

# **CONTENTS**

Preface	<i>ix</i>
<b>1</b>	<b>INTRODUCTION</b> <b>1</b>
1.1	The Nuclear World—An Historical View <b>3</b>
1.2	The Contents <b>8</b>
<b>2</b>	<b>UNITS AND GENERAL SCALE OF RADIATION DAMAGE</b> <b>10</b>
2.1	Roentgen <b>10</b>
2.2	Rad <b>11</b>
2.3	Gray <b>11</b>
2.4	Dose Threshold for Various Materials <b>12</b>
References	<i>16</i>
Problems	<i>16</i>
<b>3</b>	<b>FUNDAMENTAL INTERACTIONS OF NEUTRONS WITH MATERIALS</b> <b>17</b>
3.1	Neutron Interaction Theory <b>17</b>
3.2	Frenkel Pair Formation <b>34</b>
3.3	Activation and Transmutation <b>44</b>
References	<i>53</i>
Problems	<i>54</i>
<b>4</b>	<b>INTERACTIONS OF GAMMA RAYS WITH MATERIALS</b> <b>56</b>
4.1	What Is a Gamma Ray? <b>56</b>
4.2	Sources of Gamma Rays in a Reactor <b>58</b>
4.3	The Process Involved in the Interaction of Gamma Rays with Materials <b>59</b>
4.4	Gamma Heating <b>63</b>
4.5	Relationship between Gamma Flux and Dose Rate <b>70</b>
4.6	Free Electron Generation <b>72</b>
References	<i>74</i>
Problems	<i>74</i>
<b>5</b>	<b>TRANSIENT EFFECTS OF RADIATION ON ELECTRICAL COMPONENTS</b> <b>76</b>
5.1	Gamma-Induced Electron Emission from Surfaces <b>76</b>
5.2	Direct Ionization of Residual Gasses by Gamma Radiation <b>87</b>

5.3	Production of High-Energy Electrons by Thermal Neutron Reactions	89
5.4	Effects of Gamma Radiation on Electrical Resistances and Insulators (Photoconductivity)	90
5.5	Experimental Illustration of Gamma and Neutron Effects on Electrical Components	96
5.6	Conclusions on the Transient Effects of Radiation on Electrical Components	99
	References	101
	Problems	103
<b>6</b>	<b>EFFECTS OF RADIATION ON ORGANIC MATERIALS</b>	<b>104</b>
6.1	Radiation Effects on Organic Insulating Materials	106
6.2	Radiation-Induced Gas Evolution	108
6.3	Effects on Electrical Capacitors	112
6.4	Effects of Radiation on Epoxies	112
	References	117
	Problems	119
<b>7</b>	<b>RADIATION EFFECTS ON STEEL</b>	<b>119</b>
7.1	Radiation Effects on Strengths of Stainless Steel	119
7.2	Radiation Effects on Light Water Reactor (LWR) Pressure Vessels	180
	References	191
	Problems	199
<b>8</b>	<b>NUCLEAR FISSION EFFECTS</b>	<b>201</b>
8.1	The Fission Process	201
8.2	Effects in Reactor Fuel Elements	216
	References	232
	Problems	234
<b>9</b>	<b>SURFACE EFFECTS OF NUCLEAR RADIATIONS</b>	<b>235</b>
9.1	Fast Neutron Erosion	235
9.2	Secondary Electron Emission from Charged Nuclear Particles	240
9.3	Gamma-Induced Electron Emission	242
9.4	Gamma Radiation-Induced Outgassing (GRIO)	242
	References	255
	Problems	258
<b>10</b>	<b>MISCELLANEOUS RADIATION EFFECTS</b>	<b>259</b>
10.1	Welding Plastics	259
10.2	Gamma Sterilization of Plastic Medical Supplies	264
10.3	Improving Vacuum Levels with Gamma Radiation	265
10.4	Use of GRIO to Measure Effective Catalyst Surface Area	266

10.5	Other Miscellaneous Radiation Effects	267
	References	268
<b>11</b>	<b>RADIATION EFFECTS ON BIOLOGICAL MATERIAL</b>	<b>270</b>
11.1	Biological Damage	270
11.2	Biological Radiation Units	278
11.3	Radiation Protection Standards	282
11.4	Exposure Calculations	287
	References	301
	Problems	303
<b>12</b>	<b>NEUTRON AND GAMMA RAY DOSIMETRY</b>	<b>305</b>
12.1	Neutron Dosimetry	305
12.2	Gamma Ray Dosimetry	316
12.3	Health Physics Dosimetry	326
	References	330
	Problems	331
	<b>APPENDIX A: NUCLEAR DATA FOR VARIOUS ELEMENTS AND ISOTOPES</b>	<b>332</b>
	<b>APPENDIX B: DERIVATION OF THE FRACTION OF ALL BETAS ESCAPING FROM THE SURFACE</b>	<b>334</b>
	<b>APPENDIX C: VARIOUS CONSTANTS</b>	<b>336</b>
	<b>APPENDIX D: USEFUL CONVERSION FACTORS</b>	<b>337</b>
	Index	339