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TYPE TESTING OF AN EXTREMITY FINGER STALL DOSEMETER BASED ON HARSHAW TLD EXTRAD™ TECHNOLOGY

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A new type of extremity dosemeter, which incorporates the Harshaw TLD EXTRAD™ dosemeter element into a PVC finger stall, has been developed. The dosemeter uses high-sensitivity lithium fluoride, ^{7}LiF:Mg,Cu,P (TLD-700H) in a thin 7 mg cm^{-2} layer, with alternative coverings of PVC at 10 mg cm^{-2} and aluminised polyester at 3.2 mg cm^{-2}. Results are presented of the type testing of both versions of the finger stall dosemeter against published standards.

INTRODUCTION

Following its development in the 1980s(1–4) as a successor to systems based on loose lithium fluoride powder, the 'Vinten' extremity dosemeter became widely used in the United Kingdom. The dosemeter was based upon the use of heat-resistant Kapton™ foil and adhesives which allowed a quantity of thermoluminescent material to be deposited, in a thin but consistent layer, onto a surface which could later be heated for thermoluminescence (TL) readout. Furthermore, by extending the use of the adhesive Kapton foil, the dosemeter could be attached to a metal plate, thus providing the possibility of automatic feed through a TL dosemeter (TLD) reader.

The finger stalls(1–4) contained a dosemeter strip, 10 mm × 80 mm, which housed a bar coded label to identify the dosemeter together with the sensitive element. The latter was 6 mm × 10 mm in size, with a layer of lithium fluoride (LiF:Mg,Ti) deposited onto it at a mass thickness of 7 mg cm^{-2}. In its original format(1–3), the strip was covered in black polythene of mass thickness 6 mg cm^{-2}; later, this covering was changed to aluminised polyethylene terephthalate at 3 mg cm^{-2}, so improving the response to low-energy beta radiations(4).

In this format the dosemeter performed excellently, e.g. in a European intercomparison(5), with its particular strength being its sensitivity to low-energy radiations. A drawback was the inability to reliably re-use the dosemeter: the creasing and distortion caused to the rather long dosemeter strip during use prevented the recovery of used dosemeters from being cost-effective. On the other hand, the single-use approach meant that relatively high loss rates during use could be tolerated, at least on cost grounds.

In recent years, production of the 'Vinten'-style extremity dosemeter has been taken on by the Thermo Electron Corporation, who also manufacture Harshaw TLD™ products. As a result of decisions on rationalisation, the 'Vinten' line is to be discontinued. Whilst ring-style dosemeters are available(6,7), finger stalls remain popular in the United Kingdom. This paper describes the approach being adopted by a number of UK dosimetry services in providing a finger stall option, based on the Harshaw TLD EXTRAD™ dosemeter element.

A further opportunity has been taken at this stage to make use of high-sensitivity lithium fluoride, LiF:Mg,Cu,P. Its greater sensitivity over conventional lithium fluoride has allowed the use of a smaller quantity of material in the dosemeter design. Therefore, although the EXTRAD dosemeter configuration has been in use for some time, the development of usable LiF:Mg,Cu,P powder (Harshaw material TLD-100H, 700H, etc.) has now allowed a thin detection layer to be employed.

In turn, the use of a thin layer of LiF:Mg,Cu,P has allowed the development of a finger stall with a good response to low-energy radiations. The present paper describes the type testing of the two variants of finger stalls now available.

SYSTEM DESCRIPTION

The EXTRAD elements comprise a Kapton™ backed film of 0.165 mm thickness, 9.5 mm width and 24.2 mm long, with the thermoluminescent material LiF:Mg, Cu,P deposited, in powder form at 7 mg cm^{-2}, in an area of 18 mm^{2} located near one end. The remainder of the face bears a bar code label which can

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withstand the required anneal temperatures. The elements are stiff and robust and are designed to be re-used many times.

Before use, the EXTRAD dosemeters are loaded into the finger stalls. Two variants of finger stall, with differing coverings, were tested. Both are manufactured from PVC and have integral pockets at the finger tip to house the dosemeter elements: as supplied, one end of the pocket is open, to allow the dosemeter element to be inserted before being heat-sealed in place. Stalls are 89 mm in length, and are available for two finger sizes, corresponding to maximum diameters of ~20 and 24 mm. The reverse side of the finger stalls is matt white, to allow for labelling.

