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# ROUTINE DOSIMETRY WITH TANTALUM 182 AND IRIDIUM 192 WIRES

by

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For more than ten years, flexible radioactive wire has been used for interstitial therapy as an alternative to sealed radium sources.

Tantalum 182 wire has been described by SINCLAIR (1952), and its clinical application reported by several workers, including WALLACE, STAPLETON & TURNER (1952), ELLIS & OLIVER (1954), VAN MIERT & FOWLER (1956), and ALLT & HUNT (1963).

Iridium 192 wire was not introduced until a later date. PIERQUIN (1964) described its use, pointing out that its lower gamma energy greatly simplifies protection problems. The physical properties of tantalum 182 and iridium 192, together with the dimensions of the wires used in this department are summarised in a Table.

The purpose of the present communication is to make available our basic data to new users, to avoid further duplication of effort.

The plan, in our department, has been to express the activity of the tantalum 182 or iridium 192 wire in terms of 'mg of radium equivalent per cm filtered by 0.5 mm of platinum'. This quantity is obtained by comparing a short length

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**Table**

*Comparison of tantalum 182 and iridium 192 wire*

| Property | Tantalum 182 | Iridium 192 |
|---|---|---|
| Half life | 115 days | 74 days |
| % decay per week | 4 % | 6 % |
| Principal gamma energy range | 1.1 to 1.2 MeV | 0.3 to 0.6 MeV |
| Specific gamma-ray constant $cm^2 \cdot R/mCi \cdot hr$ | 6.8 | 4.8 |
| Approx. HVL in lead | 1 cm | 3 mm |
| Approx. 1/10 valve layer in lead | 3 cm | 1.2 cm |
| Wire dimension: | | |
| O.D. | 0.4 mm | 0.3 mm |
| Core | 0.2 mm | 0.1 mm |
| Pt. filtration | 0.1 mm | 0.1 mm |
| Cost of 100 cm of wire + irradiation for 2 weeks + measurement | £26 | £15 |
| Approx. activity produced | 1 mCi/cm | 1.5 mCi/cm |

of the wire against a radium needle of the same active length and a known radium content. The comparison is effected by inserting the wire and needle in turn into a re-entrant ionisation chamber. By always referring to the activity of the radioactive wire in terms of its radium equivalent, the confusion of using several specific gamma ray constants in routine calculations is avoided.

To calculate dose rates from implants with radioactive wire, van Miert & Fowler (1956) followed the Paterson-Parker system; Haybittle (1957) has considered in detail the dose distribution resulting from 'hairpins' of tantalum 182 wire and discussed the conditions under which the Paterson-Parker tables could be used with reasonable accuracy. In many cases, however, the standard dosage tables cannot be applied to tantalum 182 and iridium 192 wire implants because, in general, wires of different linear activities are not available to implement the distribution rules for moulds and surface applicators. In addition, one of the advantages of wires is that they may be used as long sources, the resulting implants having extremely large elongation ratios. As a result it is often simpler to calculate doses by considering the contributions from individual wires, provided the basic data are available in a convenient form. It was thought necessary therefore to calculate the complete dose distributions around radioactive wires of various lengths, and to present the

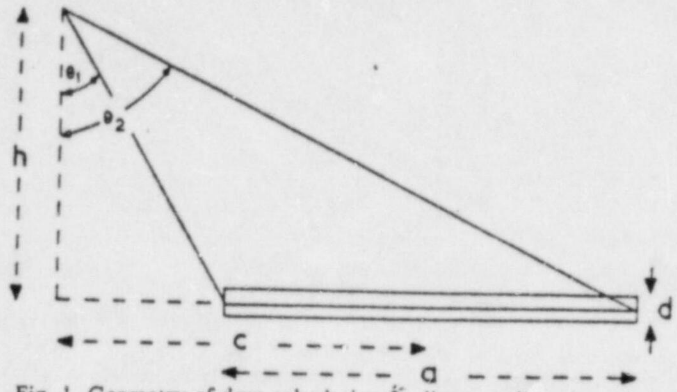

Fig. 1. Geometry of dose calculation for linear radioactive wire.

data graphically in a similar way to the data sheets for standard Amersham radium needles calculated by Kemp (1950) and Kemp & Hall (1952) and made available through the International Atomic Energy Agency. The calculations were carried out in the following way.

