ICRU ACTIVITIES

H. O. Wyckoff
7910 Woodmont Avenue
Washington, D.C. 20014

I appreciate very much the invitation from your Congress President to present a short summary of recent ICRU activities. I was asked to emphasize the current situation regarding the International System of Units so that this could be discussed in some detail following this paper. In addition, I would like to present briefly a short summary of three reports that the ICRU has just published.

The International System of Units

While the name "International System of Units" (SI) was selected in 1960, the components of this measurement system had been in the process of development for many years and there are indications that some modifications are still to come.

In order to provide a proper background for understanding the import of this system, it is well to review the hierarchy that was set up by the "Treaty of the Metre" in 1875. Under this Treaty, there are two organizations - the General Conference of Weights and Measures and the International Committee for Weights and Measures - and one laboratory, the International Bureau of Weights and Measures(1).

The General Conference of Weights and Measures is composed of delegates from the states who are signatories of the Metre convention. As of January 1, 1975, there were forty-three such states. This Conference meets at least every six years.

The International Committee for Weights and Measures is composed of eminent scientists from eighteen different countries. They are selected by the General Conference and serve in a personal capacity - that is, they are not representatives of their governments. However, many of these scientists are senior members of their national standardizing laboratory. This committee supervises the operation of the International Bureau of Weights and Measures, prepares material for consideration by the General Conference and is responsible for implementing the Conference's decisions. The International Committee meets at least every two years and its president, vice president, and secretary serve as an executive committee to examine current business, to keep the International Committee informed, and to prepare for meetings of its parent body. To assist the International Committee, there are several consultative committees of which one is the Consultative Committee for Units. Table 1 shows the inter-relationships between these organizations.

During its 1948 meeting, the General Conference instructed the International Committee: "to study the establishment of a complete set of rules for units of measurement"; "to find out for this purpose, by official inquiry, the opinion prevailing in scientific, technical, educational circles in all countries" and "to make recommendations on the establishment of a practical system of units of measurement suitable for adoption by all signatories to the Metre Convention". Before considering the system that was developed following this instruction, it may be useful to review briefly a few concepts and the rationale for the development of the system.

Even prior to the "Treaty of the Metre" the concept of "physical quantities" was fairly well developed and the interrelationships between quantities had begun to be expressed by mathematical equations. A physical quantity is an entity used for the precise description of a phenomenon. Each physical quantity can be expressed as a product of a pure number and a unit.

In developing a system of units one could, of course, decide upon a special name for the unit of each quantity. This was not done because there are known mathematical relationships between a number of the quantities. Thus, the tendency has been to limit the number of units and use the mathematical relationships between the quantities to derive the units for other quantities. For example, an area is given by the product of two lengths. Thus, if the unit for length is specified, an area has the unit of the unit of length squared. This may be expressed mathematically as:

$$
\begin{aligned}
[\text{area}] &= [\text{length}]\ [\text{length}] \\
&= [k_1(\text{unit of length})]\ [k_2(\text{unit of length})] \\
&= k_1 k_2\ (\text{unit of length})^2
\end{aligned}
$$

where k_1 and k_2 are pure numbers. Similarly, if a unit for length and one for time are specified, the unit for velocity is the quotient of the specified units. This may be expressed mathematically as:

$$
\begin{aligned}
[\text{velocity}] &= [\text{length}]/[\text{time}] \\
&= [c_1\ (\text{unit of length})]/[c_2\ (\text{unit of time})] \\
&= \frac{c_1}{c_2}\ \frac{\text{unit of length}}{\text{unit of time}}
\end{aligned}
$$

where c_1 and c_2 are pure numbers. It was found that the specification of units for length, mass and time were adequate for quantities employed in mechanics. Many of you remember the centimeter-gram-second (CGS) system which resulted. Difficulties arose when the CGS system was applied to electrical and magnetic quantities by means of the equations relating them to the mechanical quantities. The unit of electrical charge (abcoulomb) derived from electromagnetics is then equal to the velocity of light times the unit of charge (statcoulomb) derived from electrostatics.

$$1\ \text{abcoulomb} = c\ \text{statcoulomb}$$

where c = velocity of light. In addition, the expression of electrical quantities by units of the mechanical quantities, resulted in a fractional exponent for some of the mechanical quantities. For example:

$$[\text{charge in electrostatic system}] = [\text{dielectric constant}]^{\frac{1}{2}}[\text{mass}]^{\frac{1}{2}}[\text{length}]^{3/2}[\text{time}]^{-1}$$

Specification of another unit for the electrical area ("electric current" in amperes) solved these difficulties.