The optional coverings are black PVC, at 10 mg cm^{-2}, and aluminised polyester, at 3.2 mg cm^{-2}. The black PVC is heat-welded into the stall during production, whereas the aluminised polyester is in the form of a rectangular patch, glued over an open window in the PVC. Both coverings are available with both sizes. The stalls are produced by S M Alexander Plastics, St Neots, Cambridgeshire, UK. Figure 1 shows the different options.

All TLD readouts were carried out using Harshaw TLD 8800™ hot gas readers with the manufacturer's recommended time–temperature profile, including a pre-heat stage, as follows:

(i) pre-heat to 165°C for 10 s;
(ii) ramp rate 15°C s^{-1} to a readout temperature of 255°C, integrating for 13.3 s;
(iii) anneal at 255°C for 10 s.

Procedure for residual signal

One of the characteristics of LiF:Mg,Cu,P is its higher residual signal compared with that of conventional lithium fluoride[8,9]. Typically, the residual signal remaining after one read is of the order of a few per cent in most commercial LiF:Mg,Cu,P TLD. However, it has been reported recently that the Harshaw TLD has made progress to reduce the residual signal of its LiF:Mg,Cu,P to <1%[10]. One way of dealing with this is to repeatedly anneal dosemeters until the residual signal drops to an acceptable value; but since most dosemeters used in occupational exposure assessment receive little or no dose, extra anneals will only be required for a small proportion of them. The Harshaw TLD 8800™ readers used in these tests can be programmed to repeatedly anneal dosemeters to below a predefined level.

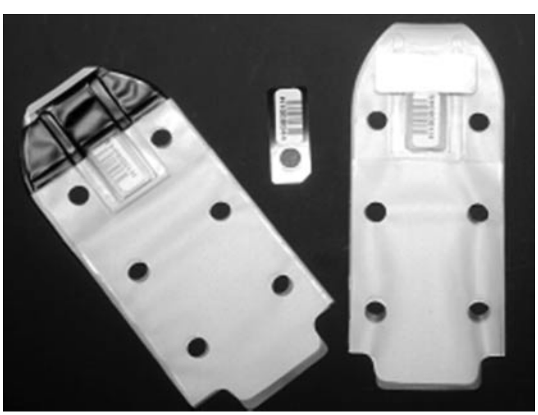

Figure 1. Finger stalls, showing different coverings and different sizes.

However, in a new development, the EXTRAD™ dosemeters now available include a bar code label which can withstand temperatures of up to 300°C and still remain legible. This means that an annealing oven can be used for the EXTRAD™ dosemeters, provided its temperature control is reliable. This allows for the mass annealing of dosemeters in routine situations, as well as providing a simple way of dealing with residual signal.

TYPE TESTING

The standard chosen against which to test the performance of the extremity finger stalls was ISO 12794:2000[11]. However, the requirements on Approved Dosimetry Services in UK[12] include an obligation to ensure that the dosemeter is suitable for all intended areas of use, and the present tests therefore go beyond the requirements of the ISO document where this was deemed necessary. Details are given in the description of results below.

Type testing was divided between the Radiation Protection Division of the Health Protection Agency (HPA RPD, formerly the National Radiological Protection Board), UK and Thermo Electron Radiation Measurement & Protection, Oakwood, OH, USA. Thermo arranged photon irradiations with the Pacific Northwest National Laboratory of the US Department of Energy.

All tests on response were carried out in terms of the ICRU[13] personal dose equivalent quantity $H_p(0.07)$. Conversion coefficients from air kerma to $H_p(0.07)$ were taken from ISO 4307-3[14] for photons and the draft standard ISO 6980[15] for betas. Irradiations for energy and angle dependence of response were carried out on a PMMA rod phantom of diameter 19 mm and length 30 mm.

EXTRAD dosemeters were sealed into finger stalls where this was necessary for the correct completion of the tests. In other cases, e.g. the test for residue, the presence of the finger stall would not affect the overall result and the EXTRAD dosemeters were therefore exposed alone.

In all tests, calibrated readers and dosemeters were used.

RESULTS—ISO 12794:2000 STANDARD TESTS

The descriptions below refer to the requirements and performance tests described in ISO 12794:2000[11], to which the reader is referred for full details. Unless otherwise stated, 20 dosemeters were used in each test.

