

THE STATUS OF DOSIMETRY IN RADIATION PROCESSING IN CHINA

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ABSTRACT Radiation processing has been a rapidly expanding technology in China since 1970 s. About 50 facilities of ^{60}Co source with the designed capacity more than 3.7 PBq have been set up in Beijing, Shanghai, and others 36 cities. The total charged activity of sources was more than 862 PBq. More than 26 electron beam (EB) irradiation facilities have been established. The total power of electron beams reached about 926 kW. The effectiveness of the process depends on the proper application of dose and its measurement. The importance of dosimetry events on the processing control of irradiation technology and the quality assurance of irradiated products have been acknowledged in China, which are introduced in this paper.

KEYWORDS Dosimetry, Verification regulations, Plastic dosifilms, National standards, Traceability

1 STANDARDIZATION AND REGULATORY CONTROL

The Provisional Regulation of Metrological Supervision and Management for Radiation Processing have been jointly issued by State Bureau of Technical Supervision (SBTS) and the State Commission of Science and Technology (SCST) on April 18, 1990 for implementing of the Law on Metrology of the People's Republic of China. This regulation stipulates to practise measurement licence for radiation processing units. Meanwhile a series of national standards, verification regulations, verification scheme and metrology technical norm have been enacted. These documents are listed as follows.

(1) Verification scheme of ^{60}Co γ -rays water absorbed dose measuring instrument for radiation processing level (JJG 2089-90)

(2) Verification regulation of γ -rays radiation source (for radiation processing) (JJG 591-89)

(3) Verification regulation of electron beams radiation source (for radiation processing) (JJG 772-92)

(4) Verification regulation of the standard dosimeter of water absorbed dose for γ -rays (radiation processing level) (JJG 735-91)

(5) Verification regulation of the working dosimeter for γ -rays radiation processing (JJG 775-92)

(6) Standard method for using the Fricke dosimetry to measure absorbed dose in water (Standard) (GB 139-89)

(7) Standard method for using the ceric sulfate-cerous sulfate dosimeter to measure γ -

Received 9 May 1995, accepted 10 August 1995

rays absorbed dose in water (Technical norm) (JJG 1017-90)

(8) Standard method for using the potassium (silver) dichromate dosimeter to measure γ -rays absorbed dose in water (Technical norm) (JJG 1018-90)

(9) Monitoring method of dose assurance for radiation processing with gamma rays (Technical norm) (JJG 1020-90)

(10) Standard method for using the silver dichromate dosimeter to measure γ -rays absorbed dose in water (Technical norm) (JJG 1028-91)

(11) Verification regulation of working dosimeter for electron beams radiation processing (JJG 851-93)

(12) Standard method for using the radiochromic film and the polymethylmethacrylate dosimetry systems (Standard) (GB 15053-94)

(13) Practical guide of dosimetry in a γ irradiation facility for food processing (National standard, to be valid)

(14) Conversion method of absorbed doses in different materials irradiated by X-, γ -rays and electron beams (National Standard, to be valid)

(15) Terminology relating to radiation processing dosimetry (National Standard, to be valid)

(16) Guide for the selection and calibration of dosimetry systems for radiation processing: (National Standard, in drafting)

(17) Standard practice for dosimetry for radiation processing at energies 100-300 keV and >300 keV (National Standard, in drafting)

(18) Guide for estimating uncertainties in dosimetry for radiation processing (National Standard, in drafting)

(19) Standard practice for characterization and performance of a high dose γ radiation dosimetry calibration laboratory (National Standard, in drafting)

(20) Method for using the alanine/EPR dosimetry system (National Standard, in drafting)

Those including the National Standard in drafting or to be valid (from 12 to 20) will play significant role in the dose measurement standardization and the regularity control.

