



# Contents

List of Tables	vii
Publisher's Foreword	ix
Preface	xi
<b>Chapter 1:</b>	
The Generation of Electric Power	1
Nuclear Steam Supply System	1
Thermal Efficiency	2
Electrical Capacity of a Generating Plant	4
Bibliography	5
<b>Chapter 2:</b>	
Fundamental Principles of Nuclear Reactors	6
Introduction	6
Characteristics of Atoms	6
Radioactivity	8
The Fission Reaction	12
Nuclear Reactors	18
Nuclear Steam Supply Systems	26
Bibliography	29
<b>Chapter 3:</b>	
Licensing of Nuclear Power Plants	30
Introduction	30
Application for a Construction Permit	38
Application for an Operating License	50
Regulation of Plant Operations	54
Bibliography	58
<b>Chapter 4:</b>	
Nuclear Reactor Safety	60
Introduction	60
Designing for Reactor Safety	70
Engineered Safety Features	77
Evaluation of Potential Accidents	87
Major Loss-of-Coolant Accident	90
Probabilities and Consequences of Class 9 Accidents	94
The Three Mile Island Accident	105
Protection Against Sabotage	108
Bibliography	110
<b>Chapter 5:</b>	
Radiation Protection Standards	112
Introduction	112
Organizations for Radiation Protection	113
Radiation Quantities and Units	120
Protection Standards for Occupational Exposure	123
Radiation Standards for the General Population	137
Bibliography	143

<b>Chapter 6:</b>	<b>The Radiation Environment: Natural and Man-Made</b>	<b>145</b>
	Natural Background Radiations	145
	Man-Made Radiations	149
	Radiation Exposures from Nuclear Power Plants	152
	Nuclear Fuel Production and Reprocessing	162
	Accumulation of Tritium, Krypton-85, and Carbon-14	166
	Estimated Annual Doses in the Year 2000	177
	Bibliography	181
<b>Chapter 7:</b>	<b>Biological Effects of Radiation</b>	<b>183</b>
	Introduction	183
	Somatic Effects of Radiation	184
	Radiation Risk Estimates	191
	Genetic Effects of Radiation	199
	Radiation Effects on Aquatic Organisms	207
	Bibliography	210
<b>Chapter 8:</b>	<b>Radioactivity in Reactor Fuel Production</b>	<b>212</b>
	Radioactivity in Uranium Mining	212
	Radioactivity from Uranium Mills	217
	Production and Enrichment of Uranium Hexafluoride	227
	Uranium Dioxide Fuel Fabrication	230
	Mixed-Oxide Fuel Fabrication	233
	Bibliography	236
<b>Chapter 9:</b>	<b>Radioactive Effluents from Nuclear Facilities</b>	<b>238</b>
	Effluents from Light-Water Reactors	238
	Radioactive Wastes from Spent-Fuel Reprocessing	254
	Bibliography	261
<b>Chapter 10:</b>	<b>Management of High-Level and TRU Wastes</b>	<b>263</b>
	Introduction	263
	Properties of High-Level Wastes	265
	Waste Management Techniques	273
	Long-Range Disposal Concepts	281
	Interagency Review	285
	Bibliography	286
<b>Chapter 11:</b>	<b>Transportation and Safeguarding of Nuclear Materials</b>	<b>288</b>
	Regulations of Packaging and Transportation	288
	Transportation of Nuclear Reactor Materials	293
	Safeguards for Special Nuclear Materials	300
	Bibliography	302
<b>Chapter 12:</b>	<b>Biological Effects of Condenser Cooling Systems</b>	<b>304</b>
	Introduction	304

	Thermal Effects	306
	Other Effects of Condenser Systems	317
	Field Observations on Condenser Discharges	322
	Water Quality Criteria	328
	Bibliography	338
<b>Chapter 13:</b>	<b>The Disposal of Waste Heat</b>	<b>340</b>
	Introduction	340
	Warm Water Discharge Systems	343
	Closed-Cycle Systems	350
	Beneficial Uses of Thermal Discharges	364
	Bibliography	369
	Appendix	371
<b>Chapter 14:</b>	<b>Nuclear Power Plant Site Assessment</b>	<b>377</b>
	Introduction	377
	Safety-Related Criteria in Site Assessment	379
	Environmental Criteria in Site Assessment	383
	Bibliography	387
	Index	389

