THE RECORDING LEVEL IN THE 1990s

P J Gilvin, D T Bartlett and R J Tanner

National Radiological Protection Board
Chilton, Didcot, Oxon OX11 0RQ, UK

ABSTRACT

This paper addresses the subject of what is the lowest occupational dose one should try to measure in personal dosimetry for external radiation. This question is raised because modern personal dosemeters have improved measurement capabilities, allowing very small doses to be detected and measured. These are similar in size to natural background doses. It is not intended to provide definitive advice here, but to show what the considerations might be; the discussion is limited to measurements of photon and beta doses, and does not deal with specific systematic sources of uncertainty, such as energy dependence of response.

THE RECORDING LEVEL

The recording level is defined by ICRP (1,2) as "a formally defined value for dose equivalent or intake above which a result from a monitoring program is of sufficient interest to be worth keeping". The Commission recommends (1) that the recording level be based on one-tenth of the dose limit, pro rata for the monitoring period concerned; for personal dosemeters, this effectively sets a minimum standard. However, the Commission also recognises that lower recording levels may be justified for purposes such as analysis of collective dose. In revising the earlier recommendations of Publication 35 (1), ICRP may consider changing the fraction of the dose limit upon which the recording level is based; however, for the present purposes, the value of one-tenth will be assumed. It is to be noted that a "result from a monitoring programme" will necessarily refer to a single component, for example the beta/photon component, of effective dose or effective dose equivalent.

During the last decade, personal monitoring for photon and beta doses was achieved almost entirely by the use of film badges and thermoluminescent dosemeters (TLDs), which, in the main, could detect doses as low as 50-100 μSv. The annual effective dose equivalent limit was 50 mSv, which implied a maximum recording level of about 400 μSv for a typical four-week or one-month monitoring period. For analysis of collective dose, there was a desire to measure doses rather lower than the dosemeters could allow, with a result that the "decision limit" (see below) for the personal dosemeter was usually taken as a recording level.

However, as the 1990 recommendations of ICRP are adopted, there is naturally a pressure to reduce recording levels. Taking an average annual dose limit of 20 mSv (2), the maximum recording level for a four-week period will be reduced to about 150 μSv. This would be achievable by most older systems for photon and beta doses; however recent technological developments now allow still lower doses to be measured comfortably, as discussed below. For demonstrating that average doses are normally well below the maximum recording level, even the improved performance of modern dosemeters might be inadequate.

FIGURES OF MERIT

In describing the limiting behaviour of dosimetric methods at low doses, clear terms must be used. Here, the terminology of Christensen and Griffith (3) is used; their choice essentially followed the work of Currie (4) and of others (5,6). There are three figures of merit for any system, which are as follows. The basic figure, and the one most often quoted, is the *decision limit.* This is also known as the "critical level" or the "detection threshold", and is defined as the level of signal, expressed in terms of dose, at which there is a given confidence (normally 97.5%) that the signal is not due to variations in intrinsic background. Results below this level are not normally reported, or included in dose summations. However, this practice of artificial truncation can be criticised on the grounds that it gives a negative bias to cumulative dose assessments.

The second figure is the level of dose which will, with a certain level of confidence (often 95%), give rise to the correct detection of a dose. This is known as the *detection limit*, and its definition entails not only confidence that the "true" dose has a value at the detection limit, but also that the signal is not due to intrinsic background. See reference (6) for a full discussion. The third figure of merit is the level of dose at which the precision of measurement reaches a certain value, and is known as the *determination limit*. Its use requires the input of the required precision: Christensen and Griffith (3) suggest the use of a relative standard deviation of 45%, derived from consideration of the recommended recording level. In published performance data on dosimetry systems, however, the latter two figures of merit are not often quoted, although it is really one of these which should be compared with the recording level. Which of the detection and determination limits should be used for this comparison is a question which needs resolving.

NEW TECHNOLOGY

Recent developments in personal dosimetry have seen both an improvement in decision limits for passive dosemeters, and the advent of electronic dosemeters. Typical standard TLD systems now have decision limits of less than 25 μSv (see for example references 7 and 8), whilst better performance is claimed to be possible when laser heating methods are used (9). The availability of systems based on LiF: Mg,Cu,P (10) is expected to reinforce this capability, giving routine decision limits of 10 μSv and lower. Most recently, a system has been described which uses a special plastic matrix in a technique known as cooled optical luminescence dosimetry (11), and which may have a decision limit much lower than 1 μSv.

Active personal dosemeters have been widely used for some years, but recent advances have allowed doses to be measured over a wide range of photon and beta energies, to the extent that electronic dosemeters can now form the basis of "legal" dosimetry services. NRPB has been running a legal dosimetry service based on the Siemens/NRPB Electronic Personal Dosemeter (EPD) (12) for over a year; the dosemeter uses PIN diodes and possesses a decision limit of 1 μSv. In a separate development, the Direct Ion Storage (DIS) dosemeter, using a modified EEPROM chip, has been shown to have a similar capability (13). One of the ways in which the mode of use of active dosemeters differs from that of passive dosemeters is in the monitoring period. Users of electronic dosemeters are likely to be nuclear site operators, where dose information may be stored on a daily basis. In this case the monitoring period can be said to be one day, and the recording level may need to be viewed accordingly.

