angle with its vertex at the center of a circle that is subtended by an arc equal in length to the radius.

steradian-sr SOLID ANGLE

The steradian is the solid angle with its vertex at the center of a sphere that is subtended by an area of the spherical surface equal to that of a square with sides equal in length to the radius.



A full-scale wall chart, NBS Special Publication 304 is available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, for 65 cents and 19th centuries, the English system of weights and measures was spread to and established in many parts of the world, including the American colonies.

However, standards still differed to an extent undesirable for commerce among the 13 colonies. The need for greater uniformity led to clauses in the Articles of Confederation (ratified by the original colonies in 1781) and the Constitution of the United States (ratified in 1790) giving power to the Congress to fix uniform standards for weights and measures. Today, standards supplied to all the States by the National Bureau of Standards assure uniformity throughout the country.

The Metric System

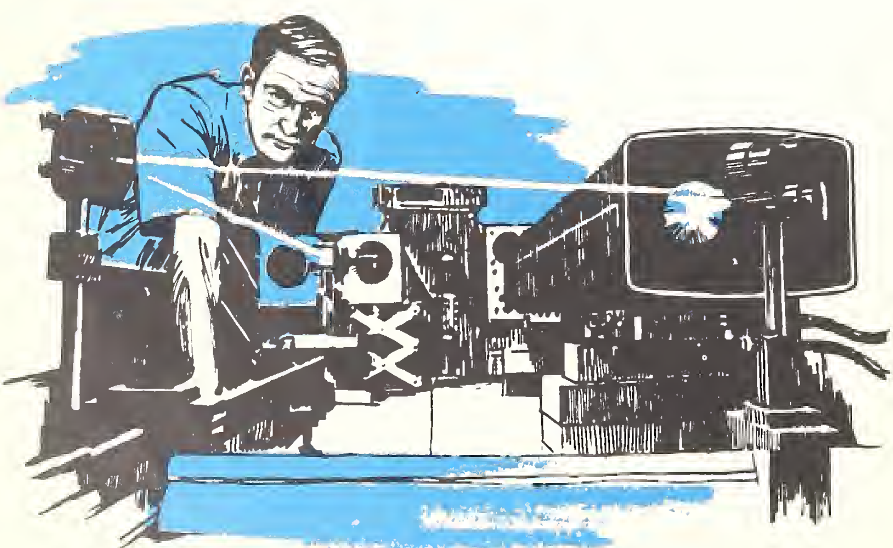
The need for a single worldwide coordinated measurement system was recognized over 300 years ago. Gabriel Mouton, Vicar of St. Paul in Lyons, proposed in 1670 a comprehensive decimal measurement system based on the length of one minute of arc of a great circle of the earth. In 1671 Jean Picard, a French astronomer, proposed the length of a pendulum beating seconds as the unit of length. (Such a pendulum would have been fairly easily reproducible, thus facilitating the widespread distribution of uniform standards.) Other proposals were made, but over a century elapsed before any action was taken.

In 1790, in the midst of the French Revolution, the National Assembly of France requested the French Academy of Sciences to "deduce an invariable standard for all the measures and all the weights." The Commission appointed by the Academy created a system that was, at once, simple and scientific. The unit of length was to be a portion of the earth's circumference. Measures for capacity (volume) and mass (weight) were to be derived from the unit of length, thus relating the basic units of the system to each other and to nature. Furthermore, the larger and smaller versions of each unit were to be created by multiplying or dividing the basic units by 10 and its powers. This feature provided a great convenience to users of the system, by eliminating the need for such calculations as dividing by 16 (to convert ounces to pounds) or by 12 (to convert inches to feet). Similar calculations in the metric system could be performed simply by shifting the decimal point. Thus the metric system is a "base-10" or "decimal" system.

The Commission assigned the name *metre* — which we spell meter — to the unit of length. This name was derived from the Greek word *metron*, meaning "a measure." The physical standard representing the meter was to be constructed so that it would equal one ten-millionth of the distance from the north pole to the equator along the meridian of the earth running near Dunkirk in France and Barcelona in Spain.

