

Table of contents

- **Preface** (p. xi)
- **Acknowledgments** (p. xv)
- **Symbols** (p. xvii)
- **Chapter 1. Introduction** (p. 1)
- **1.1 Introduction** (p. 1)
- **1.2 A Brief History of Chemical and Biological Warfare** (p. 3)
- **1.3 Bioterrorism Today** (p. 19)
- **Chapter 2. Biological Weapon Agents** (p. 23)
- **2.1 Introduction** (p. 23)
- **2.2 Microorganisms** (p. 24)
- **2.2.1 Airborne Pathogens** (p. 27)
- **2.2.2 Vector-Borne Pathogens** (p. 37)
- **2.2.3 Food-Borne and Water-Borne Pathogens** (p. 40)
- **2.3 Toxins** (p. 41)
- **2.4 Bioregulators** (p. 47)
- **2.5 Weaponizing BW Agents** (p. 49)
- **2.6 Size Distribution of BW Agents** (p. 50)
- **2.7 Survival Curves of Microbes under UV Exposure** (p. 52)
- **2.8 Summary** (p. 59)
- **Chapter 3. Chemical Weapon Agents** (p. 61)
- **3.1 Introduction** (p. 61)
- **3.2 Classification of CW Agents** (p. 61)
- **3.3 Design Basis CW Agents** (p. 66)
- **3.4 CW Agent Simulants** (p. 71)
- **3.5 Summary** (p. 71)
- **Chapter 4. Dose and Epidemiology of CBW Agents** (p. 73)
- **4.1 Introduction** (p. 73)
- **4.2 BW Agent Dosimetry** (p. 75)
- **4.3 CW Agent Exposure Dosimetry** (p. 81)
- **4.4 CBW Agent Inhalation Dosimetry** (p. 85)
- **4.5 CBW Agent Ingestion Dosimetry** (p. 87)
- **4.6 Lethal Dose Curves for Toxins** (p. 89)
- **4.7 Disease Progression Curves** (p. 89)
- **4.8 Summary** (p. 96)
- **Chapter 5. Dispersion and Delivery Systems** (p. 97)
- **5.1 Introduction** (p. 97)
- **5.2 Outdoor Dispersion Systems** (p. 97)
- **5.3 Indoor Dispersion Systems** (p. 99)
- **5.4 Dissemination of Food-Borne and Water-Borne Agents** (p. 110)
- **5.5 Summary** (p. 112)
- **Chapter 6. Buildings and Attack Scenarios** (p. 113)
- **6.1 Introduction** (p. 113)
- **6.2 Building Types and Relative Risks** (p. 115)
- **6.2.1 Commercial Buildings** (p. 119)

- **6.2.2 Government Buildings** (p. 123)
- **6.2.3 Food and Entertainment Facilities** (p. 127)
- **6.2.4 Healthcare Facilities** (p. 129)
- **6.2.5 Lodging Facilities** (p. 130)
- **6.2.6 Education Facilities** (p. 132)
- **6.2.7 Mercantile Facilities** (p. 134)
- **6.2.8 Assembly Facilities** (p. 136)
- **6.2.9 Special Facilities** (p. 138)
- **6.3 Building Attack Scenarios** (p. 140)
- **6.3.1 Outdoor Releases** (p. 140)
- **6.3.2 Air Intake Release** (p. 141)
- **6.3.3 Indoor Explosive Release** (p. 144)
- **6.3.4 Indoor Passive Release** (p. 146)
- **6.3.5 Indoor Aerosolization Release** (p. 146)
- **6.3.6 Internal Release in Duct** (p. 147)
- **6.4 Summary** (p. 150)
- **Chapter 7. Ventilation Systems** (p. 151)
- **7.1 Introduction** (p. 151)
- **7.2 Types of Ventilation Systems** (p. 151)
- **7.3 Ventilation Modeling** (p. 153)
- **7.3.1 Ventilation Modeling with Calculus Methods** (p. 156)
- **7.3.2 Ventilation Modeling with Computational Methods** (p. 157)
- **7.3.3 Ventilation Modeling with CONTAMW** (p. 162)
- **7.4 Computational Fluid Dynamics Modeling** (p. 163)
- **7.5 Summary** (p. 163)
- **Chapter 8. Air-Cleaning and Disinfection Systems** (p. 165)
- **8.1 Introduction** (p. 165)
- **8.2 Filtration** (p. 167)
- **8.2.1 Mathematical Modeling of Filtration** (p. 172)
- **8.2.2 Filtration Applications** (p. 177)
- **8.2.3 Filtration Test Results for Microbes** (p. 184)
- **8.2.4 Filtration of Liquid Aerosols** (p. 185)
- **8.3 Ultraviolet Germicidal Irradiation** (p. 188)
- **8.3.1 Mathematical Modeling of UVGI** (p. 189)
- **8.3.2 UVGI Applications** (p. 196)
- **8.4 Combining UVGI and Filtration** (p. 200)
- **8.5 Gas Phase Filtration** (p. 203)
- **8.6 Summary** (p. 208)
- **Chapter 9. Simulation of Building Attack Scenarios** (p. 211)
- **9.1 Introduction** (p. 211)
- **9.2 Baseline Building Attack Scenarios** (p. 213)
- **9.3 Simulation of CBW Attack Scenarios** (p. 214)
- **9.4 Simulation with CONTAMW** (p. 226)
- **9.5 Simulation of Several Model Buildings** (p. 230)
- **9.6 Multizone Simulation with CONTAMW** (p. 238)
- **9.7 Overload Attack Scenarios** (p. 242)