## *List of Tables*

2-I	Half-Lives of Some Radionuclides . . . . .	11
3-I	Classification of Postulated Accidents for Environmental Report . . . . .	45
3-II	Outline of Procedure for a Construction Permit . . . . .	48
3-III	Outline of Procedure for an Operating License . . . . .	55
4-I	Correlations of Health Effects and Mean Probabilities of Accidents Leading to Core Meltdown . . . . .	106
5-I	Major Landmarks for Radiation Protection Organizations . . . . .	121
5-II	Characteristics of Radiation Units . . . . .	124
5-III	Abbreviations Used in Connection with Radiation Protection Standards . . . . .	126
5-IV	Maximum Permissible Whole-Body Doses for Occupationally Exposed Persons . . . . .	130
5-V	Summary of Maximum Occupational Doses . . . . .	131
5-VI	Summary of Standards for the General Population . . . . .	140
5-VII	Concentration Limits at Plant Boundary for Selected Radionuclides in Soluble Form . . . . .	141
6-I	Average Whole-Body Doses from Natural Radiations at Sea Level in the United States . . . . .	147
6-II	Annual Doses from Global Fallout . . . . .	151
6-III	Average Human Body Burdens of Plutonium from Global Fallout . . . . .	151
6-IV	Principal Radiation Exposure Pathways from Nuclear Power Plant Effluents . . . . .	151

6-V	Steady-State Bioaccumulation Factors in Edible Portions . . . . .	157
6-VI	Calculated Annual Individual Doses from Nuclear Power Plant Effluents . . . . .	161
6-VII	Cumulative Annual Population Doses from Nuclear Power Plant Effluents. . .	162
6-VIII	Calculated Individual Radiation Doses from a Uranium Mill . . . . .	164
6-IX	Calculated Individual Radiation Doses from a Spent-Fuel Reprocessing Plant . . . . .	166
6-X	Estimated Worldwide Nuclear Power Generation Capacity . . . . .	169
6-XI	Estimated Average Annual Doses in the United States from World- wide Production of Krypton-85 Assuming Complete Release. . . . .	174
6-XII	Estimated Average Annual Doses from Worldwide Production and Distribution of Carbon-14 Assuming Complete Release . . . . .	176
6-XIII	Estimated Average Whole-Body Dose to Individuals in the United States in the Year 2000 from Nuclear Power Operations . . . . .	179
7-I	Probable Effects of Acute Whole-Body Radiation Doses . . . . .	185
7-II	Risk Estimates for Leukemia for Radiation Exposure at Age 10 Years or More . . . . .	195
7-III	Assumed Values in Calculating Radiation-Induced Cancer Incidence . . . . .	197
7-IV	Estimated Annual Number of Cancer Deaths for Population Dose of 1 Million Person-Rems per Year . . . . .	197
7-V	Estimated Increase at Equilibrium of Genetically Related Diseases for 1 Rem per Generation in 1 Million Live Births. . . . .	205
8-I	Radon and Its Decay Products . . . . .	213
9-I	Some Important Fission Products . . . . .	239
9-II	Activation Products . . . . .	240
9-III	Radioactivity in Effluents from Nuclear Power Plants in 1977 . . . . .	251
9-IV	Estimated Releases from Fuel Reprocessing per 1000-MW-Yr in an LWR . . . .	259
10-I	Estimated Accumulation Solid High-Level Wastes . . . . .	270
10-II	Significant Radioactive Species in Solidified High-Level Reprocessing Wastes . . . . .	271
10-III	Activities in Curies of Solidified High-Level Reprocessing Wastes from 1 MT of Spent LWR Fuel . . . . .	271
12-I	Provisional Maximum Acceptable Temperatures . . . . .	332
12-II	Characteristic Water Temperatures for Some Common Freshwater Fish Species . . . . .	333
13-I	Values Estimated for the Cherokee Nuclear Station, South Carolina . . . . .	354
A-I	Temperature Increase of Condenser Water . . . . .	371
A-II	Once-Through Systems . . . . .	372
A-III	Spray Canals and Cooling Ponds . . . . .	374
A-IV	Mechanical-Draft Cooling Towers . . . . .	374
A-V	Natural-Draft Cooling Towers . . . . .	375
A-VI	Variable-Cycle or Helper-Cycle Systems . . . . .	376
A-VII	Special Situations . . . . .	376

