Subject Index

A

Abbey School Sports Hall, 279 Acetone, chromatographic scan, 239 Acute respiratory health monitoring, 134-135 Aerosol, 9 Air distribution system, 54 movement pathways, ventilation efficiency, 114–115 sampling rates, 12 Airborne particles, 9 Air-conditioning system. See HVAC Air exchange, 287 parameters, 152 Air exchange rate, 121, 185 factors, 150 house, 173 measurement, 137 tracer gas decay method, 288 versus temperature difference, 45-46 Airflows, interzonal, 288, 291–294 Air handling units, 36 Airtightness, 185 Air-to-air heat exchanger, 148–149, 151, 159, 161 ASHRAE Dust Spot rating, 13, 20, 26 ASHRAE Standard 55-1981, 72, 87–88 ASHRAE Standard 62-1981, 72, 87-88 ASTM E 741-83, 44, 123, 257-258, 288 Atomic absorption analysis, 29-30 Aureobasidium, 95-96

B

Benzene, chromatographic scan, 238–239
Benzo (a) pyrene, 178–184
activity questionnaire, 182
food, 182
home selection, 180
indoor/outdoor air sampling, 180
methods validation, 180–182
seasonal variation, 183

soils, 182 study area selection, 180 study design, 182–183 water, 181 Bioaerosols, 48-49, 116, 125, 129, 141-142 data collection, 119-120 monitoring, 231 Breakthrough volume defined, 246 low boiling compounds, 247 British Gas Maintenance Depot, 283 Building illness syndrome. See Sick building syndrome Buildings, 2-3, 35-49 air distribution system, 36-38 air handling units, 36 air quality and ventilation rates, 58–59 bake out, 107-108 carbon monoxide, levels, 40 characteristics, 121-122 closeout procedure, 107-109 contractors, 76 construction closeout procedure, 99 current investigation, 42–49 bioaerosols, 48-49 indoor pollutant measurements, 47-48 inspection, 42-43 system airflows and ventilation effectiveness, 46-47 tracer gas decay tests, 43-46 description, 36-38 design professionals, 76 draft, 59, 61 envelope, 204-205 factors affecting air quality studies, 51-61 health and ventilation reduction, 57 health and temperature, 58 history of complaints, 35 indoor climate, 56-57 measurements, 55-56 investigation, 73, 203, 209 factors influencing, 74 see also NIOSH investigations

Buildings—Continued maintenance problems, 43 major findings, 38-39 materials contamination, 70 mechanical system, contaminant source, 118 mechanisms for introduction of contaminants, 77-78 microbiological contaminants, 41 organizational interests, 75-77 owners and managers, 76 past investigations, 38–41 performance, 35 pre-occupancy evaluations, 107 project and problem definition, 73-79 recommendations, 40 relief air system, 42-43 sources of difficulty, 74 statistical methods, 55-56 study design, 53-55 technical causes of problems, 73 technical systems, 58-60 time variation of air contamination, 78-79 single cell, 266 multipoint sampling, 267 see also Diagnostics; specific buildings or types

С

Calcium, 9 California state office buildings, 99-109 air sampling data, 101 Bateson building, Sacramento, 100-102 California Energy Commission Building, Sacramento, 104-105 design flaws, 106 recommendations, 107 State Office Building, Long Beach, 102-104Canister collection systems, VOC, 266–227 Carbon dioxide, 63 concentration, 48, 67, 88, 113-114 monitoring, 262–263 Carbon monoxide, 219 concentration, 40, 48 GEOMET test houses, 155 electrochemical personal exposure monitors, 221 monitoring, 172, 221 Carrier gas flow rate, electron capture detector, 271–272 Chemical reactivity, 188 equivalent volumetric flow rate, 192

