

Four Different Quantities, All Written in J/kg

— One and the Same **1 J/kg** Becomes **1 Sievert** or **20** — The Weighting Factors Are Agreements, Not Measurements, and They Have Been Revised — [Paper 273]

Yuuki YAMAGISHI (山岸 勇輝)

Yamagishi Complexity Torus Lab, Japan

August 2026

— *From thinking to syncing.* —

Abstract

Absorbed dose, equivalent dose and effective dose all carry the unit **J/kg**. This paper asks whether they are then the same quantity—the answer is that they are all different. Paper 232 counted four different claims written with the same equals sign—this paper counts four different quantities written in the same unit. No new mathematical theorem and no new law is claimed. First, set out the units. **Gy = J/kg** and **Sv = J/kg**—the dimensions are exactly the same (Section 2). Second, this is the core of the paper. One and the same **1 Gy** becomes **1 Sv** for photons, **2 Sv** for protons and **20 Sv** for alpha particles—a spread of **20** that never appears in the unit (Section 3). Third, that **20** is not a measurement. The radiation weighting factor w_R is an agreement settled by an international commission, and it has in fact been revised (Section 4). Fourth, there is one more stage. Multiplying by tissue weighting factors w_T gives the effective dose—red bone marrow **0.12**, gonads **0.08**, skin **0.01** and so on, summing to exactly **1.00** (Section 5). Fifth, that the sum is **1** is also an agreement. The **15** factors add to **1.00** because it was so stipulated (Section 5). Sixth, the same unit does not mean the same quantity. The four are told apart by what has been multiplied in—and the unit preserves not one trace of that history (Section 6).

Scope of this paper (scope note): No new mathematical theorem and no new law is claimed—the definitions of absorbed, equivalent and effective dose, the values of the radiation and tissue weighting factors, and that these are recommendations of an international commission, are all standard. Radiological protection is not discussed—what is used is multiplication and the addition of coefficients. No health effect is assessed—nothing whatever is said about which dose is dangerous. What this paper treats is the standing of quantities and their relation to units alone. The correctness of the values of w_R and w_T is not discussed—the values settled by the commission are cited only, and their biological grounds are not examined. Dosimetry is not treated—neither instruments nor calibration are treated. Epidemiology is not entered—neither risk coefficients nor the existence of a threshold is treated. The w_R of neutrons is not written as one number—it depends on energy, and is given as a range only. The greybody factor is not conflated with the gray—the 5 occurrences of “gray” in earlier papers (43 and 52) are the greybody factor, a different thing from the unit. Relation to earlier papers: Paper 232 counted four different claims written with the same equals sign—this paper is its version for units, counting four different quantities written in the same J/kg. Paper 240 counted “mass” as seven things—the same shape of roll call. Paper 255 treated accuracy as two things—this paper stands on the same figure, one word (one unit) naming several things. Paper 201 counted “complete” as four different claims—the same shape. Paper 190 measured rare on a logarithmic scale—this paper writes in ratios. What is added is setting out that one 1 Gy becomes 1, 2 and 20 Sv, writing that a spread of 20 never appears in the unit, counting the tissue weighting factors and confirming that they sum to 1.00, and making a table that tells the four quantities apart by what has been multiplied in.

1. Notation and Placement

Setting: dose is written in three stages.

The first (absorbed dose D): energy imparted per unit mass, in $\text{Gy} = \text{J/kg}$.

The second (equivalent dose H): $H = \sum_R w_R D_R$, in $\text{Sv} = \text{J/kg}$.

The third (effective dose E): $E = \sum_T w_T H_T$, in $\text{Sv} = \text{J/kg}$.

Question: if all the units are the same, are they the same quantity?

The answer is that they are all different. The unit preserves not one trace of the coefficients multiplied in.

A caution: the gray in this paper is a unit. The 5 occurrences in earlier papers are the greybody factor, a different thing—the two are not conflated.

2. Setting Out the Units

Check 2.1: write down the dimensions of the three quantities.

Quantity	Symbol	Unit	Dimension
Absorbed dose	D	Gy	J/kg
Equivalent dose	H	Sv	J/kg
Effective dose	E	Sv	J/kg

Observation 2.2

all three are J/kg. Dimensional analysis cannot tell one from another—because w_R and w_T are dimensionless.

Observation 2.3

two units are provided (Gy and Sv) to separate by name what dimension cannot separate. And inside the Sv there are two more—the names have run short.

3. The Core: One 1 Gy Becomes 1 Sv or 20

Setting: the radiation weighting factor w_R is fixed by the kind of radiation.

Check 3.1: set out what 1 Gy becomes as an equivalent dose.

Radiation	w_R	1 Gy becomes
Photons (X-rays, gamma rays)	1	1 Sv
Electrons and muons	1	1 Sv
Protons	2	2 Sv
Neutrons	energy dependent (roughly 2.5 to 20)	2.5 to 20 Sv
Alpha particles and heavy ions	20	20 Sv

Observation 3.2

one and the same 1 J/kg becomes 1 Sv or **20 Sv**. There is a spread of **20**, and nothing of it appears in the unit.

Observation 3.3

the separator—what has to be changed for the value to change. The kind of radiation. Neither the energy absorbed nor the mass has been moved—what was moved is the coefficient multiplied in.

Observation 3.4

only the neutron cannot be written as one number. It depends on energy and is therefore a function—constants and a function stand together in one table.

4. Those Coefficients Are Not Measurements

Observation 4.1

w_R is not a number that came out of measurement. It is a value recommended by the International Commission on Radiological Protection—an agreement informed by what is known of biological effect.

Check 4.2: the evidence that it is an agreement is the very fact that **it has been revised**.

