In 1960 the International Committee of Weights and Measures adopted a single International System of units (SI). In the Soviet Union the SI has been adopted on January 1, 1963 by GOST 9867-61 as the preferential system in all the spheres of science, technology and national economy [1-3].

The new ionizing radiations units have been introduced by GOST 8848-63 from July 1, 1964. The joule per kilogram has been adopted as an absorbed dose unit and the coulomb per kilogram as the exposure (radiation) dose unit, and the use of the röntgen unit was permitted temporarily. The unit ber (rem) which is widely used in ionizing radiations dosimetry is not even mentioned. We think that the adoption of the above Standard is premature.

At present almost the entire existing equipment, literature, textbooks, handbooks and instructions use the old units, including the rad and röntgen. The following relationship exists between the special nonsystem units and the SI units: 1 rad = 1 centijoule/kilogram and 1 röntgen = 0.257976 milliampere/kilogram.

It is important to note that for the units in ionizing-radiation dosimetry there exist specific recommendations of the International Commission on Radiological Units (ICRU), and that the Soviet Union participated in their drafting. The commission notes in its report [4] that its main aim consists in compiling recommendations which are acceptable to all the countries.

The commission recommended that special units, the rad and röntgen, should be used for measuring the absorbed and exposure doses respectively. The commission also considers that, side by side with the special units which, owing to existing traditions, are used for measuring certain quantities in dosimetry, it is permissible to express the absorbed dose in joules per kilogram or ergs per gram and the exposure dose in coulombs per kilogram. These recommendations were not taken into consideration in preparing the Standard for ionizing radiations units.

The value of the absorbed dose, and the more so, of the exposure dose does not provide the required information about the safety from radiations under operating conditions and about other important practical matter. This is due to the fact that different types of ionizing radiations have a varying biological effectiveness. Thus, the International Commission on Radiological Protection (ICRP) recommends [5] and our existing health protection regulations note that, for instance, the biological effect of thermal neutrons should be considered three times and that of fast neutrons ten times higher than the effect of X-ray or gamma radiations. The specified conversion factors are based on chronic irradiation of people by neutrons and are known as the RBE factors. Thus, for evaluating the degree of human irradiation it is necessary to know not only the value of the absorbed dose, but also the composition and the energy spectrum of radiation. If it is taken into consideration that in the course of irradiation the composition and spectrum of radiations normally changes, it becomes clear that the problem of dosimetric control under such conditions becomes extremely complex and sometimes overwhelming.

Similar difficulties arise in planning biological protection. If no dosimetric quantities in addition to those of GOST 8848-63 are available, it becomes necessary for characterizing the quality of protection at each relevant point behind the screening to provide information on the dose computed with the above conversion factors taken into consideration, instead of providing information on the absorbed dose.

These difficulties are eliminated in our own and international practice by using an appropriate dosimetric quantity which in the recent recommendations of the ICRU has been called the dose equivalent, and was previously known as the biological dose, the RBE dose, etc. The existing health protection rules are based entirely on this quantity. The dose equivalent of radiations is defined as the sum of absorbed doses of separate types of radiations multiplied by the corresponding conversion factors whose name the ICRU recommended in 1962 to change from RBE to quality factors. A detailed substantiation of these innovations is provided in [6].
A single-valued relationship between the quality factor and such a physical quantity as the linear energy loss (LEL) of charged particles under conditions of occupational chronic irradiation of people has been specified by the ICRP [5, 6]. A precise expression for the dose equivalent (DE) in [6] can be written in the form

\[
DE = \int_0^\infty D(L)QF(L)\,dL,
\]

where \(D(L)\) is the absorbed dose per unit LEL interval (dL), and \(QF(L)\) is the specified relationship between the quality factor \(QF\) and the LEL \(L\).

It will be seen that a precise evaluation of the dose equivalent requires the knowledge of the absorbed dose distribution with respect to the LEL. One of the methods for obtaining such distributions is described in [7]. In principle it is possible to design instruments for recording the dose equivalent according to the above formula. Dosimeters of the series RUS, DN-A1, etc., [8, 9] for measuring the dose equivalent over a wide neutron spectrum have been developed and produced, and are being widely used in international practice and in our country.

Thus, for practical measurements extending to the most important fields of our national economy it is necessary to have in the above system a unit which is suitable for measuring the dose equivalent of ionizing radiations. Such a unit is lacking from GOST8848-63. In practice at the present time the nontsystem unit ber (rem) is used for this purpose. According to definition [1] the ber corresponds to the density of the absorbed radiation energy of 100 erg/g divided by the quality factor (and other factors). Thus, 1 ber is equal to 10 erg/g of tissue when the entire human body is irradiated by fast neutrons.

The opponents of the dose equivalent's application refer to the fact that it is not a purely physical quantity, since it includes biological factors and, therefore, the value of its unit cannot be reproduced. However, these arguments are not valid.

In various branches of modern science and technology it is necessary to account for the biological properties of man.

Luminous intensity, for which a special unit, the candela, is used in the SI system, could be expressed in common units of energy, if its physiological effects were not taken into consideration. A formal analogy between light and dosimetric measurements is obvious. In the same manner as illuminance, the luminous intensity, etc., are not purely physical quantities, and their evaluation is reduced by means of specified visibility curves to the measurement of physical quantities, the dose equivalent is not a purely physical quantity, but its evaluation can be reduced by means of specified quality factors to the measurement of a physical quantity, the absorbed tissue dose.

The candela is reproduced by a specified light source with a known radiation spectrum. Hence, for the reproduction of the dose equivalent unit it is also possible to use radiations with a known quality factor, for instance, equal to unity, i.e., normal X-ray or gamma radiations.

In such a case the reproduction of the dose equivalent unit is reduced to the reproduction of an absorbed dose, which does not present any difficulties in principle.

Opponents of the dose equivalent utilization also refer to the fact that its relationship to the absorbed dose is very vague, since in addition to the type of radiation it also depends on many other factors, such as the type of the irradiated object, the value of the absorbed dose, its power, fractionalization, nonuniform irradiation, the selected method of testing, etc. These objections can be countered by pointing out that the International Commission on Radiological Units recommends the application of the dose equivalent only for evaluating under conditions of occupational irradiation of people, i.e., under completely definite conditions when people are irradiated with small doses of a low power up to the appearance of minimum detrimental irradiation effects. For such strict limitations, the dose equivalent has a sufficiently unambiguous relationship to the absorbed dose. The quality factors of different radiations for these particular conditions are specified by the ICRU regulations, and the distribution factors are taken into account in calculating the maximum permissible levels. Thus, in accordance with the International Recommendations it is necessary to legalize the application of the "dose equivalent" and the unit ber (rem) for its measurement. It should also be noted that the quantity "dose equivalent" is adopted only for use in the field of the radiological protection of man. It is also necessary to legalize the quality factor values according to the International Recommendations.