Chemiluminescence, NO₂ monitoring, 222 Coarse particles, 9 indoor and outdoor concentrations, 21-22 Combustion-related sources, 115, 166-177, 205 broad, low-intensity field studies, 171 cross-sectional studies, 171, 177 emission rates, source strengths, and venting factors, 173-174 factors affecting usage patterns, 169–170 measurement techniques and protocols, 171-175 modeling, 168-171 reactivity rates and penetration factors, 174-175 samplers, 172-173 short-term concentrations, 175 source strength, 169, 171 source usage parameters, 173 types, 167-168 venting factor, 169 Commercial buildings. See Buildings Consultation, 80, 82–83 flowchart, 84 Consumer products, 234, 237 Contaminant, 35, 99 assessment, 47-48, 55, 115 concentration, 185, 196 attenuation of differences, 196 change in, 251 factors affecting, 169–170 spatial average, 168-169 evaluations, 111 exposure-response relationship, 205 mechanisms for introduction, 77-78 sources, 115-116 outside, 116-117 time variation, 78-79 source strength. See Source strength storage and release, 188 Control strategies, 90 Cooling towers, contaminant source, 117 Courtaulds Engineering Workshop, 280 Courtaulds Pattern Making Shop, 281 Coventry Airport, 282

D

Data analysis, 214 evaluation, 213–215 flow and tracking, 213 quality, 18–19, 179

Data collection, 19, 111-125 air movement pathways, 114–115 assessing ventilation rates, 113-114 bioaerosols, 119–120 building height, 118 building mechanical system, contaminant source, 118 computer-controlled, 264 contaminant assessment, 115 history of occupant complaints and building operation, 112–113 HVAC, preventive maintenance, 118 indoor contaminant sources, 115-116 mechanical systems, 114 outside contaminant sources, 116-117 tracer gas decay measurement, 120-124 Deposition velocity, 9 Design, 99 definition, 1 flaws, 106 original intent, 113 Diagnostics consultation, 82-83 data acquisition, 84 determining appropriate instrumentation, 82 hypotheses, 85 interpreting results of mesurements, 83 knowing what to measure, 82 predicting building performance, 83 protocols, 81-83 qualitative, 82, 85–91 chemical and physical agents, 86-88 control strategy analysis, 90 flowchart, 86 load analysis, 90 performance criteria, 85-89 problem and complaint characterization, 89 report, 90-91 simulation, 90-91 system boundaries, 89 quantitative, 82, 91–97 analysis, interpretation, and report, 95-97 flowchart, 92 human resource questionnaire, 93–95 informed consent notice, 94, 96 objective measures, 93 quality assurance and control, 93 site selection, 91-93 subjective measures, 93–95 Diffusive sampling, VOC, 29 Draft, 51

commercial and office buildings, 59, 61 Dust, monitoring, 231–232

E

Electrochemical CO personal exposure monitors, 221 Electron capture detector amplifier, 268-269 block diagram, 259–261 carrier gas flow rate, 271-272 column dimensions, 269, 271 current, 269-270 performance, 271 sample loop volume, 271 sampling and calibration valves, 259 six-channel design, 271, 273–274 system optimization, 269 El ventilation rates, 259-261 Emission rate, 234 combustion-related sources, 173-174 Energy conservation, 9, 99 Energy consumption, 148, 287 factors, 150 parameters, 152 Engineering analysis, 80 Environmental chamber, 234 Environmental chamber/gas chromatographic instrumental system, 235-236 Environmental inventories, 203 Environmental Inventory Questionnaire. See Questionnaires Environmental parameters, 152 Epidemiology, 206--207 Evaluation criteria, 68 Exfiltration, 121 Exhaust systems, localized, contaminant source, 117 Exposure, 185 factors, current levels of knowledge, 206 multiple vector assessment, 179

F

Fibers, 116 Field tests, 185 protocol, 194–195 Filters, preparation and weighing, 11 Filtration, 9 household, 187 Fine particles, 9 indoor and outdoor concentrations, 21–22 sources, 26 Food, benzo(*a*)pyrene, 182 Formaldehyde, 129, 219 concentrations, 103, 164 measurements, 138–140 monitoring, 224–225 regression model, 164