Batch homogeneity

The coefficient of variation of the evaluated value for n dosemeters shall not exceed 15% for a dose of 10 mSv or less.

A total of 100 calibrated EXTRAD dosemeters (i.e. with element correction coefficients applied) were randomly chosen and irradiated to 2.18 mSv, using the built-in calibrated $^{90}Sr/^{90}Y$ source. Dosemeters were not loaded into finger stalls for this test. The average evaluated dose was 2.17 mSv and the standard deviation s was 0.14 mSv, yielding 6.5% for the coefficient of variation. The requirement was easily met.

Reproducibility

The coefficient of variation of the evaluated value for n dosemeters shall not exceed 10% for each dosemeter separately, for a dose of 10 mSv or less.

A set of 20 EXTRAD dosemeters were irradiated to 0.4 mSv using the built-in calibrated $^{90}Sr/^{90}Y$ source, and the process repeated 10 times within one working day. The coefficient of variation was computed for each dosemeter. The results lay in the range 0.4–1.8%. The performance was much better than the requirement.

An extension test was devised to simulate typical dose patterns in practical situations. Five EXTRAD dosemeters were read ~100 times with periodic irradiations of 2.1 mSv once every five reads. Figure 2 shows the percentage change in signal over the 100 re-uses as compared with the first read. The decrease in response was <4% for any dosemeter over the 100 re-uses.

Linearity

The response shall not vary by >10% over the dose equivalent range 1 mSv to 1 Sv.

The PVC style was chosen to carry out this test as the covering filtration should not effect the linearity performance. Exposures were carried out using two radiation qualities: N-80[14] (mean energy ~65 keV), with doses up to 1 Sv, and ^{137}Cs, with doses up to 100 Sv. Over the range 1 mSv to 1 Sv, no significant departure from linearity was found. Over the extended range up to 100 Sv, some fall-off of response was found, but this was limited to ~30% at the highest dose level. Results are shown in Figure 3. The requirement of the standard is met.

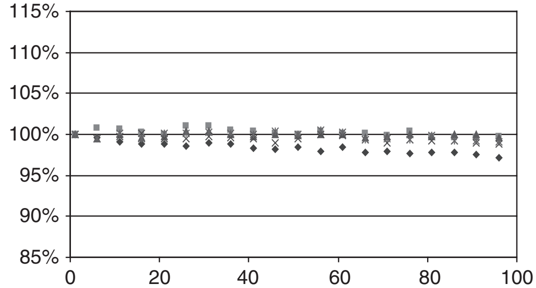

Figure 2. Change in response over 100 cycles, response assessed every fifth cycle. Cycle no. vs. relative response, five EXTRAD dosemeters.

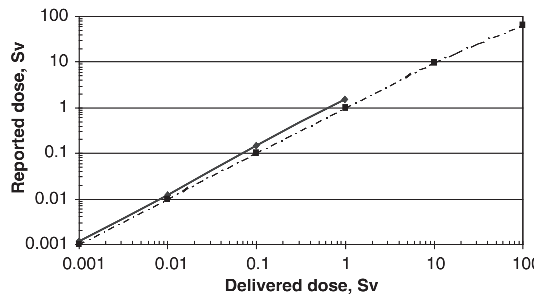

Figure 3. Linearity of Hp(0.07) response, photons. Radiation qualities N-80 (solid line) and ^{137}Cs (broken line).

Climatic stability

The evaluated values of dosemeters irradiated either at the beginning or at the end of a storage period shall not differ from the conventional true value by more than

(1) 5% for 30 d storage under standard test conditions, or
(2) 10% for 48 h storage at 40°C and 90% relative humidity.

In view of the intended use of the finger stalls for three-month issue periods, test (1) was extended to 90 d. For both tests, two groups of 15 finger stalls, one of PVC type and the other of aluminised polyester (PE-Al) type, were used. From each group, five dosemeters were given a dose of ionising radiation before the test, five were dosed after the test and five were not dosed. Doses were delivered in the ^{137}Cs routine calibration facility of the HPA Personal Dosimetry Service, and all doses were 10 mSv. The conditions for test (2) were produced in the climatic chamber of the HPA Radiation Metrology

Group (model Delta 335, produced by Design Environmental, UK). Dosemeters were evaluated promptly after exposure.