The metric unit of mass, called the "gram," was defined as the mass of one cubic centimeter (a cube that is 1/100 of a meter on each side) of water at its temperature of maximum density. The cubic decimeter (a cube 1/10 of a meter on each side) was chosen as the unit of fluid capacity. This measure was given the name "liter."

Although the metric system was not accepted with enthusiasm at first, adoption by other nations occurred steadily after France made its use compulsory in 1840. The standardized character and decimal features of the metric system made it well suited to scientific and engineering work. Consequently, it is not surprising that the rapid spread of the system coincided with an age of rapid technological development. In the United States, by Act of Congress in 1866, it was made "lawful throughout the United States of America to employ the weights and measures of the metric system in all contracts, dealings or court proceedings."



By the late 1860's, even better metric standards were needed to keep pace with scientific advances. In 1875, an international treaty, the "Treaty of the Meter," set up well-defined metric standards for length and mass, and established permanent machinery to recommend and adopt further refinements in the metric system. This treaty, known as the Metric Convention, was signed by 17 countries, including the United States.

As a result of the Treaty, metric standards were constructed and distributed to each nation that ratified the Convention. Since 1893, the internationally agreed-to metric standards have served as the fundamental weights and measures standards of the United States.

By 1900 a total of 35 nations—including the major nations of continental Europe and most of South America—had officially accepted the metric system. In 1971 the Secretary of Commerce, in transmitting to Congress the results of a 3-year study authorized by the Metric Study Act of 1968, recommended that the U.S. change to predominant use of the metric system through a coordinated national program. The Congress responded by enacting the Metric Conversion Act of 1975. Today, with the exception of a few small countries, the entire world is using the metric system or is changing to such use.

The International Bureau of Weights and Measures located at Sevres, France, serves as a permanent secretariat for the Meter Convention, coordinating the exchange of information about the use and refinement of the metric system. As measurement science develops more precise and easily reproducible ways of defining the measurement units, the General Conference on Weights and Measures—the diplomatic organization made up of adherents to the Convention—meets periodically to ratify improvements in the system and the standards.

In 1960, the General Conference adopted an extensive revision and simplification of the system. The name *Le Système International d'Unités* (International System of Units), with the international abbreviation SI, was adopted for this modernized metric system. Further improvements in and additions to SI were made by the General Conference in 1964, 1968, 1971, and 1975.

AMERICA JOINS A METRIC WORLD

"It is therefore declared that the policy of the United States shall be to coordinate and plan the increasing use of the metric system in the United States and to establish a United States Metric Board. . ." (Metric Conversion Act of 1975)

ON December 23, 1975, President Ford signed into law the Metric Conversion Act, establishing for the first time a national policy in support of metric measurement and ending a dilemma that had continued throughout the entire history of the Republic.

George Washington had raised the issue of a more uniform system of weights and measures in his first message to Congress on January 8, 1790. John Adams and Thomas Jefferson became strong advocates of that idea, speaking favorably of the recently-developed French metric system.

Instead, the young Nation followed the tradition inherited from the British, the "customary" system of measurement. In 1875, the United States committed itself to metric by signing an international agreement, the Treaty of the Meter. This treaty was followed more in the breach than the observance. Inches, not meters, continued to reign supreme at home, although one result was that, ever since 1893, our national measurement standards have been metric.

Now at last, with the signing of the new law, the dilemma has been resolved through a national policy of coordinating the increasing use of metric in this country on a voluntary basis. The impetus for such a policy has come from our business community, which has been gradually adopting metric over the last decade. Our schools have also begun to emphasize metric, and it is apparent that the country would have drifted through metrication in an uncoordinated way unless action had been taken at the national level.

The Metric Conversion Act of 1975 created a U.S. Metric Board, appointed by the President with the advice and consent of the Senate. The Board consists of 17 members representing the various economic sectors affected by the metric changeover. These include engineering, science, large and small business, organized labor, education, manufacturing, consumers, weights and measures officials, State and local governments, and the construction industry.