G

Gas analyzer block diagram, 273 calibration, 271, 275 Gas chromatography, 219, 269, 289 ventilation rates, 258 Gaseous-pollutant concentration, 168 Gaseous sample introduction system, 235-237 GEOMET test houses, 148-165, 289 closed-wall construction, 152 critique and recommendations, 161-162 data analysis and interpretation, 157-161 data flow and use, 157 experimental design, 149-151 floor plans, 153, 290 house model, 152-153 models, 158 objectives, 148 occupancy simulations, 151 post-retrofit monitoring, 149 retrofit effect, 158-159 semicontinuous measurements, 156 Governmental agencies, 77

Η

Halocarbon tracers, 291-294 Harvard Six-Cities Study, 130 Heating, See HVAC Hot water heating system, 54 Human resource questionnaire, 93-95 Humidity, 63, 68 control, contaminant source, 118 HVAC, 9, 51, 63, 111 boundaries, 89-90 capacities, 90 evaluation, 65-68, 100 malfunctions, 102 mechanical systems, 114 operation changes, 32 indoor air effect, 13 procedure implementation, 15 parameters, 16-17 status, 21

variable air volume multizone, 99 Hypersensitivity pneumonitis, 49, 69

I

Ill buildings, 51 Indoor climate attributes. 94 commercial and office buildings, 56-57 identification, 204 measurements, 55-56 Indoor concentration, 21 average, 20 inorganic gases, 24-25, 27 ionic species, 22, 26 nonpolar organic compounds, 24, 27 trace elements, 22-23, 27 VOC, 22, 24-25, 27 Infiltration, 81, 121, 148, 266, 287 instrumentation, 257 measurement, 257 prediction model, 191 rate, 279-283, 293 seasonal frequency distribution, 158-159 whole building, 282–283 Informed consent notice, 94, 96 Infra-red gas analysers, 267 Inhaled particle monitors, 223 Inorganic gases, 9 indoor and outdoor concentrations, 24-25, 27 Inspection, office building, 42-43 Instrumentation, 4, 166, 219-232 bioaerosol monitoring, 231 CO monitoring, 221 CO₂ monitoring, 262–263 failures, 16 formaldehyde monitoring, 224-225 house dust monitoring, 231-232 integration, survey studies, 212-213 monitor development, 220 NO₂ monitoring, 221–223 PAH monitoring, 228 pesticides and related SVOCs, 227-228 positioning, 18 radon monitoring, 230-231 respirable particles, 223–224 selection, 17-18, 82 surveys, 211-213 survey studies, 200 ventilation, 257 ventilation rates, 262-264 VOC monitoring, 225-227 see also specific devices

Integrative passive sampling devices, 221–223 Interest groups, 75–77 Interzone flows, 279–283 Ionic compounds, 9 Ionic species, indoor and outdoor concentrations, 22, 26

K

Kerosene heaters, 143–144 Kingston-Harriman, Tennessee, multipollutant study, 129

L

Legionella, 141–142 Loading docks, contaminant source, 117 Long-term exposure prediction, 185-197 analysis methodology, 193-194 concentrations, 196 equivalent ventilation, 196 factors affecting modeling, 186-187 field testing protocol, 194–195 future work, 197 hourly average concentration, 195 model development, 188 parametric forms, 189–191 ventilation models, 191-193 Wadden and Scheff single-sell model, 189 removal mechanisms, 187-188 sources, 195-196

M

Mass balance model, 9, 19–20, 28–30, 158, 166, 244 systematic identification, 204 two-zone case, 291-292 VOC, 251, 253 Mass spectrometry, 219 Material suppliers, 76 Measurement methods, 219 Methodology, 4, 73 Methods validation, 178 multisorbent sampling technique, 246-248 Methylene chloride, chromatographic scan, 239 Microbiological agents, 88-89 Microbiological contamination, 41, 70–71 Microbiology, 111 Microenvironmental survey, 178, 182 Microorganisms, 129 Mixing factor, 185, 191 calculation, 194-195

