Application of the constraint on instantaneous dose rate in the UK Approved Code of Practice 249 is inappropriate for radiology

Comment on 'Severe deterministic effects of external exposure and intake of radioactive material: basis for emergency response criteria'

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LETTERS TO THE EDITOR

Application of the constraint on instantaneous dose rate in the UK Approved Code of Practice 249 is inappropriate for radiology

Dear Sir

This letter sets out an issue relating to the use of instantaneous dose rate (IDR) from a source in the design of radiation protection. It concerns requirements in the Approved Code of Practice (ACoP) relating to the UK Ionising Radiations Regulations [1] and their application in radiology where exposure times are frequently short. Implementation of the principle described would lead to specification of protection far beyond measures appropriate under the ALARP principle applied to the dose to an individual.

The requirements of Regulation 16(1) of the Ionising Radiations Regulations [1] regarding the designation of controlled areas can be summarised as follows:

- special procedures are required to restrict significant exposure to an individual in that area or to limit the probability of a radiation accident and to limit its magnitude; or
- if it is likely that an individual in that area would receive an effective dose in excess of 6 mSv per year or three-tenths of any other dose limit for a radiation worker aged 18 years or over.

There are two supplementary requirements in the ACoP that, in so far as the Regulations are applied to diagnostic radiological facilities, can be summarised as requirements to designate as controlled areas when:

- the external dose rate exceeds 7.5 $\mu$Sv h$^{-1}$ when averaged over the working day (ACoP 248); or
- the dose rate exceeds 7.5 $\mu$Sv h$^{-1}$ when averaged over one minute and employees untrained in radiation protection are likely to enter that area (ACoP 249).

The Medical and Dental Guidance Notes [2] use the terminology ‘Time Averaged Dose Rate (TADR)’ to describe the first of these conditions and the IDR to describe the second.

The two requirements are not compatible. A TADR of 7.5 $\mu$Sv h$^{-1}$ is consistent with an accumulated dose of 60 $\mu$Sv in any working day, whereas IDR = 7.5 $\mu$Sv h$^{-1}$ corresponds to a dose of 0.125 $\mu$Sv from a single exposure of up to 1 minute in duration. The implication is that it is acceptable not to designate an area with a constant dose rate less than 7.5 $\mu$Sv h$^{-1}$ whereas a single exposure in a working day at a higher average dose rate would lead to designation.

The authors of this note are preparing a second edition of the BIR publication Radiation Shielding for Diagnostic X-rays. We intend to continue to recommend a design limit for the shielding from diagnostic facilities of 0.3 mSv per year based on advice given by NRPB following their 1990 recommendations [3]. We believe that this is consistent with ACoP 79, which requires shielding to be designed to the lowest level that is reasonably practicable for areas where there is continuous access by members of the public and employees who are not directly concerned with the work.

It is widely accepted that any recommended shielding design limit should take realistic account of occupancy of the areas surrounding the facility. Occupancy is defined as the
The proportion of the working day in which any individual might be in that particular area. Recommended occupancy factors are intentionally conservative and do not allow for occupancy of less than 5% corresponding to an actual annual dose in the surrounding area of less than 6 mSv in a year or 24 μSv in a working day (assuming 250 days in the working year). These values are fully compliant with the requirements of Regulation 16(1)(b) and with ACoP 248.

The issue that we have is the restriction on IDR implied by ACoP 249. The recommended design limit (0.3 mSv/year) is achieved if the average dose per exposure outside the enclosure ($D_{ave}$) is given by:

$$D_{ave} \leq 0.3/(N \ast T) \text{ mSv}$$

Where $N$ is the total number of exposures in a year and $T$ is the occupancy factor.

