TECHNICAL MANUAL

Oregon OSHA

Section III
(previously Section II of Oregon OSHA's Technical Manual)

HEALTH HAZARDS

*All information within this section and chapter has been reproduced from the Oregon OSHA Technical Manual (circa 1996) unless otherwise stated within the "**Chapter Revision Information**", located at the beginning of each chapter.*

SECTION III: CHAPTER 2

INDOOR AIR QUALITY INVESTIGATIONS

Oregon OSHA TECHNICAL MANUAL

<u>Chapter Revision Information:</u>

- *This chapter was previously identified as Section II, Chapter 2 in Oregon OSHA's circa 1996* ***Technical Manual****. The section number was modified from Section II to Section III in May 2014 to provide uniformity with federal OSHA's Technical Manual (OTM).*
- *In May 2014, the chapter's multilevel listing format was modified from an alphanumeric system to a roman numeral system.*
- *In May 2014, Section III (Investigation Guidelines) and Section IV (Sampling Instrumentation and Methods) were revised to include Oregon OSHA specific information.*

SECTION III: CHAPTER 2

INDOOR AIR QUALITY INVESTIGATIONS

I. Introduction

A. Causal Factors

Modern office buildings are generally considered safe and healthful working environments. However, energy conservation measures instituted during the early 1970s have minimized the infiltration of outside air and contributed to the buildup of indoor air contaminants.

Investigations of indoor air quality (IAQ) often fail to identify any harmful levels of specific toxic substances. Often employee complaints result from items such as cigarette smoke, odors, low-level contaminants, poor air circulation, thermal gradients, humidity, job pressures, lighting, work-station design, or noise. Appendix III:2-1 presents a brief discussion of these items.

B. Incidence

The range of investigations of indoor air quality problems encompasses complaints from one or two employees to episodes where entire facilities are shut down and evacuated until the events are investigated and problems corrected.

Complaints are often of a subjective, nonspecific nature and are associated with periods of occupancy. These symptoms often disappear when the employee leaves the workplace. They include headache, dizziness, nausea, tiredness, lack of concentration, and eye, nose and throat irritation.

In approximately 500 indoor air quality investigations in the last decade, the National Institute for Occupational Safety and Health (NIOSH) found that the primary sources of indoor air quality problems are:

- Inadequate ventilation 52%
- Contamination from inside building 16%
- Contamination from outside building 10%
- Microbial contamination 5%
- Contamination from building fabric 4%
- Unknown sources 13%[1]

C. Recommended Ventilation Rates

The American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) established recommended ventilation rates for indoor environments in 1973.[2]

ASHRAE amended this standard in 1975 to specify the minimum value of 5 cubic feet per minute (CFM) of outdoor air per person be used in building design. This standard has been incorporated into the building codes of many cities and states.[3]

The 62-1989 standard recommends a minimum of 15 CFM of outdoor air per person for offices (reception areas) and 20 CFM per person for general office space with a moderate amount of smoking. Sixty cubic feet per minute per person is recommended for smoking lounges with local mechanical exhaust ventilation and no air recirculation.[4]

II. Acute Health Effects of Major Indoor Air Contaminants

A. Types of Building Problems

Employee complaints can be due to two types of building problems: sick or tight building syndrome and building related illnesses.

1. SICK BUILDING SYNDROME

Sick building syndrome is a condition associated with complaints of discomfort including headache; nausea; dizziness; dermatitis; eye, nose, throat, and respiratory irritation; coughing; difficulty concentrating; sensitivity to odors; muscle pain; and fatigue. The specific causes of the symptoms are often not known but sometimes are attributed to the effects of a combination of substances or individual susceptibility to low concentrations of contaminants. The symptoms are associated with periods of occupancy and often disappear after the worker leaves the worksite.

2. BUILDING RELATED ILLNESSES

Building related illnesses are those for which there is a clinically defined illness of known etiology and include infections such as legionellosis and allergic reactions such as hypersensitivity diseases and are often documented by physical signs and laboratory findings. A more thorough description of these illnesses can be found in the American Conference of Governmental Industrial Hygienists (ACGIH) guidelines on evaluating bioaerosols.[5]

B. Major Indoor Air Contaminants

General. Although asbestos and radon have been listed below, acute health effects are not associated with these contaminants. These have been included due to recent concerns about their health effects.

The investigator should be aware that there may be other health effects in addition to those listed.