The Board's function is to devise and carry out a broad program of planning, coordination and public education consistent with other national policies and interests. This legislative action is, in part, the result of the comprehensive, 3-year study performed by the National Bureau of Standards for the Secretary of Commerce and submitted to the Congress in July 1971. This study recommended that the United States change to the metric system deliberately and carefully through a coordinated program. The purpose of the Metric Conversion Act of 1975 is to accomplish this goal. It allows the development of a rational plan for a voluntary changeover. In this way, metric will come as the various sectors of our economy are ready for it—and not before.

In fact, metric has come to many sectors of American life over the past several years at an ever accelerating but erratic pace. Industry continues to take the lead in the private sector. At least 37 major corporations have announced policies to convert their operations. The total sales of these companies exceed $130 billion, and the list contains four of the Nation's 10 largest firms. Some of the first metric-minded corporations included: Caterpillar Tractor, Chrysler, Ford Motor Company, General Motors, IBM, International Harvester, Minnesota Mining and Manufacturing, Travelers Insurance, and Xerox.

Whereas until just recently the metric changeover was found predominately among manufacturers with overseas interests, some of America's largest retailers have gotten on the bandwagon. Sears, Roebuck and Company, Montgomery Ward and Company, and J. C. Penney are notable leaders in this category.

As mentioned, another sector of American life that has seen growing use of the metric system is education. School systems in all 50 states have

turn page


POUNDS
100 110 120
KILOGRAMS
100
30 80
20 60
10 40
0 32
20
°C °F
WESTFIELD
40 KILOMETERS
25 MILES
50
80
0
KILOMETERS PER HOUR
MILES PER HOUR
FUEL
TOTAL SALE
42.0
LITERS
CEREAL
79¢
650 GRAMS
23 OZ
CEREAL
82¢
650 GRAMS
23 OZ
MILK
1 LITER
1.06 QTS
CUPS
1
¾
½
¼
MILLILITERS
250
200
150
100
50

underway some type of metric activity. These activities include: making metric workshops available to teachers, providing guidelines for training of teachers, producing educational television programs, and specifying the use of metric as the primary measurement language in new textbook purchases. In more than 30 states this "trend" is reinforced by State legislation or by State school board action. In Maryland, for example, the State School Board adopted a resolution in August 1973, calling for schools to be totally metric by 1980. The State Department of Education has a well developed plan and a timetable to meet this objective.

The Congress recognized the schools' swing to metric in the Education Amendments of 1974, P.L. 93-380, which authorized a Metric Education Program to be managed by the U.S. Office of Education. Appropriated funds support model and demonstration projects aimed at improving the quality and extent of metric education. The Metric Conversion Act of 1975 also recognizes the need to train teachers and introduce metric into the Nation's classrooms. A representative of the educational community is included on the U.S. Metric Board.

The States are not limiting themselves just to metric education in schools. At the time of the signing of the bill a total of 13 states had erected some metric road signs; Georgia, Maine, and California had established State metric conversion commissions; California's Division of Oil and Gas had switched to using only metric units; Pennsylvania and Florida had cooperated with the Sun Oil Company in a pilot test to sell gasoline by the liter; North Dakota had adopted metric signs for its State parks; and bills to coordinate metric conversion had been introduced into 18 State legislatures.

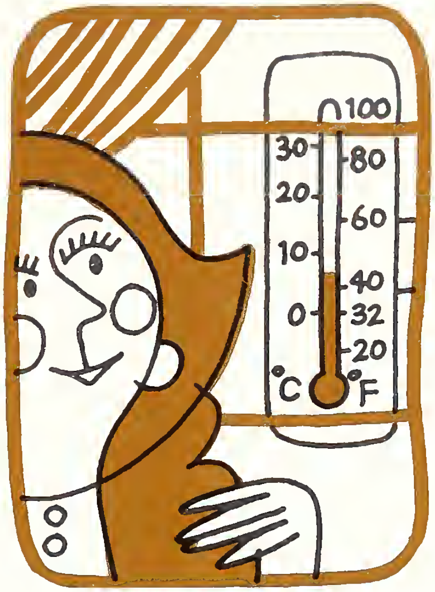
State and local weights and measures officials through their organization, the National Conference on Weights and Measures, have begun planning for the effects of metric changeover on commercial weights and measures activities. Working with this group, for which the National Bureau of Standards maintains the Secretariat, NBS has already equipped each State with a set of metric standards and laboratory instruments that are NBS-certified as to accuracy.