2 TRACEABILITY

The start points—National Standards for EB measurement are established and maintained

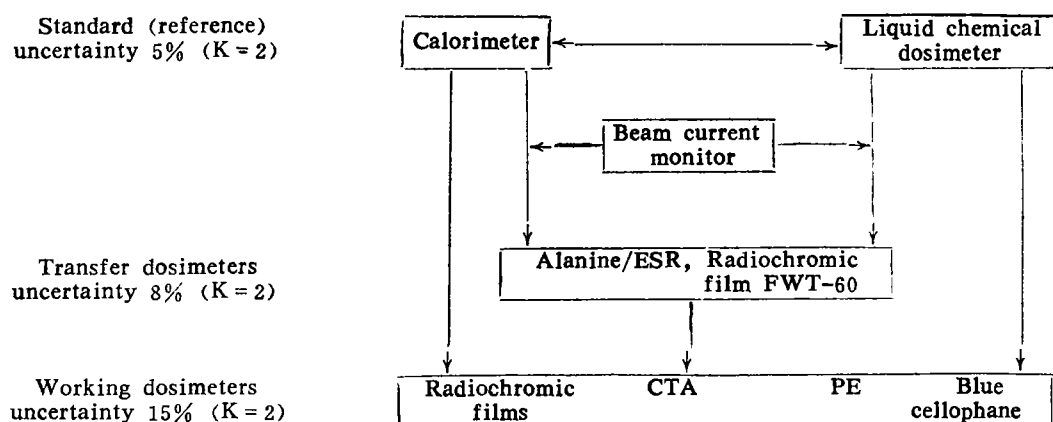


Fig 1. The high-dose dissemination system of electron beams

by the Primary Standard Laboratory, National Institute of Metrology (N.I.M), such as supply of the standard calorimeters from graphite and/or water. The graphite calorimeter for calibrating thin-film also supplied by the Secondary Standard Laboratory, Shanghai Institute of Metrological Technology. A high-dose dissemination system has been trially performed as Fig 1.

The high dose measurement systems for gamma rays, including primary standards, transfer standards and working dosimeters, have been established. The scheme of dosimetry traceability to primary standards for gamma rays is illustrated in Fig. 2.

Primary standards uncertainty 2% (K = 2)	Graphite calorimeter (1~20) Gy	Graphite cavity ionization chamber (1~20) Gy	Water calorimeter (2~50) Gy	Fricke dosimeter (40~200) Gy
Substitution method				
Transfer standards uncertainty 4% (K = 2)	Alanine/ESR dosimeter (0.05~40) Gy	LAgedc dosimeter (0.4~5) kGy	HK(Ag)Dc dosimeter (4~40) kGy	Ceric-cerous dosimeter (4~25) kGy
Substitution method				
Working standards uncertainty 10% (K = 2)	Solid working dosimeter (0.05~100) kGy		Liquid working dosimeter (0.04~50) kGy	

Fig 2. The scheme of dosimetry traceability to national primary standards for gamma rays

Several solid dosimeters have been selected as transfer and working dosimeters in above system.

3 ROUTINE AND TRANSFER DOSIMETER

In 1985~1987 a series of programs for routine and transfer dosimeter and relative products have been organized by the State Bureau of Metrology (SBM is a previous agent of SBTS) and completed by several institutions listed as table 1

The radiochromic multipurpose reader (RCR-86, by BSRDW), film reader in 510, 600 and 650 nm (FB-1. μ c-FB, by SIMT) and radiochromic dye (PR-CN, HPR-CN, by RICD) were also completed at the same time.

Tab 1. The completed dosimeters organized by SBM in 1985~1987

Dosimeter or product	Type	Dose range/kGy	Institution ⁽¹⁾
Dyed PE dosifilm	PE-Mg	0.3~80	BNU
Radiochromic film	PVT	0.2~50	BNU
Radiochromic film	BC	0.8~100	IC and IAE
Radiochromic film	PC-85	1~50	BIRM and NIM
Radiochromic film	NF-86	1~100	BSRDW
Radiochromic OWG dosimeter	OWG-86	0.01~20	RICD
Lyoluminescence dosimetry system	JR-101	0.01~10	IB and BIM
Radiation indication labels	SN 1-4	0.1~100	SINR

⁽¹⁾ BNU, Beijing Normal University; IC, Institute of Chemistry; IAE, Institute of Atomic Energy on Agriculture; BIRM and NIM, Beijing Inst. Radiat. Med. and Natl. Inst. Metrol; BSRDW, Beijing Shiying Radiation Detector Works; RICD, Research Institute of Chemical Defence; SIMT, Shanghai Institute of Metrology Technology; IB and BIM, Institute of Biophysics and Beijing Institute of Metrology; SINR, Shanghai Inst. Nucl. Res.

