Impact of the New ICRU Operational Dose Quantities - EURADOS Evaluation and Recommendations

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INTRODUCTION

In 2020 ICRU, in conjunction with ICRP, defined a new set of quantities for operational radiation protection [1]. As part of its strategic research agenda [2], the European Radiation Dosimetry Group, EURADOS (www.eurados.org), contributes to the development and understanding of fundamental dose concepts, such as operational quantities. Accordingly, EURADOS has completed a project [3] to evaluate the impact of the new operational quantities and to make initial recommendations for their application. Our report analyses the impact that the new quantities will have on: radiation protection practice; calibration and reference fields; European and national regulation; international standards; and, especially, dosemeter and instrument design. The task group included experienced scientists drawn from across the various EURADOS working groups.

THE NEW OPERATIONAL QUANTITIES

The new quantities, such as ambient dose, H^*, and personal dose, H_p, are defined as a product of a fluence or air kerma at a point and a conversion coefficient. The conversion coefficients are calculated in the same adult reference computational phantoms in which the protection quantities, such as effective dose, E, are calculated, thus bringing the operational quantities closer to the protection quantities. No new phantom is required in the definitions. Implicitly, the quantities are defined in a vacuum. Benefits include:

- Improved estimation of the protection quantities, and hence of risk.
- Removal of the current over-estimation of dose from photons of energies below about 80 keV – important in medical interventional and diagnostic procedures.
- The ability to carry out meaningful dosimetry in high-energy environments, such as around particle accelerators. (Note: the new quantities are unlikely to be used for aircrew and astronaut dosimetry.)

Switching to D for tissue reactions will help to differentiate between tissue reactions and the stochastic effects associated with H_p. However, note that ICRP are still considering whether it is correct to treat eye lens cataract formation as a tissue reaction.

CONVERSION COEFFICIENTS IN ICRU REPORT 95

When the present operational quantities were first introduced, computing power was more limited. Use was therefore made of the kerma approximation, in which it is assumed that kerma and absorbed dose, usually in air, are equal. This concept simplifies the calculations, and corresponds to the physical situation of charged particle equilibrium (CPE), where the number of secondary charged particles created at a point is equal to the number lost through absorption. The approximation becomes progressively less valid at higher energies. Modern computing power, however, is such that full-transport calculations can be made, raising the possibility of abandoning the kerma approximation.

However, the in-vacuum conditions required for the new quantities are impractical. CPE is not simply a phenomenon that has to be tolerated – it is a standardisation tool. Calibration laboratories routinely aim to ensure CPE as a standard condition. CPE can also be found in many workplace fields. Thus CPE exists:

- when calibrating dosemeters and instruments.
- when type-testing dosemeters and instruments.
- in many routine use situations.

ICRU have therefore provided a secondary set of conversion coefficients, based on the kerma approximation, for use in CPE situations. It is this set, and not the full-transport set, that will be most widely used, for example by calibration laboratories.

CARE IN INTERPRETATION

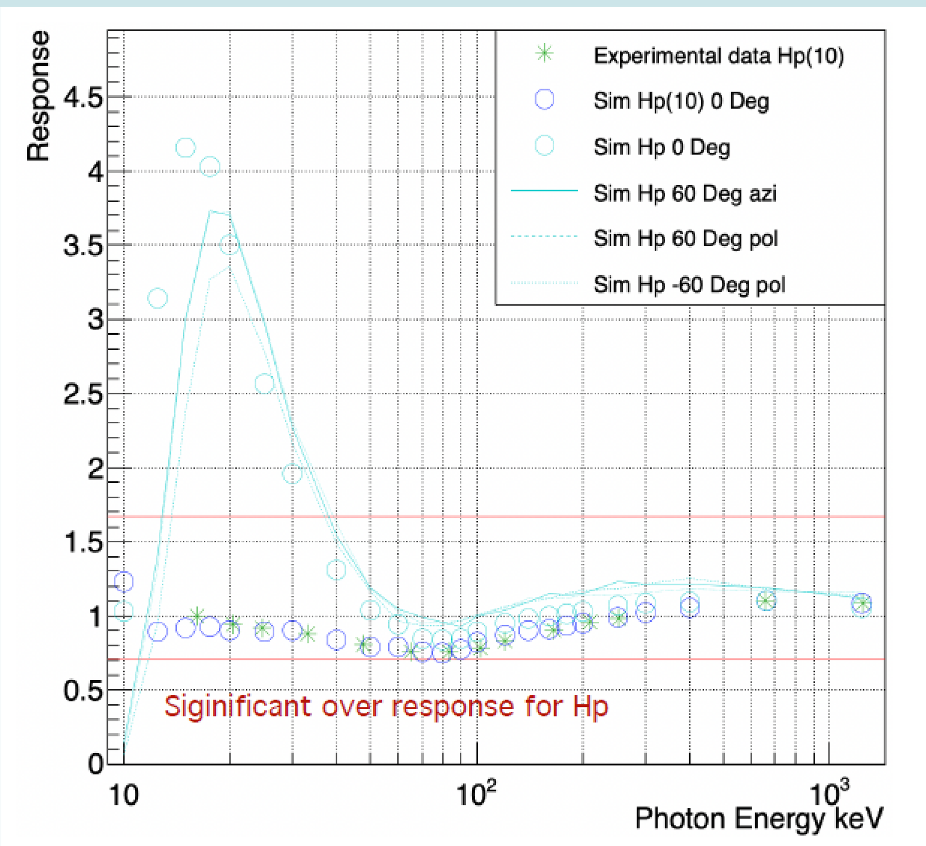
In some situations, notably in medical interventional/ diagnostic procedures, measured doses will fall, because the conversion coefficients for the new quantities are smaller than those for the old. This does not mean, however, that real doses will fall: doses in terms of the protection quantities, which represent risk and detriment, will not change. Radiation protection professionals will need to be very clear that radiation safety procedures and practice should not be relaxed. A thorough programme of training and education is recommended.