The requirement of ACoP 249 is that the maximum dose ($D_{IDR}$) observed outside the enclosure from any single exposure lasting less than a minute is 0.125 μSv. Using the current interpretation, $D_{ave}$ cannot be greater than $D_{IDR}$. These conditions are identical if:

$$D_{IDR}/D_{ave} = 0.125/300 \ast N \ast T,$$

or

$$N = D_{IDR}/D_{ave} \ast 2400/T$$

Up to the point at which $D_{IDR} = D_{ave} = 0.125$ μSv, IDR would dictate the shielding requirements as $D_{ave}$ would be greater than 0.125 μSv. This occurs until there are more than 2400 individual exposures per year—assuming 100% occupancy. That is, the shielding requirements for a facility or room making between 1 and 2400 exposures will be the same even though the annual dose will only reach 0.3 mSv at exposure number 2400. For a low occupancy area of say 10%, the amount of shielding required would be constant for the first 24,000 examinations.

Although applying to all cases with relatively low workloads, this is particularly relevant for dental radiology where the numbers of films taken per week is commonly no more than 10 or 20 in any one surgery. Despite this, blind application of ACOP 249 leads to the conclusion that all surgeries would need to be shielded as if they took a minimum of 50 films per week. The use of the IDR based design approach in this situation could lead to a shielding requirement that is very much more than the ALARP design limit, especially for areas such as corridors, store rooms and waiting areas in which the occupancy by any individual is unlikely to be any greater than 20%. In these cases, the amount of shielding specified would be constant for up to 250 films per week, i.e. all dentistry in the UK would be covered by one shielding requirement. This appears highly disproportionate.

We understand that the purpose of ACoP 249 is for the control of exposure from infrequently used sources that emit high levels of radiation in a short period, for which TADR may be inappropriate. However, we do not consider it appropriate if an overall dose constraint of 0.3 mSv per year is applied for both public and employees, as it will not result in the ALARP design required by ACoP 79.

References

- Institute of Medical Physics and Engineering in Medicine 2002 Medical and Dental Guidance Notes—A Good Practice Guide on All Aspects of Ionising Radiation Protection in the Clinical Environment (York: IPEM)
- National Radiological Protection Board 1993 Occupational, public and medical exposure Doc. NRPB 4 (2)
Dear Sir

We were very interested to read the recent paper by Kutkov, Buglova and McKenna [1] describing their risk approach for evaluating the onset of severe deterministic effects. In particular, it is very useful to see the table of relative biological effectiveness (RBE) values for various deterministic effects and various exposure routes.

Recent work, partly undertaken at AWE, into the use of whole lung lavage (WLL) highlighted that a dosimetric value related to the risk and likely severity of deterministic effects is required when considering emergency medical treatment for intake of radioactive material. The dosimetric quantity of choice for many in the radiation protection community, committed effective dose (CED), is of course weighted by radiation and tissue weighting factors that are based on the RBE and detriment for a stochastic effect endpoint. This means CED is inappropriate for examining the possibility of deterministic effects. Meanwhile, using the non-weighed absorbed dose quantity does not adequately reflect the true risks following an intake.

Therefore, a quantity based on the product of the absorbed dose and an appropriate RBE value for the correct exposure route and deterministic effect endpoint is required. Before the Kutkov, Buglova and McKenna paper we were struggling to find sufficient data on RBE values to fully implement this system.

It is also worth noting the current confusion that exists surrounding the name for this quantity. ICRP Publication 92 [2] endorsed the use of the term ‘gray-equivalent’. However, by ICRP publication 103 [3], the RBE-weighted absorbed dose quantity is expressed only in units of ‘gray’. Meanwhile, NCRP 142 [4] used the units ‘Gy-Eq’ for exposures in space, whilst the Medical Internal Radiation Dose Committee (MIRD) of the Society of Nuclear Medicine [5] have adopted a new unit called the Barendsen for the same quantity. We feel that the quantity and its unit should be distinguishable from absorbed dose, and so have been using the name and unit ‘gray-equivalent’, but it would be useful to have some international consensus on the issue.

References

Kutkov V, Buglova E and McKenna T 2011 Severe deterministic effects of external exposure and intake of radioactive material: basis for emergency response criteria J. Radiol. Prot. 31 237–53
International Commission on Radiological Protection (ICRP) 2003 Relative Biological Effectiveness (RBE), Quality Factor (Q), and Radiation Weighting Factor (wR) ICRP Publication 92 ISBN 0-08-044311-7


Yours sincerely,

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