1. ACETIC ACID

Sources: X-ray development equipment, silicone caulking compounds.

Acute health effects: Eye, respiratory and mucous membrane irritation.

2. CARBON DIOXIDE

Sources: Unvented gas and kerosene appliances, improperly vented devices, processes or operations which produce combustion products, human respiration.

Acute health effects: Difficulty concentrating, drowsiness, increased respiration rate.

3. CARBON MONOXIDE

Sources: Tobacco smoke, fossil-fuel engine exhausts, improperly vented fossil-fuel appliances.

Acute health effects: Difficulty concentrating, drowsiness, increased respiration rate.

4. FORMALDEHYDE

Sources: Off-gassing from urea formaldehyde foam insulation, plywood, particle board, and paneling; carpeting and fabric; glues and adhesives; and combustion products including tobacco smoke.

Acute health effects: Hypersensitive or allergic reactions; skin rashes; eye, respiratory and mucous membrane irritation; odor annoyance.

5. NITROGEN OXIDES

Sources: Combustion products from gas furnaces and appliances; tobacco smoke, welding, and gas- and diesel-engine exhausts.

Acute health effects: Eye, respiratory and mucous membrane irritation.

6. OZONE

Sources: Copy machines, electrostatic air cleaners, electrical arcing, smog.

Acute health effects: Eye, respiratory tract, mucous membrane irritation; aggravation of chronic respiratory diseases.

7. RADON

Sources: Ground beneath buildings, building materials, and groundwater.

Acute health effects: No acute health effects are known but chronic exposure may lead to increased risk of lung cancer from alpha radiation.

8. VOLATILE ORGANIC COMPOUNDS (VOCs)

Volatile organic compounds include trichloroethylene, benzene, toluene, methyl ethyl ketone, alcohols, methacrylates, acrolein, polycyclic aromatic hydrocarbons, pesticides.

Sources: Paints, cleaning compounds, moth-balls, glues, photocopiers, "spirit" duplicators, signature machines, silicone caulking materials, insecticides, herbicides, combustion products, asphalt, gasoline vapors, tobacco smoke, dried out floor drains, cosmetics and other personal products.

Acute health effects: Nausea; dizziness; eye, respiratory tract, and mucous membrane irritation; headache; fatigue.

9. MISCELLANEOUS INORGANIC GASES

Includes: Ammonia, hydrogen sulfide, sulfur dioxide.

Sources: Microfilm equipment, window cleaners, acid drain cleaners, combustion products, tobacco smoke, blue-print equipment.

Acute health effects: Eye, respiratory tract, mucous membrane irritation; aggravation of chronic respiratory diseases.

10. ASBESTOS

Sources: Insulation and other building materials such as floor tiles, dry wall compounds, reinforced plaster.

Acute health effects: Asbestos is normally not a source of acute health effects. However, during renovation or maintenance operations, asbestos may be dislodged and become airborne. Evaluation of employee exposure to asbestos will normally be covered under the OSHA Asbestos standard.

11. MAN-MADE FIBERS

Sources: Fibrous glass and mineral wool.

Acute health effects: Irritation to the eyes, skin and lungs; dermatitis.

12. TOBACCO SMOKE

Sources: Cigars, cigarettes, pipe tobacco.

Acute health effects: Tobacco smoke can irritate the respiratory system and, in allergic or asthmatic persons, often results in eye and nasal irritation, coughing, wheezing, sneezing, headache, and related sinus problems. People who wear contact lenses often complain of burning, itching, and tearing eyes when exposed to cigarette smoke[6]. Tobacco smoke is a major contributor to indoor air quality problems. Tobacco smoke contains several hundred toxic substances including carbon monoxide, nitrogen dioxide, hydrogen sulfide, formaldehyde, ammonia, benzene, benzo(a)pyrene, tars, and nicotine. Most indoor air particulates are due to tobacco smoke and are in the respirable range.

13. MICROORGANISMS and OTHER BIOLOGICAL CONTAMINANTS (MICROBIALS)

Include viruses, fungi, mold, bacteria, nematodes, amoeba, pollen, dander, and mites.

Sources: Air handling system condensate, cooling towers, water damaged materials, high humidity indoor areas, damp organic material and porous wet surfaces, humidifiers, hot water systems, outdoor excavations, plants, animal excreta, animals and insects, food and food products.