Property	If a measurement	If an agreement
Why the value changes	remeasurement	revision of the recommendation
How uncertainty is written	as an error	it is not written
What w_R does	—	it has been revised

Observation 4.3

w_R carries no error bar. What a measured value always carries is absent—that is the typographical evidence that it is an agreement.

Observation 4.4

so the number 20 is not a physical constant. Nor is the 2 of the proton—a physical quantity (D) and a convention (w_R) stand side by side in one table.

5. One More Stage: the Tissue Weighting Factors

Check 5.1: count the tissue weighting factors w_T .

Tissue	w_T
Red bone marrow, colon, lung, stomach, breast	0.12 each (0.60 over 5)
Gonads	0.08
Bladder, liver, oesophagus, thyroid	0.04 each (0.16 over 4)
Bone surface, brain, salivary glands, skin	0.01 each (0.04 over 4)
Remainder tissues	0.12
Total	1.00

Observation 5.2

15 factors add to exactly 1.00. This is no coincidence—it was stipulated so that $E = H$ when the whole body is uniformly irradiated.

Observation 5.3

so that the sum is 1 is a convention and not the result of a measurement. The same figure as the standings of the equals sign counted in Paper 232: the $= 1$ here is an equals sign of definition.

Observation 5.4

a point to state honestly—the values of w_T have changed between recommendations. What is given here is the values of one edition, and not permanent constants.

6. The Same Unit Does Not Mean the Same Quantity

Check 6.1: tell the four apart by what has been multiplied in.

Quantity	Multiplied in	Unit	Standing
Energy over mass	—	J/kg	a physical quantity
Absorbed dose D	nothing	Gy	a physical quantity
Equivalent dose H	w_R (a convention)	Sv	quantity $\times$ convention
Effective dose E	w_R and w_T	Sv	quantity $\times$ convention $\times$ convention

Observation 6.2

the further down, the more conventions accumulate. And the unit stays J/kg throughout—the unit preserves not one trace of the conventions multiplied in.

Observation 6.3

the separator—what has to be changed for it to become another quantity. Whether a dimensionless coefficient has been multiplied in. Being dimensionless, it leaves the unit still and moves the quantity.

Observation 6.4

Paper 232 counted four different claims written with the same equals sign. This paper counts four different quantities written in the same unit—the same figure: a symbol does not preserve a standing.

7. Roll Call and Closing

1. All three are J/kg (Check 2.1): **dimension cannot tell them apart.**
2. The names have run short (Observation 2.3): **two more inside the Sv.**
3. 1 Gy becomes 1 Sv or 20 (Check 3.1): **a spread of 20.**
4. Only the neutron is a function (Observation 3.4): **constants and a function together.**
5. w_R carries no error bar (Observation 4.3): **typographical evidence of an agreement.**
6. It has been revised (Check 4.2): **not a physical constant.**
7. The w_T sum to 1.00 (Check 5.1): **exactly, over 15.**
8. The $= 1$ is a definition (Observation 5.3): **not the result of measurement.**
9. Conventions accumulate (Check 6.1): **and the unit does not change.**

Closing: absorbed dose, equivalent dose and effective dose all carried the unit J/kg . And they are all different quantities—one and the same 1 Gy becomes 1 Sv for photons and 20 Sv for alpha particles, and a spread of 20 never appears in the unit. And that 20 is an agreement rather than a measurement—it carries no error bar and has in fact been revised. That the 15 tissue weighting factors sum to 1.00 is likewise because it was so stipulated, and not a number that came out of measuring. Paper 232 counted four different claims written with the same equals sign—this paper is its version for units, the same figure in which a symbol does not preserve a standing. One thing separates them—writing down what has been multiplied in. Write it down, and the physical quantity separates from the convention. Do not write it down, and one adds a 1 and a 20 together as the same J/kg .

References

1. ICRP (2007). *The 2007 Recommendations of the International Commission on Radiological Protection*, ICRP Publication 103. *Annals of the ICRP*, 37(2--4).
2. ICRU (2011). *Fundamental Quantities and Units for Ionizing Radiation*, ICRU Report 85. *Journal of the ICRU*, 11(1).
3. Attix, F. H. (1986). *Introduction to Radiological Physics and Radiation Dosimetry*. New York: Wiley.
4. Podgorsak, E. B. (2010). *Radiation Physics for Medical Physicists*, 2nd edition. Berlin: Springer.

5. BIPM (2019). *The International System of Units (SI)*, 9th edition. Sevres: Bureau International des Poids et Mesures.
6. Yamagishi, Y. (2026). “Rare” Is Measured on a Logarithmic Scale [Paper 190]. Zenodo. 10.5281/zenodo.22106182
7. Yamagishi, Y. (2026). “Complete” Is Four Separate Statements, and What Ties Them Into One Is That the Metric Is Positive Definite [Paper 201]. Zenodo. 10.5281/zenodo.22109052
8. Yamagishi, Y. (2026). *Learn from a Book with the Proofs Removed and the Equals Sign Loses Its Type* [Paper 232]. Zenodo. 10.5281/zenodo.22127528
9. Yamagishi, Y. (2026). “Mass” Is Seven Things, One of Which Goes Negative and One of Which Depends on the Direction of the Push [Paper 240]. Zenodo. 10.5281/zenodo.22129765
10. Yamagishi, Y. (2026). “Accuracy” Is Two Things, and Calibration Removes Only One [Paper 255]. Zenodo. 10.5281/zenodo.22168883

— *From thinking to syncing.* —

Yuuki YAMAGISHI (山岸 勇輝)

© 2026 Yamagishi Complexity Torus Lab, Japan · Licensed under Creative Commons Attribution 4.0 International (CC BY 4.0)