PERFORMANCE OF DICHROMATE DOSIMETRY SYSTEMS IN CALIBRATION AND DOSE INTERCOMPARISON

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Abstract

This report presents the results of the High Dose Dosimetry Laboratory of Argentina during ten years of international intercomparisons for high dose with the International Dose Assurance Service(IDAS) of the IAEA, using the standard high dose dichromate dosimetry system, and the results of a high dose intercomparison regional exercise in which our Laboratory acted as a reference laboratory, using the standard high dose and low dose dichromate dosimetry system.

1. INTRODUCTION

To promote the application of radiation processing in environmentally sustainable industrial development, it is very important to have the knowledge of process control in accordance with the international standards. In this context high dose dosimetry is fundamental in industrial applications of radiation technology. Irradiation facilities management are expected to give evidence of accurate and precise dose in the products they have to treat. For that purpose, the traceability of the dose measurements whereby, it can be related to appropriate standards, generally international, through an unbroken chain of comparisons must be encouraged [1]. In the present work we show the results of the dichromate dosimetry systems obtained by the High Dose Dosimetry Laboratory of Argentina, using the high dose dichromate systems (HDDS) and the low dose dichromate systems (LDDS) in two different experiments:

- A. Participation in the International Dose Assurance Service (IDAS) of the IAEA.
- B. Participation in a High Dose Intercomparison Regional Exercise.

2. MATERIALS AND METHODS

2.1 Dosimetry Systems

The High Dose Dosimetry Laboratory of Argentina uses the following dosimetry systems:

- Fricke as a reference standard dosimeter for the dose range 30 to 400 Gy.
- low dose dichromate dosimeter as a transfer standard dosimeter for the dose range 1 to10 kGy.
- high dose dichromate dosimeter as a transfer standard dosimeter for the dose range 10 to 50 kGy.
- Potassium Nitrate, dry dosimeter for routine irradiation at extreme temperatures and for the dose range 10 to 50 kGy.

All the dosimeters we use are prepared in our laboratory according to the Refs [2, 3, 4], respectively.

2.2. Apparatus

- The absorbance measurements are obtained using a Beckman Model 25, Double Beam UV-V (Wavelength range 190-700 nm) Spectrophotometer and quartz cuvettes 1-cm path length.
- Mettler H35, Analytical balance.
- Glassware, Borosilicate glass

2.3. Reagents

- All reagents we use are Merck, analytical reagent grade, except Silver Dichromate 99% from Pfaltz & Bauer,
- Three-times distilled water, conductivity 0.7 μS is obtained using single distillation apparatus, Rolco 81 and Quartz double distillation apparatus, Heraeus Bi-18

2.4. Calibrations

- The spectrophotometer wavelength calibration is performed using a Standard holmium-oxide filter. The spectrophotometer absorbance calibration is done using NIST SRM 2031a metal on quartz filters.
- he Analytical balance is calibrated periodically, according to Mettler Standards.

2.5. Methods

2.5.1. Experiment A

Our high dose gamma radiation dosimetry system has been checked since 1986 by the International Dose Assurance Service (IDAS) of the IAEA; their calibration is traceable to a Primary Standard Dosimetry Laboratory (NPL in U.K.). The IAEA sends us periodically alanine dosimeters; we irradiate our dichromate dosimeters and the IAEA alanine dosimeters together in a PMMA phantom specially designed for that purpose and monitor the irradiation temperature with a thermocouple. The intercomparison with IDAS are carried out at the semi-industrial irradiation facility. The irradiation room dimensions are 12 m x 6 m, the Co-60 source dimensions are 90 cm high and 150 cm wide, and the phantom dimensions are high 6 cm, length 20 cm an wide 2.8 cm. It is located on a special aluminium device, 60 cm away from the source and at its geometrical center (see Fig.1).

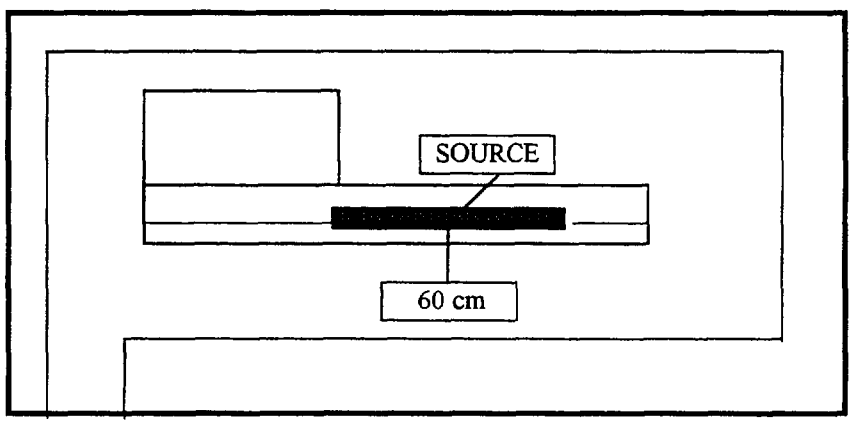

FIG. 1. Irradiation geometry.