In the Standard Conditions test (1), no difference was found between the two types of finger stall. Over 90 d, the quantity $(E \pm I_i)$[11]—which can be approximately described as the worst-case response ratio—was found to have a value of 0.97 for the set dosed at the beginning of the period (signal fading effect), and 0.94 for the set dosed at the end (ageing effect or loss of sensitivity). This indicates that, whenever the dosemeters receive a dose throughout the 90-d period, the assessed dose will typically be ~5% too low. Making the assumption that the ageing and fading occur uniformly with time, the standard is comfortably met.

This finding corresponds to a similar result for Harshaw body TLD cards[16], which also exhibit negligible ageing and fading over a similar period.

The control set in test (1) gave an average implied natural background dose rate of 1.37 μSv d^{-1}, with a relative standard deviation of 3.6%. This is close to the value of 1.27 μSv d^{-1} measured in previous tests, and it is therefore concluded that there is no age effect on unexposed dosemeters, after 90 d in standard conditions.

In the Severe Climate test (2), all results were null. For each of the dosed groups, whether for PVC or PE-Al, or whether dosed before or after the climatic exposure, the mean evaluated doses lay within 10% of, and within one standard deviation of, 10 mSv. The unexposed group, for both covering material types, showed mean net signals which were not significantly different from the expected natural background dose.

Therefore there is no effect, on either type of dosemeter, of storage for 48 h at 40°C and 90% relative humidity.

Detection threshold

The detection threshold shall not exceed 1 mSv.

The detection threshold is defined in the standard[11] as the 'minimum evaluated value for which the readout value of a dosemeter . . . is significantly different (at the 95% confidence level) from the readout value of an unirradiated dosemeter'. This definition corresponds to the quantity defined by Christensen and Griffith[17] as the *decision limit*, L_C. For a sample of 20 dosemeters, the 95% confidence level corresponds to a single-sided Student's *t* factor of 1.73. Hence, if σ is the standard deviation of the evaluated value of the group of 20 unirradiated dosemeters,

$$L_c = 1.73\sigma$$

For the present tests, a set of dosemeters was annealed, and, within 1 d, evaluated. The value of L_C was found to be 9.2 μSv, two orders of magnitude lower than that required by the standard.

Note, however, that in practice the uncertainty in assessing zero occupational dose—e.g. for a monthly issue period—will depend on the uncertainty in natural background compensation as well as in the clearance of previous residual signal.

Self-irradiation

After a storage period of 60 d, the zero point shall not exceed 2 mSv. If E is the mean evaluated value, I is the half-width of the confidence interval (95% in this case) and C_B is the background, then

$$(E+I) - C_B \geq 2\ mSv.$$

Ten EXTRAD dosemeters were prepared and stored in a 'lead castle', built with lead bricks in a normal laboratory, for 60 d. Assuming, therefore, that the background C_B was zero, the value of $(E + I)$ was 0.07 mSv. The requirement is comfortably met.

Residue

After irradiation with a conventional true value of 100 mSv, the detection threshold limit shall not be exceeded and the response shall remain within the requirement for linearity at a dose level of 2 mSv.

As discussed above, LiF:Mg,Cu,P material typically has a residual signal of ~1%. In this test, a set of calibrated EXTRAD dosemeters were dosed to 100 mSv in the HPA PDS calibration facility and read out repeatedly. The mean residual signal on second read was 1.0% and a maximum of nine reads were required to reduce the signal <0.05 mSv.

One week later, the same dosemeters were annealed, then dosed to 2 mSv. After 2 d the dosemeters were evaluated. Responses for all dosemeters lay within ±9.5% of their calibrated value. Hence, provided that the recommended annealing regime is followed, the requirement of the standard is met.

Effect of light exposure (simulated sunlight)—finger stalls

As a result of exposure to 1000 W m^{-2} equivalent to bright sunlight (295 nm to 769 nm) for 1 d, the zero point shall not change by >1 mSv and, for exposure during one week, the evaluated value shall not differ from the evaluated value of a dosemeter kept in the dark by >10%.

Because the dosemeters are re-usable, it was decided to dispense with a control 'dark' set and instead to compare the behaviour of a single set of dosemeters, after simulated sunlight exposure, with their behaviour before.

Table 1. Effects of simulated sunlight on finger stalls, PVC type and aluminised polyester (PE-Al) type.