On the Federal level, various metrication efforts have been underway to meet immediate needs. Since publication of the metric study in 1971, NBS has maintained a Metric Information Office. The volume of inquiries and requests have grown steadily. In one 6-month period in 1975, NBS answered 20,000 letters and 2,000 telephone calls for information. More than 100,000 NBS Metric Kits have been prepared and are being sold through the Government Printing Office. A national speakers bureau was formed to meet a need for metric information from civic, homemaker, PTA, and other groups.

The U.S. Metric Board assumes many of NBS' public information functions, but the Bureau will continue to provide international metric coordination through the General Conference on Weights and Measures created by the Treaty of the Meter. It is at this Conference that the components of the modernized metric system, International System of Units (SI), are agreed upon by the participating nations. The Bureau will also retain responsibility for maintaining the national measurement system, coordinating metrication with State weights and measures officials, and through its interaction with consumer, business, and scientific groups, assist the nation in the changeover to metric.

Activity in other Federal agencies is underway:

- The Department of Defense issued a policy statement in June 1975 that it would use metric when feasible, practical, and efficient.
- The Treasury Department, at the request of industry, has held hearings on new regulations that would specify metric-sized bottles for distilled alcoholic beverages. There was no opposition to these regulations at the hearings. Similar regulations have already been approved for the wine industry.
- The National Aeronautics and Space Administration has been using metric units extensively for several years.
- The Interagency Committee on Standards Policy, chaired by the Department of Commerce, has established a Metrication Subcommittee to help coordinate Federal agency metric activities.
- Other Federal agencies which have initiated some metric activity—ranging from forming committees to using metric publications and signs—include the Department of Interior, Federal Highway Administration, Federal Housing Administration, Department of Health, Education and Welfare, National Weather Service, Maritime Administration, Forest Service, National Park Service, Agriculture Department, Patent and Trademark Office, Environmental Protection Agency, and Federal Communications Commission.



Just why is the United States going metric after having lived with the English system for more than 200 years? The answer is quite simple: We cannot afford not to.

All of our major trading partners have either gone metric or are in the process of doing so. In fact, the only countries still not committed are Brunei, Burma, Liberia, and Yemen. Before the 1975 Act, we literally were an island in a metric sea. The British Commonwealth countries, with whom we shared the pounds-quarts-yards system for so long, have all committed themselves to metric. This includes Canada, our closest neighbor, which has an unofficial goal of being all-metric by 1980.

Our industrial community has also seen the necessity for metric conversion as markets for American goods and services expand overseas. In order to do effective business abroad, these large corporations have had to dual-dimension their products, create a separate production capability to turn out metric products for export, or abandon customary design altogether and produce all products in metric dimensions. More and more corporations are doing the latter.

We are also seeing some barriers being erected to U.S. products in customary dimensions. The Common Market in 1971 adopted a directive that requires all exporters to the nine Common Market nations to indicate the dimensions of their products in metric units by 1978. Dual dimensioning will be allowed only if determined not to be confusing, with each nation to judge compliance separately. This action could bar American goods from these markets or could lead to costly relabeling of products.

Ultimately, it is in our national best interest to convert to metric. And there is a decided advantage for American industries that "go metric." In addition to opening up new markets, the benefits of standardization under the metric system will be realized in reduced inventories. Manufacturers will not have to keep on hand as many product lines to correspond with various size requirements. For example, the Treasury Department's new regulations, scheduled to go into effect in 1979, will reduce the number of "standardized" wine bottles offered in this country from 16 to seven. The U.S. fastener industry will replace 59 customary sizes with 25 metric sizes for threaded fasteners.

A question frequently asked is what effect this changeover will have on the average citizen. Everyone will be affected, but the disruption in normal living will be minimal. Experience in other countries suggests that the American public will have little trouble in mastering the few metric units it will need for everyday living.

Most persons will need to know only three measurement units—meters, liters and grams. A meter is a unit of length slightly longer than a yard; a liter is a measure of volume and is a little larger than a quart; a gram is a unit of weight about as heavy as a paper clip. Because gram is such a small unit, it is easier to think about the kilogram (1000 grams), which amounts to a little more than 2 pounds.