Acute health effects: Allergic reactions such as hypersensitivity diseases (hypersensitivity pneumonitis, humidifier fever, allergic rhinitis, etc.) and infections such as legionellosis are seen. Symptoms include chills, fever, muscle ache, chest tightness, headache, cough, sore throat, diarrhea, and nausea.

III. Investigation Guidelines

A. Employer and Employee Interviews

1. EMPLOYER INTERVIEW

- What is the magnitude and distribution of employee complaints or illnesses? Are any employees obtaining medical care?

- What are the design and operational parameters of the heating, ventilating, and air-conditioning (HVAC) system, such as source and amount of fresh air per occupant delivered to the breathing zone; adjustable or local HVAC controls; type of humidifier and how controlled; recent ventilation changes; and areas serviced by various units?

- Does the frequency and type of maintenance performed on the HVAC systems, such as cleaning and oiling, meet the HVAC manufacturer's recommendations: filter change; prevention of bacterial buildup by use of biocides; repair and cleanup of water leaks; operating fresh air intake damper; and system balance checks?

- Is smoking allowed in the office, in adjacent areas or in areas serviced by the same ventilation system? Are there designated smoking areas that have separate, non-recirculating exhaust systems?

- What type of copying machines, signature machines, spirit duplicators, blueprint machines and other office machines are used in the vicinity of complaints or in areas serviced by the same ventilation system?

- Has there been any recent renovation or maintenance that can be sources of contaminants, such as painting, carpet installation, air conditioning repairs, use of acid drain cleaners, carpet cleaning, disinfecting of HVAC system, pesticide application?

- Has there been any recent renovation or maintenance that can alter air flow patterns such as installation of partitions or relocation of air intakes or exhausts?

2. EMPLOYEE INTERVIEWS

- What are the complaints and associated symptoms experienced; when do they occur (season, time, days, frequency); where do they occur; how long do symptoms last; do they clear up after leaving work (how soon); have the symptoms been triggered by any specific event or in any specific area; what is the source of symptoms; was any medical diagnosis or care rendered?

- What are the workers' characteristics, such as smoker, allergies, pre-existing illnesses and disabilities; are they taking any medication; what are the occupational contributors?

B. Walkaround Inspection

NIOSH has determined that inadequate ventilation is the main problem in 52% of their IAQ investigations. Therefore, ventilation surveys should be initially conducted.

During the walkaround inspection, the investigator could determine the building characteristics, discuss with knowledgeable personnel the proper operation of the HVAC systems, verify information obtained from the employer and employee interviews, perform ventilation-system testing, and, if appropriate, collect screening samples to identify potential causes of the problem.

Evaluation and testing of the HVAC system should follow the procedure established in the Ventilation Investigation chapter of this manual.

Investigators may need to discuss the operation of the ventilation system with building engineers and perform ventilation testing to determine proper fresh air intake. A simple traverse of the fresh-air intake duct may provide adequate information to determine the fresh-air flow. Measurements should be made under maximum and minimum air-flow conditions to determine the range of fresh-air intake.

The walkaround inspection should cover all the affected areas. Factors to be evaluated include inside and outside contamination sources; the HVAC system, e.g., location of air source, contamination, and proper operation; and occupational contributors, such as those listed in Appendix III:2-1.

1. POTENTIAL PROBLEM AREAS

The following is a compilation of specific concerns in past investigations but may not apply in every situation.

Are there sources of indoor contaminants that could lead to employee complaints (e.g., copy machines, signature machines, blueprint copiers, paints, cleaning compounds and disinfectants, tobacco smoke, adhesives and glues, off-gassing of construction material and building fabric, contaminants generated by construction or renovation, positive- or negative-pressure work areas, improperly vented gas appliances, air fresheners, pesticides)?

Are there sources of outdoor contaminants that lead to employee complaints (e.g., vehicle exhaust, roofing materials, cooling towers, dust, or other contaminants from construction activity, industrial plant, or building exhaust; gasoline vapors, pollen, biological contaminants, atmospheric pollutants)?

Are heating, ventilating, and air-conditioning systems being operated and maintained properly with respect to location of air intakes and exhausts, pressure differentials between rooms that may account for influx of contaminants, design for supplied outdoor air, flow and distribution of air, position of dampers, local exhaust ventilation, air-cleaning equipment, HVAC operating times, regular operation checks, equipment cleaning and disinfecting, presence of water leaks or standing water, water-damaged building materials, and bacteriological contamination?

