MINIATURE CALORIMETER IN ELECTRON BEAM

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INTRODUCTION

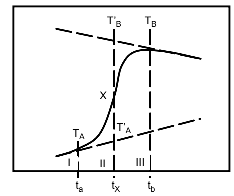
The absorbed dose in a material exposed in electron beam depends on the dimension, the density and the configuration of the material as well as on the beam parameters energy and intensity. Calorimetry is one of the methods for measuring the absorbed dose. With this method we can determine the quantity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

PUROSE

The miniature calorimeter 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. When using a non-homogenous electron beam on small surfaces, constructing a colorimeter device represents generally a special effort taking into account the dimension of the calorimeter body and the realization of the insulation for the temperature measurement elements. Our aim was to construct a device of small dimensions 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

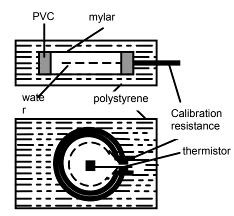
CONSTRUCTION OF THE CALORIMETER

The device is a miniature calorimeter made of a P.V.C. cylinder 3.6 mm in diameter with 2 mm thickness and 1.5 cm depth that has a thermocouple Cu-Ct as temperature detector on the inside and an electrical resistance for calibration. The plan-parallel walls of the calorimeter were made from Mylar disks of 3 microns, made through stamping and sticked to the surface of the box with a thin but strong cover of glue.

The main components of the calorimeter:

Components	m_i (grams)	s_i	$m_i s_i$
Water	8.324	1.0	8.324
Vessel	3.0	0.9	2.7
Thermocouple	0.01	0.69	0.069
Electrical resistance	0.07	0.69	0.048
Sample of dosimetric film	0.039	0.90	0.0351

The insulation of the calorimeter body was made of expanded polystyrene with an average thickness of 30 mm. With this thickness we ensured thermic stability good enough for the entire system; calorimeter body temperature variation at 30 ºC is 0.01 ºC per minute. Experimentally we observed that for polystyrene insulations of 5 mm thickness, the temperature variation is much bigger than 0.2 ºC per minute.



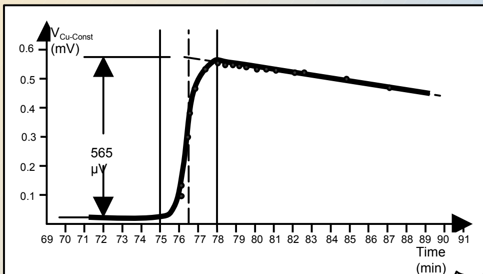
CONFIGURATION OF THE CALORIMETER DEVICE

ELECTRICAL CALIBRATION

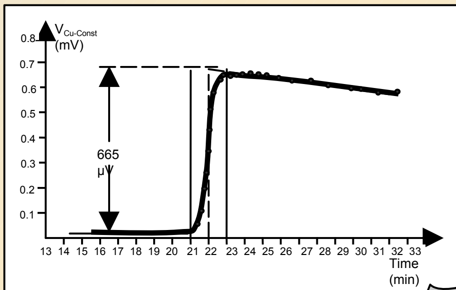
Because the specific heat of the different components of the calorimeter system is not known precise enough, it was necessary to realize an electrical calibration of the entire calorimeter. By calibrating it is transferred to the system a precise quantity of energy and the temperature variation can be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

The experimental results obtained with this device by calibrating a sample of cellulose triacetate (TAC).The value of the electrical resistence of calibration is 106.3 ohm.

Parameters	Ist Calibration	IInd Calibration
Electrical current (A)	0.183	0.308
Electrical energy (J)	640.8	1028.8
Room temperature (ºC)	21	20
Water average temperature (ºC)	27	32
$\Delta\mu V$ / ºC	42.5	41.6
Test time, ΔT (sec)	180	120
$\Delta\mu V$	565	1072
ΔT_{el} (ºC)	13.71	25.76
$\sum_i m_i c_i$	11.14	11.22



THE ELECTRICAL CALIBRATION



THE CHARACTERISTIC CALORIMETER CURVE

The temperature measurements can be made before and after the irradiation and they take a short time of 1-2 minutes. Such a device can be used many times for doses between 10-100 kGy. It is preferred that the calorimeter temperature do not exceed 30°C over the initial value.

The value of the absorbed dose into the calorimeter water determined is D=64.5 kGy.

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. Having small dimensions it can be used for reduced irradiation fields.

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