

Contents

1	Introduction	1
1.1	The Early Years	1
1.2	Source Control and Reduction	5
1.3	Outage Management	5
1.4	Benchmarking and Lessons-Learned	6
1.5	Innovation and Use of New Technology	7
1.6	Training the Next Generation of Health Physicists	8
1.7	Deregulation	9
1.8	Summary	10
	Bibliography	10
2	Radiological Aspects of PWR Systems	13
2.1	Overview	13
2.2	Plant Layout	14
2.3	Primary System	15
2.4	Chemical and Volume Control System	23
2.5	Residual Heat Removal System	26
2.6	Safety Injection System	27
2.7	Containment Spray System	28
2.8	Spent Fuel Pool Cooling and Purification	29
2.9	Reactor Cavity Filtration	32
2.10	Radioactive Waste Treatment Systems	32
2.10.1	Liquid Waste Treatment System	33
2.10.2	Gaseous Waste Treatment System	36
2.10.3	Solid Waste Treatment System	37
	Bibliography	38
3	Radiological Aspects of BWR Systems	39
3.1	Overview	39
3.2	Plant Layout	40

3.3	Containment Systems	41
3.4	Reactor Vessel	42
3.5	Recirculation System.	45
3.6	Reactor Water Cleanup System	46
3.7	Residual Heat Removal System	49
3.8	Fuel Pool Cooling and Cleanup System.	51
3.9	Reactor Core Isolation Cooling System	52
3.10	Reactor Building Closed Loop Cooling Water System	52
3.11	Main Steam System	54
3.12	Radioactive Waste Treatment Systems	54
3.12.1	Offgas System	54
3.12.2	Liquid Waste Treatment System	55
3.12.3	Solid Waste Treatment System	55
	Bibliography	56
4	Sources of Occupational Radiation Exposure.	57
4.1	Radiation Sources	57
4.2	Neutron Activation Source Terms	58
4.3	Fission Products	60
4.4	Tritium Production Processes	61
4.5	Parameters Effecting Source Terms.	62
4.5.1	System Design and Inter-Relationship	62
4.5.2	Operational History and Operational Mode	63
4.5.3	Coolant Chemistry	64
4.5.4	Construction Materials.	66
4.5.5	Fuel Integrity	67
4.6	Ambient Radiation Levels	69
4.7	Sources of Airborne Contamination	70
4.8	Summary	71
	Bibliography	72
5	Demarcation of Radiological Zones	73
5.1	Overview	73
5.2	Restricted and Controlled Areas	75
5.3	Radiological Controlled Area	76
5.4	Radiation Areas	77
5.5	Surface Contamination Areas	82
5.6	Airborne Radioactivity Areas	85
5.7	Radioactive Material Storage Areas	89
5.8	Hot Spots.	90
5.9	General Posting Guidelines	90
5.10	Summary	92
	Bibliography	92

6	Operational Radiation Protection	93
6.1	Overview	93
6.2	Radiological Surveillance	94
6.2.1	Radiation Surveys	94
6.2.2	Contamination Surveys	101
6.2.3	Equipment and Unconditional Release Surveys	108
6.2.4	Airborne Radioactivity Surveys	111
6.3	Frequency of Surveys	124
6.4	Communication of Survey Results	126
6.5	Personnel Contamination Surveys	128
6.6	Personnel Decontamination	135
6.7	Access Control	139
6.8	Secondary Radiation Protection Control Points	143
6.9	Job Coverage	146
6.10	Summary	149
	Bibliography	150
7	Exposure Management (Minimization and Control of Collective Dose)	151
7.1	Overview	151
7.2	Historical Industry Exposure Totals	152
7.3	Radiological Work Coordination	154
7.4	Radiological Work Planning and Preparation	156
7.5	Work Coordination and Effective Communications	160
7.5.1	Complexity of Radiological Work Activities	160
7.5.2	Diverse Experience of Personnel	161
7.5.3	Variable Work Conditions	163
7.5.4	Organizational and Departmental Interface	164
7.5.5	Internal Departmental Communications	165
7.6	Planning and Scheduling Aspects	167
7.6.1	Power Operation	168
7.6.2	Outage Periods	170
7.7	Radiological Safety Aspects of Work Coordination	170
7.7.1	Pre-Job Briefings	172
7.7.2	Job Coverage and Execution	176
7.7.3	Post-Job Debriefings	178
7.8	Radiation Work Permits	180
7.9	ALARA Work Plans	183
7.10	Scaffold Management	187
7.11	Summary	193
	Bibliography	194