Modeling, 148, 166, 185 combustion-related sources, 168-171 conceptual. 204 GEOMET test houses, 158 long-term exposure prediction, factors affecting, 186–187 see also Mass-balance model Monitoring, 73 Multiple exposures vector assessment, 179 Multipollutant study, 129–147 acute respiratory health monitoring, 134-135 air exchange rate, measurement, 137 bioaerosols, 141–142 core air quality monitoring, 135-137 energy use and weatherization characterization, 142–145 formaldehyde, measurements, 138-140 group classification code, 131 Harvard Six-Cities Study, 130 house construction and retrofit, 154 kerosene heater, 143-144 monitoring strategy, 154-156 nitrogen dioxide, monitoring, 135-136 PAHs, monitoring, 139-141 parameters, 152, 162 phases, 153-154 post-study evaluation survey, 145-146 protocols, 133-134, 154-156 radon, measurements, 137-139 respirable particles, monitoring, 136-137 study design, 130-133 supplemental air quality monitoring, 137-142water vapor, monitoring, 136-138 weekly initial setups, 132 Multisorbent sampling technique, 244-255 application, 248–255 laboratory and field evaluation, 246 materials and methods, 245-246 method validation, 246–248

Ν

National Ambient Air Quality Standards, 87-88, 198 NIOSH investigations, 41 building materials contamination, 70 by building type, 69-70 common health complaints, 70 inadequate ventilation, 71-72 indoor air quality questionnaire, 66-67 inside contamination, 71 methodology, 64-69 NIOSH investigations—Continued additional site assessments, 68-69 background assessments, 64-65 evaluation criteria, 68 initial site assessment, 65-68 microbiological contamination, 70–71 outside contamination, 71 by problem type, 70-71 by year, 69 Nitrogen dioxide, 129, 219 monitoring, 135-136, 221-223 Nitrous oxide, as tracer gas, 266 Non-dispersive infrared spectroscopic detection, 221 Non-Occupational Pesticides Exposure Study, 227-228 Nonpolar organic compounds, indoor and outdoor concentrations, 24, 27

0

Objective measures, 93 Odor recognition thresholds, 87, 98 Office buildings. See Buildings Operating room, model for contaminant balance, 91 Optical particle counters, 31–32 Organic chemicals, 116 Organizational interests, 75–77 Outdoor concentrations, 21, 71 inorganic gases, 24–25, 27 ionic species, 22, 26 nonpolar organic compounds, 24, 27 trace elements, 22–23, 27 VOC, 22, 24–25, 27 Ozone, 115

P

Palmes tube, 222 Parametric forms, 189–191 Parametrics, 185 Parking lots, contaminant source, 117 Particles fractionating, 29 optical counters, 31–32 source, 115 Particulate organics, 9 Particulate samples, characteristics, 12 Pasıla Office Center, 52–53 air distribution system 54 hot water heating system, 54 indoor climate measurements, 55–56 protocols

sampling, 199-200 statistical, 199 Passive badges, 219 Passive bubbler monitor, 224 Passive sampling, 19, 133 formaldehyde, 224-225 NO₂, 221–223 VOCs, 17, 226-227 PCP, levels, 103, 106 Penetration factor, 175 Perfluorocarbon tracers, 288-289, 294-296 Performance criteria, 80, 85-89 Personal exposure monitors CO, 221 respirable particles, 223-224 Personal interviews, 65 Personal monitors, 219 Pesticides, 219 monitoring, 227-228 Phillipsburg, New Jersey, 180–181 Pneumonitis, hypersensitivity, 49, 69 Polyaromatic hydrocarbons, 219 Polynuclear aromatic hydrocarbons, 129 denuder-based samplers, 229-230 monitoring, 139-141, 228-230 sources, 228 Polyurethane foam, 219, 227–228 adsorbent cartridge, PAH monitoring, 228-229 Power availability, sampling equipment, 16 Prediction, 185 Pre-occupancy evaluations, 107 Probability distributions, 184 Professional services, 76-77 Protocol, 73, 80-83, 99 combustion-related sources, 171-175 definition, 1 field tests, 194-195 long-term exposure prediction, 194–195 multipollutant study, 133-134, 154-156 sampling, 199–200 statistical, 199 telephone office buildings, 16-19 Proton-induced X-ray emission, 27, 30-31