For the description of thermal phenomena, another unit based on the thermodynamic temperature is required. The concept of "temperature" and its unit kelvin resulted.

While the mass is acceptable for mechanical phenomena, in chemistry the number of molecules is much more useful. For this reason, the concept of "amount of substance" and its unit, mole, resulted.

To include a measure of light as viewed by the eye, another quantity "luminous intensity" and its unit, candela, has been provided. It is essentially the energy of light per unit area weighted by the response of the "average" eye according to an agreed upon relative luminous efficiency. The weighting is different for photopic and scotopic vision.

The resulting seven base units of the International System of Units, along with their symbols and quantities, are listed in Table 2. These, together with two supplementary units - radian (symbol rad) for plane angle and steradian (symbol sr) for solid angle - provide the reference set of units from which the other units in the International System of Units may be derived. A few of these derived units have special names. For example, the SI unit for periodic frequency is reciprocal second. The special name for reciprocal second for use with this quantity is hertz.

There are a few units that do not fit into the International System of Units but that have been approved for use with the SI. These include some for which no time limitation of usage is specified. Some of these, such as minute and hour of time, are permitted because of long continued common usage and others are included because their magnitude depends upon experimental determinations - such as electron volt. There were a few units - as of 1972 - that were accepted for use with the International System of Units for a limited time. These included the curie, roentgen and rad whose SI units are reciprocal second, coulomb per kilogram and joule per kilogram, respectively. The "limited time" was not specified in the document on this subject prepared in 1972 by the International Bureau of Weights and Measures with the assistance of the Consultative Committee on Units, and containing the resolutions and recommendations of the General Conference of Weights and Measures. However, several countries immediately started to consider changing their laws to eliminate the units that were recommended for limited time usage.

Recognizing that senior personnel in the major national standardizing laboratories had agreed to the recommendations included in the International Bureau of Weights and Measures document, and remembering that the calibration of our ionizing radiation measuring devices ultimately depend upon calibration by such national laboratories, it appeared obvious to the ICRU that curie, roentgen and rad would soon become ruled out.

As it appeared that many persons in the field of ionizing radiation were not fully cognizant of this trend, the ICRU attempted to alert these scientists to the possible action by soliciting their comments (2,3). From these comments it appeared that a number of persons wished to retain the historical names for the units. In view of the actions that already had been taken, this didn't seem to be a viable position. An even larger group opted for a change to the International System of Units, if special names could be chosen for them and if the change-over to the new names was not too precipitous.

On the basis of these replies, the ICRU developed arguments for special names for reciprocal second and joule per kilogram. These were forwarded to the General Conference of Weights and Measures through the Consultative Committee on Units and the International Committee on Weights and Measures. On the basis of these recommendations, the General Conference of Weights and Measures approved the special name gray for joule per kilogram and the special name becquerel for reciprocal second (4).

At the time that the initial submission was made to the Consultative Committee on Units, no decision had been made by the ICRU and the ICRP on the unit for dose equivalent. Since that time there have been discussions within each of the Commissions and within the ICRP/ICRU liaison committee. Sievert was selected as the special name of the SI unit (joule per kilogram) for dose equivalent. This name (symbol Sv) is to be used in ICRP Reports. The official approval of this name must await its consideration by the Consultative Committee on Units, the International Committee of Weights and Measures and finally by the General Conference of Weights and Measures.

Before leaving the topic of the International System of Units, it should be said that there are a number of points still under discussion. For example, some thought is being given to either eliminating or placing in a special category the quantities and their units that contain weighting factors - particularly biological ones. This discussion will then include consideration of luminous intensity with its unit, candela, and dose equivalent with its unit, sievert. It is still too early to predict the outcome of these discussions.

One should also say that if the International System of Units finally comes into universal use, and it may be found that the "units to be used with the International System" are no longer needed, then the statement of the unit will be redundant if one indicates the pertinent quantity. One could then say, for example:

"The absorbed dose is 4.51×10^{-3}"

and one would understand

"The absorbed dose is 4.51 $mJ/_{kg}$ (or 4.51 mGy)". If this happens - and many feel that it will - the special names for units will no longer be needed. There may be special pressures for such a development because many persons working in this area have argued against the proliferation of specially named units.

Current ICRU Reports

In the past few months, the ICRU has published its Reports 24, 25, and 26 (6,7,8) on "Determination of Absorbed Dose in a Patient Irradiated by Beams of X or Gamma Rays in Radiation Therapy Procedures", "Conceptual Basis for the Determination of Dose Equivalent" and "Neutron Dosimetry for Biology and Medicine".