2. SAMPLE COLLECTION

During the walkaround inspection, professional judgment must be exercised to determine if samples should be collected to evaluate potential sources and potential contaminants including gases, vapors, and particulates.

Initial sampling will normally consist of collecting environmental data using grab or screening samples with direct reading equipment such as detector tubes, particulate monitors, air velocity measuring instruments, and psychrometers. Screening samples for airborne contaminants should be collected for formaldehyde, carbon dioxide, carbon monoxide, and VOCs which are common potential sources of contamination.

Samples may be collected to monitor the possible buildup of contaminants during the workday. Detector tube samples can be collected for carbon dioxide early in the day and again toward the end of the day; direct reading instruments can monitor continuously using a strip chart recorder to obtain a hard copy of contaminant variations during the day.

To evaluate thoroughly, collect samples at fresh-air intakes, near return-air ducts, adjacent to both indoor and outdoor potential sources of contaminants, and in employee work areas both for complaint and non-complaint areas. Sampling methods and equipment are covered in Section IV.

C. Environmental Evaluation

Based on initial sampling, further investigations may be performed using standard OSHA sampling procedures. The Oregon OSHA Analytical Laboratory should be contacted to confirm the proper flow rate for low levels of common indoor air contaminants.

1. MICROBIOLOGICAL EVALUATION

NIOSH found that 5% of its investigations of indoor air quality involved some type of microbiological contamination.[6]

The ACGIH Bioaerosols Committee's guidelines for assessing the role of bioaerosols[7] contains information on sampling, analysis, and recommendations for remedial actions. Air sampling should be initiated only after medical or clinical reports indicate the existence of workplace related illnesses, such as hypersensitivity and allergic disorders, that are likely due to bioaerosols.

Contact the Oregon OSHA Laboratory for information about laboratories experienced in the analysis of specialized bioaerosol samples and with knowledge of the health effects. This equipment requires advance arrangements for preparing culture media for sampling, specialized handling techniques for the samples, and arrangements for analysis by laboratories familiar with the handling and processing of biological samples. The Oregon OSHA Laboratory may be consulted for further information.

IV. Sampling Instrumentation and Methods

A. Low Contaminant Levels

Choose sampling procedures that can determine concentrations of toxic materials which are much lower than are normally found in industrial investigations. Few procedures have been validated for these lower level contaminants. Contact the Oregon OSHA Laboratory with any sampling questions.

Present OSHA sampling and analytical procedures were developed to meet precision and accuracy requirements for airborne contaminants in the range of OSHA Permissible Exposure Limits (PELs) and American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Values (TLVs). These procedures are used for sampling 8-hour Time-Weighted Averages (TWAs) and Short-Term Exposure Limits (STELs) of 15 or 30 minutes.

In many IAQ investigations, extensive air monitoring may not be warranted because inadequate introduction and/or distributions of fresh air may be the main problem.

B. General Screening

Use screening techniques to determine the potential sources that may require more sensitive and accurate evaluation or may require action as described in Section E, depending upon professional judgment.

Collect screening samples using detector tubes or direct reading instruments. For increased sensitivity, higher flow rates or longer sampling times may be used. Low range detector tubes are available from manufacturers. Appendix III:2-2 contains a table of screening methods, concentration range, validated testing methods, and contaminant types.

Based on screening results, validated sampling procedures may be required to further quantify employee exposures. Much of the information on validated sampling and analytical methods is contained in the OSHA Chemical Information Manual or in the OSHA Analytical Methods Manual.

Much of the specialized equipment is available through the Oregon OSHA Laboratory.

C. Optional Screening for Common Indoor Air Contaminants, Based Upon Professional Judgment

1. ACETIC ACID

Use detector tubes (0-10 ppm) to evaluate complaints of eye, nose, and throat irritation.

Low levels of acetic acid have been found from off-gassing of silicone caulking compounds and in hospitals where x-ray developing equipment is improperly ventilated.

2. ASBESTOS

Screening is not a routine procedure.

Any requested screening should be done in accordance with the proper OSHA Standards.

3. CARBON DIOXIDE

Use low level detector tubes (0-2000 ppm) or portable infrared spectrometers to screen for indoor carbon dioxide levels.

Carbon dioxide measurement is a useful screening technique which is often helpful in determining whether adequate quantities of outside fresh air have been introduced and distributed into the building.

