

# Dosimetry Systems for Use in Radiation Processing

## Contents

<b>Preface</b> . . . . .	1
<b>Abstract</b> . . . . .	3
<b>Executive Summary</b> . . . . .	5
<b>1 Introduction</b> . . . . .	7
<b>1.1 Scope</b> . . . . .	7
<b>1.2 Applications of Radiation Processing</b> . . . . .	7
<b>1.2.1 Industrial Processes and Requirements for Dosimetry</b> . . . . .	7
<b>1.2.2 Medical Device Sterilization</b> . . . . .	7
<b>1.2.3 Food Irradiation</b> . . . . .	8
<b>1.2.4 Polymer Modification</b> . . . . .	8
<b>1.3 Dosimetric Quantities</b> . . . . .	8
<b>1.4 Relation to Existing Reports or Standards</b> . . . . .	9
<b>2 Interactions of Electrons and Photons with Matter</b> . . . . .	11
<b>2.1 Interactions and Energy Absorption Mechanisms (Physical Effects)</b> . . . . .	11
<b>2.1.1 Introduction</b> . . . . .	11
<b>2.1.2 Photon Interactions</b> . . . . .	11
<b>2.1.3 Electron Interactions</b> . . . . .	13
<b>2.1.4 Relationship of Absorbed Doses in Different Media</b> . . . . .	14
<b>2.2 Interactions and Energy Absorption Mechanisms (Chemical Effects)</b> . . . . .	14
<b>2.2.1 Introduction</b> . . . . .	14
<b>2.2.2 Water and Aqueous Inorganic Systems</b> . . . . .	15
<b>2.2.3 Organic and Aqueous–Organic Systems</b> . . . . .	16
<b>3 Description of Irradiation Facilities</b> . . . . .	17
<b>3.1 Gamma-Ray Irradiators</b> . . . . .	17
<b>3.2 Electron-Beam Irradiators</b> . . . . .	17
<b>3.3 X-Ray (Bremsstrahlung) Irradiators</b> . . . . .	20
<b>4 General Aspects of Dosimetry for Radiation Processing</b> . . . . .	21
<b>4.1 Primary Standards and Measurement Traceability</b> . . . . .	21
<b>4.2 External Influence Quantities</b> . . . . .	23
<b>4.3 Methods of Calibration</b> . . . . .	24
<b>4.3.1 Calibration of Reference Standard Dosimeters</b> . . . . .	25
<b>4.3.2 Calibration of Routine Dosimeters</b> . . . . .	25
<b>4.4 Measurement Uncertainties</b> . . . . .	26
<b>4.4.1 Uncertainties in the Preparation of a Calibration Function</b> . . . . .	27

*DOSIMETRY SYSTEMS FOR USE IN RADIATION PROCESSING*

<b>4.4.2</b>	Uncertainties in the Use of Dosimeters . . . . .	27
<b>4.4.3</b>	Application of Uncertainty Data . . . . .	28
<b>5</b>	<b>Dosimetry Systems . . . . .</b>	<b>29</b>
<b>5.1</b>	Reference Standard and Routine Dosimetry Systems . . . . .	29
<b>5.1.1</b>	Alanine-EPR . . . . .	29
<b>5.1.2</b>	Calorimeters . . . . .	33
<b>5.1.3</b>	Cellulose Triacetate (CTA) . . . . .	37
<b>5.1.4</b>	Ceric–Cerous . . . . .	40
<b>5.1.5</b>	Dichromate . . . . .	43
<b>5.1.6</b>	Ethanol Chlorobenzene . . . . .	46
<b>5.1.7</b>	Ferrous Sulfate (Fricke) . . . . .	51
<b>5.1.8</b>	Polymethyl Methacrylate (PMMA) . . . . .	56
<b>5.1.9</b>	Radiochromic-Dye Films . . . . .	60
<b>5.2</b>	Other Dosimetry Systems . . . . .	66
<b>5.2.1</b>	General . . . . .	66
<b>5.2.2</b>	Gaseous Systems . . . . .	67
<b>5.2.3</b>	Liquid Systems . . . . .	67
<b>5.2.4</b>	Solid Systems . . . . .	68
<b>Appendix 1</b>	. . . . .	<b>71</b>
<b>Appendix 2</b>	. . . . .	<b>75</b>
<b>References</b>	. . . . .	<b>81</b>