EFFECT ON DOSEMETER AND INSTRUMENT RESPONSES

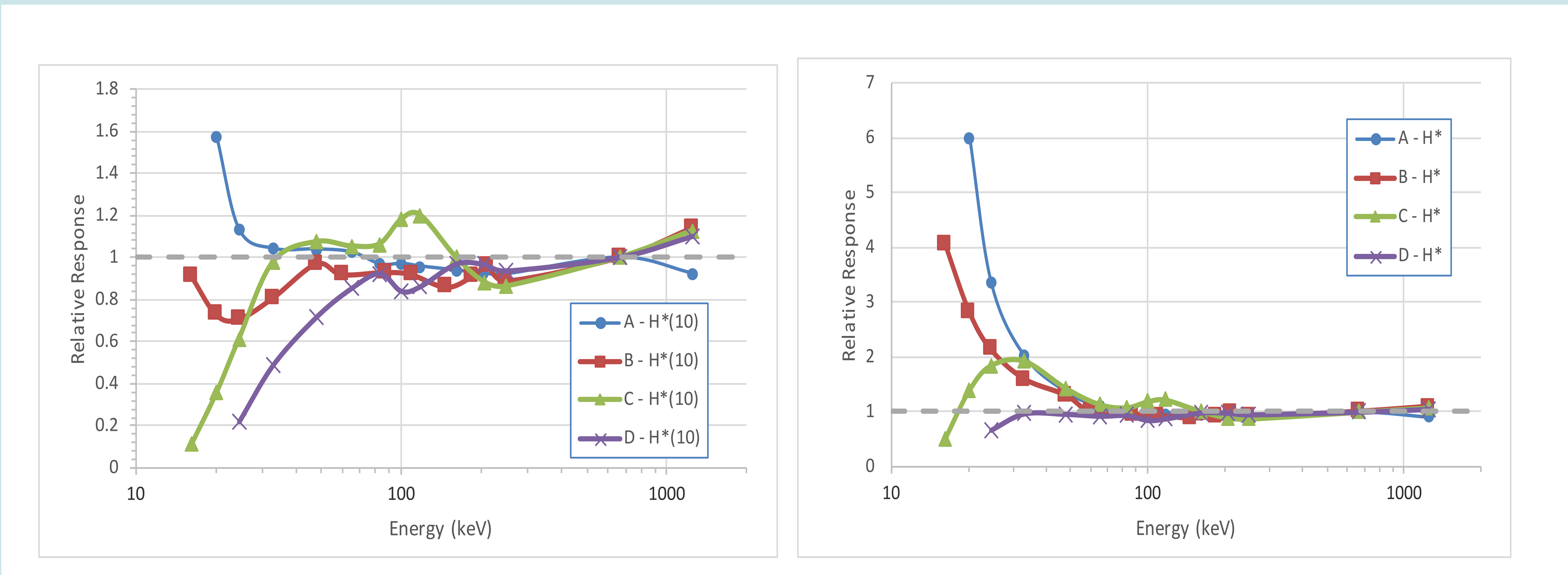
This work included a preliminary survey of the effect of adopting the new operational quantities on a variety of devices, including survey instruments, and passive and active personal dosemeters. We drew on recently-published work, work currently in progress, conversations with manufacturers, and additional calculations carried out by the authors. Representative examples are presented below. We attempted to achieve a comprehensive overview, although it was not possible to address every dosemeter or instrument design. Given that some of the necessary changes will be radical, and that there is a limit to how gradually new designs can be implemented, the changes cannot be said to be "reasonably straightforward" ([1], section 1.1). It is likely that simple dosemeters that contain only one or two sensitive elements/ filters, will need radical re-design, especially those thermoluminescence (TL) dosemeters based on "conventional" lithium fluoride LiF (Mg,Ti), which already has a significant over-response to sub-80-keV photons. In extreme cases, some designs may have to be discontinued.

On the other hand, many instruments, and most multi-filter dosemeters, are likely to be adaptable to the new quantities, by: physical re-design; change of calibration; change of dose calculation algorithm; or a combination of these. Work is still needed to confirm the feasibility of these approaches, and also to estimate whether measurement uncertainties will increase.

In neutron dosimetry, track etch dosemeters are likely to be adaptable by adjustments to encapsulation, processing parameters and/or algorithms. Albedo-type dosemeters may also be adaptable, depending on the design, the TL material, and the algorithms used.



Example 1 . $H_p(10)$ and H_p responses of a BeO dosemeter [4]. The red lines show the current IEC 62387 limits.



Example 2. Effect of the new quantities on photon survey instruments. (left) $H^*(10)$ responses and (right) H^* responses of some active GM-tube based designs.

CONCLUSIONS

Any adoption of the new operational quantities will necessarily take place over decades, as was the case with the present quantities. During this time, it is expected that ICRP will issue new general recommendations on radiological protection. The time should be used:

- to identify, at an early stage, instruments and dosemeters that will need to be re-designed, or replaced entirely.
- to carry out and optimize the necessary physical and algorithm re-designs, and to type test appropriately.
- to involve all stakeholders, including instrument manufacturers, radiation protection experts, individual monitoring services and radiation employers.
- to revise the large number of relevant international standards.
- to identify the major areas of cost and to secure the necessary national funding to meet these.
- to devise and deliver a comprehensive programme of training and communication, both at national and international levels.

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