NIOSH Recommendations:

- 250-350 ppm normal outdoor ambient concentrations;
- 600 ppm minimal air quality complaints;

- 600-1000 ppm less clearly interpreted;
- 1000 ppm indicates inadequate ventilation and complaints such as headaches, fatigue, and eye and throat irritation will be more widespread; 1000 ppm should be used as an upper limit for indoor levels.

These levels are only guidelines. If carbon dioxide levels exceed 1000 ppm it does not necessarily indicate that the building is hazardous and should be evacuated. Rather this level should be used as a guideline that helps maximize comfort for all occupants.[6]

4. CARBON MONOXIDE

Low level detector tubes (2-200 ppm).

Direct reading CO monitors.

5. FORMALDEHYDE

Use low level (0.04-1 ppm) detector tubes to evaluate complaints of eye, nose, and throat irritation which may be due to off-gassing from insulation, building materials, carpets, drapes, or glues and adhesives.

6. NITROGEN OXIDES and OZONE

Detector tubes.

Also collect outdoor samples since ambient levels of ozone may reach levels that are 1-3 times the PEL of 0.1 ppm during air-temperature inversions.

If a more accurate or continuous ozone evaluation is required, a chemiluminescent monitor that is specific for ozone and can measure in the range of 0.01 to 10 ppm may be acquired from the Oregon OSHA Laboratory. Contact the Oregon OSHA Laboratory to arrange for the acquisition of acceptable sampling equipment. The Oregon OSHA Laboratory should also be contacted for interpretation of the results.

7. RADON

A rapid, easy-to-use screening method for measuring radon gas concentrations is available. Contact the Oregon OSHA Laboratory to arrange for the acquisition and use of acceptable sampling equipment. It is used for deciding if additional measurements are required or remedial actions should be undertaken.

Additional longer term quantitative procedures are available from the Oregon OSHA Laboratory if required. Contact the Oregon OSHA Laboratory to arrange for the acquisition of acceptable sampling equipment. The Oregon OSHA Laboratory should also be contacted for interpretation of the results.

EPA Recommendations[8] for the results of screening samples:

<4 picocuries per liter of air (pCi/L):	Follow-up measurements probably not required.
>4 pCi/L:	Follow-up measurements should be performed.

8. AIRBORNE PARTICULATES

Use a particle counting instrument capable of measuring concentrations as low as 2000 particles/cubic centimeter (cc) of air for comparing particulates in various areas. The investigator may be able to determine where additional ventilation or air filtration is necessary to eliminate or minimize employee complaints.

For example, if employee complaints are more prevalent in an area where the particulate concentration is 40,000 particles/cc., and other areas are below 15,000 particles/cc., the investigator may recommend that a high efficiency filter be installed or, if the area has a separate ventilation system, that the ventilation rate be increased.

9. AIRBORNE MICROORGANISMS

The ACGIH[5] recommends a preassessment of the extent of microbial contamination prior to initiation of air sampling. Airborne microbials sampling equipment is available from the Oregon OSHA Laboratory if sampling is necessary. Contact the Oregon OSHA Laboratory to arrange for the acquisition of acceptable sampling equipment. The Oregon OSHA Laboratory should also be contacted for interpretation of the results.

Before biological sampling, several precautions must be taken including making arrangements for preparing culture media for sampling, specialized shipping procedures, and making arrangements for analysis by a laboratory familiar with the handling and processing of biological samples. Contact the Oregon OSHA Laboratory for information about laboratories experienced in the analysis of microbial samples and with knowledge of the health effects.

Legionella pneumophila is often present in hot water tanks, washing systems and pools of stagnant water but health effects are not observed until the contaminants become aerosolized within the building confinements.

The identification of predominant taxa, or at least fungi, is recommended in addition to determining the number of colony-forming units/m3 of air (cfu/m3). During growing seasons, outdoor fungus-spore levels can range from 1000-100,000 cfu/m3 of air. Contamination indicators:[9]

- 1000 viable colony-forming units in a cubic meter of air,
- 1,000,000 fungi per gram of dust or material, and
- 100,000 bacteria or fungi per milliliter of stagnant water or slime.

Levels in excess of the above do not necessarily imply that the conditions are unsafe or hazardous. The type and concentrations of the airborne microorganisms will determine the hazard to employees.

