**BUILDING PROBLEMS**

**OVERVIEW**

Modern buildings are generally considered safe and healthy working environments. However, the potential for indoor air quality problems, occupational illnesses and injuries, exposure to hazardous materials, and accidental falls beckons architects, engineers, and facility managers to design and maintain buildings and processes that ensure occupant safety and health. Notably, building designs must focus on eliminating or preventing hazards to personnel, rather than relying on personal protective equipment and administrative or process procedures to prevent mishaps.

Using 
computational fluid dynamics to study threats to occupants from indoor 
air contamination

***Threats to occupants from indoor air contamination can be studied in Computational Fluid Dynamics.***

Protecting the health, safety, and welfare (HSW) of building occupants has expanded beyond disease prevention and nuisance control to include mental as well as physical health and protecting the ecological health of a place through the creation of places that enable delight and the realization of human potential.

Therefore, the design team must engage an integrated approach, including work process analysis and hazard recognition to develop solutions that provide healthy built environments, having no undue physical stressors, as well as meeting other project requirements. In addition, consideration of HSW issues should be an integral part of all phases of a building's life cycle: planning, design, construction, operations and maintenance, renovation, and final disposal.

**RECOMMENDATIONS**

**Provide Designs that Eliminate or Reduce Hazards in the Work Place to Prevent Mishaps**

* Provide designs in accordance with good practice as well as applicable building, fire, safety, and health codes and regulations. See Standards and Code Organizations found at the end of this section.
* Conduct preliminary hazard analyses and design reviews to eliminate or mitigate hazards in the work place.
* Use registered design professionals and accredited safety professionals to ensure compliance with safety standards and codes.
* Provide engineering controls in place rather than rely on personal protective equipment or administrative work procedures to prevent mishaps.
* Integrate safety mechanisms, such as built-in anchors or tie-off points, into the building design, especially for large mechanical systems.
* Design a means for safely cleaning and maintaining interior spaces and building exteriors.
* Provide for receiving, storing, and handling of materials, such as combustibles, cleaning products, office supplies, and perishables.

**Prevent Occupational Injuries and Illnesses**

* Consider work practices, employee physical requirements, and eliminating confined spaces when designing buildings and processes.
* Design for safe replacement and modifications of equipment to reduce the risk of injury to operations and maintenance staff.
* Comply with applicable regulatory requirements such as the Occupational Safety and Health Administration (OSHA) standards. All OSHA standards are available in the 29 Code of Federal Regulation) (1926—Construction, and 1910—General Industry).
* Provide proper ventilation under all circumstances, and allow for natural lighting where possible.
* Mitigate noise hazards from equipment and processes.
* Designate safe locations for installation of RF equipment such as antennas on rooftop penthouses.

**Prevent Falls from Heights**

* Provide guardrails and barriers that will prevent falls from heights in both interior and exterior spaces.
* Provide fall protection for all maintenance personnel especially for roof-mounted equipment such as HVAC equipment and cooling towers.
* Provide certified tie-off points for fall arrest systems.

**Prevent Slips, Trips, and Falls**

* Provide interior and exterior floor surfaces that do not pose slip or trip hazards.
* Select exterior walking surface materials that are not susceptible to changes in elevation as a result of freeze/thaw cycles.
* Provide adequate illumination, both natural and artificial, for all interior and exterior areas.
* Comply with all regulatory and statutory requirements such as the Americans with Disabilities Act.

**Ensure Electrical Safety**

* Ensure compliance with the National Electrical Code (NEC) NFPA-70.
* Provide adequate space for maintenance, repair, and expansion in electrical rooms and closets.
* Provide adequate drainage and/or containment from areas with energized electrical equipment.
* Evaluate all areas where ground fault circuit interruption (GFI) and arc fault interruption (AFI) devices may be needed.
* Consider response of emergency personnel in cases of fires and natural disasters.
* Label all electrical control panels and circuits.
* Install non-conductive flooring at service locations for high voltage equipment.
* Specify high-visibility colors for high voltage ducts and conduits.