	PVC	PE-Al
Mean change in zero point after 24 h exposure	0.02 mSv	0.09 mSv
Mean relative response after 1 week exposure	0.99	0.84

Twenty EXTRAD dosemeters were prepared and dosed to 10 mSv in the HPA RPD ^{137}Cs calibration facility. They were evaluated and their individual relative responses noted. The dosemeters were then annealed and used to produce two groups of finger stalls, PVC and PE-Al.

Both groups of finger stalls were then exposed to simulated sunlight for 24 h in a SOL 2 solar simulation unit, produced by Dr Hönle (AG of Munich, Germany) and providing a total intensity of 910 W m^{-2}. The dosemeters were removed from the stalls, evaluated and annealed. The evaluated values were compared with the zero-point values determined before the exposure.

The initial 10 mSv exposure was then repeated and the EXTRAD™ dosemeters loaded into fresh sets of finger stalls before being exposed once more in the SOL 2 unit, this time for 1 week. At the end of this time the dosemeters were removed from the stalls, evaluated and annealed. The evaluated values were compared with the corresponding values evaluated before the exposure to simulated sunlight.

The results of these tests are given in Table 1. Both types comfortably passed the zero-point test, although the PE-Al type gave a higher result, with an average additional signal of 0.09 mSv. The worst single result was 0.13 mSv.

However, whereas the PVC type comfortably passed the response test, the PE-Al type failed, with a 16% drop in relative response following a continuous exposure for 1 week to simulated sunlight.

Exposure to strong sunlight for such lengthy periods is highly improbable in normal situations, and this finding should not preclude the use of the PE-Al variant of the finger stall. However, clients should be advised of the possible effects. In this respect the PVC stall is more robust.

Isotropy (photons)

When irradiated with photons of (60 ± 5) keV, the mean value of the response at angles of incidence of 0°, 20°, 40° and 60° from normal shall not differ from the corresponding response for normal incidence by >15%.

The prescribed test was extended to include ^{137}Cs as well as N-80[14] (mean energy ~65 keV), with extension in angle to 90° from normal. The angles used were 30°, 60°, 80° and 90°. This was applied to both PVC and PE-Al styles. All rotations were made about the principal or longitudinal axis of the rod phantom, and the delivered doses were ~10 mSv. Results are shown in Figure 4, normalised to the response at 0° in each case. In no case does the deviation from normal-incidence response exceed 10%, even at 90°. The requirement of the standard is exceeded.

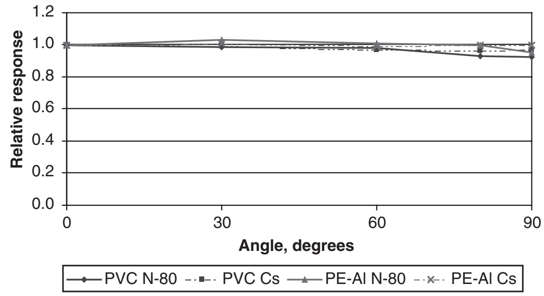

Figure 4. Isotropy or angle dependence of response, for the two types of the finger stall, for N-80 and ^{137}Cs qualities.

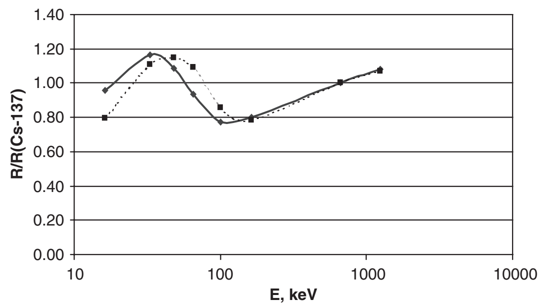

Figure 5. Photon energy dependence of response for finger stalls, PE-Al (solid line) and PVC (broken line).

Energy response (photons)

When irradiated with photons in the energy range 15 keV to 3 MeV, the response shall not vary by more than ±50%.