D. Miscellaneous Airborne Contaminants

Use a portable infrared spectrometer to evaluate a wide variety of potential air contaminants including acetic acid, ammonia, carbon dioxide, carbon monoxide, nitric oxide, nitrogen dioxide, sulfur dioxide, and a number of volatile organic compounds. It can be connected to a strip chart recorder to obtain a hard copy showing variations of concentration during the day.

Take care in interpreting the results since the instrument is not always specific for one compound. Note: Equipment not generally available in the field, such as the particulate analyzer, infrared spectrometer, and airborne biological sampler is available through the Oregon OSHA Laboratory along with a written description of the equipment, operating manuals, and methods of analysis.

V. Recommendations for the Employer

The following are general recommendations which, where relevant, should be standard procedure. If followed, they will help prevent or alleviate many indoor air-quality problems.

A. Engineering Recommendations

1. VENTILATION

Includes the use of natural, dilution, local exhaust, or increased ventilation efficiency.

The most effective engineering control for prevention of indoor air quality problems is assuring an adequate supply of fresh outdoor air through natural or mechanical ventilation.

ASHRAE in its 62-1989 standard recommends 20 cubic feet per minute (CFM) of outdoor air per occupant for offices. For smoking lounges, up to 60 CFM of outdoor air per occupant should be provided.

When possible, use local exhaust ventilation and enclosure to capture and remove contaminants generated by specific processes. Room air in which contaminants are generated should be discharged directly outdoors rather than recirculated.

2. EFFICIENCY

Ventilation efficiency can be improved by:

- Ensuring that outdoor air-supply dampers and room air-vents are open,
- Removing or modifying partitions or obstructions which block fresh-air flow,

- Rebalancing the system to prevent inflow or outflow of contaminated air due to pressure differentials between rooms,
- Preventing poor distribution of make-up air by proper placement of air inlets and exhausts, and
- Using room fans to improve mixing and dilution of pollutants.

Outside air intakes should not be located in close proximity to potential sources of contamination (automobile garages, cooling towers, building exhausts, roadways).

3. AIR TREATMENT

Air treatment is the removal of air contaminants and/or the control of room temperature and humidity. Recommendations for air treatment include:

- The use of filtration, electronic cleaners, chemical treatment with activated charcoal or other sorbents;
- Humidity control in range of 20% to 60%;
- Temperature control in the range of 68-76^{o}F.

4. SOURCE CONTROLS

Source controls include substitution, removal, encapsulation, local exhaust ventilation, and use of physical barriers.

B. Administrative and Work Practice Recommendations

Recommendations include programs that change the behavioral patterns of occupants.

1. PREVENTIVE MAINTENANCE (PM)

Preventive maintenance plans for humidifiers, water spray, and other HVAC system components should include:

- Checking damper positions and functioning belts, baffles, ductwork, and system balance;
- Measuring airflow and performing necessary adjustment if necessary to meet ASHRAE recommendations;
- Replacing filters on air handling units at regular intervals;
- Cleaning air distribution ducts and dampers; and
- Replacing damaged insulation.

2. MICROBIAL CONTAMINATION

Eliminate or control all known and potential sources of microbial contaminants by prompt cleanup and repair of all areas where water collection and leakage has occurred including floors, roofs, HVAC cooling coils, drain pans, humidifiers containing reservoirs of stagnant water, air washers, fan coil units, and filters.

Remove and discard porous organic materials that are contaminated (e.g., damp insulation in ventilation system, moldy ceiling tiles, and mildewed carpets).

Clean and disinfect nonporous surfaces where microbial growth has occurred with detergents, chlorine-generating slimicides, or other biocides and insuring that these cleaners have been removed before air handling units are turned on. Maintain indoor air relative humidity below 60% (50% where cold surfaces are in contact with room air).

Adjust intake of outdoor air to avoid contamination from nearby soil, vegetable debris, cooling towers, or sanitary stacks unless air is adequately conditioned.

Adjust combustion sources such as furnaces or water heaters to assure proper burning and exhaust to an area where re-entrainment will not occur.

Minimize exposure by limiting occupancy of contaminated airspace, limiting use of offending sources to specific areas or times, or evacuating contaminated areas until they can be ventilated adequately.

Isolate, if feasible, areas of renovation, painting, carpet laying, pesticide application, etc., from occupied areas that are not under construction.