**Eliminate Exposure to Hazardous Materials**

* Identify, isolate, remove, or manage in place hazardous materials such as lead, asbestos, etc.
* Consider use of sampling techniques for hazardous substances in all phases of the project to include planning, design, construction, and maintenance.
* Consider occupant operations and materials in designing ventilation and drainage systems.
* Incorporate integrated pest management (IPM) concepts and requirements into facility design and construction (e.g., use of proper door sweeps, lighting, trash compactors, etc.) and require the use of IPM be performed by qualified personnel during all phases of construction and after the facility is completed. This should include not only interior pest management, but landscape and turf pest management as well.
* Provide adequate space for hazardous materials storage compartments and segregate hazardous materials to avoid incompatibility.
* Substitute high hazardous products with those of lower toxicity/physical properties.

Diagram of a 
typical ventilation system design for fume hood systems in laboratories.
 The diagram shows outside air intake moving through the supply fan duct
 system and then moving into the exhaust hood and then onto the exhaust 
fan and exhaust stack.

***Typical ventilation system design for fume hood systems in laboratories. Air may be supplied through single- or dual-duct constant air volume (CAV) or variable air volume (VAV) systems.***

**Provide Good Indoor Air Quality and Adequate Ventilation**

* Consider ventilation systems that will exceed minimum ASHRAE standards.
* Recognize and provide specially designed industrial ventilation for all industrial processes to remove potential contaminants from the breathing zone.
* Design separate ventilation systems for industrial and hazardous areas within a building.
* Consider the use of carbon monoxide (CO) monitoring equipment if there are CO sources, such as fuel-burning equipment or garages, in the building.
* Specify materials and furnishings that are low emitters of indoor air contaminants such as volatile organic compounds (VOCs).
* Consider the indoor relative humidity in the design of the ventilation system.
* Avoid interior insulation of ductwork.
* Locate outside air intakes to minimize entrainment of exhaust fumes and other odors. (e.g., vehicle exhaust, grass cutting and ground maintenance activities, industrial pollutant sources, cooling tower blow-offs, and sewage ejector pits).
* Ensure the integrity of the building envelope, including caulks and seals, to preclude water intrusion that may contribute to mold growth.
* Prevent return air plenums/systems from entraining air from unintended spaces.
* Provide air barriers at interior walls between thermally different spaces to prevent mold and mildew.

**Provide Ergonomic Workplaces and Furniture to Prevent Work-Related Musculoskeletal Disorders (WMSD)**

* Design work places that make the job fit the person.
* Select furnishings, chairs, and equipment that are ergonomically designed and approved for that use.
* Design equipment and furnishings reflective of work practices in an effort to eliminate repetitive motions and vibrations as well as prevent strains and sprains.
* Consider using worker comfort surveys in the design phase to help eliminate work-related musculoskeletal disorders.
* Accept the principle that one size does not fit all employees.
* Consider providing break areas to allow the employees to temporarily leave the work place.
* Minimize lighting glare on computer monitor screens. Provide task lighting at workstations to minimize eye fatigue.

**Perform Proper Building Operations and Maintenance**

Proper preventative maintenance (PM) not only improves the useful life of the systems and building structures, but it can lend to good indoor air quality and prevent "sick building" syndromes.

* Ensure all maintenance and operation documentation, especially an equipment inventory, is submitted to the building owner/operator prior to building occupancy.
* Follow manufacturer recommendations for proper building operations and maintenance.
* Include safety training of operator personnel as part of the construction contractor's deliverables.
* Require the use of integrated pest management (IPM) for all pest management services, interior and exterior of the building.
* Require building maintenance personnel to maintain the HVAC air infiltration devices and condensate water biocides appropriately.
* Monitor chemical inventories to identify opportunities to substitute green products.

**Related Issues**

During the last week of January 2000, the Department of Labor said that employers would not be held liable for health and safety violations occurring in the homes of telecommuting employees. The Department of Labor stated that it would not hold employers responsible for health and safety violations that occur in home workplaces other than home offices, for example, fireworks being manufactured in the home or other activities involving the use of hazardous materials.

Illustration of 
cotton-pleated filter

***Cotton-pleated filters are possible safe, cost-effective alternatives to conventional fiberglass filters***

Potential exposure of building occupants to molds from contaminated HVAC systems, especially during maintenance and renovation projects, remains a serious concern. Reaction to exposure can range from negligible to severe among building occupants and can frequently be very difficult to definitively identify as a causal factor for occupants' symptoms. Special care must be exercised in HVAC design, especially, to prevent excessive humidity in system components.