Metric is a decimal system that uses multiples of 10, as does our currency system. Each basic metric unit can be multiplied or divided by factors of 10 to get larger and smaller units. These multiples and submultiples are indicated by prefixes such as kilo (one thousand), centi (one hundredth) and milli (one thousandth). Thus a kilometer means 1000 meters, a centimeter is 1/100 of a meter and a millimeter is 1/1000 of a meter.

Temperatures in metric are measured on the Celsius scale rather than Fahrenheit scale. (Celsius was formerly called Centigrade.) In the Celsius scale, water boils at 100 degrees and freezes at 0 degrees. This is easier to remember than in Fahrenheit, where water boils at 212 degrees and freezes at 32 degrees.

The changeover will create minimal confusion. Initially most items such as roadsigns and consumer goods will be labeled in both customary and metric dimensions. This is already happening with some automobile speedometers that are dually labeled. In the supermarket, canned goods will be labeled in both ounces and grams for a time (many are already) and eventually in grams alone.

The Metric Conversion Act of 1975 and the U.S. Metric Board which that Act creates will provide the necessary focal point for a smooth, coordinated conversion to the metric system in this country. No one will be forced to "go metric." But gradually, as each of our country's economic sectors see the desirability of going metric in a rational way, we will become a predominately metric nation. □

NBS METRIC PUBLICATIONS

See Page 5 for Ordering Information

The National Bureau of Standards has compiled six useful items into a single official metric information kit which is available for sale. Priced items are also sold individually at the prices listed. Ordering information is on the back of this publication.

COMPLETE NBS METRIC KIT, NBS SP 410, SD Stock No. SN 003-003-01736-1.	$2.00 per kit 25% discount for 100 or more
Metric Conversion Card, NBS SP 365, SD Stock No. SN 003-003-1068-5	$4.70 per 100
For Good Measure (ruler), NBS SP 376, SD Stock No. SN 003-003-1080-4.	$4.70 per 100
Brief History of Measurement Systems with Chart of the Modernized Metric System, NBS SP 304A, SD Stock No. SN 003-003-1713-2.	$5.70 per 100
What About Metric?, NBS CIS 7, SD Stock No. SN 003-003-1688-8.	$ .35 $23.50 per 100
America Joins the Metric World, Reprinted from DIMENSIONS/NBS (February 1976)	Not sold separately
NBS Metric Information (bibliography), NBS LC 1070 (includes chart "All You Need to Know About Metric")	Not sold separately

The following are other metric materials published by the National Bureau of Standards.

FACTORS FOR HIGH-PRECISION CONVERSION—U.S. CUSTOMARY AND METRIC UNITS. NBS LC 1071, 8 pages (July 1976).	See page 5
METRIC STYLE GUIDE (for the News Media). NBS LC 1069, 6 pages (September 1976).	See page 5
UNITS AND SYSTEMS OF WEIGHTS AND MEASURES. NBS LC 1035, 26 pages (1976).	See page 5
HOUSEHOLD WEIGHTS AND MEASURES. NBS SP 430, 2 pages (1975), SD Stock No. SN 003-003-01542-3.	$ .25
THE INTERNATIONAL SYSTEM OF UNITS (SI). NBS SP 330, 43 pages (1974), SD Stock No. SN 003-003-01326-9.	$ .80
WALL CHART OF THE MODERNIZED METRIC SYSTEM. NBS SP 304, 1 page (1972), SD Stock No. SN 003-003-00079-5.	$ .65
SUCCESSFUL EXPERIENCES IN TEACHING METRIC. NBS SP 441, 115 pages (1976), SD Stock No. SN 003-003-01568-7.	$2.30
INTERNATIONAL BUREAU OF WEIGHTS AND MEASURES. NBS SP 420, 256 pages (1975), SD Stock No. SN 003-003-01408-7.	$3.00

ADDITIONAL SOURCES OF METRIC INFORMATION

See Page 5 for Ordering Information

American National Metric Council, 1625 Massachusetts Ave., NW., Washington, D.C. 20036. Established originally under the auspices of the American National Standards Institute to provide guidance to industrial and commercial segments of society.