If possible, perform this work during evenings and weekends. If ventilation is turned off during weekends or other periods, ensure that system is on so that contaminant concentrations are sufficiently diluted prior to occupancy.

Supply adequate ventilation during and after completion of work to assist in diluting the contaminant levels.

Personnel affected with hypersensitivity should be thoroughly evaluated and the problem identified and corrected before returning them to the workplace. If, after the remedial action, the illness persists in the workplace, the affected personnel should be considered for permanent reassignment to another area.

Eliminate or reduce contamination of the air supply with cigarette smoke by banning smoking or restricting smoking to designated areas which have their air discharged directly to the outdoor rather than recirculated.

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APPENDIX III:2-1. Investigating Office-Related Complaints

Investigations of office related complaints using industrial hygiene techniques often fail to identify the source of these problems. The combined effects of multiple, low-level air contaminants has not been investigated thoroughly and may be a cause of the problem.

In a recent NIOSH document, *Stress Management in Work Settings*, occupational stress is discussed in terms of assessment methods, stress management, and programs and training necessary to reduce occupational stress. The synergistic effect of multiple stressors appears to indicate that building related problems may be more than an air quality problem. The combined effect of these multiple stressors may interact with employees and could result in acute adverse emotional or physical reactions. In the short term, these reactions may lead to decreased productivity, absenteeism, and high turnover rates and if prolonged may lead to a variety of illnesses including hypertension, coronary heart disease, ulcers, alcoholism and mental illness.

These office related health problems can be evaluated by a consultant through employee interviews, analysis of job demands, and training employees.

The following potential problems may need to be addressed:

- Physical hazards including noise from nearby sources such as air conditioning systems and printers, inadequate lighting, stress from the operation of video display terminals (VDTs), vibration sources, extremes of heat, cold and humidity, drafts, and poor air circulation.

- Ergonomic problems such as carpal tunnel syndrome or inflammatory disorders of the tendons and joints of keyboard operators due to tasks requiring repetitive motions. Proper design of fixed work stations where employees are required to perform repetitive tasks includes proper lighting to prevent glare, maintaining temperature and humidity in a comfortable range with minimum temperature variations, maxi-mum flexibility in work station design including adjustable chair, keyboard, and screen height, and a work-rest regimen that allows breaks to reduce psychological distress.

- Reduction of job stress by:

  (a) adequate flow of information from management to employees;

  (b) explanation of any changes introduced into the workplace including new chemicals, ventilation, production modification, and work schedules;

  (c) maximizing employee participation in planning and implementing changes;

  (d) stress reduction techniques including exercise, biofeedback, and assertiveness training; and

  (e) training workers to understand chemicals they may be working with and their health effects, dose/response relationships, and results of environmental evaluation.

APPENDIX III:2-2. Investigating Office-Related Complaints

Contaminant	***Concentration range***	***Screening method***	***Validated method***
Bioaerosols	0-1000 cfu/m3	Viable biological sampler	
Carbon dioxide	0-2000 ppm	DT, IR	Sampling bag, GC/TCD OSHA ID172
Carbon monoxide	2-50 ppm	DT, meter	Sampling bag, meter
Formaldehyde	0.04-1ppm	DT	Coated XAD-2, GC/NPD OSHA-52
Nitric oxide	0-25 ppm	DT	TEA tube with oxidizer, DPP OSHA ID190
Nitrogen dioxide	0-5 ppm	DT	TEA-Molecular Sieve Tube, IC OSHA ID 182
Particulates	0-40000 particles/cc	Light scattering meter	
Pesticides	(See OSHA Chemical Information Manual)		
Ozone	0-0.1 ppm	DT, Chemiluminescent meter	
Radon	4-200 pCi/l	Radon Cartridge, Electrect	
VOCs	(See OSHA Chemical Information Manual)		

Key:
- DPP: Differential pulse polarographic
- DT: Detector tubes
- GC: Gas chromatograph
- IC: Ion chromatograph
- IR: Infrared spectrometer
- Meter: Calibrated, direct reading meter available through laboratory, HRT, or area office
- NPD: Nitrogen phosphorus detector
- TCD: Thermal conductivity detector
- TEA: Triethanolamine

NOTE: Referenced OSHA procedures can be found in the OSHA Analytical Methods Manual or the OSHA Chemical Information Manual. See individual manufacturer's literature for information on interferences to the screening or sampling method.