2.5.2. Experiment B

Our laboratory organised the high dose intercomparison regional exercise which was carried out during the Regional Workshop on High Dose Dosimetry and Process and Quality Control in Industrial Radiation Processing, held at Buenos Aires during 22 to 26 July 1996, and in which our laboratory acted as the Reference Laboratory. The following countries participated in this exercise employing their own dosimeters: Brazil, Chile, Colombia, Cuba, Ecuador and Austria (IAEA).

3. TRACEABILITY

Our traceability is to:

- Primary Laboratory N. P. L. (U. K.) using calorimeter or Fricke
- Primary Laboratory N. P. L.(U. K.) using dichromate for Co-60 gamma field
- Laboratory I.A.E.A. (Austria) using alanine and High Dose Laboratory (Argentina) using dichromate and Fricke

Also our Laboratory is reference for:

- the irradiation plant at CNEA (Argentina), that uses Perspex Red-Amber as routine dosimeters
- the private irradiation plant Ionics (Argentina) that uses Perspex Red-Amber as routine dosimeters
- a mobile irradiator that uses Fricke
- blood irradiators that use Fricke
- Gammacell 220 that uses Fricke.

4. RESULTS

The results of the Experiment A are given in Table I.

TABLE I. TEN YEARS OF DOSE INTERCOMPARISONS BY IDAS

Year	Source Activity (kCi)	Estimated Irr. Temperature (°C)	IAEA Estimated Dose Alanine (kGy)	CNEA Estimated Dose HDDD (kGy)	Relative Deviation (%)
1986	243	25	25,2	25,35	0,60
1987	213	25	23,5	23,54	0,17
1990	500	22	24,40	24,51	0,45
1992	340	30	24,24	24,00	0,97
1993	290	30	23,46	23,41	0,23
1994	410	44	24,32	24,92	2,46
1996	340	35	26,44	25,67	2,93
1997	277	30	26,56	26,60	0,15

The source activity and the estimated irradiation temperature are shown in columns 2 and 3. The estimated dose of high dose dichromate dosimeter at CNEA and the corresponding estimated dose given by IDAS alanine dosimeter are shown in columns 4 and 5. Both estimated doses are corrected for the irradiation temperature. The relative deviation of the two estimated doses are given in column 6.

The results of the Experiment B are given in Table II and Table III.

TABLE II. COMPARATIVE ESTIMATED DOSES BETWEEN DIFFERENT DOSIMETRY SYSTEMS EMPLOYED BY PARTICIPATING COUNTRIES AND THE CNEA HDDD SYSTEM TAKEN AS REFERENCE FOR THE DOSE RANGE 10 kGy - 50 kGy

Country	$K_2 Cr_2 O_7$ - $Ag_2 Cr_2 O_7$ Dosimeter (HDDD) Estimated Dose (kGy)	Dosimeter Country Estimated Dose (kGy)	Relative Deviation (%)
1	15.17 (3)	15.00	1.2
	25.46 (3)	25.00	1.8
2	25.24 (3)	23.60	6.5
	28.55 (3)	27.40	4.0
3	14.39 (2)	15.02	4.4
	28.75 (2)	30.15	4.9
	42.80 (2)	45.27	5.8
4	27.48 (6)	23.70	13.7
5	24.38 (6)	21.07	13.6
6	11.91 (1)	10.00	16.0

TABLE III. COMPARATIVE ESTIMATED DOSES BETWEEN DIFFERENT DOSIMETRY SYSTEMS EMPLOYED BY PARTICIPATING COUNTRIES AND THE CNEA LDDD SYSTEM TAKEN AS REFERENCE FOR THE DOSE RANGE 1 kGy - 10 kGy.

Country	$Ag_2 Cr_2 O_7$ (LDDD) Dosimeter Estimated Dose (kGy)	Dosimeter Country Estimated Dose (kGy)	Relative Deviation (%)
1	3.01 (3)	3.00	0.33
	8.07 (3)	8.00	0.87
2	4.59 (6)	4.60	0
3	1.87 (2)	2.04	9.1
	4.64 (2)	4.85	4.5
	7.61 (2)	8.54	12.2
4	6.59 (6)	7.07	7.3
5	6.36 (6)	5.71	10.2
6	1.11 (1)	1.00	9.9

5. CONCLUSIONS

Experiment A - In column 6 of Table I, the relative deviation of the two estimated doses are given, where it has been observed that the relative deviations are less than 3% in all the cases, but within 1% in 75 % of the experiments.

Experiment B -The regional intercomparison exercise showed that about 50 % of the cases were well within 5% of the relative deviation .

We conclude that experiments A and B showed a good behaviour for the dichromate dosimetry system. More than ten years of experience in this field show, in our opinion, that a simple, reliable cheap and outstanding dosimetry system, **the dichromate dosimetry systems,** can be adopted without losing accuracy and reproducibility for the industrial dose radiation applications.

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