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A BETA IRRADIATOR FOR USE IN TL DATING

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An irradiator unit is briefly described which houses a 40 mCi Sr90/Y90 beta source (RCC Amersham; type S1P, 1cm^2 active area, 19mm overall diameter). It has been designed with the following aims in mind;

a) to remove the hazard of accidental exposure of the operator to the source.

b) to obtain radiation levels external to the irradiator of the order of mrad h^{-1} or less in routine operation.

c) to irradiate samples located on the heater plate of the TL oven.

Construction

A cross-section of the irradiator unit (without its transport mechanism) located on the TL oven is shown in figure 1. The oven body and lead housing of the irradiator have cylindrical symmetry about the same vertical axis. The lead housing, manufactured in two parts, has a spherical cavity within which the source-carrying mechanism is located.

The stainless steel axle runs in precision bearings which are supported by two pillars mounted on the steel baseplate. Two rods are fixed to the centre of the axle at right angles to its axis and in the same plane. The source, surrounded by a lead shield, is mounted on one rod and on the other, a lead counterweight/shield. Both lead shields are shaped so that the whole assembly can be rotated within the spherical cavity. An extension of the axle passes through the lead housing and is attached to a control handle. The operator, by turning the handle through 180^{o}, takes the source from its SAFE position to IRRADIATION position facing vertically downwards (there is a stop to locate the source in its correct position). The lead housing and baseplate have been cut so as to provide a circular aperture in the underside of the unit. When in the SAFE position (as shown) the lead counterweight blocks the aperture providing shielding from bremsstrahlung and scattered low energy beta radiation (M.J. Aitken, TLS 60, PACT 3). The lip shown along the outer edge of the horizontal division of the housing also prevents the escape of scattered low energy beta radiation. The source is located at a fixed distance - 15.3mm - above the heater plate (nichrome) by means of three reference locators, one of which is shown in the figure. The locators are manufactured from titanium but stainless steel would be equally suitable.

Use in Laboratory

The oven body, as shown in figure 1, is surrounded by a 25mm thick lead collar from the bench level upwards (6.5cm). The bench is 1m above floor level and wire mesh is fastened to the bench structure to prevent any access to the underside (where the maximum dose-level during irradiation is in excess of 50 mrad h^{-1}).

The irradiator unit is transported to and located on the oven by means of a gantry running on rails (figure 2). The unit is stored in a fire proof steel storage box, adjacent to the oven. The irradiator housing is lowered on and raised from the oven by means of a hydraulic ram.

Once located on the oven, a safety bar (figure 2) is pulled towards the operator, locking the unit onto the oven and allowing the control handle to be rotated. The housing cannot be raised until the handle is restored to the SAFE position as shown and the safety bar returned to its original position. After irradiation the unit is simply raised and wheeled back into the storage box.

Radiation Levels

Measurements with uncalibrated beta and gamma contamination meters have indicated maximum dose-rates on the surface of the housing to be in the region of several mrad h^{-1} and over a substantial area surrounding the unit, below 1 mrad h^{-1}. The maximum dose-rate measured at the wire mesh (below bench level) during an irradiation was 2 mrad h^{-1}.

Subsequent measurements with LiF dosimeters (NRPB, Harwell) placed at various locations on the bench and irradiator during routine use confirmed that the radiation levels are below 2 mrad h^{-1}.

Calibration

The source has been calibrated using a similar procedure to Murray and Wintle (PACT 3, 1979) with calcium fluoride grains on stainless steel discs (calibrated gamma irradiations by NRPB, Harwell). The source delivers a dose-rate of 162 ± 1.5 rad min^{-1} (std. error of six measurements) to 90-105 µm grains of quartz on 0.48mm thick discs of stainless steel resting on the heater plate. The calibrated dose-rate is some 7% less for grains located directly on the heater plate. For pre-dose dating work, an aluminium absorber (3mm thick), interposed between source and sample, gives a 100 fold reduction of the full dose-rate.

A 'probe' disc (with CaF_2 grains spread within a circle of 3mm diameter) has been used to map the dose-rate at different positions on the heater plate. The results show a 10% fall-off in dose-rate at a distance of 5mm from the centre of the plate which is similar to Zimmerman's findings (see Aitken, TLS 60, PACT 3). The mapping procedure, besides providing a useful check on the alignment of the source, gives an important reminder to the operator that 'calibrated' dose-rates apply only over a defined area. For samples spread over a greater area corrections may be necessary.

The Oxford laboratory is also currently testing various designs of irradiator housing, requiring less lead than we have used here.

The author appreciated discussions with Dr. M. Weston (University Radiation Protection Officer) and Mr. A. Sutherland of NRPB, Leeds.