Q

Quality assurance, 93 control, 93 Questionnaires, 66–67, 203–210 administration issues, 210–211 assessment, 211 comfort and psycho-social considerations, 209 design, 210–211 development, 209–210 effectiveness, 206 logic of conceptualization, 210 necessary information, 207–209 reliability and validity, 207 significant questions, 207–209 standard, 209–210 survey role, 206–207 techniques of operationalization, 210

R

Radon, 116–117, 129, 219 concentrations, 48 measurements, 137-139 monitoring, 230-231 Reactivity, 185 Reactivity rate, 174 Regression model, formaldehyde, 164 Relief air system, 42–43 Removal mechanisms, 205 Residential buildings, 3–4 field studies, 129 Respirable particles, 129 monitoring, 136-137, 223-224 sampling, 172 Retrofit, 148 effect, 158-159 monitoring after, 149 procedure, 154 Roadways, contaminant source, 117 Room temperature, 51, 63, 68 distribution, 56–57 draft sensation and, 61 health and, 58 performance criteria, 87–88

S

Sampling combustion-related sources. 172–173 periods, 18 program, California state office buildings, 103 protocols. 199–200 site selection, 91–93 sufficient material, 17
Scandium-titride source, 259
Semivolatile organic chemicals, monitoring, 227–228
Sick building syndrome, 51, 219 Aureobasidium, 95–96 SBS-score, 55–57 symptoms, 51–52, 69–70, 244, 246

adjusted summation score, 58-60 correlation with room temperature, 61 passive smoking and, 61 Simulation, 90–91 Single-cell model, 187, 189 Site assessment, 65–69 Smoking environmental smoke, 208 particle source, 115 passive, SBS symptoms and, 61 Soils, benzo(a)pyrene, 182 Sorbents, 219 Sorbent sampler, 244 Sorbent tube samplers, VOC, 246 Sources, 185 inventories, 107 Source strength, 169, 185, 244 apparent specific, 251–253 combustion-related sources, 171-174 parametric response to step change, 190 VOC, 249–250, 254 Space heater source strengths, 171 usage, 208 Stack effect parameters, 192 Standardization, 203 State Office Building, Long Beach, 102–104 Statistical protocols, 199 Stuffy offices, 51 Subjective measures, 93–95 Sulfate, 9 Sulfur hexafluoride calibration curve, 262-263 concentrations, 155–156 decay method, 293 electron capture detector, 259-261, 268 peaks height and base line, 269-270, 272 various concentrations, 259, 261 as tracer gas, 257–264, 266, 289 tygon tubing, 262 Surface sampling, 11-12 Survey studies, 198-201, 203 design considerations, 199 evaluation, 213-215 identification of factors, 203–207 integration of instruments, 212–213 issues, 200-201 measurement methods and instruments. 200microenvironmental, 178, 182 monitoring instrument selection, 211–213 post-study evaluation, 145-146 recommendations, 201 role of questionnaires, 206-207

Survey studies—*Continued* sampling protocols, 199–200 statistical protocols, 199 walk-through, 65 Suspended particles, indoor and outdoor concentrations, 21–22