Report 24 is the second in a series of primers on the subject of therapeutic dosimetry - the first, ICRU Report 23 (9), dealt with the absorbed dose in a phantom from a single beam of x and gamma rays. Report 24 outlines methods for taking into account (a) multiple ports of entry of the radiation, (b) inhomogeneities in the body, and (c) the body's contours. It also deals with the accuracy desired in therapy. In addition, there is a glossary and an extended series of references for more detailed information.

Report 25 summarizes the relationships between the various quantities of interest in radiation protection and expands on the concepts associated with the "index quantities" recommended in ICRU Report 19 (5). The use of such concepts permits the specification of an absorbed dose index field or a dose equivalent index field for external sources (in the same way as is now done for exposure free in air) without the lengthy presentation of the geometry that would otherwise be required. It does this by specifying a phantom size, requiring it to be spherical so that orientation is unimportant and specifying that the "index" be the maximum value of the quantity in that phantom. The 30 cm diameter selected for the phantom size approximates that of the trunk of an adult.

ICRU Report 26 deals primarily with neutron dosimetry but because gamma rays are always present in most applications, the document includes some treatment of their measurement also. The various methods are discussed and compared. The document includes some didactic treatment of the quantities given very succinctly in ICRU Report 19 (5). In addition, the document includes material on neutron sources, beam monitoring, and deals briefly with special problems that arise in neutron dosimetry for therapy and radiobiology. It also includes a series of appendices on fundamental data of interest for this topic and a short discussion of ionization chamber construction.

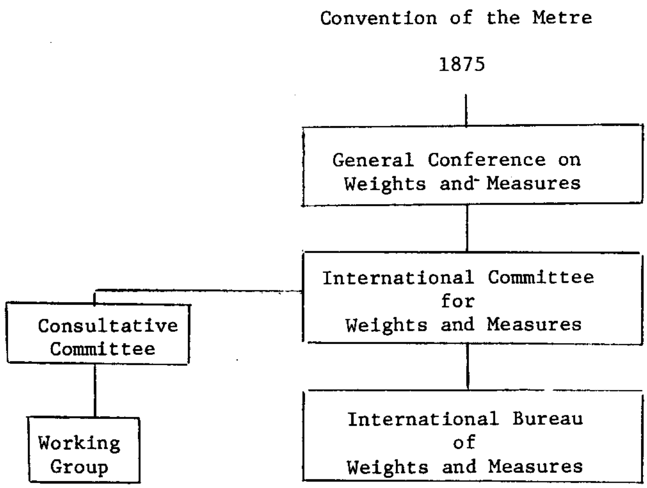

Table 1 Organs of the Metre Convention

Table 2

SI Base Units

Quantity	Unit	
name	name	symbol
length	metre	m
mass	kilogram	kg
time	second	s
electric current	ampere	A
thermodynamic temperature	kelvin	K
amount of substance	mole	mol
luminous intensity	candela	cd

References

(1) "Le Bureau International des Poids et Mesures 1875-1975" Pavillon de Breteuil, F 92310 Sevres, France (1975) also in English translation by U.S. National Bureau of Standards as NBS Special Publication 420 (Page, C. H., Vigoureux, P. Eds) U.S. Government Printing Office, Washington, D.C. 20402

(2) Liden, K., SI Units in Radiology and Radiation Measurement Health Physics 25, 2-0 (1973)

(3) Liden, K., Special Radiation Units and/or SI-Units Health Physics 26, 583 (1974)

(4) Liden, K., The New Special Names of SI Units in the Field of Ionizing Radiation, Health Physics 30, 417 (1976)

(5) "Radiation Quantities and Units", ICRU Report 19, International Commission on Radiation Units and Measurements, Washington, (1971)

(6) "Determination of Absorbed Dose in a Patient Irradiated by Beams of X or Gamma Rays in Radiation Therapy Procedures", ICRU Report 24, International Commission on Radiation Units and Measurements, Washington (1976)

(7) "Conceptual Basis for the Determination of Dose Equivalent" ICRU Report 25, International Commission on Radiation Units and Measurements, Washington (1976)

(8) "Neutron Dosimetry for Biology and Medicine", ICRU Report 26, International Commission on Radiation Units and Measurements, Washington (1976)

(9) "Measurement of Absorbed Dose in a Phantom Irradiated by A Single Beam of X or Gamma Rays", ICRU Report 23, International Commission on Radiation Units and Measurements, Washington (1973)

Notes

Notes

Notes

Notes

Notes