- **9.8 Sudden-Release Scenarios** (p. 244)
- **9.9 CW Removal by Outside Air Purging** (p. 246)
- **9.10 Summary** (p. 247)
- **Chapter 10. Detection of CBW Agents** (p. 249)
- **10.1 Introduction** (p. 249)
- **10.2 Chemical Detection** (p. 250)
- **10.2.1 Chemical Detector Response Time** (p. 256)
- **10.3 Biological Detection** (p. 257)
- **10.3.1 Air Sampling** (p. 258)
- **10.3.2 Biosensors** (p. 261)
- **10.3.3 Particle Detectors** (p. 263)
- **10.3.4 Mass Spectrometry and LIDAR** (p. 267)
- **10.4 Summary** (p. 268)
- **Chapter 11. Immune Building Control Systems** (p. 269)
- **11.1 Introduction** (p. 269)
- **11.2 Control Systems** (p. 270)
- **11.3 Control System Architectures** (p. 271)
- **11.3.1 Detect-to-Alarm** (p. 272)
- **11.3.2 Detect-to-Isolate** (p. 273)
- **11.3.3 Detect-to-Treat** (p. 275)
- **11.4 Emergency Systems** (p. 276)
- **11.4.1 Outside Air Purging** (p. 277)
- **11.4.2 Secondary System Operation** (p. 278)
- **11.4.3 Sheltering Zone Isolation** (p. 279)
- **11.5 Building Automation for Immune Buildings** (p. 281)
- **11.6 Summary** (p. 285)
- **Chapter 12. Security and Emergency Procedures** (p. 287)
- **12.1 Introduction** (p. 287)
- **12.2 Physical Security Measures** (p. 288)
- **12.3 Incident Recognition** (p. 293)
- **12.7 Sheltering in Place** (p. 304)
- **12.4 Emergency Response** (p. 297)
- **12.5 Disabling Devices** (p. 301)
- **12.6 Emergency Evacuation** (p. 303)
- **12.8 Medical Response** (p. 306)
- **12.9 Security Protocol** (p. 307)
- **12.10 Personnel Training** (p. 309)
- **12.11 Summary** (p. 310)
- **Chapter 13. Decontamination and Remediation** (p. 311)
- **13.1 Introduction** (p. 311)
- **13.2 Decontamination by Physical Means** (p. 312)
- **13.3 Decontamination by Chemical Means** (p. 314)
- **13.4 Ozone** (p. 315)
- **13.5 Chlorine Dioxide** (p. 322)
- **13.6 SNL Foam** (p. 323)
- **13.7 Summary** (p. 325)

- **Chapter 14. Alternative Technologies** (p. 327)
- **14.1 Introduction** (p. 327)
- **14.2 Thermal Disinfection** (p. 329)
- **14.3 Cryogenic Freezing** (p. 329)
- **14.4 Desiccation** (p. 329)
- **14.5 Passive Solar Exposure** (p. 330)
- **14.6 Vegetation Air Cleaning** (p. 331)
- **14.7 Antimicrobial Coatings** (p. 332)
- **14.8 Electrostatic Filters** (p. 333)
- **14.9 Negative Ionization** (p. 333)
- **14.10 Ultrasonication** (p. 334)
- **14.11 Photocatalytic Oxidation** (p. 336)
- **14.12 Ozone Air Disinfection** (p. 337)
- **14.13 Microwave Irradiation** (p. 340)
- **14.14 Pulsed White Light** (p. 341)
- **14.15 Pulsed Filtered Light** (p. 343)
- **14.16 Pulsed Electric Fields** (p. 346)
- **14.17 Gamma Irradiation** (p. 346)
- **14.18 Electron Beams** (p. 347)
- **14.19 Summary** (p. 348)
- **Chapter 15. Economics and Optimization** (p. 349)
- **15.1 Introduction** (p. 349)
- **15.2 Selecting Performance Criteria** (p. 349)
- **15.3 Economics of Filtration** (p. 350)
- **15.4 Economics of UVGI** (p. 354)
- **15.5 Economics of Carbon Adsorbers** (p. 363)
- **15.6 Energy Analysis** (p. 365)
- **15.7 Summary** (p. 366)
- **Chapter 16. Mailrooms and CBW Agents** (p. 367)
- **16.1 Introduction** (p. 367)
- **16.2 Mailroom Contamination** (p. 367)
- **16.3 Building Ventilation Systems** (p. 368)
- **16.4 Building General Areas** (p. 369)
- **16.5 Mail Handling by Employees** (p. 372)
- **16.6 Contaminated Letters and Packages** (p. 373)
- **16.7 Mail Processing Equipment** (p. 378)
- **16.8 Delivery Vehicles** (p. 379)
- **16.9 Mailroom Protocol** (p. 380)
- **16.10 Summary** (p. 382)
- **Chapter 17. Epilogue** (p. 383)
- **17.1 Introduction** (p. 383)
- **17.2 The Future of Bioterrorism** (p. 385)
- **17.3 Collateral Indoor Air Quality Benefits** (p. 387)
- **17.4 The Engineer and the Future of Disease Control** (p. 388)
- **Appendix A Database of Biological Weapon Agents** (p. 391)
- **Appendix B Database of Pathogen Disease and Lethal Dose Curves** (p. 439)

- **Appendix C Database of Toxins and Dose Curves** (p. 453)
- **Appendix D Database of Chemical Weapon Agents** (p. 469)
- **Appendix E UVGI System Sizes and Kill Rates** (p. 519)
- **Appendix F Source Code for Direct UVGI Field Average Intensity** (p. 525)
- **Glossary** (p. 531)
- **References** (p. 549)
- **Index** (p. 571)