

## CONTENTS

### PART I SOURCES, MITIGATION

|   |    |
|---|----|
| SUMMARY   | 2  |
| 1. INTRODUCTION   | 4  |
| 2. POLLUTANT CHARACTERIZATION   | 5  |
| 2.1 Sick Building Syndrome and the Combined Effects of Pollutants       | 5  |
| 2.2 Volatile Organic Compounds  | 9  |
| 2.3 Respirable Suspended Particulates                                   | 28 |
| 2.4 Biological Contaminants   | 35 |
| 2.5 Combustion Gases  | 42 |
| 2.6 Radon   | 49 |
| 3. VENTILATION  | 54 |
| 3.1 Characterization of Ventilation                                     | 54 |
| 3.2 Interaction with Pollutants   | 57 |
| 3.3 Standards   | 57 |
| 3.4 Characterization of Building Air Exchange Rates                     | 58 |
| 4. MITIGATION   | 61 |
| 4.1 Building Commissioning  | 61 |
| 4.2 Source Avoidance and Control  | 63 |
| 4.3 Indoor Air Quality Management                                       | 64 |
| 4.4 Building Diagnostics  | 64 |
| 4.5 Mechanical Control of Indoor Air Pollutants                         | 67 |
| 5. ENERGY CONSERVATION MEASURES AND INDOOR AIR QUALITY-<br>IMPLICATIONS | 75 |
| 6. REFERENCES   | 81 |

### PART II HEALTH EFFECTS

|   |     |
|---|-----|
| SUMMARY   | 90  |
| 1. Introduction   | 92  |
| 1.1 Definition of Terms                                     | 93  |
| 1.2 The NEPA Process  | 104 |
| 1.3 Selection of Pollutants for Health Effect Analysis      | 104 |
| 1.4 Study Methodology                                       | 105 |
| 2. INDOOR AIR QUALITY                                       | 108 |
| 2.1 The Sick Building Syndrome and Building-Related Illness | 108 |
| 2.2 Volatile Organic Compounds                              | 109 |

|   |     |
|---|-----|
| 2.3 Combustion Products                                   | 204 |
| 2.4 Fibers  | 246 |
| 2.5 Biogenic Particles                                    | 255 |
| 2.6 Other Potential Contaminants                          | 261 |
| 3. POLYCHLORINATED BIPHENYLS                              | 263 |
| 3.1 Summary   | 263 |
| 3.2 Health Effects  | 264 |
| 4. CHLOROFLUOROCARBONS                                    | 280 |
| 4.1 Direct Health Effects of CFCs                         | 280 |
| 4.2 Health Effects of Stratospheric Ozone Layer Reduction | 283 |
| 5. IMPLICATIONS OF RISK ASSESSMENT IN INDOOR AIR          | 285 |
| 6. REFERENCES   | 287 |

### PART III

#### SUGGESTED METHODS OF ANALYSIS FOR INDOOR AIR ENVIRONMENTAL CARCINOGENS

|  |     |
|--|-----|
| INTRODUCTION   | 292 |
| RADON  | 293 |
| Overview   | 293 |
| Sampling   | 293 |
| Analysis   | 294 |
| ASBESTOS   | 300 |
| Overview   | 300 |
| Phase Contrast Microscopy                                  | 300 |
| Scanning Electron Microscopy (SEM)                         | 301 |
| Transmission Electron Microscopy (TEM)                     | 302 |
| Fibrous Aerosol Monitor (FAM-1)                            | 302 |
| ORGANIC COMPOUNDS  | 303 |
| Overview   | 303 |
| General Analytical Methods for Gas Phase Organic Compounds | 303 |
| Formaldehyde   | 306 |
| Polycyclic Aromatic Hydrocarbons                           | 309 |
| Pesticides   | 309 |
| INORGANIC SPECIES  | 310 |
| Overview   | 310 |
| Inorganic Arsenic (Salts, Arsenates, and Arsenites)        | 310 |
| Beryllium  | 310 |
| Cadmium (Oxide, Bromide, and Chloride)                     | 312 |
| Chromium (Hexavalent)                                      | 312 |
| Nickel (Carbonyl and Subsulfide)                           | 312 |
| Selenium (Sulfide)   | 313 |

|  |     |
|--|-----|
| PARTICLES                              | 314 |
| Overview                               | 314 |
| Environmental Tobacco Smoke            | 314 |
| NONIONIZING RADIATION                  | 317 |
| Overview                               | 317 |
| Radiometric Measurements               | 317 |
| Interaction Coefficients               | 318 |
| Dosimetry                              | 318 |
| OTHER APPROACHES TO ASSESSING EXPOSURE | 319 |
| Biological Markers                     | 319 |
| Questionnaires                         | 320 |
| Exposure Modeling                      | 320 |
| REFERENCES                             | 321 |