Samples of dosemeters were irradiated using a selection of radiation qualities in the prescribed range, covering from N-20[14] (mean energy ~16 keV) to ^{60}Co (mean energy 1250 keV). The delivered doses were ~10 mSv. Results for both styles of finger stall are shown, normalised to ^{137}Cs, in Figure 5. The maximum overresponse for either type is around +20%, occurring in both cases at low-photon energies of 50 keV or less, whilst the maximum under-response is approximately −20%, occurring at energies

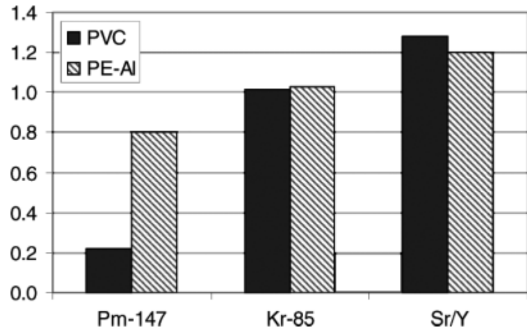

Figure 6. Energy dependence of beta response for PVC and aluminised polyester (PE-Al) types of finger stall. Responses normalised to ^{137}Cs photon response.

~100 keV. The requirement of the standard is met. The data shown here are comparable with those given elsewhere[7] for the LiF:Mg,Cu,P version of the DXTRAD™ finger-ring dosemeter[7].

Energy response (beta radiation)

When irradiated with beta radiation in the energy range (E_{max}) 0.5 to 3 MeV, the response shall not vary by more than ±50%.

Irradiations were carried out using a PTB secondary standard unit. In view of the use by some clients of low-energy beta emitters, the nuclide ^{147}Pm (E_{max} = 224 keV) was included in addition to nuclides in the prescribed range. These were ^{85}Kr (E_{max} = 687 keV) and ^{90}Sr/^{90}Y (E_{max} = 546 keV and 2280 keV). A further set of exposures was carried out using the HPA PDS ^{137}Cs calibration facility, and all the beta response values have been normalised to this result. Figure 6 shows the results for both types of finger stall.

Both types of finger stall meet the requirements of the standard, based on the nuclides chosen to represent the specified energy range. For low-energy beta emitters, however, the aluminised polyester version is superior, giving a relative response within ±20% over the full range.

RESULTS—EXTENSION TESTS

Further tests were undertaken to demonstrate suitability in particular applications. These were

(1) *Isotropy, or angle dependence of response, for beta radiations.* Since dosemeters can be worn on the finger in a variety of orientations, and likewise can be presented to the source of radiation in a variety of orientations, it should be demonstrated that the response does not fall off significantly with the angle of incidence.
(2) *Immersion test.* Since extremity dosemeters are used in medical applications, they often require sterilisation. Water and sterilising agents could affect the EXTRAD elements if they are not protected properly. It should be demonstrated that the dosemeters are unaffected by immersion in water.
(3) *Solvent test.* Should solvents penetrate the sealed pocket in which the EXTRAD element resides, there is a risk that the lithium fluoride powder will be dissolved. Resistance to this risk should be tested.
(4) *Effects of laboratory lighting on the dosemeter element.* Whereas ISO 12794[11] calls for tests on light exposure of the complete finger stalls—as in routine use—it is useful to check how the EXTRAD elements respond to laboratory lighting.

Table 2. Isotropy or angle dependence of response.

Finger stall type	Nuclide	Relative response 30°	60°
PVC	^{147}Pm	0.94	0.99
	^{85}Kr	1.00	1.18
	^{90}Sr/^{90}Y	0.95	0.96
PE-Al	^{147}Pm	0.96	0.91
	^{85}Kr	0.98	0.99
	^{90}Sr/^{90}Y	0.97	0.92

Responses normalised to 0°. Typical relative standard deviations were 10–15%.

Isotropy (beta radiations)

The draft standard ISO 6980[15] contains conversion coefficients for $H_p(0.07)$, for exposures on the ISO rod phantom and for angles of incidence up to 60° only. Accordingly, exposures were carried out in the Radiation Metrology Laboratory of HPA RPD at angles of 0°, 30° and 60° for each of the three nuclides used in assessing the energy dependence of response. Five finger stalls were used, mounted on the rod phantom. Table 2 shows the evaluated responses for 30° and 60°, normalised to the corresponding 0° response, in each case.

Apart from one result, all the responses lie within ±10% of the 0° response; and all, including the outlier, lie within ±20%. Since the relative standard deviations for each test are between 10% and 15%, it can be concluded that the isotropy for beta radiations is acceptable over the range 0–60°.

Immersion

Of the two types of finger stall, both require heat-sealing to encapsulate the EXTRAD element within the stall. However, in the aluminised polyester

(PE-Al) type, the covering is provided by an adhesive patch rather than a heat-welded layer of PVC. Arguably, therefore, there is more risk of fluid ingress with the PE-Al type, and therefore this was the type of stall tested against immersion. The test focused on the potential for spurious signals caused by deposits of chemicals left by fluids on the EXTRAD element.