4 PLASTIC FLIM DOSIMETER

Plastic dosifilm started in 1970s. It was suitably used on radiation processing as a routine dosimeter with reasonable cost for the convenience of dose mapping and for the possibility of file keeping. Its dyensitis close to water and tissue.

A series of dosifilms (PE, PE-MG, PE-CV, PE-MB, PVA-MG, PVA-MB, PVT and PVG) have been investigated or manufactured in Radiation Chemistry Group, BNU for dose measurement.

Dosifilm is particularly suit to EB dose measurement due to EB with less penetrability. The Alanine/ESR dosifilm started in 1980s. It also must be made as a dosifilm for EB dose measurement by blended with a matrix material plastic, the brief requirement of EB measurement is light stability, measurement of high, dose with high dose rate and calibration possibility.

The improvement and development of various plastic films were laid a strong emphasis upon EB dose measurement as its traceability was mentioned.

5 SUMMARY

The radiation processing business including radiation sterilization, food irradiation and polymer modification is very active in China. The national standards of dosimetry for quality assurance were documented and drafted, in reference with the standards of ASTM and in compliance with the demands of ISO standards. The radiation measurement can be made traceable to national standards, its precision and accuracy are satisfactory. There is a continue effort to improve the dosimetry. Recently the plastic dosifilms are emphasized using for EB dose measurement also are made understanding of the impact of various influence parameters on the performance of the routine dosimetry.

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(下接第 91 页, Continued to P91)

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一种新型的无色染料的 PVG 剂量膜

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摘要 新研制的无色染料剂量膜可测试 ^{60}Co γ 辐射的剂量, 定名为 PVG 剂量膜。它用基料聚乙烯醇缩丁醛(PVB)、无色孔雀绿(LMG)和添加剂卤化物(RX)加工而成。剂量范围 0.5~80 kGy, 在 627 nm 处其吸收($\Delta A/L$)与剂量的关系呈线性(相关系数 $r > 0.999$), 温度校正系数 $+0.053/^\circ\text{C}$ 。相对湿度(r.h)在 0~96.4% 范围内, 其剂量响应随相对湿度的增加而增加, 其校正系数为 $+0.006/\Delta r.h(\%)$ 。在 r.h 54.9%~96.4% 范围内, 其偏差小于 4%。PVG 剂量膜在一定的相对湿度下存放于暗处, 在辐照前后皆很稳定。放在棕色保干器内, 40 d 后剂量膜的响应偏差小于 4%, 它可作为适用的常规剂量计。

关键词 聚乙烯醇缩丁醛, 无色孔雀绿, 卤化物, 辐射剂量膜, 辐射加工

(上接第 68 页, Continued from P68)

中国辐射工艺剂量方法的现状

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摘要 七十年代以来中国的辐射工艺技术获得了迅速发展。现今遍布在北京、上海等 38 个城市中, 设计容量在 3.7 PBq 以上的 ^{60}Co 辐照装置约有 50 套, 其总装载容量已超过 862 PBq。电子束辐照装置约 26 套, 其总功率已达到 926 kW。辐射工艺(或辐射加工)的效果与辐射剂量方法的合理应用及测试密切相关。剂量方法对于辐射工艺技术及其质量保证、质量控制的重要性在中国已被认识。为履行《中华人民共和国计量法》, 1990 年 4 月 18 日国家科委与国家技术监督局联合发布《辐射加工计量监督管理暂行规定》。在此基础上已实施和正在起草的有关辐射加工的技术法规包括国家标准、计量技术规范、检定系统与检定规程等文件已达 20 余种。为提高电子束和 ^{60}Co γ 射线的剂量测量的准确性, 一级标准实验室(国家计量研究院)和二级标准实验室(上海计量技术所)建立了溯源的体系。在国家技术监督局的前身国家计量局的支持下已完成近 10 种常规剂量计和传递剂量计及其测试装置。塑料膜剂量计的测试与应用也受到重视, 今后将进一步完善电子束辐射的剂量测试, 使我国剂量技术的水平持续地保持在国际水平的前沿。

关键词 剂量方法, 检定规程, 塑料剂量膜, 国家标准, 溯源