Т

Telephone office buildings, 9-33 air sampling rates, 12 data collection and management procedures, 19 design variables affecting accuracy, 13 goal of study, 10, 28 implementation and protocols adequate samples, 17 data quality assurance, 18–19 HVAC parameters, 16–17 instrument failure, 16 instrument positioning, 18 instrument selection, 17–18 power availability, 16 procedure development, 14 procedure implementation, 14-16 sampling periods, 18 unusual activities at sites, 17 weather effects, 16 indoor and outdoor concentrations fine, coarse and total suspended particles, 21 inorganic gases, 24-25, 27 ionic species, 22, 26 nonpolar organic compounds, 24, 27 trace elements, 22-23, 27 VOC, 22, 24–25, 27 interpretation of results, 25-28 leakage rate, 30 model 30-31 development, 19-21 origin of study, 9-10 particulate samples, characteristics, 12 preparation and weighing of filters, 11 recommendations, 31-32 retrospective analysis. 28-31 sampling duration, 10 site selection, 13 study design, 10-13, 28-30 surface sampling, 11-12 volatile organic sampling, 12–13 Tenants, 76 Tenax-GC sorbent tubes, 219, 225–226 Thermosorb cartridge, 222-223 Threshold limit values, 87 Tight office building syndrome, 51

Toluene, chromatographic scan, 239 Total exposure assessment methodology study, 198 Total human environmental exposure study, 178 Trace contaminants, exposure vectors, 179 Trace elements, 9 indoor and outdoor concentrations, 22-23, Tracer gas decay method, 43-46, 111, 114, 120-124, 266-285 air exchange evaluation, 121-124 rates, 45-46, 288 airflows, 46-47, 124 air sampling, 44-45 automated measurement system, 44 block diagram, 274 building characteristics, 121-122 calibration, 271, 275-276 constant concentration, 287 data analysis, 277–278 effective volume, 123-124 future developments, 285 halocarbons, 291 infiltration rates, 279-283 injection system 123, 277 constant injection, 287, 289 instrumentation, 122-123 interzone flows, 279-283 multiple, 287-296 calculations, 291-292 interzonal airflows, 288, 291-294 results, 292-296 multipoint, 267 oscillation due to time lags, 284–285 percent recirculation, 124 perfluorocarbon tracers, 288-289, 294-296 quantities of outside air delivered, 123 setup, 277 site calibration, 277 specification, 267-268 Tracer gas dilution, 257, 275–276 1,1,1-Trichloroethane, 105

V

Ventilation, 35, 63, 121, 185 assessment, 111 effective, 185 effectiveness, 47, 187 efficiency, air movement pathways, 114– 115 equivalent, 196

inadequate, 71-72 instrumentation, 257 measurement, 257 mechanical, 121 models, 191-193 natural, 81, 121 reduction and health, 57 testing, 104 Ventilation rate, 51, 244, 257-264 across-the-envelope, 187 air quality and, 58-59 assessment, 113-114 calibration system, 262-263 codes and standards, 81 computer-controlled data acquisition system and driving software, 264 effective, 113-114, 191 electron capture detector, 259-261 equivalent, 185, 188 gas chromatograph, 258 instrumentation, 262-264 sampling system, 262 Venting factors, 174 Volatile organic chemicals, 4, 9, 219 adhesive, 243 chromatographic scan, 239, 241 source strength, 254–255 carpet, chromatographic scan, 239-240 collection on solid sorbents, 234 concentrations, 48, 105, 250-252 as function of ventilation rate, 250, 252-253 consumer product testing, 237 diffusive sampling, 29 environmental chamber/gas chromato-

graphic instrumental system, 235–236

experimental procedure, 236–238 gaseous sample introduction system, 235-237 indoor and outdoor concentrations, 22, 24-25, 27, 248-250 low-boiling compounds breakthrough volumes, 247 precision and accuracy, 247-248 mass-balance model, 251, 253 monitoring, 225-227 multisorbent sampling technique. See Multisorbent sampling technique paint, chromatographic scan, 239, 242 passive sampling, 17, 226-227 retention times, 237-238 sampling, 12-13 valving diagram, 236–237 source strengths, 254

W

Wadden and Scheff single-cell model, 189
Walk-through survey, 65
Water

benzo(a)pyrene, 181
vapor, monitoring, 136–138

Weather, effects on procedure implementation, 16
Weatherization, 142
Wind effect parameter, 192

X

XAD-2 resin, 229