The dose rate (in rad per hour in soft tissue) at a point $P$ due to a radioactive line source of length $a$ cm, filtered by material of thickness $d/2$ mm is given by the expression below which follows closely that derived originally by Sievert (1923, 1932)

$$I_p = \frac{8{\cdot}05\, p f}{h} \int_{\theta_1}^{\theta_2} \varepsilon^{-\frac{\mu d}{2\cos\theta}} d\theta \qquad (1)$$

where

$\theta_1 \quad = \tan^{-1} \frac{c - a/_2}{h}$

$\theta_2 \quad = \tan^{-1} \frac{c + a/_2}{h}$

$h$ = perpendicular distance of the point $P$ from the wire (cm)

$c$ = the cross-line, i. e. the distance from the centre of the wire to the foot of the perpendicular from $P$ (cm)

8.05 = specific gamma ray constant for radium (8.3) x roentgen to rad conversion factor for soft tissue (0.97)

$p$ = measured activity of the wire per cm expressed in equivalent mg of radium, filtered by 0.5 mm of platinum

$f$ = correction factor to convert the linear activity of the wire, measured through the screenage, to true linear activity

$\mu$ = linear absorption coefficient of the filtering material, i. e. platinum ($mm^{-1}$).

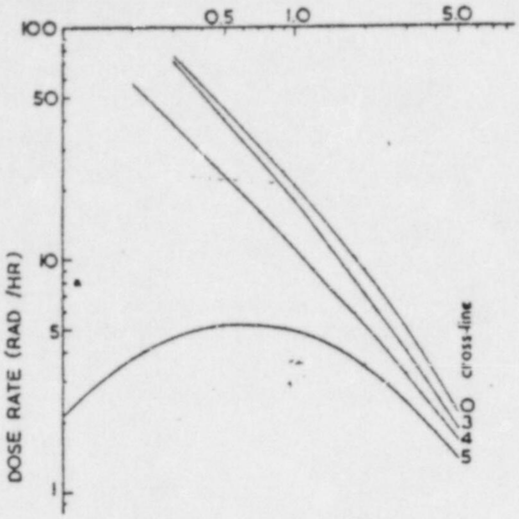


Fig. 2. Data sheet for a length of 8 cm $^{192}$Ir wire of activity 1 mg radium equivalent per cm, filtered by 0.5 mm of platinum. 'Distance' and 'cross-line' are the quantities labelled *h* and *c*, respectively, in fig. 1.

Eq. (1) has been evaluated for tantalum 182 and iridium 192 wires of lengths from 2 to 15 cm. The values of the constants used for the two isotopes are summarized below.

| Constant | Tantalum 182 | Iridium 192 |
|---|---|---|
| $p$ | 1.0 | 1.0 |
| $f$ | 1.02 | 1.07 |
| $\mu$ (mm$^{-1}$) | 0.11 | 0.43 |
| $d$ mm | 0.40 | 0.30 |

When calculating the dose distributions due to radium filtered by a platinum screen KEMP (1950, 1952) introduced a screenage function which allows for the fact that since the gamma radiation is not homogeneous, the effective absorption coefficient of the platinum is a function of path length and therefore varies with obliquity. In the present calculations this effect is ignored and assumed to be constant because the platinum sheath is much less thick in the case of radioactive wire than for radium.

The University of Oxford 'Mercury Computer' was programmed to perform the calculations, making use of the standard Sievert integrals available in the library of this machine. The resultant data were plotted graphically. Fig. 2 gives an example of one of the data sheets for a length of 8 cm of iridium 192 wire. Copies of such data sheets from these calculations for tantalum 182 and iridium 192 wires of lengths from 2 to 15 cm are now available at a nominal charge on application to the Medical Section, Department of Research and Isotopes, International Atomic Energy Agency, Vienna 1, Kaerntnerring 11, Austria.


## Acknowledgements

The stimulus to develop the work described in this paper came from Dr Frank Ellis, Director of the Radiotherapy Department, who routinely uses radioactive wire for implants. We wish to record our appreciation of the facilities provided for us by Professor L. Fox, the Director of the Oxford University Computing Laboratory, for the computations involved.



## SUMMARY

Data sheets have been prepared of the dose distribution around radioactive wires of tantalum 182 and iridium 192. A computor was programmed to perform the calculations, which included an allowance for oblique filtration in the platinum screen.

## ZUSAMMENFASSUNG

Data-Tabellen wurden aufgestellt, die die Dosisverteilung radioaktiver Drähte aus Tantal 182 und Iridium 192 geben. Eine elektronische Rechenmaschine wurde programmiert, um solche Berechnungen auszuführen, wobei eine schräge Filtrierung durch das Platinfilter gesichert wird.

## RÉSUMÉ

Les auteurs ont établi des tableaux donnant la distribution de dose autour de fils radioactifs de tantale 182 et d'iridium 192. Un ordinateur a été programmé pour faire ces calculs qui tiennent compte de la filtration oblique à travers le filtre de platine.


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