Ten calibrated EXTRAD dosemeters were annealed before being heat-sealed in a random sample of finger stalls and immersed in water for 6 h. The water was agitated regularly. At the end of the period the finger stalls were cut open and the EXTRAD elements inspected. All were dry. They were next evaluated, and no significant difference found over the pre-immersion value.

This not only demonstrates the low risk of spurious signals, but also the low risk of another effect: the possible reduction of stored signal and of dosemeter sensitivity by dissolution, by a contaminating fluid, of the lithium fluoride powder.

Solvents

The test was conducted by soaking a 'cotton bud' in a solvent and firmly rubbing at the lithium fluoride powder contained on a calibrated EXTRAD element, for ~5 s. The solvents tested were alcohol-based hand wash, a common screen cleaner and water. The EXTRAD elements were then re-calibrated. No significant difference was found in the element correction coefficients.

This result shows that the EXTRAD elements are resistant to dissolution, for the solvents in question.

Laboratory lighting

The simulated sunlight test required by ISO 12794[11] is intended to indicate effects during use in the field, with the EXTRAD dosemeters loaded into the finger stalls. However, during dosemeter production and processing the naked EXTRAD dosemeters will be exposed to ambient laboratory lighting, and it is useful to ensure that any effects of such lighting are minimal. A previous study had found that laboratory lighting could produce spurious signals, but that these were small[18].

Tests were designed to simulate likely exposures in routine operations at the dosimetry service. Two exposures were given:

- a 1 h exposure on a desktop, at ~1.7 m distance from a typical fluorescent tube (predominant wavelength 366 nm);
- a 0.25 h exposure under a workbench inspection lamp, also of fluorescent type, at a distance of ~0.2 m.

A set of 10 EXTRAD dosemeters was calibrated using the Harshaw TLD Model 8800™ reader built-in irradiator, and annealed, before undergoing the above exposures. Following the exposures, the dosemeters were evaluated immediately. The results, in terms of excess net signal, were the same for both types of exposure. The average excess doses were 14 μSv (desktop) and 13 μSv (workbench), with the worst cases being 41 μSv (desktop) and 54 μSv (workbench). Both these worst-case values were for the same EXTRAD. This dosemeter and the relevant glow curves were inspected, but no abnormality was found.

Finally, the test EXTRAD dosemeters were given a dose of 1 mSv and the 'desktop' exposure repeated. The observed mean difference in response, of +1.3%, was not significant.

The conclusion is that, in terms of apparent excess dose, laboratory handling may induce signals of up to 50 μSv on unused dosemeters, but that in most cases the effect will be smaller. Meanwhile, exposure to laboratory lighting is most unlikely to affect the stored signal on used dosemeters.

CONCLUSIONS

The two types of finger stall tested here are suitable for use in a wide variety of applications. The requirements of the ISO 12794 standard[11] are met or exceeded, provided that the LiF:Mg,Cu,P dosemeters are annealed as prescribed, with the exception mentioned below.

The two types are equivalent in performance except in two respects:

(1) *The PE-Al version is able to detect beta radiations with maximum energies as low as 224 keV (^{147}Pm), whereas the PVC version is limited to* E_{max} = 687 keV (^{85}Kr);
(2) *The PVC version has a better resistance to the effects of sunlight, showing negligible effects whereas small spurious signals, and a reduction in stored signal beyond that allowed by the standard, can be induced by sunlight in the PE-Al version.*

Provided users are informed about the potential effects of sunlight on the PE-Al version, it is not felt that the latter will be a significant issue.

The PE-Al version of the finger stall provides a suitable replacement for the Vinten-type dosemeter[4]. Its response to the low-energy beta radiations from ^{147}Pm is almost as good as that of the Vinten dosemeter, and its angle dependence of response is equally good. Like the Vinten dosemeter, it is stable in a variety of use conditions, but care must be taken to protect it from sunlight[4]. In view of its superior resistance to sunlight exposure, the PVC stall should be preferred where the low-energy beta response is not required.

Further work

The work reported here constitutes a full laboratory-based type test of the two variants of finger stall, using the EXTRAD dosemeter with LiF:Mg,Cu,P. To complete suitability testing, work is now proceeding to field trials.

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