American National Standards Institute (ANSI), 1430 Broadway, New York, N.Y. 10018. Publishes national standards and metric practice guides.

American Society for Testing and Materials, 1916 Race St., Philadelphia, PA 19103. Publishes assorted metric aids.

The Department of Defense has reproduced for free distribution two NBS metric items —the Modernized Metric System (wall chart in color) and the Metric Conversion Card (wallet card)—which are available upon request from your nearest Army school representative or Army reserve center.

National Council of Teachers of Mathematics, 1906 Association Drive, Reston, VA 22091. Publishes listings of organizations marketing metric material for educators.

National Science Teachers Association, 1201 Sixteenth St., NW., Washington, D.C. 20036. Publishes metric kit for teachers.

Science Service, 1719 N St., NW., Washington, D.C. 20009. Publishes "Things-of-Science" metric kit for students.

U.S. Metric Association, Sugarloaf Star Route, Boulder, CO 80302. Distributes educational material and publishes a quarterly newsletter, which is available to members.

National metric conversion boards in other countries can supply general information about conversion in their respective countries and can also provide referrals to other organizations therein. Their addresses are listed below.

Metric Conversion Board
18-24 Chandos Street
St. Leonards, N.S.W. 2065 Australia

Metric Advisory Board
P. O. Box 10-243
The Terrace
Wellington, New Zealand

South African Bureau of Standards
Private Bag X191
Pretoria, South Africa

Metrication Board
22 Kingsway
London WG2B 6LE England

Metrication Board of Zambia
P. O. Box 1968
Lusaka, Zambia

Metric Commission
320 Queen Street
Ottawa K1A OH5 Canada

ORDERING INFORMATION

Single copies of metric materials which are not priced are available from:

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National Bureau of Standards
Washington, D.C. 20234

For quantity copies reproduce freely.

Other government publications can be purchased from:

Superintendent of Documents
U.S. Government Printing Office
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All You Will Need to Know About Metric

(For Your Everyday Life)

10

Metric is based on Decimal system

The metric system is simple to learn. For use in your everyday life you will need to know only ten units. You will also need to get used to a few new temperatures. Of course, there are other units which most persons will not need to learn. There are even some metric units with which you are already familiar: those for time and electricity are the same as you use now.

BASIC UNITS

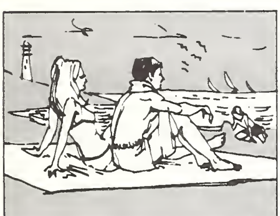
METER: a little longer than a yard (about 1.1 yards)
LITER: a little larger than a quart (about 1.06 quarts)
GRAM: a little more than the weight of a paper clip

(comparative sizes are shown)

1 METER

1 YARD

25 DEGREES FAHRENHEIT



25 DEGREES CELSIUS

COMMON PREFIXES
(to be used with basic units)

milli: one-thousandth (0.001)
centi: one-hundredth (0.01)
kilo: one-thousand times (1000)

For example:
1000 millimeters = 1 meter
100 centimeters = 1 meter
1000 meters = 1 kilometer

1 LITER

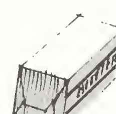
1 QUART

OTHER COMMONLY USED UNITS

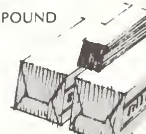
millimeter:	0.001 meter	diameter of paper clip wire
centimeter:	0.01 meter	a little more than the width of a paper clip (about 0.4 inch)
kilometer:	1000 meters	somewhat further than ½ mile (about 0.6 mile)
kilogram:	1000 grams	a little more than 2 pounds (about 2.2 pounds)
milliliter:	0.001 liter	five of them make a teaspoon

OTHER USEFUL UNITS

hectare: about 2½ acres
metric ton: about one ton



1 POUND



1 KILOGRAM

WEATHER UNITS:

FOR TEMPERATURE
degrees Celsius

FOR PRESSURE
kilopascals are used
100 kilopascals = 29.5 inches of Hg (14.5 psi)