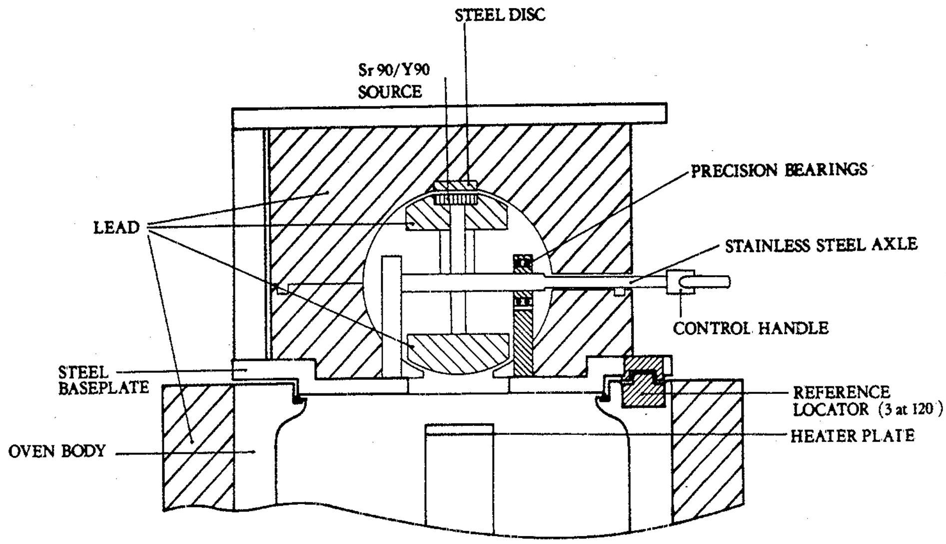

FIGURE 1 Cross-section of irradiator housing located on TL oven (Oxford design). The locators and pillars are spaced at intervals of 120^{o} as indicated in Figure 2.

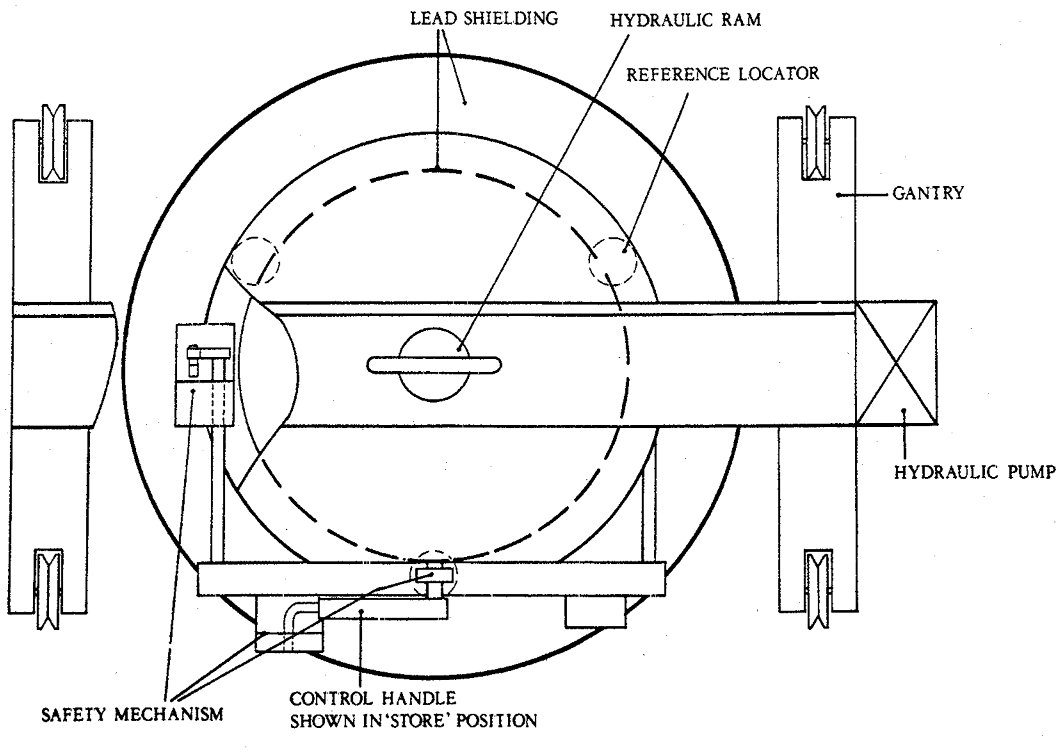

FIGURE 2 A plane view of the irradiator unit, located on the TL oven, with its transportation gantry. The cut-away shows a detail of the safety mechanism. The rails and steel storage cabinet are omitted.