Using the ICRP recommended average annual effective dose limit of 20 mSv, the recording level for a four week or one month monitoring period can be derived as about 150 μSv. For one day, the figure will be about 5 μSv. As suggested above, this figure ought to be compared with either the detection or the determination limit for the dosemeter concerned; however the foregoing paragraphs have quoted values of the decision limit. The relationship between the decision limit and the higher figures of merit will vary according to the specific dosemeter type, and it is therefore impossible to infer the values for the latter in a general way. For the present purposes, however, it may be appropriate to compare the recording level with a value equal to twice the decision limit. Using this simplistic approach, it can be seen that most passive systems will comfortably meet the requirement to measure doses as low as the recording level for four weekly or monthly wearing; whilst active devices can similarly meet the recording level for daily monitoring. However, for analysis of collective dose, the limitations of the dosimetry systems still need to be borne in mind.

NATURAL BACKGROUND

There remains one further factor to be considered when dealing with recording levels: the magnitude and variability of natural radiation background dose. The components of natural background which are detected by beta/photon dosemeters are solely those of cosmic rays and terrestrial gamma radiations. In the UK, for example, these amount to an annual average effective dose of 600 μSv, with a range of about 300 - 1000 μSv (14) determined by geological and geographical factors.

Whilst mean occupational doses have been higher in the past, these are now being reduced to levels where natural background doses are significant by comparison. The operators of single sites can take reasonable account of local natural background by measurement, provided that the distinction between natural and occupational dose is clear. Here the uncertainty in natural background will depend chiefly upon the measurement method. By contrast, commercial personal monitoring services who supply many sites may adopt one of two approaches: a global average figure can be used, or extra dosemeters can be supplied, as controls. Both approaches have drawbacks. In the first case, local variations in background are not taken into account, whilst in the second, extra cost is involved and several dosemeters must be used to obtain a useful value.

CONCLUSION

At very low dose levels, such as are measurable by modern dosemeters, it may be the case that natural background represents a large fraction of the total dose received by an individual. It may at least be true that it is no longer the technical capability of the dosemeter which limits the smallest dose to be recorded (the local recording level), but rather the complexity and cost of eliminating natural background doses from measurements of personal dose. At present it appears that passive dosemeters with decision limits of 10 - 20 μSv, and electronic dosemeters with decision limits of 1 μSv, are sufficient to meet all low dose measurement requirements. It is probably not worth investing resources in improving decision limits further, when dosimetric performance is no longer a limiting factor in determining practical recording levels.

The views expressed herein are those of the authors and not necessarily those of NRPB.

REFERENCES

1. ICRP Publication 35, *Ann.ICRP* 9 No. 4 (1982)
2. ICRP Publication 60, *Ann.ICRP* 21 Nos. 1-3 (1991)
3. P Christensen and R V Griffith, *Radiat.Prot.Dosim.* 54, 279-285 (1994)
4. L A Currie, *Anal.Chem.* 40, 586-593 (1968)
5. P L Roberson and R D Carlson, *Health Physics* 62(1), 2-9, 1992
6. C R Hirning, *Health Physics* 62(3), 223-227, 1992
7. P J Gilvin, J D Steele, D C Rose, D K Perkins, D T Bartlett, D J Sandford and J C Dutt, "Changes in the NRPB Body TLD System", 11th Int. Conf. Solid State Dosimetry, Budapest, July 1995. To be published in *Rad.Prot.Dosim.*
8. J W E van Dijk and H W Julius, "Dose Thresholds and Statistical Analysis of Routine Individual Monitoring Data", ibid.
9. V K Mathur, J K Barkyoumb et al. "Performance of a Laser Heated System for Personnel Radiation Protection Dosimetry", ibid.
10. T Nakajima, Y Murayama, T Matsuzawa and A Koyano, *Nucl.Instr.Meth.* 157, 155-162 (1978)
11. S D Miller and C Yoder, "Cooled Optical Luminescence Dosimetry in Plastic Matrices", 11th Int. Conf. Solid State Dosimetry, Budapest, July 1995. To be published in *Rad.Prot.Dosim.*
12. D T Bartlett, P H Burgess, C Cranston, D Higginbottom, T O Marshall and K W Sutton, *"Radiation Protection Theory and Practice"*, Proc. 4th Int.Symposium of SRP, Malvern, UK, June 1989, 265-268
13. C Wernli, "Dosimetric Characteristics of a Novel Personal Dosemeter Based on Direct Ion Storage (DIS)", 11th Int. Conf. Solid State Dosimetry, Budapest, July 1995. To be published in *Rad.Prot.Dosim.*
14. J S Hughes and M C O'Riordan, *"Radiation Exposure of the UK Population - 1993 Review"*, NRPB Report R263, HMSO, UK, 1993.