A CALORIMETER FOR LARGE FIELDS OF ACCELERATED ELECTRON BEAM

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INTRODUCTION

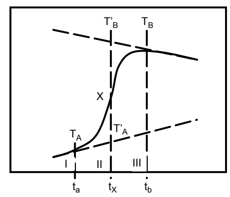
The absorbed dose in a material exposed in electron beam depends on the dimension, the density and the configuration of the material as well as on the beam parameters energy and intensity. Calorimetry is one of the methods for measuring the absorbed dose. With this method we can determine the quantity of heat generated in the absorbent material supposing that the whole energy dissipated by the beam is transformed in heat.

AIM

The calorimeter for large irradiation fields was made for emphasizing a precise and easy method to determine the value of the absorbed dose on the surface and in the depth of a material exposed to electron beam treatment. Our aim was to construct a device useful to the process of electron beam irradiation for the calibration of secondary dosimeters as well as for obtaining a good precision in measurements that should be simple and easy to do.

THEORETICAL CONSIDERATIONS

For measuring the dose in electron beam it was chosen an adiabatic system characterized by minimum thermal change between the calorimeter body and the envelope system. The real temperature variation for the ideal adiabatic case is obtained by extrapolating in temperature region II the linear variation from I and III supposing that the whole quantity of energy is absorbed instantly at the moment t_x.

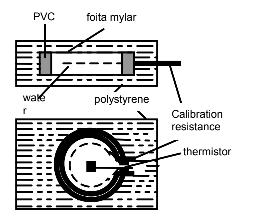


THE EVOLUTION IN TIME OF THE CALORIMETER BODY TEMPERATURE

EXPERIMENT AND RESULTS

CONSTRUCTION OF THE CALORIMETER

In an air-proof cylindrical container of 92 mm diameter and 25 mm height with rigid lateral walls made of PVC is introduced a well determined quantity of distilled water. The temperature detector, a thermistor, is fixed in the middle of the calorimeter body. The glass lid thickness is 2 mm.



THE CONFIGURATION OF THE CALORIMETER DEVICE

The main components of the calorimeter

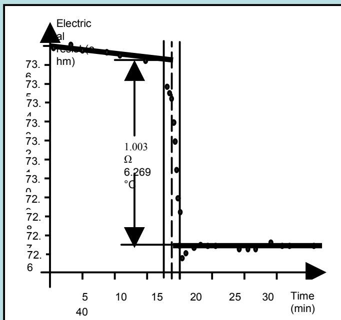
Component	Value
Water mass (grams)	82.03
Electrical resistance (ohm)	40.78
Calorimeter body mass (grams)	119.31
Electrical resistance mass(grams)	0.33
Diode mass (grams)	0.09
Insulation thickness(cm)	3.0
total mass (grams)	241.6

CALIBRATION AND RESULTS

Because the specific heat of the different components of the calorimeter system is not known precise enough, it was necessary to realize an electrical calibration of the entire calorimeter. By calibrating it is transferred to the system a precise quantity of energy and the temperature variation can be determined.

The experimental parameters in the electrical calibrations:

Parameters	Ist Calibration	IInd Calibration
Electrical current (A)	0.75	0.75
Electrical resistance (ohm)	40.78	40.78
Room temperature (ºC)	22	22
ΔΩ / ºC (ohm/ºC)	0.159	0.159
Test time (sec)	120	60
$\sum_i m_i c_i$ ΔΩ (ohm)	1.003	0.348
ΔT_{el} (ºC)	6.269	2.919
	104.89	112.6



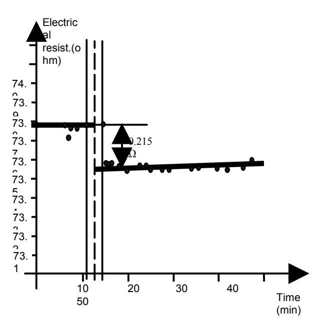
THE ELECTRICAL CALIBRATION

The irradiation was made in vertical unscanned beam with the 10 MeV linear accelerator at the surrounding temperature of 22 ºC. The electron range is 3.5 cm at 7 MeV average energy of the particles and for materials with the density of ρ = 1 g/cm3. The dosimetric system was irradiatted from a distance of 40cm from the exit window of the electrons in the accelerator.By measuring the time and the electrical current that crosses the ohm resistance and the temperature variation can be calculated the electrical energy given to the calorimeter and then the dose absorbed by the material.

The experimental results

Parameters	Experiment Nb.1	Experiment Nb. 2	Experiment Nb. 3
Room temperature (ºC)	20	20	20
Water average temp. (ºC)	25	23	26
ΔΩ / ºC	0.159	0.159	0.159
ΔΩ (ohm)	0.215	0.215	0.215
$\sum_i m_i c_i$ Δt_{irad} (sec)	240	180	60
$\sum_i m_i s_i$ ΔT_{irad} (ºC)	1.535	1.344	0.362
	105.2	105.2	105.2
	187.9	187.9	187.9
Absorbed dose (kGy)	35.9	31.4	0.84

The measurements are affected by an error up to 3%.



THE CALORIMETER CALIBRATION CURVE

CONCLUSIONS

Realized in a simple, constructive manner, the device is easy to use when the energy absorbtion from the primary beam takes place in a short time interval and when the calorimeter body temperature before and after the irradiation is not too high comparing to the surrounding temperature.

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