8	Source Reduction	195
8.1	Overview	195
8.2	Contamination Control	196
8.3	Source Control Techniques	198
8.3.1	Water Chemistry Fundamentals	198
8.3.2	Water Purification	201
8.4	Corrosion Processes	203
8.5	RCS Oxygenation (Hydrogen Peroxide Addition and Crud Burst Promotion)	205
8.6	Techniques to Reduce Source Terms	208
8.7	Summary	209
	Bibliography	210
9	Protective Clothing and Equipment	211
9.1	Overview	211
9.2	Protective Clothing	213
9.2.1	Donning and Use of Protective Clothing	216
9.2.2	Double Sets of Protective Clothing	218
9.2.3	Disposable Protective Clothing	220
9.2.4	Wet Work Protective Clothing	221
9.2.5	Staging and Maintenance of Protective Clothing Inventories	223
9.3	Respiratory Protection Program	225
9.3.1	Elements of a Respiratory Protection Program	227
9.3.2	Types of Respiratory Protection Equipment	228
9.3.3	Selection of Respiratory Protection Equipment	231
9.3.4	Maintenance and Inspection	232
9.3.5	Training and Qualification	233
9.4	Portable Air Filtration Units	235
9.5	Temporary Shielding	238
9.6	Summary	243
	Bibliography	244
10	Personnel Dosimetry (Monitoring of Personnel Exposures and Bioassay Programs)	245
10.1	Overview	245
10.2	Dose Limits	246
10.3	Personnel Monitoring Devices	248
10.3.1	Primary Dosimeters	249
10.3.2	Thermoluminescent Dosimeters	250
10.3.3	Film Badges	255
10.3.4	Optically Stimulated Luminescence Dosimeters	256

10.4	Accreditation of Personnel Dosimetry Measurement Programs	257
10.5	Electronic Dosimeters	259
10.6	Teledosimeters	263
10.7	Extremity and Multi-Badges	266
10.8	Secondary Dosimeters	269
10.9	Internal Dosimetry and Bioassay Programs	270
10.9.1	Whole-Body Counting	273
10.9.2	Whole Body Counting Systems	274
10.9.3	Interpretation and Evaluation of Whole-Body Counting Results	278
10.9.4	Calibration of Whole-Body Counters	281
10.9.5	Passive Whole-Body Counting	283
10.9.6	Urine Analysis	284
10.10	Summary	285
	Bibliography	286
11	Radiological Survey and Monitoring Instrumentation	289
11.1	Overview	289
11.2	Ionization Detector Radiation Survey Instruments	290
11.3	Geiger-Mueller Detector Survey Instruments	293
11.4	Neutron Radiation Survey Instruments	296
11.5	Contamination Survey Instruments	300
11.6	Sodium Iodide Detector Survey Instruments	304
11.7	Instrument Source Response Checks	305
11.8	Laboratory Counting Equipment	306
11.9	Area Radiation Monitors	311
11.9.1	Installed Area Radiation Monitors	311
11.10	Portable Area Radiation Monitors	314
11.11	Air Sampling Equipment	315
11.12	Continuous Air Monitors	318
11.12.1	Installed Continuous Air Monitors	318
11.12.2	Portable Continuous Air Monitors	320
11.13	Summary	324
	Bibliography	325
	Appendix A	327
	Appendix B	329
	Appendix C	331

Appendix D. 337

Appendix E. 347

Appendix F. 349

Index 361