Fiberglass is used extensively in building construction, especially for insulation and sound attenuation in HVAC systems. Considerable concern exists regarding the potential adverse health effects of inhaling fiberglass fibers. A number of studies are currently investigating the long-term effects of inhalation exposure to fiberglass. At a minimum, fiberglass exposed to the air stream in an HVAC system will shed particles and serve as a matrix for collecting dust and dirt that act as a substrate for microbial growth.

Contamination of domestic hot water systems, cooling towers, and condensate pans continues to result in infections of building occupants on a regular basis. The results of such infections can range from mild to fatal and affect one or many employees. They invariably result in employee apprehension and media attention. Mechanical engineers must be vigilant to avoid system designs that may promote the growth of legionella sp.

**RELEVANT CODES AND STANDARDS**

* ANSI/AIHA Z9, Ventilation Package - American National Standards Institute and American Industrial Hygiene Association
* Industrial Ventilation, A Manual of Recommended Practice - American Conference of Governmental Industrial Hygienists
* International Building Code - International Code Council
* NFPA 5000 Building Construction and Safety Code - National Fire Protection Association
* Occupational Safety and Health (OSH) Act 1970, 29 U.S.C. § 651 et seq.; 29 C.F.R. Part 1903.1 et seq.
* Occupational Safety and Health Administration, 29 CFR Part 1910 Code of Federal Regulations for General Industry (pertains to post-occupancy)
* Occupational Safety and Health Administration, 29 CFR Part 1926 Code of Federal Regulations for Construction (pertains to construction phase)

**Ensure Electrical Safety**

* Occupational Safety and Health Administration, 29 CFR Part 1910-Subpart S, Sections 301 to 309
* UFC 3-560-01 Electrical Safety, O&M; with Change 2

**Eliminate Exposure to Hazardous Materials**

* ASTM E1368 Standard Practice for Visual Inspection of Asbestos Abatement Projects
* ASTM E2356 Standard Practice for Comprehensive Building Asbestos Surveys
* ASTM E2394 Standard Practice for Maintenance, Renovation and Repair of Installed Asbestos Cement Products
* EP 1110-1-11 Engineering and Design Asbestos Abatement Guideline Detail Sheets
* EPA 20T-2003 Managing Asbestos in Place
* EPA 560/5-85-024 Guidance for Controlling Asbestos-Containing Materials in Buildings
* EPA 560-OPTS-86-001 A Guide to Respiratory Protection for the Asbestos Abatement Industry
* UFGS 02 82 14.00 10 Asbestos Hazard Control Activities
* UFGS 02 82 16.00 20 Engineering Control of Asbestos Containing Materials
* VA VHA Program Guide 1850.2, Integrated Pest Management (IPM)

**Provide Good Indoor Air Quality (IAQ) and Adequate Ventilation**

* ASHRAE Standard 52—Method of Testing Air-Cleaning Devices Used in General Ventilation for Removing Particulate Matter
* ASHRAE Standard 55—Thermal Environmental Conditions for Human Occupancy
* ASHRAE Standard 62.1—Ventilation for Acceptable Indoor Air Quality: Sets the minimum acceptable ventilation requirements.
* ASHRAE Standard 90.1—Energy Efficient Design of New Buildings
* UFC 3-410-02N Heating, Ventilating, Air Conditioning and Dehumidifying Systems
* UFC 3-410-04N Industrial Ventilation
* NISTIR 5329 Manual for Ventilation Assessment in Mechanically Ventilated Commercial Buildings
* OSHA Technical Manual—Section III, Legionnaires' Disease

**Provide Ergonomic Work Places to Prevent Work-Related Musculoskeletal Disorders (WMSD)**

* DoD Ergonomics Working Group
* OSHA Ergonomics
* UFC 4-021-02NF Security Engineering Electronic Security Systems, with Change 1

**Perform Proper Building Operations and Maintenance**

* ASHRAE Guideline 1.1—HVAC&R Technical Requirements for The Commissioning Process
* VA VHA Program Guide 1850.2, Integrated Pest Management (IPM)